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April 2, 1980
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Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Denton:

Under separate cover, we are transmitting forty copies of the Annual Environmental Operating Report for the Donald C. Cook Nuclear Plant corresponding to the year 1979. This report was prepared in accordance with Section 5.4 of Appendix B Technical Specifications of the Donald C. Cook Nuclear Plant.

Very truly yours,

G. P. Maloney
Vice President

GPM/emc

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Donald C. Cook Nuclear Plant
Units No. 1 and 2
Indiana & Michigan Electric Company
Annual Environmental Operating Report
January 1 through December 31, 1979

Docket Nos. 50-315 and 50-316
License Nos.DPR-58 and DPR-74

#8005050137

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I. INTRODUCTION

This Annual Environmental Operating Report for Unit Nos. 1 and 2 of the Donald C. Cook Nuclear Plant for the period ending December 31, 1979, meets the requirements of Section 5.4 of the facility Environmental Technical Specifications. These Technical Specifications require that a report on all environmental surveillance programs for the previous 12 months of operation be submitted for NRC review.

The Report is divided into two subdivisions, non-radiological and radiological. Section IV of this report deals with non-radiological surveillance reports and Section V is devoted to radiological environmental surveillance reports, and assessments of the observed impact of plant operation. One abnormal environmental occurrence was reported in 1979. No changes were made to the Environmental Technical Specifications.

The Cycle III-IV Refueling Outage for Unit No. 1 took place during this reporting period beginning on April 6, 1979.

Unit No. 1 generated 5,867,680 (MWH) gross of electrical energy. The Monthly Operating Reports indicate that during the year 1979, Unit No. 1 was operating at a Unit Service Factor of 64.7%, at an average Unit Capacity Factor of 61.9%.

Unit No. 2 was removed from service on October 19, 1979 for its first refueling. This Unit generated 6,168,880 (MWH) gross of electrical energy. Monthly Operating Reports indicate that Unit No. 2 was operating at a Unit Service Factor of 65.9%, at an average Unit Capacity Factor of 62.8% for 1979.

The semi-annual effluent release reports for 1979 indicated no adverse effects to the environment and population within a sixty mile radius of the Plant.

II. The Abnormal Environmental Occurrences

The following abnormal environmental occurrence was reported during the year 1979.

Date	Number	Occurrence
2-24-79	79-001/04X-0	Possible unplanned release of radioactive steam from MSR on Unit #2. Safety valve lifted for no apparent reason, causing a possible unmonitored release of Sodium-24 contaminated steam.

III. Changes to the Environmental Technical Specifications

During the 1979 reporting period the Commission did not issue any changes to the Appendix B Environmental Technical Specifications.

IV. NON-RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

1. PHYSICAL OBSERVATIONS

A. Underwater Observations

Forty dives were performed during the reporting period: one during April, nine during May, five during June, July and August, and four during September and October.

Scour was noted in 1978 and 1979 adjacent to the south discharge structure, directly in the flow path of high-velocity water discharge; placement of the concrete scour pad in front of the north discharge appears to have alleviated scour adjacent to that structure. The riprap surrounding the south intake structure was undisturbed; the sand/riprap interface to the southwest remained stable during 1978-1979. Accumulations of floc typically ranged from 1 to 5 mm thick. Large depressions (10 m across by 1 m deep) in the bottom were occasionally encountered in control areas; these depressions often contained a silt overburden 20-40 cm thick. Both uni-directional and eddy current patterns were detectable throughout the water column within 100-200 m of the discharges. Currents estimated at 1 m/sec between the discharges and 0.5 m/sec at the top and base of the south intake structure were encountered. Increased current and possible recirculation of water were noted at the south intake structure during 7-pump operation. Trash (primarily from fishermen) was observed less frequently during 1979 than before. Relative to concentrations in control (sand substrate) areas, organic debris (algae and terrestrial vegetation) were concentrated in the riprap zone by the trapping action of the uneven substrate, but appreciable accumulations were not noted. Dead fish and fecal pellets were seen occasionally. Increased turbidity within the plume was not encountered during 1979 but distinct masses of turbid water were encountered during swims around the south intake structure. In 1979, periphyton growth was reduced on top of the south intake structure, relative to earlier years, but was more luxuriant within 5 m of the base. As noted in previous years, peak lengths were attained during July-August. Macrophytes were not observed. Attached invertebrates (sponge, bryozoans and Hydra) increased steadily in numbers during 1973-1976, but numbers of sponge and bryozoan colonies appeared to plateau during 1977 and have declined subsequently; Hydra remained extremely abundant. Numbers (concentrations) of snails decreased dramatically during 1977-1978; snails were not observed during 1979. Density of crayfish in the riprap area during 1978 was less than one half that estimated during 1975. Riprap macroinvertebrates showed a predictable pattern of opportunistic colonization followed by peaking and then by declining numbers of species and individuals in accordance with initial niche exploitation, saturation and subsequent change (decline) in resource availability. Alewife, spottail shiner and perch eggs were noted during 1979 (as in previous years), documenting continued minor spawning in the vicinity of Cook Plant. Eggs were observed attached to periphyton, entangled in loose algae and lying loose on the sand. Eleven species of fish were observed during the reporting period. Listed in descending frequency of observation, they were: alewife, spottail shiner, yellow perch, sculpin (Cottus spp.), trout-perch, johnny darter, rainbow smelt, burbot, carp, longnose sucker and redhorse (Moxostoma spp.). Carp were observed primarily in the discharge area and rarely near the intake structures. Young-of-the-year alewife were very abundant during August-October 1979, a pattern documented previously.

Relative to numbers observed in control areas, fish congregated near the structure (alewife, spottail shiner, yellow perch) and in riprap areas (demersal species, e.g., johnny darter and sculpin). Numbers, diversity and activity of fish were highest at night and during summer months. Presence of Cook Plant structures and riprap has created an atypical, more sheltered and more diverse habitat that attracts and concentrates biota which follow a predictable successional pattern. Diver-observed effects of plant operation upon the local environment were minimal.

Further details of the underwater observations are given in Appendix A of this report.

1.B SCOUR BED STUDY

A. Specification 4.1.1.4 SCOUR STUDIES

The one full year after start-up of Unit 2 Scour Bed Study requirement was completed in 1978. No Scour Studies were performed in 1979.

1.C GROUNDWATER MONITORING

4.1.1.5 GROUNDWATER

The above specification is addressed in two parts. Part A, describes the chemical analyses of groundwater samples taken from shallow groundwater wells in the vicinity of the on-site absorption pond.

Part B describes the groundwater movements or the hydraulic properties of groundwater such as direction and velocity of flow.

This information is contained in Appendix C to this report.

Chemical analyses of groundwater is performed to determine the following parameters:

Sodium	Conductivity
Sulfate	Nitrate
Phosphate	Iron
pH	Copper

Samples from wells, 1a, 8,11 and 12 were tested for the above parameters, as were samples of lake water free from chlorination. Also groundwater levels were reported with each sample report for each well. Samples were taken during the months of February, March and September. February's samples were taken to meet the 26 week interval Technical Specification requirement. Sampling was done in March to synchronize Appendix B Technical Specification requirements with those of the NPDES Permit.

2. A. CHEMICAL DISCHARGES

Actual quantities of chemical released to the lake or absorption field during 1979 are listed below arranged according to the relevant Technical Specification:

1. 4.1.1.6.2 Corrosion And Deposition Inhibitiors

Amount discharged - lbs.

1. Phosphate 80.5 (heating boiler blowdown)

2. Ammonium hydroxide 257.6

2. 4.1.1.7.2 Other Chemical Discharges to Lake And Absorption Field

		Amt. Discharged	Discharged To
1.	Sodium Sulfate	229.6 tons	absorption field
2.	Boron	534.4 lbs.	Lake
3.	Detergent	5,360 lbs.	Lake

a. 5,000 lbs. decontamination

b. 360 lbs. condenser leaks

The majority of the detergents used for decontamination of the Auxiliary Building were processed through the waste disposal system. Values reported are based on inventory control of the detergents with the assumption that all that was used was discharged to the lake. The materials presently used are Spartan DC-13, Syntech Rad-ex, and By-Pas. The above cleaning compounds have the following active ingredients:

SPARTAN DC-13

Sodium Nitrite	Less than 0.5 %
Phosphate	0.7 %
Alkylaryl Polyethelene Glycol Ether	10 %
Potassium Hydroxide	Less than 0.1 %
Perfume	0.1 %
Rhodamine B Dye Basic (Violet #10)	3 ppm

SYNTECH RAD-EX

Caustic Soda	1 %
Metailicate	0.5 %
NTA	0.15%
Non Ionic	0.15%
Amphotenic Surfactant	0.15%
Water	Balance

BY-PAS

Ar_5O_3	2 ppm
Lead	1 ppm
Chlorine	10 ppm
Na_2O	.51 %
SiO_2	.465 %
Dye	Phenamine brillant blue GB conc.33-3-30 Lot #46687

The detergent used for condenser leak detection is discharged through the circulating water system. Values reported are based on inventory control of the detergent with the assumption that all used was discharged to the lake. The material presently in use is the LGS formula 64 sudsing agent has the following active ingredients:

Sodium Nitrate
Sodium Silicate
Sodium Phosphate

3. <u>4.1.1.7.2 Other Chemical Discharges to Absorption Field</u>

a. Turbine Room Sump composite data

Sodium	156,131.3	lbs
Calcium	56,149.5	lbs
Magnesium	27,391.0	lbs
Sulfate	310,577.1	lbs
Chloride	16,412.8	lbs
Total Solids	775,229.3	lbs

b. pH values on sump discharge

Low	High
5.5	8.9

c. Chemicals discharged to absorption pond other than spent regenerates. Rhodamine B Dye used for condenser leak detection was discharged to absorption pond. Six pounds were used in 1979.

2B. CIRCULATING WATER CHLORINATION

1. Specification 2.2.1.2

No chlorination of the circulating water system was done during 1979. No periods of chlorine experimentations took place in 1979.

3. AQUATIC STUDIES

A. Zooplankton

i. Lake Survey

Lake survey data from August to November 1978 and April to July 1979 are discussed in this report. Normal temporal succession patterns were observed for the numerically dominant taxa, and there was no strong evidence of a trend for these taxa to increase or decrease in abundance with continuing plant operation; nor was there strong evidence suggesting that power plant operation disrupted zooplankton distributions in the vicinity of the plume.

Zooplankton mean abundances in the operational years were compared with their abundances in the preoperational years. Analyses (Mann-Whitney U test) were made by month and by zone for the numerically dominant taxa. Four years of operational October data (1975 to 1978) and five years of operational April and July data (1975 to 1979) were used in these analyses. For each cruise-month analysis, several taxa occurred in statistically significant ($\alpha=0.05$) different preoperational and operational zone mean concentrations. Differences in the two plume zones (zones 2 and 5) were of the most concern. In October, nauplii, immature Cyclops spp. copepodites, adult Diaptomus spp., Bosmina longirostris, and Eubosmina coregoni occurred in significantly higher operational abundances in at least one of the two plume zones while adult Cyclops spp. and Daphnia spp. occurred in lower operational concentrations. In April, total zooplankton, nauplii, adult Diaptomus spp., and Limnocalanus macrurus copeodities were significantly more abundant while immature Cyclops spp. copepodites were significantly less abundant in the operational period in at least one of the two plume zones. In July, Daphnia spp. were significantly more abundant in the operational period while immature Cyclops spp. copepodites, immature and adult Diaptomus spp. copepodites, and Asplanchna were significantly less abundant in the operational period in at least one of the two plume zones. Differences in preoperational and operational zone mean concentrations were generally less than a factor of three. Similar magnitudes of differences were observed in the control zones suggesting that these differences were not directly related to plant operation.

Daphnia sp., tentatively identified as D. parvula was first observed in the survey area in May of 1978 and was again observed in low numbers in May of 1979. Simocephalus serrulatus was first observed in May 1978 but was not seen in 1979. Pleuroxus procurvis was observed for the first time in September 1978. Daphnia pulex was observed for the first time at several stations in October and November 1978. Mesocyclops edax and Daphnia pulex have been shown to be eliminated from the zooplankton under intense fish predation. Mesocyclops edax was a more abundant copepod in Lake Michigan prior to the large increase in alewife populations. The increased occurrences of these two zooplankton species may be indicative of declines in planktivorous fish populations or changes in fish feeding behavior. Alternatively, changes may be related to lake eutrophication and increased secondary production rates.

ii. Condenser-passage Studies

This report discusses data collected from the August to December 1978 period and the January to July 1979 period. No studies were conducted in June 1979 when both units were not operating.

Zooplankton mortalities were generally low, averaging 14.0% in the intake waters, 15.4% in Unit 1 discharge waters, and 16.4% in Unit 2 discharge waters. Average mortalities were higher than in previous years and were associated with high mortalities in September 1978 when discharge water temperatures may have reached the upper thermal limit (35°C) for short-term exposures to elevated temperatures, with high mortalities in March and February of 1979 when the plant was recirculating water, and relatively high mortalities in intake and discharge waters in April and May of 1979. Nauplii and immature *Diaptomus* spp. copepodites accounted for most of the dead zooplankton in April and May. High mortalities may have been associated with storm activity with detrital zooplankton being swept off the lake bottom.

There was no evidence for increasing mortality with increasing ΔT, discharge-water temperature (except when temperatures reached or exceeded 35°C), or with plant pumping rate (except during recirculation) under the conditions observed during our study. Mortality levels were generally statistically similar in the two discharge locations despite different operating characteristics.

There was a general relationship between percent composition of the zooplankton and percent composition of the dead zooplankton. However, certain taxa tended to have relatively high mortalities. Statistical analyses of the 1975 to 1978 mortality data set revealed that *Diaptomus minutus*, *D. ashlandi*, *D. oregonensis*, *Daphnia retrocurva*, *Eubosmina coregoni*, nauplii, and immature *Cyclops* spp. copepodites had significantly higher mortalities after plant passage at least for one of the incubation periods. The greatest number of differences were detected 6 hours after plant passage. The mean differences in mortality between discharge and intake waters generally were less than 10%. Analyses conducted on the August 1978 to July 1979 data set by month, incubation period, and by taxa revealed significant differences. Differences were shown for immature *Diaptomus* spp. copepodites, adult *Diaptomus* spp., immature *Cyclops* spp., copepodites and *Eubosmina coregoni*.

Zooplankton compositions and abundances in the cooling waters were similar to those observed in previous years. However, because both units were operating a larger number and biomass of zooplankton were entrained. Maximum estimated loss was higher than in previous years due to higher plant pumping rates and somewhat higher zooplankton mortalities. Numbers entrained ranged from 700 to 50,000 billion per month while biomass entrained varied from 1500 to 40,000 kg dry weight per month. Maximum estimated loss varied from .416 kg to 5,000 kg per month in contrast to 10 to 3500 kg/month as observed in the last operational report.

Results of the heterogeneity study are summarized. Zooplankton did exhibit statistically significant differences in abundance and composition between grate locations and depths in the intake forebay with concentrations tending to be highest at MTR 1-5 and MTR 1-1. Selection of MTR 1-5 as a representative sampling location may result in a slight overestimate of the numbers of zooplankton passing through the plant. Zooplankton generally were less abundant in Unit 1 discharge forebay than in the intake forebay and estimated abundances were lowest in Unit 2 discharge forebay. Since abundances are based on numbers of animals per volume of water, it is not clear why these differences should occur. Calculations of numbers and biomass of zooplankton passing through the plant are based on estimates obtained from the discharge locations.

Details of the aquatic studies conducted to investigate the effects of Cook Plant operation on zooplankton are given in Appendix B-1.

3.B. Phytoplankton

The section on numbers of forms in phytoplankton collections from the Cook Plant region is presented this year for the last time. Over the nine years for which numbers of forms were studied there had occurred taxonomic name changes which led us to suspect the validity of this parameter. When the matter was investigated the continuing increases in numbers of forms could be accounted for by a combination of taxonomic changes plus chance-occurrence captures of very rare forms.

Similarly, a section on new forms found in the phytoplankton since 1972 also was affected by revisions in phytoplankton taxonomy and by chance captures of very rare entities. Elimination of name changes and of low-density very rare forms reduced the new forms list to three which appear to have established (or may be establishing) themselves in the Cook region phytoplankton since 1972. These forms are Chromulina parvula and Cyclotella comensis which have been common or dominant since 1975, and Skeletonema subsalsum that became common for the first time in July shoreline samples in 1978.

Wilhm and Dorris diversity indices of Cook Plant phytoplankton collections taken during the seasonal surveys of 1970 through 1978 showed increasing trends, in all three depth zones as well as inner and outer station groups, from 1972 through 1976 with stable levels from 1976 through 1978. There is no evidence from this study that plant operation has adversely affected (lowered the diversity of) the phytoplankton community, instead the community in the operational years has continued to be more diverse than it was in the preoperational years.

Values of phytoplankton redundancy for collections during the seasonal surveys of 1970 through 1978 have been calculated. Plots of mean redundancies against time show visual evidence of a trend, beginning in 1973, for redundancies to become somewhat lower. If real, the trend would indicate a tendency for the species in the community to become more equal in numbers of individuals. Rising redundancies (one or a few species dominating the community) would be an adverse effect. Parallelism between the curves for redundancies at inner and outer station groups has, since 1972, been much better than in 1970 and 1971. This indication that changes in redundancy in the two station groups are now more alike than in the earliest years is taken to mean some change in the lake, not any effect of Cook Plant operation.

Of the ten major algal categories, only filamentous blue-greens have shown increases limited to the operational years. In depth zone 0 (0-8m) the abundances of these algae at inner and outer stations have been parallel and close together during all the years studied. In depth zone 1 (8-16m) summer abundances had been higher in the outer stations in 1975 through 1977; this reversed to higher summer numbers at inner stations in 1978. Depth zone 2 (16-24m) having shown higher summer abundances at inner stations in 1976 and 1977, reversed to greater abundances at outer stations in 1978.

The 1978 reversals in the latter two depth zones may be related to the July upwelling of that year, but the causal mechanism is unclear.

Coccoid blue-green algae showed a notable fall increase in pre-operational 1974 (due in part to a change in counting method then) and this pattern has continued since in both station groups. There is no clear evidence of any plant operation effect; the increases appear to be consistent with a depletion of silica in the epilimnion in fall.

The changes in mean abundances of the other categories have been:

Flagellates	Increasing trend since 1970
Pennate diatoms	" " " "
Centric diatoms	" " " "
Other algae	" " " "
Total algae	" " " "

The trends toward increasing abundances show in both station sets and in all three depth zones. They are attributable to changing conditions in the lake, rather than to effects of Cook Plant operation.

Details of the aquatic studies conducted to investigate the effects of Cook Plant operation on Phytoplankton are given in Appendix B-2.

3.C. Benthos

i. LAKE SURVEYS

In 1979, three seasonal surveys (April, July, and October) were taken with four replicates at each of 10 stations shallower than 8 m and two replicates at each of 20 stations at greater depths. The stations are divided into three depth ranges; 0-8 m (Zone 0), 8-16 m (Zone 1), and 16-24 m (Zone 2). In each depth range or zone, there are five stations within 1.6 km of the plant (Inner area) and five reference stations 3.2-11 km away from the plant (Outer area).

Fifty-four statistical tests were performed on the 1971-1979 data. Of these, only Pontoporeia hoyi in the October surveys of Zone 2 shows significant Inner/Outer t-test differences at the 0.05 level. Observed trends indicate Pontoporeia to be decreasing in density at the Inner Zone 2 while those of the Outer Zone 2 are increasing. At present, the observed significant differences in Inner/Outer ratios for Pontoporeia hoyi in October Zone 2 surveys cannot be associated with plant operation. Results most likely are to be attributed to naturally occurring physical and biological processes and patterns.

Previously reported significant Inner/Outer differences for Pontoporeia hoyi and Chironomidae in the April Zone 2 surveys were not apparent with inclusion of the 1979 data.

ii. ENTRAINMENT STUDIES

Concentrations of the four major species of macrocrustaceans, Pontoporeia hoyi, Mysis relicta, Gammarus, and Asellus were measured in the intake and discharge forebays of the cooling water which circulates through the Cook Plant. Samples were taken in the intake and discharge forebays twice monthly except in June, July, and August when sample sets were collected four times monthly. On sampling dates, collections were made during four consecutive approximately 6-hour periods (depending on the season of the year) corresponding to midnight-sunrise, sunrise-noon, noon-sunset, and sunset-midnight.

The 1979 concentrations of the four major crustaceans in entrainment samples were at levels similar to one or more of the previous operational years. Densities of Pontoporeia hoyi were comparable to those recorded for 1976 and 1977; Mysis relicta densities were similar to 1976; densities of Gammarus were slightly greater than the levels recorded during 1976 and 1978 but lower than the peak year of 1977; Asellus occurs in such small numbers that year to year comparisons are difficult; however, fewer were entrained than in previous years. No effect of plant operation has been detected on lake populations of Pontoporeia hoyi. The causes of yearly fluctuations in Mysis relicta, Gammarus, and Asellus are not known as our collection methods are not designed to sample their populations.

iii. IMPINGEMENT STUDIES

The projected total impingement of the crayfish Orconectes propinquus for 1979 (28 kg) is less than impingement levels for previous operational years (1975, 90 kg; 1976, 92 kg; 1977, 70 kg, and the revised total for 1978, 33 kg). The average weight per specimen in 1979 (6.7 gm projected) is slightly greater than observed for previous years 1975-1978 (5.5-6.5 gm). With inculsion of November and December 1978 data, the projected average weight per individual has been updated from 3.1 gm to 5.5 gm. The effect of impingement and other plant operations on crayfish populations is unknown. Crayfish were rare in the area of the plant until the riprap was established.

Further details of the aquatic studies conducted to investigate the effects of Cook Plant operation on Benthos are given in Appendix B-3.

3.D. Periphyton

The Cook Plant's underwater intake and discharge structures and the associated riprap field constitute an artificial reef, providing shelter and solid substrates in a region naturally devoid of them.

After their completion the underwater installations underwent a period of modifications of surfaces followed by colonization by periphytic algae and animal species. We consider that the single preoperational year, 1974, was insufficient for the installations to become fully colonized and that pre- vs post-operational comparisons of periphyton abundances and species compositions are probably not valid because of additional colonization and changes due to natural succession which took place after 1974.

This study uses diver-collected periphyton samples from the underwater installations to determine the taxa living on the installations, and examines intake entrainment samples for these taxa as a means of assessing the efficiency of entrainment as a monitor of the offshore periphyton community.

The numbers of periphyte taxa taken by the divers have been: 1975, 97; 1976, 67; 1977, 97; and 1978, 117. Forty-five taxa have been present in each of the four years, 15 in three of the four years, 36 in two of the four years, 20 were present in 1975 only, 1 was present in 1976 only, 34 were present in 1977 only, and 43 were present in 1978 only.

Dominant periphyte taxa in 1978 were: the blue-green, Oscillatoria sp., the green, Cladophora sp., and seven genera of diatoms. The numbers of dominant taxa were reduced from 1977. Increased numbers of taxa (diversity) and decreased dominants are characteristics of the post-pioneer stages of ecological succession.

With capture rates ranging from 74% to 89% of the resident periphytes, intake entrainment sampling is considered adequate to monitor the periphyte community in months when diving is not possible.

The changes observed in the periphyton community are consistent with advancing stages of the "artificial reef" ecological succession, not with any effect of Cook Plant operation.

Further details of studies conducted to investigate the effects of Cook Plant operation on Periphyton are given in Appendix B-4.

3.E Fish

Results of fish larvae sampling at Cook and Warren Dunes field stations during the years 1973-1978 were evaluated. Data for the most abundant species -- alewife, spottail shiner and yellow perch -- were analyzed by ANOVA. Larval densities of these species did not differ significantly between Cook Plant and Warren Dunes stations. However, open water alewife and beach zone spottail shiner larval concentrations generally declined in the study area during operational years (1975-1978). Yellow perch larvae, which had declined in 1975 and 1976, showed an increase during 1977-1978. Rainbow smelt larvae occurred intermittently in 1977-1978 field samples; their continued low abundance reflects an apparent decline of smelt populations during recent years in southeastern Lake Michigan.

Estimates of fish larvae entrainment were evaluated for 1977 and 1978. Total estimated entrainment of larval fish for 1977 and 1978 was 42.8×10^6 and 20.1×10^6, respectively. These estimates were less than estimates for the three preceding years 1974 through 1976 when 64.6×10^6, 105×10^6 and 61.2×10^6 larvae were entrained per year. Most larval entrainment occurred during June, July and August 1977 and 1978. Alewife was the most common species entrained, accounting for 79% of the total estimated 2-yr entrainment. Other species entrained, listed in decreasing order of abundance were: spottail shiner, yellow perch, johnny darter, rainbow smelt, trout-perch, slimy sculpin, carp, fourhorn sculpin, white sucker, burbot, ninespine stickleback and logperch.

Fish egg entrainment during 1977 and 1978 was lower than the three preceding years. Eggs were most abundant in June and July of both 1977 and 1978.

Alewife was the most abundant adult species collected by standard series fishing from 1973 to 1979. During 1979 all gear and areas showed an increased alewife presence in our survey area over 1978. Statistical analysis failed to identify any long-term population trends directly attributable to plant operation. Most variability in our catches appeared to be linked to species biology. Our data suggest a long-term alewife decline since 1973. However, the 1979 catch revealed the occurrence of a large 1979 year class.

Spottail shiners were the second most abundant fish collected in all survey years (1973 to 1979). Significant ANOVA main effects occurred, but none could be directly associated with plant operation. Most variation was ascribed to year class strength variability and species ecology. Spottail populations in our survey areas appear robust and periodically produce large year classes (1973, 1977 and 1979). Our analyses suggest that the 1979 year class was very large and may result in elevated (or at least stable) catches in 1980-1981.

Results of analysis of variance (ANOVA) of rainbow smelt data for 1973-1979 were not significantly different from 1973-1978 ANOVA results. ANOVA results for 1973-1979 did not demonstrate any change in the abundance or distribution of rainbow smelt attributable to Cook Plant operations. Significant effects identified by statistical analyses were attributable to natural population fluctuations, sampling during periods of upwelling or natural selection of the Warren Dunes study area over the Cook Plant vicinity.

The 1979 total catch of 4,381 yellow perch was the second largest catch of perch from 1973 to 1979. Large trawl catches of the apparently large 1979 year class caused much of the increased catch. Addition of 1979 trawl and seine data to the ANOVA's did not change our previous conclusions about no plant operational effects as evidenced by field abundance. However, gill net data for the 7 yr showed an attraction of larger perch to the Cook Plant area compared to Warren Dunes. The plant's riprap and discharge plumes are attracting perch to the plant vicinity.

Addition of 1979 data did not change conclusions drawn from 1973-1978 data. Comparisons of catch between gear types reveal inconsistent patterns and results continue to be complicated by many significant interactions. In general, significant effects can be attributed to phenomena such as upwellings, natural population oscillations and behavior rather than plant impacts.

From January to October 1979, no fish were seen in the forebay of the Donald C. Cook Plant.

Field data on common adult species were examined for catch differences between preoperational and operational years and between Cook Plant and Warren Dunes areas within years. Comparing Cook to Warren Dunes, no abundance declines were found which could be attributed to impingement or entrainment mortality. For most of these species, no attraction to the Cook Plant (consistent higher catches) or avoidance (lower catches) were observed, nor were differences in catch between preoperational or operational years detected. However, three species did exhibit some consistent catch differences. More chinook salmon were collected in the vicinity of the Cook Plant than at Warren Dunes, which we tentatively interpreted as chinook being attracted to the thermal plume or its associated currents. Gizzard shad were also attracted to the plume, currents or riprap associated with the intake and discharge structures. Carp catches increased both in operational years and at the Cook Plant when compared with Warren Dunes. Clearly, adults have been attracted to the plant vicinity in apparent response to the plume, currents and riprap. In addition, carp larvae were found in large numbers in field and entrainment samples after the plant went on-line (none before), and there has been an increase in the number of carp impinged associated with Unit 2 operation.

Impingement data for 1978 through September 1979 were examined and compared to 1975-1977 data in relation to Unit 2 operation. Impingement rates were not consistently higher with 2-unit operation, but under certain circumstances, extremely large numbers of fish were impinged over a short period. The most extreme example of this occurred in September 1979 when over

500,000 fish (mostly young-of-the-year alewives and juvenile yellow perch) were estimated to have been impinged. Species composition of impingement collections showed no major changes related to two-unit operation, though a few minor species (white suckers, longnose sucker, burbot, carp and silver redhorse) did increase in abundance, probably because of increased plant pumping. No change in field abundance was detected which could be attributed to impingement.

Details of the aquatic studies conducted to investigate the effects of Cook Plant operation on fish are given in Appendix B-5.

4. ICE STUDIES

A. Ice Conditions

Ice conditions were studied by personal visits (25 January and 29 March 1979), by airplane overflights (1 February, 17 February, and 12 March 1979), by stereo time-lapse photography looking north from the office building, and by single-camera time-lapse photography looking west at the discharge melthole from the office building.

Effects of two-unit operation on the local shore ice was probably supramaximal during the winter of 1978-1979. In addition to full two-unit operation, there was a leak in the south discharge pipe near the shoreline. Warmed water from this leak induced nearshore melting of the ice complex; this melting was, to an unknown degree, in excess of what would have taken place had the discharge pipe been intact.

During a visit to the plant on 25 January 1979 there was, over the south discharge pipe, a strip estimated to be 30-40 feet wide, completely melted from the beach out to the main melthole. During the overflight of 1 February there were two rather narrow breaches through the second ice ridge and an expanded area of melting in the first lagoon. We believe that water from the leaking pipe ponded in the first lagoon and melted the northern of the breaches through the ice ridge. During the overflight of 17 February the ice was melted from beach to melthole along a stretch estimated to be about 1400 feet long in front of the plant. The overflight of 12 March showed a belt of brash ice between the melthole and the shore; though the brash ice near shore was probably the result of an invasion of the melthole by the outer ice field, we consider that the condition seen on 12 March would have been typical (or more typical) were the discharge pipe not leaking.

Although the plant's waste heat produced a large melthole in the ice complex during the winter of 1978-1979 (the first winter of two-unit operation), the melthole did not extend north-south to the limits of the plant site. In front of the plant the third ice ridge was disrupted and the second ridge underwent varying degrees of melting and re-formation. To the north and south of the melthole the normal ice complex of ridges and lagoons was present within the limits of the plant property and continued for miles in either direction.

Melting in the first lagoon was first observed during construction of Unit 1 and has been a characteristic feature of the shoreice complex since then. It is attributed to road-salt-containing runoff from the plant's parking lots. During the winter of 1978-1979 this melting was more extensive than previously, evidently as a result of warmed water from the leaking discharge pipe. The winter of 1978-1979 was the first in which melting of the icefoot on the beach was observed. Whether this would be a regular feature of two-unit operation with intact discharge pipes cannot now be determined.

Except for the area in front of the plant, the melted first lagoon and bared beach were protected from erosion by ice ridges.

B. Deicing Operation and Circulating Water Pump Operation

1. Specification 2.1.1.2.3

Circulating Water Pump #23 was removed from service during the period from 3-19-79 to 3-23-79 due to malfunction.

Circulating Water Pump #13 was removed from service during the periods from 9-13-79 to 9-14-79, and 12-8-79 to 12-16-79 due to malfunction.

2. Specification 2.1.3.2.2

The deicing mode of operation was utilized from 1-1-79 to 1-3-79, 1-19-79 to 1-22-79 and 1-24-79 to 1-25-79.

5. Thermal Plume Studies

A. Specification 4.1.1.2 THERMAL CHARACTERISTICS

The Thermal Plume Studies requirement was completed in 1979 with a report on the characteristics of the thermal discharge from two unit operation at the Donald C. Cook Plant. For further details see the following report:

Indiana & Michigan Electric Company
Donald C. Cook Nuclear Plant, Units
1 and 2

Report On The Charteristics Of
Thermal Discharge From Donald
C. Cook Units 1 and 2

Volume I

January 1980

V. RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT (SEE APPENDIX E)

VI. CONCLUSION

In accordance with the objective of our Appendix B Environmental Technical Specifications, the operation of Units 1 and 2 of the Donald C. Cook Nuclear Plant had no detrimental impact on the surrounding ecological environment for the 1979 calendar year.

Data from the environmental radiological monitoring program during this year were within the usual ranges for environmental readings. None of the samples contained radioactivity clearly attributable to operation of the Cook Plant. The results of the data analysis show no abnormal environmental conditions that will cause adverse environmental effects from the operation of the Plant.

VII. CORRECTION AND ADDITIONS TO PREVIOUS REPORTS

1. Terrestrial Studies

Appendix F to this report contains data not included in the 1978 Annual Environmental Operating Report.

This Appendix describes the terrestrial ecology studies done at the Donald C. Cook Nuclear Plant in 1978 and fulfills the requirements of Technical Specification 4.1.2.2.

APPENDIX A

ENVIRONMENTAL OPERATING REPORT

UNDERWATER OBSERVATIONS AT THE DONALD C. COOK NUCLEAR PLANT

VISUAL INSPECTIONS

The underwater observation program has been designed to facilite visual monitoring of the study area. The program should enable divers to assess macroscopic physical and biological conditions of locations within one quarter mile of the intake and discharge structures. Observational methodologies have been designed to allow divers to observe previously itemized conditions which, by changing, might indicate alteration of the ecological system at the monitoring locations. Data gathered during the dives and analysis of samples collected are used to write the reports on underwater operations.

The Technical Specifications require a schedule which includes five dives each month, weather permitting, at standard locations. These locations and dive times are: one day dive in the area of the discharge structures, one day dive in the area of the intake structures, one night dive at a depth of 30 ft to compare day and night observations, and two day dives in control areas outside the plume. As a result of the start-up of Unit 2 (seven circulation pump operation), dangerously strong currents were produced in the area of each of the discharge structures. During 1978 and 1979, a marked (buoyed) station was located midway between the two discharge structures which enables us to monitor in an area where the discharge current was not excessive. Adverse weather (i.e., rough lake conditions) and discharge currents occasionally combined to preclude safe diver-entry into the discharge area, forcing a reduction in the monthly diving schedule. However, supplementary dives were made to examine the area during periods of circulation pump shut-down. A total of 40 dives were performed during 1979 in the vicinity of the study area (Table 1); 33 required dives and seven supplementary dives. Required dives completed were (Table 3): one in April, nine in May, five during June through August, and four during September through October. Prolongued adverse weather did not permit completion of the April dives until May 2. Currents and weather conditions precluded safe entry into the discharge area during September and October diving. The control dives were performed in areas north and south of the riprap field, in line with the discharge structures and at locations within and outside of areas immediate to the plume.

Discussion of observations is presented in previously utilized categorical format: scour, sediment, turbidity, current, inorganic debris, organic detritus, periphyton, loose algae, macrophytes, invertebrates (attached invertebrates, molluscs, crayfish, others), fish eggs, fish, and other observations. Discussion integrates data from preceeding years with 1979 observations, notes significant preoperational/operational changes (if any), and describes any diver-observed plant effects.

Scour

Examinations of riprap areas directly in the flowpath of high velocity water discharge has been limited (1975 - one dive, 1978 - one dive, 1979 - one dive) because of diver inability to enter the areas during pumping. Limited observations in the flowpath area during 1975 showed some displacement of the riprap immediately adjacent to the north discharge structure. During 1979, the north discharge area and concrete scour pad were examined. Little scour was noted. The pad appeared relatively free of sediment, periphyton, and invertebrates. During 1978 and 1979, the flowpath area of the south discharge was examined. In 1978, some displacement of the riprap immediately adjacent (2-3 m) to the structure was observed, but little displacement was noted outside of this zone. In 1979, flowpath scour was more extensive; scour was noted extending 6-9 m outward from the slot discharge to depths of 1-3 m below the slots. Limited scour (1-2 m depth) was noted adjacent to the sides and back of the structure. Sand had encroached over the riprap up to the back of the structures, but neither sand nor vinyl filter cloth were exposed in the flowpath area. Scour has never been observed in the vicinity of the intake structures, although observations are focussed in the vicinity of the south structure. Recent (1978-1979) intake area observations indicate that the southwest sand/riprap interface is relatively stable; other areas of the riprap field perimeter were not examined during 1979. Ice or wave scour has never been observed, but extensive ice damage to intake structure ice guards was noted during 1977-1979.

Sediment

Encroachment of sand onto the riprap in the discharge area has been previously documented. Sand encroachment over riprap located between the intake and discharge structures and on the north side of the intake area riprap field has not been examined. Previous reports have documented suspension and transport of floc (loose accumulation of sediment, some periphyton and loose algae, diatomaceous material, and organic detritus) in the area. Floc layers usually ranged from a trace (discernible, but not measurable) to 5 mm in thickness; 2-3 mm was typical. No pattern of deposition was evident, but depressions (e.g., ripple mark troughs, riprap interstices) contained more floc than did elevated surfaces (e.g., ripple mark crests, top of structures). Areas examined between the discharge structures during 1978-1979 pumping revealed that they were devoid of floc.

During swims in control areas north and south of Cook Plant, depressions 5-10 m across containing silt 20-40 cm thick overlying sand were occasionally encountered. No patterns of occurence were established, but depressions were more frequently encountered north of Cook Plant. During 1979, a 5-m wide depression containing approximately 20 cm of silt was encountered about 100 m north of the north discharge structure. During August 1979, about ten 10-cm diameter lumps of clay were noted 100 m north of the discharge riprap field; their occurrence was unique, but enexplained.

Ripple marks were frequently observed in sandy sediments. Generation usually appeared to have occurred from the northwest or southwest. Although usually small (wavelength less than 15 cm, amplitude less than 5 cm, length along crests less than 100 cm), occasional large ripple marks (wavelength 1 m, amplitude 0.3 m, length 10 m or more) were observed during 1974-1979. These large ripple marks were observed exclusively in very coarse sand; pebbles were often present in the troughs. Large ripple marks were observed more frequently north of Cook; no seasonal pattern of occurrence was discerned.

Current

As previously noted, currents exceeding 30 cm/sec (1 fps) were experienced regularly 100 m or less north and south of the discharges during two-unit operation. At reference (control) stations more than 300 m from the discharges, currents were not discernible by divers. Currents at the station located between the two discharge structures were often nearly 1 m/sec making diver-operations difficult. Currents appeared similar at surface and bottom; no gradient was discerned.

At the south intake structure, current was noticeably increased following Unit 2 start-up. Increase in current was most noticeable along the top edge of the structure and at its base. As previously noted, fish often exhibited pronounced positive rheotaxis and some position-holding. Generally, fish were less frequently observed to ingress and egress the structure during 7-pump circulation, but young-of-the-year (YOY) alewife were noted to repeatedly swim in and out of the structures in schools during October 1979. Intake current was usually discernible 40 m southwest of the south structure.

Inorganic debris

Input of debris by fishermen continued to be observed. Debris was primarily fishing tackle and plastic materials.. Numbers of beverage containers (cans) appeared to be reduced relative to previous years.

Organic detritus and dead animals

Organic detritus (primarily terrestrial vegetation and dead algae) and dead animals (crayfish and fish) were observed occasionally during 1979, as in previous years. Appreciable accumulations or patterns of distribution were not evident. Occasionally, fecal pellets of fish (alewife and carp) were noted in great abundance, primarily during the summer on sand substrate areas. No large sections of trees, accumulations of branches, or dune grass were observed.

Turbidity

Although reduced visibility within the plume north of Cook Plant was reported previously, this condition was not encountered during 1979. Occasionally during 1979, regions of reduced visibility (i.e., turbid water masses) were encountered immediate to the structure or, more often, at the edge of the sand/riprap interface. Visibility was often reduced about 50%. Abrupt changes in temperature (usually decreases) were often associated with these turbid water masses. These observations suggest some possible recirculation of water during 7-pump circulation.

Periphyton

Periphyton, predominately the filamentous green alga, Cladophora, has been previously documented to attain peak lengths on top of the south intake structure and surrounding riprap during July-August. Peak 1979 length of periphyton on the structure top was 60 mm (August) with lengths ranging to a minimum of 10 mm. Mechanical (buoy line, construction divers) and ice-scouring reduced periphytic growth during the summer and winter, respectively. Maximum length of Cladophora on top of the structure occurred in protected (crevices, oblique surfaces) areas. Maximum length of Cladophora on riprap surrounding the structure was 150 mm during July-August. Periphytic growth on riprap appeared to be more extensive in 1979, but luxuriant growth was confined to riprap located within 5 m of the structure. More distant riprap supported notably reduced periphytic growth, possibly as a function of increased depth (reduced light penetration) and decreased current velocity.

Limited observations during 1978-1979 between the discharge structures revealed that periphyton growth (e.g., seasonal length and luxuriance or percentage of substrate supporting periphyton) was similar to growth observed prior to Unit 2 start-up. Reduction of periphyton in the direct flowpath of discharge water was previously documented and was observed again during 1979.

Finally, since 1973, periphyton growing on the intake structures and riprap has provided substrate for fish spawning (alewife and spottail shiner). Periphyton provide an expanded, but probably minor, habitat for fish spawning (Jude et al. 1979) that would not be present if the structures and riprap were absent.

Loose algae and macrophytes

Small clumps (10- to 50-mm diameter) of loose algae were observed occasionally in the control areas (densities ranged from 1 to 5 clumps/m^2) and less frequently in riprapped areas. Random occurrence of algae clumps has been observed regularly during 1974-1979. Dead algae appeared to be the major constituent of most clumps and fish eggs were often entangled in them. Macrophytes have never been observed in the vicinity of Cook Plant.

Invertebrates

As previously documented, numbers of attached invertebrates (Hydra, bryozoans, and freshwater sponge) increased steadily during 1973-1976. During 1977-1978 rate of increase slowed and in 1979 numbers of bryozoan and freshwater sponge colonies appeared to decrease, particularly in areas of heavy Cladophora growth adjacent to the south intake structure. Hydra continued to be observed in tremendous numbers, particularly on riprap lateral and undersides where algal growth was reduced. It appears that heavy algal growth may be precluding growth of bryozoans and freshwater sponge.

Unattached invertebrates were also present during 1979, but numbers were reduced greatly relative to earlier years (1973-1975). Live snails were not observed during 1979. Observance of empty and fragmented mollusc shells (sphaeriids, pisids, and gastropods) was common in sand substrate (reference station) areas; shells were rarely observed in riprapped areas.

Abundance of crayfish has followed a pattern similar to that observed for snails; one of increasing, peaking, and subsequent declining abundance. During 1975, maximum density (no./10 m^2 ± S.E.) of crayfish was 27 ± 15 attained during July in the intake area. During 1979 crayfish were observed on five occasions; two in June, 8 in July, one in August, less than ten in September, and two in October. Decline in numbers observed reflects a dramatic reduction of the crayfish population over the past four years. Decline in crayfish abundance has been further documented by pronounced reduction in numbers of crayfish impinged during 1979 (see benthos section).

Causes of declining abundance of freshwater sponge, bryozoans, snails and crayfish have not been firmly established, but may be related to changes in habitat and predation. Increased periphytic growth (primarily Cladophora) may have reduced the suitability of riprap as a habitat through reduction of exposed substrate surface area. Also, initially high exploitation followed by subsequent successional decline in species "richness" has been documented for marine artificial reefs (Smith 1978), possibly as a result of competition and/or a decline in available resources.

Fish eggs

Presence of fertile eggs of alewife, spottail shiner, yellow perch, sculpin (Cottus bairdi or Cottus cognatus), and johnny darter has been documented previously. During June and July 1979, eggs of alewife and possibly spottail shiner and/or carp were observed attached to periphyton growing on the south intake structure and surrounding riprap. Eggs were noted loose and entangled in algae at reference stations north and south of Cook Plant during July. Eggs were not observed in the discharge station area. One strand of yellow perch eggs was seen and sampled on riprap near the south intake structure on May 29; the eggs did not appear to be viable upon subsequent laboratory examination.

Fish

Eleven species of fish were observed during 1979 and listed in descending frequency of sightings (measured as presence or absence not as numbers of fish) within and across dives were: alewife, spottail shiner, yellow perch, sculpin, trout-perch, johnny darter, rainbow smelt, burbot, carp, longnose sucker, and redhorse. As in previous years, multiple sightings of the first seven species often occurred during a dive; numbers seen were usually less than ten. But adult alewife and perch were observed commonly in schools (10-50 fish per school) during early summer and schools of hundreds of YOY alewife were seen during August-October.

Several generalizations related to fish may be made based upon observations made over the period 1973-1979: alewife, spottail shiner, yellow perch, sculpin, and johnny darter were the most frequently (occasions and numbers) observed species. Alewife, spottail shiner, and (in particular) yellow perch, were sighted primarily during warm-water months (late May through October). Sculpins and darters were locally abundant on the riprap and were conspicuous because of their demersal nature. Numbers of sculpin and darters observed during 1979 declined relative to previous years. Observations of alewife, spottail shiner, and yellow perch followed patterns documented in the 1978 Environmental Operating Report.

The remaining species were observed infrequently during 1979; little can be inferred from data related to the incidental sightings of these species.

Carp were observed during May (3), July (4), and August (1) in the vicinity of the discharge structure. They were seen during August (1) and September (1) night dives in the vicinity of the south intake structure. Preoperational and operational data (1973-1979) indicate that carp are attracted to and are more abundant in the vicinity of the discharge structures. Visual observations suggest that carp may be attracted to the warmer water rather than associated turbulence since fish were seldom observed at reference stations within the plume just outside the area of noticeably elevated temperatures. Elevated concentrations of macroinvertebrates (prey or potential food items) were not observed within the plume. However, Cook Plant was not circulating (no thermal discharge) water during May 1979, but carp continued to be observed occasionally in the discharge area. Carp appeared to concentrate in the discharge area and to wander to neighboring areas. Gill net data also suggest concentration of carp near the discharge, but document concurrent incidental presence elsewhere in the study area.

Fish were observed in greater numbers and species diversity at night than during the day. Activity levels were also higher at night (only perch appeared to be consistently less active at night) with fish concentrating near the bottom during the day. Numbers of fish observed within riprap areas were much higher than numbers observed in control areas. Daytime observations of fish in sand-bottom control areas were very infrequent, often equaling less than five sightings per year, usually schools of alewife or a solitary darter. During 1978-1979, a night station was examined in a sand area near the intake structures; fish (sculpin, spottail shiner, alewife, trout-perch, smelt, and burbot) were sighted in numbers much larger than numbers observed at daytime control stations, but far less than numbers observed within the riprap area.

Schooling was manifested by several species including: alewife, spottail shiner, perch, and carp. Alewife and perch schooled more tightly during the day; schooling was observed rarely at night. Spottail shiner schooling was loose and observed infrequently. Carp were observed rarely at night, but were always solitary. Numbers of alewife per school ranged from 10 to 100 for adults to several hundred for YOY.

Other observations

Reduction of floc and periphyton in the immediate flowpath of discharge water, heightened nocturnal abundance, diversity and activity of biota, uneven (patchy) distribution of biota, seasonal trends in biological activity and diversity, and attraction of biota to riprapped areas were biological patterns documented in the 1978 Environmental Operating Report that were observed again during 1979.

Shifts (declines) in numbers and/or frequency of observations of various invertebrates (snails, crayfish, bryozoans, freshwater sponge) indicate continued ecological succession in the riprapped area. Species richness and abundance of invertebrates appears to have peaked prior to 1978 and subsequently declined. Operations of the Cook Plant during 1979 has had no major diver-observed physical or biological effects that have not been noted in previous reports.

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TABLE 2. Summary of underwater time accrued during 1978 diving activities near the Donald C. Cook Nuclear Plant. January through October.

	DAYLIGHT		NIGHT		TOTAL	
MONTH	No. divers	Time (min)	No. divers	Time (min)	No. divers	Time (min)
April	1	45	0	0	1	45
May	9	134	2	70	11	204
June	4	70	1	30	5	100
July	4	125	1	60	5	185
August	8	254	2	55	10	309
September	3	40	1	60	4	100
October	3	50	1	40	4	90
TOTAL	32	718	8	315	40	1033

TABLE 1. Summary of 1979 diving activities near the Donald C. Cook Nuclear Plant. January through October.

Dive no.	Date	Location	Depth (m)	Day or night	Start time	Under time	No. of divers
1	Apr 27	S. intake structure	3-9	D	1440	45	2
2	May 2	N. reference stations	4-6	D	1925	10	2
3	May 2	S. reference stations	4-6	D	1950	6	2
4	May 2	Discharge station	6	D	2004	8	2
5	May 2	S. intake station	3-9	N	2030	35	2
6	May 29	S. intake structure	3-9	D	1507	40	2
7	May 29	N. reference stations	4-6	D	1611	15	2
8	May 29	S. reference stations	4-6	D	1645	15	2
9	May 29	Discharge station	6	D	1730	15	2
10*	May 29	S. discharge structure	6	D	1745	15	2
11*	May 29	N. discharge structure	6	D	1805	10	2
12	May 29	S. intake structure	3-9	N	2040	35	2
13	Jun 25	N. reference stations	4-6	D	1605	15	2
14	Jun 25	Discharge station	6	D	1640	10	2
15	Jun 25	S. reference stations	4-6	D	1655	5	2
16	Jun 25	S. intake structure	3-9	D	1750	40	3
17	Jun 25	S. intake structure	3-9	N	2105	30	3
18	Jul 23	N. reference stations	4-6	D	1700	25	2
19	Jul 23	Discharge station	6	D	1730	15	2
20	Jul 23	S. reference stations	4-6	D	1750	25	2
21	Jul 23	S. intake structure	3-9	D	1820	60	2
22	Jul 23	S. intake structure	3-9	N	2115	60	2
23	Aug 30	N. reference stations	4-6	D	1023	26	2
24	Aug 30	Discharge station	6	D	1110	6	2
25	Aug 30	S. reference stations	4-6	D	1120	17	2
26	Aug 30	S. intake structure	3-9	D	1200	50	4
27*	Aug 30	Offshore of Cook	25	D	1325	15	4
28*	Aug 30	New Buffalo Shoals	9-14	D	1615	30	4
29*	Aug 30	8 km. N. of Cook	6-7	D	1820	20	4
30*	Aug 30	2 km. N. St. Joseph Har.	4-6	N	2020	10	2
31	Aug 30	S. intake structure	3-9	N	2215	45	4
32*	Aug 31	Michigan City	2-16	D	1315	90	4
33	Sep 21	S. intake structure	3-9	N	0400	60	2
34	Sep 21	S. intake structure	3-9	D	0645	30	2
35	Sep 21	S. reference stations	4-6	D	0720	5	2
36	Sep 21	N. reference stations	4-6	D	0745	5	2
37	Oct 18	N. reference stations	6	D	1707	15	2
38	Oct. 18	S. reference stations	3-6	D	1740	15	2
39	Oct 18	S. intake structure	3-9	D	1800	20	2
40	Oct 18	S. intake structure	3-9	N	1900	40	2

* Supplementary dive not required by the technical specifications

TABLE 2. Summary of underwater time accrued during 1978 diving activities near the Donald C. Cook Nuclear Plant. January through October.

MONTH	DAYLIGHT		NIGHT		TOTAL	
	No. divers	Time (min)	No. divers	Time (min)	No. divers	Time (min)
April	1	45	0	0	1	45
May	9	134	2	70	11	204
June	4	70	1	30	5	100
July	4	125	1	60	5	185
August	8	254	2	55	10	309
September	3	40	1	60	4	100
October	3	50	1	40	4	90
TOTAL	32	718	8	315	40	1033

TABLE 3. Record of completion of dives required by the technical specifications (given favorable weather conditions). The number of each dive from Table 1 is shown.

	DAYLIGHT				NIGHT
MONTH	Intake area	Discharge area	First control area	Second control area	9m (30 ft)
April	1	4*	2*	3*	5*
May	6	9	7	8	12
June	16	14	13	15	17
July	21	19	18	20	22
August	26	24	23	25	31
September	34	**	36	35	33
October	39	**	37	38	40

* Prolongued adverse weather before and after April 27 did not permit completion of April diving until May 2.

** Adverse weather, strong currents and drift of the station buoy anchor towards the south discharge structure did not permit safe diver-entry into the area.

APPENDIX B1

ZOOPLANKTON COLLECTED AT THE DONALD C. COOK NUCLEAR PLANT

JANUARY TO DECEMBER 1979

LAKE SURVEYS

Introduction

Lake surveys are conducted once a month April through November. Technical specifications require that three major surveys and five short surveys be conducted. Major surveys (30 stations) are conducted in April, July, and October and provide detailed information on zooplankton spatial distributions over the 250 km^2 area of the survey grid during spring, summer, and autumn. Short surveys (14 stations) are conducted in the remaining months to provide information on zooplankton temporal succession patterns and long-term population trends.

For the period April through November 1979, a total of 320 of the required 320 samples were collected. Samples up to and including July have been examined at the time of this writing. In addition, samples collected in 1978 during the August, September, October,and November cruises have been examined and the data analyzed.

Statistical analyses of the preoperational and operational data base continues. As has been discussed in previous reports, the survey grid has been divided into eight zones (Fig 1) for the purposes of these analyses. We are continuing to perform preoperational versus operational zone mean comparisons for the major taxa during each major survey cruises. The Mann-Whitney U test is used. Such comparisons have been made for four years of operational October data (1975 to 1978) and five years of operational April and July (1975 to 1979) data. We are continuing to examine long-term seasonal trends in the abundance of major zooplankton in the inshore plume zone (zone 2). The distribution of the rare taxa is considered. New occurrences and shifts in abundances of these taxa are of particular interest since they may be more sensitive indicators of change than the more ubiquitous dominants.

RESULTS

Physical Data (April to November 1979)

Surface-water temperatures in the first half of 1979 tended to be 1 to 2 °C lower than in 1975 and 1976. Temperatures ranged from 1 to 5°C on April 12. The thermal bar was located within a kilometer of shore south of the Cook plant but had not developed to the north. Temperatures increased to 4 to 14°C by May 9, and ranged from 13 to 15°C on June 13. Temperatures during the July 11 cruise were also low ranging from 19 to 20°C. August 9 temperatures reached 23°C. After August temperatures declined to 18 to 20°C on September 13, 14 to 15°C on October 18 and 7 to 10°C on November 14. The lake was thermally stratified from June to September.

The thermal plume generally was small. Temperatures measured over the discharge jets were 2 or 3 C° above ambient lake temperatures.

Secchi disc depths followed the typical seasonal pattern and were similar to depths observed in other years. Depths ranged from less than 1 m to over 6 m in April, 2 to 5 m in May, 3 to 6 m in June, 6 to 10 m in July, 3 to 8 m in August, 3 to 5 m in September, 2 to 6 m in October, and 3 to 7 m in November. Secchi disc depths were similar in the plume and in control stations suggesting that the suspended particulates were similar in plume and ambient water.

Biological Data August to November 1978

The August zooplankton were dominated by the cladoceran *Bosmina longirostris* which generally occurred in concentrations of 96,000 to 294,000/m^3 and percentage composition of 75 to 92% over the inshore and middle zones. Exceptions were two stations located half a mile north and south of the discharge jets. At SDC .5-1, *B. longirostris* accounted for 69% of the zooplankton and occurred in concentration of 27,300/m^3 versus 294,000/m^3 over the discharge jets. Abundances were even lower at NDC .5-1 where *B. longirostris* occurred in concentrations of only 9,000/m^3 and accounted for 42% of the zooplankton. While we have previously observed wide variations in *B. longirostris* concentrations in the vicinity of the plume, these observations were made during our special plume studies where samples were collected from a single depth. Vertical displacement of zooplankton probably accounted for these differences. However, since field survey collections are made from the entire water column, this hypothesis cannot account for the distributions observed during the August cruise. Lake temperature data indicate that an upwelling did not take place during the cruise.

The September zooplankton were dominated by *Bosmina longirostris*, immature *Cyclops* spp. copepodites, and immature *Diaptomus* spp. copepodites. No unusual occurrences were noted in the vicinity of the power plant. *Pleuroxus procurvis*, a cladoceran, was observed in low numbers (9/m^3) at DC-4, a station 4 km offshore from the power plant. This is the first time this species has been observed in the survey area. It is unlikely that this occurrence is directly associated with power plant activity.

The October zooplankton were numerically dominated by *Bosmina longirostris*, *Daphnia* spp. (primarily *D. galeata mendotae*), and immature *Cyclops* spp. and *Diaptomus* spp. copepodites. There were no obvious spatial disruptions in zooplankton distributions in the vicinity of the plume.

The November zooplankton were numerically dominated by immature *Cyclops* spp. copepodites, immature and adult *Diaptomus* spp. copepodites, and by *Eubosmina coregoni*. *Mesocyclops edax*, a cyclopoid copepod, which was only rarely seen in the survey area prior to 1975, increased in abundance since 1977. It was widespread both in October and November and accounted for over 1% of the zooplankton at many stations. *Daphnia pulex* has not previously been observed in the survey area but was seen at several stations during the October and November cruises, although in low numbers (less than 50/m^3). Wells (1970) demonstrated the decline in *M. edax* populations in Lake Michigan in conjunction with increased alewife populations. In other lakes, *D. pulex* has also been shown to be eliminated under severe planktivorous fish predation (Galbraith

1967). Increased occurrences of both species in the survey area therefore may be indicative of lower fish predation (possibly alewife) than in previous years.

Biological Data April to July 1979

The April zooplankton were numerically dominated by nauplii which generally accounted for at least 50% of the inshore and middle zone zooplankton. Adult Diaptomus spp. (primarily D. ashlandi) were of secondary abundance while adult Cyclops bicuspidatus thomasi was of lesser numerical importance. There was no evidence of alterations in zooplankton distributions in the vicinity of the plume.

The May zooplankton were numerically dominated by nauplii. Immature Diaptomus spp. copepodites, immature Limnocalanus macrurus copepodites, and adult Diaptomus spp. (primarily D. ashlandi) were of secondary abundance. Daphnia sp., tentaively identified as D. parvula, and first observed in the survey area in May 1978 was again observed in May 1979. This cladoceran occurred in low numbers (less than $24/m^3$) at two stations. There was no evidence of alterations in zooplankton distributions in the vicinty of the plume.

Bosmina longirostris and immature Cyclops spp. copeodites dominated the inshore and middle zone zoolankton in June. Nauplii, Asplanchna spp., and immature Diaptomus spp. copepodites were of secondary abundance. There was no evidence of alterations in zooplankton distributions in the vicinity of the plume.

The July zooplankton were numerically dominated by Bosmina longirostris. Immature Cyclops spp. copepodites were of secondary abundance while nauplii, Daphnia spp. and immature Diaptomus spp. copepodites were numerous at some stations. There was no evidence of spatial alterations in zooplankton distributions in the vicinity of the plume.

Statistical Comparison of October Preoperational and Operational (1975 to 1978) Abundances

The preoperational and operational abundances of twelve zooplankton taxa were examined for each of eight zones (Fig. 1) of the survey grid. All taxa occurred in statistically significant (α=0.05) different concentrations (Table 1) between the preoperational and operational periods in at least one zone.

Total zooplankton mean densities were higher in the operational period (by less than 50%) in all zones (Fig. 2) although differences were statistically significant in only the southern and northern middle zones, and in the inner offshore zone. Cladocerans were more abundant during the operational period in all zones except the outer offshore zone, where a lower operational mean density was statistically significant. Bosmina longirostris and Eubosmina coregoni exhibited significant differences in concentration between preoperational and operational periods only in the inshore plume zone, where both species had higher operational densities, and in the outer offshore zone, where operational densities were lower. Similar magnitudes of differences were observed in one of the inshore control zones suggesting that differences in preoperational and operational cladoceran abundances in the inshore plume zone were not related to plant operation. Daphnia spp. occurred in lower densities in the operational period in all zones except the inner offshore zone. However, these differences were statistically significant in only the plume and northern inshore zones.

Cyclopoid copepods occurred in statistically higher mean concentrations during the operational period in all three middle zones. Immature copepodites were more abundant in the operational period in all zones except the outer offshore, although differences were significant only in the northern inshore zone and the southern and plume middle zones. In contrast, adult Cyclops spp. were less abundant during the operational period in all zones, with significant differences only in the plume inshore and outer offshore zone.

Calanoid copepodites occurred in statistically similar densities during the preoperational and operational periods except in the southern inshore zone. Diaptomus spp. immature copepodites occurred in statistically significant higher concentrations in the operational period in the northern middle and inner offshore zone. Adult Diaptomus spp. were significantly more abundant in the operational period in the southern and plume middle zones and in the inner offshore zone. Adults were particularly abundant in 1978. Nauplii were more abundant during the operational period in all zones with differences statistically significant in all zones except the northern inshore and the outer offshore.

The figures for mean zooplankton densities in October for each zone that were given in the 1978 Operational Report (Fig. 2) were incorrectly labeled. The preoperational means were labeled as being operational means, and vice versa. The text and all other figures are correct as given in the 1978 report.

Statistical Comparisons of April Preoperational and Operational (1975 to 1979) Abundances

The preoperational and operational abundances of nine zooplankton taxa were examined in each of the eight zones of the survey grid. All taxa with the exception of immature Diaptomus spp. copepodites occurred in statistically significant (α=0.05) different concentrations (Table 2) between the preoperational and operational periods in at least three zones.

Total zooplankton (Fig. 3) mean densities were higher during the operational period in all zones except the outer offshore zone. Differences were statistically significant in all zones except the southern and northern middle zones and the two offshore zones.

Cyclopoid copepods were more abundant in the inshore zones and less abundant in the middle and offshore zones during the operational period. These differences were statistically significant only for the southern inshore zone, the northern middle zone, and the offshore zone. Immature copepodites were less abundant in the operational period except in the southern inshore and middle zones. These differences were statistically significant in all zones except the southern inshore and middle zones. Adults were more abundant in the inshore zone and less abundant in the middle and offshore zones during the operational period. These differences were significant only in the offshore zones.

Calanoid copepods were more abundant in the operational period and differences were significant in all zones except the two offshore. Immature and adult Diaptomus spp. were more abundant in the operational period (except immatures in the southern and northern middle zones and the two offshore zones). Adults occurred in significantly different concentrations in the middle and inshore zones. Limnocalanus macrurus copepodids were more abundant in the operational period except in the offshore zone. These differences were statistically significant for all inshore and middle zones.

Statistical Comparisons of July Preoperational and Operational (1975 to 1979) Abundances

The preoperational and operational abundances of thirteen zooplankton taxa were examined for each of the eight zones of the survey grid. With the exception of copepod nauplii and Eurytemora affinis (Table 3), all taxa occurred in statistically significant ($\alpha=0.05$) different concentrations between the preoperational and operational periods in at least one zone.

Total zooplankton were less abundant (Fig. 4) in the operational period (except in the southern inshore zone). These differences were significant only in the outer offshore zone. Nauplii also were less abundant in the operational period (except in the northern and southern inshore zones) but these differences were not significant. Immature Cyclops spp. copepodites were less abundant in the operational period (except in the southern inshore zone) but differences were significant only in the two plume zones and in the outer offshore zone. Adult Cyclops spp. were less abundant in the operational period but differences were significant only in the outer offshore zone.

Among the calanoids, immature Diaptomus spp. copepodites were less abundant in the operational period (except in the southern inshore and outer offshore zones). These differences were significant only in the inshore plume zone and the three middle zones. Adults also were less abundant in the operational period (except in the southern plume zone) and differences were significant in the two plume zones. Conversely, Eurytemora affinis was more abundant in the operational period (except in the outer offshore zone) but these differences were not statistically significant.

Among the cladocerans, Bosmina longirostris was more abundant in the inner zone and the southern middle zone and less abundant elsewhere during the operational period. However, these differences were statistically significant only for the outer offshore zone. Daphnia spp. were more abundant in the operational period and these differences were significant for all zones except the northern middle zone. Daphnia were particularly abundant in July 1979.

Asplanchna spp. was less abundant in the operational period. Differences were significant in all zones except the southern inshore and the outer offshore zone.

Seasonal Cycles of Zooplankton in the Inshore Plume Zone

Seasonal plots of zooplankton abundances in the inshore plume zone (Fig. 5) generally were similar in the preoperational and operational periods. Total zooplankton occurred in low numbers in the spring, increased in abundance through the summer, and declined over the late autumn and winter. There was no apparent trend for increasing numbers of zooplankton with increasing plant operation.

Copepod nauplii, cyclopoid copepods, immature calanoid copepodites, adult *Diaptomus* spp., and *Eurytemora affinis* all exhibited similar preoperational and operational seasonal cycles with plant operation apparently neither advancing nor retarding developmental periods. Cladocerans (*Bosmina lonigrostris*, *Eubosmina coregoni*, and *Daphnia* spp.) exhibited similar seasonal cycles in the preoperational and operational periods as did the rotifer *Asplanchna* spp.

Discussion

As in previous reports, differences were observed between preoperational and operational abundances for the numerically dominant zooplankton taxa in the inshore plume zone. Many of these differences were statistically significant (=0.05). At present, these differences are not interpreted as resulting from a direct effect of power plant operation on the zooplankton. Reasons for this judgment are:

(1) Operational versus preoperational differences in zooplankton zone mean abundances were not restricted to the inshore plume zone but occurred over most of the survey area.

(2) Similar magnitudes of change were observed in plume and in control zones.

(3) There was no consistent trend for zooplankton to increase or decrease in abundance in the plume zone with continued plant operation. High operational zone-mean concentrations were most frequently associated with high concentrations in one or two of the four to five operational years and concentrations in the remaining years were generally similar to populations levels in preoperational years.

(4) Results of our entrainment studies suggest that plant passage generally is not a severe physiological stress for the zooplankton. Since stresses are low and because plume-entrained zooplankton are exposed to temperatures only slightly above ambient for short periods of times (hours), we have no basis for predicting that power plant operation will disrupt zooplankton distributions in the vicinity of the plume. A possible disruption which could occur and which we have not investigated is that certain zooplankton, notably cladocerans, may become trapped at the water-air interface in the turbulent zone around the discharge jets. These trapped zooplankton may clump together and be subject to differential motality by planktivorous fish.

Such an hypothesis may account for the clumpy Bosmina longirostris distibutions in the vicinity of the plume during the August 1978 survey.

Two species of rare Lake Michigan zooplankton are increasing in abundance in the survey area. The most pronounced increase has occurred since fall of 1978. Possible reduced fish predation may account for this increase. Since zooplankton standing stocks are not increasing in the survey area, it is unlikely that Daphnia pulex and Mesocyclops edax are increasing in abundance because increased zooplankton production compensates for fish predation. Such apparently occurs in Green Bay (Gannon 1972).

CONDENSER PASSAGE STUDIES

Introduction

Zooplankton passing through the condensers are subjected to mechanical and thermal stresses which can kill up to 100% of the population. Mortality studies are conducted to evaluate the severity of these stresses.

Technical Specifications require that zooplankton be collected monthly from the intake and discharge structures of the power plant. Since Unit 1 and Unit 2 have different operating characteristics (flow rates, ΔT), it is necessary to estimate zooplankton mortality due to plant passage from both locations. However, this was not always possible. Unit 1 was in an outage from April to July 1979 while Unit 2 was in an outage in June and November 1979. Consequently samples were not collected from these locations at these times.

Four samples were collected from each location within an hour or two of sunrise. Sampling times were generally one to two minutes depending on the concentration of zooplankton in the waters. A total of 104 samples were collected during the January to November 1979 period out of a possible total of 120 samples if both units were running at all times. Each sample was divided into a series of subsamples each containing a few hundred organisms, and visual examinations for dead zooplankton were made 0, 6, 24 hours after collection. A total of 312 (out of a possible total of 348) subsamples were examined for the January to November 1979 period. Data up to and including July have been examined completely and are included in this report. In addition, we report data collected from August to December 1978 period which were not included in the last operational report.

Statistical analyses of the data continue. As in previous reports, we examine the mortality data to determine whether or not discharge mortalities are higher than intake mortalities for various zooplankton taxa after the three incubation periods. One test involves combining several months of data and is used to detect long-term trends; the upper-sided median test is used. This is the only possible test procedure for most of our earlier data sets when only two samples were collected at each sampling location and time. We have analyzed the 1975 to 1978 mortality data with this test.

A second test, the Smirnov one-sided two-sample test examines mortality differences by taxa and incubation period for each collection time. This test became possible when we changed our sampling design by collecting four samples from each location. This procedure has been discussed in the last operational report. In this report, we present the results of two sets of analyses. In the first, we compared mortality in the two discharge locations to determine whether or not one unit was more damaging to zooplankton than another. In the second test, we combined the mortality data from the discharge locations and determined whether or not these mortalities were significantly different (α=0.05) from intake mortalities.

Results

Intake temperatures ranged from a low of 1.7°C (January 1979) to a high of 25.7°C (September 1978). Intake temperatures were 7.5°C in February and 5.9°C in March 1979 suggesting that the plant was recirculating discharge water through the intakes. Discharge water temperatures for Unit 1 ranged from 14.0°C (January 1979) to 35.5°C (September 1978) while ΔT's ranged from 8.8C° (December 1978) to 12.8 C° (January 1979) and averaged 10.2 C°. Flow rates ranged from 0.79 x 10^9 gpd (January 1979) to 1.02 x 10^9 gpd (October 1978) and averaged 0.95 x 10^9 gpd. Unit 2 discharge water temperatures ranged from a low of 11.3°C (April 1979) to a high of 35.0°C (September 1978) while ΔT's ranged from 6.8 C° (December 1978) to 9.9 C° (January 1979) and averaged 8.6 C° (versus 10.2 C° for Unit 1). Flow rates ranged from 1.22 x 10^9 gpd (May 1979) to 1.59 x 10^9 gpd (February and March 1979) and averaged 1.46 x 10^6 (versus 1.02 x 10^9 gpd for Unit 1).

Mortalities

Zooplankton mortalities were low in most months (Fig. 6) averaging 14.0% (0-hours) in the intake waters, 15.4% in Unit 1 discharge waters and 16.4% in Unit 2 discharge waters. Intake mortalities ranged from a low of 7.0% (January 1979) to highs of 20.5% (April 1979) and 48.3% (May 1979). Unit 1 mortalities ranged from a low of 9.4% (January 1979) to a high of 39.5% (September 1978). Unit 2 mortalities ranged from a low of 5.6% (January 1979) to a high of 30% (September 1978, April and May 1979).

There were three periods of high mortalities. The first, in September 1978, occurred when discharge water temperatures reached or exceeded 35°C. We have previously indicated that 35°C appears to represent an upper critical temperature for short-term exposures to elevated temperatures. Mortalities in discharge waters were twice as great as in the intake waters.

A second period of high mortalities occurred during recirculation, particularly in March 1979. Mortalities also tended to be high in February. Previous data have suggested that recirculation is particularly damaging to zooplankton.

The third period of high mortalities occurred in April and May of 1979. Water temperatures were not high and ΔT's were moderate. The plant was not recirculating water and flow rates were average. A storm did occur during the April sampling period and a less intense storm occurred in May. It is possible that these high intake and discharge water mortalities were in some way connected with the storm. Most of the dead zooplankton were nauplii and immature Diaptomus spp. copepodites which were produced during the spring reproductive period. Similar high spring mortalities have not been observed in previous years (1975 to 1978).

Zooplankton mortalities did not increase with incubation time. Nor did they increase with increasing water temperature (except in discharge water in September 1978), ΔT, or pumping rate. Most of the dead zooplankton were the numerically dominant taxa, i.e., nauplii, Cyclops spp. copepodites, Diaptomus spp. copepodites, Bosmina longirostris, Eubosmina coregoni Daphnia spp., and Asplanchna spp. (Fig. 7). There were no obvious seasonal patterns in mortality.

Mortalities generally were statistically similar in the two discharge locations. For the August 1978 to March 1979 period, only a few statistically significant differences were detected. These were nauplii at 0-hour (August 1978); immature Cyclops spp. copepodites at 0, 6, and 24 hours in September; immature Diaptomus spp. copepodites at 24 hours in January 1979; and adult Diaptomus spp. at 24 hours in March 1979. Except for adult Diaptomus spp. in March 1979, mortalities were lower for Unit 2 than for Unit 1.

Analysis of the mortality data were performed by comparing intake mortalities with the combined discharge mortalities by month and incubation period for the numerically dominant taxa. Several significant differences were detected. Discharge mortalities were significantly higher than intake mortalities for immature Diaptomus spp. copepodites for all incubation periods in August 1978 and for adult Cyclops spp. at 0-hours; for nauplii, immature Diaptomus spp. copepodites, and Eubosmina coregoni at 0-hours and for immature Cyclops spp. copepodites at 6 hours in September; for immature Diaptomus spp. copepodites at 6 and 24 hours in October and 6 hours in November; for adult Diaptomus spp. at 6 hours in December; and January; for Eubosmina coregoni at 6 hours in December; and for immature Cyclops spp. copepodites and adult Diaptomus spp. at 0 hours in March. No significant differences were detected in February, April, May, or July; samples were not collected in June.

Further analyses were performed on the combined 1975 to 1978 data set to determine, by taxa and incubation period, whether or not discharge mortalities were significantly higher than intake mortalities. Several significant differences were detected. Diaptomus minutus adults and Daphnia retrocurva had significantly higher discharge mortalities at 0-hours with the mean mortality difference between intake and discharge waters averaging 7 to 8%. More differences were detected for the 6-hour incubation period with nauplii, immature Cyclops spp. copepodites, Eubosmina coregoni, Diaptomus ashlandi, D. minutus, and D. oregonensis all having significantly higher discharge mortalities; mean mortality differences were less than or equal to 8%. Only Eubosmina coregoni had significantly higher discharge mortalities at 24-hours with the mean difference averaging 10%. These results are similar to previous analyses of the 1975 to 1976 data set (Evans et al. 1978) although more taxa (nauplii, D. ashlandi, Cyclops spp. copepodites, D. retrocurva, and Eubosmina coregoni) had significantly higher mortalities in discharge waters than in intake waters. Mean mortality differences averaged less than 10% for both analyses.

Entrainment Abundance

Zooplankton samples are collected monthly from the intake and discharge forebays of the power plant. Samples generally were not collected from a discharge forebay if that unit was in an outage.

Two five-minute samples were collected from each of two or three locations at sunset, midnight, sunrise, and noon to give a total of 16 (one-unit) or 24 (two-unit operation) samples for a complete series. Data from these samples provide information on the concentration and composition of zooplankton in the cooling waters. These data and data on zooplankton dry weights and pumping rates are used to estimate the biomass of zooplankton passing through the power plant. Mortality data allow us to estimate the maximum loss of zooplankton due to plant passage.

A total of 208 samples were collected for the period January to November 1979. No samples were collected from Unit 1 from April to August and no samples were collected from Unit 2 in June and November 1979.

Data analysis has been completed on the heterogeneity study conducted in September 1978. We conducted this required study to determine whether or not there were statistically significant differences in zooplankton abundances and compositions at different locations in the intake forebay. Four locations (MTR 1-1, MTR 1-5, MTR 2-1, and MTR 2-5) were sampled. Simultaneous collections were made at each location at three depth series (0.6 m, 5.5m, and 8.5m). In addition, simultaneous collections were made from the two discharge forebays from a single depth determined by the location of the rigid pipe installed in each of these forebays. Two replicate five-minute samples were collected from each location at each time to provide a total of 36 samples. These samples were later examined and zooplankton identified and enumerated. In this report, we briefly summarize the results of the several analyses which were performed on these data. The results of this study will be reported more completely in the 1977 and 1978 zooplankton operational report which is currently in preparation.

The concentration of zooplankton in the cooling waters decreased from 200,000/m^3 in August 1978 to 30,000/m^3 in September, increased in October, and then declined over late autumn and winter to reach a March low of 2,000/m^3. Numbers of zooplankton passing through the plant (Fig. 8) were a function of zooplankton concentration and pumping rate and ranged from a high of 50,000 billion in August to a low of 700 billion in March 1979. Low values in November were primarily associated with the fact that Unit 2 was in an outage for part of the month. Maximum estimated numerical loss generally followed the numbers entrained curve except in September 1978 where numbers entrained decreased from August to September but estimated maximum loss remained the same. This was associated with the fact that zooplankton mortalities were relatively high in September, probably due to the fact that discharge water temperatures exceeded the thermal tolerances of the zooplankton.

Biomass

The seasonal cycle of zooplankton biomass passing through the plant was not always similar to the seasonal cycle of numbers of zooplankton passing through the plant. This is because the summer zooplankton, while numerous, tend to be dominated by relatively small animals (mean dry weight of 1 to 2 ug/individual); the winter zooplankton, while less abundant, to be dominated by relatively large animals (mean dry weight of 3 to 6 ug/individual). The monthly biomass of zooplanton entrained ranged from an October high of 40,000 kg dry weight to a May low of 1,500 kg dry weight (Fig. 9). Maximum biomass loss ranged from 416 to 5,000 kg.

Heterogeneity study

As in the previous heterogeneity study, several taxa exhibited statistically significant differences in abundance and composition with respect to grate location and depth in the intake forebay (Fig. 10). Zooplankton also differed in abundance and composition between the two discharge locations. Analyses were performed to compare zooplankton abundances and compositions at the six locations and three depths (intake forebay) or times (discharge forebays). Several significant differences were detected (analysis of variance). Further tests were made (Scheffe simultaneous test-pairwise) to identify the specific differences. These revealed that zooplankton abundances at grate locations MTR 1-1 and MTR 1-5 were never significantly lower than at other locations in the intake forebay although they were higher on several occasions. Discharge abundances in Unit 1 were significantly lower than in the intake forebay for several taxa. Discharge abundances in Unit 2 were lower than abundances both in the intake forebay and in Unit 1 for several taxa.

The selection of grate location MTR 1-5 and a depth of 5.5m as a representative sampling location for the intake forebay provides a good estimate of the number of zooplankton passing through the plant. Although estimated abundances are slightly higher than at other locations in the intake forebays. However, calculations of zooplankton numbers and biomass passing through the plant and numerical losses are based on the estimates of concentration and biomass obtained for each discharge location. It is not clear why there should be a difference in zooplankton concentrations between the two discharge locations nor why zooplankton concentrations should be greatest at MTR 1-5. These differences are relatively small in comparison to natural temporal variability in zooplankton numbers.

Table 1. Results of Mann-Whitney U tests comparing October preoperational and operational densities of twelve taxa in each of 8 zones. The preoperational period is 1971-74 or a subset of years ending in 1974, and the operational period is 1975-78. Stars indicate significant differences ($\alpha = 0.05$)

Taxa	Zone								Period
	1	2	3	4	5	6	7	8	
Composite catagories									
Cyclopoid C1-C6	ns	ns	ns	*	*	*	ns	ns	1972-78
Calanoid C1-C6	*	ns	ns	ns	ns	ns	ns	ns	1972-78
Cladoceran	ns	ns	ns	ns	ns	ns	ns	*	1972-78
Total zooplankton	ns	ns	ns	*	ns	*	*	ns	1972-78
Genus, species, or developmental stage									
Copepod nauplii	*	*	ns	*	*	*	*	ns	1972-78
Cyclopoid C1-C5	ns	ns	*	*	*	ns	ns	ns	1973-78
Cyclops spp. C6	ns	*	ns	ns	ns	ns	ns	*	1973-78
Diaptomus spp. C1-C5	ns	ns	ns	ns	ns	*	*	ns	1973-78
Diaptomus spp. C6	ns	ns	ns	*	*	ns	*	ns	1973-78
Bosmina longirostris	ns	*	ns	ns	ns	ns	ns	*	1972-78
Eubosmina coregoni	ns	*	ns	ns	ns	ns	ns	*	1972-78
Daphnia spp.	ns	*	*	ns	ns	ns	ns	ns	1972-78

Table 2. Results of Mann-Whitney U tests comparing April preoperational and operational densities of nine taxa in each of 8 zones. The preoperational period is 1971-74 or a subset of years ending in 1974, and the operational period is 1975-79. Stars indicate significant differences (α=0.05).

Taxa	Zone 1	2	3	4	5	6	7	8	Period
Composite catagories									
Cyclopoid C1-C6	ns	ns	ns	*	ns	*	*	*	1971-79
Calanoid C1-C6	*	*	*	*	*	*	ns	ns	1971-79
Total zooplankton	*	*	*	ns	*	ns	ns	ns	1972-79
Genus, species, or developmental stage									
Copepod nauplii	*	*	ns	ns	*	ns	ns	ns	1972-79
Cyclopoid C1-C5	ns	*	*	ns	*	*	*	ns	1973-79
Cyclops spp. C6	ns	ns	ns	ns	ns	ns	*	*	1973-79
Diaptomus spp. C1-C5	ns	ns	ns	ns	ns	ns	ns	ns	1973-79
Diaptomus spp. C6	*	*	*	*	*	*	ns	ns	1973-79
Limnocalanus macrurus C1-C6	*	*	*	*	*	*	ns	ns	1973-79

Table 3. Results of Mann-Whitney U tests comparing July preoperational and operational densities of thirteen taxa in each of 8 zones. The preoperational period is 1971-74 or a subset of years ending in 1974, and the operational period is 1975-79. Stars indicate significant differences ($\alpha = 0.05$).

Taxa	Zone 1	2	3	4	5	6	7	8	Period
Composite catagories									
Cyclopoid C1-C6	ns	*	ns	ns	ns	ns	ns	*	1971-79
Calanoid C1-C6	*	ns	ns	ns	ns	ns	ns	ns	1971-79
Cladoceran	ns	*	ns	ns	ns	ns	ns	*	1971-79
Total zooplankton	ns	ns	ns	ns	ns	ns	ns	*	1972-79
Genus, species, or developmental stage									
Copepod nauplii	ns	ns	ns	ns	ns	ns	ns	ns	1972-79
Cyclopoid C1-C5	ns	*	ns	ns	*	ns	ns	*	1973-79
Cyclops spp. C6	ns	ns	ns	ns	ns	ns	ns	*	1973-79
Diaptomus spp. C1-C5	ns	*	ns	ns	ns	ns	ns	ns	1973-79
Diaptomus spp. C6	ns	*	*	*	*	ns	ns	ns	1973-79
Eurytemora affinis C1-C6	ns	ns	ns	ns	ns	ns	ns	ns	1973-79
Bosmina longirostris	ns	ns	ns	ns	ns	ns	ns	*	1972-79
Daphnia spp.	*	*	*	*	*	ns	*	*	1971-79
Asplanchna spp.	ns	*	*	*	*	*	*	ns	1971-79

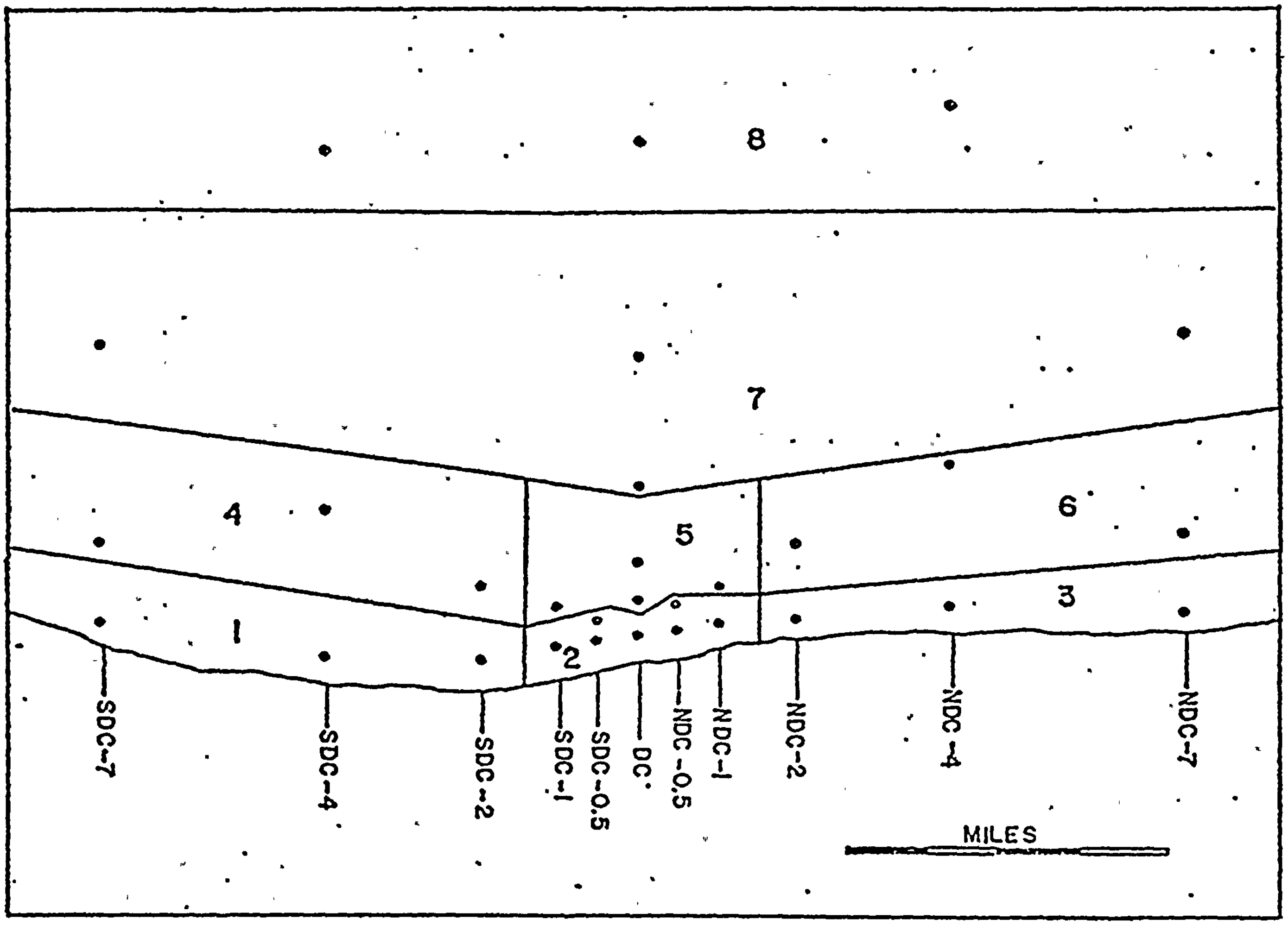


FIG. 1. The survey grid divided into eight zones. Circles indicate major survey stations.

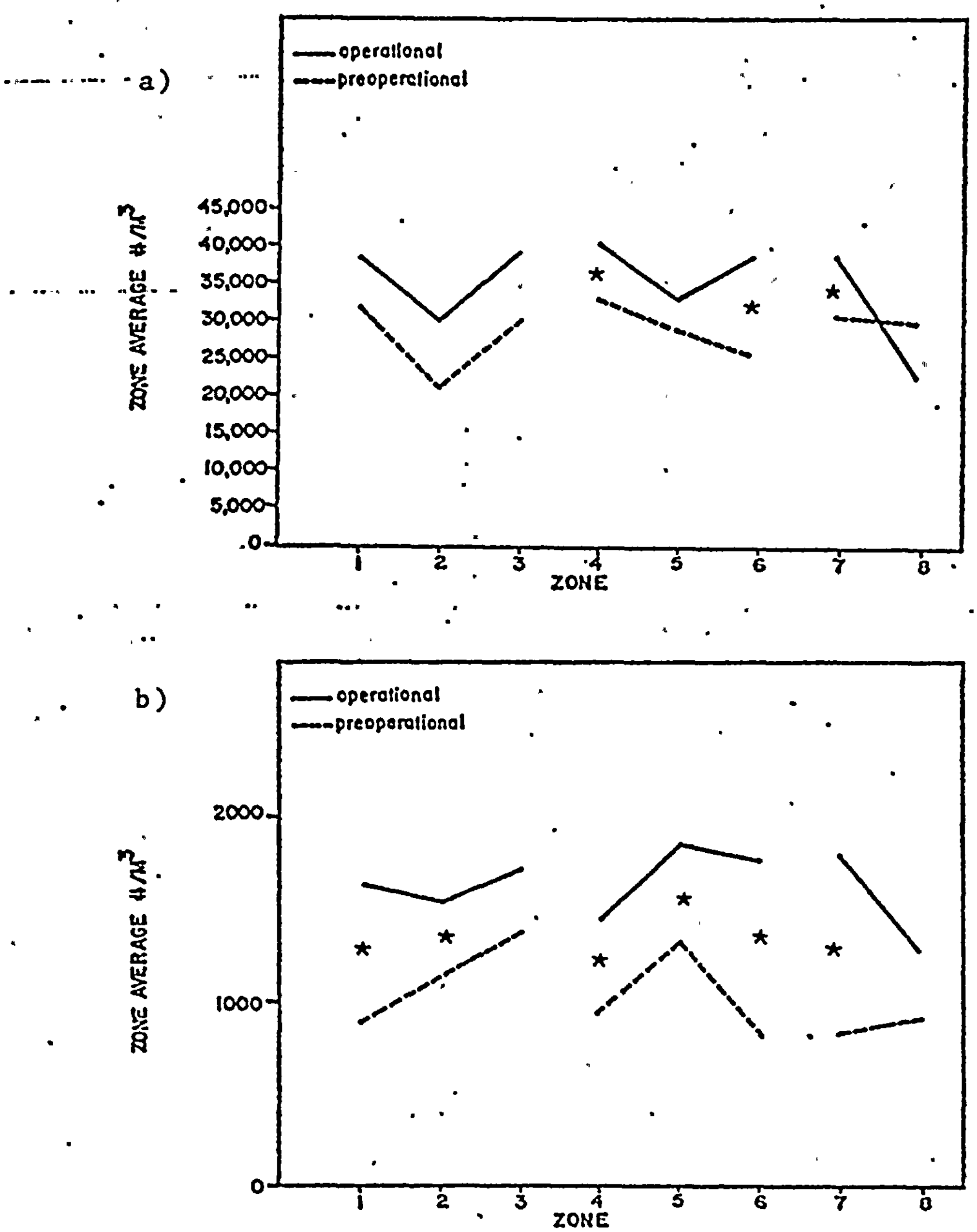
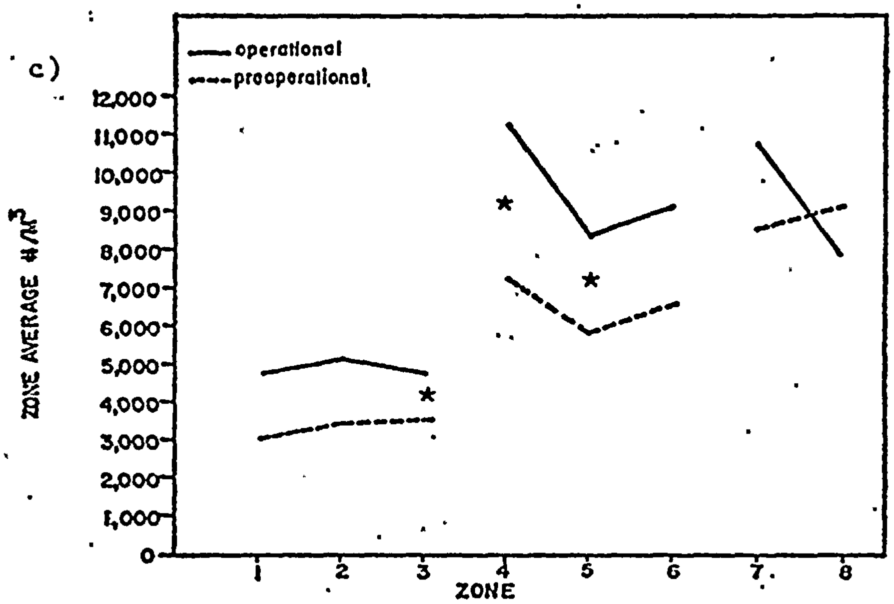


Figure 2. Mean zooplankton densities in October for each zone (dashed lines = preoperational periods, solid lines = operational period). Stars indicate zones with significant differences between the preoperational and operational periods (Mann Whitney U test, $\alpha = 0.05$). Lines connect zones in the same depth range (inshore zones = 1-3, middle zones = 4-6, and inner and outer zones = 7 and 8. Stations in zone 8 were not sampled in 1975 or 1976. a) total zooplankton 1972-74 and 1975-78. b) <u>Copepod nauplii</u> 1972-74 and 1975-78.

c)



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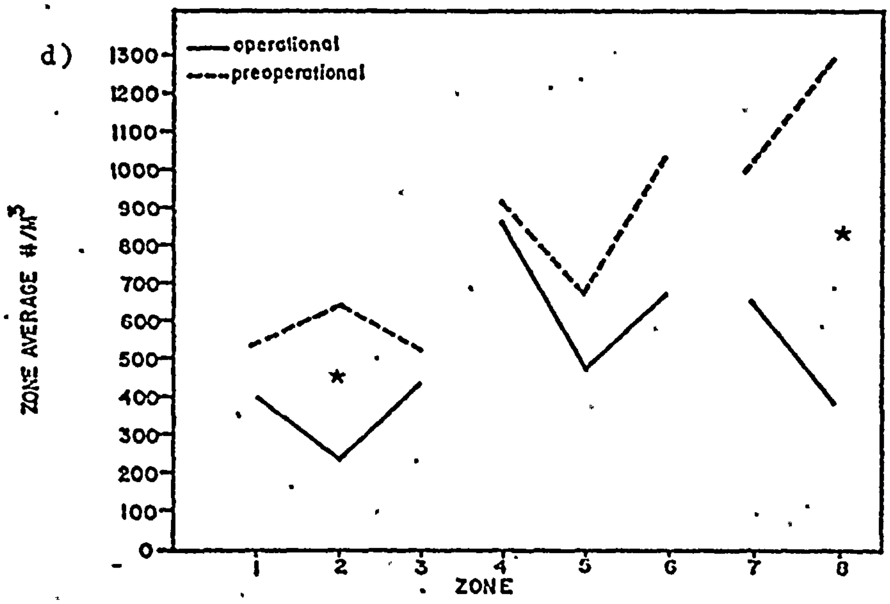


Figure 2 continued c) Cyclopoid C1-C5 1973-74 and 1975-78. d) Cyclops spp. C6 1973-74 and 1975-78.

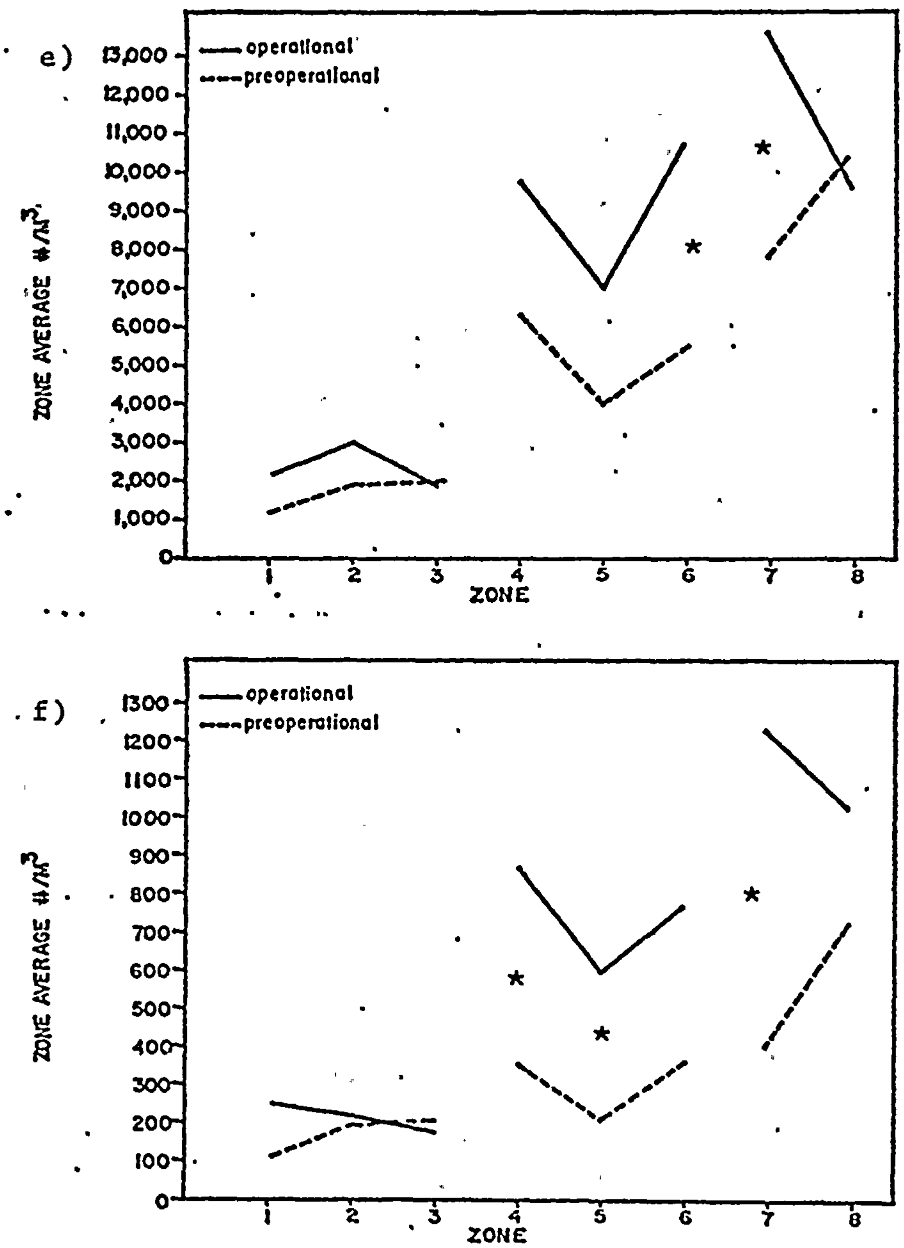
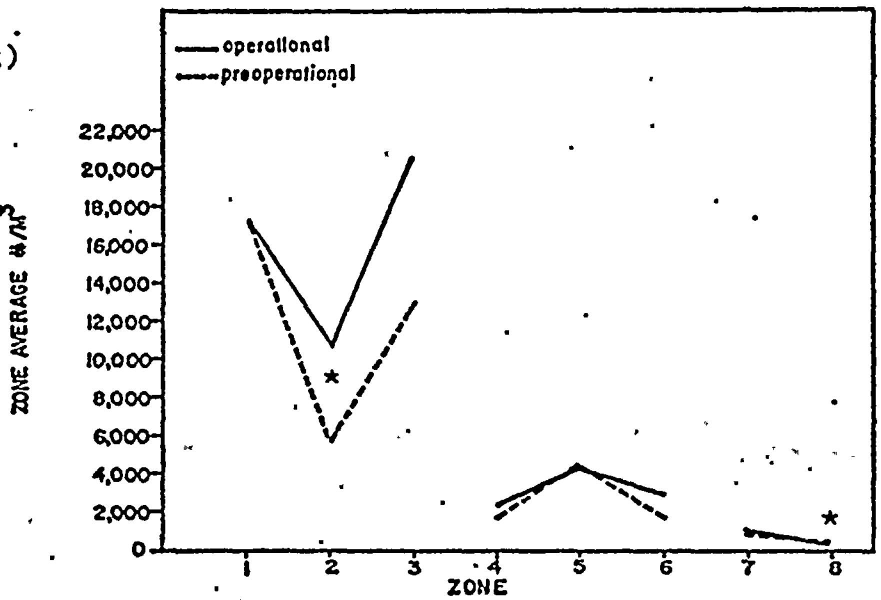


Figure 2 continued. e) Diaptomus spp. C1-C5 1973-74 and 1975-78. f) Diaptomus spp. C6 1973-74 and 1975-78.

g)



h)

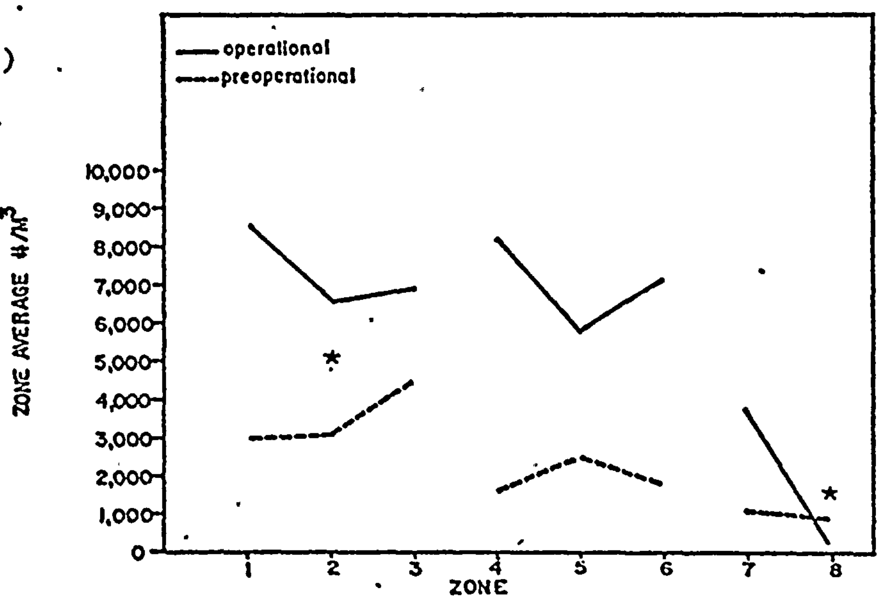


Figure 2 continued. g) Bosmina longirostris 1972-74 and 1975-78. h) Eubosmina coregoni 1972-74 and 1975-78.

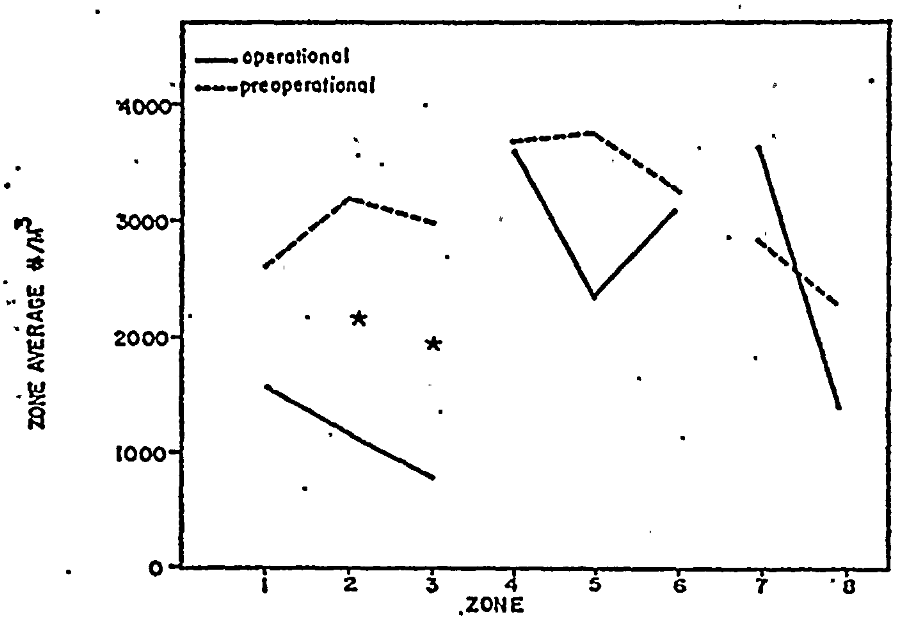


Figure 2 continued. Daphnia spp. 1972-74 and 1975-78.

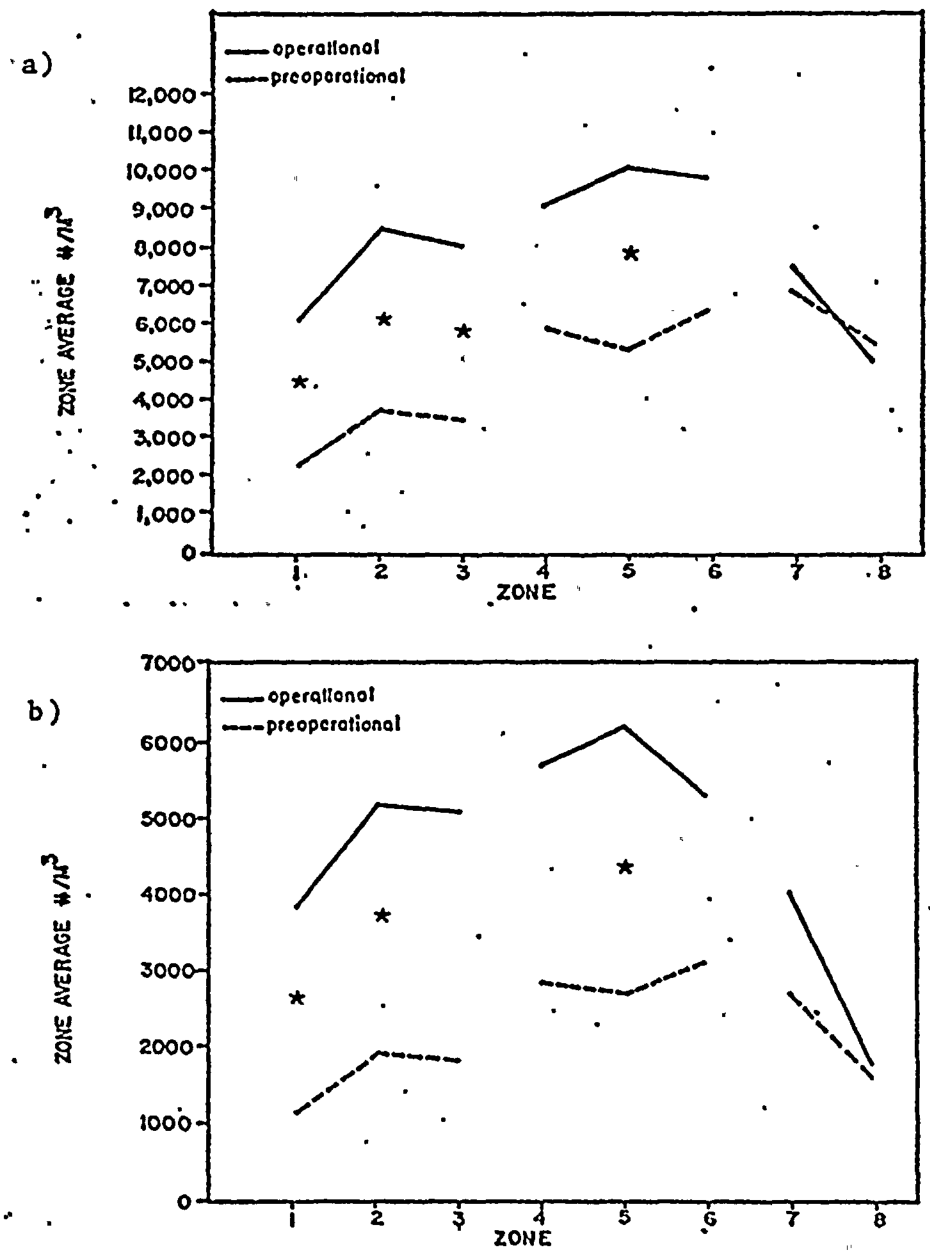
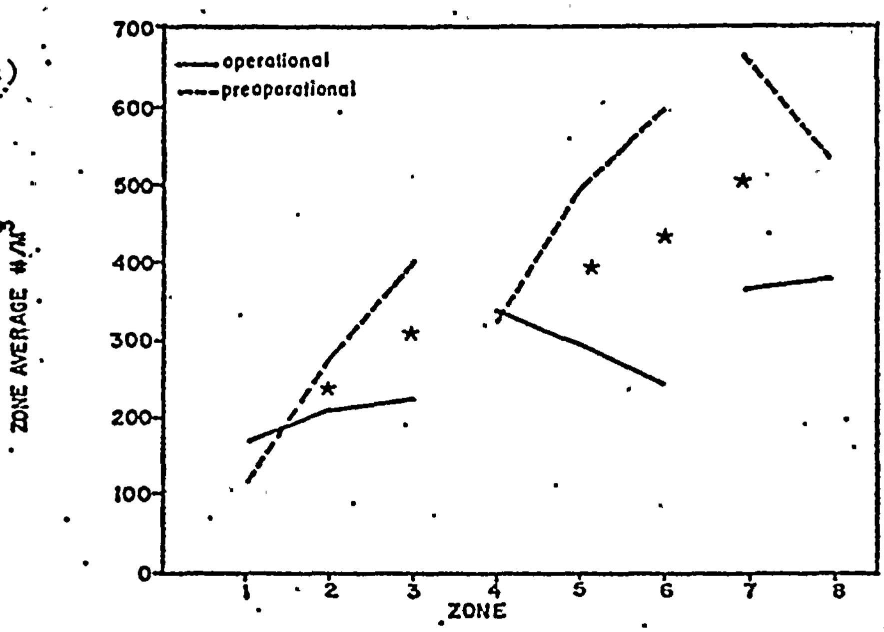


Figure 3. Mean zooplankton densities in April for each zone (dashed lines = preoperational period, solid lines = postoperational period). Stars indicate zones with significant differences between the preoperational and post operational periods (Mann-Whitney U test, $\alpha = 0.05$). Lines connect zones in the same depth range (inshore zones = 1-3, middle zones = 4-6, and the inner and outer offshore zones = 7 & 8). a) total zooplankton 1972-74 and 1975-79. b) Copepod nauplii 1972-1974 and 1975-1979.

c)



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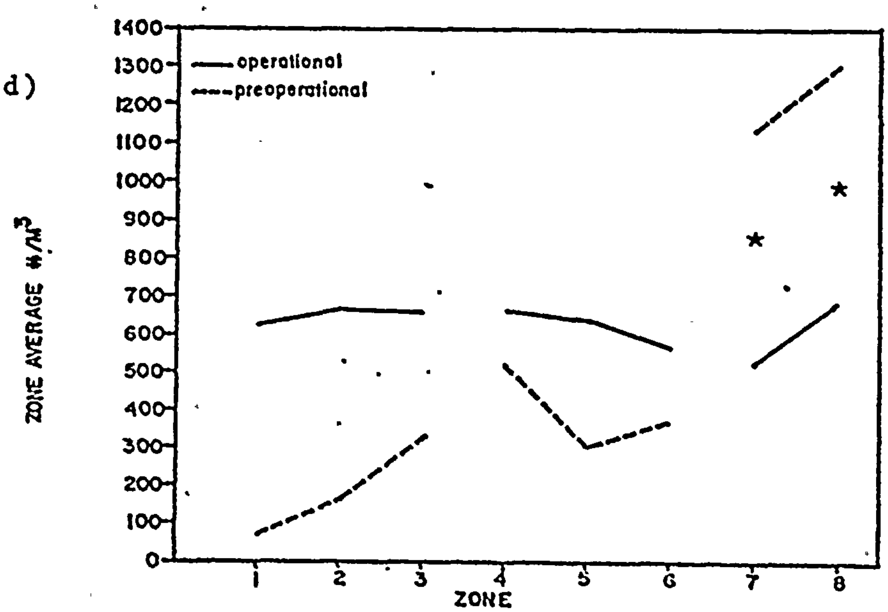
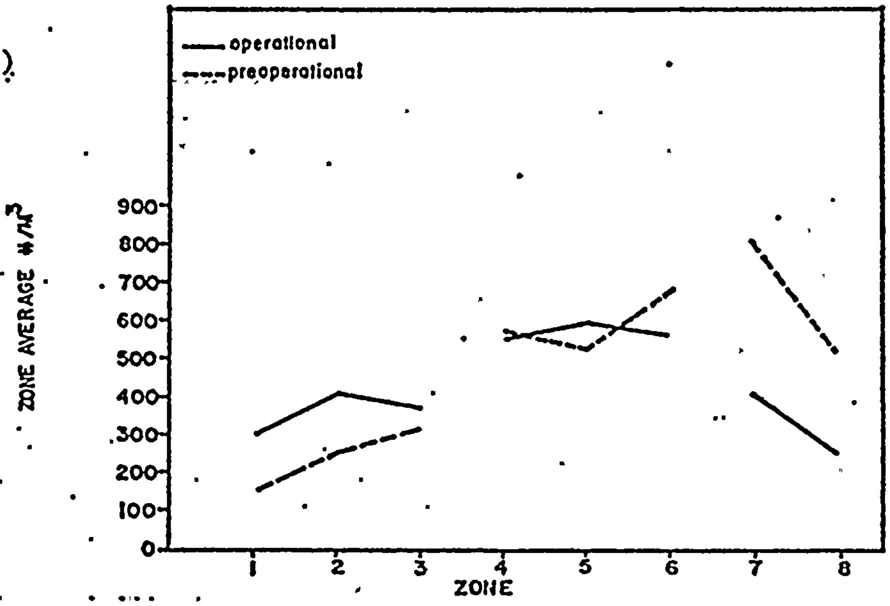


Figure 3 continued. c) Cyclopoid C1-5 1973-74 and 1975-79. d) <u>Cyclops</u> spp. C6 1973-74 and 1975-79.

e)



f)

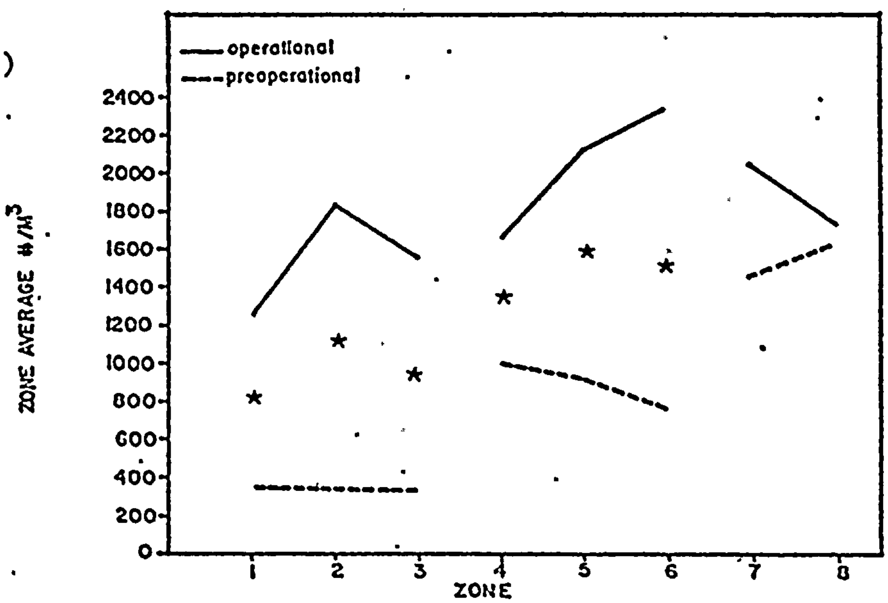


Figure 3 continued. e) Diaptomus spp. C1-C5 1973-74 and 1975-79. f) Diaptomus spp. C6 1973-74 and 1975-79.

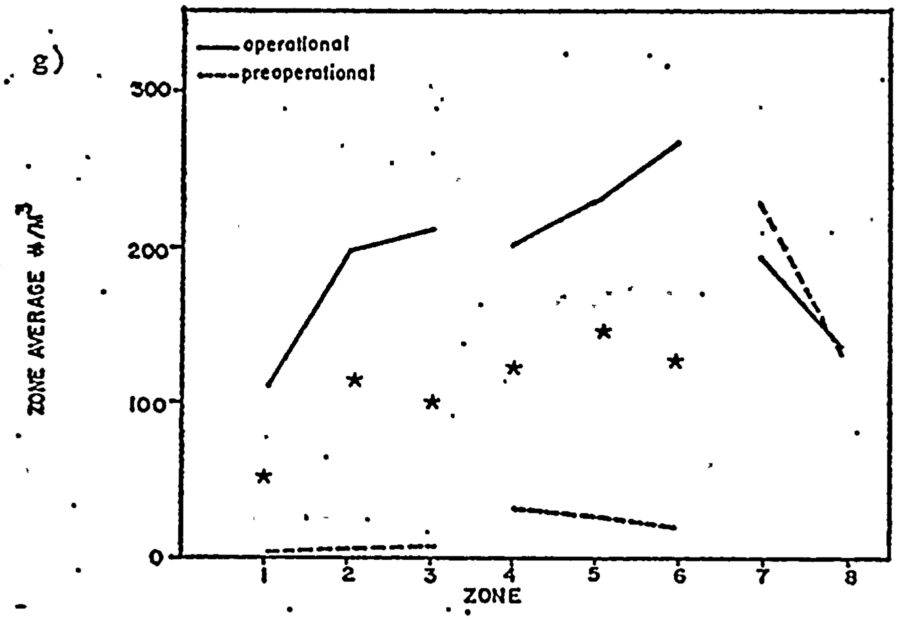


Figure 3 continued. g) Limnocalanus macrurus C1-6 1973-74 and 1975-79

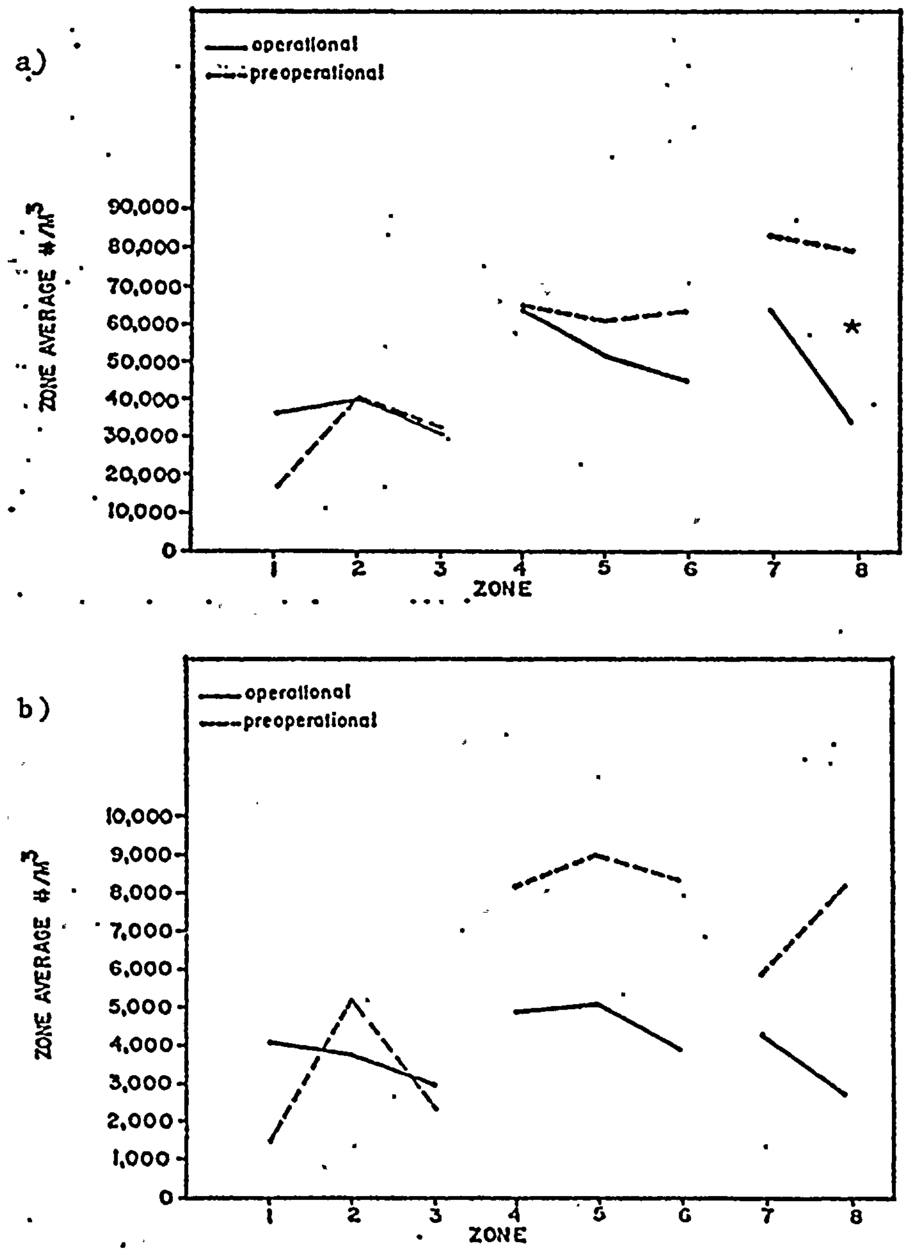
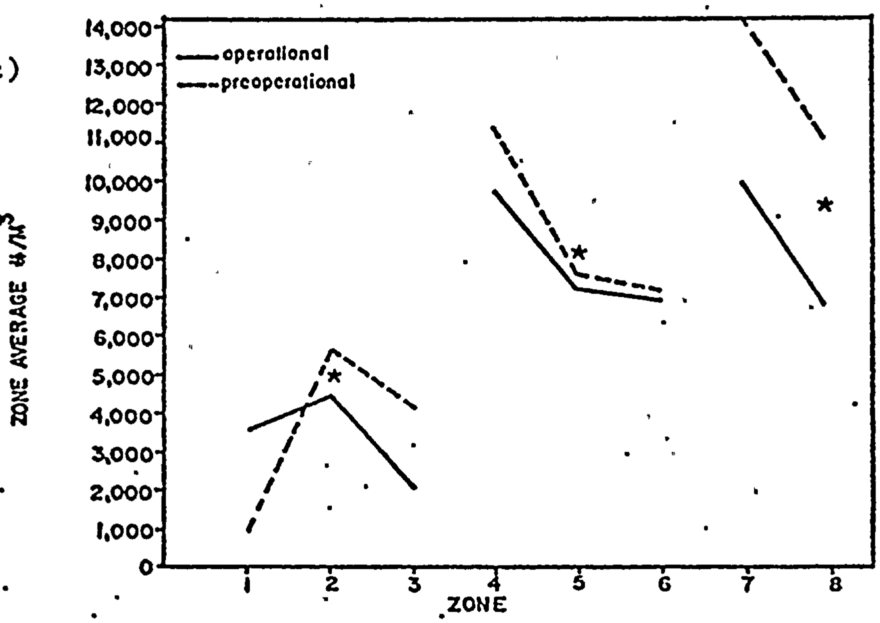


Figure 4. Mean zooplankton densities in July for each zone (dashed lines = preoperational period, solid lines = operational period). Stars indicate zones with significant differences between the pre-operational and operational periods (Mann-Whitney U test, $\alpha = 0.05$). Lines connect zones in the same depth range (inshore zones = 1-3, middle zones = 4-6, and the inner and outer offshore zones = 7 and 8). a) Total zooplankton 1972-74 and 1975-79. b) Copepod nauplii 1972-74 and 1975-79.

c)



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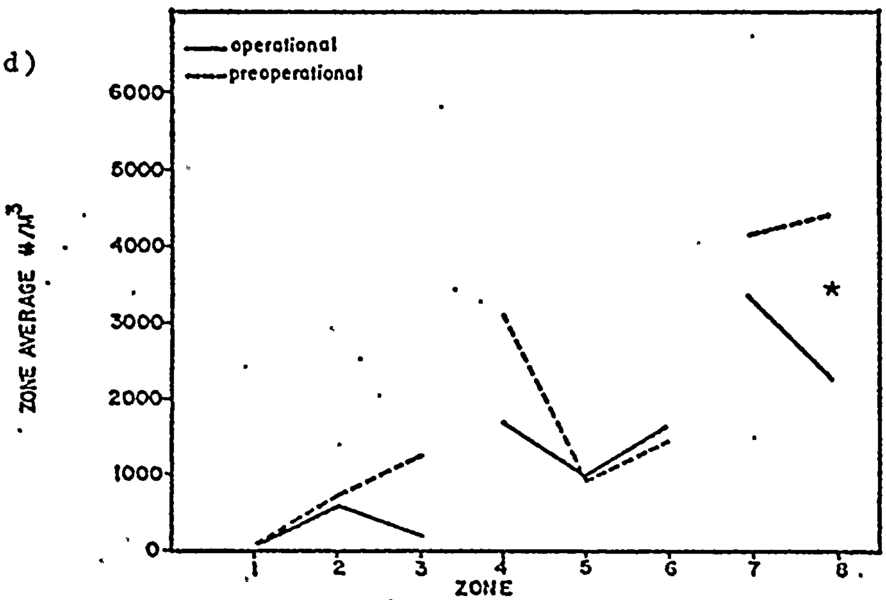
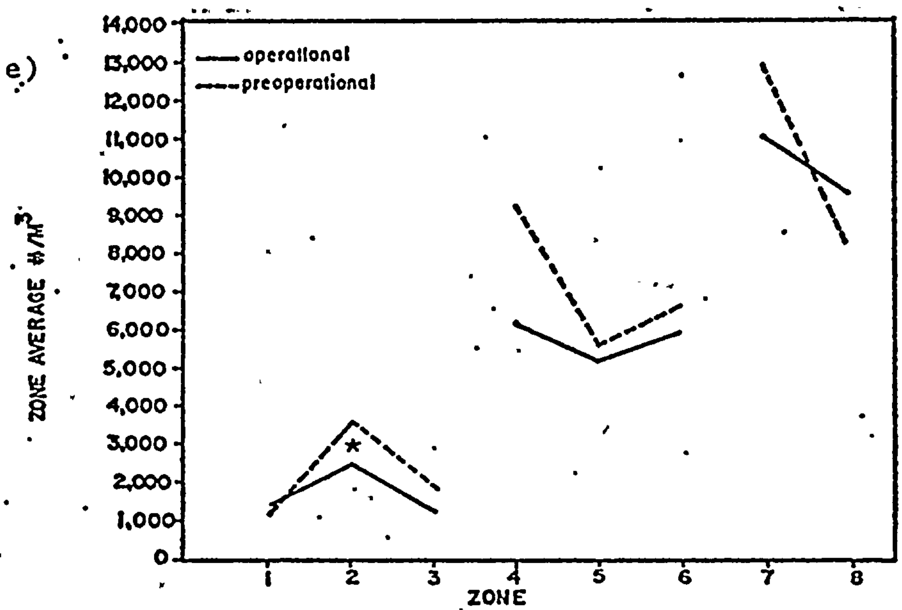


Figure 4 continued. c) Cyclopoid C1-C5 1973-74 and 1975-79. d) <u>Cyclops</u> spp. C6 1973-74 and 1975-79.

e)



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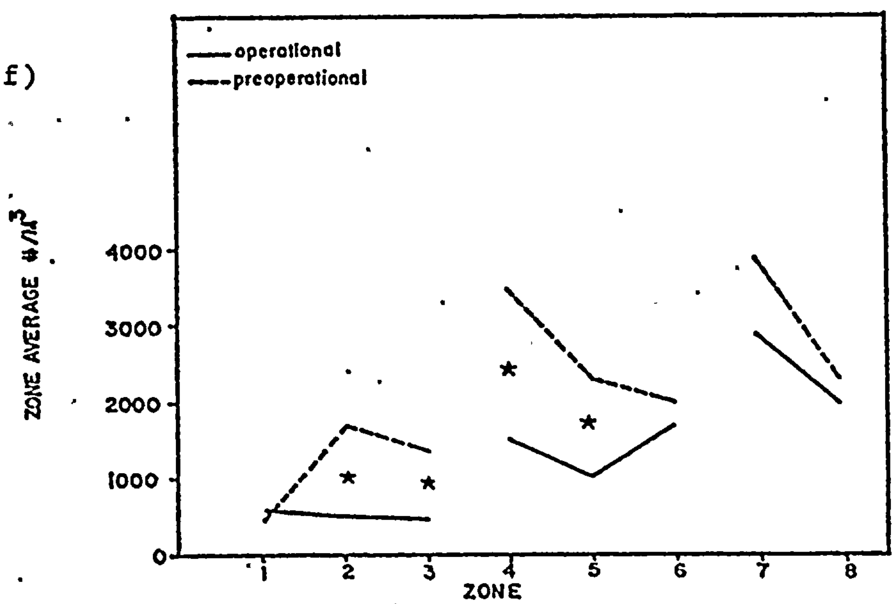

Figure 4 continued: e) Diaptomus spp. C1-C5 1973-74 and 1975-79. f) Diaptomus spp. C6 1973-74 and 1975-79.

g)

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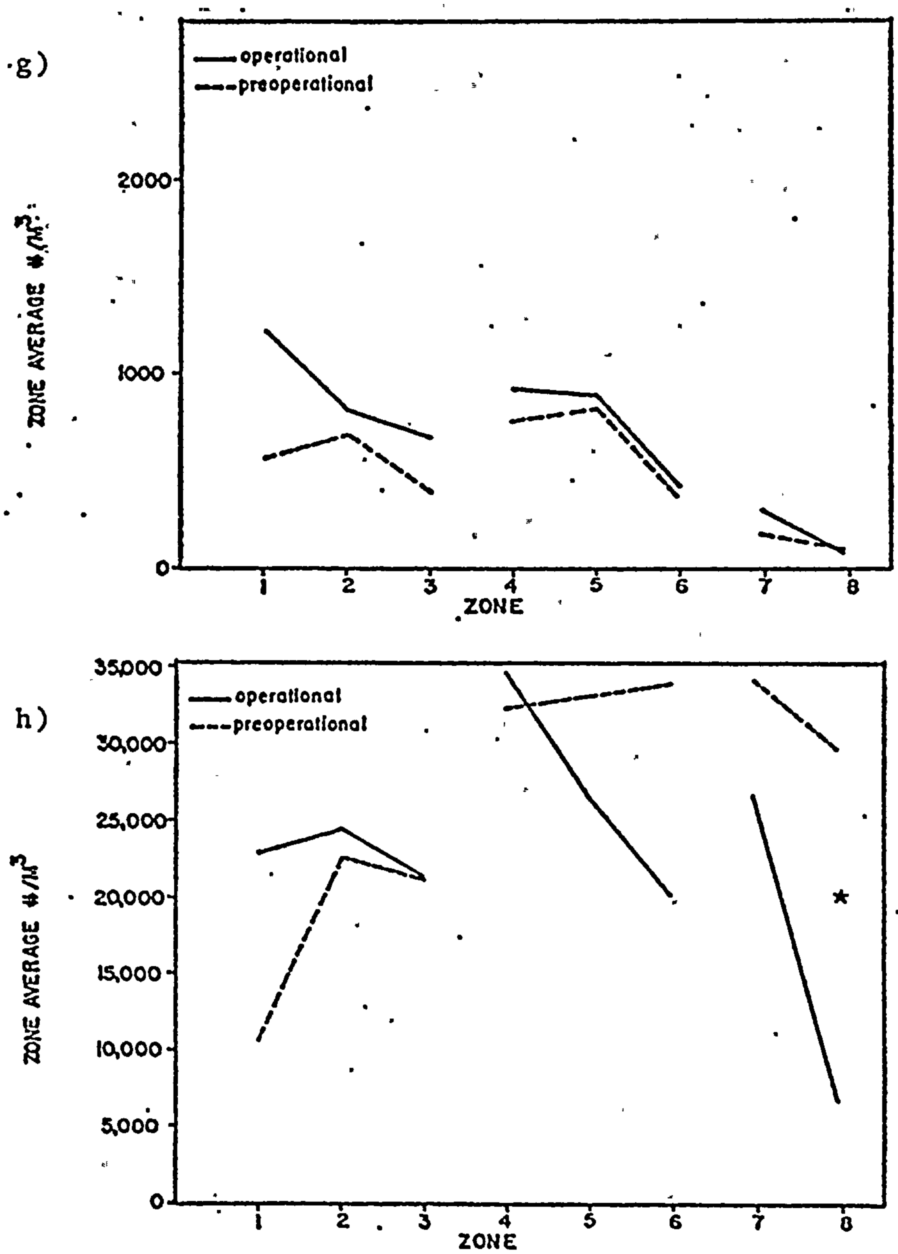
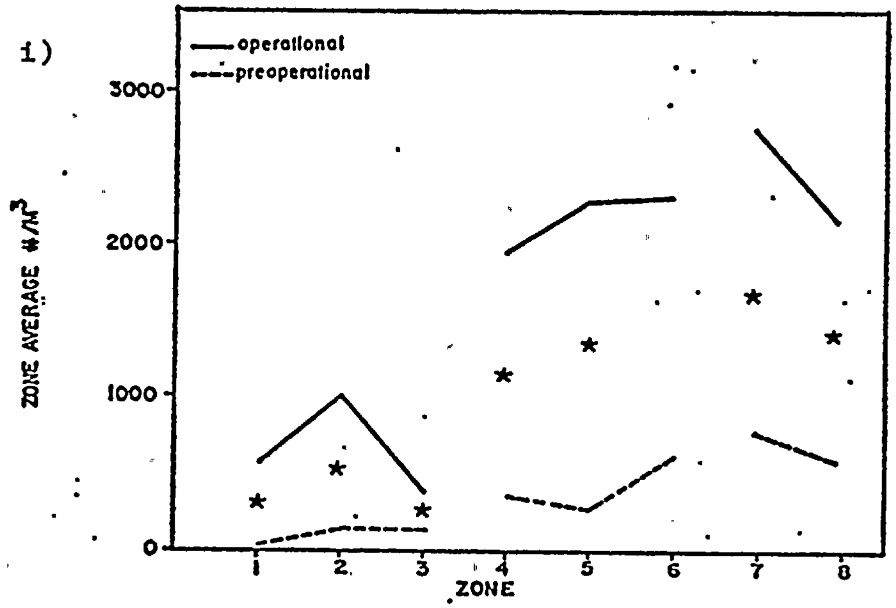


Figure 4 continued. g) Eurytemora affinis C1-C6 1973-74 and 1975-79. h) Bosmina longirostris 1972-74 and 1975-79.



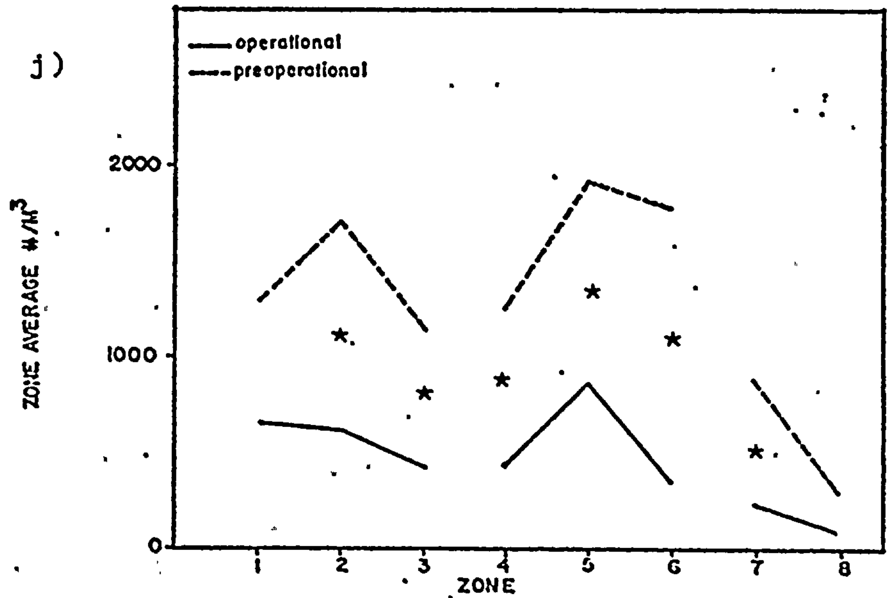


Figure 4 continued. i) Daphnia spp. 1971-74 and 1975-79. j) Asplanchna spp. 1971-74 and 1975-79.

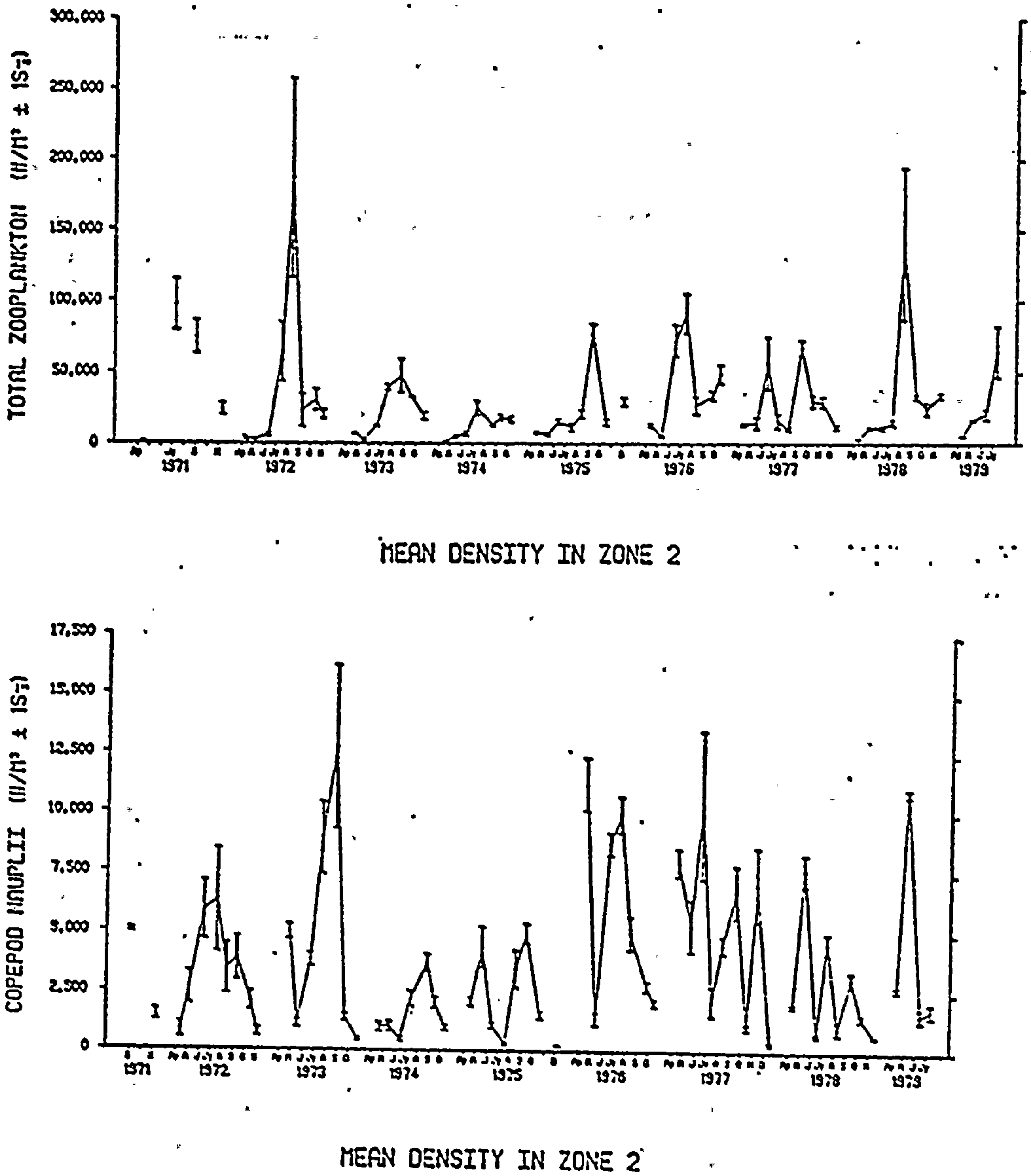
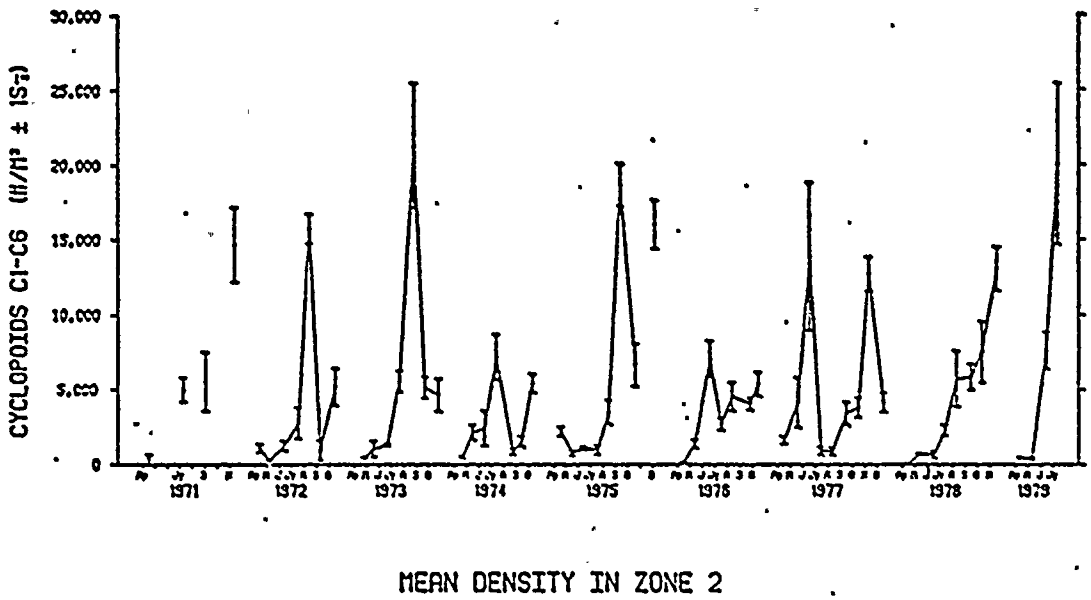


FIG. 5. The monthly abundance of zooplankton in the inshore plume zone (zone 2) between 1971 and July 1979. a) Total zooplankton; b) copepod nauplii



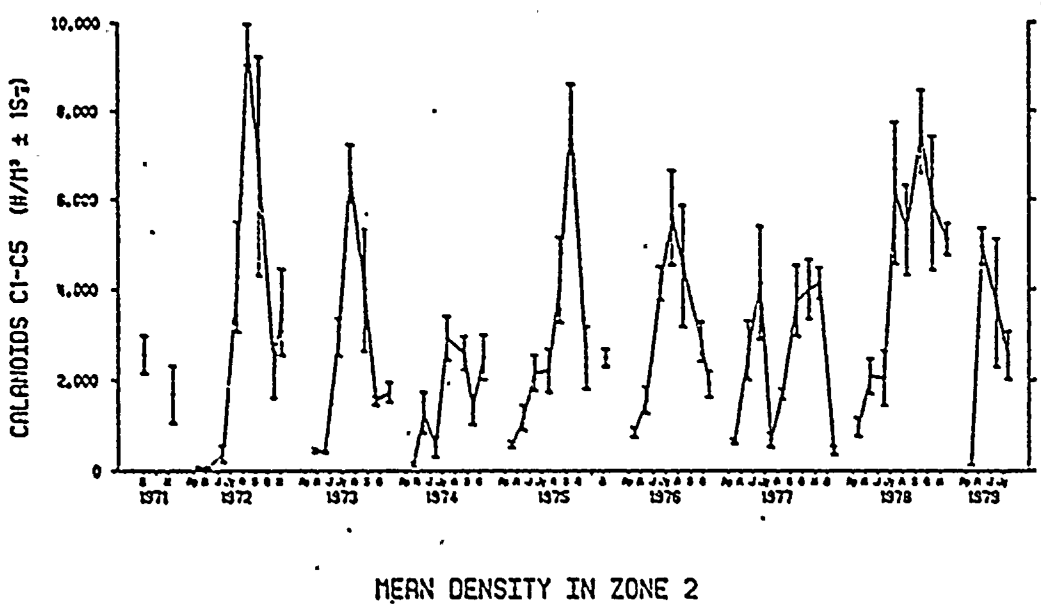
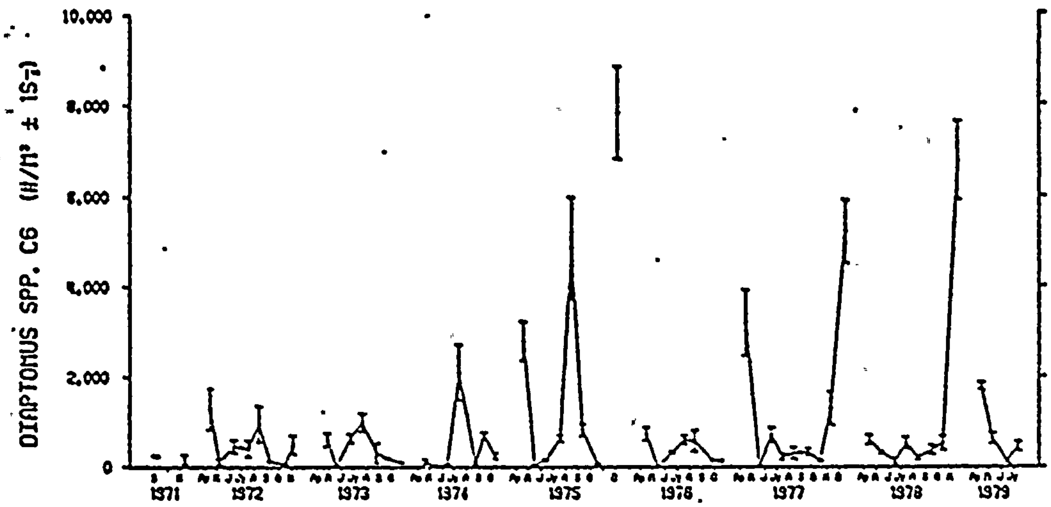
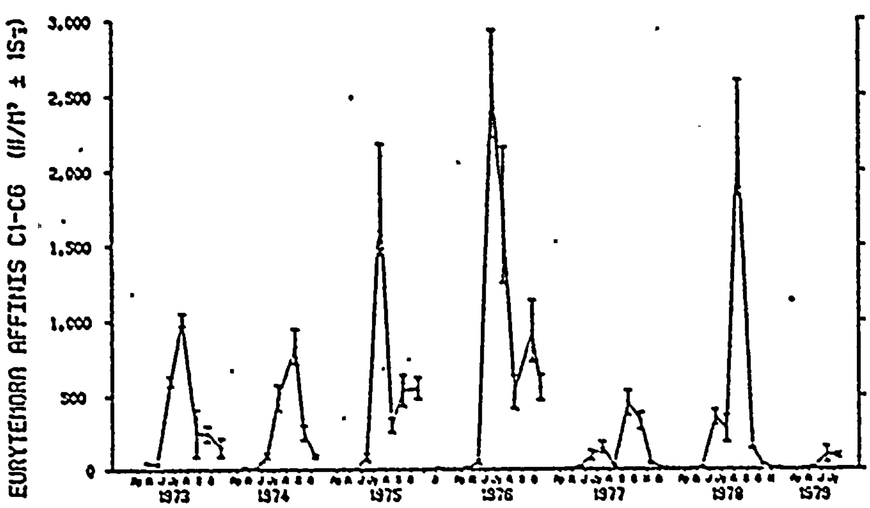


FIG. 5 continued. c) cyclopoid copepodites; d) immature calanoid copepodites.

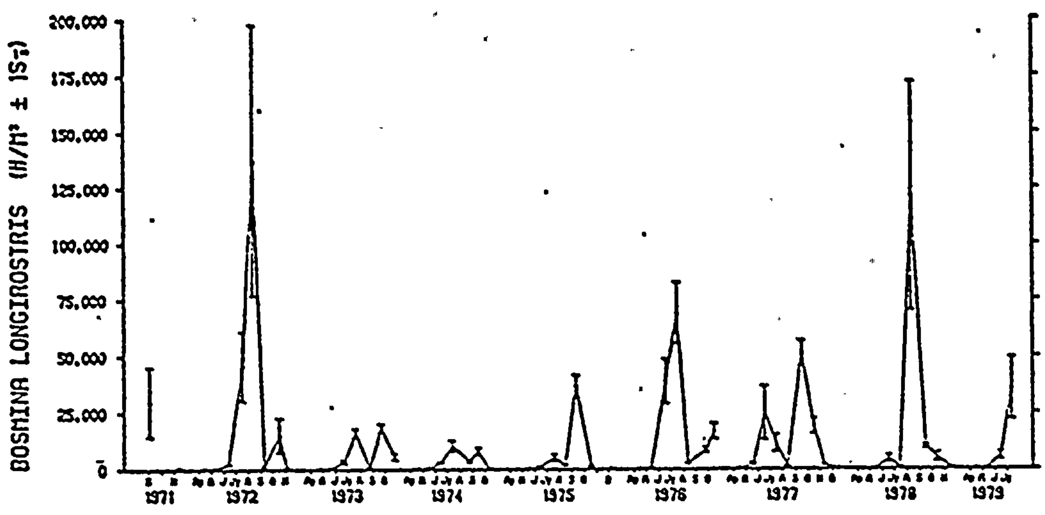


MEAN DENSITY IN ZONE 2



MEAN DENSITY IN ZONE 2

FIG. 5 continued. e) *Diaptomus spp.* adults; f) *Eurytemora affinis* copepodites.



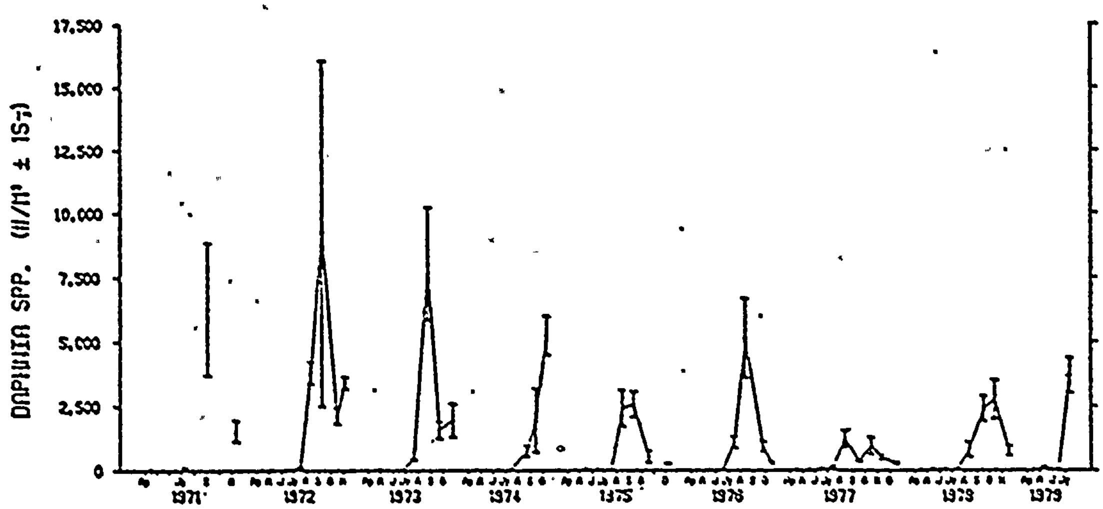
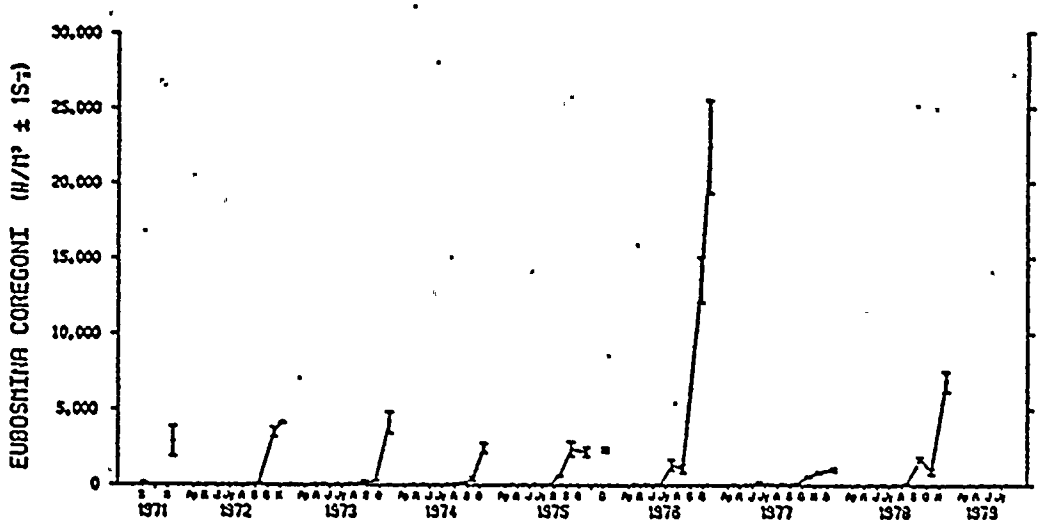
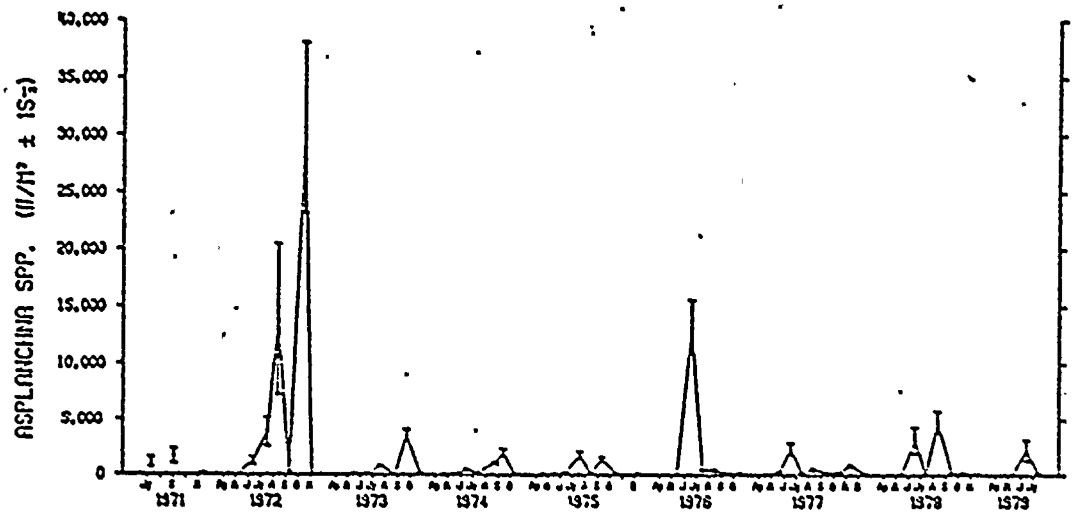


FIG. 5 continued. g) Bosmina longirostris; h) Daphnia spp.



MEAN DENSITY IN ZONE 2.



MEAN DENSITY IN ZONE 2

FIG. 5 continued. i) Eubosmina coregoni; j) Asplanchna spp.

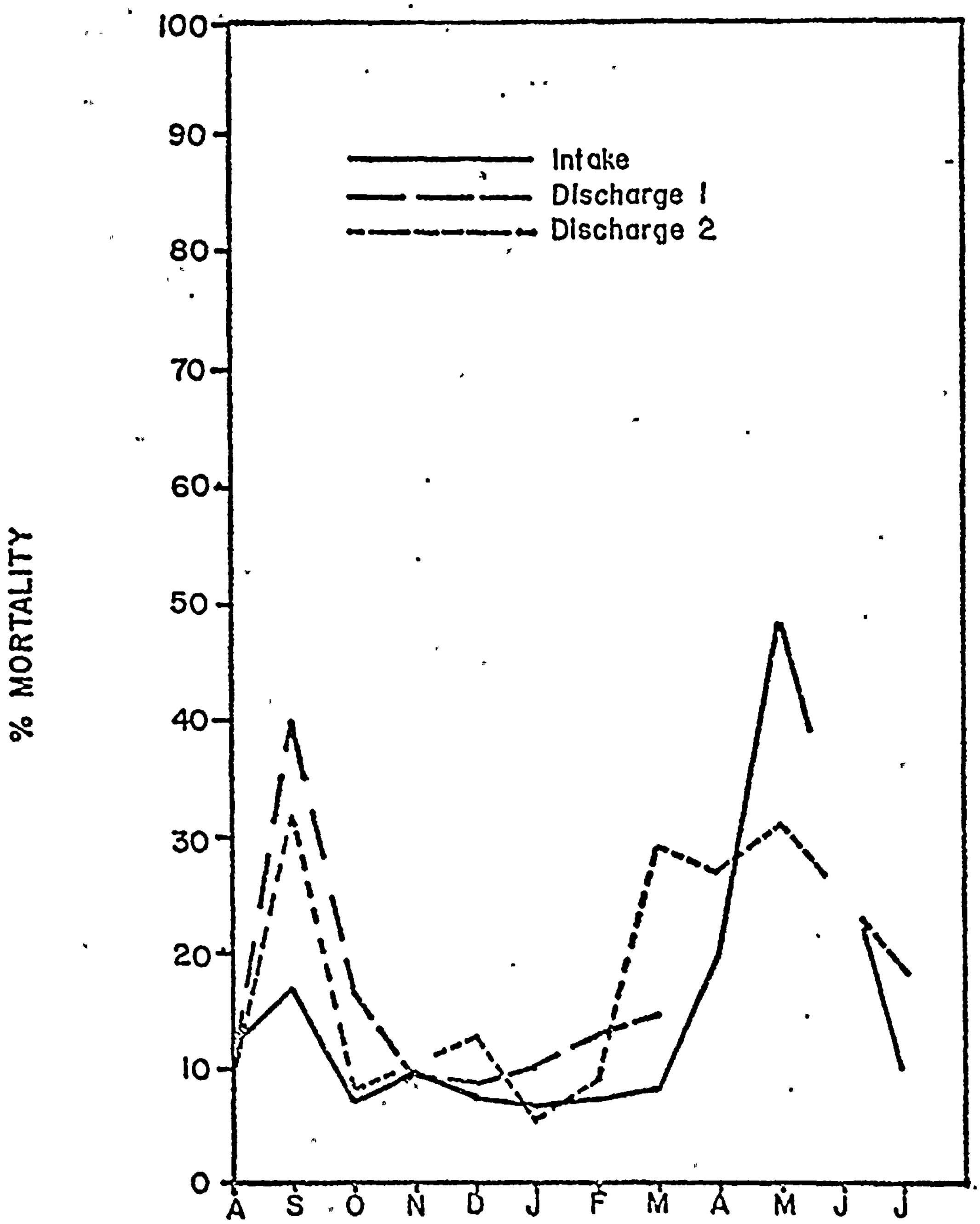


Figure 6. Total zooplankton mean mortality (%) immediately following collection (0 hour count) for zooplankton collected in the intake forebay (MTR1-5) and both Unit 1 and Unit 2 discharge bays.

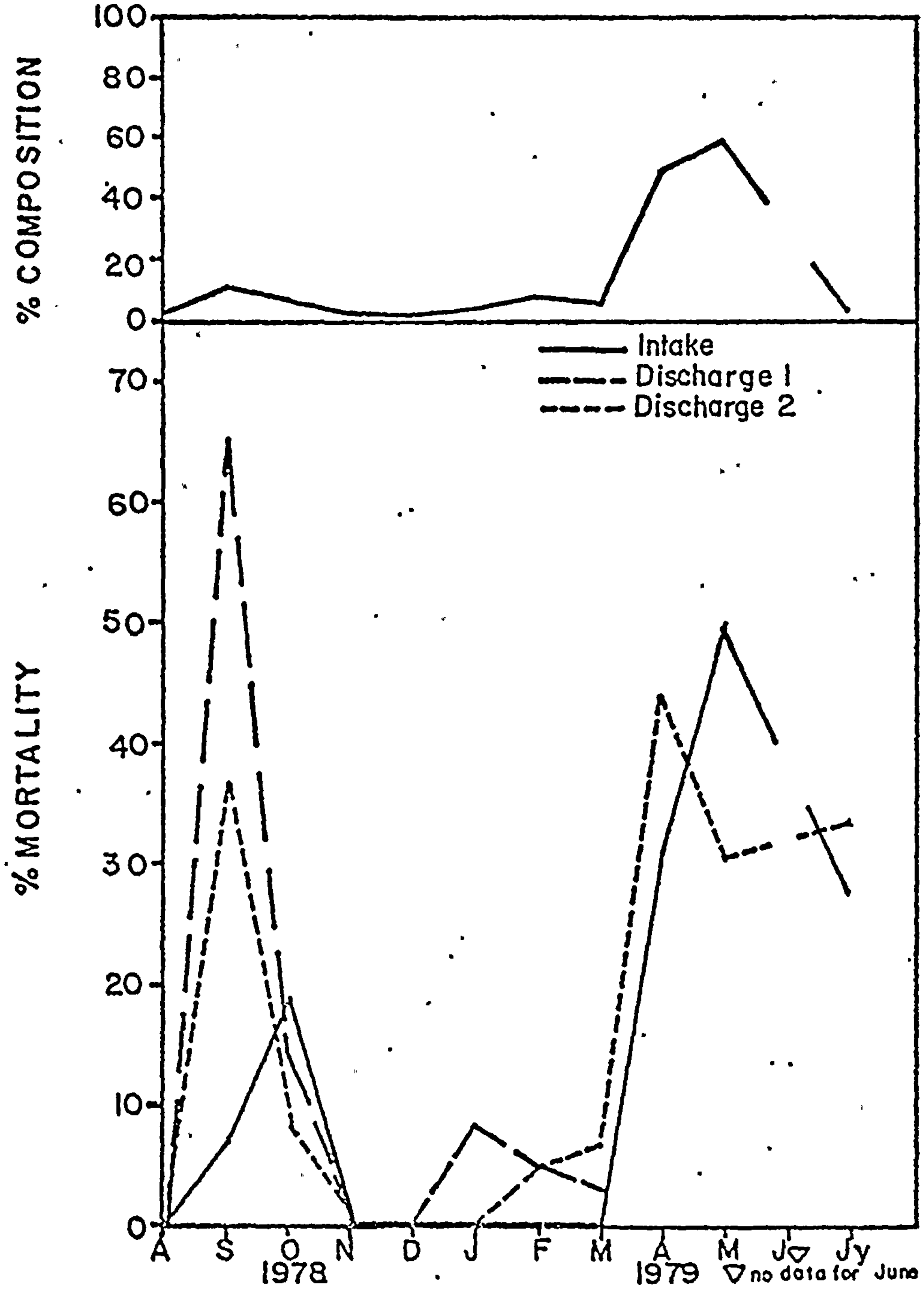


Figure 7. The mean mortality (% dead) immediately following collection (0 hour count) and relative density (% composition) for zooplankton collected in the intake forbay (MTR1-5) and both Unit 1 and Unit 2 discharge bays. a) Copepod nauplii

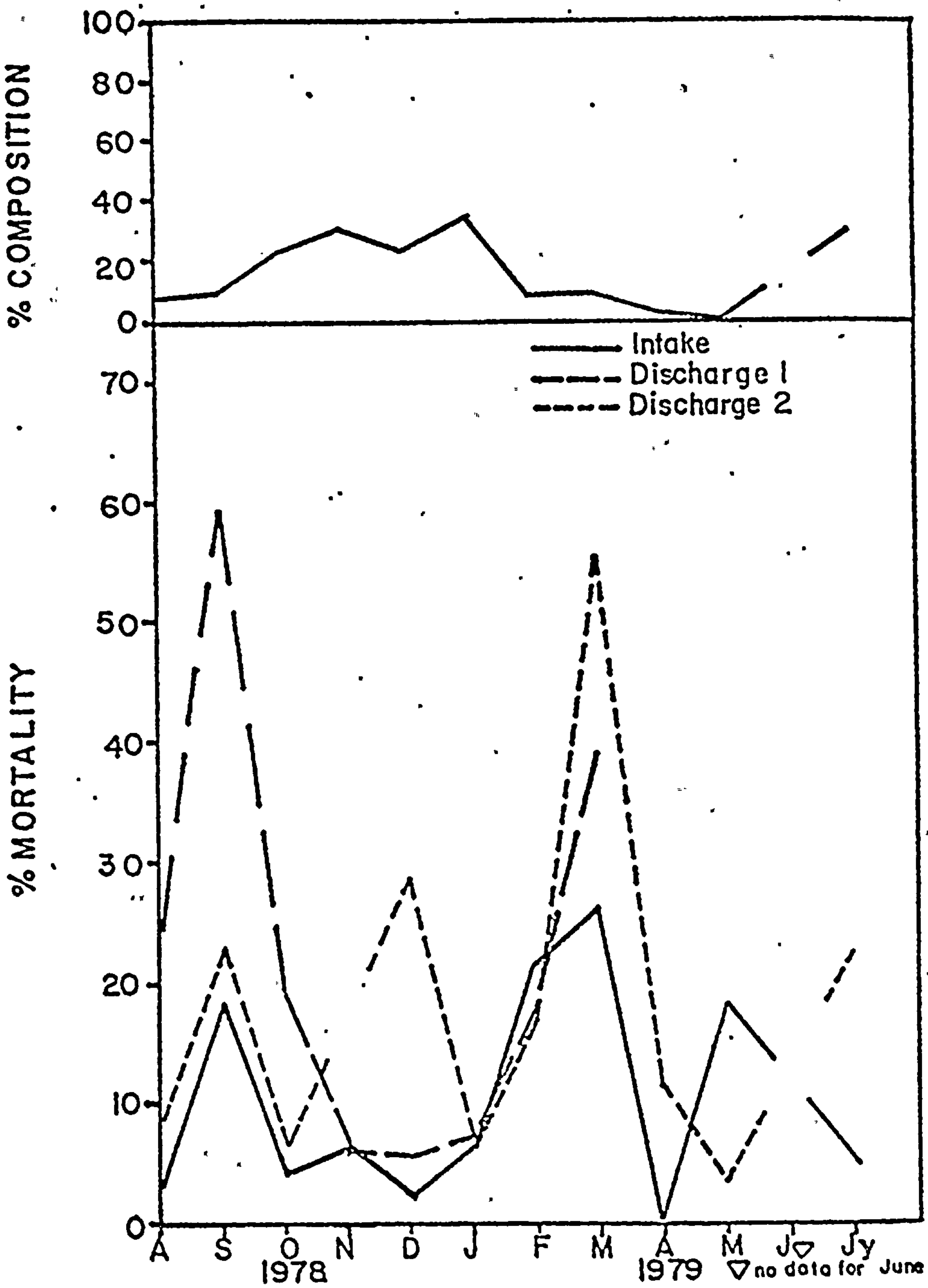


Figure 7 continued. b) <u>Cyclops</u> spp. C1-C5.

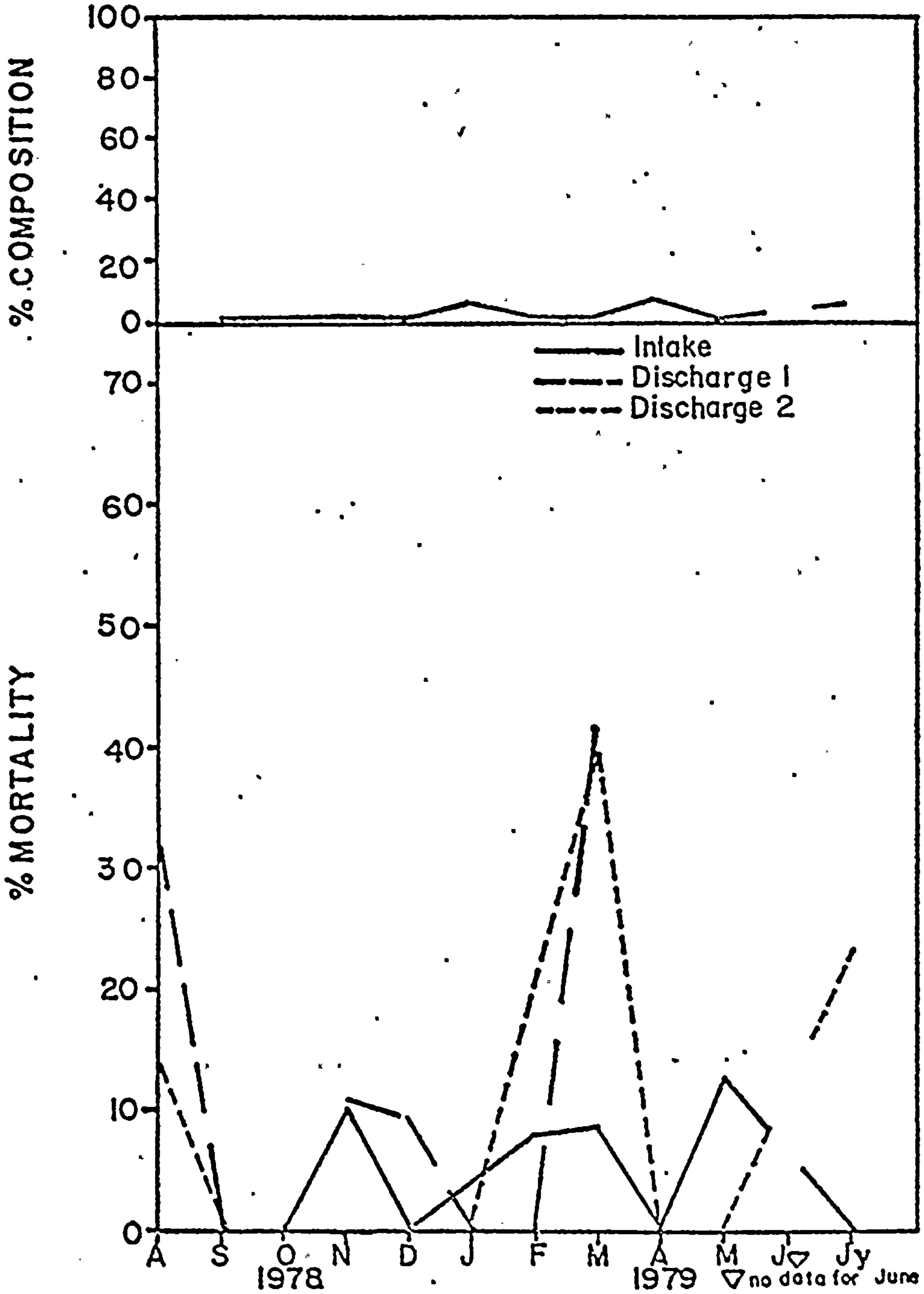


Figure 7 continued. c) Cyclops bicuspidatus C6.

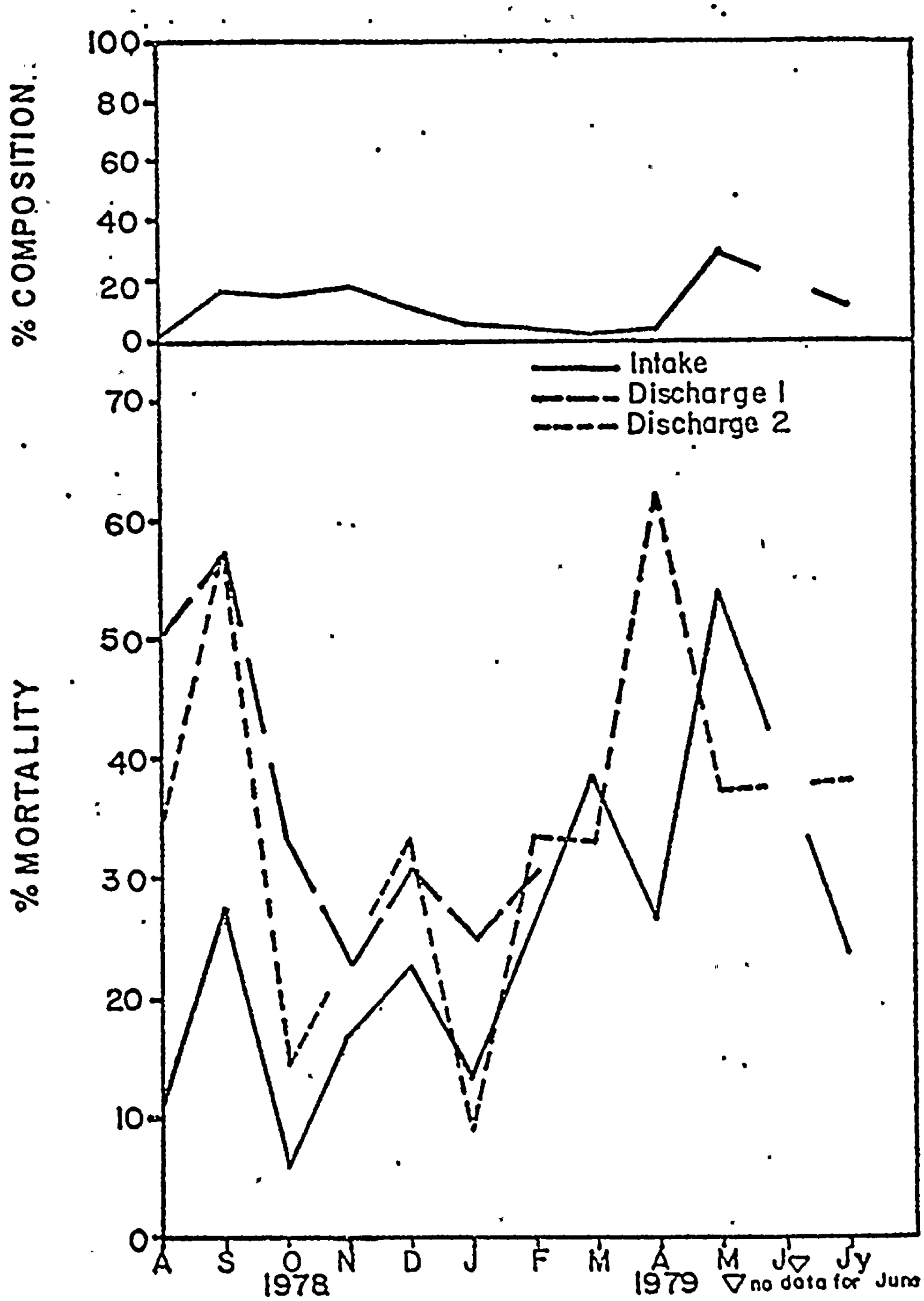


Figure 7 continued. d) *Diaptomus* spp. C1-C5.

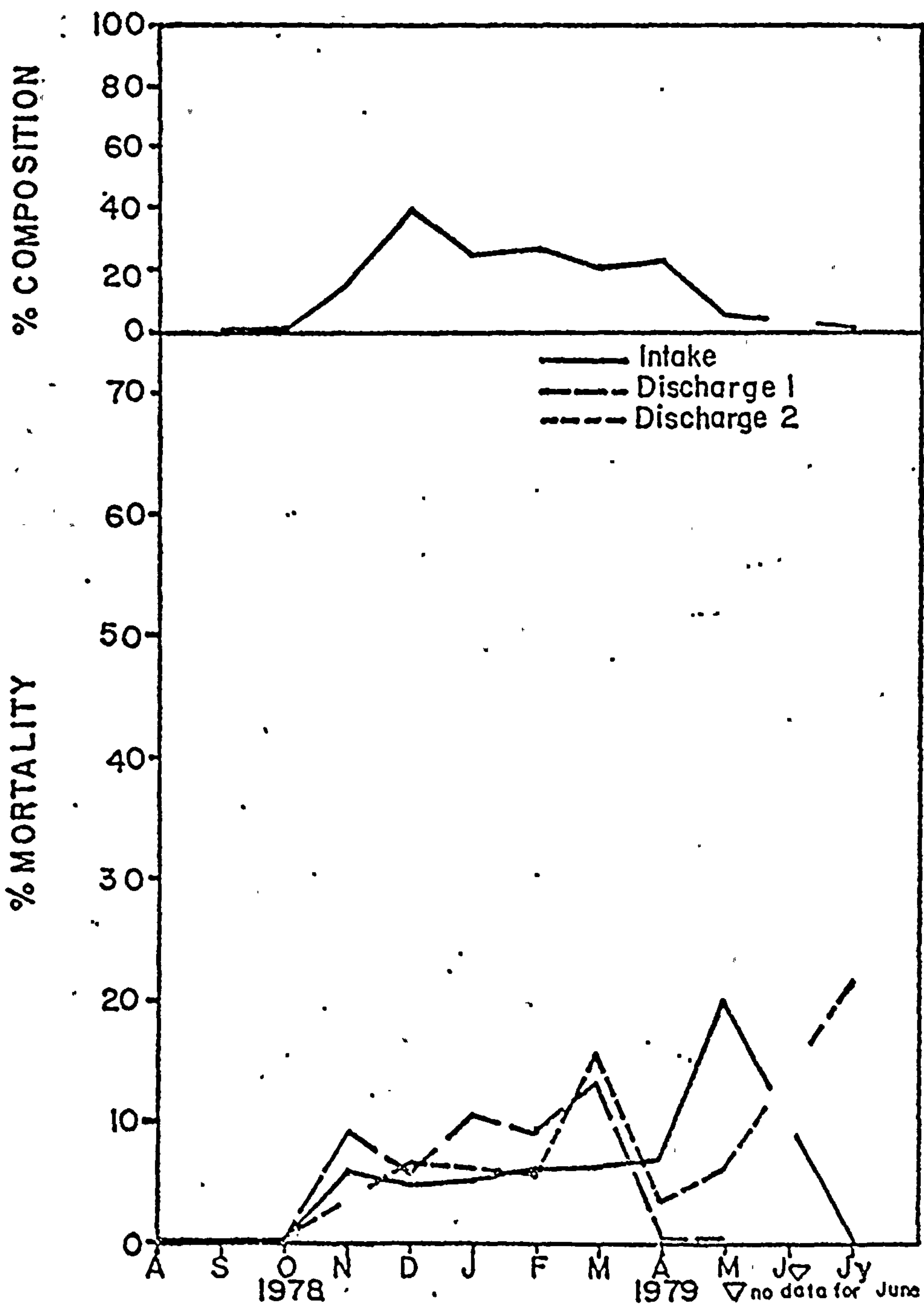


Figure 7 continued. e) Diaptomus spp. C6.

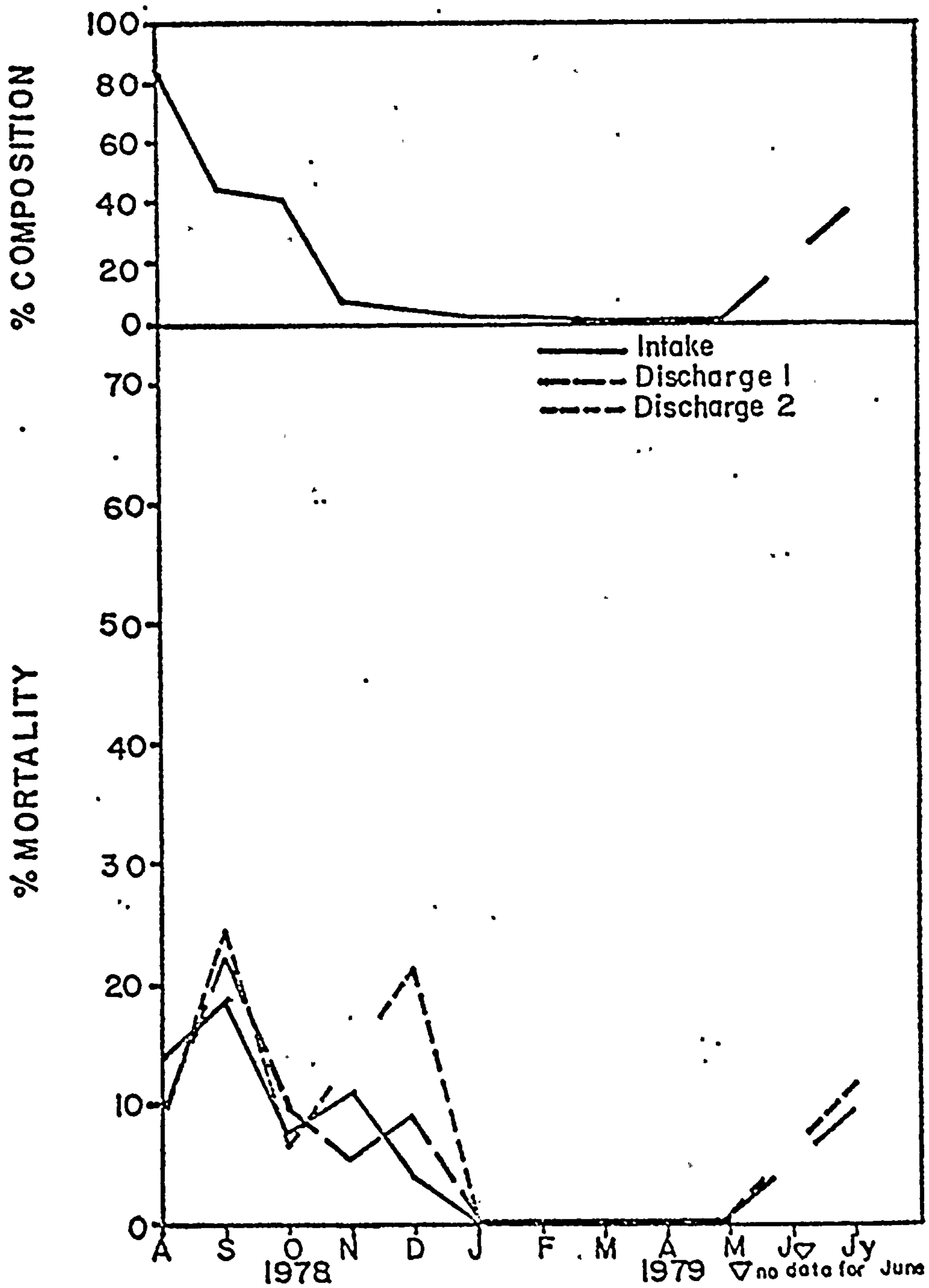


Figure 7 continued. f) Bosmina longirostris.

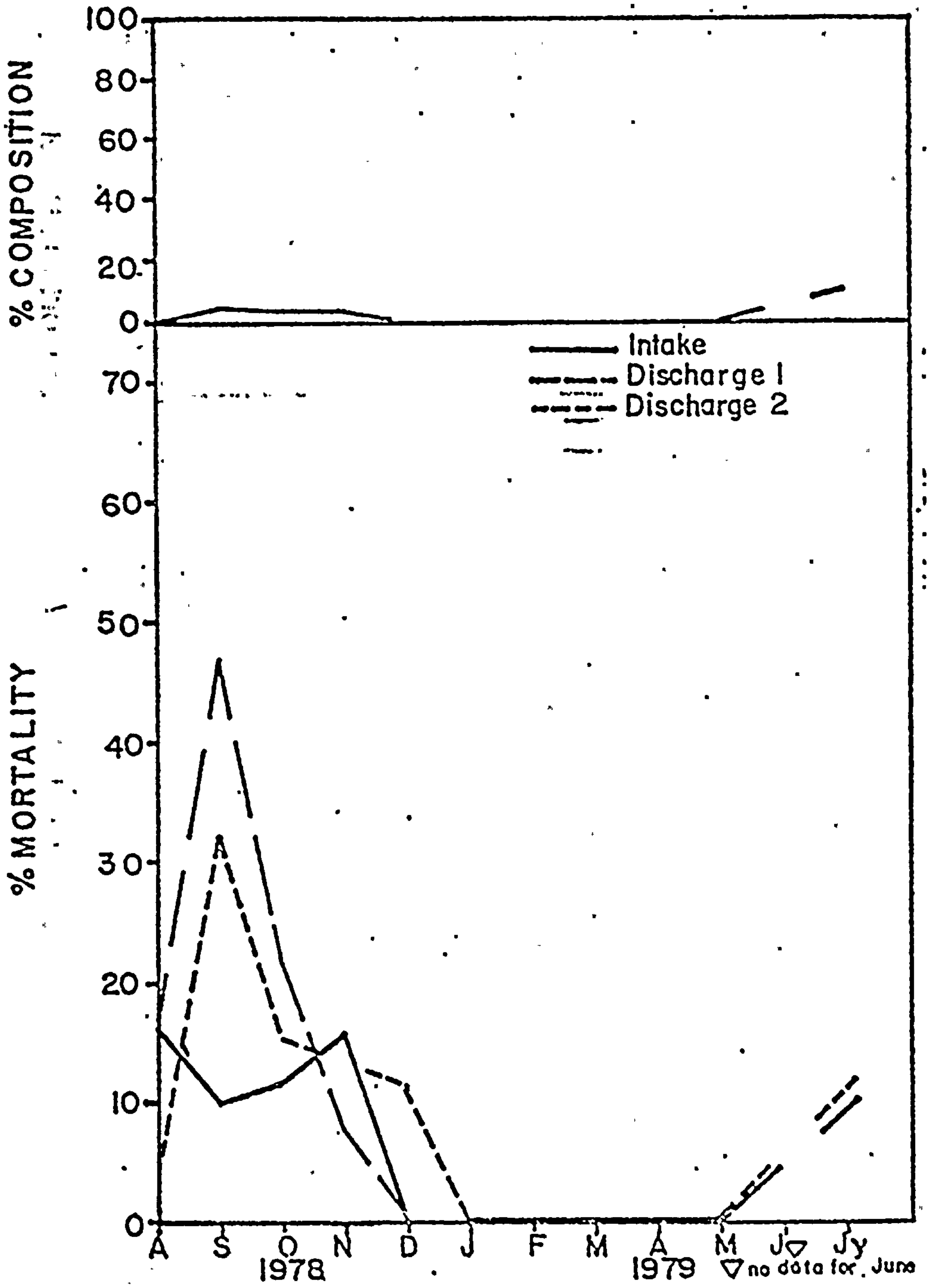


Figure 7 continued. g) <u>Daphnia retrocurva</u>.

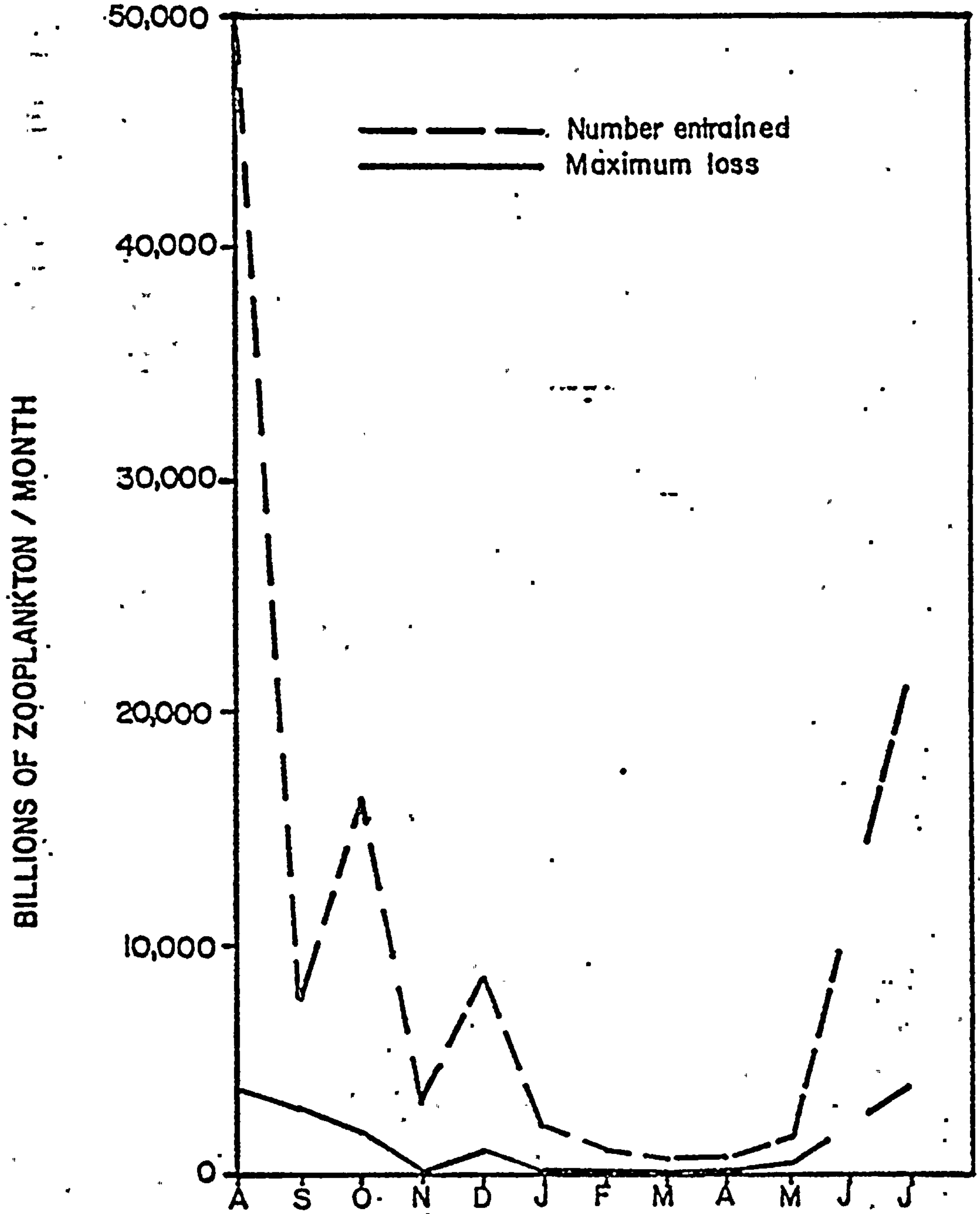


Figure 8. Estimates of zooplankton numbers entrained and maximum numbers lost from August 1978 to July 1979.

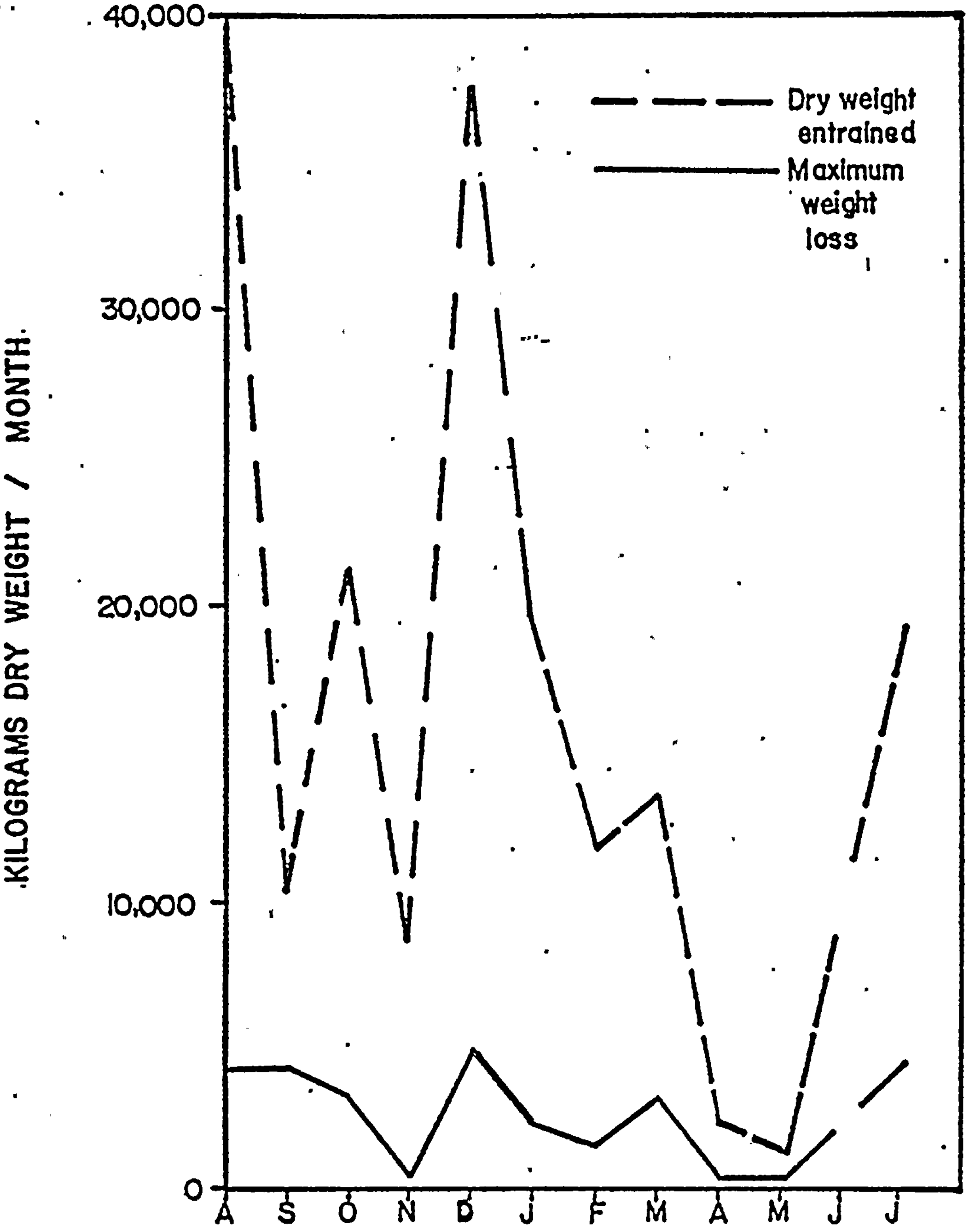


Figure 9. Estimates of entrained zooplankton dry weights and maximum losses from August 1978 to July 1979.

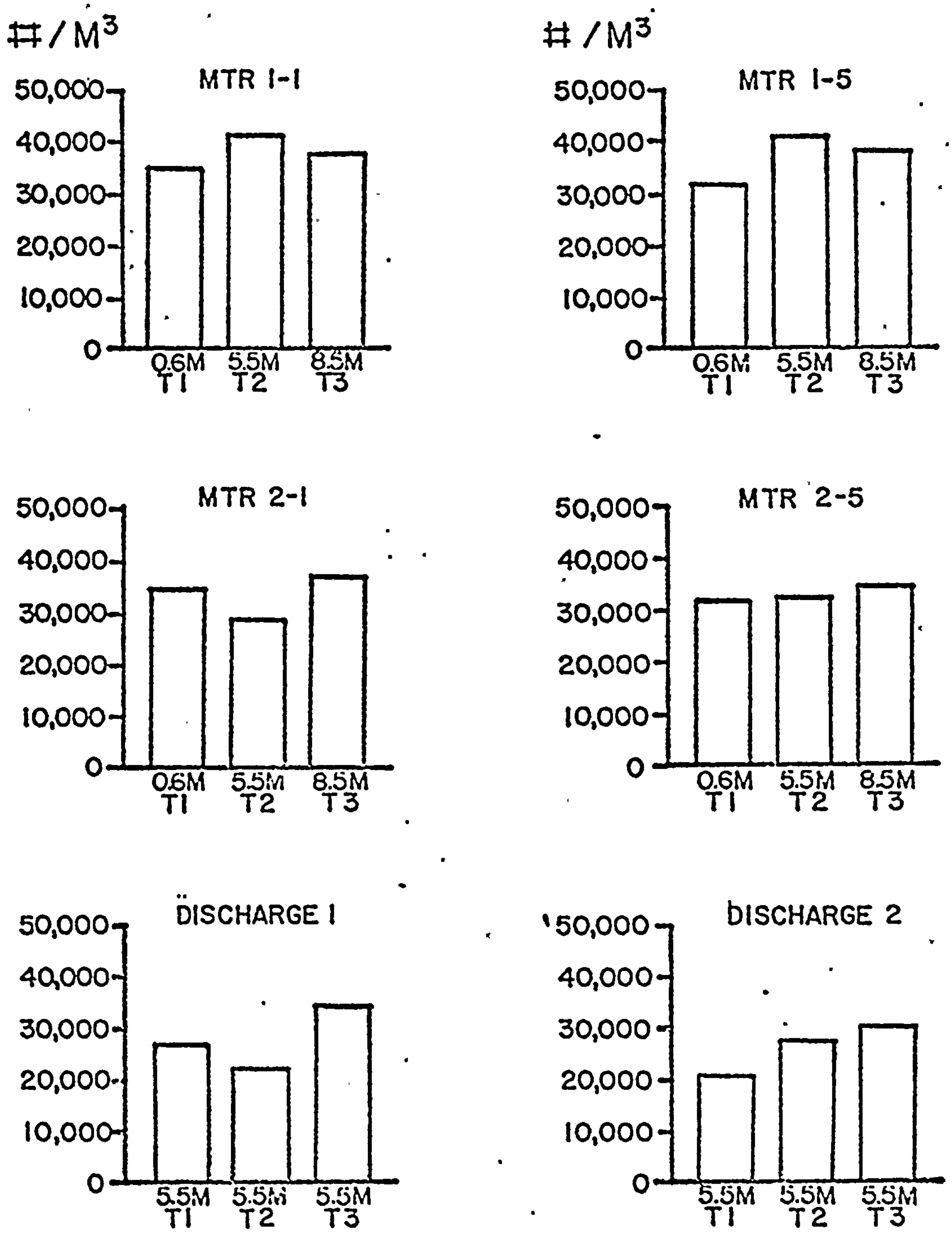


FIG. 10. Mean abundances of total zooplankton at six sampling locations for three depths (intake forebay) or times (discharge forbays). T1 is the first sampling time, T2 the second, and T3 the third.

APPENDIX B-2
PART I
PHYTOPLANKTON LAKE SURVEY

INTRODUCTION

The Technical Specifications require that phytoplankton in the Cook Plant region be sampled monthly from April through November, with major surveys over the 36-station sampling grid in April, July, and October and with short surveys over a reduced 11-station grid in the intervening months.

The phytoplankton surveys are designed to provide a broad background of phytoplankton numbers in spring, summer, and fall. They also provide species compositions, numbers of forms, diversities, and redundancies under preoperational conditions against which the same parameters from surveys similarly conducted under operational conditions may be contrasted to determine long-term changes that may be attributable to Cook Plant operation.

The short surveys give a continuum between major surveys and provide a means of better watching temporal changes that might be missed or only partially covered by the major seasonal surveys.

November is notorious for storms on Lake Michigan and November surveys in 1973, 1974, 1975, and 1976 were missed for this reason.

Phytoplankton sampling at station SDC-4-1 was accidentally omitted in the survey of July 1977.

The phytoplankton samples of 1979 are still being worked up and are not yet available for analysis.

This report extends our reporting of the in-lake phytoplankton by adding the surveys of 1978. The phytoplankton surveys of previous years are given by Ayers et al. (1971), Ayers, Mozley, and Roth (1973), Ayers, Mozley, and Stewart (1974), Ayers (1975), Ayers, Southwick, and Robinson (1976), Ayers (1978), and Ayers and Wiley (1979).

In accordance with the Technical Specifications requirement to report summaries, interpretations, and statistical analyses, the great bulk of the new raw data from 1978 are not presented here; they are given in Ayers and Wiley (in preparation).

The strategy for detecting changes in the phytoplankton community near Cook Plant involves comparisons of phytoplankton parameters at stations in three depth zones near the plant to the same parameters at stations in the same depth zones two miles or more away from the plant. In any one survey these comparisons are spatial, but, repeated over a time, they allow temporal comparisons as well. The temporal comparisons consist primarily of comparing preoperational conditions to conditions in operational years. Conditions in preoperational years provide a measure of natural variation against which variations in operational years may be compared to detect possible plant-related perturbations.

This report continues through 1978 our analyses of possible plant effects on the phytoplankton according to the strategy outlined above.

Phytoplankton samples in all surveys are collected and treated according to the techniques reported in the Cook Plant Environmental Operating Report for 1977, pages B2-58 through B2-60. Beginning with the samples of 1974 the individual cells of nearly all blue-green algae have been counted; prior to that, colonies were counted as one organism. The counting change resulted in an apparent increase in blue-greens beginning with 1974.

Inner-Outer Graphical Comparisons: Numbers of Forms.

The term "forms" includes organisms identified to species (e.g. *Melosira granulata*), organisms identified only to genus (e.g. *Ulothrix* sp. or spp.), and composite groups of unidentified organisms (e.g. Flagellates).

Data on the numbers of phytoplanktonic forms in collections from the Cook Plant region in the years 1971 through 1975 have been presented and discussed by Ayers, Southwick, and Robinson (1977), Ayers (1978) extended these materials to include 1970 and 1976, Ayers and Wiley (1979) covered 1977, and Ayers and Wiley (in preparation) will give 1978.

Data on numbers of forms are stratified by seasons, three depth zones, and inner and outer station groups. Mean numbers of forms, the associated standard errors, and numbers of observations are given in Table 1.

Means, standard errors, and three-season averages of numbers of forms are plotted against time in Figure 1. The three-season averages of numbers of forms in 1978 were: Zone 0, inner 79.5, outer 79.0; Zone 1, inner 59.7, outer 59.2; and Zone 2, inner 52.7, outer 52.2. Ayers (1978) gives the values for 1971 through 1976 and Ayers and Wiley (1979) give them for 1977.

The annual curves of mean numbers of forms in Figure 1 show substantial degrees of parallelism, indicating that the numbers of forms in inner and outer station groups have in general varied in the same directions from season to season in each year.

It should be noted in Figure 1 that the trends toward increased numbers of forms are steepest in zone 0 and decrease with distance off shore. This is primarily a reflection of the greater frequency in this zone of chance-occurrence forms from other habitats, particularly the benthic assemblage.

In all the zones, the numbers of forms found are influenced by the fact that increasing knowledge provides means of splitting out named taxa from composite groups such as "Flagellates" and "*Stephanodiscus* spp." We consider this to be a factor in the increase of form numbers in the deeper zones, but are also aware that Tarapchak and Stoermer (1976, p. 26) showed increased numbers of species in the offshore water and attributed it to eutrophication of the southern basin of the lake.

TABLE 1. Means, standard errors, and numbers of observations of phytoplankton forms by seasons, depth zones, and inner and outer station groups in Cook Plant seasonal surveys in 1978. Previous years are reported by Ayers, Southwick, and Robinson (1977), Ayers (1978), and Ayers and Wiley (1979). Standard errors are computed only when number of observations is 2 or more.

1978		14 April	12 July	11 October
Zone 0,	Inner			
	Mean	69.00	87.33	82.25
	S. E.	4.61	10.19	6.73
	N	12	12	12
	Outer			
	Mean	71.90	88.70	76.40
	S. E.	3.62	8.53	4.52
	N	10	10	10
Zone 1,	Inner			
	Mean	60.00	59.00	60.00
	S. E.	7.94	6.56	8.39
	N	3	3	3
	Outer			
	Mean	52.25	64.50	60.75
	S. E.	4.66	7.31	11.27
	N	4	4	4
Zone 2,	Inner			
	Mean	52.50	65.50	40.00
	S. E.	3.50	4.50	7.00
	N	2	2	2
	Outer			
	Mean	51.50	60.00	45.00
	S. E.	2.26	6.34	4.21
	N	4	4	4

In view of the facts that for nine years the seasonal surveys have shown substantial parallelism of curves for inner and outer station groups, and that the increases observed are complicated by chance-occurrence collections combined with artifacts of phytoplankton taxonomy, this section will no longer be presented. The basic data will continue to be presented in the phytoplankton station data of the appendices.

There is no evidence from this type of analysis that operation of Cook Plant since 1975 has had any effect on the local phytoplankton community.

New Forms in the Phytoplankton Community Since 1972.

Taxonomy is defined as "the systematic distinguishing, ordering

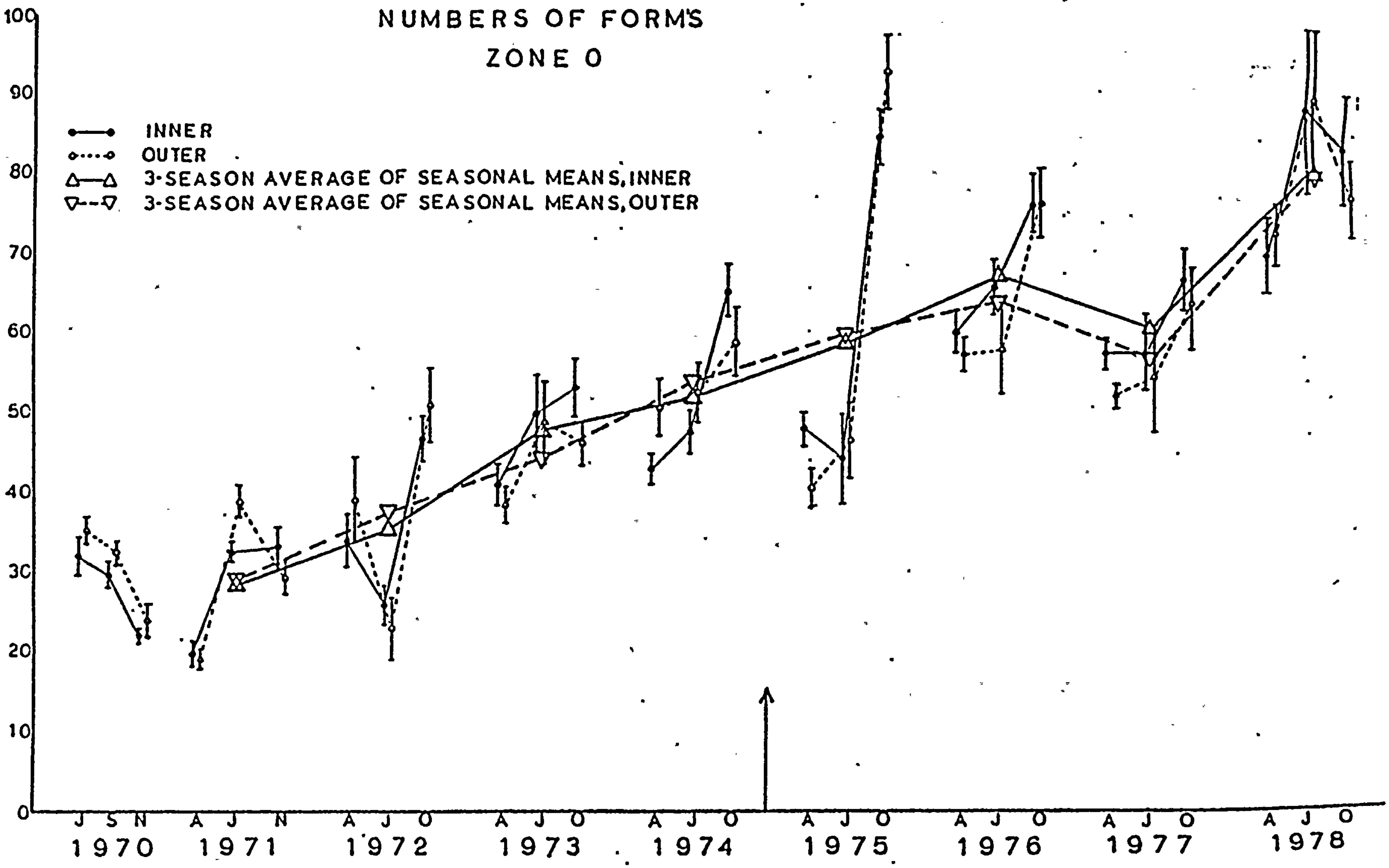


Fig. 1A. Mean numbers of phytoplankton forms in Zone 0 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 1 for numbers of observations.

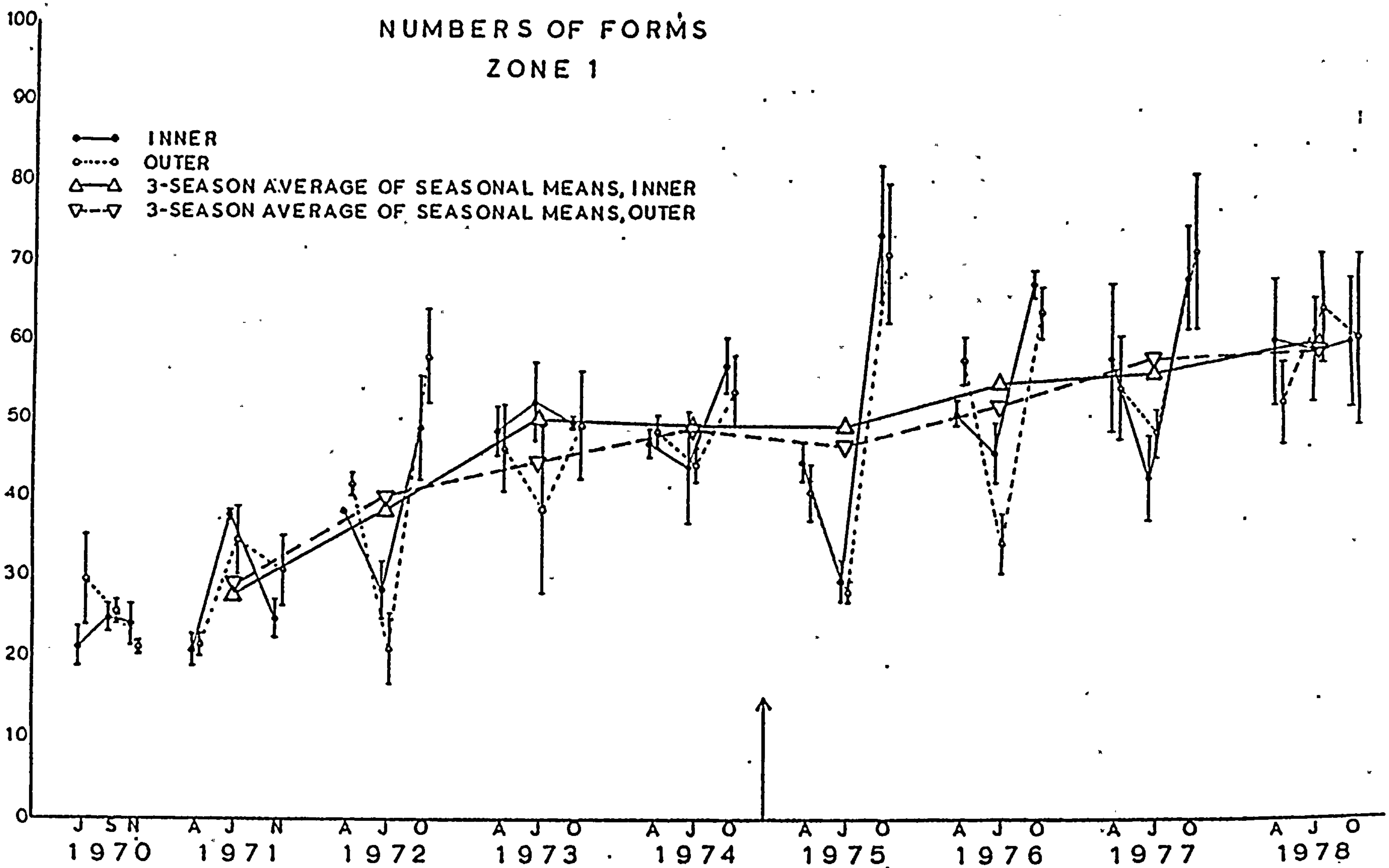


Fig. 1B. Mean numbers of phytoplankton forms in Zone 1 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 1 for numbers of observations.

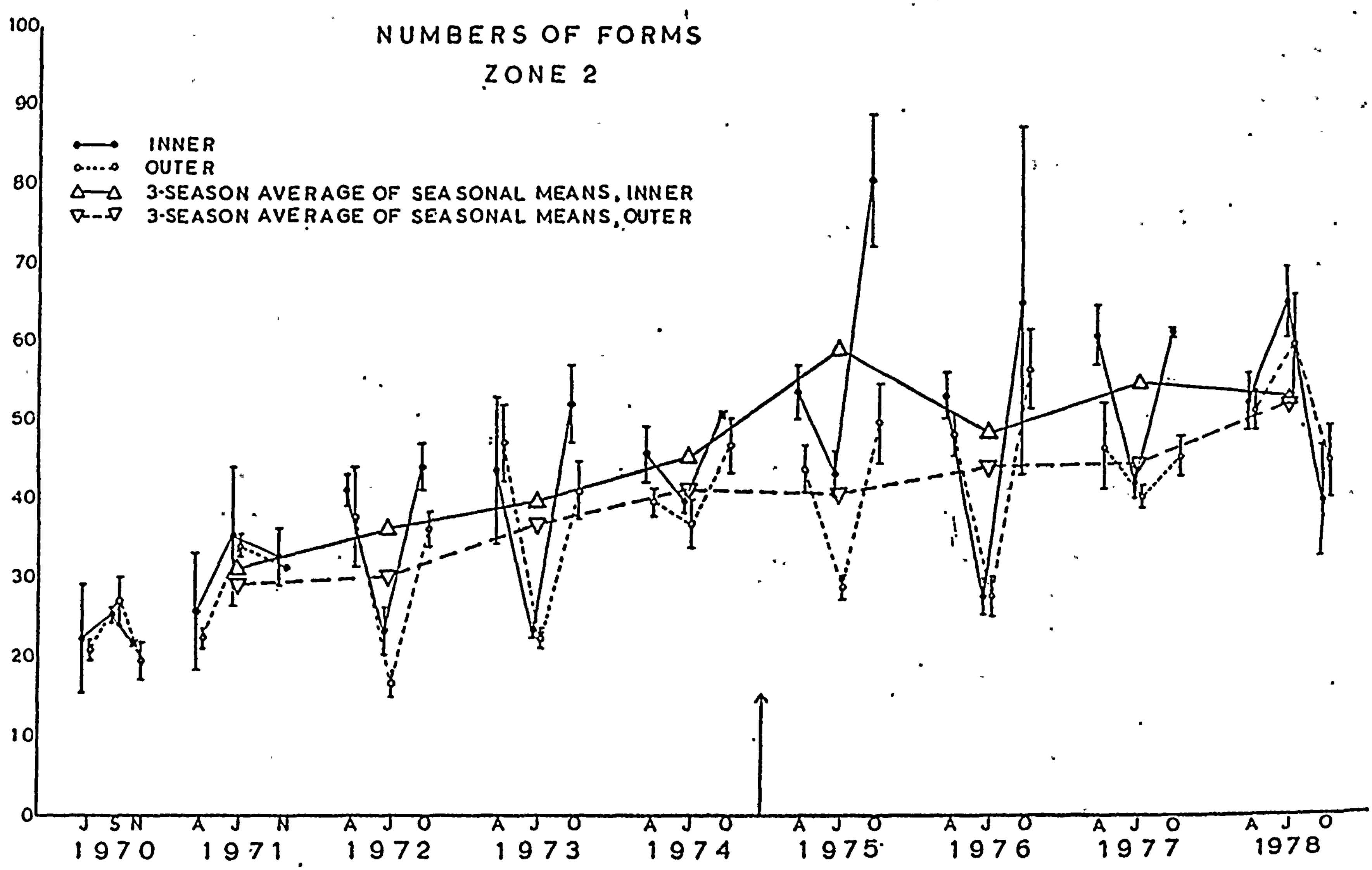


Fig. 1C. Mean numbers of phytoplankton forms in Zone 2 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 1 for numbers of observations.

and naming of type groups within a subject field." Taxonomic studies, continued over time in a given locality, have the potentiality of revealing change in the population being studied by detecting the appearance of new entities and/or the disappearance of entities formerly present. Problems arise in comparing species lists over the years, however, because of revisions and name changes made by taxonomists. Without detailed knowledge of the revisions, false impressions may be gained by comparing these lists (e.g. apparent new forms may just be new names for already occurring forms).

Ayers, Southwick, and Robinson (1977) and Ayers (1978) became unwitting victims of some name changes when they introduced into two Cook Plant reports a section entitled, "New Forms in the Phytoplankton Community since 1972." That section has since been held in abeyance while the changed names were traced.

Other problems have also been reconsidered in detecting and identifying the presence of a new form. The appearance of a form "new" to the Cook sampling area is not necessarily of great significance or importance to this study. Accidental occurrences of benthic or periphytic species do not imply water quality changes, only that these species are available as possible recruits to the plankton community, should conditions become more favorable.

The Cook area has no natural boundaries which separate it from the rest of Lake Michigan. It is an inseparable part of that ecosystem, and as such it does not make sense to call a form new to the Cook area when it has already been reported from nearby regions of Lake Michigan. This is especially true of forms which occur at very low densities, when it is probable that they were present all along and simply were not captured.

The section is now reintroduced and modified with these points in mind. The criteria used to identify new forms shall be:

1.) The form either species or genus, is new to the Cook area since 1972
2.) The form has occurred in bloom proportions, or has become established at densities beyond "rare"
3.) The form has not previously been reported as common in southern Lake Michigan

The forms which meet these criteria are found in the table below.

Form	1973	1974	1975	1976	1977	1978
Chromulina parvula			D	C	C	C
Cyclotella comensis			C	D	D	C
Skeletonema subsalsum		R				R (common in July shoreline samples)

The letters R, C and D are used to convey the following:

R = rare

C = common, but occurred at low densities (i.e. form occurred in at least 50% of the samples of some month, and made up at least 1.0% of the total cell count of that sample)

D = common, and achieved dominant or codominant status in at least some of the samples of some month

Chromulina parvula, a chrysophycean flagellate, is noted here because of its sudden dominance in August 1975. Previous reports of this genus could not be found from Lake Michigan surveys in the literature, and Prescott (1951) did not find any of this genus in his Great Lakes region studies. Its small size (1-3 microns) makes it highly likely that it could have missed capture and identification in other studies, however. Little is known of this species' trophic preferences.

In August 1975 Chromulina parvula displayed a pattern of distribution in which highest densities were found at the stations located furthest from shore. An exception to this was a high abundance found at SDC-.5-1, an inner station and one potentially effected by the plant's thermal plume. Other months showed no such obvious patterns of abundance, however.

The centric diatom Cyclotella comensis continued to be common in the plankton in 1978, though it did not achieve dominant status as in 1976 and 1977. It is considered to be recently introduced to Lake Michigan, and recent reports are just beginning to reveal this diatom's pattern of distribution and physiological requirements. Stoermer and Kreis (in press) reported bloom quantities of this species in Saginaw Bay of Lake Huron in August 1974, with continued abundance through October. They noted that C. comensis tolerated very low levels of silicon. In a survey done in southern Lake Michigan in the summer of 1977, Stoermer and Tuchman (in press) found highest abundances of C. comensis in August and September. Highest densities were found nearshore, and in particular along the Gary and Burns Harbor transects, which the authors postulated as indicating a high tolerance for perturbed habitats. Positive correlations were also found with NO_3, NH_3 and conductivity in the months of August and September.

Our studies revealed similar seasonal trends in C. comensis abundance, with highest densities occurring during August through October 1976, July through September 1977, and in August 1978.

Table 2 gives the means and standard errors of C. comensis densities found at inner and outer stations in the seasonal surveys since its first appearance in October 1975. Except in zone 1 in July and October 1977 the densities of this diatom have been essentially the same in the inner and outer stations of each depth zone; in the two months of 1977 its densities in zone 1 were significantly greater in the outer stations, a condition that has not recurred.

TABLE 2. Means, standard errors, and numbers of observations of Cyclotella comensis densities (cells/ml) by seasons, depth zones, and inner or outer station groups in Cook Plant major surveys since the diatom was first taken in October 1975. Standard errors are computed only when the number of observations is 2 or more.

		1975	1976			1977			1978		
		Oct.	Apr.	July	Oct.	Apr.	July	Oct.	Apr.	July	Oct.
Zone 0,	Inner										
	Mean	16.7	2.2	0.1	152.0	3.9	453.1	58.7	22.4	22.4	10.9
	S. E.	3.4	1.2	0.1	29.2	0.9	98.6	8.5	4.6	6.9	3.2
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	13.0	1.3	0.2	142.1	8.4	429.3	60.9	31.8	21.2	8.9
	S. E.	4.4	1.0	0.2	26.6	3.7	99.0	9.6	4.7	9.2	2.4
	N	10	10	10	10	10	9	10	10	10	10
Zone 1,	Inner										
	Mean	3.8	1.7	1.1	92.8	1.7	275.0	29.8	16.0	7.2	3.3
	S. E.	3.8	1.7	1.1	43.6	1.7	121.0	8.5	10.2	0.6	1.9
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	0.0	1.3	0.4	132.2	7.5	624.5	51.0	13.3	10.0	4.2
	S. E.	0.0	0.8	0.4	21.3	5.5	109.5	5.9	6.6	4.3	2.0
	N	4	4	4	4	4	4	4	4	4	4
Zone 2,	Inner										
	Mean	28.5	1.7	0.0	129.4	8.3	141.0	48.0	10.8	10.8	0.0
	S. E.	19.9	1.7	0.0	6.7	0.0	89.6	21.6	5.8	2.5	0.0
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	7.8	0.8	0.0	304.5	7.0	396.9	36.1	14.9	8.7	5.8
	S. E.	5.4	0.8	0.0	135.0	1.0	180.3	18.3	3.5	3.4	2.5
	N	4	4	4	4	4	4	4	4	4	4

Skeletonema subsalsum, a centric diatom, was traditionally assumed to be a brackish-water diatom (Cleve-Euler 1951) but has now been recorded from the Great Lakes. The earliest report of this species in Lake Michigan was in 1971, by Stoermer and Ladewski (1976). However, Skeletonema has frequently been confused with various other taxa, including Stephanodiscus and Melosira (Hasle and Evensen 1975), so that it cannot be clearly ascertained whether it is a form recently introduced to the Great Lakes area, or simply newly identified. It is included here because it was common in our surf-zone samples in July 1978, and as an entity associated with brackish water its presence may have ecological significance. Stoermer and Ladewski (1976) reported that Stephanodiscus subsalsus (Skeletonema subsalsum) had preferences for both slightly saline conditions and warm water (in excess of 15°C), and noted that most specimens came from nearshore waters. They noted highest population densities near Burns Ditch during their 1971 sampling season which may demonstrate a tolerance for disturbed habitats. The pattern of occurrence of S. subsalsum in our samples did not suggest any effect of the Cook Plant, however. It occurred equally at inner and outer stations.

In conclusion, two of the algal species considered new to the Cook sampling area, Cyclotella comensis and Skeletonema subsalsum, are reported as tolerant of perturbed habitats. As such, their distribution patterns have the potentiality of revealing any effects the thermal discharge may be having on the phytoplankton community. No clear evidence was found of any such effect, however, and it seems that their introduction and establishment in the region of the Cook Plant simply coincides with the documented occurrence of these species in the rest of southern Lake Michigan, probably due to the cultural modification of the nearshore waters.

Inner-Outer Graphical Comparisons: Diversity Indices.

Cook Plant species diversity data for the years 1971 through 1975 have been presented by Ayers, Southwick, and Robinson (1977), Ayers (1978) extended them to include 1970 and 1976, and Ayers and Wiley (1979) added 1977. This section extends the previous summaries, interpretations, and statistical analyses to include the major surveys of 1978.

As was done in the reports cited above, the diversity index data for 1978 have been stratified by three depth zones and by inner (treatment) stations near the plant and by outer (reference or control) stations away from the plant. The Environmental Operating Report for 1977 presents the depth intervals used in each depth zone and the stations which comprise the inner and outer stations groups in each depth zone.

The diversity index used is, as previously, that of Wilhm and Dorris (1968):

$$\overline{d} = -\sum_{i=1}^{S} (n_i/n)\log_2 (n_i/n)$$

where S is the number of species, n is the total number of phytoplankton in cells/ml, n_i is the number of phytoplankton of the i^{th} species.

Mean diversity indices and associated standard errors for each depth-zone-station-group combination in the major surveys of 1978 are given in Table 3. In Figure 2 the surveys of 1978 have been added at the end of the time plots of diversity indices and standard errors which were presented in the Environmental Operating Report for 1977.

TABLE 3. Means, standard errors, and numbers of observations of phytoplankton diversity indices by seasons, depth zones, and inner or outer station groups in Cook Plant major surveys during operational 1978. The diversity index used is that of Wilhm and Dorris (1968) based on log 2. Standard errors are computed only when the number of observations is 2 or more.

1978			14 April	12 July	11 October
Zone 0,	Inner				
		Mean	4.47	4.60	3.77
		S. E.	0.10	0.17	0.17
		N	12	12	12
	Outer				
		Mean	4.61	4.66	4.01
		S. E.	0.11	0.10	0.16
		N	10	10	10
Zone 1,	Inner				
		Mean	4.22	4.14	3.21
		S. E.	0.14	0.13	0.27
		N	3	3	3
	Outer				
		Mean	3.98	4.51	3.29
		S. E.	0.12	0.10	0.27
		N	4	4	4
Zone 2,	Inner				
		Mean	4.02	4.36	3.60
		S. E.	0.15	0.16	0.58
		N	2	2	2
	Outer				
		Mean	4.07	3.95	2.74
		S. E.	0.17	0.51	0.49
		N	4	4	4

In Figure 2 the annual curves of mean diversity generally show substantial degrees of parallelism between inner and outer station groups, though parallelism was poor in all zones in 1971 and 1972, in zone 0 in 1974, in zone 1 in 1970 and 1973, and zone 2 in 1977. Parallelism between the curves for inner and outer station groups indicates that changes in

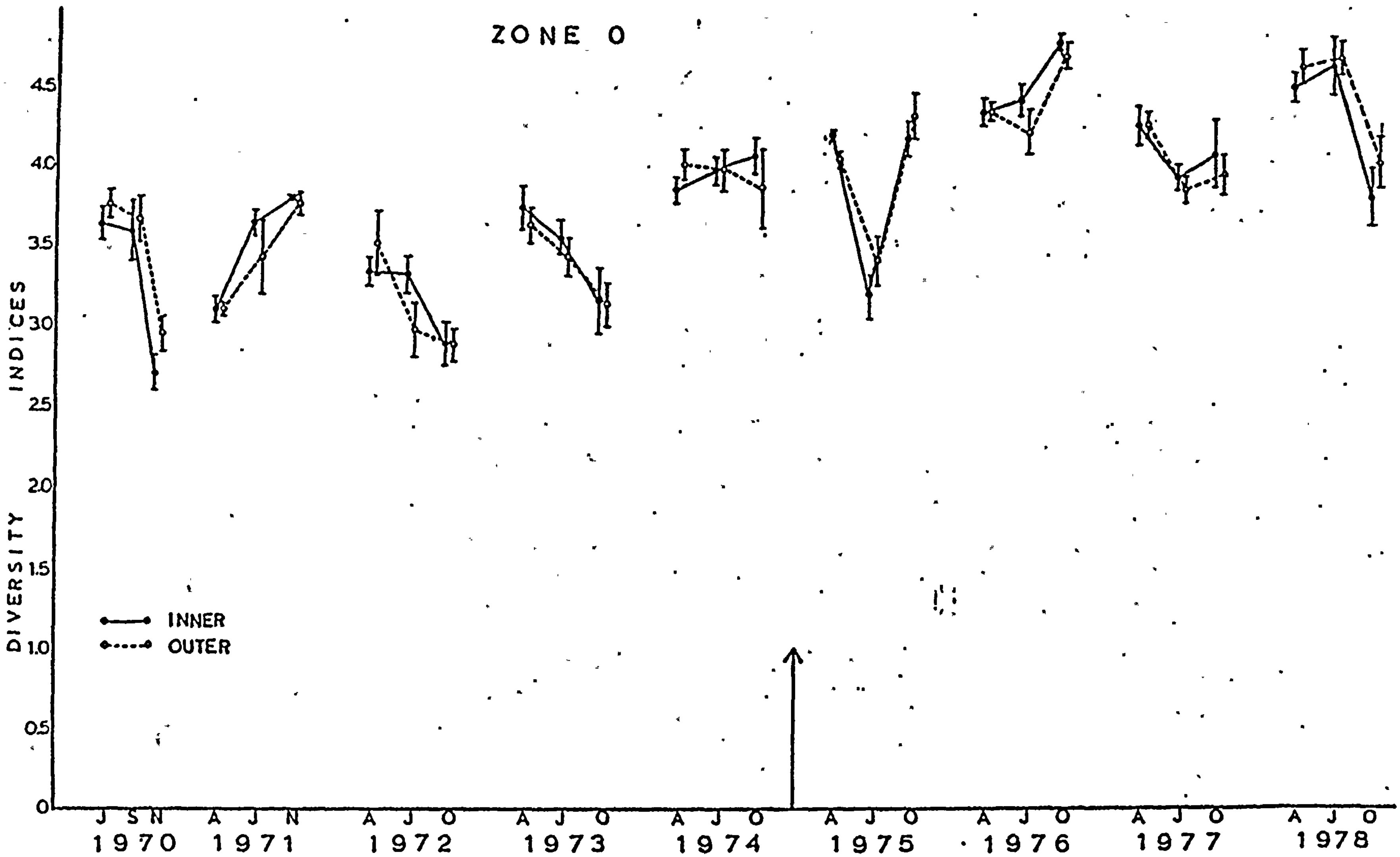


Fig. 2A. Mean diversity indices in Zone 0 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 3 for numbers of observations.

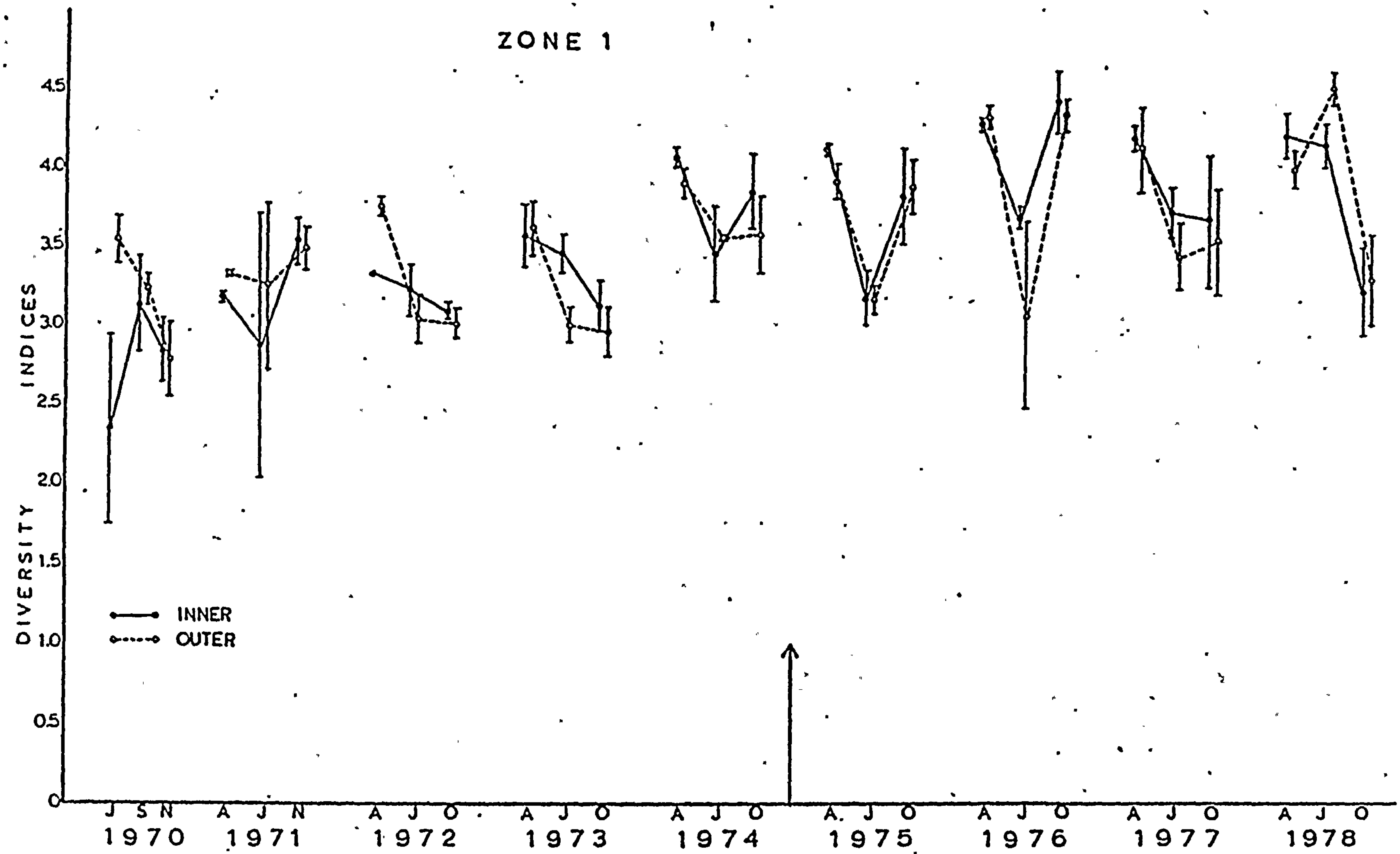


Fig. 2B. Mean diversity indices in Zone 1 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 3 for numbers of observations.

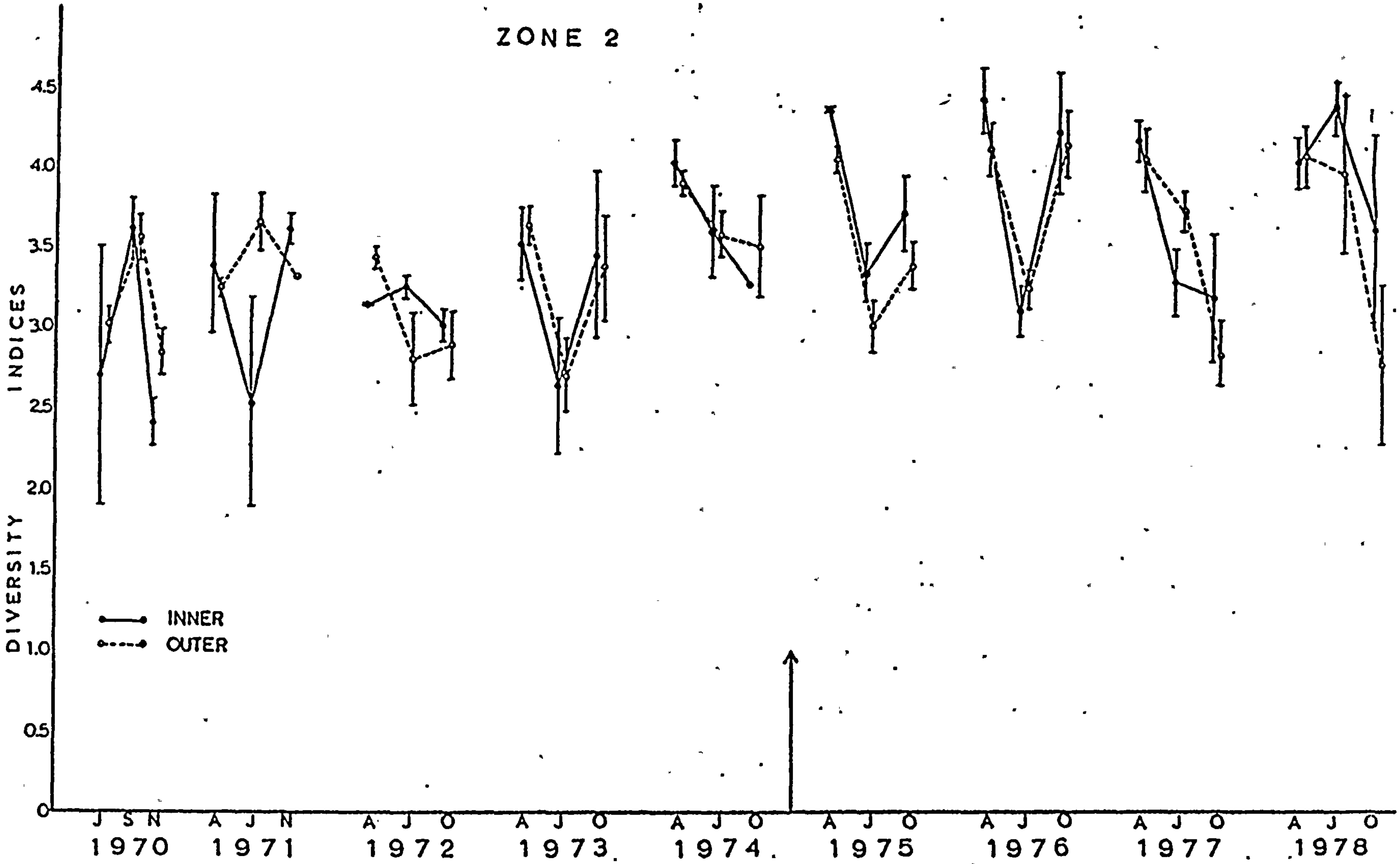


Fig. 2C. Mean diversity indices in Zone 2 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 3 for numbers of observations.

diversity from season to season were the same in both sets of stations. With the exception of July 1977 in depth zone 2, the parallelism between curves for inner and outer stations during the operational years has been as good as or better than in the preoperational years. In 1977 the curves, though not parallel, agree in showing declines at both inner and outer stations. In October 1978 mean diversity indices in both station groups and all depth zones were substantially lower than in April and July.

Temperatures in early July 1978 were lower than usual, and during our sampling were about 10°C lower than 1975-1977, causing a delay in the normal summer increase of blue-green algae. Thus diversity values for this month were higher than usual, as blue-greens were not so predominant as to depress diversity.

With the warming of the epilimnion, blue-greens increased and maintained high levels September through November, and clearly dominated in the more offshore stations. It was the high percentage of blue-greens, particularly Anacystis incerta, which depressed diversity values in October 1978. Normally during fall bloom conditions there is a high percentage of diatoms, along with the typical blue-green population, that raises the diversity index. The normal fall downward mixing of the thermocline and resupply of nutrients to the surface waters had not occurred at our sampling time, however, as evidenced by the drastic decrease in diatoms in the offshore stations as compared to the nearshore stations (where land runoff continually supplies nutrients to the surface waters). This low in diatom abundance caused by late summer and early fall silica depletion is described by Tarapchak and Stoermer (1976).

The placement of the annual curves on the graphs shows, in all depth zones, either a trend for increasing diversity from 1972 through 1976 with no increase from 1976 to 1977 or (alternatively) an increase from 1972 through 1974 with a horizontal trend since then. With the addition of 1978 the first alternative now appears apt to be the correct one.

There is no evidence from our diversity studies thus far that operation of Cook Plant has adversely affected (lowered the diversity of) the local phytoplankton community in the operational years. Instead, the phytoplankton community has in the operational years continued to be more diverse than it was in the preoperational years prior to 1974.

Inner-Outer Graphical Comparisons: Phytoplankton Redundancies.

Redundancy values are derived from the diversity index of Wilhm and Dorris (1968):

$$\bar{d} = - \sum_{i=1}^{S} (n_i/n) \log_2 (n_i/n)$$

where S is the number of species, n is the total number of phytoplankton in cells/ml, n_i is the number of phytoplankton of the i^{th} species. Diversity as presented here is not the true diversity since not all forms encountered can be identified to the species level. Therefore, this diversity must be viewed with caution. However, since these diversities do mean something about community structure they will be used to illustrate changes occurring within the phytoplankton population from year to year and for the derivation of redundancies.

Redundancy is a measure of the dominance of one or a few species within a given population. As presented by Wilhm and Dorris (1968) it is:

$$r = \frac{\bar{d}_{max} - \bar{d}}{\bar{d}_{max} - \bar{d}_{min}}$$

where $\bar{d}$ is the observed diversity as calculated above, $\bar{d}_{max}$ is the maximum diversity for a particular community, and d_{min} is the minimum possible diversity for a particular community, d_{max} is calculated using the following equation:

$$\bar{d}_{max} = (1/n)(\log_2 n! - s \log_2 [n/S]!)$$

and $\bar{d}_{min}$ is calculated using the equation:

$$\bar{d}_{min} = (1/n)(\log_2 n! - s \log_2 [n-(S-1)]!)$$

The values of r range between 0 and 1. An r equal to 0 implies that the species encountered in a community each have the same number of cells. An r equal to 1 implies that one species dominates the community of phytoplankton.

Redundancy values for the phytoplankton collection of the years 1970-1976 have been reported by Ayers (1978); those for 1977 by Ayers and Wiley (1979), and 1978 will be reported by Ayers and Wiley (in preparation).

Table 4 presents the means, standard errors, and numbers of redundancy observations for the phytoplankton collections at inner and outer station groups in three depth zones during the major surveys of 1978. The means and standard errors for the years 1970 through 1978 are plotted on a time axis in Figure 3.

Being derived from the diversity indices, redundancies should also reflect aspects of the structure of the phytoplankton community, and they do.

During 1973-76, when diversities were increasing (more forms and/ or more uniform distribution of abundance among forms comprising the community), the redundancies showed visual evidence of a downward trend (decreasing dominance of the community by any one form). During 1976-1978, when diversities levelled off (numbers and relative abundances of different

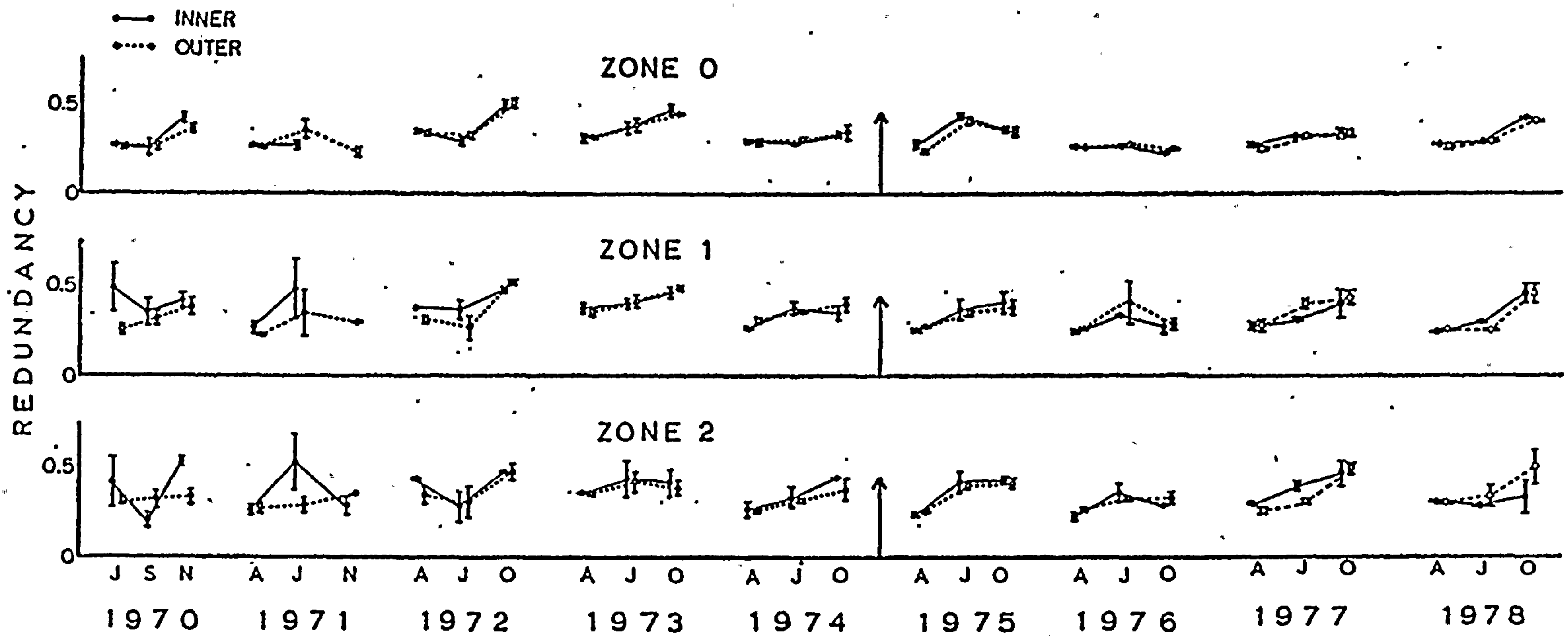


Fig. 3. Mean redundancies of phytoplankton collections from three depth zones in the Cook Plant area, in spring, summer, and fall and inner and outer station groups. The vertical bars show the standard error. See Table 4 for numbers of observations.

TABLE 4. Means, standard errors, and number of observations of phytoplankton redundancies by seasons, depth zones, and inner or outer station groups in Cook Plant major surveys during operational 1978. Standard errors are computed only when the number of observations is 2 or more.

1978		14 April	12 July	11 October
Zone 0,	Inner			
	Mean	0.26	0.28	0.41
	S. E.	0.01	0.01	0.01
	N	12	12	12
	Outer			
	Mean	0.25	0.27	0.36
	S. E.	0.02	0.01	0.03
	N	10	10	10
Zone 1,	Inner			
	Mean	0.28	0.29	0.46
	S. E.	0.03	0.03	0.07
	N	3	3	3
	Outer			
	Mean	0.30	0.24	0.45
	S. E.	0.02	0.01	0.05
	N	4	4	4
Zone 2,	Inner			
	Mean	0.30	0.28	0.33
	S. E.	0.01	0.02	0.08
	N	2	2	2
	Outer			
	Mean	0.28	0.34	0.51
	S. E.	0.03	0.08	0.08
	N	4	4	4

forms were fairly constant), the redundancies also levelled off (degree of dominance in the community stabilized).

The significance of the changes during 1973-78 is not yet clear. The increase in diversity during 1973-1976 may have reflected increases in our ability to taxonomically recognize named forms in the phytoplankton community. They may also be partially attributed to increases in eutrophication due to nutrient additions from river runoff, since increases in nutrient loading of a modestly productive system have a tendency to increase the diversity index (Tarapchak and Stoermer 1976).

Perhaps more important is that after 1972 there has been much better parallelism between the annual curves of redundancies at inner and outer station groups, i.e., changes in mean redundancies of collections from the two station groups have been much more alike than was the case in the earlier preoperational years. Having begun in preoperational years and continued during the operational years, the tendency for improved parallelism is attributed to some cause in the lake itself. There is nothing in this analysis of phytoplankton redundancies to indicate that the operation of Cook Plant has exerted any adverse impact on the local phytoplankton community.

Inner-Outer Graphical Comparisons: Phytoplankton Abundances by Algal Categories.

This section applies the inner-outer graphical analysis method to the abundances (in cells per ml) of ten major categories of phytoplankton and extends previously reported tabulations, figures, and discussions to include the seasonal surveys of 1978. Earlier years have been reported by Ayers, Southwick, and Robinson (1977), Ayers (1978), and Ayers and Wiley (1979).

The phytoplankton categories used are: total algae, coccoid blue-greens, filamentous blue-greens, coccoid greens, filamentous greens, flagellates, centric diatoms, pennate diatoms, desmids, and other algae. The use of major algal groups bypasses difficulties stemming from inability to always identify to species, and is justifiable on the basis that members of each category have more or less similar functions in the ecosystem.

Table 5 presents, for the seasonal surveys of 1978, the means, standard errors, and numbers of observations of abundances of total algae and the nine major groups of planktonic algae in the three depth zones and the inner and outer stations groups. These are graphed with the preceding years in Figure 4.

The phytoplankton collections of July 1978 took place during an upwelling event, and inspection of the temperature records from the plant intake forebay suggests that upwellings also had occurred in the weeks prior to the July survey. Since upwellings bring in water from the hypolimnion that is richer in nutrients, it is probable that the inshore water had been for some days more nutrient-rich than usual for midsummer. Forms capable of responding quickly to increased nutrients might, then, be expected to show greater numbers near shore under this condition; other algae, flagellates, pennate diatoms, and centric diatoms (especially the smaller forms of each) are considered capable of quick response, and their increased abundances near shore in Figure 4 are probably responses to more nutrients there. Numbers of forms and total algae apparently also reflect this, but in ways somewhat blurred by the variations of other taxa.

Desmids (Fig. 4A) have shown almost no variation in abundance over the entire nine years of the study.

Filamentous green algae (Fig. 4B), which in April 1976 had somewhat increased in abundance in both station groups and all three depth zones, returned to preoperational levels in July of that year and have remained there ever since.

Other algae (Fig. 4C) increased in abundance in all depth zones and both station groups in 1976 and 1977, but similar abundances had been

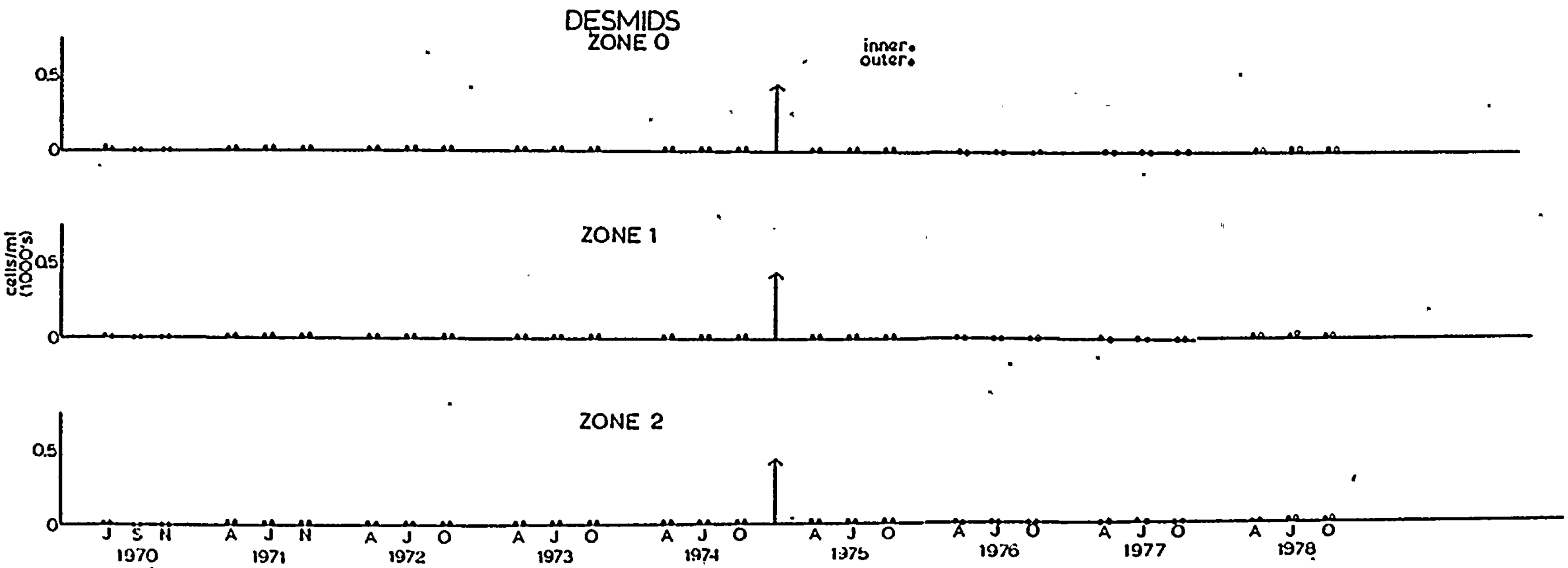


Fig. 4A. Mean abundances of desmids in Zones 0 - 2 in spring, summer, and fall and inner and outer station groups. Space does not permit the drawing of standard error bars. See Table 5 for standard errors and numbers of observations.

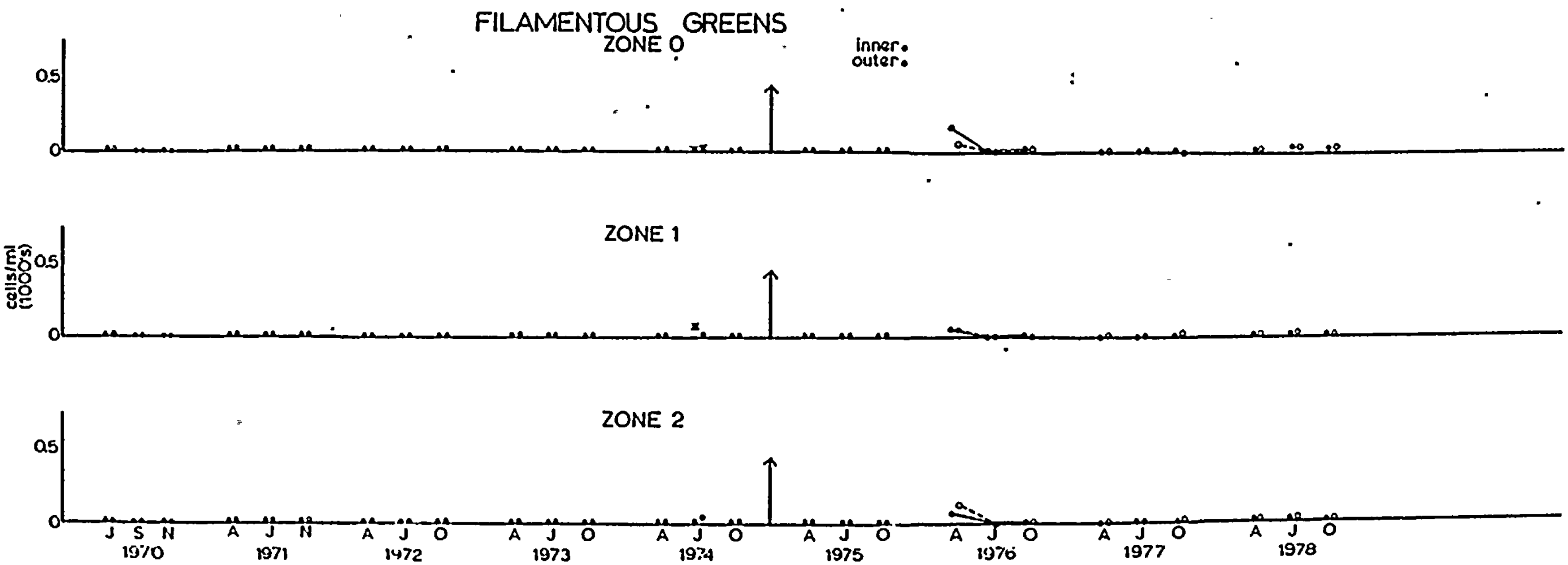


Fig. 4B. Mean abundances of filamentous green algae in Zones 0 - 2 in spring, summer, and fall and inner and outer station groups. Space does not permit the drawing of standard error bars. See Table 5 for standard errors and numbers of observations.

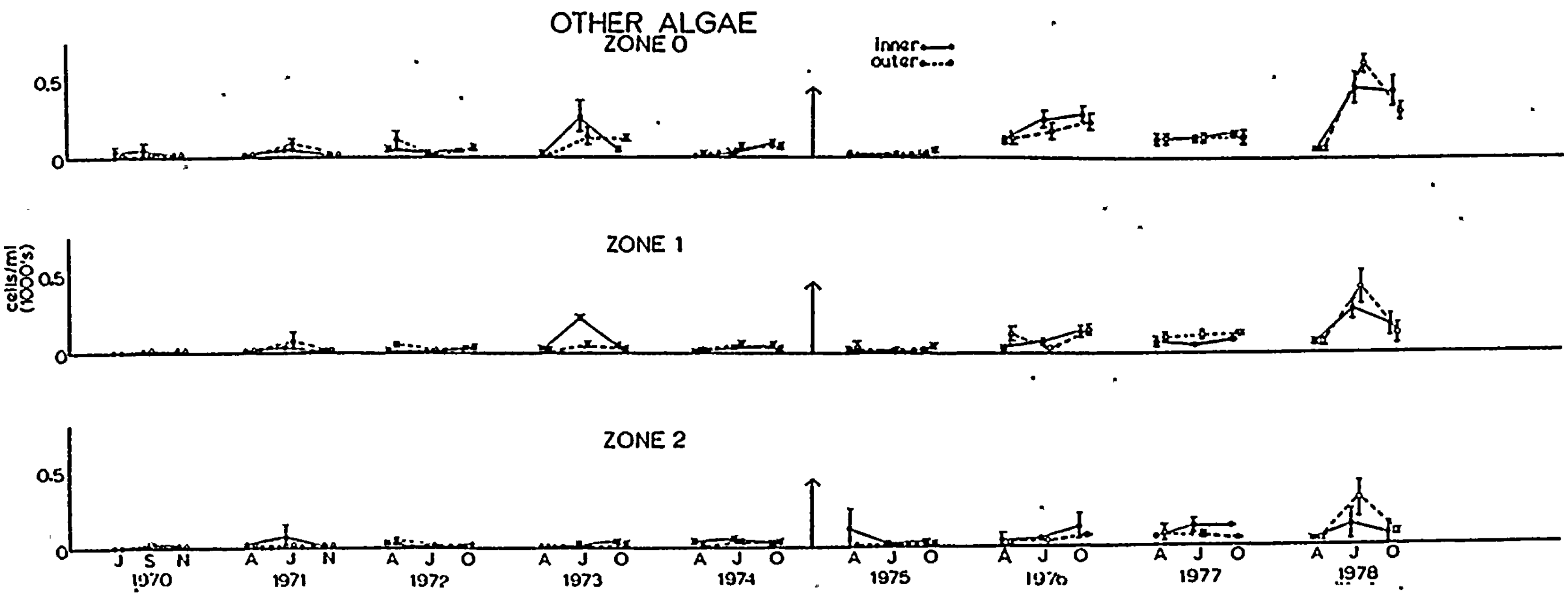


Fig. 4C. Mean abundances of "other algae" in Zones 0 - 2 in spring, summer, and fall and inner and outer station groups. The vertical bars show the standard error. See Table 5 for numbers of observations.

TABLE 5. Means, standard errors, and numbers of observations of phytoplankton abundances by seasons, depth zones, and inner or outer station groups in Cook Plant major surveys during 1978. Previous years have been reported by Ayers, Southwick, and Robinson (1977), Ayers (1978), and Ayers and Wiley (1979). Units are cells per ml. B-G = blue-greens, Filam. = filamentous.

Zone	Inner, Outer	Coccoid B-G	Filam. B-G	Coccoid greens	Filam. greens	Flagel-lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total
14 APRIL 1978											
0	Inner										
	Mean	55.83	3.58	417.28	3.87	1180.27	1273.39	884.31	0.55	50.58	3869.44
	S. E.	30.88	1.89	143.36	3.87	109.99	142.40	96.56	0.37	9.58	356.68
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	138.62	4.96	317.04	1.66	1114.23	1146.39	1035.30	0.33	53.05	3811.54
	S. E.	58.69	1.42	171.93	1.33	130.48	100.05	75.30	0.33	12.52	252.96
	N	10	10	10	10	10	10	10	10	10	10
1	Inner										
	Mean	116.07	5.53	123.80	1.10	1272.83	1250.20	919.70	1.10	58.57	3748.87
	S. E.	116.06	4.00	10.89	1.10	371.99	386.87	196.17	1.10	19.68	1023.72
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	26.53	4.13	114.03	6.65	1592.58	910.25	692.65	0.83	52.65	3400.25
	S. E.	24.38	1.58	8.86	3.84	267.37	150.66	186.16	0.83	17.29	316.88
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	0.00	13.25	73.75	0.00	1243.55	682.30	444.35	0.00	29.00	2486.30
	S. E.	0.00	9.95	38.95	0.00	338.25	299.30	192.35	0.00	0.80	879.60
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	37.30	4.55	41.88	2.48	1154.83	636.68	345.28	0.00	36.88	2259.95
	S. E.	37.30	1.23	12.93	2.48	121.92	50.79	52.25	0.00	3.61	99.73
	N	4	4	4	4	4	4	4	4	4	4

TABLE 5 continued.

Zone	Inner, Outer	Coccoid B-G	Filam. B-G	Coccoid greens	Filam. greens	Flagel- lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total
12 JULY 1978											
0	Inner										
	Mean	803.33	196.62	189.85	23.76	1181.23	3780.93	4693.83	8.43	451.69	11329.69
	S. E.	276.15	92.73	55.33	7.96	162.04	1192.13	1371.07	3.11	98.05	2837.24
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	1082.37	199.61	238.76	31.83	1695.11	3923.30	6461.81	8.28	608.84	14253.04
	S. E.	324.97	60.76	90.99	9.25	295.26	1333.29	2188.01	4.05	56.68	3654.73
	N	10	10	10	10	10	10	10	10	10	10
1	Inner										
	Mean	259.77	170.77	43.63	12.13	869.93	579.80	727.33	0.57	271.37	2935.37
	S. E.	134.14	139.35	29.99	5.85	15.93	71.64	321.09	0.57	50.61	598.50
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	290.58	49.75	173.25	26.53	1309.88	599.38	682.73	4.55	416.18	3552.83
	S. E.	40.37	11.24	69.41	9.30	215.78	134.18	182.43	2.65	98.11	576.86
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	248.70	36.45	58.85	9.10	613.50	450.20	646.65	1.65	127.70	2192.80
	S. E.	99.50	24.85	27.35	9.10	31.50	100.30	159.15	1.65	91.20	77.10
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	21.55	463.00	177.83	19.88	1448.73	491.60	871.73	3.30	291.40	3789.10
	S. E.	21.55	424.60	73.33	5.74	337.49	142.50	118.80	1.35	117.01	164.89
	N	4	4	4	4	4	4	4	4	4	4

TABLE 5 continued.

Zone	Inner, Outer	Coccoid B-G	Filam. B-G	Coccoid greens	Filam. greens	Flagel-lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total
11 OCTOBER 1978											
0	Inner										
	Mean	3966.64	170.09	507.49	3.59	774.04	1471.52	910.13	2.76	419.33	8227.30
	S. E.	542.74	45.46	121.59	1.66	104.79	409.85	214.33	1.34	98.44	1228.32
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	2772.91	106.61	476.53	5.46	786.42	1107.59	659.25	0.99	291.49	6205.45
	S. E.	440.35	22.98	109.46	2.10	83.20	198.53	84.98	0.71	63.44	607.25
	N	10	10	10	10	10	10	10	10	10	10
1	Inner										
	Mean	5002.93	99.47	264.20	4.40	927.43	472.03	497.43	1.10	165.80	7434.73
	S. E.	2630.76	73.87	127.36	2.20	234.32	92.15	145.01	1.10	70.06	3346.95
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	2180.98	72.10	89.95	4.98	611.20	360.23	282.08	0.20	118.78	3720.48
	S. E.	868.02	30.60	33.84	4.98	194.25	211.07	72.10	0.20	66.31	1860.24
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	798.40	74.60	104.50	0.0	473.35	121.00	192.30	0.85	64.65	1829.70
	S. E.	37.30	51.40	11.60	0.0	150.05	91.20	102.80	0.85	64.65	382.20
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	3432.20	177.03	42.25	0.43	786.75	149.23	86.63	0.85	72.55	4747.85
	S. E.	1538.83	82.02	15.75	0.43	54.70	44.89	8.70	0.49	14.26	1581.04
	N	4	4	4	4	4	4	4	4	4	4

observed in preoperational years. In 1978 this category showed, in zone 0, summer and fall increases to numbers higher than previously found; in zone 1 record new highs were attained only in summer; and in zone 2 a new high was reached in the outer station group. In all zones the summer high was greatest in the outer stations. It is noted, however, that the standard errors overlap in all zones and in all seasons, the inference being that probably there was no significant difference between means in the two station groups.

Filamentous blue-green algae (Fig. 4D) have in general been more abundant in the study region since plant startup in 1975 than they were in the preoperational years. In zone 0 during the four years of operation their abundances at inner and outer stations have been parallel and close together. In zone 1 during 1975-1977 summer densities of these algae were greater at the outer stations than at the inner, with probably significant differences in 1975 and 1977; in 1978 mean summer density was higher (but probably not significantly so) at the inner station group. In zone 2, where mean summer densities in 1976 and 1977 were significantly greater at the inner stations than at the outer, the situation reversed in 1978 with significantly higher densities at the outer stations. At present no reasons for the 1977-1978 reversals of summer conditions in zones 1 and 2 can be advanced.

Coccoid blue-greens (Fig. 4E), which had been recorded in small numbers during most of the preoperational surveys, increased notably in October 1974 (due in part to a change in counting method that year) and this pattern has been characteristic in the years since, not so pronounced in 1976 but very pronounced in 1977 and 1978. The increases took place in both the inner and outer stations.

Coccoid green algae (Fig. 4F) have been present in both station groups in variable abundances of a few hundred cells per ml in each survey of the study area. In all but one of the operational surveys the abundances of these algae were at levels which had been observed in the preoperational years; the exception was at the inner station group of zone 2 in July 1977 when abundances were somewhat higher than previously seen. These being offshore stations where the plant plume is not expected, the high of that month is attributed to some lake effect, not plant operation.

Flagellates (Fig. 4G) in both station groups and all three depth zones continued in 1978 the trends of steadily increasing abundances that had been going on since 1971. The trends show no evident relationship to the startup of Cook Plant. We consider them to be effects of eutrophication, and note with interest that Stoermer et al. (1974, p. 366) hypothesize that the great abundance of flagellates in Lake Ontario may be related to elevated organic loadings.

Pennate diatoms (Fig. 4H), like the flagellates, show in all depth zones and in both station groups rising trends in their abundances. Parallelism between the annual curves for inner and outer stations has been generally good, with a typical pattern of high in spring, low in summer, and moderate increase in the fall. The collections of 1978 depart from this pattern by showing the highest mean abundances in July with spring and fall

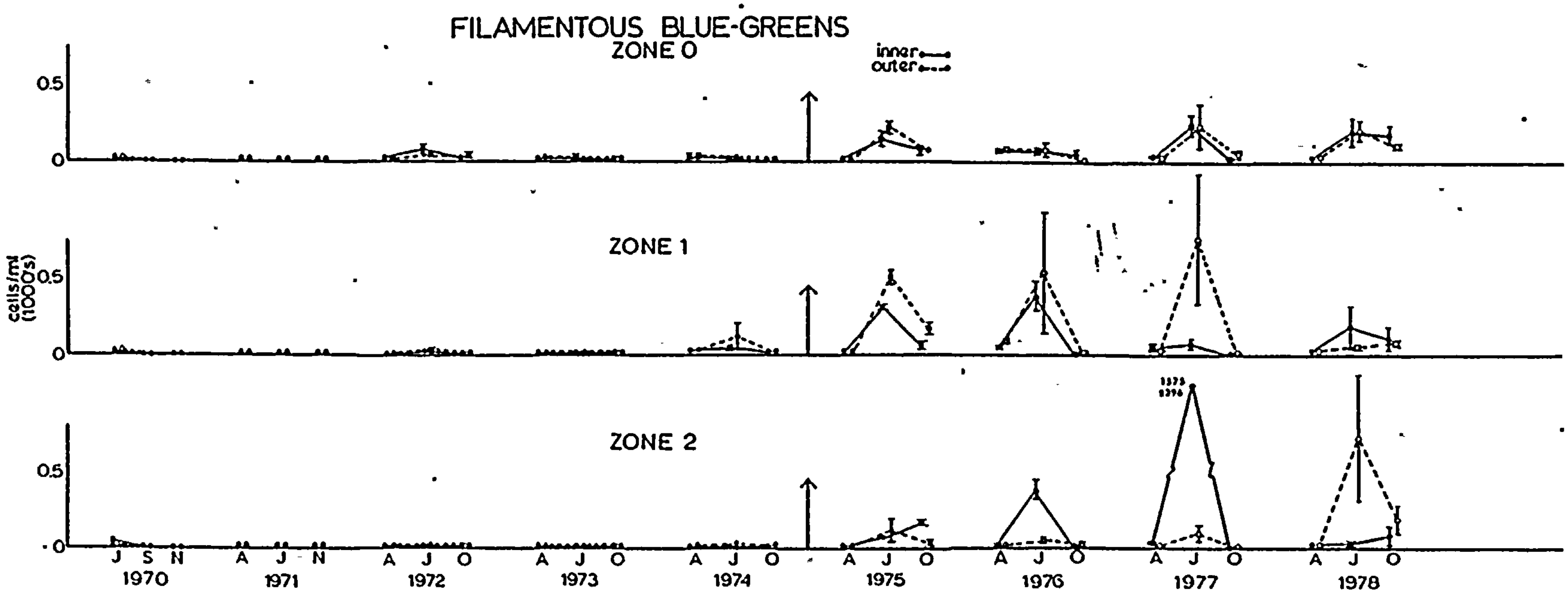


Fig. 4D. Mean abundances of filamentous blue-green algae in Zones 0 - 2 in spring, summer, and fall and inner and outer station groups. Where space permits, vertical bars show the standard error. See Table 5 for numbers of observations and other standard errors.

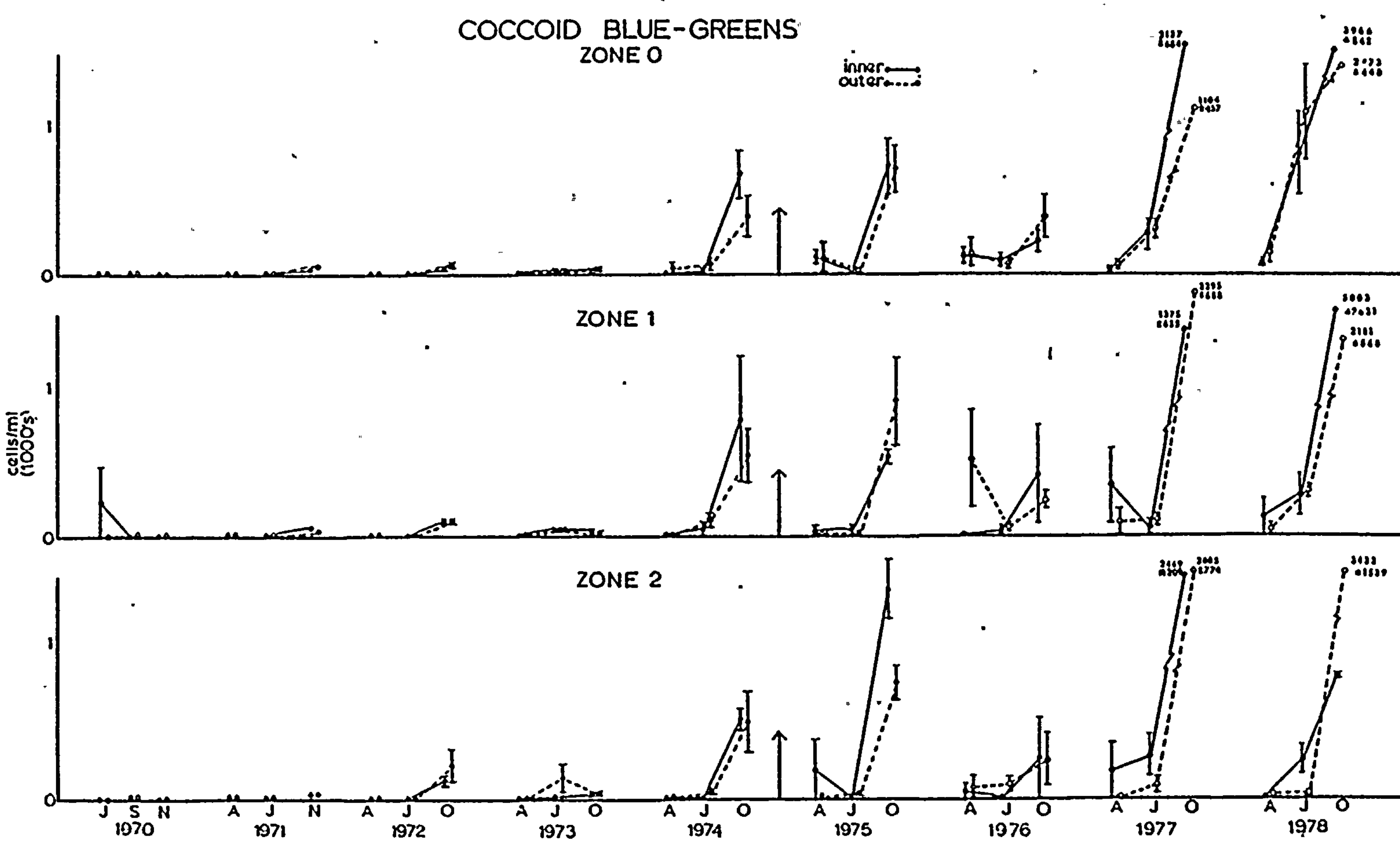


Fig. 4E. Mean abundances of coccoid blue-green algae in Zones 0 - 2 in spring, summer, and fall and inner and outer station groups. Standard error shown by vertical bars or numbers. See Table 5 for numbers of observations.

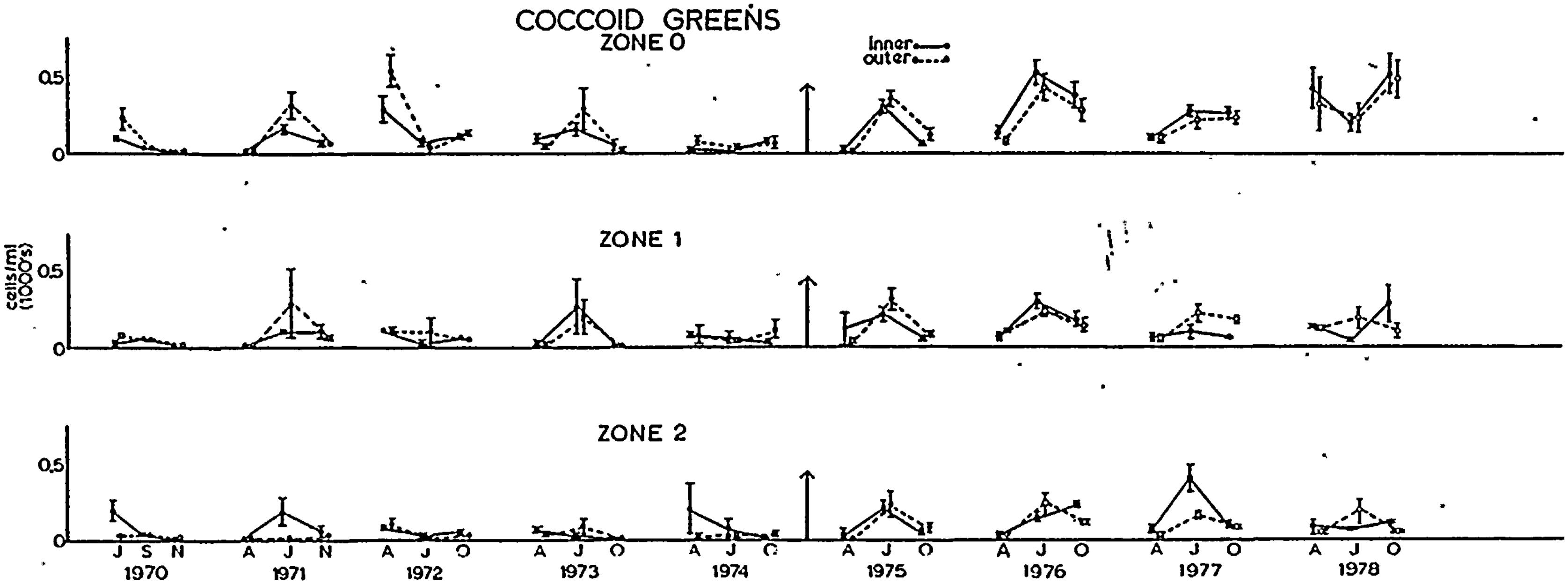


Fig. 4F. Mean abundances of coccoid green algae in Zones 0 - 2 in spring, summer, and fall and inner and outer station groups. Vertical bars show the standard error. See Table 5 for numbers of observations.

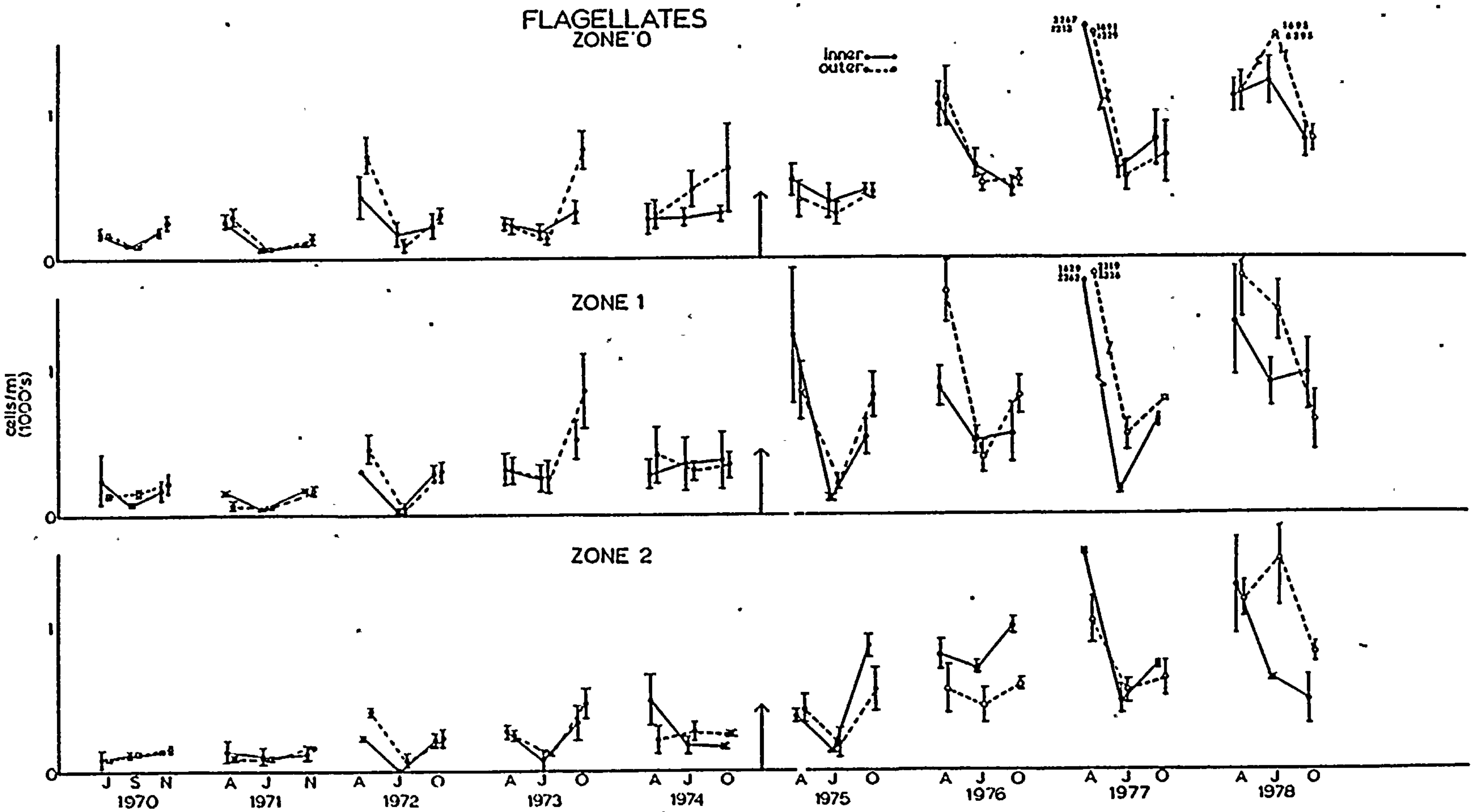


Fig. 4G. Mean abundances of flagellates in Zones 0 - 2 in spring, summer, and fall and inner and outer station groups. Vertical bars show the standard error. See Table 5 for numbers of observations.

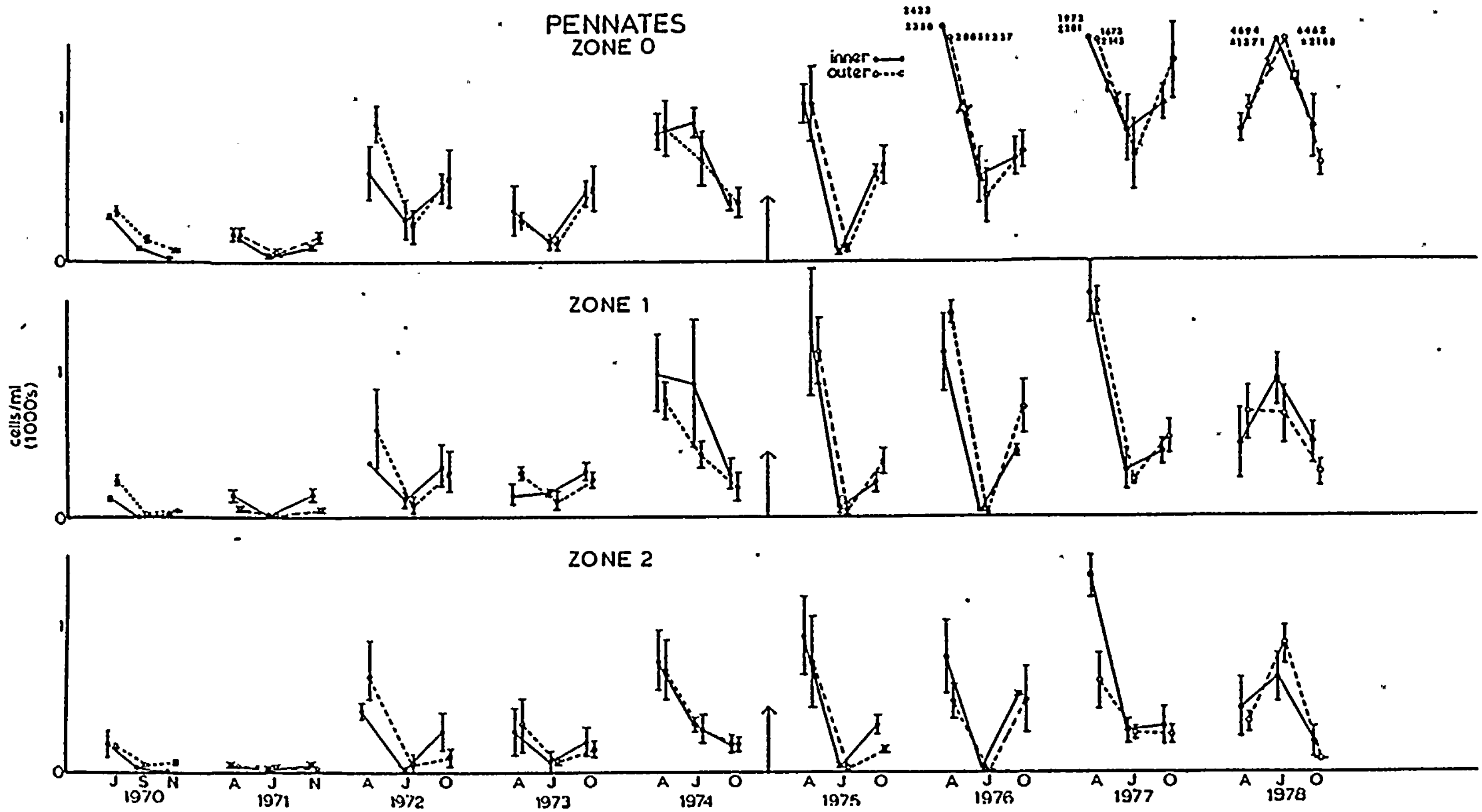


Fig. 4H. Mean abundances of pennate diatoms in Zones 0 - 2 in spring, summer, and fall and inner and outer station groups. Standard error shown by vertical bars or numbers. See Table 5 for numbers of observations.

bundances being lower and only little different from each other. As was true in numbers of forms and the flagellates, the trends toward greater abundances were steepest in shallow zone 0 and progressively less steep in the deeper zones. This we consider to be the combined effects of more nutrients near shore (from the July upwelling) and greater nearshore contributions of entities from the benthic and periphytic communities.

Centric diatoms (Figs. 4I, 4J, 4K) have varied widely during the period of study. Abundance variations at inner and outer stations have been directionally similar within each year. The expected summer minimum did not occur in any zone in 1977 nor in zones 0 or 1 in 1973; Rossmann et al. (1979) report upwellings during most of the field season of 1977 and review of the field logs of July 1973 reveals surface water temperatures typical of the end of an upwelling at that time. No effect of Cook Plant operation has emerged from these data.

Total algae (Figs. 4L, 4M, 4N) have, with the exception of zone 2 inner in 1978, exhibited steadily rising trends in abundance since 1974. The declines in July and October 1978 are at this time attributed to the unusually cold July and delayed fall overturn in that year which have been discussed in the section on diversity indices. Trends of abundance increase in the flagellates, pennate diatoms, and blue-green algae have been commented upon; it appears that these algal categories are probably responsible for increasing trends in the total algae.

Except in zone 2 in 1977 and 1978, parallelism between the annual curves of abundances at inner and outer station groups has been good. There is no evidence from total algae that plant operation has affected the phytoplankton in depth zones 0 or 1; judgement as to plant effects in zone 2 must be reserved, but present evidence suggests that seasonal climatological variations are probably a dominating factor there.

Inner-Outer Statistical Comparisons: Phytoplankton Abundances by Algal Categories.

In the Environmental Operating Report for 1978 we reported statistical tests for significant differences in abundances of ten algal categories at inner versus outer stations in three depth zones and during three seasons of each year from 1971 through 1977; the two available seasons of 1970 were also reported. The test used was the two-sample Students *t* test. This section extends the testing through 1978.

The strategy was that if plant-caused effects on the phytoplankton were present they could be expected to show as consistent significant differences in cell densities between the inner and outer stations. Corollary to this was the possibility that plant operation might differently affect phytoplankters in the three depth zones and show consistent significant differences in the affected zone but not in the others. Another corollary was that plant operation might selectively act upon only one or a few of the ten categories of algae, producing consistent significant differences in densities of the affected categories between inner and outer station groups.

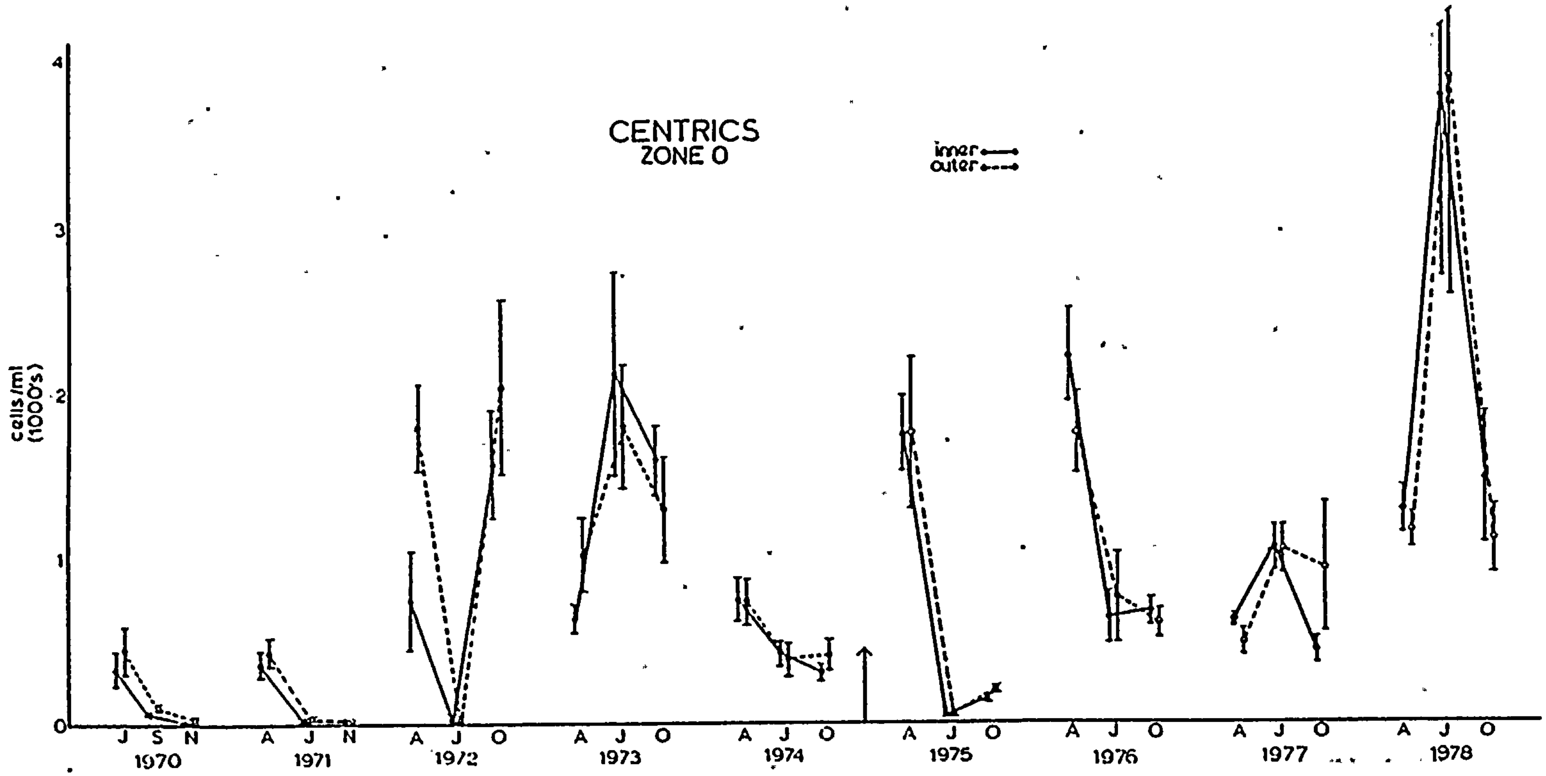


Fig. 41. Mean abundances of centric diatoms in Zone 0 in spring, summer, and fall and inner and outer station groups. Vertical bars show the standard error. See Table 5 for numbers of observations.

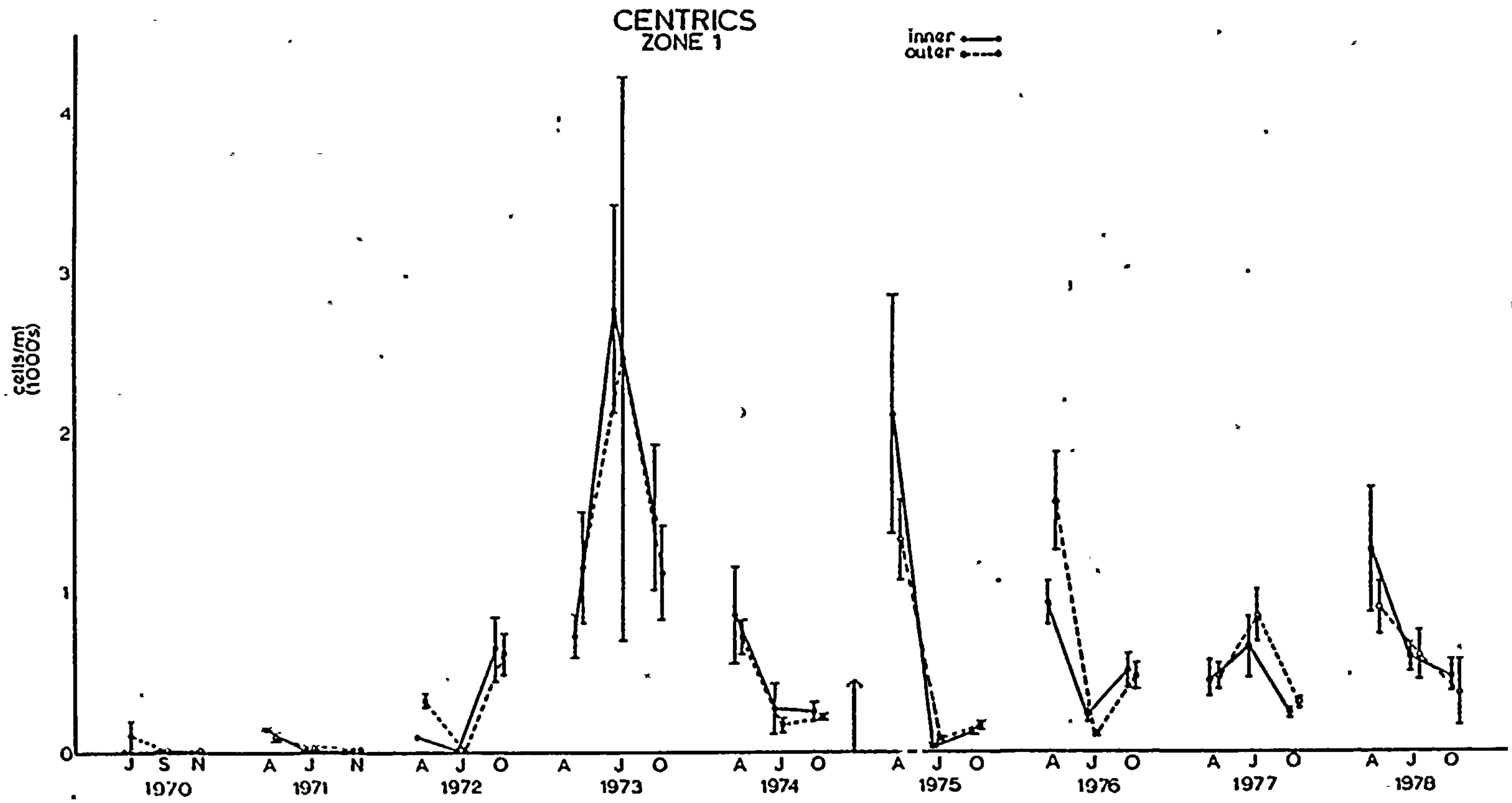


Fig. 4J. Mean abundances of centric diatoms in Zone 1 in spring, summer, and fall and inner and outer station groups. Vertical bars show the standard error. See Table 5 for numbers of observations.

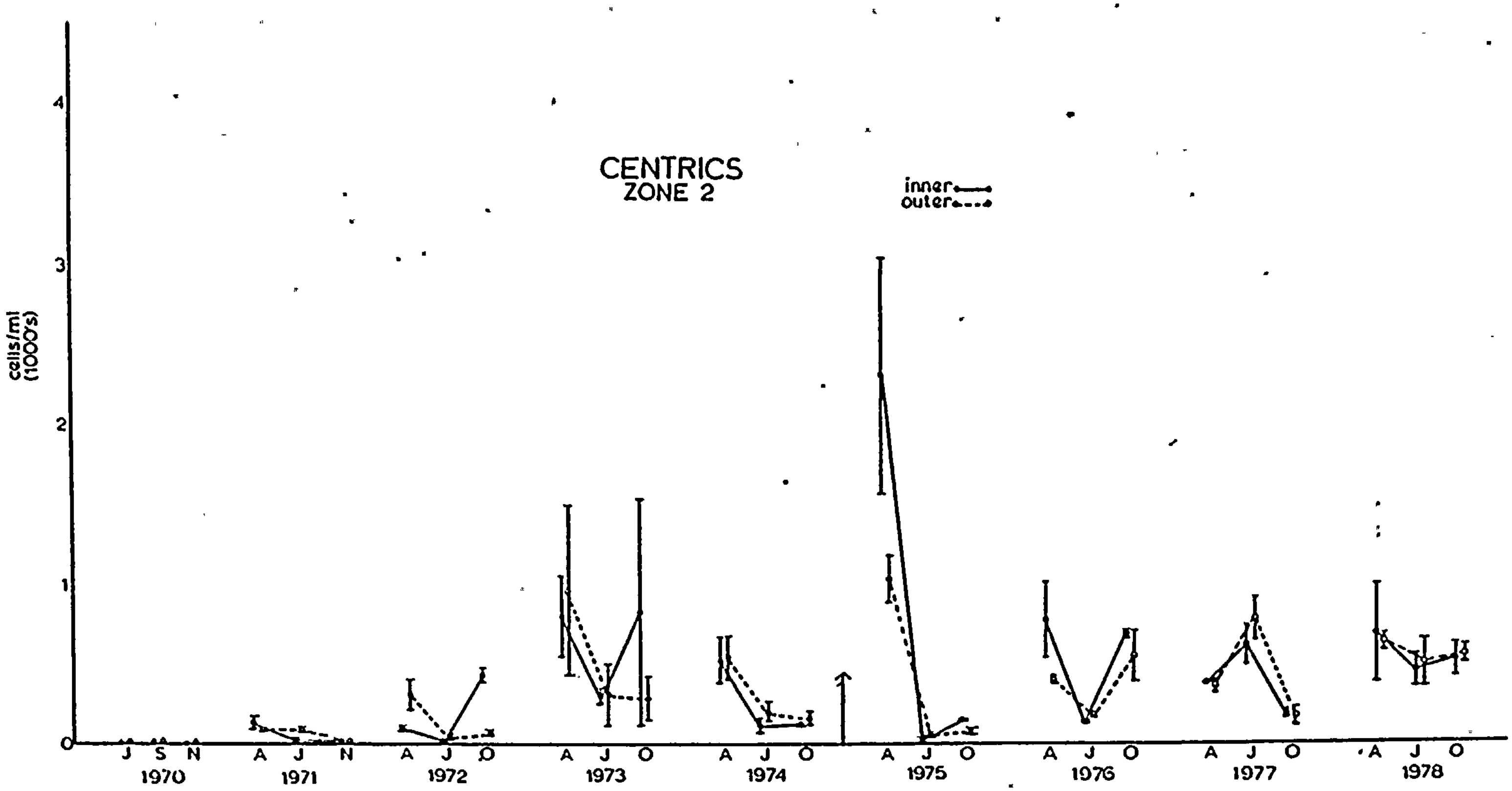


Fig. 4K. Mean abundances of centric diatoms in Zone 2 in spring, summer, and fall and inner and outer station groups. Vertical bars show the standard error. See Table 5 for numbers of observations.

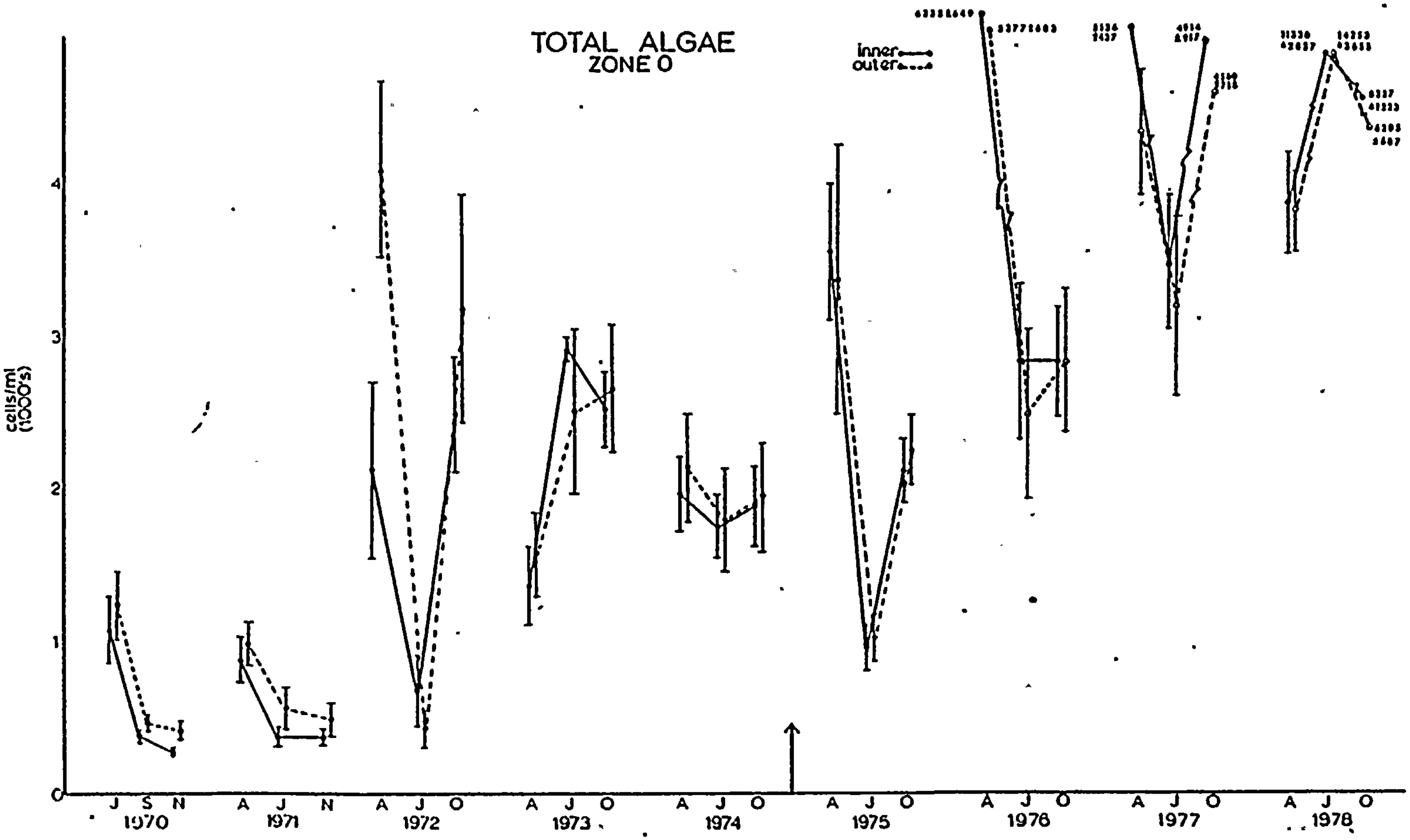


Fig. 4L. Mean abundances of total algae in Zone 0 in spring, summer, and fall and inner and outer station groups. Standard error shown by vertical bars or numbers. See Table 5 for numbers of observations.

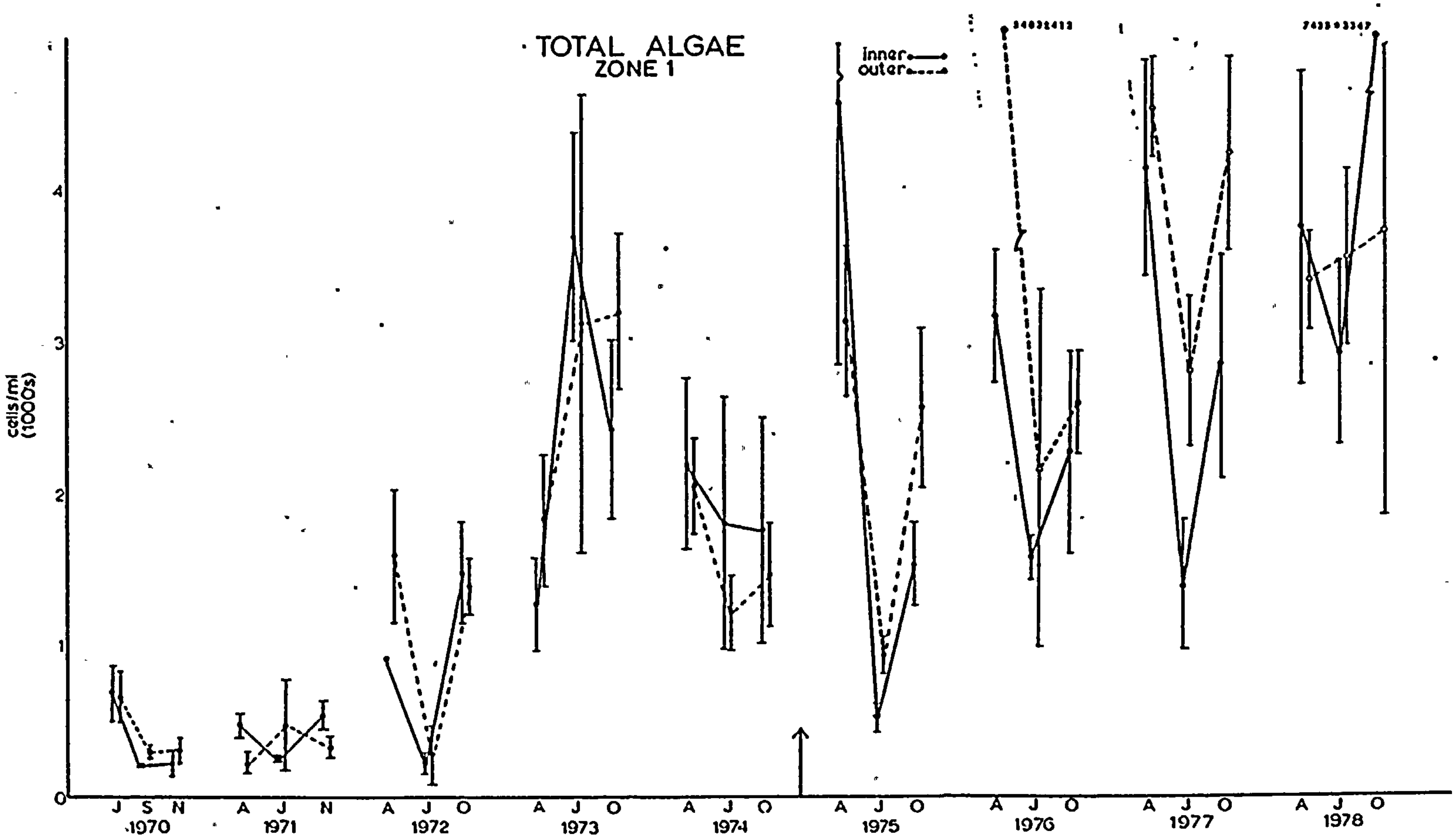


Fig. 4M. Mean abundances of total algae in Zone 1 in spring, summer, and fall and inner and outer station groups. Standard error shown by vertical bars or numbers. See Table 5 for numbers of observations.

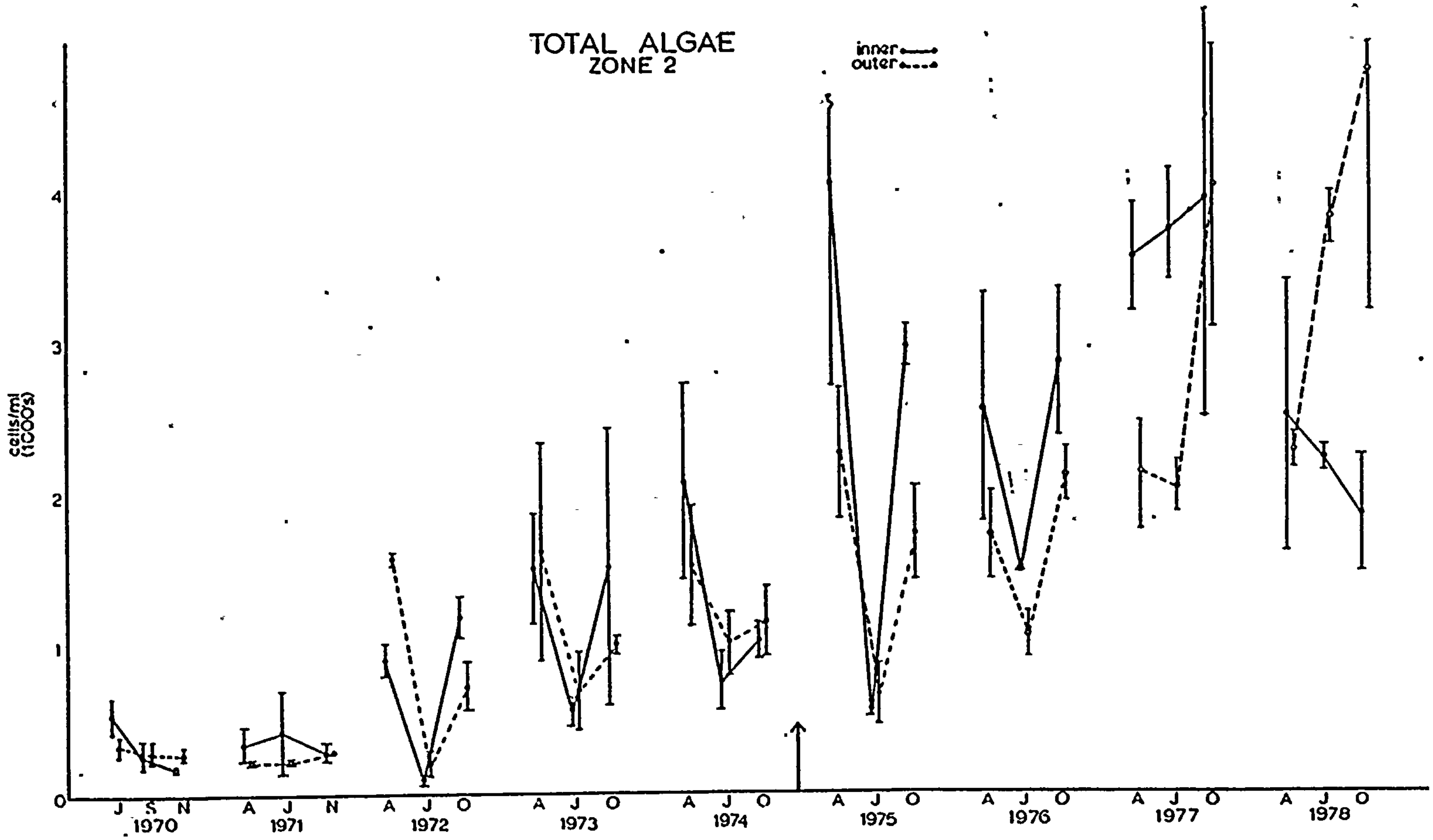


Fig. 4N. Mean abundances of total algae in Zone 2 in spring, summer, and fall and inner and outer station groups. Vertical bars show the standard error. See Table 5 for numbers of observations.

For these tests spring was defined as April; summer as July; and fall as October. For each season in each depth zone all available abundances of each algal category were averaged to give seasonal mean abundances at the inner and outer stations of each depth zone and comparisons were made between inner and outer mean abundances of each category in each depth zone.

Table 6 summarizes the means, variance, numbers of observations, and t-test of significance for each algal category in each season, station group, and depth zone during 1978.

During the period from July 1970 through October 1978, 677 paired comparisons of inner vs. outer station group cell density means have been possible; of these 350 were from preoperational years and 327 were from operational years. During the entire period there have been a total of 38 cases of significant differences of mean densities between inner and outer station groups; these amount to 5.6% of the possible comparisons.

The following tabulation summarizes the distribution of the cases wherein there were significant (at the .05 or .01 levels) differences between mean densities of phytoplankton categories in inner and outer station groups. In each case the order of the abbreviations is: year, depth zone, season (Sp, Su, Fa), and I or O indicating which station group had the greater mean density of cells; cases in operational years are underlined.

Coccoid blue-greens	75,Z2,Fa,I	78,Z2,Su,I		
Filamentous blue-greens	75,Z1,Su,O	75,Z2,FA,I	76,Z2,Su,I	77,Z2,Su,I
Coccoid greens	70,Z2,Su,I	71,Z2,Su,I	76,Z2,Fa,I	77,Z2,Su,I
Filamentous greens		None		
Flagellates	71,Z1,Su,O	72,Z2,Sp,O	73,Z1,Fa,O	74,Z2,Fa,O
	76,Z2,Fa,I	77,Z1,Su,O	77,Z1,Fa,O	
Centric diatoms	72,Z1,Sp,O	72,Z1,Fa,I	75,Z1,Fa,I	75,Z2,Fa,I
Pennate diatoms	70,Z1,Su,O	71,Z2,Su,O	73,Z1,Sp,O	75,Z2,Fa,I
Desmids	71,Z1,Su,O	71,Z2,Su,I		
Other algae	71,Z1,Sp,O	73,Z0,Sp,I	73,Z1,Sp,I	73,Z2,Fa,I
	74,Z2,Sp,I	77,Z2,Fa,I		
Total algae	72,Z0,Sp,O	72,Z2,Sp,O	76,Z1,Sp,O	77,Z2,Su,I
	78,Z2,Su,O			

Summarized by years the cases of significant differences were:

1970 (2 seasons)	2 cases	1975	6 cases
1971	6	1976	4
1972	5	1977	6
1973	5	1978	2
1974	2		

It is noted that the six cases of difference in operational 1975 and 1977 are not greater than the six that occurred in preoperational 1971; it is also noted that the four in operational 1976 are less than the five that occurred in preoperational 1972 and 1973. The numbers of cases by years appear to be within the natural range of variation, and no effect of plant operation is evident.

Table 6. Algal abundances (cells/ml), by algal categories, at inner (treatment) and outer (control) station groups in three depth zones in April, July, and October of 1978. In each season in each depth zone the mean count of cells/ml at inner stations is compared to that at outer stations using a two-sample t-test. Symbols used: n.s. = no significant difference between the two groups; * = significance at the .05 level; ** = significance at the .01 level; N = the number of stations for which data were available. No test was made if one of the groups contained only a single observation, or if one of the group variances was zero.

Survey	Station group	Zone 0 (0-8m)				Zone 1 (8-16m)				Zone 2 (16-24m)			
		Means	Variance	N	t-test	Means	Variance	N	t-test	Means	Variance	N	t-test
COCCOID BLUE-GREEN ALGAE													
Spring	Inner	55.825	11445.0	12	0.2051 n.s.	116.07	40414.0	3	0.4172 n.s.	0	0	2	----
	Outer	138.62	34446.0	10		26.525	2376.50	4		37.300	5565.20	4	
Summer	Inner	803.32	$.91512 \times 10^6$	12	0.5175 n.s.	259.77	53979.0	3	0.8106 n.s.	248.70	19800.0	2	0.0301 *
	Outer	1082.4	$.10561 \times 10^7$	10		290.57	6518.50	4		21.550	1857.60	4	
Fall	Inner	3966.6	$.35348 \times 10^7$	12	0.1123 n.s.	5002.9	$.20763 \times 10^6$	3	0.2978 n.s.	798.40	2782.60	2	0.3175 n.s.
	Outer	2772.9	$.19391 \times 10^7$	10		2181.0	$.30137 \times 10^7$	4		3432.2	$.94720 \times 10^7$	4	
FILAMENTOUS BLUE-GREEN ALGAE													
Spring	Inner	3.5833	42.843	12	0.5798 n.s.	5.5333	47.963	3	0.7283 n.s.	13.250	198.00	2	0.2435 n.s.
	Outer	4.9600	20.149	10		4.1250	9.9825	4		4.5500	6.0300	4	
Summer	Inner	196.62	$.10318 \times 10^6$	12	0.9797 n.s.	170.77	58255.0	3	0.3497 n.s.	36.450	1235.0	2	0.5398 n.s.
	Outer	199.61	36919.0	10		49.750	505.35	4		463.00	$.72112 \times 10^6$	4	
Fall	Inner	170.09	24797.0	12	0.2551 n.s.	99.467	16368.0	3	0.7181 n.s.	74.600	5283.90	2	0.4651 n.s.
	Outer	106.61	5278.9	10		72.100	3743.9	4		177.02	26905.0	4	
COCCOID GREEN ALGAE													
Spring	Inner	417.28	$.24661 \times 10^6$	12	0.6564 n.s.	123.80	355.75	3	0.5130 n.s.	73.750	3034.2	2	0.3583 n.s.
	Outer	317.04	$.29561 \times 10^6$	10		114.02	314.01	4		41.875	668.01	4	
Summer	Inner	139.85	36735.0	12	0.6388 n.s.	43.633	2698.8	3	0.1916 n.s.	58.850	1496.0	2	0.3451 n.s.
	Outer	238.76	82732.0	10		173.25	19268.0	4		177.82	21507.0	4	
Fall	Inner	507.49	$.17742 \times 10^6$	12	0.8545 n.s.	264.20	48665.0	3	0.1864 n.s.	104.50	269.12	2	0.0651 n.s.
	Outer	476.53	$.11982 \times 10^6$	10		89.950	4531.1	4		42.250	992.25	4	
FILAMENTOUS GREEN ALGAE													
Spring	Inner	3.8667	179.41	12	0.6233 n.s.	1.1000	3.6300	3	0.2848 n.s.	0	0	2	----
	Outer	1.6600	17.803	10		6.6500	58.963	4		2.4750	24.502	4	
Summer	Inner	23.758	760.24	12	0.5135 n.s.	12.133	102.74	3	0.2856 n.s.	9.1000	165.62	2	0.3527 n.s.
	Outer	31.830	855.13	10		26.525	345.86	4		19.875	131.78	4	
Fall	Inner	3.5917	32.999	12	0.4869 n.s.	4.4000	14.520	3	0.9293 n.s.	0	0	2	----
	Outer	5.4600	43.978	10		4.9750	99.002	4		0.4250	0.7225	4	
FLAGELLATES													
Spring	Inner	1180.3	$.14518 \times 10^6$	12	0.7007 n.s.	1272.8	$.41512 \times 10^6$	3	0.5035 n.s.	1243.5	$.22883 \times 10^6$	2	0.3211 n.s.
	Outer	1114.2	$.17026 \times 10^6$	10		1592.6	$.28594 \times 10^6$	4		1154.8	59453.0	4	
Summer	Inner	1182.1	$.31511 \times 10^6$	12	0.1262 n.s.	869.93	761.21	3	0.1459 n.s.	613.50	1984.5	2	0.1746 n.s.
	Outer	1695.1	$.87176 \times 10^6$	10		1309.9	$.18623 \times 10^6$	4		1448.7	$.45559 \times 10^6$	4	
Fall	Inner	774.04	$.13177 \times 10^6$	12	0.9293 n.s.	927.43	$.16472 \times 10^6$	3	0.3431 n.s.	473.35	45030.0	2	0.0637 n.s.
	Outer	786.32	69216.0	10		611.15	$.15097 \times 10^6$	4		786.75	11967.0	4	

Table 6 continued.

Survey	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
CENTRIC DIATOMS													
Spring	Inner	1273.4	$.24333\times10^{6}$	12	0.4912 n.s.	1250.2	$.44900\times10^{6}$	3	0.3998 n.s.	682.30	$.17916\times10^{6}$	2	0.8295 n.s.
	Outer	1146.4	$.10010\times10^{6}$	10		910.25	$.90795\times10^{6}$	4		636.67	10316.0	4	
Summer	Inner	3780.9	$.17054\times10^{8}$	12	0.9372 n.s.	579.80	15398.0	3	0.9127 n.s.	450.20	20120.0	2	0.8614 n.s.
	Outer	3923.3	$.17777\times10^{8}$	10		599.37	72017.0	4		491.60	81220.0	4	
Fall	Inner	1471.5	$.20157\times10^{7}$	12	0.4622 n.s.	472.03	25472.0	3	0.6866 n.s.	121.00	16635.0	2	0.7631 n.s.
	Outer	1107.6	$.39296\times10^{6}$	10		360.22	$.17820\times10^{6}$	4		149.22	8060.6	4	
PENNATE DIATOMS													
Spring	Inner	884.31	$.11188\times10^{6}$	12	0.2460 n.s.	919.70	$.11544\times10^{6}$	3	0.4461 n.s.	444.35	73997.0	2	0.5247 n.s.
	Outer	1035.3	56699.0	10		692.65	$.13682\times10^{6}$	4		345.27	11341.0	4	
Summer	Inner	4693.8	$.22558\times10^{8}$	12	0.4867 n.s.	727.33	$.30929\times10^{6}$	3	0.9021 n.s.	646.65	50657.0	2	0.3299 n.s.
	Outer	6461.8	$.47874\times10^{8}$	10		682.72	$.13312\times10^{6}$	4		871.72	56451.0	4	
Fall	Inner	910.13	$.55126\times10^{6}$	12	0.3240 n.s.	497.43	63080.0	3	0.2062 n.s.	192.30	21136.0	2	0.1756 n.s.
	Outer	659.25	72211.0	10		282.07	20790.0	4		86.625	30236.0	4	
DESMIDS													
Spring	Inner	0.5500	1.6500	12	0.6685 n.s.	1.1000	3.6300	3	0.8457 n.s.	0	0	2	——
	Outer	0.3300	1.0890	10		0.8250	2.7225	4		0	0	4	
Summer	Inner	8.4250	115.82	12	0.9773 n.s.	0.5667	0.9633	3	0.2641 n.s.	1.6500	5.4450	2	0.5057 n.s.
	Outer	8.2800	164.40	10		4.5500	28.030	4		3.3000	7.2600	4	
Fall	Inner	2.7583	21.641	12	0.2850 n.s.	1.1000	3.6300	3	0.3871 n.s.	0.8500	1.4450	2	1.0000 n.s.
	Outer	0.9900	4.9610	10		0.2000	0.1600	4		0.8500	0.9633	4	
OTHER ALGAE													
Spring	Inner	50.525	1096.1	12	0.8721 n.s.	58.567	1161.2	3	0.8306 n.s.	29.000	1.2800	2	0.2212 n.s.
	Outer	53.050	1567.4	10		52.650	1195.0	4		36.875	52.149	4	
Summer	Inner	451.69	$.11537\times10^{6}$	12	0.2034 n.s.	271.37	7684.2	3	0.2940 n.s.	127.70	16635.0	2	0.4243 n.s.
	Outer	608.84	32125.0	10		416.17	38498.0	4		291.40	54762.0	4	
Fall	Inner	419.33	$.11628\times10^{6}$	12	0.3097 n.s.	165.80	14727.0	3	0.6514 n.s.	64.650	8359.2	2	0.2879 n.s.
	Outer	291.49	40245.0	10		118.77	17569.0	4		72.550	812.62	4	
TOTAL ALGAE													
Spring	Inner	3869.6	$.15267\times10^{7}$	12	0.8996 n.s.	3748.9	$.31440\times10^{7}$	3	0.7245 n.s.	2486.3	$.15474\times10^{7}$	2	0.7063 n.s.
	Outer	3811.5	$.63990\times10^{6}$	10		3400.2	$.40165\times10^{7}$	4		2259.9	39783.0	4	
Summer	Inner	11330.0	$.96599\times10^{8}$	12	0.5284 n.s.	2935.4	$.10746\times10^{7}$	3	0.4985 n.s.	2192.8	11889.0	2	0.0032 **
	Outer	14253.0	$.13357\times10^{9}$	10		3552.8	$.13311\times10^{7}$	4		3789.1	$.10876\times10^{6}$	4	
Fall	Inner	8227.3	$.18105\times10^{8}$	12	0.1812 n.s.	7434.7	$.33606\times10^{8}$	3	0.3058 n.s.	1829.7	$.29215\times10^{6}$	2	0.2879 n.s.
	Outer	6205.4	$.36876\times10^{7}$	10		3720.5	$.79049\times10^{7}$	4		4747.8	$.99987\times10^{7}$	4	

Summarized by depth zones, with the station group having the greatest density of algae indicated, and with operational year cases underlined, the cases of significant difference were:

Zone 0	Zone 1	Zone 2
Inner greater 1 + <u>0</u>	Inner greater 0 + <u>2</u>	Inner greater 6 + <u>12</u>
Outer greater 1 + <u>0</u>	Outer greater 7 + <u>4</u>	Outer greater 4 + <u>1</u>

In zone 0 the cases of significant difference in abundances at inner and outer stations have been equally divided in preoperational and operational years. No evidence of plant operation effects show in these data.

With the plant's thermal plume in zone 1 most of the time, the significantly greater abundances in this zone have been at the outer stations in 11 of 13 cases. In the preoperational years all seven cases were of greater abundances at the outer stations; greater abundances at the outer stations appear to be a natural feature of this depth zone. In operational years four of six cases were of greater abundances at the outer stations, which does not gainsay greater abundances at these stations as a natural feature of the zone.

In zone 2 during the preoperational years six of ten cases of significant differences involved higher mean cell densities in the inner stations; in operational years 12 of 13 cases have been of higher abundances in the inner stations. With the plant's thermal plume in zone 1 most of the time, and with zone 2 beginning at about two kilometers off shore and continuing farther, it is unlikely that waste heat from the plant has caused the higher densities in the inner stations of this zone.

<u>Major Algal Group Percentages at Plant and Reference Stations, 1970-1978.</u>

Figure 5 is a presentation of the year to year variations in the primary algal components of the phytoplankton of the Cook Plant region. The figure compares mean densities of five major phytoplankton groups at four inshore stations in front of the plant to those at two reference stations located seven miles north and seven miles south of the plant. The strategy being to obtain from the preoperational years an idea of the degree of natural similarity or dissimilarity in population composition existing at stations near the plant and away from it and to look in the operational years for dissimilarities that might be attributable to effects of plant operation.

The plant stations (stations DC-0, DC-1, NDC-.5-1, and SDC-.5-1) were chosen as being shallow water stations close to the plant's cooling water discharge where discharged waste heat could be expected to be present more often than at others. The reference stations, NDC-7-1 and SDC-7-1, are also in shallow water but seven miles from the plant where waste heat should not be expected. The stations used are collected during both major and short surveys.

In the computations for Figure 5, abundances in cells/ml of each

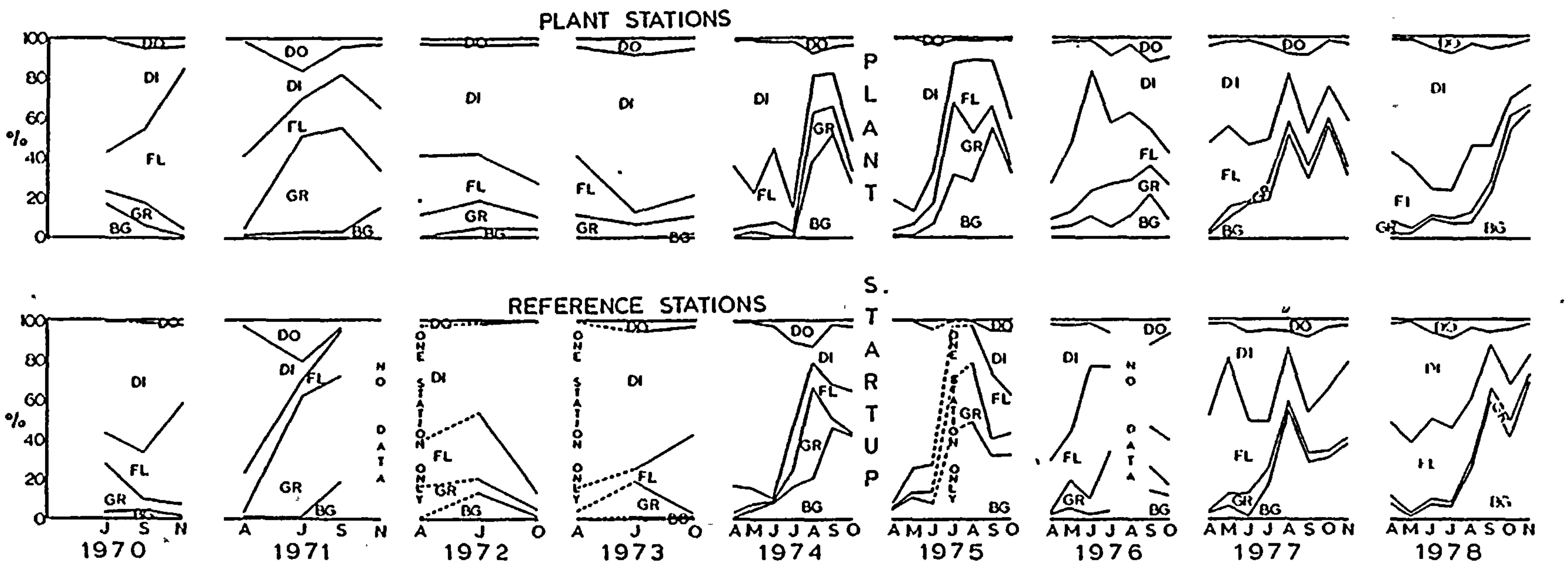


Fig. 5. Major group percentage compositions of the Cook Plant region phytoplankton. The upper diagram is based on mean abundances at four stations near the plant: NDC-.5-1, SDC-.5-1, DC-0, and DC-1. The lower is based on mean abundances at the reference stations NDC-7-1 and SDC-7-1, each seven miles from the plant. Combined blue-greens are abbreviated as BG, combined greens as GR, flagellates as FL, combined diatoms as DI, and combined desmids and other algae as DO.

of ten categories of algae (coccoid blue-greens, filamentous blue-greens, coccoid greens, filamentous greens, flagellates, centric diatoms, pennate diatoms, desmids, other algae, and total algae) in the two station groups have been averaged and the mean abundances expressed as percentages of the mean total algae. Coccoid and filamentous blue-greens are combined, as are coccoid and filamentous greens, centric and pennate diatoms, and desmids and other algae. The percentages are progressively summed in plotting the graphs.

Extremely cold weather in November 1971 caused cancellation of the extreme north and south station lines in which the reference stations were contained. Preservation failure caused a lost sample in April 1972. Broken samples caused missed data in April 1973 and July 1975. Phytoplankton samples at the reference stations were accidently omitted in August 1976.

Although the graphs of population compositions differ substantially from year to year, the graphs for the plant stations and reference stations in any one preoperational year show many similarities in the temporal changes of population components, especially in the cases of the components making up the larger percentages of the population. See, as examples, the decreases in diatoms and increases in flagellates between September and November 1970; the peak abundances of desmids and other algae in July 1971 and the large proportions of green algae in July and September of that year; the absences of summer minima of diatoms in the Julys of 1970, 1972, and 1973; large proportions of flagellates in April and July 1972 which diminished into October of that year; very low proportions of blue-green algae throughout 1973 and decreasing proportions of diatoms from July to October 1973; peak abundances of desmids and other algae and pronounced summer minima of diatoms in August 1974; and peak abundances of blue-greens in September 1974. Greens and blue-greens taken together showed similar variations in the two station groups in 1970 and 1972.

On the whole, temporal changes in the component parts of the phytoplankton at the plant stations and the reference stations in each of the preoperational years were qualitatively similar. Only in the flagellates and green algae in 1973 were the changes directionally different in the two station groups.

In both the plant and the reference stations in 1975 flagellates represented a greater proportion of the population than in 1974, though not so great a one as was observed in September-November 1970 and about the same as in July 1972. As a result of the warmer summer, flagellates in both station groups reached their greater abundances a month earlier than in 1974. Green algae in both plant and reference stations began their greater abundances in July 1975, again an effect of the warmer summer. In neither station group did these algae reach the massive proportions of the populations that were observed in 1971.

In 1976 the partitionings of the five components of the phytoplankton populations were, in both the plant stations and reference stations, different from those observed in previous years. Blue-green and green algae did not exhibit the pronounced maxima or minima of other years. Flagellates in both station groups were generally a higher and more sustained proportion of the

Desmids, filamentous green algae, and coccoid green algae have shown essentially no change during the period of study.

T-tests of significance of difference between seasonal mean densities of nine algal categories and total algae at inner and outer stations in each of the three depth zones during the years 1970 through 1978 have been performed. Of 677 paired comparisons, significant differences between mean densities were found in only 38 cases; these amount to 5.6% of the comparisons.

Summarizing by categories in the preoperational and operational years, with the numbers of significant differences in operational years underlined, gives: filamentous greens 0 + 0; coccoid blue-greens 0 + 2; desmids 2 + 0; filamentous blue-greens 0 + 4; coccoid greens 2 + 2; centric diatoms 2 + 2; pennate diatoms 3 + 1; total algae 2 + 3; other algae 5 + 1; and flagellates 4 + 3. Only in the blue-green algae were all the cases of significant differences in the operational years, but five of the six cases were in offshore zone 2. There is no convincing evidence of Cook Plant operation selectively affecting any of the algal categories.

Summarizing by years, with operational years underlined, the cases of significant differences become: 1970 (2), 1971 (6), 1972 (5), 1973 (5), 1974 (2), 1975 (6), 1976 (4), 1977 (6), and 1978 (2). The number of significant differences in operational years are within the ranges of natural variation established during the preoperational years. There is no evidence that plant operation has produced a greater number of significant differences.

Summarized by depth zones, indicating the station group having the greater mean density of algae and with operational years underlined, the cases of significant differences are:

Zone 0	Zone 1	Zone 2
Inner greater 1 = 0	Inner greater 0 + 2	Inner greater 6 + 12
Outer greater 1 + 0	Outer greater 7 + 4	Outer greater 4 + 1

Cases of significant differences were equally divided in zone 0. In zone 1 where the plant plume is located most of the time 11 of the 13 cases were of greater abundances in the outer stations. In offshore zone 2, 18 of the 23 cases involved higher abundances at the inner stations. In this situation where local currents move parallel to shore, an hypothesis that plant operation inhibits phytoplankton abundances in zone 1 inner while stimulating them in zone 2 inner is not considered tenable.

No convincing evidence that plant operation affects local phytoplankton densities has come to light from these analyses.

population than in other years. Desmids and other algae peaked in September, which had not been seen before. The summer diatom minimum occurred in June in the plant stations and in June and July in the reference stations; in both sets of stations the minima were less severe than in 1974 or 1975. In general it appears that in 1976 flagellates and desmids and other algae increased at the expense of diatoms, greens, and blue-green algae in both the plant and the reference stations.

In 1977 blue-greens returned to the summer peak levels of 1974 and 1975. Green algae, in both sets of stations, were a minor part of the population in each of the surveys. Flagellates were somewhat more abundant in spring 1977 than in the springs of preceding years and had a May peak in abundance at the expense of the diatoms. Diatom summer minima occurred in August in each station set; a second minimum occurred in October at the plant stations and in November in the reference stations. Desmids and other algae peaked in September as they had in 1976. Except that the fall increase in diatoms and decrease in blue-greens had begun in November at the plant stations but not yet at the reference stations, the abundance changes in the two sets of stations were directionally similar in 1977.

In 1978 blue-green algae showed increases from spring to November with an isolated high in the reference stations in September. Were it not for that high, and a resulting diminution in diatoms, the partitionings of population components would have been almost identical in the two station groups during 1978. Green algae were a small part of the population during the year, while flagellates were a substantial part of the population at each set of stations in each survey. The spring-to-fall increase in blue-greens, with corresponding decrease in diatoms, took place in both plant and reference stations and is considered to demonstrate a summer and fall depletion of silica in the epilimnion.

No dissimilarities attributable to plant operation have been revealed by this method of analysis.

CONCLUSIONS

The section on numbers of forms in phytoplankton collections from the Cook Plant region is presented this year for the last time. Over the nine years for which numbers of forms were studied there had occurred taxonomic name changes which led us to suspect the validity of this parameter. When the matter was investigated the continuing increases in numbers of forms could be accounted for by a combination of taxonomic changes plus chance-occurrence captures of very rare forms.

Similarly, a section on new forms found in the phytoplankton since 1972 also was affected by revisions in phytoplankton taxonomy and by chance captures of very rare entities. Elimination of name changes and of low-density very rare forms reduced the new forms list to three which appear to have established (or may be establishing) themselves in the Cook region phytoplankton since 1972. These forms are *Chromulina parvula* and *Cyclotella comensis* which have been common or dominant since 1975, and

Skeletonema subsalsum that became common for the first time in July shoreline samples in 1978.

Wilhm and Dorris diversity indices of Cook Plant phytoplankton collections taken during the seasonal surveys of 1970 through 1978 showed increasing trends, in all three depth zones as well as inner and outer station groups, from 1972 through 1976 with stable levels from 1976 through 1978. There is no evidence from this study that plant operation has adversely affected (lowered the diversity of) the phytoplankton community, instead the community in the operational years has continued to be more diverse than it was in the preoperational years.

Values of phytoplankton redundancy for collections during the seasonal surveys of 1970 through 1978 have been calculated. Plots of mean redundancies against time show visual evidence of a trend, beginning in 1973, for redundancies to become somewhat lower. If real, the trend would indicate a tendency for the species in the community to become more equal in numbers of individuals. Rising redundancies (one or a few species dominating the community) would be an adverse effect. Parallelism between the curves for redundancies at inner and outer station groups has, since 1972, been much better than in 1970 and 1971. This indication that changes in redundancy in the two station groups are now more alike than in the earliest years is taken to mean some change in the lake, not any effect of Cook Plant operation.

Of the ten major algal categories, only filamentous blue-greens have shown increases limited to the operational years. In depth zone 0 (0-8m) the abundances of these algae at inner and outer stations have been parallel and close together during all the years studied. In depth zone 1 (8-16m) summer abundances had been higher in the outer stations in 1975 through 1977; this reversed to higher summer numbers at inner stations in 1978. Depth zone 2 (16-24m) having shown higher summer abundances at inner stations in 1976 and 1977, reversed to greater abundances at outer stations in 1978. The 1978 reversals in the latter two depth zones may be related to the July upwelling of that year, but the causal mechanism is unclear.

Coccoid blue-green algae showed a notable fall increase in pre-operational 1974 (due in part to a change in counting method then) and this pattern has continued since in both station groups. There is no clear evidence of any plant operation effect; the increases appear to be consistent with a depletion of silica in the epilimnion in fall.

The changes in mean abundances of the other categories have been:

Flagellates	Increasing trend since 1970
Pennate diatoms	" " " "
Centric diatoms	" " " "
Other algae	" " " "
Total algae	" " " "

The trends toward increasing abundances show in both station sets and in all three depth zones. They are attributable to changing conditions in the lake, rather than to effects of Cook Plant operation.

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*BHPPLS = Benton Harbor Power Plant Limnological Studies

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APPENDIX B2

PART II

PHYTOPLANKTON ENTRAINED AT THE DONALD C. COOK NUCLEAR PLANT

During the period of November 1978 through October 1979, most samples for both enumeration and viability studies were collected. On September 10, 1979, a broken pump prevented collection of samples from the discharge of unit #1. However, samples from the intake and the discharge of unit #2 were collected. One January 1978 noon enumeration sample was lost during slide preparation. During viability analysis, one January 1979 incubated evening replicate from the unit #1 discharge, one January 1979 noon replicate from the intake and one from unit #2 discharge, one February 1979 evening twilight replicate from each of the discharges, two February 1979 morning twilight replicates from the intake and one from unit #2 discharge, one March 1979 morning twilight replicate from the intake, one March 1979 noon replicate from each discharge, one April 1979 evening replicate from the intake, one May 1979 evening replicate from the intake, one May 1979 noon replicate from both the intake and unit #2 discharge, one July 1979 evening replicate from unit #2 discharge, one July 1979 incubated evening replicate from the intake, one July 1979 morning replicate from the intake, two July 1979 morning replicates from the unit #2 discharge, one August 1979 evening twilight replicate from the unit #2 discharge, two August 1979 morning replicates from the intake, one August 1979 morning replicate from the unit #1 discharge, one August 1979 noon replicate from the unit #2 discharge, and one September 1979 incubated evening replicate from both the unit #1 and unit #2 discharges were lost. At no time did the number of replicates number less than the three required.

Comparison of phytoplankton major group mean concentrations for 1975 through August 1978 gave the following general observations: 1) coccoid blue-green algae and desmids were least abundant during 1976; 2) flagellates were most abundant during 1978; 3) filamentous blue-green algae, coccoid green algae, centric diatoms, pennate diatoms, and total algae were least abundant in 1977, other algae showed an increase in 1978, and filamentous green algae were most abundant in 1976.

The number of forms of phytoplankton was highest in 1976 and 1978, redundancy was highest in 1977, and diversity was highest in 1976 and 1978 and lowest in 1977. These changes in community structure statistics mimic changes noted in the major groups, especially for 1977. Decreases in filamentous blue-green algae, coccoid green algae, centric diatoms, pennate diatoms, and total algae in 1977, the increased redundancy in 1977, and the decreased diversity in 1977 describe a phytoplankton community considerably different from those of 1975, 1976, and 1978.

With the exception of 1977 when the character of the entrained phytoplankton community was such that a negative impact on viability was noted, no consistent viability increase or decrease has been observed that can be attributed to the plant.

However, samples from the intake and the discharge of unit #2 were collected. One January 1978 noon enumeration sample was lost during slide preparation. During viability analysis, one January 1979 incubated evening replicate from the unit #1 discharge, one January 1979 noon replicate from the intake and one from unit #2 discharge, one February 1979 evening twilight replicate from each of the discharges, two February 1979 morning twilight replicates from the intake and one from unit #2 discharge, one March 1979 morning twilight replicate from the intake, one March 1979 noon replicate from each discharge, one April 1979 evening replicate from the intake, one May 1979 evening replicate from the intake, one May 1979 noon replicate from both the intake and unit #2 discharge, one July 1979 evening replicate from unit #2 discharge, one July 1979 incubated evening replicate from the intake, one July 1979 morning replicate from the intake, two July 1979 morning replicates from the unit #2 discharge, one August 1979 evening twilight replicate from the unit #2 discharge, two August 1979 morning replicates from the intake, one August 1979 morning replicate from the unit #1 discharge, one August 1979 noon replicate from the unit #2 discharge, and one September 1979 incubated evening replicate from both the unit #1 and unit #2 discharges were lost. At no time did the number of replicates number less than the three required.

Temperature at Time of Collection

Table 2 contains a summary of intake and discharge temperatures during those periods of time when phytoplankton entrainment samples were collected. During June 1978 and July 1978, phytoplankton collection coincided with large rapid temperature changes due to upwelling of colder bottom water along the eastern shore of Lake Michigan in the vicinity of the D. C. Cook Nuclear Plant. Similar events took place the weeks preceeding the June 1978, August 1978, and September 1979 entrainment collections. Upwelling transports colder bottom water rich in nutrients and containing its own phytoplankton assemblage to nearshore regions of the lake. Any mixing of these hypolimnentic and epilimnetic waters yields a water mass having characteristics of each and results in increased sampling error. The increased heterogeneity is particularly important if upwelling occurs during sampling periods.

RESULTS AND DISCUSSION

Variation of Major Phytoplankton Groups

For the purpose of contrasting changes in abundance and in species diversity, comparisons between phytoplankton assemblages from 1975 through August 1978 were made. The phytoplankton assemblages are divided into nine major groups. These groups are filamentous blue-green, coccoid blue-green, filamentous green, coccoid green, flagellates, centric diatoms, pennate diatoms, desmids, and other algae. Other algae are those not belonging to the other major groups. Major group abundances (cells/ml) are tabulated monthly for each year. The annual means, for those years for which the counts are complete, are included in this tabulation.

Coccoid blue-green algae were less abundant in 1976 than in 1975 and 1977 (Table 3). This is similar to what Ayers and Wiley (1979) found in lake survey phytoplankton and is thought to be a lake-wide phenomenon. The highest coccoid blue-green abundances in entrained samples occurred during summer (June-August) and fall (September-November).

Filamentous blue-green algae were less abundant in 1977 than in either 1975 or 1976 (Table 4). The cause of this decrease is unknown at this time. Peak abundances were reached in spring (March-May) and summer.

Coccoid green algae were less abundant in 1977 than in the preceeding two years (Table 5). This was similar to what Ayers and Wiley (1979) reported for the lake survey phytoplankton. They concluded that it was associated with the continuing eutrophication of Lake Michigan. Peak concentrations occurred during the summer and fall.

Filamentous green algae were more abundant during 1976 than either 1975 or 1977 (Table 6). Ayers and Wiley (1979) found similar differences in the lake survey phytoplankton and attributed this change to the natural long-term variability of Lake Michigan. Peak abundances were reached during late spring or summer.

Flagellates showed no significant variation in abundance from 1975 to 1977 (Table 7), but when data available in 1978 were considered the average yearly abundance for that year showed an increase compared to those of previous years. The monthly increase between 1978 and the preceeding years was most marked in June when at least a four fold increase in population density was observed compared to the previous years. Peak abundances generally occurred during late spring or summer.

Centric diatoms showed a marked reduction in population density during 1977 compared to the previous years (Table 8) but increased during 1978 (January to August) compared to 1977. The 1978 monthly increase was largest in May and June, 1978 as compared to those months in the preceeding years. The population density reduction in 1977 can be attributed to natural long-term variation of the phytoplankton community. Population density peaks were usually reached in the spring.

Pennate diatoms occurred in reduced numbers in 1977 compared to 1975, 1976, and 1978 (January to August). The reason for the decline in 1977 is unknown at this time. Peak abundances were reached in spring and winter (December-February).

Desmid numbers were somewhat lower in 1976 relative to 1975 and 1977 (Table 10). Peak abundances generally occurred in the late spring or summer.

The group of other algae was similar in abundance for 1975, 1976, and 1977 (Table 11), but when the data available in 1978 were considered, the average yearly abundance showed an increase for 1978 compared to those of previous years. The monthly increase was noted most significantly in June. Peak abundances occurred in the summer or early fall.

Total algae were significantly lower in 1977 relative to 1975 and 1976 (Table 12). This trend appeared to be continuing in the early part of spring, 1978, but it seemed to reverse starting in May, 1978. The data available in 1978 showed an increase in average yearly population density when compared to the data for 1977. The exact reason for these changes is unknown. Peak abundances generally occurred in the spring. However, peak abundances of total algae and any of the major groups (especially diatoms) may occur during any of the months of thermal stratification. Increased numbers during these months were generally related to upwelling along the eastern shore of Lake Michigan in the vicinity of the Donald C. Cook Nuclear Plant.

Changes noted for each major group are either unexplained at this time or are attributable to long-term changes in the phytoplankton community reflecting the continuing eutrophication of Lake Michigan.

Numbers of Forms, Diversity, and Redundancy

When working with complex and variable assemblages of phytoplankton such as those appearing in entrainment samples from the nearshore of Lake Michigan, it is advantageous to seek some quantitative measure of the distribution of populations within the various assemblages; such measures can furnish information for assessing changes in planktonic community structure. The quantitative measures employed in this study are the number of species (forms), the diversity index, and redundancy.

The diversity index is calculated using the formula presented by Wilhm and Dorris (1968):

$$\bar{d} = -\sum_{i=1}^{S} (n_i/n) \log_2 (n_i/n)$$

where S is the number of species, n is the total number of phytoplankton in cells/ml, and n_i is the number of phytoplankton of the i_{th} species. Since not all forms encountered can be identified to the species level, the diversity index presented may differ somewhat from the true diversity measure; one must view this with caution.

Redundancy is a measure of the dominance of one or a few species within population asseblages. As presented by Wilhm and Dorris (1968), it is:

$$r = \frac{\bar{d}_{max} - \bar{d}}{\bar{d}_{max} - \bar{d}_{min}}$$

where $\bar{d}$ is the diversity of a community as calculated above, $\bar{d}_{max}$ is the maximum diversity for the community, and $\bar{d}_{min}$ is the minumum diversity for the community. $\bar{d}_{max}$ and $\bar{d}_{min}$ are computed as follows:

$$\bar{d}_{max} = (1/n)(\log_2 n! - S\log_2 [n/S]!)$$

$$\bar{d}_{min} = (1/n)(\log_2 n! - S\log_2 [n/S-1]!)$$

The possible values of r vary in a range between 0 and 1. When an r equals 0, it indicates that all the species encountered in a community have the same abundance, whereas when an r equals 1, it implies that one species dominates a community. As shown in the formula, the value is derived from the measures of species number, abundance and diversity.

The number of forms of phytoplankton was high in 1976 relative to 1975 and 1977, but when the monthly data available for 1978 were considered, the number of species (forms) present in May and June represented a significant increase over the same months in the preceeding years (Table 13). In general, the numbers of forms have increased since 1975. Ayers and Wiley (1979) observed this occurring in samples collected during surveys of Lake Michigan phytoplankton in the vicinity of the plant. The observed increase is concluded to be a natural increase related to the continuing eutrophication of Lake Michigan.

Though no trend is apparent in diversity, 1976 diversities are higher than those of 1975 and 1977 (Table 14). The increase in diversity in 1976 may in part be due to upwelling and mixing events which enriched the nearshore region with nutrients and a different phytoplankton community. The mean yearly diversity for 1978 was high compared to those for 1975 and 1977, and was close to the value for 1976. The monthly average of diversity in 1978 reached a peak in May corresponding to the high number of species (forms) appearing during this period, but such a correlation was not observed in June due to the increased dominancy in Chrysophycean flagellates.

Redundancy variation during 1975 through 1977 shows no distinct trend. Though highest in 1977, the difference between the 1977 and 1975 redundancies is not much greater than the difference between the 1975 and 1976 redundancies.

All phytoplankton cell counts and their derived community descriptions do not, at this time, indicate any observable plant impact.

Phytoplankton Viability

Because the phaeophytin a / chlorophyll a ratio is relatively insensitive to changes in viability, all chlorophyll data will be presented as in the reports on the 1975 and 1976 data (Rossmann et al. 1977; Rossmann et al. 1979). Chlorophyll a is the most sensitive of all the variables for detecting any change in viability.

During 1979, changes in viability resembled those noted for 1978 (Table 16). The higher rate of occurance of changes during 1979 was similar to that of 1978 and 1977 and higher than those of 1975 and 1976. The increased occurance of statistically significant differences at the 0.05 level of significance during 1977 through 1979 coincides with our change in methodology whereby grinding is used instead of sonification and 5 replicates are collected rather than 3. The higher rate does not coincide with two unit operation.

During 1979, chlorophyll a decreased 14% of the time in all samples and 11% of the time in incubated samples compared to 22% and 23% respectively during 1978 (Tables 17-18). Chlorophyll a increased 17% of the time in all samples and 33% of the time in incubated samples compared to 12% and 5% respectively during 1978. For all samples, chlorophyll b (Tables 18-19) increased 8% of the time in 1979 and 10% of the time 1978 and decreased 3% of the time for 1979 and 6% of the time in 1978. For incubated samples, it increased 33% of the time for 1979 and 23% of the time for 1978 and decreased 0% and 8% of the time, respectively. For all samples, chlorophyll c (Tables 20-21), decreased in 6% of the 1979 samples and 8% of the 1978 samples and increased in 11% and 8% of the samples, respectively. Incubated samples showed increases 10% of the time in 1978 and 11% of the time in 1979 and showed decreases 0% and 6% of the time, respectively. For all samples, phaeophytin a (Tables 22-23) increased 3% of the time in 1979 and 6% of the time in 1978, and it decreased 8% of the time in 1979 and 4% of the time in 1978. In 1979, phaeophytin a decreased 8% and increased 8% of the time for the incubated samples. For the 1978 incubated samples, it decreased 3% and increased 8% of the time. For all the 1979 samples the phaeophytin a / chlorophyll a ratio (Tables 24 25) increased 3% and decreased 6% of the time. In 1978, the ratio increased 6% and decreased 6% of the time. During 1979, the ratio for the incubated samples showed no significant change. For the 1978 incubated samples, the ratio decreased 8% and increased 8% of the time.

With the exception of 1977 when the character of the entrained phytoplankton community was such that a negative impact was noted, no consistent viability increase or decrease has been observed which can be attributed to the plant.

CONCLUSIONS

Comparison of phytoplankton major group mean concentrations for 1975 through August 1978 gave the following general observations: 1) coccoid blue-green algae and desmids were least abundant during 1976; 2) flagellates were most abundant during 1978; 3) filamentous blue-green algae, coccoid green algae, centric diatoms, pennate diatoms, and total algae were least abundant in 1977, other algae showed an increase in 1978, and filamentous green algae were most abundant in 1976.

The number of forms of phytoplankton was highest in 1976 and 1978, redundancy was highest in 1977, and diversity was highest in 1976 and 1978 and lowest in 1977. These changes in community structure statistics mimic changes noted in the major groups, especially for 1977. Decreases in filamentous blue-green algae, coccoid green algae, centric diatoms, pennate diatoms, and total algae in 1977, the increased redundancy in 1977, and the decreased diversity in 1977 describe a phytoplankton community considerably different from those of 1975, 1976, and 1978.

With the exception of 1977 when the character of the entrained phytoplankton community was such that a negative impact on viability was noted, no consistent viability increase or decrease has been found that can be attributed to the plant.

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TABLE 1. Status of Phytoplankton Enumeration Samples.

SAMPLE STATUS[1]

Month and Sample	Not Collected	Lost	Not Yet Counted	Counted But Not Yet Available for Discussion	Complete
January 1978					
Evening Twilight					IA IB DA DB
Morning Twilight					IA IB DA DB
Noon		IB			IA DA DB
February 1978					
Evening Twilight					IA IB DA DB
Morning Twilight					IA IB DA DB
Noon					IA IB DA DB
March 1978					
Evening Twilight					IA IB DA DB
Morning Twilight					IA IB DA DB
Noon					IA IB DA DB
April 1978					
Evening Twilight					IA IB DA DB
Morning Twilight					IA IB DA DB
Noon					IA IB
May 1978					
Evening Twilight					IA IB DA DB
Morning Twilight					IA IB DA DB
Noon					IA IB DA DB

(continued)

[1] A and B are replicate designations
I is Intake
D1 is Discharge Unit #1
D2 is Discharge Unit #2

TABLE I (continued)

Month and Sample	Not Collected	Lost	Not Yet Counted	Counted But Not Yet Available for Discussion	Complete
June 1978					
Evening Twilight					IA IB DA DB
Morning Twilight					IA IB DA DB
Noon					IA DA DB
July 1978					
Evening Twilight					IA IB D1A D1B D2A D2B
Morning Twilight					IA IB D1A D1B D2A D2B
Noon					IA IB D1A D1B D2A D2B
August 1978					
Evening Twilight					IA IB D1A D1B D2A D2B
Morning Twilight					IA IB D1A D1B D2A D2B
Noon					IA IB D1A D1B D2A D2B
September 1978					
Evening Twilight				IA IB D1A D1B D2A D2B	
Morning Twilight				IA IB D1A D1B D2A D2B	
Noon				IA IB D1A D1B D2A D2B	
October 1978					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		

(continued)

[1]A and B are replicate designations
I is Intake
D1 is Discharge Unit #1
D2 is Discharge Unit #2

TABLE 1 (continued)

Month and Sample	Not Collected	Lost	Not Yet Counted	Counted But Not Yet Available for Discussion	Complete
November 1978					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
December 1978					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
January 1979					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
February 1979					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
March 1979					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB DIA D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		

(continued)

[1] A and B are replicate designations
I is Intake
D1 is Discharge Unit #1
D2 is Discharge Unit #2

TABLE 1 (continued)

Month and Sample	Not Collected	Lost	Not Yet Counted	Counted But Not Yet Available for Discussion	Complete
April 1979					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
May 1978					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
June 1979			Plant not Operational		
July 1979					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
August 1979					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
September 1979					
Evening Twilight	D1A D1B		IA IB D2A D2B		
Morning Twilight			IA IB DIA D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
October 1979					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		

(continued)

[1]A and B are replicate designations
I is Intake
D1 is Discharge Unit #1
D2 is Discharge Unit #2

TABLE 2. Entrainment temperatures for 1978 and 1979.

Date	Time	Intake, °C	Discharge #1, °C	Discharge #2, °C
January 10, 1978	Morning Twilight	3.0	13.5	
11	Noon	2.8	14.0	
11	Evening Twilight	5.6	17.0	
February 6, 1978	Evening Twilight	0.8	10.6	
7	Morning Twilight	0.8	10.9	
7	Noon	0.8	10.2	
March 6, 1978	Evening Twilight			
7	Morning Twilight	0.8	12.1	
7	Noon	0.6	1.6	
April 10, 1978	Evening Twilight	4.2		8.7
11	Morning Twilight	2.8		8.1
11	Noon	4.8		10.2
May 9, 1978	Evening Twilight	8.9		17.6
10	Morning Twilight	9.9		18.8
10	Noon			17.8
June 12, 1978	Evening Twilight	17.8		26.3
13	Morning Twilight	17.8		25.8
13	Noon	9.9		11.0
July 10, 1978	Evening Twilight	10.0	21.5	15.2
11	Morning Twilight	11.0	21.5	16.4
11	Noon	10.7	22.2	17.7
August 7, 1978	Evening Twilight	19.0	31.0	28.2
8	Morning Twilight	20.8	32.2	30.0
8	Noon	21.0	32.6	29.9
September 11, 1978	Evening Twilight	26.5	36.5	35.1
12	Morning Twilight	26.2	36.0	35.1
12	Noon	25.1	36.0	35.0
October 9, 1978	Evening Twilight	17.4		25.0
10	Morning Twilight	15.1	26.0	23.2
10	Noon	16.8	26.7	25.0
November 13, 1978	Evening Twilight	11.2	22.0	
14	Morning Twilight	11.1	21.8	
14	Noon	11.0	21.6	
December 4, 1978	Evening Twilight	4.8	15.2	13.3
5	Morning Twilight	4.8	15.6	14.0
5	Noon	4.8	14.8	13.9

(continued)

TABLE 2 (continued)

Date	Time	Intake, °C	Discharge #1, °C	Discharge #2, °C
January 8, 1979	Evening Twilight	1.0	13.5	11.8
9	Morning Twilight	1.8	14.0	12.0
9	Noon	1.2	14.5	16.0
February 12, 1979	Evening Twilight	6.2	17.0	15.6
13	Morning Twilight	6.2	16.8	16.2
13	Noon	6.8	17.0	16.5
March 5, 1979	Evening Twilight	0.5	13.5	10.2
6	Morning Twilight	6.2	17.8	15.8
6	Noon	5.2	17.2	15.5
April 9, 1979	Evening Twilight	3.2		12.5
10	Morning Twilight	3.2		11.8
10	Noon	3.5		12.3
May 7, 1979	Evening Twilight	10.0		20.8
8	Morning Twilight	10.1		20.9
8	Noon	10.8		21.2
July 10, 1979	Evening Twilight	16.7		25.8
10	Morning Twilight	17.0		25.8
10	Noon	18.0		26.6
August 6, 1979	Evening Twilight	24.5	35.0	34.0
7	Morning Twilight	24.0	34.2	34.0
7	Noon	24.3	35.5	34.0
September 10, 1979	Evening Twilight	19.8	broken pump	29.2
11	Morning Twilight	19.8	31.0	29.6
11	Noon	21.0	31.1	30.2
October 8, 1978	Evening Twilight	16.0	27.2	25.0
9	Morning Twilight	16.0	27.0	24.5
9	Noon	15.0	26.0	24.0

TABLE 3. Monthly variation of cocciod blue-green algae during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		461.(149.)		296.(91.9)
February	109.(59.7)	254.(71.7)		95.0(50.0)
March	257.(186.)	347.(110.)	137.(57.2)	28.7(12.6)
April	312.(125.)	143.(63.6)	110.(76.2)	78.8(30.7)
May	689.(169.)	87.1(46.6)	47.3(27.3)	142.(54.6)
June	235.(155.)	33.6(25.1)	114(45.6)	521.(166.)
July	1050.(155.)	57.8(26.5)	133.(28.5)	244.(75.7)
August	286.(53.2)	439.(93.8)	1210.(254.)	149.(35.4)
September	1220.(169.)	339.(118.)	917.(93.6)	
October	945.(212.)	560.(196.)	727.(145.)	
November	600.(166.)	422.(121.)	1320.(289.)	
December	176.(106.)	275.(73.4)	872.(124.)	
Yearly Mean	535.(117.)	285.(50.1)	599.(159.)	

'Mean is followed by the standard error.

TABLE 4. Monthly variation of filamentous blue-green algae during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		22.0(8.06)		15.2(5.61)
February	28.2(8.10)	16.4(3.53)		6.22(2.46)
March	59.7(17.6)	13.4(2.53)	16.7(3.19)	3.60(.921)
April	27.6(5.40)	57.9(5.16)	110.(76.2)	2.63(.919)
May	103.(37.0)	457.(52.8)	17.5(4.09)	14.4(4.53)
June	314.(38.1)	81.1(16.1)	24.3(8.29)	111.(51.9)
July	95.1(25.5)	72.1(12.7)	59.9(14.3)	65.0(12.6)
August	8.90(2.70)	9.24(3.08)	17.6(6.37)	111.(25.5)
September	17.3(9.20)	46.8(15.8)	25.0(8.84)	
October	98.8(34.0)	45.9(23.8)	21.4(7.61)	
November	21.6(17.8)	6.35(4.31)	12.7(3.13)	
December	15.4(7.70)	74.5(44.3)	45.2(18.6)	
Yearly Mean	71.8(26.5)	75.2(35.6)	35.0(9.54)	

'Mean is followed by the standard error.

TABLE 5. Monthly variation of coccoid green algae during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		42.2(12.2)		56.8(17.4)
February	39.3(14.2)	29.5(11.1)		10.7(2.57)
March	55.2(24.7)	22.9(7.63)	21.1(4.43)	16.6(4.54)
April	49.7(14.8)	57.9(12.3)	51.4(8.31)	108.(25.2)
May	47.1(19.7)	145.(30.6)	15.3(4.89)	145.(23.6)
June	141.(23.2)	98.4(26.9)	39.2(15.8)	150.(45.3)
July	1000.(107.)	689.(123.)	152.(19.2)	103.(36.0)
August	197.(37.1)	494.(46.8)	115.(16.5)	166.(33.0)
September	176.(24.2)	755.(129.)	54.4(8.31)	
October	116.(16.1)	242.(37.1)	232.(85.4)	
November	138.(66.9)	134.(36.1)	65.1(18.2)	
December	110.(47.8)	240.(54.4)	49.5(11.4)	
Yearly Mean	188.(82.8)	246.(74.6)	79.5(21.5)	

'Mean is followed by the standard error.

TABLE 6. Monthly variation of filamentous green algae during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		31.6(17.4)		2.26(1.35)
February	18.0(9.70)	2.00(1.20)		.350(.241)
March	34.8(12.6)	16.4(6.62)	6.63(4.37)	3.04(1.82)
April	0.0(0.0)	18.1(10.5)	18.2(12.3)	2.21(1.70)
May	1.50(1.50)	57.8(23.0)	4.63(2.32)	1.70(1.15)
June	29.5(20.6)	55.0(14.0)	.417(.417)	2.62(1.03)
July	0.3(0.3)	37.3(11.1)	22.9(4.79)	11.2(2.82)
August	0.8(0.6)	4.28(2.52)	0.0(0.0)	8.15(2.83)
September	0.2(0.2)	13.7(6.13)	1.86(.888)	
October	2.8(1.1)	9.67(2.47)	6.63(4.02)	
November	1.5(1.2)	6.35(5.48)	26.8(6.92)	
December	14.4(7.3)	5.52(2.39)	14.0(6.97)	
Yearly Mean	9.44(3.87)	21.5(5.64)	10.2(3.06)	

'Mean is followed by the standard error.

TABLE 7. Monthly variation of flagellated algae during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		110.(18.7)		156.(44.0)
February	90.8(20.8)	252.(32.1)		109.(21.7)
March	272.(56.6)	268.(25.5)	628.(60.2)	97.5(24.6)
April	857.(190.)	351.(36.6)	1010.(116.)	435.(69.9)
May	641.(82.3)	1350.(220.)	1200.(160.)	728.(153.)
June	802.(148.)	633.(70.5)	235.(30.6)	2840.(275.)
July	561.(94.6)	452.(31.6)	267.(33.9)	395.(77.7)
August	504.(56.7)	482.(86.6)	376.(31.9)	191.(19.0)
September	587.(71.6)	426.(70.3)	302.(57.8)	
October	696.(85.4)	559.(91.7)	550.(91.8)	
November	417.(51.9)	524.(47.6)	754.(156.)	
December	368.(59.9)	415.(84.2)	78.9(19.3)	
Yearly Mean	527.(69.0)	485.(89.0)	540.(114.)	

'Mean is followed by the standard error.

TABLE 8. Monthly variation of centric diatoms during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		1810.(191.)		310.(46.7)
February	1040.(130.)	560.(45.0)		125.(12.8)
March	1290.(111.)	807.(56.8)	463.(57.7)	423.(37.8)
April	2550.(427.)	930.(51.1)	779.(83.9)	592.(74.5)
May	1190.(170.)	1400.(189.)	139.(23.1)	1800.(168.)
June	817.(64.3)	212.(18.3)	451.(91.5)	1450.(141.)
July	914.(108.)	3370.(361.)	967.(65.9)	1100.(99.6)
August	132.(23.9)	272.(25.9)	175.(12.0)	200.0(30.0)
September	69.2(8.3)	1060.(157.)	183.(14.8)	
October	286.(21.2)	644.(50.9)	140.(18.1)	
November	404.(64.5)	1090.(69.4)	194.(24.2)	
December	1700.(132.)	503.(58.8)	165.(18.5)	
Yearly Mean	945.(224.)	1050.(249.)	366.(93.7)	

'Mean is followed by the standard error.

TABLE 9. Monthly variation of pennate diatoms during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		991.(186.)		598.(79.0)
February	1640.(196.)	265.(43.0)		62.2(8.27)
March	1340.(146.)	329.(46.3)	1210.(90.6)	41.7(4.68)
April	1160.(306.)	1340.(123.)	1710.(187.)	226.(37.1)
May	3040.(278.)	864.(158.)	383.(45.0)	1910.(162.)
June	1220.(102.)	332.(29.9)	743.(129.)	1750.(134.)
July	90.8(12.8)	2900.(459.)	487.(44.8)	1450.(160.)
August	84.8(16.8)	1250.(207.)	73.2(10.1)	514.1(17.2)
September	270.(52.7)	1920.(411.)	146.(15.5)	
October	295.(34.6)	498.(36.6)	822.(45.2)	
November	501.(74.2)	842.(100.)	724.(100.)	
December	333.(43.4)	1320.(148.)	548.(50.2)	
Yearly Mean	907.(271.)	1070.(220.)	685.(155.)	

'Mean is followed by the standard error.

TABLE 10. Monthly variation of desmids during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		0.0(0.0)		1.05(.640)
February	0.8(0.5)	.238(.191)		.275(.207)
March	0.8(0.5)	.417(.298)	.142(.142)	.208(.151)
April	1.2(1.2)	.825(.592)	.275(.275)	0.0(0.0)
May	3.0(0.0)	1.65(.642)	1.52(.583)	0.83(0.44)
June	2.5(0.9)	.142(.142)	1.25(.580)	0.83(0.43)
July	2.2(1.2)	1.25(.843)	1.47(.325)	2.22(0.70)
August	0.4(0.2)	.550(.371)	1.11(.587)	0.51(0.22)
September	0.3(0.3)	.275(.275)	.0667(.0667)	
October	0.8(0.4)	0.0(0.0)	0.0(0.0)	
November	0.5(0.3)	0.0(0.0)	.825(.431)	
December	0.0(0.0)	.447(.298)	1.38(.604)	
Yearly Mean	1.14(.298)	.484(.150)	.804(.197)	

'Mean is followed by the standard error.

TABLE 11. Monthly variation of other algae during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		62.4(18.1)		50.8(11.2)
February	7.0(3.2)	58.3(30.4)		53.9(8.07)
March	29.4(4.4)	39.9(5.93)	16.7(5.49)	66.2(7.79)
April	70.0(16.9)	91.1(42.8)	167.(20.8)	57.6(10.9)
May	84.0(17.2)	148.(27.8)	55.6(10.5)	104.(11.3)
June	148.(29.0)	104.(12.1)	37.9(7.65)	400.(44.3)
July	480.(57.1)	361.(52.3)	193.(22.0)	514.(63.9)
August	55.0(22.1)	192.(19.8)	206.(26.7)	119.(23.4)
September	31.6(6.2)	481.(54.7)	62.0(7.15)	
October	44.0(5.0)	166.(23.7)	183.(21.4)	
November	65.7(13.0)	84.7(14.5)	119.(15.6)	
December	71.0(13.1)	42.0(7.67)	63.4(15.1)	
Yearly Mean	98.7(39.7)	153.(39.5)	110.(22.6)	

'Mean is followed by the standard error.

TABLE 12. Monthly variation of total algae during 1975, 1976, 1977 and 1978 (cells/ml).

Month	1975'	1976'	1977'	1978'
January		3530.(429.)		1490.(210.)
February	2970.(318.)	1410.(147.)		465.(81.7)
March	3340.(421.)	1840.(182.)	2500.(206.)	681.(63.9)
April	5020.(816.)	2990.(200.)	3890.(336.)	1500.(170.)
May	5800.(413.)	4520.(396.)	1860.(214.)	4840.(397.)
June	3710.(302.)	1550.(132.)	1650.(249.)	7220.(461.)
July	4200.(243.)	7940.(836.)	2280.(156.)	3880.(321.)
August	1270.(92.8)	3140.(292.)	2170.(296.)	1460.(172.)
September	2380.(208.)	5050.(675.)	1690.(140.)	
October	2490.(286.)	2720.(291.)	2680.(285.)	
November	2150.(259.)	3090.(237.)	3210.(428.)	
December	2790.(170.)	2870.(312.)	1840.(189.)	
Yearly Mean	3280.(399.)	3390.(519.)	2380.(228.)	

'Mean is followed by the standard error.

TABLE 13. Comparison of the number of forms of phytoplankton for the years 1975, 1976, 1977 and 1978. Standard errors are included in parentheses.

Month	1975 Replicates	1975 Forms	1976 Replicates	1976 Forms	1977 Replicates	1977 Forms	1978 Replicates	1978 Forms
January	-[1]	----[1]	11	59.4(2.79)	--[1]	---[1]	11	62.9(2.47)
February	9	51.1(1.90)	12	57.3(1.64)	--	----	12	48.9(1.01)
March	9	51.7(1.89)	12	59.3(1.59)	12	52.9(2.36)	12	40.3(1.16)
April	9	48.3(1.38)	12	56.1(1.43)	12	55.5(3.37)	12	55.1(3.24)
May	9	47.4(1.78)	12	60.3(2.84)	12	46.4(2.91)	12	81.9(2.07)
June	12	49.2(1.77)	12	65.8(1.77)	12	64.1(3.59)	12	85.3(4.17)
July	12	51.6(.892)	12	87.3(3.78)	12	57.7(2.64)	16	69.7(2.73)
August	12	44.5(2.32)	12	53.4(3.31)	12	46.9(2.26)	16	49.9(1.93)
September	10	44.1(3.12)	12	84.8(4.30)	12	60.3(2.75)		
October	12	54.9(2.18)	12	58.8(2.77)	12	52.3(2.60)		
November	12	50.3(2.11)	12	57.2(1.74)	12	46.6(1.85)		
December	11	50.8(1.74)	12	56.5(1.81)	12	56.4(2.52)		
Yearly Mean		49.4(.969)		63.1(3.25)		53.9(1.92)		

[1] Samples were not collected where dashes appear. Samples have not yet been analyzed where blanks appear.

TABLE 14. Comparison of phytoplankton form diversities for the years 1975, 1976, 1977 and 1978. Standard errors are included in parentheses.

	1975		1976		1977		1978	
Month	Replicates	Diversity	Replicates	Diversity	Replicates	Diversity	Replicates	Forms
January	---[1]	----[1]	11	4.29(.0547)	-[1]	---[1]	11	4.53(.0918)
February	9	4.35(.0473)	12	4.47(.0591)	--	----	12	4.37(.103)
March	9	4.30(.0544)	12	4.34(.0633)	12	3.85(.0680)	12	3.69(.108)
April	9	4.21(0.569)	12	4.30(.0466)	12	4.36(.0872)	12	4.21(.119)
May	9	3.76(.228)	12	4.37(.112)	12	2.98(.186)	12	4.96(0.03)
June	12	4.17(.0809)	12	4.67(.0616)	12	4.62(.0836)	12	4.31(0.10)
July	12	3.93(.0654)	12	5.08(.0380)	12	4.00(.0564)	16	4.86(0.05)
August	12	3.58(.163)	12	3.50(.114)	12	3.29(.161)	16	4.07(0.97)
September	10	3.36(.189)	12	4.92(.0973)	12	3.29(.109)		
October	12	3.96(.138)	12	4.48(.0823)	12	4.00(.0764)		
November	12	4.02(.119)	12	3.97(.0608)	12	3.69(.0945)		
December	11	3.83(.0982)	12	3.96(.0963)	12	3.82(.113)		
Yearly Mean.		3.95(.0924)		4.36(.124)		3.79(.159)		

[1] Samples were not collected where dashes appear. Samples have not yet been analyzed where blanks appear.

TABLE 15. Comparison of phytoplankton redundancies for the years 1975, 1976, 1977 and 1978. Standard errors are included in parentheses.

	1975		1976		1977		1978	
Month	Replicates	Redundancies	Replicates	Redundancies	Replicates	Redundancies	Replicates	Redundancies
January	–[1]	----[1]	11	.270(.0114)	--[1]	---[1]	11	.238(.0163)
February	9	.230(.00916)	12	.231(.0111)	--	----	12	.207(.0238)
March	9	.243(.00781)	12	.263(.0106)	12	.329(.00821)	12	.317(.0212)
April	9	.246(.00879)	12	.260(.00667)	12	.244(.00581)	12	.272(.0134)
May	9	.327(.0540)	12	.259(.0150)	12	.474(.0304)	12	.217(.007)
June	12	.258(.00973)	12	.223(.0101)	12	.223(.0105)	12	.329(.013)
July	12	.310(.0114)	12	.210(.00759)	12	.318(.0115)	16	.201(.006)
August	12	.353(.0262)	12	.393(.0172)	12	.411(.0336)	16	.280(.009)
September	10	.389(.0290)	12	.227(.0127)	12	.457(.0215)		
October	12	.317(.0212)	12	.232(.0141)	12	.299(.0112)		
November	12	.289(.0196)	12	.322(.0106)	12	.335(.0154)		
December	11	.325(.0173)	12	.322(.0175)	12	.348(.0194)		
Yearly Mean		299(.0152)		.268(.0154)		.344(.0262)		

[1] Samples were not collected where dashes appear. Samples have not yet been analyzed where blanks appear.

TABLE 16. Changes in viability noted by comparison of chlorophyll data from the intake with those from the discharges.

Year	% of Comparisons showing increase	% of Comparisons showing decrease
1975	2	4
1976	4	5
1977	1	16
1978	9	9
1979 (through Oct.)	6	10

TABLE 17. MEAN CHLOROPHYLL A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5	0	5	0.446E+01	0.271E+00			
01/10/78	0730	D1	0	5	0.487E+01	0.327E+00	INTAKE VS. DISCHARGE	0.925E+00	0.367E+00
01/10/78	0730	I5	27	5	0.468E+01	0.695E+00			
01/10/78	0730	D1	27	5	0.408E+01	0.380E+00	INTAKE VS. DISCHARGE	0.566E+00	0.478E+00
01/11/78	1400	I5	0	4	0.381E+01	0.669E-01			
01/11/78	1400	D1	0	4	0.717E+01	0.236E+00	INTAKE VS. DISCHARGE	0.188E+03	0.139E-03
01/11/78	1400	I5	4	2	0.379E+01	0.0			
01/11/78	1400	D1	4	4	0.360E+01	0.307E+00	INTAKE VS. DISCHARGE	0.161E+00	0.703E+00
01/11/78	2000	I5	0	5	0.311E+01	0.151E+00			
01/11/78	2000	D1	0	5	0.360E+01	0.209E+00	INTAKE VS. DISCHARGE	0.361E+01	0.938E-01
02/06/78	2001	I5	0	5	0.135E+01	0.135E+00			
02/06/78	1950	D1	0	4	0.136E+01	0.644E-01	INTAKE VS. DISCHARGE	0.715E-02	0.923E+00
02/06/78	2001	I5	33	5	0.132E+01	0.468E-01			
02/06/78	1950	D1	33	5	0.156E+01	0.187E-01	INTAKE VS. DISCHARGE	0.220E+02	0.221E-02
02/08/78	0650	I5	0	5	0.153E+01	0.149E+00			
02/08/78	0650	D1	0	4	0.123E+01	0.171E+00	INTAKE VS. DISCHARGE	0.174E+01	0.229E+00
02/07/78	1215	I5	0	5	0.103E+01	0.251E+00			
02/07/78	1215	D1	0	5	0.127E+01	0.750E-01	INTAKE VS. DISCHARGE	0.805E+00	0.399E+00
03/06/78	2017	I5	0	5	0.220E+01	0.203E+00			
03/06/78	2017	D1	0	5	0.216E+01	0.111E+00	INTAKE VS. DISCHARGE	0.361E-01	0.840E+00
03/06/78	2017	I5	37	5	0.249E+01	0.917E-01			
03/06/78	2017	D1	37	5	0.363E+01	0.623E+00	INTAKE VS. DISCHARGE	0.330E+01	0.107E+00
03/07/78	0550	I5	0	4	0.188E+01	0.123E+00			
03/07/78	0550	D1	0	5	0.192E+01	0.823E-01	INTAKE VS. DISCHARGE	0.762E-01	0.780E+00
03/07/78	1230	I5	0	5	0.190E+01	0.223E+00			
03/07/78	1230	D1	0	5	0.197E+01	0.273E+00	INTAKE VS. DISCHARGE	0.330E-01	0.847E+00
04/10/78	2105	I5	0	5	0.287E+01	0.484E+00			
04/10/78	2105	D2	0	5	0.335E+01	0.178E+00	INTAKE VS. DISCHARGE	0.852E+00	0.386E+00
04/10/78	2105	I5	38	5	0.353E+01	0.218E+00			
04/10/78	2105	D2	38	5	0.342E+01	0.181E+00	INTAKE VS. DISCHARGE	0.167E+00	0.690E+00
04/11/78	0440	I5	0	5	0.172E+01	0.164E+00			
04/11/78	0440	D2	0	5	0.241E+01	0.490E+00	INTAKE VS. DISCHARGE	0.180E+01	0.216E+00

TABLE 17. MEAN CHLOROPHYLL A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT HAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5	0	5	0.308E+01	0.302E+00			
04/11/78	1225	D2	0	5	0.317E+01	0.319E+00	INTAKE VS. DISCHARGE	0.498E-01	0.816E+00
05/09/78	2215	I5	0	5	0.114E+02	0.404E+00			
05/09/78	2215	D2	0	5	0.121E+02	0.224E+00	INTAKE VS. DISCHARGE	0.229E+01	0.168E+00
05/09/78	2215	I5	39	5	0.128E+02	0.399E+00			
05/09/78	2215	D2	39	5	0.128E+02	0.526E+00	INTAKE VS. DISCHARGE	0.367E-02	0.942E+00
05/10/78	0350	I5	0	5	0.136E+02	0.311E+00			
05/10/78	0340	D2	0	5	0.137E+02	0.219E+00	INTAKE VS. DISCHARGE	0.136E+00	0.717E+00
05/10/78	1219	I5	0	5	0.118E+02	0.177E+00			
05/10/78	1205	D2	0	4	0.107E+02	0.380E+00	INTAKE VS. DISCHARGE	0.700E+01	0.338E-01
06/12/78	2307	I5	0	5	0.120E+02	0.707E-01			
06/12/78	2310	D1	0	5	0.121E+02	0.198E+00	INTAKE VS. DISCHARGE	0.144E+00	0.709E+00
06/13/78	0010	I5	34	5	0.109E+02	0.265E+00			
06/13/78	2307	D1	34	5	0.119E+02	0.222E+00	INTAKE VS. DISCHARGE	0.835E+01	0.209E-01
06/13/78	0218	I5	0	5	0.154E+02	0.348E+00			
06/13/78	0220	D1	0	4	0.136E+02	0.771E+00	INTAKE VS. DISCHARGE	0.530E+01	0.552E-01
06/13/78	1237	I5	0	5	0.125E+02	0.200E+00			
06/13/78	1237	D1	0	5	0.117E+02	0.350E+00	INTAKE VS. DISCHARGE	0.355E+01	0.960E-01
07/11/78	2307	I5	0	5	0.161E+02	0.916E+00			
07/11/78	2315	D1	0	5	0.147E+02	0.589E+00			
07/11/78	2321	D2	0	5	0.166E+02	0.102E+01	INTAKE VS. DISCHARGE	0.129E+01	0.312E+00
07/11/78	2307	I5	34	5	0.192E+02	0.198E+00			
07/11/12	2315	D1	34	5	0.162E+02	0.641E+00			
07/11/78	2321	D2	34	5	0.193E+02	0.333E+00	INTAKE VS. DISCHARGE	0.172E+02	0.601E-03
07/11/78	0240	I5	0	5	0.155E+02	0.408E+00			
07/11/78	0240	D1	0	5	0.151E+02	0.818E+00			
07/11/78	0246	D2	0	5	0.147E+02	0.216E+00	INTAKE VS. DISCHARGE	0.574E+00	0.580E+00
07/11/78	1212	I5	0	5	0.111E+02	0.267E+00			
07/11/78	1213	D1	0	5	0.100E+02	0.179E+00			
07/11/78	1225	D2	0	5	0.109E+02	0.158E+00	INTAKE VS. DISCHARGE	0.757E+01	0.832E-02
08/07/78	2243	I5	0	5	0.400E+01	0.857E-01			
08/07/78	2238	D1	0	5	0.386E+01	0.109E+00			
08/07/78	2219	D2	0	5	0.451E+01	0.357E-01	INTAKE VS. DISCHARGE	0.167E+02	0.654E-03

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5 35	5	0.389E+01	0.103E+00			
08/07/78	2238	D1 35	3	0.368E+01	0.533E-01			
08/08/78	2219	D2 35	5	0.387E+01	0.835E-01	INTAKE VS. DISCHARGE	0.123E+01	0.335E+00
08/08/78	0340	I5 0	5	0.388E+01	0.939E-01			
08/08/78	0335	D1 0	5	0.462E+01	0.694E-01			
08/08/78	0335	D2 0	5	0.360E+01	0.129E+00	INTAKE VS. DISCHARGE	0.274E+02	0.140E-03
08/08/78	1233	I5 0	5	0.240E+01	0.773E-01			
08/08/78	1225	D1 0	5	0.185E+01	0.460E-01			
08/08/78	1229	D2 0	5	0.216E+01	0.122E-01	INTAKE VS. DISCHARGE	0.283E+02	0.127E-03
09/11/78	2115	I5 0	5	0.195E+01	0.136E+00			
09/11/78	2115	D1 0	5	0.161E+01	0.999E-01			
09/11/78	2115	D2 0	5	0.146E+01	0.113E+00	INTAKE VS. DISCHARGE	0.442E+01	0.374E-01
09/11/78	2115	I5 37	5	0.108E+01	0.269E-01			
09/11/78	2115	D1 37	5	0.128E+01	0.666E-01			
09/11/78	2115	D2 37	5	0.119E+01	0.880E-01	INTAKE VS. DISCHARGE	0.242E+01	0.132E+00
09/12/78	0555	I5 0	5	0.214E+01	0.107E+00			
09/12/78	0555	D1 0	5	0.174E+01	0.430E-01			
09/12/78	0554	D2 0	5	0.211E+01	0.904E-01	INTAKE VS. DISCHARGE	0.672E+01	0.119E-01
09/12/78	1207	I5 0	5	0.312E+01	0.639E-01			
09/12/78	1200	D1 0	5	0.297E+01	0.499E-01			
09/12/78	1215	D2 0	5	0.349E+01	0.559E-01	INTAKE VS. DISCHARGE	0.223E+02	0.261E-03
10/09/78	2007	I5 0	5	0.935E+01	0.507E+00			
10/09/78	2000	D1 0	5	0.947E+01	0.364E+00			
10/09/78	2004	D2 0	4	0.956E+01	0.202E+00	INTAKE VS DISCHARGE	0.681E-01	0.930E+00
10/09/78	2007	I5 36	5	0.101E+02	0.247E+00			
10/09/78	2000	D1 36	5	0.853E+01	0.377E+00			
10/09/78	2004	D2 36	5	0.796E+01	0.217E+00	INTAKE VS DISCHARGE	0.145E+02	0.104E-02
10/10/78	0533	I5 0	5	0.794E+01	0.135E+00			
10/10/78	0520	D1 0	4	0.802E+01	0.148E+00			
10/10/78	0523	D2 0	4	0.809E+01	0.785E-01	INTAKE VS DISCHARGE	0.383E+00	0.692E+00
10/10/78	1218	I5 0	5	0.757E+01	0.145E+00			
10/10/78	1200	D1 0	5	0.702E+01	0.213E+00			
10/10/78	1213	D2 0	5	0.672E+01	0.108E+00	INTAKE VS DISCHARGE	0.724E+01	0.956E-02

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5 0	3	0.534E+01	0.223E+00			
11/13/78	1910	D1 0	5	0.472E+01	0.139E+00	INTAKE VS DISCHARGE	0.621E+01	0.479E-01
11/13/78	1925	I5 36	5	0.551E+01	0.244E+00			
11/13/78	1910	D1 36	5	0.478E+01	0.186E+00	INTAKE VS DISCHARGE	0.572E+01	0.441E-01
11/14/78	0615	I5 0	5	0.579E+01	0.142E+00			
11/14/78	0557	D1 0	4	0.571E+01	0.396E+00	INTAKE VS DISCHARGE	0.344E-01	0.844E+00
11/14/78	1215	I5 0	4	0.710E+01	0.235E+00			
11/14/78	1200	D1 0	5	0.670E+01	0.192E+00	INTAKE VS DISCHARGE	0.181E+01	0.220E+00
12/04/78	1910	I5 0	5	0.623E+01	0.712E+00			
12/04/78	1931	D1 0	5	0.578E+01	0.774E+00			
12/04/78	1900	D2 0	5	0.708E+01	0.178E+00	INTAKE VS DISCHARGE	0.115E+01	0.350E+00
12/04/78	1910	I5 34	5	0.713E+01	0.364E+00			
12/04/78	1931	D1 34	5	0.624E+01	0.501E+00			
12/04/78	1900	D2 34	5	0.588E+01	0.242E+00	INTAKE VS DISCHARGE	0.282E+01	0.101E+00
12/05/78	0620	I5 0	5	0.684E+01	0.102E+00			
12/05/78	0635	D1 0	5	0.642E+01	0.242E+00			
12/05/78	0610	D2 0	5	0.584E+01	0.777E+00	INTAKE VS DISCHARGE	0.113E+01	0.358E+00
12/05/78	1206	I5 0	4	0.614E+01	0.382E+00			
12/05/78	1215	D1 0	4	0.699E+01	0.261E+00			
12/05/78	1150	D2 0	3	0.716E+01	0.113E+00	INTAKE VS DISCHARGE	0.334E+01	0.898E-01

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	5	0.303E+01	0.859E-01			
01/08/79	1916	D1	0	5	0.305E+01	0.629E-01			
01/08/79	1948	D2	0	5	0.317E+01	0.952E-01	INTAKE VS DISCHARGE	0.834E+00	0.461E+00
01/08/79	1930	I5	36	5	0.301E+01	0.106E+00			
01/08/79	1916	D1	36	4	0.304E+01	0.726E-01			
01/08/79	1948	D2	36	5	0.287E+01	0.121E+00	INTAKE VS DISCHARGE	0.772E+00	0.488E+00
01/09/79	0731	I5	0	5	0.318E+01	0.606E-01			
01/09/79	0716	D1	0	5	0.300E+01	0.750E-01			
01/09/79	0740	D2	0	5	0.329E+01	0.829E-01	INTAKE VS DISCHARGE	0.398E+01	0.484E-01
01/09/79	1208	I5	0	4	0.323E+01	0.147E+00			
01/09/79	1155	D1	0	5	0.292E+01	0.863E-01			
01/09/79	1219	D2	0	4	0.291E+01	0.140E+00	INTAKE VS DISCHARGE	0.210E+01	0.175E+00
02/12/79	2044	I5	0	5	0.170E+01	0.459E-01			
02/12/79	1958	D1	0	5	0.151E+01	0.132E+00			
02/12/79	2022	D2	0	5	0.148E+01	0.863E-01	INTAKE VS DISCHARGE	0.157E+01	0.250E+00
02/12/79	2044	I5	36	5	0.166E+01	0.101E+00			
02/12/79	1958	D1	36	4	0.157E+01	0.168E+00			
02/12/79	2022	D2	36	4	0.111E+01	0.216E+00	INTAKE VS DISCHARGE	0.343E+01	0.749E-01
02/13/79	0644	I5	0	3	0.146E+01	0.251E+00			
02/13/79	0612	D1	0	5	0.162E+01	0.426E-01			
02/13/79	0628	D2	0	4	0.164E+01	0.194E+00	INTAKE VS DISCHARGE	0.348E+00	0.715E+00
02/13/79	1225	I5	0	5	0.168E+01	0.129E+00			
02/13/79	1145	D1	0	5	0.148E+01	0.991E-01			
02/13/79	1158	D2	0	5	0.907E+00	0.225E+00	INTAKE VS DISCHARGE	0.621E+01	0.150E-01
03/05/79	2025	I5	0	5	0.240E+01	0.180E+00			
03/05/79	2048	D1	0	5	0.287E+01	0.717E-01			
03/05/79	2102	D2	0	5	0.290E+01	0.195E+00	INTAKE VS DISCHARGE	0.314E+01	0.811E-01
03/05/79	2025	I5	36	5	0.300E+01	0.154E+00			
03/05/79	2048	D1	36	5	0.263E+01	0.717E-01			
03/05/79	2102	D2	36	5	0.245E+01	0.208E+00	INTAKE VS DISCHARGE	0.335E+01	0.711E-01
03/06/79	0520	I5	0	4	0.257E+01	0.670E-01			
03/06/79	0552	D1	0	5	0.269E+01	0.825E-01			
03/06/79	0605	D2	0	5	0.259E+01	0.722E-01	INTAKE VS DISCHARGE	0.696E+00	0.522E+00

TABLE 18. MEAN CHLOROPHYLL A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5 0	5	0.254E+01	0.430E-01			
03/06/79	1238	D1 0	4	0.224E+01	0.132E+00			
03/06/79	1210	D2 0	4	0.266E+01	0.233E+00	INTAKE VS DISCHARGE	0.204E+01	0.182E+00
04/09/79	2127	I5 0	4	0.995E+01	0.131E+00			
04/09/79	2122	D2 0	5	0.106E+02	0.116E+00	INTAKE VS DISCHARGE	0.131E+02	0.941E-02
04/09/79	2127	I5 32	5	0.947E+01	0.423E+00			
04/09/79	2122	D2 32	5	0.761E+01	0.518E+00	INTAKE VS DISCHARGE	0.772E+01	0.246E-01
04/10/79	0429	I5 0	5	0.125E+02	0.474E+00			
04/10/79	0418	D2 0	5	0.136E+02	0.372E+00	INTAKE VS DISCHARGE	0.333E+01	0.105E+00
04/10/79	1136	I5 0	5	0.102E+02	0.371E+00			
04/10/79	1132	D2 0	5	0.113E+02	0.305E+00	INTAKE VS DISCHARGE	0.541E+01	0.487E-01
05/07/79	2200	I5 0	4	0.102E+02	0.413E+00			
05/07/79	2201	D2 0	5	0.977E+01	0.269E+00	INTAKE VS DISCHARGE	0.847E+00	0.391E+00
05/07/79	2229	I5 36	5	0.111E+02	0.980E-01			
05/07/79	2229	D2 36	5	0.106E+02	0.303E+00	INTAKE VS DISCHARGE	0.285E+01	0.129E+00
05/08/79	0327	I5 0	4	0.113E+02	0.185E+00			
05/08/79	0330	D2 0	4	0.112E+02	0.303E+00	INTAKE VS DISCHARGE	0.174E+00	0.687E+00
05/08/79	1208	I5 0	5	0.105E+02	0.261E+00			
05/08/79	1205	D2 0	5	0.103E+02	0.268E+00	INTAKE VS DISCHARGE	0.298E+00	0.602E+00
07/10/79	2302	I5 0	5	0.184E+01	0.167E+00			
07/10/79	2302	D2 0	4	0.161E+01	0.197E+00	INTAKE VS DISCHARGE	0.772E+00	0.412E+00
07/10/79	2402	I5 32	4	0.176E+01	0.279E+00			
07/10/79	2402	D2 32	5	0.120E+01	0.190E+00	INTAKE VS. DISCHARGE	0.302E+01	0.126E+00
07/10/79	0252	I5 0	4	0.183E+01	0.352E+00			
07/10/79	0249	D2 0	3	0.171E+01	0.545E+00	INTAKE VS DISCHARGE	0.390E-01	0.837E+00
07/10/79	1208	I5 0	5	0.523E+00	0.195E+00			
07/10/79	1205	D2 0	5	0.169E+01	0.211E+00	INTAKE VS DISCHARGE	0.165E+02	0.441E-02
08/06/79	2217	I5 0	5	0.170E+01	0.841E-01			
08/06/79	2223	D1 0	5	0.146E+01	0.620E-01			
08/07/79	0004	D2 0	4	0.152E+01	0.108E+00	INTAKE VS DISCHARGE	0.228E+01	0.150E+00
08/06/79	2217	I5 36	5	0.134E+01	0.841E-01			
08/06/79	2223	D1 36	5	0.129E+01	0.637E-01			
08/07/79	0004	D2 36	5	0.168E+01	0.726E-01	INTAKE VS DISCHARGE	0.826E+01	0.638E-02

TABLE 18. MEAN CHLOROPHYLL A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=HTR1-1, I3=HTR1-3, I5=HTR1-5, I6=HTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	3	0.200E+01	0.107E+00			
08/07/79	0335	D1	C	4	0.183E+01	0.614E-01			
08/07/79	0340	D2	0	5	0.166E+01	0.716E-01	INTAKE VS DISCHARGE	0.452E+01	0.451E-01
08/07/79	1210	I5	C	5	0.124E+01	0.122E+00			
08/07/79	1212	D1	0	5	0.101E+01	0.559E-01			
08/07/79	1220	D2	0	4	0.115E+01	0.146E+00	INTAKE VS DISCHARGE	0.114E+01	0.357E+00
09/10/79	2048	I5	0	5	0.251E+01	0.210E+00			
09/10/79	2048	D2	C	5	0.230E+01	0.169E+00	INTAKE VS DISCHARGE	0.618E+00	0.459E+00
09/10/79	2048	I5	33	5	0.185E+01	0.873E-01			
09/10/79	2048	D2	33	4	0.230E+01	0.173E+00	INTAKE VS DISCHARGE	0.937E+01	0.598E-02
09/11/79	0455	I4	0	5	0.359E+01	0.128E+00			
09/11/7C	0508	D1	0	5	0.292E+01	0.112E+00			
09/11/79	0455	D2	0	5	0.338E+01	0.109E+00	INTAKE VS DISCHARGE	0.866E+01	0.549E-02
09/11/79	0520	D1	28	4	0.274E+01	0.190E+00			
09/11/79	1210	I5	C	5	0.354E+01	0.767E-01			
09/11/79	1204	D1	0	4	0.330E+01	0.129E+00			
09/11/79	1202	D2	0	5	0.355E+01	0.849E-01	INTAKE VS DISCHARGE	0.216E+01	0.163E+00
10/08/79	2025	I5	0	5	0.387E+01	0.178E+00			
10/08/79	2010	D1	0	4	0.388E+01	0.939E-01			
10/08/79	2007	D2	0	5	0.385E+01	0.206E+00	INTAKE VS DISCHARGE	0.625E-02	0.992E+00
10/08/79	2025	I5	36	4	0.355E+01	0.135E+00			
10/08/79	2010	D1	36	5	0.362E+01	0.222E+00			
10/08/79	2007	D2	36	5	0.428E+01	0.153E+00	INTAKE VS DISCHARGE	0.510E+01	0.281E-01
10/09/79	0952	I5	0	4	0.533E+01	0.230E+00			
10/09/70	0534	D1	0	5	0.497E+01	0.257E+00			
10/09/79	0537	D2	0	5	0.499E+01	0.175E+00	INTAKE VS DISCHARGE	0.761E+00	0.493E+00
10/09/79	1220	I5	0	5	0.640E+01	0.233E+00			
10/09/79	1204	D1	0	5	0.635E+01	0.104E+00			
10/09/79	1205	D2	0	4	0.428E+01	0.479E+00	INTAKE VS DISCHARGE	0.169E+02	0.806E-03

TABLE 19. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5 0	5	0.493E-01	0.372E-01			
01/10/78	0730	D1 0	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.175E+01	0.223E+00
01/10/78	0730	I5 27	5	0.200E-03	0.200E-03			
01/10/78	0730	D1 27	5	0.670E-02	0.645E-02	INTAKE VS. DISCHARGE	0.101E+01	0.345E+00
01/11/78	1400	I5 0	4	0.0	0.0			
01/11/78	1400	D1 0	4	0.130E-02	0.129E-02	INTAKE VS. DISCHARGE	0.100E+01	0.358E+00
01/11/78	1400	I5 4	2	0.0	0.0			
01/11/78	1400	D1 4	4	0.551E-01	0.205E-01	INTAKE VS. DISCHARGE	0.320E+01	0.150E+00
01/11/78	2000	I5 0	5	0.436E+00	0.411E+00			
01/11/78	2000	D1 0	5	0.300E-01	0.132E-01	INTAKE VS. DISCHARGE	0.973E+00	0.355E+00
02/06/78	2001	I5 0	5	0.150E+00	0.323E-01			
02/06/78	1950	D1 0	4	0.129E+00	0.171E-01	INTAKE VS. DISCHARGE	0.279E+00	0.615E+00
02/06/78	2001	I5 33	5	0.393E-01	0.131E-01			
02/06/78	1950	D1 33	5	0.139E+00	0.179E-01	INTAKE VS. DISCHARGE	0.202E+02	0.269E-02
02/08/78	0650	I5 0	5	0.835E-01	0.318E-01			
02/08/78	0650	D1 0	4	0.795E-01	0.122E-01	INTAKE VS. DISCHARGE	0.113E-01	0.905E+00
02/07/78	1215	I5 0	5	0.408E-01	0.685E-02			
02/07/78	1215	D1 0	5	0.444E-02	0.274E-02	INTAKE VS. DISCHARGE	0.243E+02	0.172E-02
03/06/78	2017	I5 0	5	0.926E-01	0.326E-01			
03/06/78	2017	D1 0	5	0.799E-01	0.148E-01	INTAKE VS. DISCHARGE	0.125E+00	0.726E+00
03/06/78	2017	I5 37	5	0.347E+00	0.173E+00			
03/06/78	2017	D1 37	5	0.518E-01	0.212E-01	INTAKE VS. DISCHARGE	0.288E+01	0.128E+00
03/07/78	0550	I5 0	4	0.808E-01	0.179E-01			
03/07/78	0550	D1 0	5	0.731E-01	0.242E-01	INTAKE VS. DISCHARGE	0.604E-01	0.801E+00
03/07/78	1230	I5 0	5	0.674E-01	0.190E-01			
03/07/78	1230	D1 0	5	0.162E-01	0.835E-02	INTAKE VS. DISCHARGE	0.608E+01	0.393E-01
04/10/78	2105	I5 0	5	0.128E-01	0.582E-02			
04/10/78	2105	D2 0	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.469E+01	0.622E-01
04/10/78	2105	I5 38	5	0.945E-01	0.389E-01			
04/10/78	2105	D2 38	5	0.551E-01	0.239E-01	INTAKE VS. DISCHARGE	0.746E+00	0.416E+00
04/11/78	0440	I5 0	5	0.849E-02	0.784E-02			
04/11/78	0440	D2 0	5	0.177E-01	0.177E-01	INTAKE VS. DISCHARGE	0.228E+00	0.646E+00

TABLE 19. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5	0	5	0.195E-01	0.136E-01			
04/11/78	1225	D2	0	5	0.447E-01	0.208E-01	INTAKE VS. DISCHARGE	0.102E+01	0.343E+00
05/09/78	2215	I5	0	5	0.938E-01	0.735E-01			
05/09/78	2215	D2	0	5	0.609E-01	0.495E-01	INTAKE VS. DISCHARGE	0.138E+00	0.714E+00
05/09/78	2215	I5	39	5	0.808E-01	0.512E-01			
05/09/78	2215	D2	39	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.248E+01	0.154E+00
05/10/78	0350	I5	0	5	0.184E-01	0.184E-01			
05/10/78	0340	D2	0	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.978E+00	0.353E+00
05/10/78	1219	I5	0	5	0.308E-01	0.234E-01			
05/10/78	1205	D2	0	4	0.158E-01	0.158E-01	INTAKE VS. DISCHARGE	0.251E+00	0.632E+00
06/12/78	2307	I5	0	5	0.139E+00	0.128E+00			
06/12/78	2310	D1	0	5	0.0	0.0	INTAKE VS. DISCHARGE	0.118E+01	0.311E+00
06/13/78	0010	I5	34	5	0.866E-01	0.866E-01			
06/13/78	2307	D1	34	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.995E+00	0.349E+00
06/13/78	0218	I5	0	5	0.200E-03	0.200E-03			
06/13/78	0220	D1	0	4	0.250E-03	0.250E-03	INTAKE VS. DISCHARGE	'0.251E-01	0.865E+00
06/13/78	1237	I5	0	5	0.784E-02	0.759E-02			
06/13/78	1237	D1	0	5	0.248E-02	0.248E-02	INTAKE VS. DISCHARGE	0.450E+00	0.525E+00
07/11/78	2307	I5	0	5	0.200E-03	0.200E-03			
07/11/78	2315	D1	0	5	0.200E-01	0.173E-01			
07/11/78	2321	D2	0	5	0.200E-03	0.200E-03	INTAKE VS. DISCHARGE	0.131E+01	0.306E+00
07/11/78	2307	I5	34	5	0.699E-01	0.520E-01			
07/11/12	2315	D1	34	5	0.200E-03	0.200E-03			
07/11/78	2321	D2	34	5	0.238E-01	0.238E-01	INTAKE VS. DISCHARGE	0.115E+01	0.350E+00
07/11/78	0240	I5	0	5	0.246E-01	0.246E-01			
07/11/78	0240	D1	0	5	0.966E-01	0.966E-01			
07/11/78	0246	D2	0	5	0.674E-01	0.674E-01	INTAKE VS. DISCHARGE	0.272E+00	0.765E+00
07/11/78	1212	I5	0	5	0.398E-01	0.398E-01			
07/11/78	1213	D1	0	5	0.587E-01	0.418E-01			
07/11/78	1225	D2	0	5	0.416E-01	0.193E-01	INTAKE VS. DISCHARGE	0.882E-01	0.911E+00
08/07/78	2243	I5	0	5	0.150E+00	0.449E-01			
08/07/78	2238	D1	0	5	0.241E+00	0.191E-01			
08/07/78	2219	D2	0	5	0.183E+00	0.624E-01	INTAKE VS. DISCHARGE	0.101E+01	0.394E+00

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5 35	5	0.109E+00	0.558E-02			
08/07/78	2238	D1 35	3	0.153E+00	0.633E-02			
08/08/78	2219	D2 35	5	0.505E-01	0.239E-01	INTAKE VS. DISCHARGE	0.857E+01	0.772E-02
08/08/78	0340	I5 0	5	0.100E+00	0.257E-01			
08/08/78	0335	D1 0	5	0.148E+00	0.290E-01			
08/08/78	0335	D2 0	5	0.130E+00	0.251E-01	INTAKE VS. DISCHARGE	0.824E+00	0.465E+00
08/08/78	1233	I5 0	5	0.108E+00	0.133E-01			
08/08/78	1225	D1 0	5	0.835E-01	0.111E-01			
08/08/78	1229	D2 0	5	0.110E+00	0.180E-01	INTAKE VS. DISCHARGE	0.106E+01	0.380E+00
09/11/78	2115	I5 0	5	0.633E-01	0.161E-01			
09/11/78	2115	D1 0	5	0.732E-01	0.163E-01			
09/11/78	2115	D2 0	5	0.845E-01	0.149E-01	INTAKE VS. DISCHARGE	0.456E+00	0.647E+00
09/11/78	2115	I5 37	5	0.766E-01	0.120E-01			
09/11/78	2115	D1 37	5	0.137E+00	0.219E-01			
09/11/78	2115	D2 37	5	0.776E-01	0.125E-01	INTAKE VS. DISCHARGE	0.463E+01	0.334E-01
09/12/78	0555	I5 0	5	0.185E-01	0.103E-01			
09/12/78	0555	D1 0	5	0.673E-01	0.103E-01			
09/12/78	0554	D2 0	5	0.201E-01	0.897E-02	INTAKE VS. DISCHARGE	0.786E+01	0.742E-02
09/12/78	1207	I5 0	5	0.925E-01	0.159E-01			
09/12/78	1200	D1 0	5	0.879E-01	0.851E-02			
09/12/78	1215	D2 0	5	0.151E+00	0.155E-01	INTAKE VS. DISCHARGE	0.656E+01	0.128E-01
10/09/78	2007	I5 0	5	0.167E+00	0.869E-01			
10/09/78	2000	D1 0	5	0.170E+00	0.803E-01			
10/09/78	2004	D2 0	4	0.255E+00	0.746E-01	INTAKE VS DISCHARGE	0.339E+00	0.720E+00
10/09/78	2007	I5 36	5	0.772E-01	0.369E-01			
10/09/78	2000	D1 36	5	0.140E+00	0.429E-01			
10/09/78	2004	D2 36	5	0.944E-01	0.457E-01	INTAKE VS DISCHARGE	0.603E+00	0.565E+00
10/10/78	0533	I5 0	5	0.317E-01	0.151E-01			
10/10/78	0520	D1 0	4	0.179E+00	0.992E-01			
10/10/78	0523	D2 0	4	0.161E+00	0.483E-01	INTAKE VS DISCHARGE	0.197E+01	0.191E+00
10/10/78	1218	I5 0	5	0.106E+00	0.293E-01			
10/10/78	1200	D1 0	5	0.183E+00	0.520E-01			
10/10/78	1213	D2 0	5	0.762E-01	0.251E-01	INTAKE VS DISCHARGE	0.218E+01	0.157E+00

TABLE 19. MEAN CHLOROPHYLL a CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5	0	3	0.549E-01	0.302E-01			
11/13/78	1910	D1	0	5	0.442E-01	0.255E-01	INTAKE VS DISCHARGE	0.704E-01	0.788E+00
11/13/78	1925	I5	36	5	0.125E-01	0.565E-02			
11/13/78	1910	D1	36	5	0.124E+00	0.572E-01	INTAKE VS DISCHARGE	0.378E+01	0.876E-01
11/14/78	0615	I5	0	5	0.790E-01	0.256E-01			
11/14/78	0557	D1	0	4	0.557E-01	0.191E-01	INTAKE VS DISCHARGE	0.480E+00	0.514E+00
11/14/78	1215	I5	0	4	0.148E+00	0.576E-01			
11/14/78	1200	D1	0	5	0.185E+00	0.330E-01	INTAKE VS DISCHARGE	0.338E+00	0.581E+00
12/04/78	1910	I5	0	5	0.167E+00	0.685E-01			
12/04/78	1931	D1	0	5	0.421E-01	0.238E-01			
12/04/78	1900	D2	0	5	0.122E+00	0.236E-01	INTAKE VS DISCHARGE	0.206E+01	0.171E+00
12/04/78	1910	I5	34	5	0.270E-02	0.270E-02			
12/04/78	1931	D1	34	5	0.455E-01	0.294E-01			
12/04/78	1900	D2	34	5	0.319E-01	0.147E-01	INTAKE VS DISCHARGE	0.131E+01	0.306E+00
12/05/78	0620	I5	0	5	0.669E-01	0.278E-01			
12/05/78	0635	D1	0	5	0.356E-01	0.161E-01			
12/05/78	0610	D2	0	5	0.445E-01	0.209E-01	INTAKE VS DISCHARGE	0.533E+00	0.602E+00
12/05/78	1206	I5	0	4	0.136E+00	0.518E-01			
12/05/78	1215	D1	0	4	0.122E+00	0.737E-01			
12/05/78	1150	D2	0	3	0.450E-01	0.238E-01	INTAKE VS DISCHARGE	0.623E+00	0.563E+00

TABLE 20. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	5	0.166E+00	0.595E-01			
01/08/79	1916	D1	0	5	0.150E-01	0.125E-01			
01/08/79	1948	D2	0	5	0.570E-01	0.339E-01	INTAKE VS DISCHARGE	0.377E+01	0.546E-01
01/08/79	1930	I5	36	5	0.453E-01	0.221E-01			
01/08/79	1916	D1	36	4	0.194E-01	0.178E-01			
01/08/79	1948	D2	36	5	0.200E-02	0.200E-02	INTAKE VS DISCHARGE	0.191E+01	0.195E+00
01/09/79	0731	I5	0	5	0.228E-02	0.228E-02			
01/09/79	0716	D1	0	5	0.181E-01	0.174E-01			
01/09/79	0740	D2	0	5	0.0	0.0	INTAKE VS DISCHARGE	0.943E+00	0.419E+00
01/09/79	1208	I5	0	4	0.231E-01	0.231E-01			
01/09/79	1155	D1	0	5	0.330E-01	0.221E-01			
01/09/79	1219	D2	0	4	0.173E-01	0.119E-01	INTAKE VS DISCHARGE	0.160E+00	0.850E+00
02/12/79	2044	I5	0	5	0.615E-01	0.375E-01			
02/12/79	1958	D1	0	5	0.719E-01	0.325E-01			
02/12/79	2022	D2	0	5	0.376E-01	0.128E-01	INTAKE VS DISCHARGE	0.354E+00	0.709E+00
02/12/79	2044	I5	36	5	0.102E+00	0.415E-01			
02/12/79	1958	D1	36	4	0.314E-01	0.190E-01			
02/12/79	2022	D2	36	4	0.283E-01	0.135E-01	INTAKE VS DISCHARGE	0.194E+01	0.196E+00
02/13/79	0644	I5	0	3	0.575E-01	0.129E-01			
02/13/79	0612	D1	0	5	0.101E+00	0.191E-01			
02/13/79	0628	D2	0	4	0.982E-01	0.342E-01	INTAKE VS DISCHARGE	0.819E+00	0.474E+00
02/13/79	1225	I5	0	5	0.129E+00	0.243E-01			
02/13/79	1145	D1	0	5	0.137E+00	0.210E-01			
02/13/79	1158	D2	0	5	0.568E-01	0.135E-01	INTAKE VS DISCHARGE	0.482E+01	0.301E-01
03/05/79	2025	I5	0	5	0.321E-01	0.171E-01			
03/05/79	2048	D1	0	5	0.363E-01	0.165E-01			
03/05/79	2102	D2	0	5	0.571E-01	0.272E-01	INTAKE VS DISCHARGE	0.410E+00	0.674E+00
03/05/79	2025	I5	36	5	0.152E-01	0.975E-02			
03/05/79	2048	D1	36	5	0.578E-01	0.190E-01			
03/05/79	2102	D2	36	5	0.582E-02	0.522E-02	INTAKE VS DISCHARGE	0.474E+01	0.313E-01
03/06/79	0620	I5	0	4	0.489E-01	0.959E-02			
03/06/79	0552	D1	0	5	0.317E-01	0.123E-01			
03/06/79	0605	D2	0	5	0.458E-01	0.218E-01	INTAKE VS DISCHARGE	0.320E+00	0.733E+00

TABLE 20. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	5	0.193E-01	0.608E-02			
03/06/79	1238	D1	0	4	0.470E-01	0.431E-01			
03/06/79	1219	D2	0	4	0.481E-01	0.240E-01	INTAKE VS DISCHARGE	0.412E+00	0.674E+00
04/09/79	2127	I5	0	4	0.830E-01	0.571E-01			
04/09/79	2122	D2	0	5	0.477E-01	0.362E-01	INTAKE VS DISCHARGE	0.284E+00	0.612E+00
04/09/79	2127	I5	32	5	0.925E-01	0.504E-01			
04/09/79	2122	D2	32	5	0.681E-01	0.442E-01	INTAKE VS DISCHARGE	0.132E+00	0.720E+00
04/10/79	0429	I5	0	5	0.107E-01	0.107E-01			
04/10/79	0418	D2	0	5	0.101E+00	0.670E-01	INTAKE VS DISCHARGE	0.177E+01	0.220E+00
04/10/79	1136	I5	0	5	0.344E-01	0.305E-01			
04/10/79	1132	D2	0	5	0.120E+00	0.764E-01	INTAKE VS DISCHARGE	0.108E+01	0.330E+00
05/07/79	2200	I5	0	4	0.478E-01	0.277E-01			
05/07/79	2201	D2	0	5	0.182E-01	0.182E-01	INTAKE VS DISCHARGE	0.858E+00	0.388E+00
05/07/79	2229	I5	36	5	0.0	0.0			
05/07/79	2229	D2	36	5	0.435E-01	0.345E-01	INTAKE VS DISCHARGE	0.159E+01	0.242E+00
05/08/79	0327	I5	0	4	0.227E-01	0.227E-01			
05/08/79	0330	D2	0	4	0.130E+00	0.754E-01	INTAKE VS DISCHARGE	0.187E+01	0.220E+00
05/08/79	1208	I5	0	5	0.280E-04	0.280E-04			
05/03/79	1205	D2	0	5	0.0	0.0	INTAKE VS DISCHARGE	0.100E+01	0.348E+00
07/10/79	2302	I5	0	5	0.0	0.0			
07/10/79	2302	D2	0	4	0.218E-01	0.214E-01	INTAKE VS DISCHARGE	0.135E+01	0.285E+00
07/10/79	2402	I5	32	4	0.393E-01	0.341E-01			
07/10/79	2402	D2	32	5	0.289E-01	0.165E-01	INTAKE VS. DISCHARGE	0.888E-01	0.765E+00
07/10/79	0252	I5	0	4	0.213E-01	0.191E-01			
07/10/79	0249	D2	0	3	0.384E-01	0.239E-01	INTAKE VS DISCHARGE	0.324E+00	0.595E+00
07/10/79	1208	I5	0	5	0.393E-01	0.955E-02			
07/10/79	1205	D2	0	5	0.334E-01	0.334E-01	INTAKE VS DISCHARGE	0.290E-01	0.855E+00
08/06/79	2217	I5	0	5	0.420E-02	0.420E-02			
08/06/79	2223	D1	0	5	0.194E-01	0.138E-01			
08/07/79	0004	D2	0	4	0.900E-03	0.900E-03	INTAKE VS DISCHARGE	0.121E+01	0.337E+00
08/06/79	2217	I5	36	5	0.0	0.0			
08/06/79	2223	D1	36	5	0.140E-01	0.861E-02			
08/07/79	0004	D2	36	5	0.438E-01	0.975E-02	INTAKE VS DISCHARGE	0.888E+01	0.508E-02

TABLE 20. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	3	0.194E-01	0.969E-02			
08/07/79	0335	D1	0	4	0.538E-01	0.287E-01			
08/07/79	0340	D2	0	5	0.898E-02	0.438E-02	INTAKE VS DISCHARGE	0.193E+01	0.202E+00
08/07/79	1210	I5	0	5	0.110E-01	0.438E-02			
08/07/79	1212	D1	0	5	0.589E-02	0.588E-02			
08/07/79	1220	D2	0	4	0.977E-02	0.977E-02	INTAKE VS DISCHARGE	0.176E+00	0.837E+00
09/10/79	2048	I5	0	5	0.0	0.0			
09/10/79	2048	D2	0	5	0.104E-01	0.104E-01	INTAKE VS DISCHARGE	0.100E+01	0.348E+00
09/10/79	2048	I5	33	5	0.440E-02	0.200E-02			
09/10/79	2048	D2	33	4	0.829E-01	0.327E-01	INTAKE VS DISCHARGE	0.586E+01	0.218E-01
09/11/79	0455	I4	0	5	0.0	0.0			
09/11/70	0508	D1	0	5	0.274E-02	0.274E-02			
09/11/79	0455	D2	0	5	0.178E-01	0.178E-01	INTAKE VS DISCHARGE	0.849E+00	0.454E+00
09/11/79	0520	D1	28	4	0.887E-02	0.888E-02			
09/11/79	1210	I5	0	5	0.0	0.0			
09/11/79	1204	D1	0	4	0.171E-01	0.171E-01			
09/11/79	1202	D2	0	5	0.816E-02	0.816E-02	INTAKE VS DISCHARGE	0.739E+00	0.502E+00
10/08/79	2025	I5	0	5	0.190E-02	0.190E-02			
10/08/79	2010	D1	0	4	0.628E+00	0.474E+00			
10/08/79	2007	D2	0	5	0.484E-01	0.375E-01	INTAKE VS DISCHARGE	0.211E+01	0.169E+00
10/08/79	2025	I5	36	4	0.310E-01	0.310E-01			
10/08/79	2010	D1	36	5	0.800E-01	0.395E-01			
10/08/79	2007	D2	36	5	0.118E+00	0.372E-01	INTAKE VS DISCHARGE	0.131E+01	0.309E+00
10/09/79	0552	I5	0	4	0.175E-01	0.175E-01			
10/09/70	0534	D1	0	5	0.196E+00	0.154E+00			
10/09/79	0537	D2	0	5	0.106E-01	0.106E-01	INTAKE VS DISCHARGE	0.122E+01	0.334E+00
10/09/79	1220	I5	C	5	0.529E-01	0.513E-01			
10/09/79	1204	D1	0	5	0.129E+00	0.264E-01			
10/09/79	1205	D2	0	4	0.412E-01	0.255E-01	INTAKE VS DISCHARGE	0.159E+01	0.248E+00

TABLE 21. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5	0	5	0.115E+01	0.867E-01			
01/10/78	0730	D1	0	5	0.105E+01	0.796E-01	INTAKE VS. DISCHARGE	0.677E+00	0.438E+00
01/10/78	0730	I5	27	5	0.108E+01	0.133E+00			
01/10/78	0730	D1	27	5	0.861E+00	0.850E-01	INTAKE VS. DISCHARGE	0.189E+01	0.206E+00
01/11/78	1400	I5	0	4	0.765E+00	0.891E-01			
01/11/78	1400	D1	0	4	0.128E+01	0.988E-01	INTAKE VS. DISCHARGE	0.147E+02	0.974E-02
01/11/78	1400	I5	4	2	0.106E+01	0.600E-01			
01/11/78	1400	D1	4	4	0.108E+01	0.399E-01	INTAKE VS. DISCHARGE	0.536E-01	0.815E+00
01/11/78	2000	I5	0	5	0.669E+00	0.169E+00			
01/11/78	2000	D1	0	5	0.859E+00	0.483E-01	INTAKE VS. DISCHARGE	0.117E+01	0.311E+00
02/06/78	2001	I5	0	5	0.378E+00	0.681E-01			
02/06/78	1950	D1	0	4	0.528E+00	0.763E-01	INTAKE VS. DISCHARGE	0.216E+01	0.185E+00
02/06/78	2001	I5	33	5	0.371E+00	0.437E-01			
02/06/78	1950	D1	33	5	0.594E+00	0.858E-01	INTAKE VS. DISCHARGE	0.534E+01	0.499E-01
02/08/78	0650	I5	0	5	0.281E+00	0.748E-01			
02/08/78	0650	D1	0	4	0.268E+00	0.501E-01	INTAKE VS. DISCHARGE	0.175E-01	0.885E+00
02/07/78	1215	I5	0	5	0.349E+00	0.517E-01			
02/07/78	1215	D1	0	5	0.270E+00	0.322E-01	INTAKE VS. DISCHARGE	0.172E+01	0.226E+00
03/06/78	2017	I5	0	5	0.603E+00	0.920E-01			
03/06/78	2017	D1	0	5	0.664E+00	0.269E-01	INTAKE VS. DISCHARGE	0.405E+00	0.546E+00
03/06/78	2017	I5	37	5	0.140E+01	0.505E+00			
03/06/78	2017	D1	37	5	0.449E+00	0.806E-01	INTAKE VS. DISCHARGE	0.347E+01	0.994E-01
03/07/78	0550	I5	0	4	0.649E+00	0.302E-01			
03/07/78	0550	D1	0	5	0.498E+00	0.510E-01	INTAKE VS. DISCHARGE	0.568E+01	0.492E-01
03/07/78	1230	I5	0	5	0.526E+00	0.307E-01			
03/07/78	1230	D1	0	5	0.449E+00	0.341E-01	INTAKE VS. DISCHARGE	0.283E+01	0.131E+00
04/10/78	2105	I5	0	5	0.470E+00	0.316E-01			
04/10/78	2105	D2	0	5	0.639E+00	0.145E-01	INTAKE VS. DISCHARGE	0.237E+02	0.183E-02
04/10/78	2105	I5	38	5	0.478E+00	0.371E-01			
04/10/78	2105	D2	38	5	0.509E+00	0.493E-01	INTAKE VS. DISCHARGE	0.249E+00	0.632E+00
04/11/78	0440	I5	0	5	0.445E+00	0.500E-01			
04/11/78	0440	D2	0	5	0.427E+00	0.449E-01	INTAKE VS. DISCHARGE	0.686E-01	0.789E+00

TABLE 21. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5	0	5	0.449E+00	0.517E-01			
04/11/78	1225	D2	0	5	0.481E+00	0.571E-01	INTAKE VS. DISCHARGE	0.177E+00	0.682E+00
05/09/78	2215	I5	0	5	0.141E+01	0.752E-01			
05/09/78	2215	D2	0	5	0.169E+01	0.717E-01	INTAKE VS. DISCHARGE	0.737E+01	0.270E-01
05/09/78	2215	I5	39	5	0.158E+01	0.128E+00			
05/09/78	2215	D2	39	5	0.185E+01	0.141E+00	INTAKE VS. DISCHARGE	0.207E+01	0.188E+00
05/10/78	0350	I5	0	5	0.192E+01	0.151E+00			
05/10/78	0340	D2	0	5	0.206E+01	0.143E+00	INTAKE VS. DISCHARGE	0.453E+00	0.524E+00
05/10/78	1219	I5	0	5	0.162E+01	0.100E+00			
05/10/78	1205	D2	0	4	0.141E+01	0.255E+00	INTAKE VS. DISCHARGE	0.701E+00	0.434E+00
06/12/78	2307	I5	0	5	0.287E+01	0.568E+00			
06/12/78	2310	D1	0	5	0.246E+01	0.832E-01	INTAKE VS. DISCHARGE	0.510E+00	0.499E+00
06/13/78	0010	I5	34	5	0.254E+01	0.421E+00			
06/13/78	2307	D1	34	5	0.248E+01	0.141E+00	INTAKE VS. DISCHARGE	0.171E-01	0.886E+00
06/13/78	0218	I5	0	5	0.267E+01	0.126E+00			
06/13/78	0220	D1	0	4	0.242E+01	0.972E-01	INTAKE VS. DISCHARGE	0.214E+01	0.187E+00
06/13/78	1237	I5	0	5	0.217E+01	0.899E-01			
06/13/78	1237	D1	0	5	0.175E+01	0.501E-01	INTAKE VS. DISCHARGE	0.172E+02	0.401E-02
07/11/78	2307	I5	0	5	0.282E+01	0.144E+00			
07/11/78	2315	D1	0	5	0.254E+01	0.143E+00			
07/11/78	2321	D2	0	5	0.284E+01	0.128E+00	INTAKE VS. DISCHARGE	0.151E+01	0.261E+00
07/11/78	2307	I5	34	5	0.284E+01	0.235E+00			
07/11/12	2315	D1	34	5	0.240E+01	0.236E+00			
07/11/78	2321	D2	34	5	0.265E+01	0.243E+00	INTAKE VS. DISCHARGE	0.849E+00	0.454E+00
07/11/78	0240	I5	0	5	0.238E+01	0.935E-01			
07/11/78	0240	D1	0	5	0.245E+01	0.687E-01			
07/11/78	0246	D2	0	5	0.215E+01	0.128E+00	INTAKE VS. DISCHARGE	0.250E+01	0.125E+00
07/11/78	1212	I5	0	5	0.183E+01	0.104E+00			
07/11/78	1213	D1	0	5	0.165E+01	0.182E+00			
07/11/78	1225	D2	0	5	0.192E+01	0.154E+00	INTAKE VS. DISCHARGE	0.855E+00	0.452E+00
08/07/78	2243	I5	0	5	0.691E+00	0.758E-01			
08/07/78	2238	D1	0	5	0.719E+00	0.616E-01			
08/07/78	2219	D2	0	5	0.745E+00	0.717E-01	INTAKE VS. DISCHARGE	0.150E+00	0.858E+00

TABLE 21. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5 35	5	0.446E+00	0.176E-01			
08/07/78	2238	D1 35	3	0.315E+00	0.158E+00			
08/08/78	2219	D2 35	5	0.519E+00	0.856E-01	INTAKE VS. DISCHARGE	0.129E+01	0.318E+00
08/08/78	0340	I5 0	5	0.571E+00	0.581E-01			
08/08/78	0335	D1 0	5	0.713E+00	0.147E-01			
08/08/78	0335	D2 0	5	0.556E+00	0.300E-01	INTAKE VS. DISCHARGE	0.501E+01	0.271E-01
08/08/78	1233	I5 0	5	0.484E+00	0.317E-01			
08/08/78	1225	D1 0	5	0.399E+00	0.397E-01			
08/08/78	1229	D2 0	5	0.384E+00	0.495E-01	INTAKE VS. DISCHARGE	0.175E+01	0.217E+00
09/11/78	2115	I5 0	5	0.500E+00	0.465E-01			
09/11/78	2115	D1 0	5	0.401E+00	0.460E-01			
09/11/78	2115	D2 0	5	0.451E+00	0.580E-01	INTAKE VS. DISCHARGE	0.962E+00	0.412E+00
09/11/78	2115	I5 37	5	0.326E+00	0.203E-01			
09/11/78	2115	D1 37	5	0.433E+00	0.621E-01			
09/11/78	2115	D2 37	5	0.330E+00	0.287E-01	INTAKE VS. DISCHARGE	0.216E+01	0.159E+00
09/12/78	0555	I5 0	5	0.395E+00	0.783E-01			
09/12/78	0555	D1 0	5	0.487E+00	0.502E-01			
09/12/78	0554	D2 0	5	0.509E+00	0.496E-01	INTAKE VS. DISCHARGE	0.993E+00	0.401E+00
09/12/78	1207	I5 0	5	0.654E+00	0.285E-01			
09/12/78	1200	D1 0	5	0.578E+00	0.416E-01			
09/12/78	1215	D2 0	5	0.448E+00	0.114E+00	INTAKE VS. DISCHARGE	0.208E+01	0.169E+00
10/09/78	2007	I5 0	5	0.628E+00	0.263E+00			
10/09/78	2000	D1 0	5	0.179E+01	0.712E+00			
10/09/78	2004	D2 0	4	0.141E+01	0.211E+00	INTAKE VS DISCHARGE	0.159E+01	0.249E+00
10/09/78	2007	I5 36	5	0.119E+01	0.138E+00			
10/09/78	2000	D1 36	5	0.100E+01	0.133E+00			
10/09/78	2004	D2 36	5	0.995E+00	0.793E-01	INTAKE VS DISCHARGE	0.886E+00	0.440E+00
10/10/78	0533	I5 0	5	0.107E+01	0.460E-01			
10/10/78	0520	D1 0	4	0.938E+00	0.966E-01			
10/10/78	0523	D2 0	4	0.961E+00	0.826E-01	INTAKE VS DISCHARGE	0.102E+01	0.396E+00
10/10/78	1218	I5 0	5	0.108E+01	0.739E-01			
10/10/78	1200	D1 0	5	0.844E+00	0.861E-01			
10/10/78	1213	D2 0	5	0.969E+00	0.102E+00	INTAKE VS DISCHARGE	0.183E+01	0.203E+00

TABLE 21. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5 0	3	0.866E+00	0.809E-01			
11/13/78	1910	D1 0	5	0.649E+00	0.597E-01	INTAKE VS DISCHARGE	0.482E+01	0.712E-01
11/13/78	1925	I5 36	5	0.749E+00	0.101E+00			
11/13/78	1910	D1 36	5	0.480E+00	0.448E-01	INTAKE VS DISCHARGE	0.592E+01	0.414E-01
11/14/78	0615	I5 0	5	0.854E+00	0.680E-01			
11/14/78	0557	D1 0	4	0.786E+00	0.212E-01	INTAKE VS DISCHARGE	0.725E+00	0.426E+00
11/14/78	1215	I5 0	4	0.960E+00	0.119E+00			
11/14/78	1200	D1 0	5	0.109E+01	0.778E-01	INTAKE VS DISCHARGE	0.960E+00	0.362E+00
12/04/78	1910	I5 0	5	0.931E+00	0.111E+00			
12/04/78	1931	D1 0	5	0.101E+01	0.101E+00			
12/04/78	1900	D2 0	5	0.101E+01	0.506E-01	INTAKE VS DISCHARGE	0.260E+00	0.773E+00
12/04/78	1910	I5 34	5	0.912E+00	0.158E+00			
12/04/78	1931	D1 34	5	0.719E+00	0.851E-01			
12/04/78	1900	D2 34	5	0.572E+00	0.384E-01	INTAKE VS DISCHARGE	0.259E+01	0.117E+00
12/05/78	0620	I5 0	5	0.925E+00	0.473E-01			
12/05/78	0635	D1 0	5	0.894E+00	0.919E-01			
12/05/78	0610	D2 0	5	0.759E+00	0.511E-01	INTAKE VS DISCHARGE	0.175E+01	0.217E+00
12/05/78	1206	I5 0	4	0.941E+00	0.921E-01			
12/05/78	1215	D1 0	4	0.780E+00	0.115E+00			
12/05/78	1150	D2 0	3	0.905E+00	0.117E+00	INTAKE VS DISCHARGE	0.655E+00	0.547E+00

TABLE 22. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	5	0.289E+00	0.870E-01			
01/08/79	1916	D1	0	5	0.587E+00	0.791E-01			
01/08/79	1948	D2	0	5	0.787E+00	0.123E+00	INTAKE VS DISCHARGE	0.652E+01	0.130E-01
01/08/79	1930	I5	36	5	0.581E+00	0.620E-01			
01/08/79	1916	D1	36	4	0.802E+00	0.155E+00			
01/08/79	1948	D2	36	5	0.623E+00	0.282E-01	INTAKE VS DISCHARGE	0.172E+01	0.225E+00
01/09/79	0731	I5	0	5	0.583E+00	0.174E-01			
01/09/79	0716	D1	0	5	0.546E+00	0.530E-01			
01/09/79	0740	D2	0	5	0.624E+00	0.269E-01	INTAKE VS DISCHARGE	0.117E+01	0.344E+00
01/09/79	1208	I5	0	4	0.484E+00	0.120E+00			
01/09/79	1155	D1	0	5	0.517E+00	0.277E-01			
01/09/79	1219	D2	0	4	0.625E+00	0.540E-01	INTAKE VS DISCHARGE	0.975E+00	0.412E+00
02/12/79	2044	I5	0	5	0.660E+00	0.885E-01			
02/12/79	1958	D1	0	5	0.445E+00	0.578E-01			
02/12/79	2022	D2	0	5	0.390E+00	0.142E-01	INTAKE VS DISCHARGE	0.538E+01	0.224E-01
02/12/79	2044	I5	36	5	0.593E+00	0.134E+00			
02/12/79	1958	D1	36	4	0.336E+00	0.381E-01			
02/12/79	2022	D2	36	4	0.420E+00	0.465E-01	INTAKE VS DISCHARGE	0.196E+01	0.193E+00
02/13/79	0644	I5	0	3	0.427E+00	0.118E+00			
02/13/79	0612	D1	0	5	0.689E+00	0.422E-01			
02/13/79	0528	D2	0	4	0.570E+00	0.820E-01	INTAKE VS DISCHARGE	0.293E+01	0.107E+00
02/13/79	1225	I5	0	5	0.680E+00	0.647E-01			
02/13/79	1145	D1	0	5	0.653E+00	0.484E-01			
02/13/79	1158	D2	0	5	0.481E+00	0.626E-01	INTAKE VS DISCHARGE	0.337E+01	0.702E-01
03/05/79	2025	I5	0	5	0.552E+00	0.439E-01			
03/05/79	2049	D1	0	5	0.712E+00	0.462E-01			
03/05/79	2102	D2	0	5	0.710E+00	0.111E+00	INTAKE VS DISCHARGE	0.155E+01	0.252E+00
03/05/79	2025	I5	36	5	0.718E+00	0.352E-01			
03/05/79	2048	D1	36	5	0.524E+00	0.738E-01			
03/05/79	2102	D2	36	5	0.683E+00	0.856E-01	INTAKE VS DISCHARGE	0.230E+01	0.144E+00
03/06/79	0620	I5	0	4	0.631E+00	0.615E-01			
03/06/79	0552	D1	0	5	0.728E+00	0.261E-01			
03/06/79	0605	D2	0	5	0.607E+00	0.459E-01	INTAKE VS DISCHARGE	0.219E+01	0.160E+00

TABLE 22. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	5	0.631E+00	0.851E-01			
03/06/79	1238	D1	0	4	0.686E+00	0.163E+00			
03/06/79	1210	D2	0	4	0.701E+00	0.645E-01	INTAKE VS DISCHARGE	0.123E+00	0.880E+00
04/09/79	2127	I5	0	4	0.151E+01	0.133E+00			
04/09/79	2122	D2	0	5	0.146E+01	0.420E-01	INTAKE VS DISCHARGE	0.132E+00	0.721E+00
04/09/79	2127	I5	32	5	0.135E+01	0.112E+00			
04/09/79	2122	D2	32	5	0.120E+01	0.134E+00	INTAKE VS DISCHARGE	0.782E+00	0.405E+00
04/10/79	0429	I5	0	5	0.178E+01	0.634E-01			
04/10/79	0418	D2	0	5	0.161E+01	0.922E-01	INTAKE VS DISCHARGE	0.236E+01	0.163E+00
04/10/79	1136	I5	0	5	0.156E+01	0.250E+00			
04/10/79	1132	D2	0	5	0.157E+01	0.919E-01	INTAKE VS DISCHARGE	0.223E-02	0.953E+00
05/07/79	2200	I5	0	4	0.170E+01	0.110E+00			
05/07/79	2201	D2	0	5	0.177E+01	0.541E-01	INTAKE VS DISCHARGE	0.365E+00	0.567E+00
05/07/79	2229	I5	36	5	0.173E+01	0.798E-01			
05/07/79	2229	D2	36	5	0.148E+01	0.913E-01	INTAKE VS DISCHARGE	0.432E+01	0.712E-01
05/08/79	0327	I5	0	4	0.187E+01	0.174E+00			
05/08/79	0330	D2	0	4	0.102E+01	0.373E+00	INTAKE VS DISCHARGE	0.423E+01	0.861E-01
05/08/79	1208	I5	0	5	0.180E+01	0.140E+00			
05/08/79	1205	D2	0	5	0.150E+01	0.165E+00	INTAKE VS DISCHARGE	0.183E+01	0.213E+00
07/10/79	2302	I5	0	5	0.286E+00	0.606E-01			
07/10/79	2302	D2	0	4	0.479E+00	0.944E-02	INTAKE VS DISCHARGE	0.773E+01	0.280E-01
07/10/79	2402	I5	32	4	0.609E+00	0.852E-01			
07/10/79	2402	D2	32	5	0.413E+00	0.101E+00	INTAKE VS. DISCHARGE	0.206E+01	0.194E+00
07/10/79	0252	I5	0	4	0.550E+00	0.789E-01			
07/10/79	0249	D2	0	3	0.643E+00	0.104E+00	INTAKE VS DISCHARGE	0.528E+00	0.503E+00
07/10/79	1208	I5	0	5	0.436E+00	0.338E-01			
07/10/79	1205	D2	0	5	0.382E+00	0.103E+00	INTAKE VS DISCHARGE	0.256E+00	0.627E+00
08/06/79	2217	I5	0	5	0.290E+00	0.598E-01			
08/06/79	2223	D1	0	5	0.184E+00	0.762E-01			
08/07/79	0004	D2	0	4	0.227E+00	0.550E-01	INTAKE VS DISCHARGE	0.694E+00	0.522E+00
08/06/79	2217	I5	36	5	0.151E+00	0.513E-01			
08/06/79	2223	D1	36	5	0.213E+00	0.629E-01			
08/07/79	0004	D2	36	5	0.280E+00	0.365E-01	INTAKE VS DISCHARGE	0.157E+01	0.248E+00

TABLE 22. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT HAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	3	0.404E+00	0.642E-01			
08/07/79	0335	D1	0	4	0.374E+00	0.474E-01			
08/07/79	0340	D2	0	5	0.294E+00	0.336E-01	INTAKE VS DISCHARGE	0.163E+01	0.251E+00
08/07/79	1210	I5	0	5	0.227E+00	0.377E-01			
08/07/79	1212	D1	0	5	0.201E+00	0.275E-01			
08/07/79	1220	D2	0	4	0.167E+00	0.804E-01	INTAKE VS DISCHARGE	0.356E+00	0.709E+00
09/10/79	2048	I5	0	5	0.310E+00	0.458E-01			
09/10/79	2048	D2	0	5	0.624E+00	0.924E-01	INTAKE VS DISCHARGE	0.929E+01	0.166E-01
09/10/79	2048	I5	33	5	0.220E+00	0.277E-01			
09/10/79	2048	D2	33	4	0.362E+00	0.610E-01	INTAKE VS DISCHARGE	0.266E+01	0.120E+00
09/11/79	0455	I4	0	5	0.603E+00	0.411E-01			
09/11/70	0508	D1	0	5	0.427E+00	0.329E-01			
09/11/79	0455	D2	0	5	0.453E+00	0.418E-01	INTAKE VS DISCHARGE	0.597E+01	0.168E-01
09/11/79	0520	D1	28	4	0.234E+00	0.549E-01			
09/11/79	1210	I5	0	5	0.372E+00	0.631E-01			
09/11/79	1204	D1	0	4	0.450E+00	0.476E-01			
09/11/79	1202	D2	0	5	0.393E+00	0.642E-01	INTAKE VS DISCHARGE	0.410E+00	0.675E+00
10/08/79	2025	I5	0	5	0.500E+00	0.612E-01			
10/08/79	2010	D1	0	4	0.289E+00	0.109E+00			
10/08/79	2007	D2	0	5	0.398E+00	0.509E-01	INTAKE VS DISCHARGE	0.202E+01	0.181E+00
10/08/79	2025	I5	36	4	0.364E+00	0.491E-01			
10/08/79	2010	D1	36	5	0.524E+00	0.973E-01			
10/08/79	2007	D2	36	5	0.763E+00	0.252E-01	INTAKE VS DISCHARGE	0.873E+01	0.620E-02
10/09/79	0552	I5	0	4	0.645E+00	0.680E-01			
10/09/70	0534	D1	0	5	0.107E+01	0.428E+00			
10/09/79	0537	D2	0	5	0.704E+00	0.785E-01	INTAKE VS DISCHARGE	0.719E+00	0.511E+00
10/09/79	1220	I5	0	5	0.836E+00	0.118E+00			
10/09/79	1204	D1	0	5	0.915E+00	0.116E+00			
10/09/79	1205	D2	0	4	0.740E+00	0.913E-01	INTAKE VS DISCHARGE	0.574E+00	0.582E+00

TABLE 23. MEAN PHAEOPHYTIN A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANLAYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5 0	5	0.842E+00	0.136E+00			
01/10/78	0730	D1 0	5	0.121E+01	0.236E+00	INTAKE VS. DISCHARGE	0.179E+01	0.217E+00
01/10/78	0730	I5 27	5	0.109E+01	0.130E+00			
01/10/78	0730	D1 27	5	0.146E+01	0.331E+00	INTAKE VS. DISCHARGE	0.112E+01	0.323E+00
01/11/78	1400	I5 0	4	0.109E+01	0.895E-01			
01/11/78	1400	D1 0	4	0.718E+00	0.223E+00	INTAKE VS. DISCHARGE	0.237E+01	0.175E+00
01/11/78	1400	I5 4	2	0.881E+00	0.417E-06			
01/11/78	1400	D1 4	4	0.605E+00	0.357E+00	INTAKE VS. DISCHARGE	0.266E+00	0.632E+00
01/11/78	2000	I5 0	5	0.510E+00	0.122E+00			
01/11/78	2000	D1 0	5	0.468E+00	0.142E+00	INTAKE VS. DISCHARGE	0.518E-01	0.813E+00
02/06/78	2001	I5 0	5	0.114E+00	0.467E-01			
02/06/78	1950	D1 0	4	0.442E+00	0.634E-01	INTAKE VS. DISCHARGE	0.182E+02	0.461E-02
02/06/78	2001	I5 33	5	0.605E+00	0.942E-01			
02/06/78	1950	D1 33	5	0.205E+00	0.564E-01	INTAKE VS. DISCHARGE	0.132E+02	0.744E-02
02/08/78	0650	I5 0	5	0.303E+00	0.125E+00			
02/08/78	0650	D1 0	4	0.379E+00	0.130E+00	INTAKE VS. DISCHARGE	0.172E+00	0.687E+00
02/07/78	1215	I5 0	5	0.676E+00	0.206E+00			
02/07/78	1215	D1 0	5	0.321E+00	0.618E-01	INTAKE VS. DISCHARGE	0.272E+01	0.137E+00
03/06/78	2017	I5 0	5	0.578E+00	0.232E+00			
03/06/78	2017	D1 0	5	0.751E+00	0.129E+00	INTAKE VS. DISCHARGE	0.424E+00	0.537E+00
03/06/78	2017	I5 37	5	0.104E+01	0.518E+00			
03/06/78	2017	D1 37	5	0.112E+00	0.722E-01	INTAKE VS. DISCHARGE	0.315E+01	0.114E+00
03/07/78	0550	I5 0	4	0.780E+00	0.107E+00			
03/07/78	0550	D1 0	5	0.664E+00	0.132E+00	INTAKE VS. DISCHARGE	0.423E+00	0.539E+00
03/07/78	1230	I5 0	5	0.821E+00	0.238E+00			
03/07/78	1230	D1 0	5	0.578E+00	0.271E+00	INTAKE VS. DISCHARGE	0.454E+00	0.523E+00
04/10/78	2105	I5 0	5	0.658E+00	0.408E+00			
04/10/78	2105	D2 0	5	0.423E+00	0.170E+00	INTAKE VS. DISCHARGE	0.283E+00	0.611E+00
04/10/78	2105	I5 38	5	0.472E+00	0.163E+00			
04/10/78	2105	D2 38	5	0.328E+00	0.889E-01	INTAKE VS. DISCHARGE	0.603E+00	0.464E+00
04/11/78	0440	I5 0	5	0.180E+01	0.198E+00			
04/11/78	0440	D2 0	5	0.126E+01	0.397E+00	INTAKE VS. DISCHARGE	0.150E+01	0.256E+00

TABLE 23. MEAN PHAEOPHYTIN A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANLAYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5	0	5	0.625E+00	0.192E+00			
04/11/78	1225	D2	0	5	0.421E+00	0.195E+00	INTAKE VS. DISCHARGE	0.559E+00	0.480E+00
05/09/78	2215	I5	0	5	0.182E+01	0.208E+00			
05/09/78	2215	D2	0	5	0.108E+01	0.293E+00	INTAKE VS. DISCHARGE	0.428E+01	0.723E-01
05/09/78	2215	I5	39	5	0.170E+01	0.134E+00			
05/09/78	2215	D2	39	5	0.161E+01	0.371E+00	INTAKE VS. DISCHARGE	0.467E-01	0.821E+00
05/10/78	0350	I5	0	5	0.949E+00	0.820E-01			
05/10/78	0340	D2	0	5	0.992E+00	0.190E+00	INTAKE VS. DISCHARGE	0.420E-01	0.829E+00
05/10/78	1219	I5	0	5	0.694E+00	0.214E+00			
05/10/78	1205	D2	0	4	0.501E+00	0.217E+00	INTAKE VS. DISCHARGE	0.388E+00	0.556E+00
06/12/78	2307	I5	0	5	0.297E+01	0.369E+00			
06/12/78	2310	D1	0	5	0.203E+01	0.211E+00	INTAKE VS. DISCHARGE	0.495E+01	0.569E-01
06/13/78	0010	I5	34	5	0.243E+01	0.491E+00			
06/13/78	2307	D1	34	5	0.235E+01	0.220E+00	INTAKE VS. DISCHARGE	0.232E-01	0.869E+00
06/13/78	0218	I5	0	5	0.254E+01	0.294E+00			
06/13/78	0220	D1	0	4	0.198E+01	0.672E+00	INTAKE VS. DISCHARGE	0.689E+00	0.438E+00
06/13/78	1237	I5	0	5	0.117E+01	0.258E+00			
06/13/78	1237	D1	0	5	0.117E+01	0.262E+00	INTAKE VS. DISCHARGE	0.358E-04	0.983E+00
07/11/78	2307	I5	0	5	0.363E+01	0.919E+00			
07/11/78	2315	D1	0	5	0.366E+01	0.847E+00			
07/11/78	2321	D2	0	5	0.391E+01	0.873E+00	INTAKE VS. DISCHARGE	0.303E-01	0.967E+00
07/11/78	2307	I5	34	5	0.125E+01	0.290E+00			
07/11/12	2315	D1	34	5	0.153E+01	0.319E+00			
07/11/78	2321	D2	34	5	0.193E+01	0.342E+00	INTAKE VS. DISCHARGE	0.116E+01	0.348E+00
07/11/78	0240	I5	0	5	0.203E+01	0.414E+00			
07/11/78	0240	D1	0	5	0.199E+01	0.578E+00			
07/11/78	0246	D2	0	5	0.265E+01	0.181E+00	INTAKE VS. DISCHARGE	0.768E+00	0.488E+00
07/11/78	1212	I5	0	5	0.103E+01	0.524E+00			
07/11/78	1213	D1	0	5	0.103E+01	0.257E+00			
07/11/78	1225	D2	0	5	0.858E+00	0.242E+00	INTAKE VS. DISCHARGE	0.753E-01	0.923E+00
08/07/78	2243	I5	0	5	0.144E+01	0.103E+00			
08/07/78	2238	D1	0	5	0.121E+01	0.954E-01			
08/07/78	2219	D2	0	5	0.987E+00	0.108E+00	INTAKE VS. DISCHARGE	0.482E+01	0.301E-01

TABLE 23. MEAN PHAEOPHYTIN A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANLAYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5	35	5	0.101E+01	0.664E-01			
08/07/78	2238	D1	35	3	0.726E+00	0.125E+00			
08/08/78	2219	D2	35	5	0.103E+01	0.114E+00	INTAKE VS. DISCHARGE	0.224E+01	0.158E+00
08/08/78	0340	I5	0	5	0.862E+00	0.700E-01			
08/08/78	0335	D1	0	5	0.126E+01	0.144E+00			
08/08/78	0335	D2	0	5	0.120E+01	0.116E+00	INTAKE VS. DISCHARGE	0.355E+01	0.628E-01
08/08/78	1233	I5	0	5	0.348E+00	0.892E-01			
08/08/78	1225	D1	0	5	0.679E+00	0.989E-01			
08/08/78	1229	D2	0	5	0.504E+00	0.580E-01	INTAKE VS. DISCHARGE	0.390E+01	0.506E-01
09/11/78	2115	I5	0	5	0.230E+00	0.802E-01			
09/11/78	2115	D1	0	5	0.391E+00	0.973E-01			
09/11/78	2115	D2	0	5	0.368E+00	0.119E+00	INTAKE VS. DISCHARGE	0.760E+00	0.492E+00
09/11/78	2115	I5	37	5	0.581E+00	0.469E-01			
09/11/78	2115	D1	37	5	0.333E+00	0.923E-01			
09/11/78	2115	D2	37	5	0.240E+00	0.132E+00	INTAKE VS. DISCHARGE	0.332E+01	0.725E-01
09/12/78	0555	I5	0	5	0.570E+00	0.855E-01			
09/12/78	0555	D1	0	5	0.749E+00	0.705E-01			
09/12/78	0554	D2	0	5	0.550E+00	0.110E+00	INTAKE VS. DISCHARGE	0.147E+01	0.270E+00
09/12/78	1207	I5	0	5	0.746E+00	0.656E-01			
09/12/78	1200	D1	0	5	0.747E+00	0.784E-01			
09/12/78	1215	D2	0	5	0.799E+00	0.841E-01	INTAKE VS. DISCHARGE	0.156E+00	0.853E+00
10/09/78	2007	I5	0	5	0.139E+01	0.332E+00			
10/09/78	2000	D1	0	5	0.180E+01	0.513E+00			
10/09/78	2004	D2	0	4	0.551E+00	0.215E+00	INTAKE VS DISCHARGE	0.240E+01	0.138E+00
10/09/78	2007	I5	36	5	0.781E+00	0.245E+00			
10/09/78	2000	D1	36	5	0.231E+01	0.389E+00			
10/09/78	2004	D2	36	5	0.252E+01	0.277E+00	INTAKE VS DISCHARGE	0.938E+01	0.427E-02
10/10/78	0533	I5	0	5	0.863E+00	0.137E+00			
10/10/78	0520	D1	0	4	0.527E+00	0.128E+00			
10/10/78	0523	D2	0	4	0.507E+00	0.244E+00	INTAKE VS DISCHARGE	0.144E+01	0.283E+00
10/10/78	1218	I5	0	5	0.792E+00	0.172E+00			
10/10/78	1200	D1	0	5	0.937E+00	0.274E+00			
10/10/78	1213	D2	0	5	0.923E+00	0.215E+00	INTAKE VS DISCHARGE	0.126E+00	0.877E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5	0	3	0.457E+00	0.278E+00			
11/13/78	1910	D1	0	5	0.745E+00	0.211E+00	INTAKE VS DISCHARGE	0.687E+00	0.442E+00
11/13/78	1925	I5	36	5	0.378E+00	0.117E+00			
11/13/78	1910	D1	36	5	0.752E+00	0.131E+00	INTAKE VS DISCHARGE	0.452E+01	0.663E-01
11/14/78	0615	I5	0	5	0.686E+00	0.175E+00			
11/14/78	0557	D1	0	4	0.925E+00	0.314E+00	INTAKE VS DISCHARGE	0.494E+00	0.508E+00
11/14/78	1215	I5	0	4	0.669E+00	0.293E+00			
11/14/78	1200	D1	0	5	0.131E+01	0.281E+00	INTAKE VS DISCHARGE	0.245E+01	0.162E+00
12/04/78	1910	I5	0	5	0.219E+01	0.934E+00			
12/04/78	1931	D1	0	5	0.303E+01	0.129E+01			
12/04/78	1900	D2	0	5	0.595E+00	0.183E+00	INTAKE VS DISCHARGE	0.178E+01	0.211E+00
12/04/78	1910	I5	34	5	0.998E+00	0.230E+00			
12/04/78	1931	D1	34	5	0.493E+00	0.188E+00			
12/04/78	1900	D2	34	5	0.507E+00	0.126E+00	INTAKE VS DISCHARGE	0.237E+01	0.137E+00
12/05/78	0620	I5	0	5	0.374E+00	0.222E+00			
12/05/78	0635	D1	0	5	0.647E+00	0.241E+00			
12/05/78	0610	D2	0	5	0.240E+01	0.126E+01	INTAKE VS DISCHARGE	0.212E+01	0.164E+00
12/05/78	1206	I5	0	4	0.215E+01	0.969E+00			
12/05/78	1215	D1	0	4	0.743E+00	0.279E+00			
12/05/78	1150	D2	0	3	0.495E+00	0.172E+00	INTAKE VS DISCHARGE	0.191E+01	0.211E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	5	0.200E+00	0.967E-01			
01/08/79	1916	D1	0	5	0.116E+00	0.402E-C1			
01/08/79	1948	D2	0	5	0.122E+00	0.559E-01	INTAKE VS DISCHARGE	0.464E+00	0.642E+00
01/08/79	1930	I5	36	5	0.918E-01	0.253E-01			
01/08/79	1916	D1	36	4	0.218E+00	0.963E-01			
01/08/79	1948	D2	36	5	0.300E+00	0.134E+00	INTAKE VS DISCHARGE	0.125E+01	0.324E+00
01/09/79	0731	I5	0	5	0.197E+00	0.387E-01			
01/09/79	0716	D1	0	5	0.385E+00	0.158E+C0			
01/09/79	0740	D2	0	5	0.716E-01	0.467E-01	INTAKE VS DISCHARGE	0.261E+01	0.116E+00
01/09/79	1208	I5	0	4	0.159E+00	0.986E-01			
01/09/79	1155	D1	0	5	0.266E+00	0.105E+C0			
01/09/79	1219	D2	0	4	0.272E+00	0.964E-01	INTAKE VS DISCHARGE	0.373E+00	0.698E+00
02/12/79	2044	I5	0	5	0.205E+00	0.729E-01			
02/12/79	1958	D1	0	5	0.360E+00	0.165E+C0			
02/12/79	2022	D2	0	5	0.272E+00	0.848E-01	INTAKE VS DISCHARGE	0.456E+00	0.646E+00
02/12/79	2044	I5	36	5	0.174E+00	0.120E+C0			
02/12/79	1958	D1	36	4	0.140E+00	0.140E+00			
02/12/79	2022	D2	36	4	0.546E+00	0.236E+00	INTAKE VS DISCHARGE	0.175E+01	0.223E+00
02/13/79	0644	I5	0	3	0.585E+00	0.318E+C0			
02/13/79	0612	D1	0	5	0.365E+00	0.764E-01			
02/13/79	0628	D2	0	4	0.270E+00	0.138E+00	INTAKE VS DISCHARGE	0.827E+00	0.471E+00
02/13/79	1225	I5	C	5	0.256E+00	0.152E+C0			
02/13/79	1145	D1	0	5	0.515E+00	0.106E+00			
02/13/79	1158	D2	0	5	0.990E+00	0.235E+00	INTAKE VS DISCHARGE	0.465E+01	0.330E-01
03/05/79	2025	I5	0	5	0.990E+00	0.254E+C0			
03/05/79	2048	D1	0	5	0.439E+00	0.127E+C0			
03/05/79	2102	D2	0	5	0.389E+00	0.191E+00	INTAKE VS DISCHARGE	0.285E+01	0.985E-01
03/05/79	2025	I5	36	5	0.782E+00	0.153E+00			
03/05/79	2048	D1	36	5	0.925E+00	0.109E+C0			
03/05/79	2102	D2	36	5	0.136E+01	0.331E+00	INTAKE VS DISCHARGE	0.186E+01	0.199E+00
03/06/79	0620	I5	0	4	0.106E+01	0.115E+00			
03/06/79	0552	D1	0	5	0.103E+01	0.124E+00			
03/06/79	0605	D2	0	5	0.126E+01	0.143E+00	INTAKE VS DISCHARGE	0.773E+00	0.488E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	5	0.116E+01	0.693E-01			
03/06/79	1238	D1	0	4	0.158E+01	0.534E+00			
03/06/79	1210	D2	0	4	0.819E+00	0.318E+00	INTAKE VS DISCHARGE	0.122E+01	0.336E+00
04/09/79	2127	I5	0	4	0.157E+01	0.191E+00			
04/09/79	2122	D2	0	5	0.855E+00	0.112E+00	INTAKE VS DISCHARGE	0.116E+02	0.122E-01
04/09/79	2127	I5	32	5	0.228E+00	0.950E-01			
04/09/79	2122	D2	32	5	0.641E+00	0.323E+00	INTAKE VS DISCHARGE	0.151E+01	0.255E+00
04/10/79	0429	I5	0	5	0.113E+01	0.335E+00			
04/10/79	0418	D2	0	5	0.562E+00	0.134E+00	INTAKE VS DISCHARGE	0.249E+01	0.153E+00
04/10/79	1136	I5	0	5	0.639E+00	0.270E+00			
04/10/79	1132	D2	0	5	0.0	0.0	INTAKE VS DISCHARGE	0.561E+01	0.456E-01
05/07/79	2200	I5	0	4	0.201E+01	0.409E+00			
05/07/79	2201	D2	0	5	0.152E+01	0.359E+00	INTAKE VS DISCHARGE	0.843E+00	0.392E+00
05/07/79	2229	I5	36	5	0.962E+00	0.250E+00			
05/07/79	2229	D2	36	5	0.741E+00	0.330E+00	INTAKE VS DISCHARGE	0.284E+00	0.610E+00
05/08/79	0327	I5	0	4	0.769E+00	0.777E-01			
05/08/79	0330	D2	0	4	0.462E+00	0.170E+00	INTAKE VS DISCHARGE	0.269E+01	0.152E+00
05/08/79	1208	I5	0	5	0.868E+00	0.216E+00			
05/08/79	1205	D2	0	5	0.789E+00	0.133E+00	INTAKE VS DISCHARGE	0.154E+00	0.701E+00
07/10/79	2302	I5	0	5	0.138E+00	0.134E+00			
07/10/79	2302	D2	0	4	0.159E+00	0.964E-01	INTAKE VS DISCHARGE	0.149E-01	0.893E+00
07/10/79	2402	I5	32	4	0.412E+00	0.226E+00			
07/10/79	2402	D2	32	5	0.711E+00	0.167E+00	INTAKE VS. DISCHARGE	0.119E+01	0.313E+00
07/10/79	0252	I5	0	4	0.559E+00	0.277E+00			
07/10/79	0249	D2	0	3	0.628E+00	0.361E+00	INTAKE VS DISCHARGE	0.239E-01	0.869E+00
07/10/79	1208	I5	0	5	0.120E+01	0.252E+00			
07/10/79	1205	D2	0	5	0.152E+00	0.958E-01	INTAKE VS DISCHARGE	0.150E+02	0.551E-02
08/06/79	2217	I5	0	5	0.102E+00	0.623E-01			
08/06/79	2223	D1	0	5	0.694E-01	0.314E-01			
08/07/79	0004	D2	0	4	0.263E+00	0.124E+00	INTAKE VS DISCHARGE	0.182E+01	0.209E+00
08/06/79	2217	I5	36	5	0.150E+00	0.774E-01			
08/06/79	2223	D1	36	5	0.178E+00	0.840E-01			
08/07/79	0004	D2	36	5	0.716E-01	0.487E-01	INTAKE VS DISCHARGE	0.594E+00	0.570E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	3	0.694E-01	0.373E-01			
08/07/79	0335	D1	0	4	0.103E+00	0.661E-01			
08/07/79	0340	D2	0	5	0.251E+00	0.973E-01	INTAKE VS DISCHARGE	0.144E+01	0.287E+00
08/07/79	1210	I5	0	5	0.124E+00	0.818E-01			
08/07/79	1212	D1	0	5	0.362E-01	0.237E-01			
08/07/79	1220	D2	0	4	0.147E-01	0.147E-01	INTAKE VS DISCHARGE	0.117E+01	0.346E+00
09/10/79	2048	I5	0	5	0.437E-01	0.201E-01			
09/10/79	2048	D2	0	5	0.301E+00	0.142E+00	INTAKE VS DISCHARGE	0.324E+01	0.109E+00
09/10/79	2048	I5	33	5	0.250E+00	0.886E-01			
09/10/79	2048	D2	33	4	0.480E-01	0.480E-01	INTAKE VS DISCHARGE	0.131E+01	0.312E+00
09/11/79	0455	I4	0	5	0.0	0.0			
09/11/70	0508	D1	0	5	0.248E+00	0.141E+00			
09/11/79	0455	D2	0	5	0.598E-01	0.487E-01	INTAKE VS DISCHARGE	0.225E+01	0.149E+00
09/11/79	0520	D1	28	4	0.175E+00	0.116E+00			
09/11/79	1210	I5	0	5	0.417E-01	0.403E-01			
09/11/79	1204	D1	0	4	0.103E+00	0.103E+00			
09/11/79	1202	D2	0	5	0.341E-01	0.225E-01	INTAKE VS DISCHARGE	0.395E+00	0.684E+00
10/08/79	2025	I5	0	5	0.596E+00	0.154E+00			
10/08/79	2010	D1	0	4	0.479E+00	0.984E-01			
10/08/79	2007	D2	0	5	0.624E+00	0.295E+00	INTAKE VS DISCHARGE	0.120E+00	0.883E+00
10/08/79	2025	I5	36	4	0.184E+00	0.693E-01			
10/08/79	2010	D1	36	5	0.468E+00	0.226E+00			
10/08/79	2007	D2	36	5	0.876E-01	0.876E-01	INTAKE VS DISCHARGE	0.173E+01	0.223E+00
10/09/79	0552	I5	0	4	0.926E+00	0.310E+00			
10/09/70	0534	D1	0	5	0.931E+00	0.258E+00			
10/09/79	0537	D2	0	5	0.994E+00	0.133E+00	INTAKE VS DISCHARGE	0.259E-01	0.972E+00
10/09/79	1220	I5	0	5	0.121E+01	0.233E+00			
10/09/79	1204	D1	0	5	0.106E+01	0.177E+00			
10/09/79	1205	D2	0	4	0.200E+01	0.446E+00	INTAKE VS DISCHARGE	0.295E+01	0.954E-01

TABLE 25. MEAN PHAEOPHYTIN A TO CHLOROPHYLL A RATIO WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/10/78	0730	I5	0	5	0.196E+00	0.371E-01			
01/10/78	0730	D1	0	5	0.244E+00	0.363E-01	INTAKE VS. DISCHARGE	0.858E+00	0.384E+00
01/10/78	0730	I5	27	5	0.240E+00	0.255E-01			
01/10/78	0730	D1	27	5	0.368E+00	0.911E-01	INTAKE VS. DISCHARGE	0.184E+01	0.212E+00
01/11/78	1400	I5	0	4	0.286E+00	0.267E-01			
01/11/78	1400	D1	0	4	0.984E-01	0.301E-01	INTAKE VS. DISCHARGE	0.218E+02	0.448E-02
01/11/78	1400	I5	4	2	0.232E+00	0.0			
01/11/78	1400	D1	4	4	0.198E+00	0.121E+00	INTAKE VS. DISCHARGE	0.341E-01	0.848E+00
01/11/78	2000	I5	0	5	0.161E+00	0.312E-01			
01/11/78	2000	D1	0	5	0.130E+00	0.380E-01	INTAKE VS. DISCHARGE	0.388E+00	0.554E+00
02/06/78	2001	I5	0	5	0.100E+00	0.417E-01			
02/06/78	1950	D1	0	4	0.332E+00	0.628E-01	INTAKE VS. DISCHARGE	0.102E+02	0.161E-01
02/06/78	2001	I5	33	5	0.463E+00	0.833E-01			
02/06/78	1950	D1	33	5	0.133E+00	0.372E-01	INTAKE VS. DISCHARGE	0.131E+02	0.758E-02
02/08/78	0650	I5	0	5	0.239E+00	0.109E+00			
02/08/78	0650	D1	0	4	0.368E+00	0.162E+00	INTAKE VS. DISCHARGE	0.472E+00	0.518E+00
02/07/78	1215	I5	0	5	0.127E+01	0.664E+00			
02/07/78	1215	D1	0	5	0.267E+00	0.679E-01	INTAKE VS. DISCHARGE	0.226E+01	0.171E+00
03/06/78	2017	I5	0	5	0.314E+00	0.146E+00			
03/06/78	2017	D1	0	5	0.364E+00	0.794E-01	INTAKE VS. DISCHARGE	0.900E-01	0.763E+00
03/06/78	2017	I5	37	5	0.447E+00	0.235E+00			
03/06/78	2017	D1	37	5	0.445E-01	0.296E-01	INTAKE VS. DISCHARGE	0.289E+01	0.127E+00
03/07/78	0550	I5	0	4	0.428E+00	0.802E-01			
03/07/78	0550	D1	0	5	0.356E+00	0.782E-01	INTAKE VS. DISCHARGE	0.405E+00	0.548E+00
03/07/78	1230	I5	0	5	0.511E+00	0.171E+00			
03/07/78	1230	D1	0	5	0.402E+00	0.200E+00	INTAKE VS. DISCHARGE	0.173E+00	0.686E+00
04/10/78	2105	I5	0	5	0.426E+00	0.346E+00			
04/10/78	2105	D2	0	5	0.136E+00	0.568E-01	INTAKE VS. DISCHARGE	0.683E+00	0.436E+00
04/10/78	2105	I5	38	5	0.147E+00	0.575E-01			
04/10/78	2105	D2	38	5	0.102E+00	0.313E-01	INTAKE VS. DISCHARGE	0.481E+00	0.511E+00
04/11/78	0440	I5	0	5	0.113E+01	0.247E+00			
04/11/78	0440	D2	0	5	0.812E+00	0.367E+00	INTAKE VS. DISCHARGE	0.533E+00	0.490E+00

TABLE 25. MEAN PHAEOPHYTIN A TO CHLOROPHYLL A RATIO WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
04/11/78	1225	I5 0	5	0.234E+00	0.821E-01			
04/11/78	1225	D2 0	5	0.142E+00	0.717E-01	INTAKE VS. DISCHARGE	0.705E+00	0.429E+00
05/09/78	2215	I5 0	5	0.161E+00	0.202E-01			
05/09/78	2215	D2 0	5	0.899E-01	0.252E-01	INTAKE VS. DISCHARGE	0.482E+01	0.596E-01
05/09/78	2215	I5 39	5	0.133E+00	0.101E-01			
05/09/78	2215	D2 39	5	0.131E+00	0.360E-01	INTAKE VS. DISCHARGE	0.247E-02	0.951E+00
05/10/78	0350	I5 0	5	0.703E-01	0.750E-02			
05/10/78	0340	D2 0	5	0.720E-01	0.132E-01	INTAKE VS. DISCHARGE	0.648E-02	0.926E+00
05/10/78	1219	I5 0	5	0.601E-01	0.190E-01			
05/10/78	1205	D2 0	4	0.451E-01	0.184E-01	INTAKE VS. DISCHARGE	0.310E+00	0.596E+00
06/12/78	2307	I5 0	5	0.249E+00	0.316E-01			
06/12/78	2310	D1 0	5	0.169E+00	0.203E-01	INTAKE VS. DISCHARGE	0.454E+01	0.658E-01
06/13/78	0010	I5 34	5	0.225E+00	0.505E-01			
06/13/78	2307	D1 34	5	0.198E+00	0.211E-01	INTAKE VS. DISCHARGE	0.247E+00	0.633E+00
06/13/78	0218	I5 0	5	0.166E+00	0.222E-01			
06/13/78	0220	D1 0	4	0.154E+00	0.552E-01	INTAKE VS. DISCHARGE	0.515E-01	0.814E+00
06/13/78	1237	I5 0	5	0.943E-01	0.219E-01			
06/13/78	1237	D1 0	5	0.102E+00	0.251E-01	INTAKE VS. DISCHARGE	0.591E-01	0.802E+00
07/11/78	2307	I5 0	5	0.241E+00	0.723E-01			
07/11/78	2315	D1 0	5	0.259E+00	0.675E-01			
07/11/78	2321	D2 0	5	0.254E+00	0.801E-01	INTAKE VS. DISCHARGE	0.161E-01	0.982E+00
07/11/78	2307	I5 34	5	0.654E-01	0.154E-01			
07/11/12	2315	D1 34	5	0.975E-01	0.219E-01			
07/11/78	2321	D2 34	5	0.100E+00	0.180E-01	INTAKE VS. DISCHARGE	0.107E+01	0.376E+00
07/11/78	0240	I5 0	5	0.134E+00	0.304E-01			
07/11/78	0240	D1 0	5	0.140E+00	0.418E-01			
07/11/78	0246	D2 0	5	0.182E+00	0.143E-01	INTAKE VS. DISCHARGE	0.709E+00	0.514E+00
07/11/78	1212	I5 0	5	0.973E-01	0.514E-01			
07/11/78	1213	D1 0	5	0.105E+00	0.269E-01			
07/11/78	1225	D2 0	5	0.795E-01	0.225E-01	INTAKE VS. DISCHARGE	0.132E+00	0.873E+00
08/07/78	2243	I5 0	5	0.360E+00	0.298E-01			
08/07/78	2238	D1 0	5	0.316E+00	0.324E-01			
08/07/78	2219	D2 0	5	0.220E+00	0.252E-01	INTAKE VS. DISCHARGE	0.606E+01	0.161E-01

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/78	2243	I5 35	5	0.262E+00	0.247E-01			
08/07/78	2238	D1 35	3	0.198E+00	0.359E-01			
08/08/78	2219	D2 35	5	0.268E+00	0.355E-01	INTAKE VS. DISCHARGE	0.117E+01	0.352E+00
08/08/78	0340	I5 0	5	0.224E+00	0.225E-01			
08/08/78	0335	D1 0	5	0.275E+00	0.345E-01			
08/08/78	0335	D2 0	5	0.340E+00	0.457E-01	INTAKE VS. DISCHARGE	0.266E+01	0.112E+00
08/08/78	1233	I5 0	5	0.150E+00	0.414E-01			
08/08/78	1225	D1 0	5	0.374E+00	0.644E-01			
08/08/78	1229	D2 0	5	0.234E+00	0.278E-01	INTAKE VS. DISCHARGE	0.579E+01	0.184E-01
09/11/78	2115	I5 0	5	0.129E+00	0.461E-01			
09/11/78	2115	D1 0	5	0.265E+00	0.903E-01			
09/11/78	2115	D2 0	5	0.281E+00	0.102E+00	INTAKE VS. DISCHARGE	0.100E+01	0.398E+00
09/11/78	2115	I5 37	5	0.544E+00	0.567E-01			
09/11/78	2115	D1 37	5	0.273E+00	0.850E-01			
09/11/78	2115	D2 37	5	0.240E+00	0.148E+00	INTAKE VS. DISCHARGE	0.259E+01	0.117E+00
09/12/78	0555	I5 0	5	0.277E+00	0.560E-01			
09/12/78	0555	D1 0	5	0.433E+00	0.459E-01			
09/12/78	0554	D2 0	5	0.271E+00	0.575E-01	INTAKE VS. DISCHARGE	0.296E+01	0.913E-01
09/12/78	1207	I5 0	5	0.240E+00	0.234E-01			
09/12/78	1200	D1 0	5	0.252E+00	0.272E-01			
09/12/78	1215	D2 0	5	0.229E+00	0.248E-01	INTAKE VS. DISCHARGE	0.202E+00	0.817E+00
10/09/78	2007	I5 0	5	0.159E+00	0.467E-01			
10/09/78	2000	D1 0	5	0.198E+00	0.625E-01			
10/09/78	2004	D2 0	4	0.591E-01	0.242E-01	INTAKE VS DISCHARGE	0.191E+01	0.196E+00
10/09/78	2007	I5 36	5	0.795E-01	0.261E-01			
10/09/78	2000	D1 36	5	0.280E+00	0.556E-01			
10/09/78	2004	D2 36	5	0.319E+00	0.421E-01	INTAKE VS DISCHARGE	0.897E+01	0.492E-02
10/10/78	0533	I5 0	5	0.110E+00	0.190E-01			
10/10/78	0520	D1 0	4	0.665E-01	0.170E-01			
10/10/78	0523	D2 0	4	0.635E-01	0.310E-01	INTAKE VS DISCHARGE	0.140E+01	0.293E+00
10/10/78	1218	I5 0	5	0.106E+00	0.230E-01			
10/10/78	1200	D1 0	5	0.137E+00	0.411E-01			
10/10/78	1213	D2 0	5	0.138E+00	0.336E-01	INTAKE VS DISCHARGE	0.310E+00	0.739E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/78	1925	I5	0	3	0.899E-01	0.554E-01			
11/13/78	1910	D1	0	5	0.164E+00	0.530E-01	INTAKE VS DISCHARGE	0.817E+00	0.404E+00
11/13/78	1925	I5	36	5	0.722E-01	0.246E-01			
11/13/78	1910	D1	36	5	0.161E+00	0.329E-01	INTAKE VS DISCHARGE	0.462E+01	0.640E-01
11/14/78	0615	I5	0	5	0.122E+00	0.349E-01			
11/14/78	0557	D1	0	4	0.174E+00	0.595E-01	INTAKE VS DISCHARGE	0.634E+00	0.456E+00
11/14/78	1215	I5	0	4	0.981E-01	0.453E-01			
11/14/78	1200	D1	0	5	0.201E+00	0.480E-01	INTAKE VS DISCHARGE	0.232E+01	0.171E+00
12/04/78	1910	I5	0	5	0.437E+00	0.205E+00			
12/04/78	1931	D1	0	5	0.701E+00	0.334E+00			
12/04/78	1900	D2	0	5	0.865E-01	0.272E-01	INTAKE VS DISCHARGE	0.185E+01	0.200E+00
12/04/78	1910	I5	34	5	0.143E+00	0.344E-01			
12/04/78	1931	D1	34	5	0.925E-01	0.428E-01			
12/04/78	1900	D2	34	5	0.893E-01	0.251E-01	INTAKE VS DISCHARGE	0.752E+00	0.495E+00
12/05/78	0620	I5	0	5	0.548E-01	0.319E-01			
12/05/78	0635	D1	0	5	0.107E+00	0.417E-01			
12/05/78	0610	D2	0	5	0.584E+00	0.330E+00	INTAKE VS DISCHARGE	0.229E+01	0.145E+00
12/05/78	1206	I5	0	4	0.388E+00	0.205E+00			
12/05/78	1215	D1	0	4	0.111E+00	0.432E-01			
12/05/78	1150	D2	0	3	0.699E-01	0.254E-01	INTAKE VS DISCHARGE	0.169E+01	0.245E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	5	0.698E-01	0.347E-01			
01/08/79	1916	D1	0	5	0.391E-01	0.138E-01			
01/08/79	1948	D2	0	5	0.400E-01	0.186E-01	INTAKE VS DISCHARGE	0.525E+00	0.607E+00
01/08/79	1930	I5	36	5	0.302E-01	0.821E-02			
01/08/79	1916	D1	36	4	0.727E-01	0.322E-01			
01/08/79	1949	D2	36	5	0.114E+00	0.562E-01	INTAKE VS DISCHARGE	0.124E+01	0.327E+00
01/09/79	0731	I5	0	5	0.615E-01	0.122E-01			
01/09/79	0716	D1	0	5	0.134E+00	0.581E-01			
01/09/79	0740	D2	0	5	0.226E-01	0.149E-01	INTAKE VS DISCHARGE	0.254E+01	0.121E+00
01/09/79	1208	I5	0	4	0.538E-01	0.339E-01			
01/09/79	1155	D1	0	5	0.950E-01	0.386E-01			
01/09/79	1219	D2	0	4	0.977E-01	0.340E-01	INTAKE VS DISCHARGE	0.435E+00	0.660E+00
02/12/79	2044	I5	0	5	0.124E+00	0.445E-01			
02/12/79	1958	D1	0	5	0.288E+00	0.146E+00			
02/12/79	2022	D2	0	5	0.195E+00	0.647E-01	INTAKE VS DISCHARGE	0.741E+00	0.500E+00
02/12/79	2044	I5	36	5	0.120E+00	0.862E-01			
02/12/79	1958	D1	36	4	0.125E+00	0.125E+00			
02/12/79	2022	D2	36	4	0.708E+00	0.407E+00	INTAKE VS DISCHARGE	0.205E+01	0.181E+00
02/13/79	0644	I5	0	3	0.525E+00	0.369E+00			
02/13/79	0612	D1	0	5	0.230E+00	0.509E-01			
02/13/79	0628	D2	0	4	0.196E+00	0.106E+00	INTAKE VS DISCHARGE	0.984E+00	0.413E+00
02/13/79	1225	I5	0	5	0.190E+00	0.123E+00			
02/13/79	1145	D1	0	5	0.376E+00	0.104E+00			
02/13/79	1158	D2	0	5	0.189E+01	0.820E+00	INTAKE VS DISCHARGE	0.375E+01	0.555E-01
03/05/79	2025	I5	0	5	0.453E+00	0.139E+00			
03/05/79	2048	D1	0	5	0.158E+00	0.511E-01			
03/05/79	2102	D2	0	5	0.153E+00	0.769E-01	INTAKE VS DISCHARGE	0.318E+01	0.790E-01
03/05/79	2025	I5	36	5	0.274E+00	0.660E-01			
03/05/79	2048	D1	36	5	0.353E+00	0.439E-01			
03/05/79	2102	D2	36	5	0.623E+00	0.201E+00	INTAKE VS DISCHARGE	0.214E+01	0.162E+00
03/06/79	0620	I5	0	4	0.414E+00	0.541E-01			
03/06/79	0552	D1	0	5	0.407E+00	0.569E-01			
03/06/79	0605	D2	0	5	0.493E+00	0.635E-01	INTAKE VS DISCHARGE	0.686E+00	0.526E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	5	0.457E+00	0.316E-01			
03/06/79	1238	D1	0	4	0.750E+00	0.301E+00			
03/06/79	1210	D2	0	4	0.352E+00	0.166E+00	INTAKE VS DISCHARGE	0.120E+01	0.343E+00
04/09/79	2127	I5	0	4	0.158E+00	0.196E-01			
04/09/79	2122	D2	0	5	0.811E-01	0.110E-01	INTAKE VS DISCHARGE	0.131E+02	0.942E-02
04/09/79	2127	I5	32	5	0.236E-01	0.956E-02			
04/09/79	2122	D2	32	5	0.886E-01	0.451E-01	INTAKE VS DISCHARGE	0.199E+01	0.196E+00
04/10/79	0429	I5	0	5	0.949E-01	0.294E-01			
04/10/79	0418	D2	0	5	0.416E-01	0.999E-02	INTAKE VS DISCHARGE	0.294E+01	0.124E+00
04/10/79	1136	I5	0	5	0.650E-01	0.275E-01			
04/10/79	1132	D2	0	5	0.0	0.0	INTAKE VS DISCHARGE	0.558E+01	0.460E-01
05/07/79	2200	I5	0	4	0.203E+00	0.464E-01			
05/07/79	2201	D2	0	5	0.158E+00	0.392E-01	INTAKE VS DISCHARGE	0.545E+00	0.488E+00
05/07/79	2229	I5	36	5	0.866E-01	0.227E-01			
05/07/79	2229	D2	36	5	0.739E-01	0.348E-01	INTAKE VS DISCHARGE	0.930E-01	0.759E+00
05/08/79	0327	I5	0	4	0.675E-01	0.587E-02			
05/08/79	0330	D2	0	4	0.425E-01	0.161E-01	INTAKE VS DISCHARGE	0.212E+01	0.196E+00
05/08/79	1208	I5	0	5	0.862E-01	0.227E-01			
05/08/79	1205	D2	0	5	0.776E-01	0.145E-01	INTAKE VS DISCHARGE	0.101E+00	0.751E+00
07/10/79	2302	I5	0	5	0.918E-01	0.896E-01			
07/10/79	2302	D2	0	4	0.120E+00	0.703E-01	INTAKE VS DISCHARGE	0.554E-01	0.808E+00
07/10/79	2402	I5	32	4	0.316E+00	0.197E+00			
07/10/79	2402	D2	32	5	0.754E+00	0.263E+00	INTAKE VS. DISCHARGE	0.161E+01	0.245E+00
07/10/79	0252	I5	0	4	0.408E+00	0.213E+00			
07/10/79	0249	D2	0	3	0.713E+00	0.552E+00	INTAKE VS DISCHARGE	0.337E+00	0.588E+00
07/10/79	1208	I5	0	5	0.926E+01	0.646E+01			
07/10/79	1205	D2	0	5	0.124E+00	0.781E-01	INTAKE VS DISCHARGE	0.200E+01	0.195E+00
08/06/79	2217	I5	0	5	0.668E-01	0.410E-01			
08/06/79	2223	D1	0	5	0.490E-01	0.229E-01			
08/07/79	0004	D2	0	4	0.194E+00	0.104E+00	INTAKE VS DISCHARGE	0.170E+01	0.228E+00
08/06/79	2217	I5	36	5	0.129E+00	0.711E-01			
08/06/79	2223	D1	36	5	0.148E+00	0.686E-01			
08/07/79	0004	D2	36	5	0.468E-01	0.316E-01	INTAKE VS DISCHARGE	0.807E+00	0.472E+00

TABLE 26. MEAN PHAECPHYTIN A TO CHLOROPHYLL A RATIO WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=HTR1-1, I3=HTR1-3, I5=HTR1-5, I6=HTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5 0	3	0.370E-01	0.205E-01			
08/07/79	0335	D1 0	4	0.582E-01	0.401E-01			
08/07/79	0340	D2 0	5	0.161E+00	0.669E-01	INTAKE VS DISCHARGE	0.150E+01	0.276E+00
08/07/79	1210	I5 0	5	0.127E+00	0.820E-01			
08/07/79	1212	D1 0	5	0.415E-01	0.275E-01			
08/07/79	1220	D2 0	4	0.183E-01	0.183E-01	INTAKE VS DISCHARGE	0.110E+01	0.369E+00
09/10/79	2048	I5 0	5	0.194E-01	0.857E-02			
09/10/79	2048	D2 0	5	0.150E+00	0.745E-01	INTAKE VS DISCHARGE	0.305E+01	0.118E+00
09/10/79	2048	I5 33	5	0.143E+00	0.508E-01			
09/10/79	2048	D2 33	4	0.243E-01	0.243E-01	INTAKE VS DISCHARGE	0.183E+01	0.212E+00
09/11/79	0455	I4 0	5	0.0	0.0			
09/11/79	0508	D1 0	5	0.928E-01	0.541E-01			
09/11/79	0455	D2 0	5	0.189E-01	0.155E-01	INTAKE VS DISCHARGE	0.227E+01	0.147E+00
09/11/79	0520	D1 28	4	0.717E-01	0.493E-01			
09/11/79	1210	I5 0	5	0.126E-01	0.122E-01			
09/11/79	1204	D1 0	4	0.343E-01	0.342E-01			
09/11/79	1202	D2 0	5	0.101E-01	0.669E-02	INTAKE VS DISCHARGE	0.465E+00	0.642E+00
10/08/79	2025	I5 0	5	0.162E+00	0.469E-01			
10/08/79	2010	D1 0	4	0.125E+00	0.267E-01			
10/08/79	2007	D2 0	5	0.182E+00	0.945E-01	INTAKE VS DISCHARGE	0.175E+00	0.838E+00
10/08/79	2025	I5 36	4	0.541E-01	0.206E-01			
10/08/79	2010	D1 36	5	0.148E+00	0.760E-01			
10/08/79	2007	D2 36	5	0.224E-01	0.224E-01	INTAKE VS DISCHARGE	0.178E+01	0.215E+00
10/09/79	0552	I5 0	4	0.181E+00	0.629E-01			
10/09/70	0534	D1 0	5	0.201E+00	0.660E-01			
10/09/79	0537	D2 0	5	0.204E+00	0.355E-01	INTAKE VS DISCHARGE	0.448E-01	0.952E+00
10/09/79	1220	I5 0	5	0.195E+00	0.411E-01			
10/09/79	1204	D1 0	5	0.169E+00	0.294E-01			
10/09/79	1205	D2 0	4	0.520E+00	0.163E+00	INTAKE VS DISCHARGE	0.490E+01	0.311E-01

APPENDIX B3

1979 Benthos Collected at the Donald C. Cook Nuclear Plant

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A. LAKE SURVEYS

LAKE SURVEYS

Technical Specifications for environmental monitoring are designed to determine if benthic animal populations have changed significantly in the lake after the establishment of the thermal plume and chemical discharges. Benthos populations are examined in detail by three "seasonal" surveys in April, July, and October of each year. "Inner" areas (within 1.6 km of the plant) and "Outer" areas (3.2-11 km from the plant) are analyzed by depth zones, with the Outer areas acting as a reference. The depths encompassed are Zone 0 (0-8 m deep), Zone 1 (8-16 m), and Zone 2 (16-24 m). Five locations are sampled per zone in both the Inner and Outer areas for a total of 30 stations. Four replicate grabs are collected at each of the 10 shallow stations of Zone 0 and two at each of the 20 deeper stations of Zones 1 and 2.

Data in this report include April, July, and October of 1979 and comparisons with 1971-1978 surveys. A summary of the 1979 data is presented in Tables 1-3, and Inner and Outer comparisons of the major taxa from 1971-1979 are shown in Figures 1-19. Five years of operational monitoring have been completed, allowing statistical tests of plant effects. The test design uses Zone mean densities of the major taxa in a two-sample *t*-test for each survey date and the faunal parameters of Figures of 1-18. All means are transformed by the equation

$$y = \log_{10} x;$$

however, if one or more of the means of a set are 0.0, then all means for that set are transformed by

$$y = \log_{10}(x + 1).$$

Transformed values for the Outer areas of each Zone are subtracted from corresponding values for Inner areas, providing a logarithmic equivalent of Inner to Outer mean ratios. Ratios are determined for each of the major taxa in Zones 0, 1, and 2 for each seasonal survey of April 1971 to October 1979. The pre-operational ratios for each season, 1971-1974, are compared with operational year ratios, 1975-1979. Significance of differences between the two sets of ratios are tested at the 0.05 level.

Of the total 54 statistical tests performed on the 1971-1979 data (Tables 4-9) (3 depth zones x 3 seasonal surveys x 6 major benthic animal categories), only one Inner/Outer ratio produced a *t*-test value with a probability less than 0.05. A significant difference was found between the Inner/Outer data for *Pontoporeia hoyi* in Zone 2 of the October surveys (Table 4). Significant differences for *Pontoporeia hoyi* and Chironomidae reported last year for the Zone 2 April surveys were not apparent with the inclusion of the 1979 data.

Preoperational and operational Inner/Outer ratios for *Pontoporeia hoyi* occuring in Zone 2 during October surveys are significantly different at the 0.05 level. The trend observed in both pre- and operational years is one of generally higher densities in the Outer region of October Zone 2. Following the first operational year (1975), the mean October densities in the Outer regions generally have increased by 119% while densities in the Inner region have decreased by 19% (Figure 3). The differences have resulted in a slowly decreasing Inner/Outer ratio (Figure 19). In all the preoperational years averaged for October, Inner densities were 3202 m^{-2} and Outer 3982 m^{-2}. For all operational years in October, Inner densities were 2601 m^{-2} and Outer 4737 m^{-2} with the resulting log-ratio differences per year being significant at the 0.05 level. It is our opinion that the trend will need to be evaluated over a greater number of years to determine if it is associated with plant operations.

B. ENTRAINMENT STUDIES

Technical Specifications require that the samples collected for fish egg and larvae entrainment be "inspected for entrainable benthos. Samples are collected from the intake and discharge forebays four times monthly during June, July, and August and twice monthly during the remaining months of the year. Specifications require at least a single sample from the intake and discharge during each of three consecutive 8-hour periods. To better define the effects of entrainment, two replicates are taken at the intake forebay, and four consecutive collection periods are used corresponding to midnight-sunrise, sunrise-noon, noon-sunset, and sunset-midnight.

It is of interest to determine if large quantities of the more important fish-food organisms are being entrained by the plant's cooling system, because it is assumed that entrained organisms are killed or are in some manner lost from the lake populations. In particular, the monitoring concerns entrained densities of the larger benthic crustaceans which are of known food value to many fish species. Densities (number m^{-3}) of the four most commonly entrained crustacean genera are tabulated for each approximately quarter-day period using the discharge sample and the mean of the two intake samples. No suitable definition of a significant impact has been developed for entrained benthos, but the data reported may permit furture comparisons with similar studies and other sources of data.

Included in this report are the entrainment data for November through December 1978 and January through October 1979. November and December 1979 will be included in the next operating report. Because the plant was not in operation during the second week of June, only 3 of 4 sample periods are reported for that month. Numbers m^{-3} for the four groups of entrained crustaceans are listed in Tables 10-13.

The larger crustaceans such as *Pontoporeia hoyi* and *Mysis relicta* are night active with greatest densities being entrained between sunset and sunrise (Tables 10-11). Numbers of *Pontoporeia* entrained during this reporting period were similar to those reported for 1976 and 1977. Seasonally, numbers are consistantly greatest in December and January during the lake-wide inshore reproductive migrations. The very large values reported during the May 24-25 sample period were likely the result of equipment failure as the pumps employed to remove water from the forebay pumped a negligable amount of water. Consequently, the entrainment of a single *Pontoporeia* during each of the periods midnight-sunrise and sunrise-noon combined with the small volume of water pumped resulted in very large densities when converted to numbers m^{-3}. While the number of *Pontoporeia* entrained during June and July 1979 was slightly higher compared with previous years, densities entrained during most other 1979 months were similar to those reported during the same months in previous years..

We have not been able to detect any effects of entrainment on Pontoporeia populations in the immediate vicinity of the plant.

Entrainment of Mysis in 1979 was greatest from January through April and late June. This pattern more clearly approximated the 1976 Mysis entrainment data when compared with 1978. Greatest observed density of Mysis in 1979 samples was 0.15 m^{-3} (Table 11). It is not possible to assess the effects of entrainment of Mysis on lake populations as our regime does not adequately sample existing populations, but it is well known that the great bulk of the population is well offshore in deep water. With the inclusion of the January-October 1979 Mysis entrainment data, there appeared to be no uniquely different trends when compared with previous years.

Entrainment of Gammarus (Table 12) in 1979 was similar to that of 1976 and 1978. Since only a single individual of Gammarus was entrained in the May 24-25 sunset-midnight samples, the high density (0.55 m^{-3}) resulted from pump breakdown (see Pontoporeia entrainment). Entrainment of Asellus always is sporatic and was much less frequent in 1979 than from 1976-1978. Both Gammarus and Asellus are not taxa of the open lake and originally were rare in the survey area; present populations are established on the riprap, and their entrainment reflects population dynamics occurring there.

While entrainment of Pontoporeia, Mysis, Gammarus, and Asellus varies from year to year, numbers do remain fairly consistent. It is not possible to do more than present the data at this time as the sampling design does not estimate adequately the abundances of the latter three taxa in Lake Michigan.

C. IMPINGEMENT

Although impingement studies of benthic macroinvertebrates are not required by Techincal Specifications, we have been maintaining records of the species, numbers, and weights of crayfish (Astacidae) collected on travelling screens at the Cook Plants. By virtue of their small size, other benthic macroivertebrates should pass through the screens. These studies are an adjunct to collection of data on fish impingement. As stated in previous reports, all evidence indicates that impinged crayfish originate from colonies recently established on or near the riprap apron around the discharge and intake structures which were installed to protect the bottom from scour. From fish trawling and diving records, crayfish populations appear to be very small outside the immediate vicinity of the riprap, particularly on smooth or sandy bottoms. Consequently, impingement of seemingly large quantities of crayfish has not been considered a negative impact on the ecology of the lake.

November and December 1978 data were not available for the last report but have been included here (Table 14). Data for January through October 1979 are presented in Table 15. With the exception of a single Cambarus diogenes, all specimens recovered in 1978 and 1979 were Orconectes propinquus. Species other than O. propinquus are rare and may represent occasional immigrants from nearby ponds and streams (e.g., C. diogenes and Orconectes rusticus).

Because of collection methods which are not wholly reliable and partial decomposition of some specimens, total impingement is, at best, a rough estimate. Numbers and weights from samples (column A, Tables 14-15) are multiplied by the number of days in each semi-monthly period, then divided by the number of 24-hr samples for which crayfish were processed in the corresponding period (column B, Tables 14-15). Since no crayfish samples were preserved during March 1-16, July 17-31, and November 16- December 16 1978, it is assumed that no crayfish were impinged in those periods. Similarly, when the 1979 crayfish data is completed with the inclusion of October through December data, any periods left blank in this report (Table 15) will assume the value of zero for the 1980 Environmental Operating Report.

Inclusion of the November and December data for 1978 brings that year's totals to 6064 specimens and 33.15 kg crayfish (Table 14). This is less than the 7791 specimes and 42.17 kg projected for 1978 given in the last report. Crayfish impinged in 1979 have been processed through September (Table 15). Since samples for 4-two week periods within the months January to September have not been processed as yet, the projected total impingement for 1979 is based on 53% of the year. The projected total for impinged crayfish in 1979 is 4210 individuals and 28.30 kg.

Through five years that the plant has been in operation, there has been a general decrease in numbers and total weights of impinged crayfish: 1975 = 90 kg, 1976 = 92 kg, 1977 = 70 kg, 1978 = 33 kg, and 1979 = 28 kg (projected). The average weights per crayfish impinged in 1975-1978 were 6.0, 5.8, 6.5, and 5.5 gm, respectively. In 1979, the average weight per specimen was 6.7 gm. We do not know the age structure, density, or seasonal and yearly fluctuations of the crayfish populations on the riprap; therefore, it is not possible to determine if impingement is a factor in apparent population changes.

CONCLUSIONS

Lake Surveys

There is a demonstrable significant result for Inner/Outer ratios of *Pontoporeia hoyi* in the Zone 2 October surveys. Results likely are associated with sample design that does not measure adequately some of the physical and biological processes of the lake (e.g., current and sediment interactions, competition). These factors are not associated necessarily with operation of the plant.

One *t*-test gave a probability less than 0.05: *Pontoporeia hoyi* in the October surveys of Zone 2. Observed trends indicate that October Outer Zone 2 means for *Pontoporeia* always were greater than Inner Zone 2 means. However, this trend appears to be coming more extreme.

Entrainment Studies

In 1979, entrainment of *Pontoporeia hoyi* was similar to that recorded in 1976 and 1977. *Mysis relicta* density in 1979 was more similar to that observed during 1976. *Gammarus* density in 1979 was slightly greater than that recorded during 1976 and 1978 and was lower than the peak year of 1977. *Asellus* occurred much less frequently and abundantly in 1979 than in previous years. No effect of plant operation has been detected on lake populations of *Pontoporeia*. The reasons behind yearly fluctuations of *Mysis*, *Gammarus*, and *Asellus* are not known as our collection methods do not sample their lake populations.

Impingement Studies

Projected impingement of the crayfish *Orconectes propinquus* for 1979 is down from previous years; however, the average weight per individual was the greatest observed over the years 1975-1978. Since we presently have no way of examining lake populations, it is not possible to determine if the changes are significant or if there is an effect of plant operation.

TABLE 1. Mean density (number per square meter) of major benthic taxa in April, 1979. The standard error (S.E.) is given in each case. The number (n) of Inner and Outer stations in each zone for which data was available is given in parentheses following the Total Animals entry.

Taxon	Region	Zone 0 (0-8 m) Mean	Zone 0 (0-8 m) S.E.	Zone 1 (8-16 m) Mean	Zone 1 (8-16 m) S.E.	Zone 2 (16-24 m) Mean	Zone 2 (16-24 m) S.E.
Pontoporeia hoyi	INNER	106.0	95.0	418.1	365.2	1005.9	442.6
	OUTER	9.0	6.0	466.6	217.3	3720.8	1360.9
Tubificidae	INNER	609.0	213.8	1654.3	940.3	387.8	169.0
	OUTER	287.8	254.0	1818.0	786.6	2448.2	800.4
Naididae	INNER	212.1	193.3	121.2	34.5	36.3	17.6
	OUTER	33.3	21.6	151.5	50.7	24.2	11.3
Stylodrilus heringianus	INNER	15.1	9.5	36.3	11.3	378.8	229.8
	OUTER	12.1	8.8	278.7	195.7	2957.2	949.4
Sphaerium nitidum	INNER	3.3	3.3	0.0	0.0	72.7	65.4
	OUTER	0.0	0.0	0.0	0.0	181.8	91.4
Sphaerium striatinum	INNER	3.0	3.0	6.0	6.0	0.0	0.0
	OUTER	0.0	0.0	18.1	12.1	0.0	0.0
Pisidium	INNER	72.7	35.0	115.1	67.3	666.6	549.4
	OUTER	6.0	6.0	369.6	180.6	2284.6	968.8
Chironomidae	INNER	457.5	116.3	345.4	106.5	84.8	45.3
	OUTER	160.5	28.1	406.0	152.5	333.3	106.6
Hirudinea	INNER	39.3	17.6	18.1	7.4	18.1	7.4
	OUTER	3.0	3.0	24.2	17.6	24.2	11.3
Operculata	INNER	6.0	3.7	12.1	7.4	24.2	11.3
	OUTER	0.0	0.0	48.4	18.1	103.0	66.1
Pulmonata	INNER	0.0	0.0	0.0	0.0	0.0	0.0
	OUTER	0.0	0.0	18.1	12.1	78.7	51.2
Other	INNER	93.9	67.8	48.4	12.1	36.3	36.3
	OUTER	3.0	3.0	78.7	42.4	115.1	48.2
Total Animals	INNER	1618.	539.(5)	2775.	1010.(5)	2720.	1519.(5)
	OUTER	515.	283.(5)	3678.	1492.(5)	12271.	3393.(5)

TABLE 2. Mean density (number per square meter) of major benthic taxa in July, 1979. The standard error (S.E.) is given in each case. The number (n) of Inner and Outer stations in each zone for which data was available is given in parentheses following the Total Animals entry.

Taxon	Region	Zone 0 (0-8 m)		Zone 1 (8-16 m)		Zone 2 (16-24 m)	
		Mean	S.E.	Mean	S.E.	Mean	S.E.
Pontoporeia hoyi	INNER	69.6	18.9	2569.4	438.1	4423.8	847.4
	OUTER	6.0	3.7	4217.7	1669.2	8380.9	4083.6
Tubificidae	INNER	290.8	155.7	1593.7	815.9	12344.2	10335.1
	OUTER	19.1	11.1	3593.5	2536.1	5181.3	2126.5
Naididae	INNER	1911.9	646.0	1060.5	146.8	781.7	201.9
	OUTER	607.0	150.3	1405.9	345.1	793.8	309.2
Stylodrilus heringianus	INNER	21.2	7.7	193.9	66.7	1187.7	357.9
	OUTER	4.0	4.0	805.9	431.6	3005.7	988.8
Sphaerium nitidum	INNER	0.0	0.0	12.1	7.4	60.6	27.1
	OUTER	0.0	0.0	6.0	6.0	121.2	51.5
Sphaerium striatinum	INNER	0.0	0.0	18.1	18.1	6.0	6.0
	OUTER	0.0	0.0	24.2	11.3	30.3	13.5
Pisidium	INNER	27.2	10.0	315.1	83.3	478.7	220.8
	OUTER	21.2	14.0	472.6	272.8	1830.1	792.5
Chironomidae	INNER	3336.0	1202.7	496.9	49.4	260.5	49.4
	OUTER	1631.1	276.0	884.7	408.5	327.2	134.6
Hirudinea	INNER	6.0	6.0	0.0	0.0	42.4	18.1
	OUTER	0.0	0.0	6.0	6.0	0.0	0.0
Operculata	INNER	3.0	3.0	18.1	12.1	30.3	16.5
	OUTER	0.0	0.0	24.2	17.6	121.2	48.8
Pulmonata	INNER	9.0	9.0	0.0	0.0	6.0	6.0
	OUTER	7.0	4.4	0.0	0.0	42.2	22.6
Other	INNER	375.5	223.5	399.9	87.5	460.5	112.7
	OUTER	118.1	51.9	260.5	31.1	339.3	115.9
Total Animals	INNER	6050.	1995.(5)	6678.	1353.(5)	20082.	9950.(5)
	OUTER	2413.	206.(5)	11701.	4758.(5)	20173.	5318.(5)

TABLE 3. Mean density (number per square meter) of major benthic taxa in October, 1979. The standard error (S.E.) is given in each case. The number (n) of Inner and Outer stations in each zone for which data was available is given in parentheses following the Total Animals entry.

Taxon	Region	Zone 0 (0-8 m)		Zone 1 (8-16 m)		Zone 2 (16-24 m)	
		Mean	S.E.	Mean	S.E.	Mean	S.E.
Pontoporeia hoyi	INNER	33.3	5.6	266.6	61.6	2254.3	1069.4
	OUTER	18.1	8.8	1254.4	546.2	5066.1	2221.1
Tubificidae	INNER	1187.7	734.2	10877.7	9344.2	7908.3	4802.0
	OUTER	496.9	307.5	10938.3	5247.3	1811.9	434.4
Naididae	INNER	599.9	174.7	272.7	184.5	224.2	179.4
	OUTER	336.6	128.8	763.5	481.6	78.7	34.0
Stylodrilus heringianus	INNER	6.0	6.0	315.1	180.4	927.1	537.4
	OUTER	21.2	14.0	715.0	273.6	3078.4	620.4
Sphaerium nitidum	INNER	0.0	0.0	36.3	29.3	84.8	44.3
	OUTER	0.0	0.0	54.5	36.3	290.8	132.9
Sphaerium striatinum	INNER	0.0	0.0	12.1	7.4	18.1	12.1
	OUTER	0.0	0.0	12.1	7.4	0.0	0.0
Pisidium	INNER	75.7	20.8	999.9	649.4	1236.2	632.9
	OUTER	84.8	38.5	1030.2	412.2	2024.0	840.9
Chironomidae	INNER	527.2	60.4	763.5	173.3	533.2	131.5
	OUTER	427.2	112.9	739.3	113.6	351.4	78.1
Hirudinea	INNER	12.1	8.8	121.2	106.6	60.6	41.7
	OUTER	0.0	0.0	90.9	47.9	12.1	12.1
Operculata	INNER	3.0	3.0	42.4	35.3	115.1	107.7
	OUTER	12.1	12.1	90.9	44.9	187.8	65.9
Pulmonata	INNER	3.0	3.0	6.0	6.0	36.3	29.3
	OUTER	0.0	0.0	24.2	17.6	42.4	29.6
Other	INNER	69.6	19.5	103.0	32.6	60.6	21.4
	OUTER	39.3	24.7	133.3	20.5	157.5	55.3
Total Animals	INNER	2517.	957.(5)	13816.	10186.(5)	13459.	5466.(5)
	OUTER	1436.	523.(5)	15846.	5774.(5)	13101.	3218.(5)

TABLE 4. Logarithms of ratios of Inner to Outer mean population densities for <u>Pontoporeia hoyi</u> by year, month and depth zone. The value of Student's *t* is shown for each season and depth zone. The vertical dotted line indicates the start of plant operation. An asterisk (*) indicates that the ratio was significantly different after the start of plant operation ($p < .05$).

Month	Depth Zone	Year									Student's *t*
		1971	1972	1973	1974	1975	1976	1977	1978	1979	
April	0	0.38	-0.26	0.48	-0.30	-0.04	0	1.49	0.95	1.03	1.57
	1	-0.67	-0.06	-0.27	-0.15	-0.20	0.11	-0.19	0	0.05	1.63
	2	-0.74	-0.77	-0.39	-0.17	0.33	0.01	-0.03	-0.05	-0.57	2.20
July	0	-0.82	-0.41	-1.56	0.32	-0.39	0.18	-0.10	0.58	1.07	1.96
	1	0.09	0.36	0.03	-0.08	-0.19	0.17	-0.10	-0.52	-0.22	1.81
	2	-0.65	-0.09	-0.10	-0.21	-0.17	-0.07	-0.16	-0.13	-0.28	0.82
October	0	---	0.28	-0.11	1.11	0.39	0.27	-1.20	0.29	0.25	0.89
	1	---	-0.61	-0.18	-0.28	-0.31	-0.37	-0.57	-0.73	-0.67	1.20
	2	---	-0.13	-0.06	-0.13	-0.17	-0.16	-0.22	-0.29	-0.35	2.56*

TABLE 5. Logarithms of ratios of Inner to Outer mean population densities for *Stylodrilus* (Lumbriculidae) by year, month and depth zone. The value of Student's *t* is shown fro each season and depth zone. The vertical dotted line indicates the start of plant operation. An asterisk (*) indicates that the ratio was significantly different after the start of plant operation ($p < .05$).

Month	Depth Zone	Year									Student's *t*
		1971	1972	1973	1974	1975	1976	1977	1978	1979	
April	0	0.70	-0.26	0.18	0	0	-0.89	0.60	0.60	0.09	0.21
	1	-1.24	-0.21	0.82	0.16	-1.50	-0.28	0.18	-1.03	-0.89	1.16
	2	-0.88	-0.64	-0.51	-0.57	-0.39	-0.24	-0.74	0.09	-0.88	1.10
July	0	1.00	-0.30	-0.70	-0.60	-0.68	1.00	-0.24	0	0.64	0.60
	1	0.11	-0.80	-0.16	-0.70	-1.00	-1.28	-0.52	-0.24	-0.62	1.22
	2	-0.74	0.61	-0.02	-0.58	-0.60	-0.20	-0.01	-0.74	-0.40	0.67
October	0	---	-0.95	0.22	-0.27	0	-0.85	-0.24	-0.40	-0.50	0.21
	1	---	-1.36	0.12	-0.57	-0.71	-1.18	-0.64	-0.58	-0.36	0.25
	2	---	0.28	0.18	-0.49	-0.51	-0.03	-0.45	-0.42	-0.52	1.76

TABLE 6. Logarithms of ratios of Inner to Outer mean population densities for *Pisidium* spp. by year, month and depth zone. The value of Student's *t* is shown for each season and depth zone. The vertical dotted line indicates the start of plant operation. An asterisk (*) indicates that the ratio was significantly different after the start of plant operation ($p < .05$).

Month	Depth Zone	Year									Student's *t*
		1971	1972	1973	1974	1975	1976	1977	1978	1979	
April	0	0.38	0.30	0.83	-0.60	-0.36	-0.74	1.69	-0.70	1.02	0.07
	1	-0.05	0.17	-0.18	-0.02	-0.83	0.19	0.10	-0.78	-0.51	1.37
	2	-0.36	-0.57	-0.44	-0.09	-0.07	-0.61	-0.27	0.27	-0.53	0.61
July	0	-1.53	-0.42	-1.82	0.20	-0.87	-0.27	0.09	1.28	0.10	1.67
	1	0.72	-0.23	-0.01	0.34	-0.21	-0.15	0.41	-0.25	-0.18	1.22
	2	-0.71	0.34	-0.03	-0.71	-0.41	-0.16	-0.04	-0.50	-0.58	0.24
October	0	---	0.29	-0.10	0.11	-0.12	0.26	-0.68	0.69	-0.05	0.26
	1	---	-0.58	0.31	0.15	-0.08	0.04	0.30	-0.01	-0.01	0.40
	2	---	-0.30	-0.14	0.17	-0.09	0.01	-0.19	-0.64	-0.21	0.75

TABLE 7. Logarithms of ratios of Inner to Outer mean population densities for Tubificidae by year, month and depth zone. The value of Student's t is shown for each season and depth zone. The vertical dotted line indicates the start of plant operation. An asterisk (*) indicates that the ratio was significantly different after the start of plant operation ($p < .05$).

Month	Depth Zone	Year									Student's t
		1971	1972	1973	1974	1975	1976	1977	1978	1979	
April	0	0.58	0.08	0.35	-0.90	0.25	0	1.16	-0.36	0.33	0.62
	1	-0.04	0.45	-0.80	0.36	-1.02	0.24	0.22	-1.41	-0.04	0.86
	2	0.12	-0.10	-0.14	0.37	0.59	-0.05	0.30	0.43	-0.80	0.11
July	0	-0.13	-0.58	-0.89	0.98	-0.88	-0.24	1.79	0.90	1.19	1.07
	1	0.11	0.02	0.09	-0.32	-0.30	-0.52	0.14	-0.08	-0.35	0.99
	2	-0.06	0.08	0.30	-0.31	0.20	0.67	0.28	-0.39	0.38	0.99
October	0	---	-0.12	0.12	0.56	-0.08	0.67	-0.22	-0.10	0.38	0.21
	1	---	-0.16	0.48	0.36	-0.32	0.01	0.45	-0.29	0.00	1.10
	2	---	0.07	0.35	0.26	0.57	0.93	0.34	0.24	0.64	1.84

TABLE 8. Logarithms of ratios of Inner to Outer mean population densities for Chironomidae by year, month and depth zone. The value of Student's *t* is shown for each season and depth zone. The vertical dotted line indicates the start of plant operation. An asterisk (*) indicates that the ratio was significantly different after the start of plant operation ($p < .05$).

Month	Depth Zone	Year									Student's *t*
		1971	1972	1973	1974	1975	1976	1977	1978	1979	
April	0	0.56	-0.04	-0.02	-1.07	1.31	0.11	0.52	-0.12	0.45	1.47
	1	0.21	0.30	-0.40	-0.25	-0.67	-0.17	0.34	-0.42	-0.07	0.67
	2	0.17	-0.14	-0.17	-0.09	0.45	0.18	0.03	0.52	-0.59	0.75
July	0	0.23	0.35	0.02	0.25	-0.05	0.15	0.19	0.18	0.31	0.63
	1	0.81	0.14	-0.05	0.54	-0.03	-0.09	0.26	-0.20	-0.25	2.13
	2	-0.08	-0.14	0.28	0.02	-0.21	0.25	0.01	-0.11	-0.10	0.43
October	0	---	0.32	-0.24	0.34	0.09	0.05	-0.11	0.33	0.09	0.30
	1	---	-0.01	0.22	0.22	-0.14	-0.22	-0.18	0.13	0.01	2.16
	2	---	-0.83	-0.23	0.44	0.31	-.67	0.28	0.24	0.18	1.35

TABLE 9. Logarithms of ratios of Inner to Outer mean population densities for Total Animals by year, month and depth zone. The value of Student's t is shown for each season and depth zone. The vertical dotted line indicates the start of plant operation. An asterisk (*) indicates that the ratio was significantly different after the start of plant operation ($p < .05$).

Month	Depth Zone	Year									Student's t
		1971	1972	1973	1974	1975	1976	1977	1978	1979	
April	0	0.61	0	0.39	-1.04	0.13	0	0.83	-0.22	0.50	0.67
	1	-0.11	0.33	-0.64	0.11	-0.55	0.15	0.17	-0.86	-0.12	0.56
	2	-0.42	-0.41	-0.27	0.04	0.20	-0.20	-0.09	0.16	-0.65	0.75
July	0	0.14	0.18	-0.16	0.27	-0.37	0.08	0.47	0.22	0.40	0.28
	1	0.19	0.08	-0.04	-0.01	-0.23	-0.04	0.17	-0.22	-0.24	1.65
	2	-0.44	0.07	0.08	-0.39	-0.11	0.10	0.09	-0.26	0.00	0.92
October	0	---	0.04	-0.06	0.37	0.09	0.12	-0.19	0.26	0.24	0.09
	1	---	-0.26	0.40	0.24	-0.28	-0.02	0.13	-0.20	-0.06	1.22
	2	---	0	0.11	0.11	0.09	0.39	-0.04	-0.09	0.01	0.01

TABLE 10. Benthos entrainment data, November-December 1978 and January-October 1979: Pontoporeia hoyi, number m^{-3}. I = intake, D = discharge, * = based on one intake sample, --- = missing data.

	SAMPLE PERIOD							
Sampling Date	MIDN----->SUNR		SUNR------>NOON		NOON------>SUNS		SUNS----->MIDN	
	I	D	I	D	I	D	I	D
Nov. 13-14	0.030	0.012	0	0	0	0	0.016	0.081
Nov. 29-30	0.009	0	0	0	0	0	0	0
Dec. 4-5	0.014	0.012	0	0	0	0	0.016	0.014
Dec. 20-21	0.112	0.172	0.130	0	0.043	0.038	0.198	0.212
Jan. 8-9	0.383*	0.331	0.291	0	0.011	0.040	0.344	0.539
Jan. 25-26	0.076*	0.132	0.083*	0.027	0.030*	0.061	0-079*	0.056
Feb. 12-13	0.045	0.049	0	0	0	0	0.086	0.068
Feb. 22-23	0.008	0.026	0	0	0	0	0.014	0.019
Mar. 5-6	0.020*	0.029	0*	0	0*	0	0	0.035
Mar. 22-23	0	0	0	0	0*	0	0	0
Apr. 9-10	0	0	0*	0	0	0	0.081	0.040
Apr. 29-30	0.032	0.018	0	0	0*	0	0	0
May 7-8	0	0	0	0	0	0.046	0	0
May 24-25	5.000	---	2.632	---	0*	0	0	0
June 6-7	0.012	0	0	0	0.040	0.012	0	0.034
June 13-14	PLANT NOT IN OPERATION							
June 21-22	0.191	0	0.026	0.032	0.095	0.013	0.115	0
June 27-28	0.529	0.145	0.083	0	0.070	0.056	0.293	0.098
July 5-6	0.064	0.047	0	0	0	0	0.077	0.132
July 0-10	0	0.050	0	0	0	0	0.030	0.091
July 18-19	0.024	0.070	0*	0	0*	0	1.057*	0.809
July 26-27	0	0.020	0	0	0*	0	0.073*	0.059
Aug. 1-2	0.047	0.217	0	0	0	0	0.102	0.029
Aug. 6-7	0.019*	0.121	---	0	0*	0	0.200	0.347
Aug. 15-16	0.132	0.182	0	0	0.013	0.024	0*	0.225
Aug. 22-23	0.021	0.029	0	0	0	0	0.204	0.241
Aug. 30-31	0.010	0	0	0	0	0.012	0.270	0.188
Sep. 10-11	0	0	0	0	0	0	0.167	0.041
Sep. 25-26	0.010	0.016	0	0	0	0	0*	0
Oct. 8-9	0	0	0*	0	0*	0	0.030	0.024
Oct. 16-17	0.040*	0.081	0	0	0	0	0.261	0

TABLE 11. Benthos entrainment data, November-December 1978 and January-October 1979: Mysis relicta, number m^{-3}. I = intake, D = discharge, * = based on one intake sample, --- = missing data.

Sampling Date		SAMPLING PERIOD MIDN---->SUNR I	D	SUNR---->NOON I	D	NOON---->SUNS I	D	SUNS---->MIDN I	D
Nov.	13-14	0.031	0.024	0	0	0.029	0	0.049	0.032
Nov.	29-30	0.009	0.014	0	0	0	0	0.008	0.015
Dec.	4-5	0.036	0.024	0	0	0	0	0.013	0
Dec.	20-21	0.014	0.040	0*	0	0	0	0.152	0.045
Jan.	8-9	0.045*	0.011	0.074	0	0.014	0	0.039	0.090
Jan.	25-26	0.151*	0.093	0*	0	0.030*	0.040	0.079*	0.093
Feb.	12-13	0.082	0.037	0	0	0	0	0.136	0.119
Feb.	22-23	0.025	0.026	0	0	0	0	0.033	0
Mar.	5-6	0.099*	0.043	0*	0	0*	0	0.031	0.035
Mar.	22-23	0.025	0.015	0.026	0	0*	0	0.032	0.019
Apr.	9-10	0.037	0.124	0.033*	0	0	0	0.057	0.040
Apr.	29-30	0.021	0	0	0	0*	0	0.011	0.021
May	7-8	0.011	0.014	0	0	0	0	0	0
May	24-25	0	---	0	---	0*	0	0	0
June	6-7	0	0	0	0	0	0	0	0
June	13-14		PLANT NOT IN OPERATION						
June	20-21	0.025	0	0.007	0	0	0	0	0.024
June	27-28	0.152	0.097	0.014	0.015	0.009	0.014	0	0
July	5-6	0.024	0.070	0	0	0	0	0	0
July	9-10	0	0.012	0	0	0	0	0.037	0
July	18-19	0*	0	0*	0	0*	0	0*	0
July	26-27	0	0	0	0	0*	0	0*	0
Aug.	1-2	0	0	0	0	0	0	0	0
Aug.	6-7	0*	0	---	0	0*	0	0	0
Aug.	15-16	0	0	0	0	0	0	0*	0
Aug.	22-23	0.022	0	0	0	0	0	0	0
Aug.	30-31	0	0	0	0	0	0	0	0
Sep.	10-11	0	0.015	0	0	0	0	0	0.041
Sep.	25-26	0.029	0	0	0	0	0	0*	0
Oct.	8-9	0	0.022	0*	0	0*	0	0	0
Oct.	16-17	0*	0.016	0	0.016	0	0	0	0

TABLE 12. Benthos entrainment data, November-December 1978 and January-October 1979: Gammarus, Number m^{-3}. I = intake, D = discharge, * = based on one intake sample, --- = missing data.

Sampling Date	MIDN---->SUNR I	MIDN---->SUNR D	SUNR---->NOON I	SUNR---->NOON D	NOON---->SUNS I	NOON---->SUNS D	SUNS---->MIDN I	SUNS---->MIDN D
Nov. 13-14	0.012	0.048	0	0.104	0	0.016	0	0.016
Nov. 29-30	0.034	0.014	0.027	0	0.010	0.016	0.017	0.015
Dec. 4-5	0	0.24	0.018	0	0	0.016	0.021	0
Dec. 20-21	0	0.010	0*	0	0	0.019	0.018	0.045
Jan. 8-9	0*	0	0	0	0.014	0.020	0	0
Jan. 25-26	0*	0.013	0*	0	0*	0	0*	0.019
Feb. 12-13	0	0.024	0	0	0	0	0	0
Feb. 22-23	0	0	0	0	0	0	0	0
Mar. 5-6	0*	0	0*	0.37	0*	0	0	0
Mar. 22-23	0	0	0.013	0	0*	0	0.011	0
Apr. 9-10	0	0	0*	0	0.014	0	0.017	0
Apr. 29-30	0	0	0	0	0*	0	0	0
May 7-8	0	0	0.011	0	0.016	0	0	0
May 24-25	0	---	0	---	0*	0	0.550	0
June 6-7	0	0	0.009	0.046	0.014	0	0	0.034
June 13-14		PLANT NOT IN OPERATION						
June 20-21	0	0	0*	0	0*	0	0	0
June 27-28	0	0	0.007	0	0.016	0	0	0
July 5-6	0	0	0	0	0	0.012	0	0
July 9-10	0	0.012	0	0	0	0.010	0	0
July 18-19	0*	0.023	0*	0.032	0*	0	0*	0
July 26-27	0	0	0	0	0*	0	0*	0
Aug. 1-2	0	0	0.008	0	0	0.014	0	0
Aug. 6-7	0.019*	0	---	0	0*	0	0.034	0
Aug. 15-16	0.024	0.020	0	0	0.009	0	0*	0
Aug. 22-23	0.015	0.014	0	0.037	0	0	0.012	0
Aug. 30-31	0	0.057	0.031	0	0	0	0	0
Sep. 10-11	0.042	0.073	0	0.126	0	0	0	0
Sep. 25-26	0.009	0.016	0.009	0	0	0.013	0.045*	0.042
Oct. 8-9	0.092	0.022	0*	0	0*	0.069	0.015	0.072
Oct. 16-17	0.020*	0	0	0	0.009	0.048	0.166	0.172

TABLE 13. Benthos entrainment data, November-December 1978 and January-October 1979: <u>Asellus</u>, number m^{-3}. I = intake, D = discharge, * = based on one intake sample, ---- = missing data.

Sampling Date	SAMPLING PERIOD MIDN----->SUNR I	D	SUNR----->NOON I	D	NOON----->SUNS I	D	SUNS----->MIDN I	D
Nov. 13-14	0	0	0	0	0	0	0	0
Nov. 29-30	0	0	0	0	0	0	0	0
Dec. 4-5	0	0.012	0	0	0	0	0	0
Dec. 20-21	0	0	0*	0	0	0	0.009	0.030
Jan. 8-9	0*	0	0	0	0	0	0	0
Jan. 25-26	0*	0	0*	0	0*	0	0*	0
Feb. 12-13	0	0	0	0	0	0	0	0
Feb. 22-23	0	0	0	0	0	0	0	0
Mar. 5-6	0*	0	0*	0	0*	0	0	0
Mar. 22-23	0	0	0	0	0*	0	0	0
Apr. 9-10	0	0	0*	0	0	0	0	0
Apr. 29-30	0	0	0	0	0*	0	0	0
May 7-8	0	0	0	0	0	0	0	0
May 24-25	0	----	0	----	0*	0	0	0
June 6-7	0	0	0	0	0	0	0.020	0
June 13-14		PLANT NOT IN OPERATION						
June 20-21	0	0	0	0	0	0	0	0
June 27-28	0	0	0	0	0	0	0	0
July 5-6	0	0	0	0	0	0	0.021	0
July 9-10	0	0	0	0	0	0	0	0
July 18-19	0*	0	0*	0	0*	0	0*	0
July 26-27	0	0	0	0	0*	0	0*	0
Aug. 1-2	0	0	0	0	0	0	0	0
Aug. 6-7	0*	0	----	0	0*	0	0	0
Aug. 15-16	0	0	0	0	0	0	0*	0
Aug. 22-23	0	0	0	0	0	0	0	0
Aug. 30-31	0	0	0	0	0	0	0	0
Sep. 10-11	0	0	0	0	0	0	0	0
Sep. 25-26	0	0	0	0	0	0	0*	0
Oct. 8-9	0	0	0*	0	0*	0	0	0
Oct. 16-17	0*	0	0	0	0	0	0	0

TABLE 14. Numbers and weights of crayfish (Orconectes propinquus) impinged on the travelling screens of the Donald C. Cook Nuclear Plant in 1978. The number of 24-hour samples processed for crayfish from each period is given in parentheses. A = sampled quantities. B = estimated totals.

INCLUSIVE DATES			A		B	
			NUMBER	WEIGHT (kg)	NUMBER	WEIGHT (kg)
January	1-16	(2)	25	0.12	200	0.98
	17-31	(4)	15	0.10	56	0.39
February	1-14	(3)	17	0.12	79	0.57
	15-28	(2)	4	0.04	28	0.25
March	1-16	(0)	0	0	0	0
	17-31	(4)	101	0.60	379	2.26
April	1-15	(5)	170	0.99	510	2.97
	16-30	(2)	28	0.17	210	1.25
May*	1-16	(1)	8	0.05	128	0.78
	17-31	(1)	10	0.05	150	0.75
June*	1-15	(1)	10	0.06	150	0.93
	16-30	(1)	20	0.13	300	2.01
July	1-16	(2)	286	1.28	2288	10.25
	17-31	(0)	0	0	0	0
August*	1-16	(3)	90	0.52	480	2.77
	17-31	(3)	130	0.72	650	3.60
September*	1-15	(2)	26	0.17	195	1.28
	16-30	(3)	6	0.04	30	0.20
October	1-16	(4)	9	0.07	36	0.29
	17-31	(3)	15	0.12	75	0.60
November	1-15	(2)	2	0.02	15	0.08
	16-30	(0)	0	0	0	0
December	1-16	(0)	0	0	0	0
	17-31	(1)	7	0.03	105	0.39
TOTAL					6064	33.15

*Although month was recorded on sample labels, some samples lacked exact days.

TABLE 15. Numbers and weights of crayfish (*Orconectes propinquus*) impinged on the travelling screens of the Donald C. Cook Nuclear Plant in 1979. The number of 24-hour samples processed for crayfish from each period is given in parentheses. A = sampled quantities. B = estimated totals. (-) = samples either missing or no crayfish collected.

INCLUSIVE DATES			A		B	
			NUMBER	WEIGHT (kg)	NUMBER	WEIGHT (kg)
January	1-16	(1)	9	0.06	144	0.99
	17-31	(1)	4	0.03	60	0.51
February*	1-14	(1)	5	0.05	70	0.66
	15-28	(-)				
March*	1-16	(2)	7	0.07	56	0.56
	17-31	(2)	33	0.21	248	1.54
April	1-15	(1)	11	0.08	165	1.22
	16-30	(3)	36	0.21	180	1.07
May	1-16	(1)	3	0.02	16	0.09
	17-31	(-)				
June	1-15	(-)				
	16-30	(-)				
July*	1-16	(4)	35	0.02	140	0.81
	17-31	(4)	80	0.52	300	1.95
August	1-16	(3)	95	0.63	507	3.39
	17-31	(3)	66	0.42	330	2.11
September*	1-15	(3)	41	0.28	205	1.41
	16-30	(3)	7	0.04	35	0.20
TOTAL, January - September, excluding February 15-28 and May 17 - June 30 (58% of the year)					2456	16.51
PROJECTED TOTAL for January - December 1979					4210	28.30

*Although the month was recorded on sample labels, some samples lacked exact days.

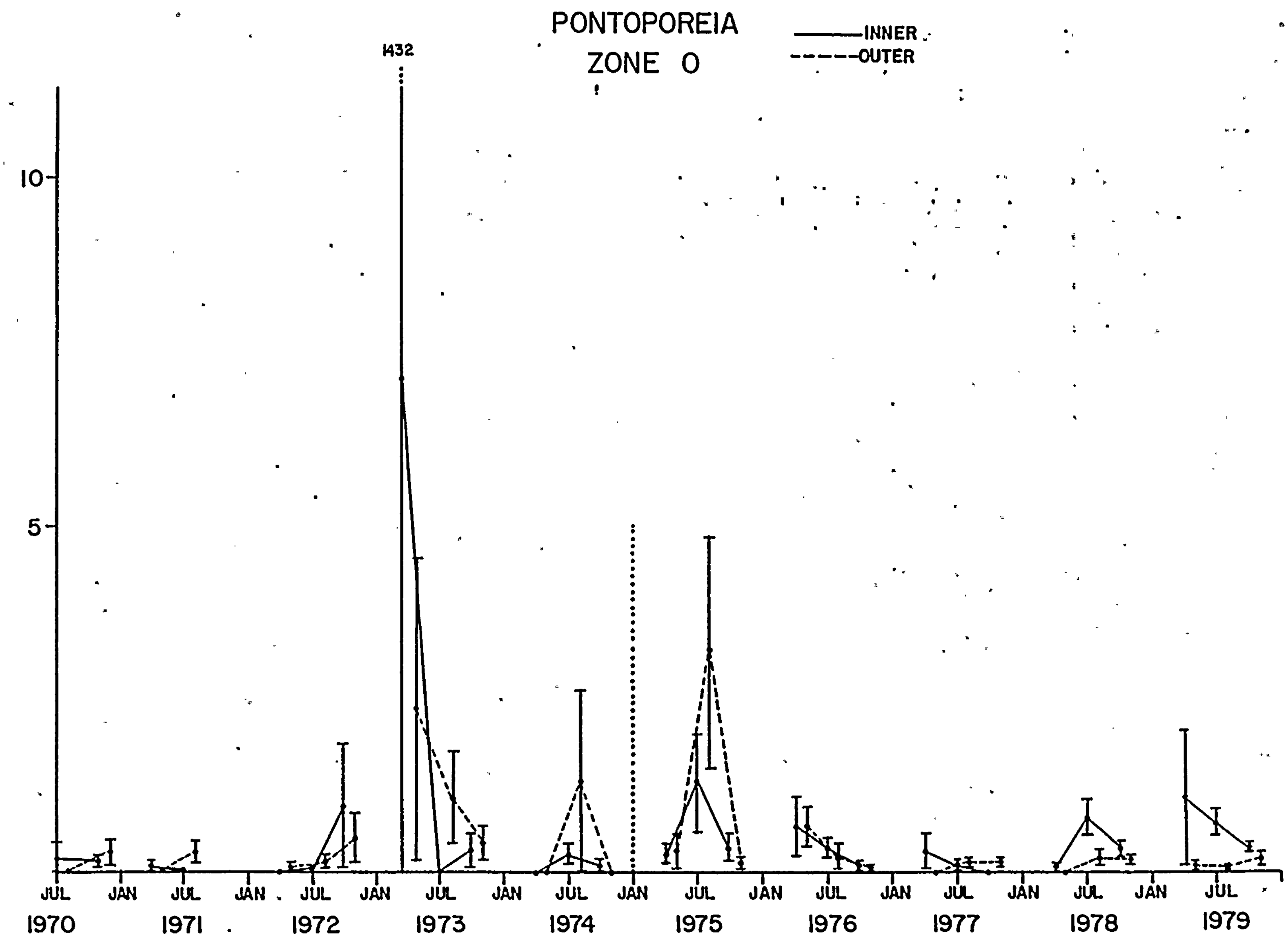

FIGURE 1. Density (animals m^{-2}) of Pontoporeia hoyi in the Inner and Outer sections of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

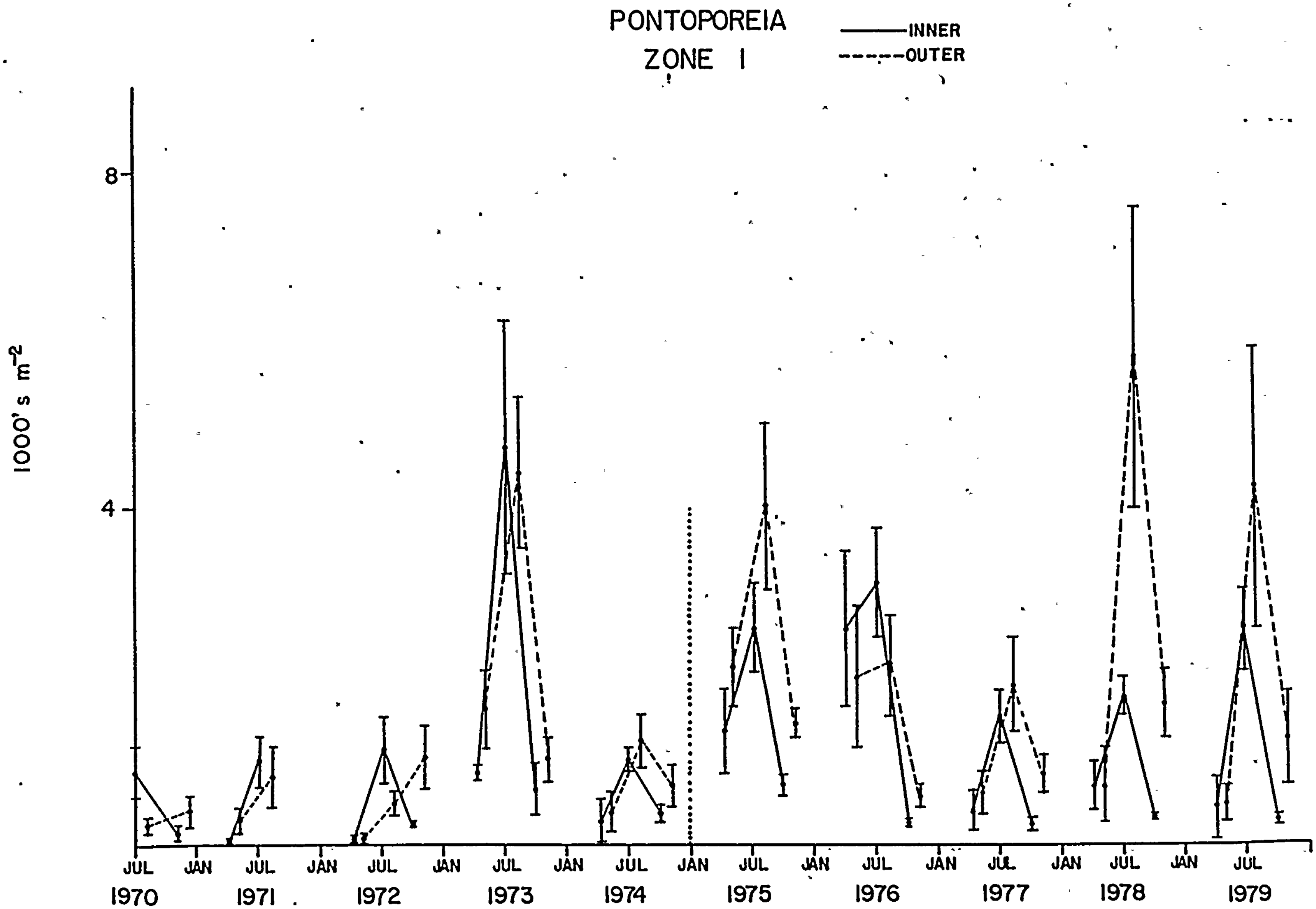

FIGURE 2. Density (animals m^{-2}) of Pontoporeia hoyi in the Inner and Outer sections of Zone 1 (8-16 m depth), vertical bars are stardard errors, vertical dotted line indicates the start of plant operation.

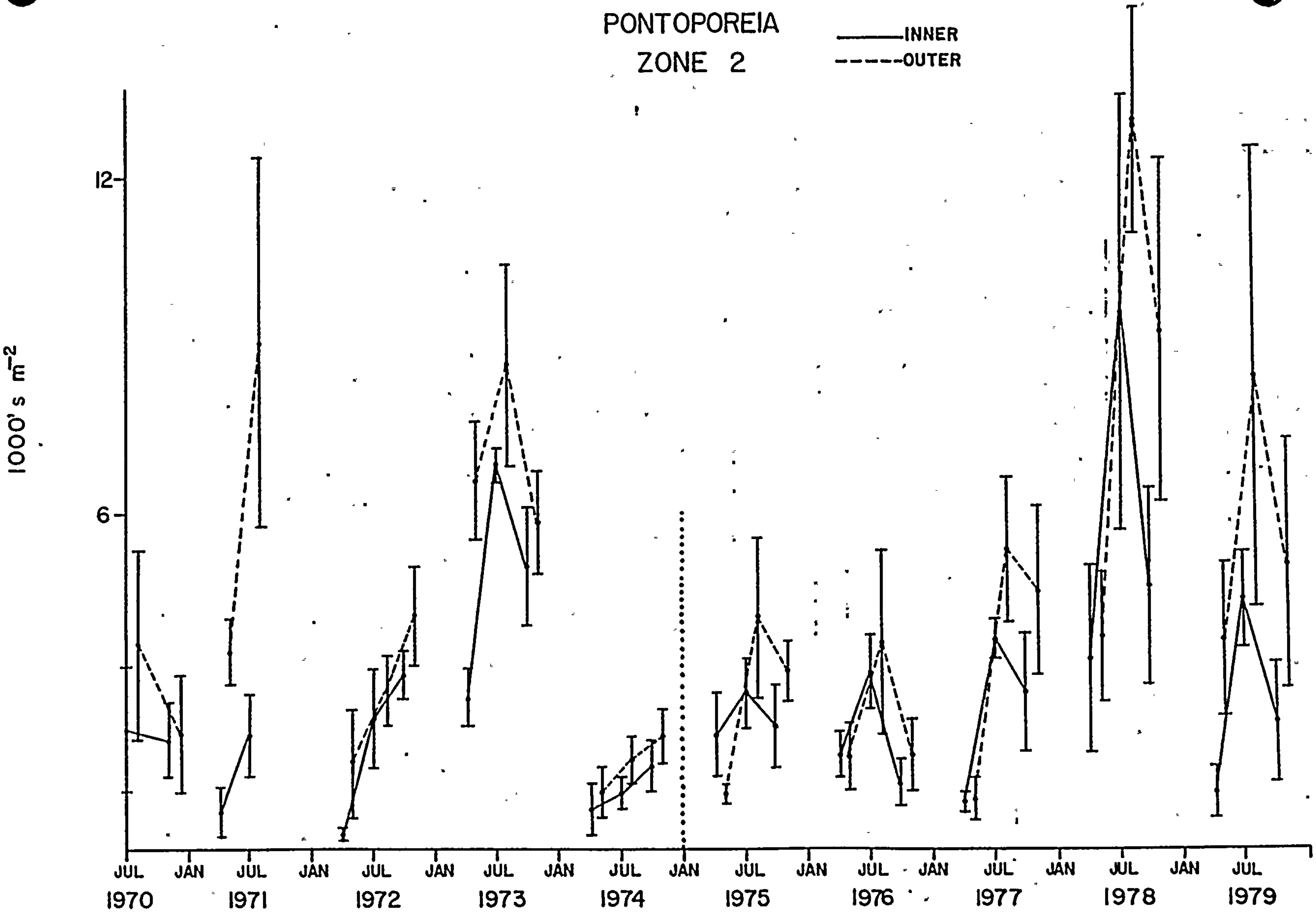

FIGURE 3. Density (animals m^{-2}) of Pontoporeia hoyi in the Inner and Outer sections of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

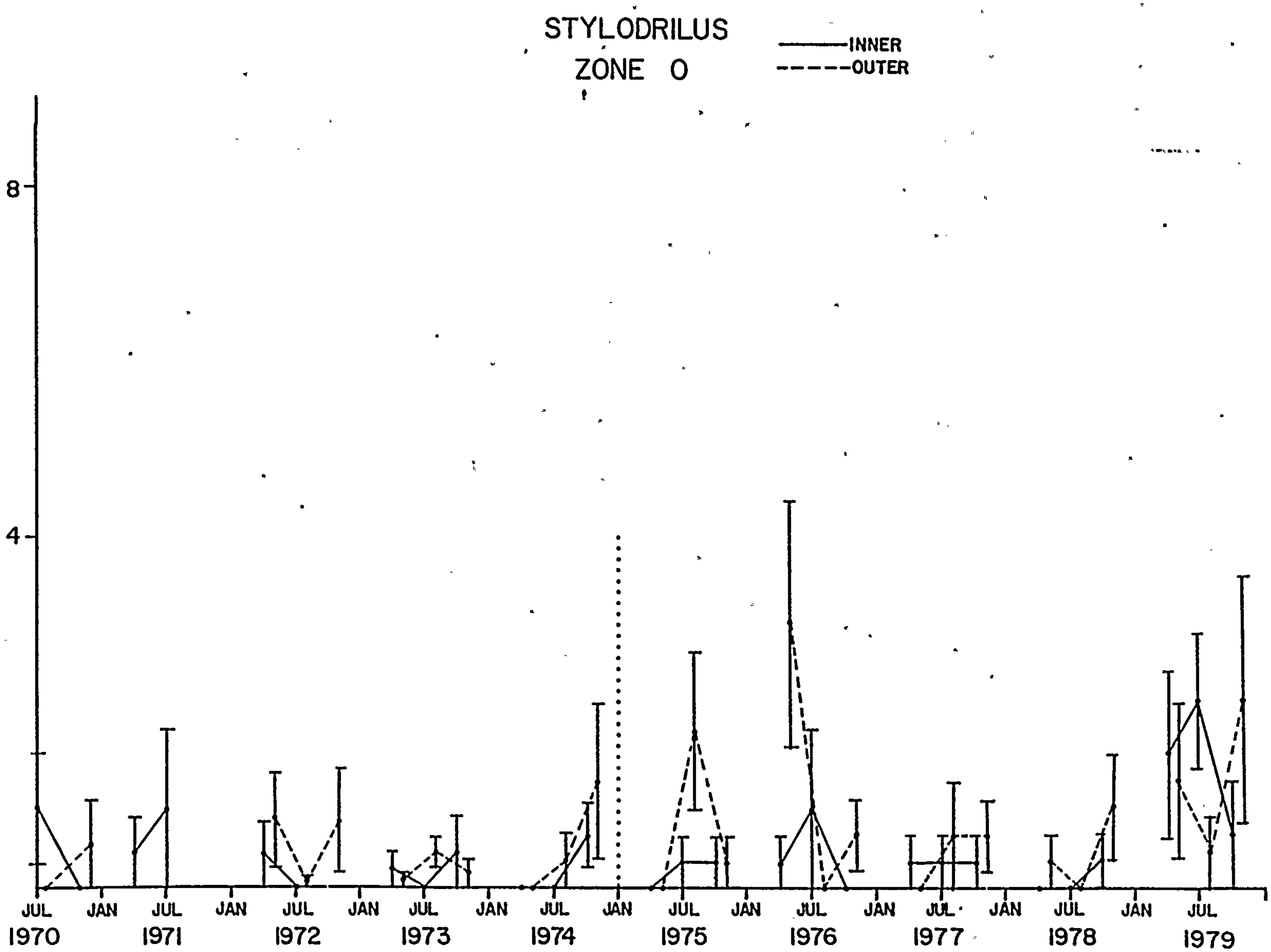

FIGURE 4. Density (animals m^{-2}) of Stylodrilus heringianus in the Inner and Outer sections of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

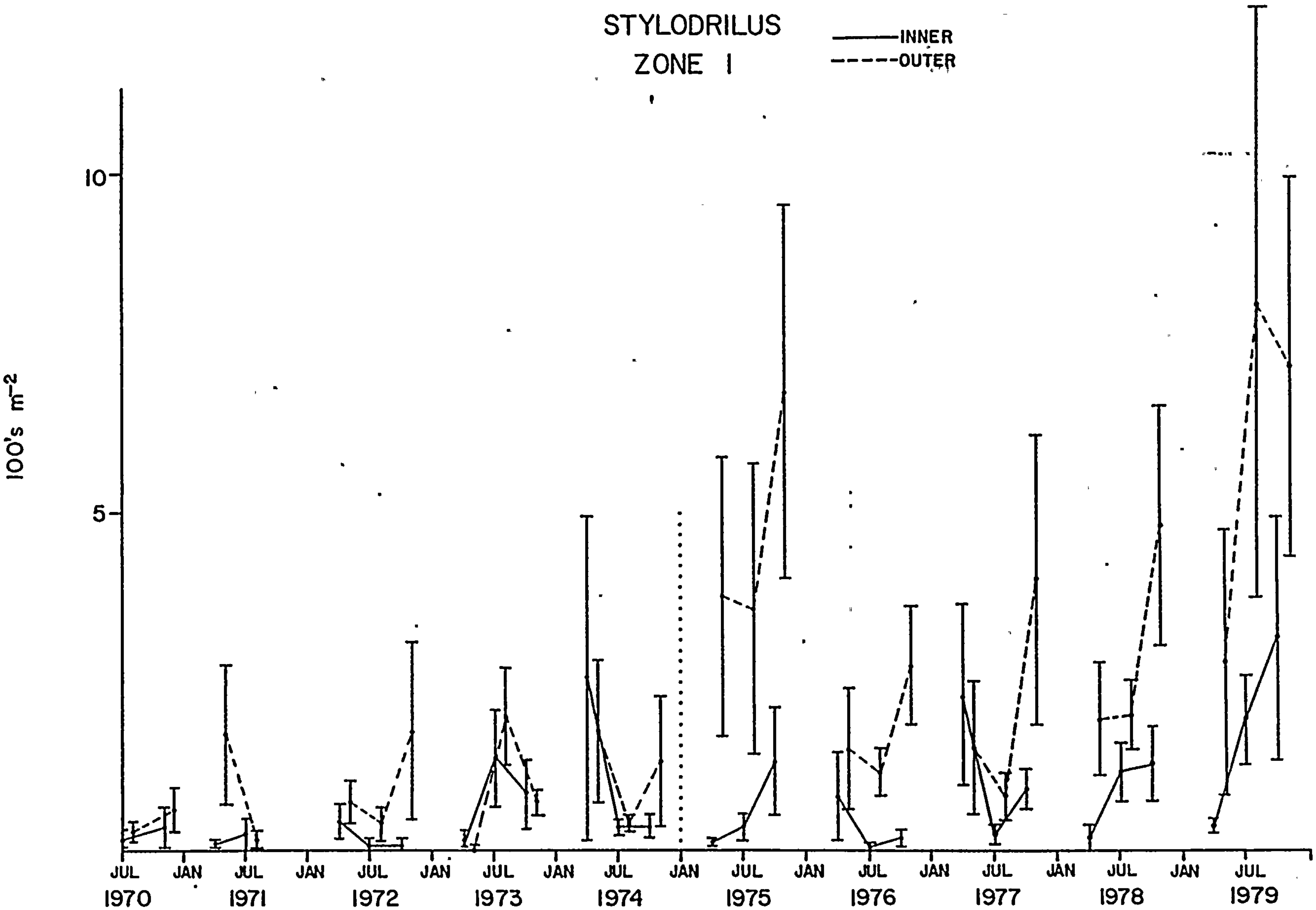

FIGURE 5. Density (animals m^{-2}) of <u>Stylodrilus heringianus</u> in the Inner and Outer sections of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

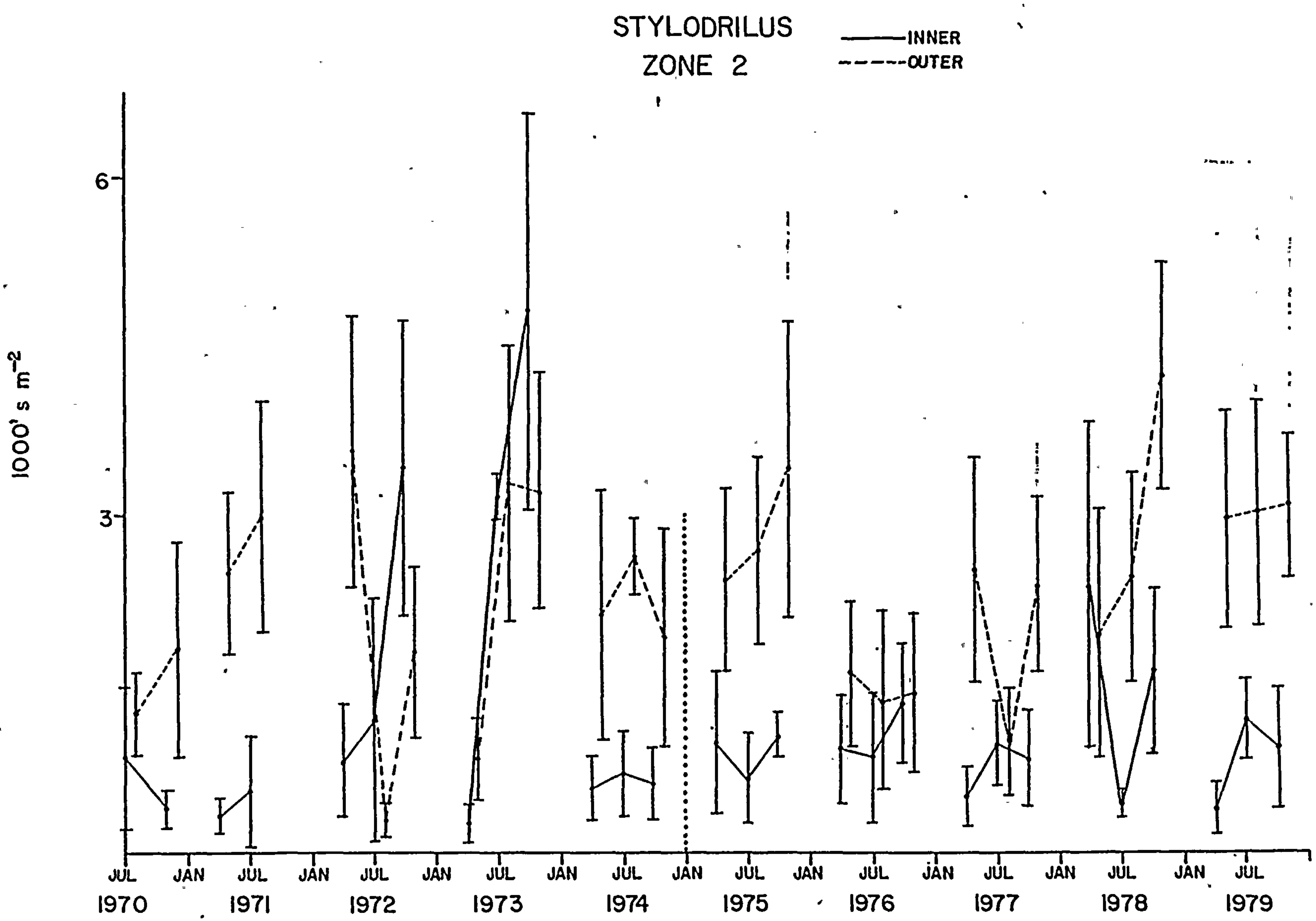

FIGURE 6. Density (animals m^{-2}) of Stylodrilus heringianus in the Inner and Outer sections of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

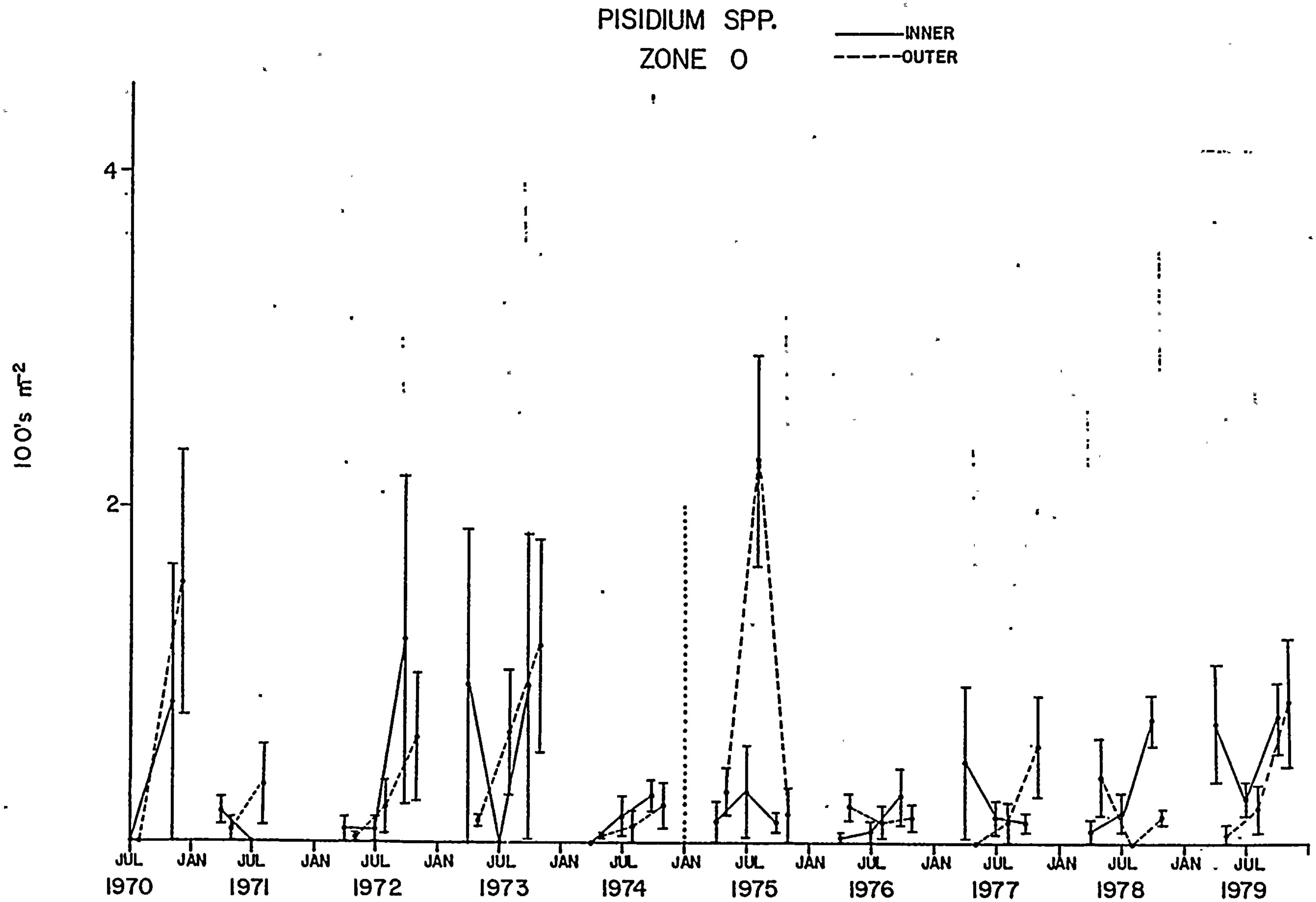

FIGURE 7. Density (animals m^{-2}) of Pisidium spp. in the Inner and Outer sections of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

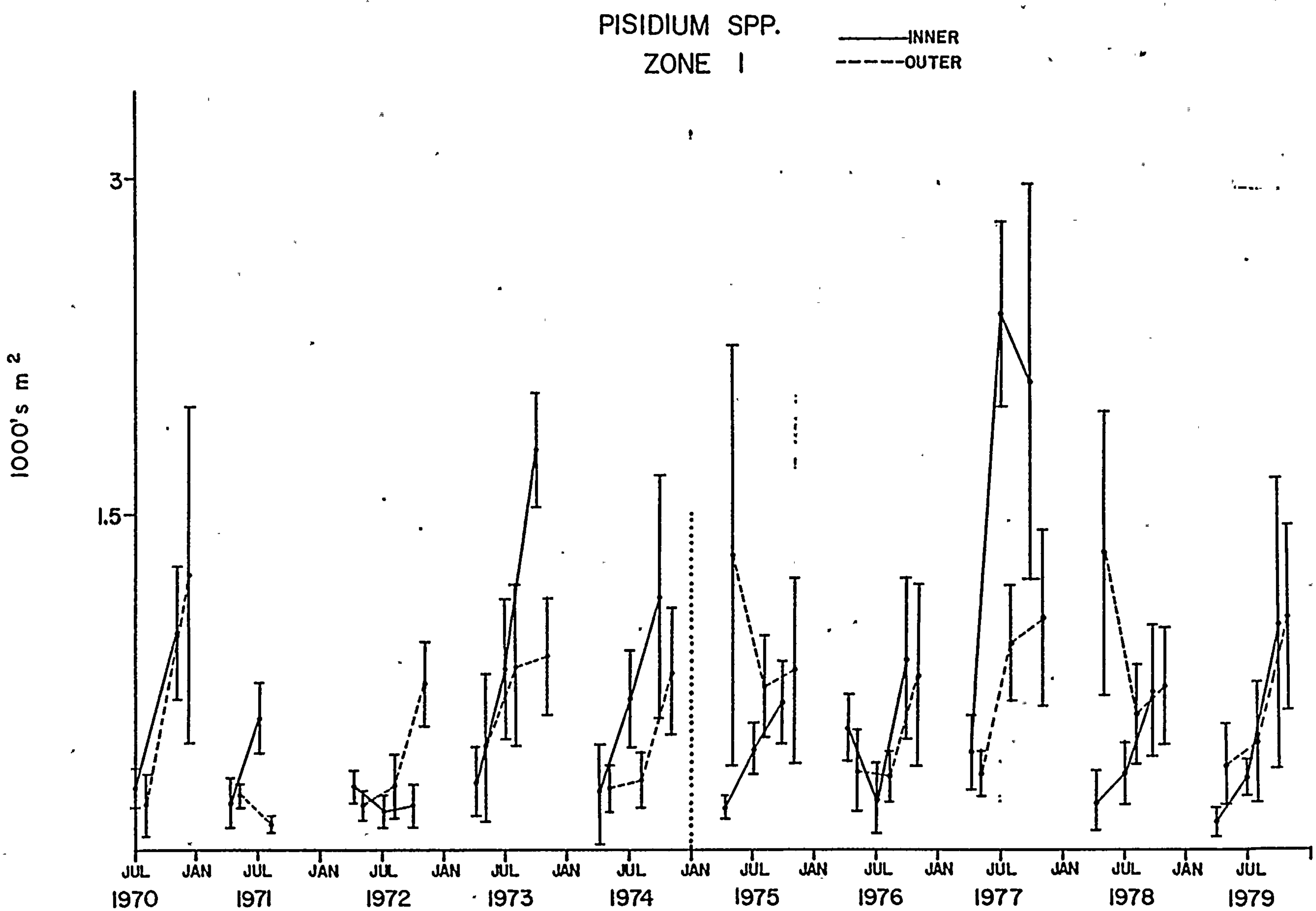

FIGURE 8. Density (animals m^{-2}) of Pisidium spp. in the Inner and Outer sections of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

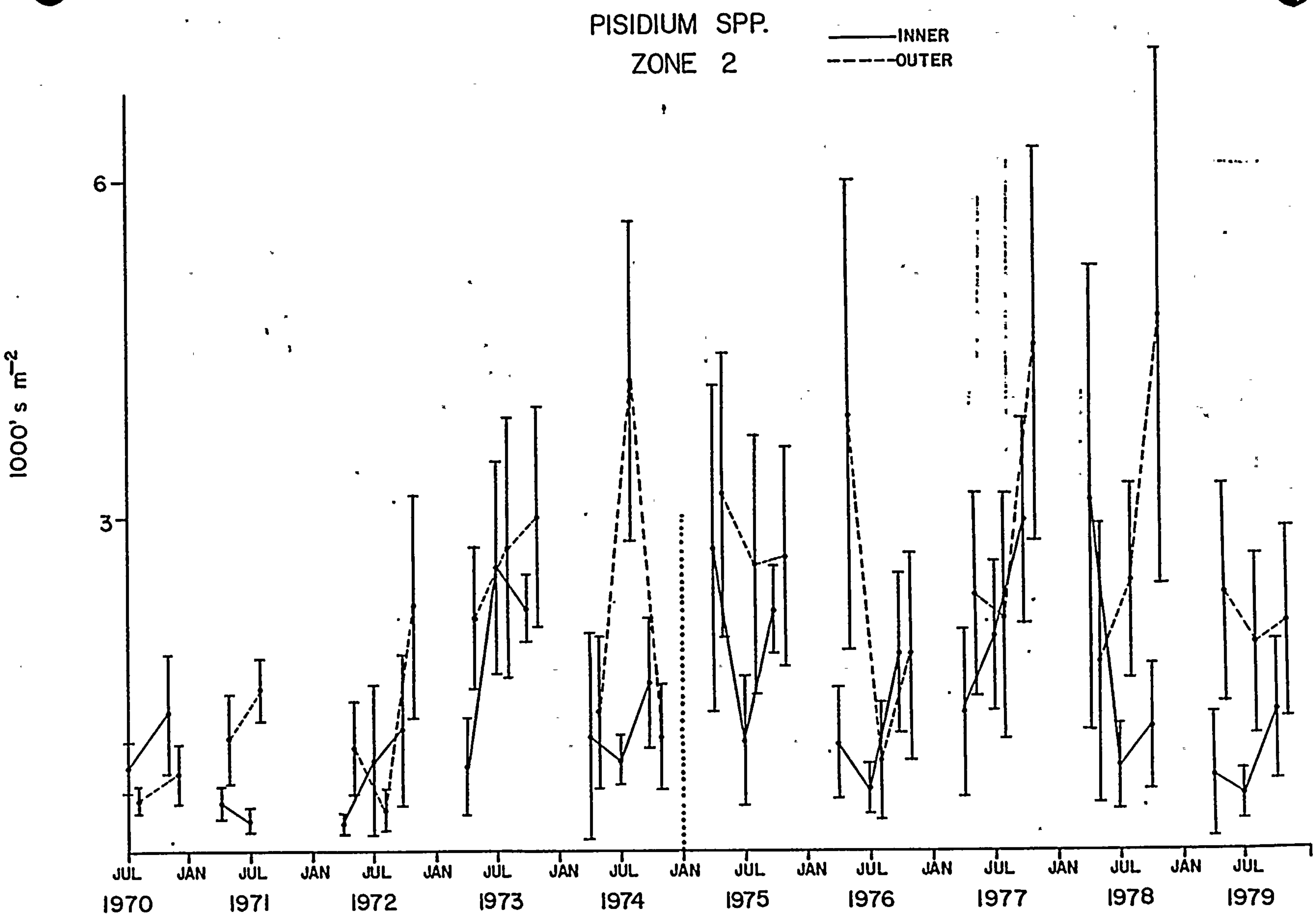

FIGURE 9. Density (animals m^{-2}) of Pisidium spp. in the Inner and Outer sections of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

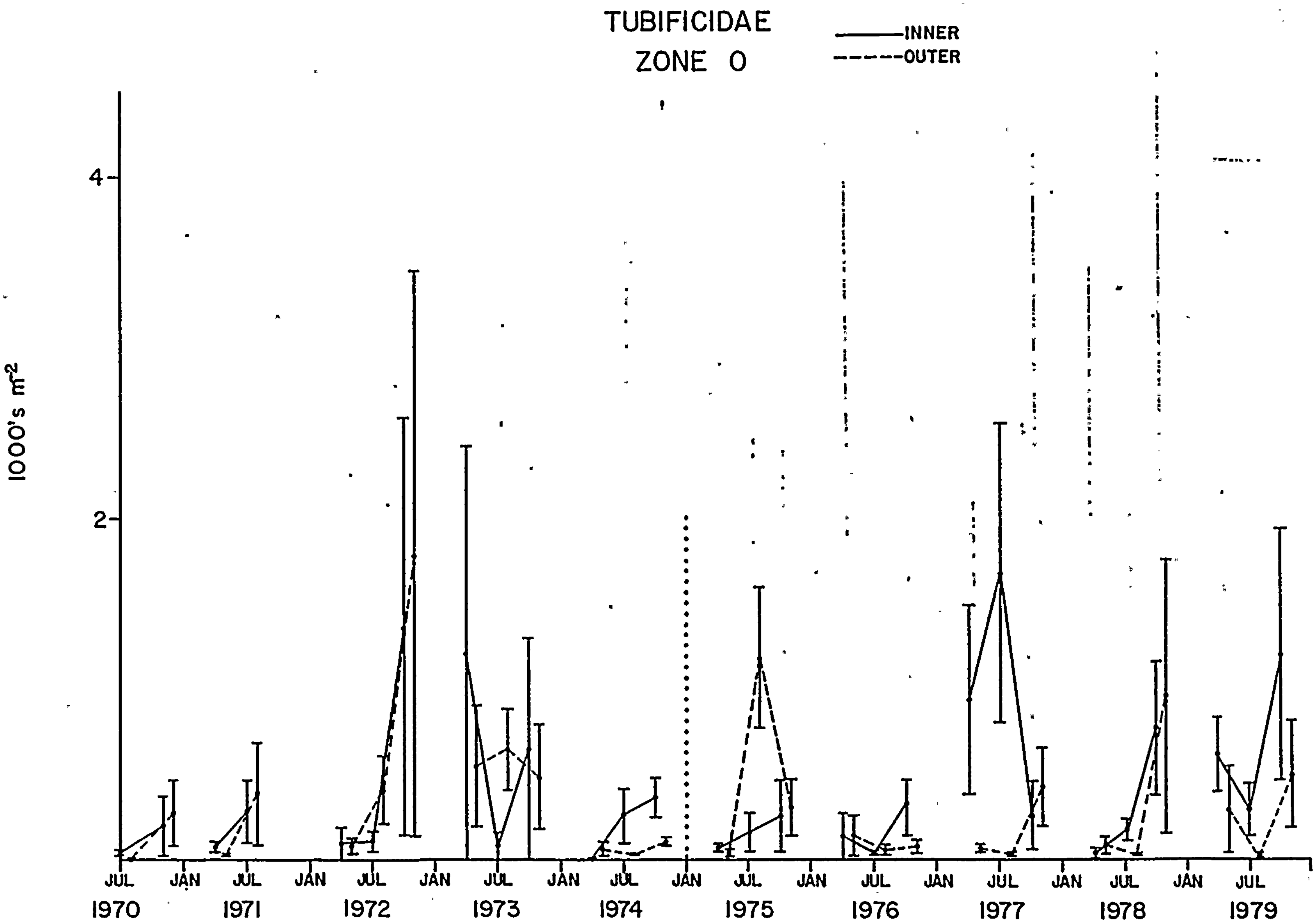

FIGURE 10. Density (animals m^{-2}) of Tubificidae in the Inner and Outer sections of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

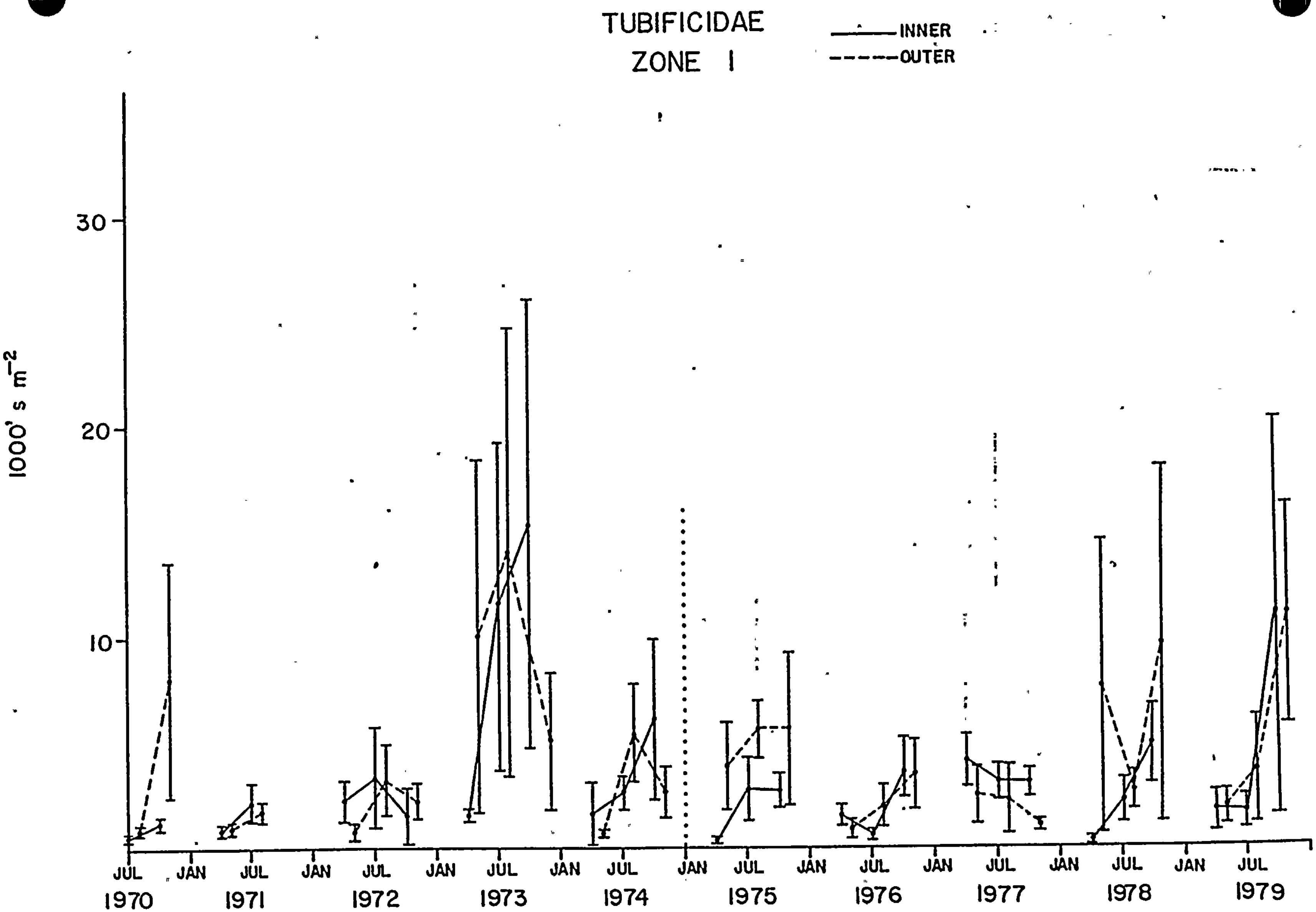

FIGURE 11. Density (animals m^{-2}) of Tubificidae in the Inner and Outer sections of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

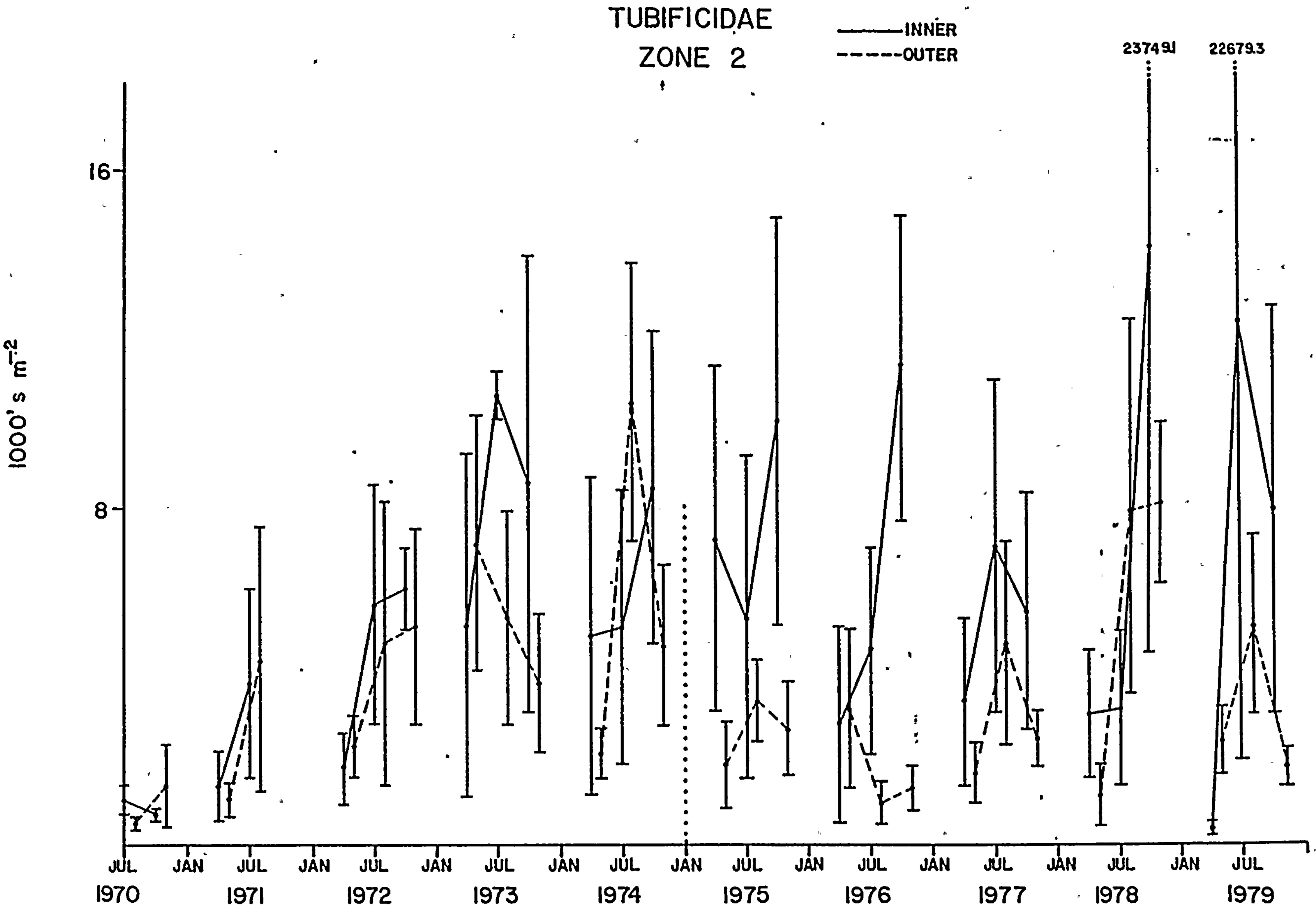

FIGURE 12. Density (animals m^{-2}) of Tubificidae in the Inner and Outer sections of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

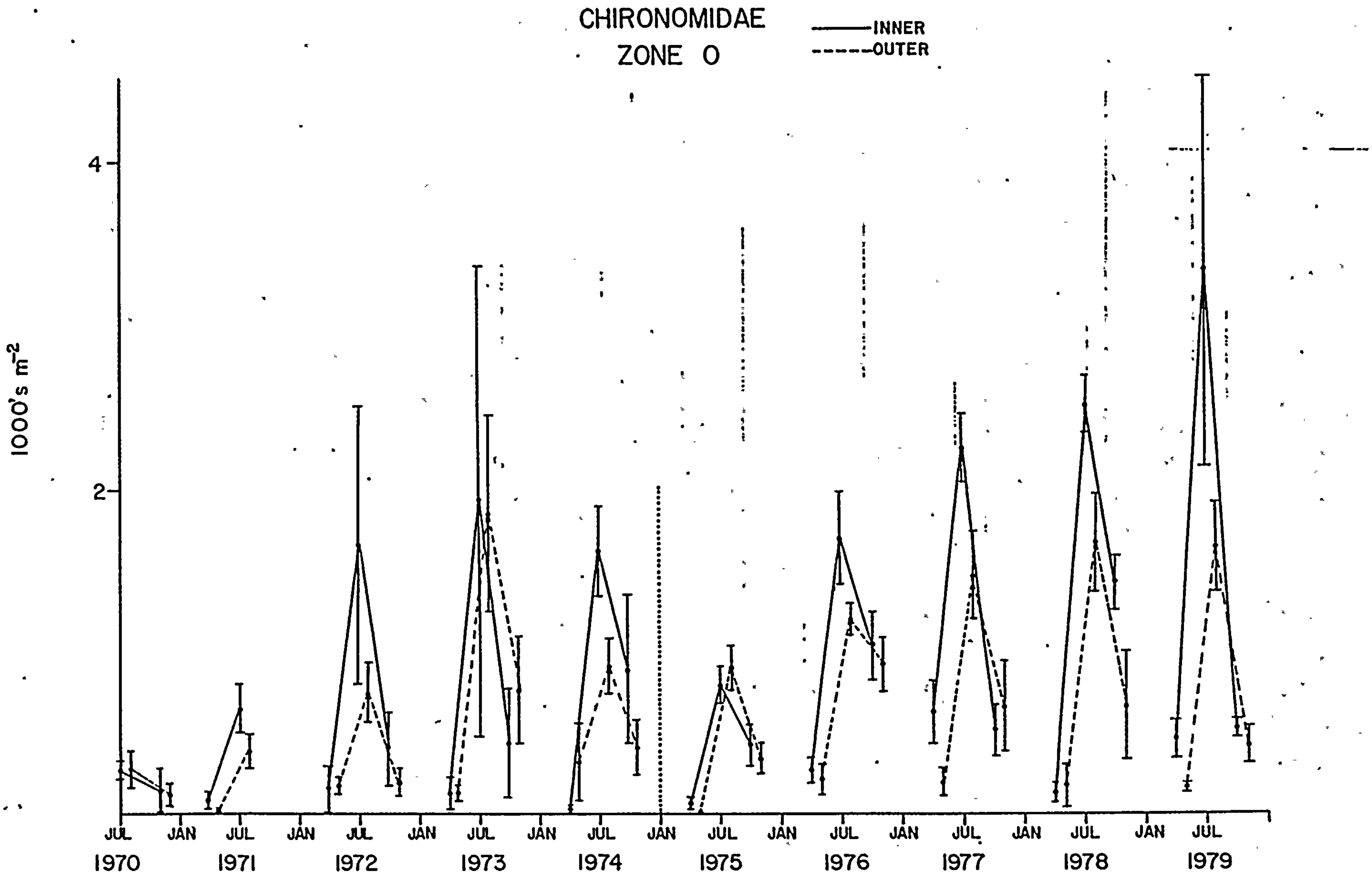

FIGURE 13. Density (animals m^{-2}) of Chironomidae in the Inner and Outer sections of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

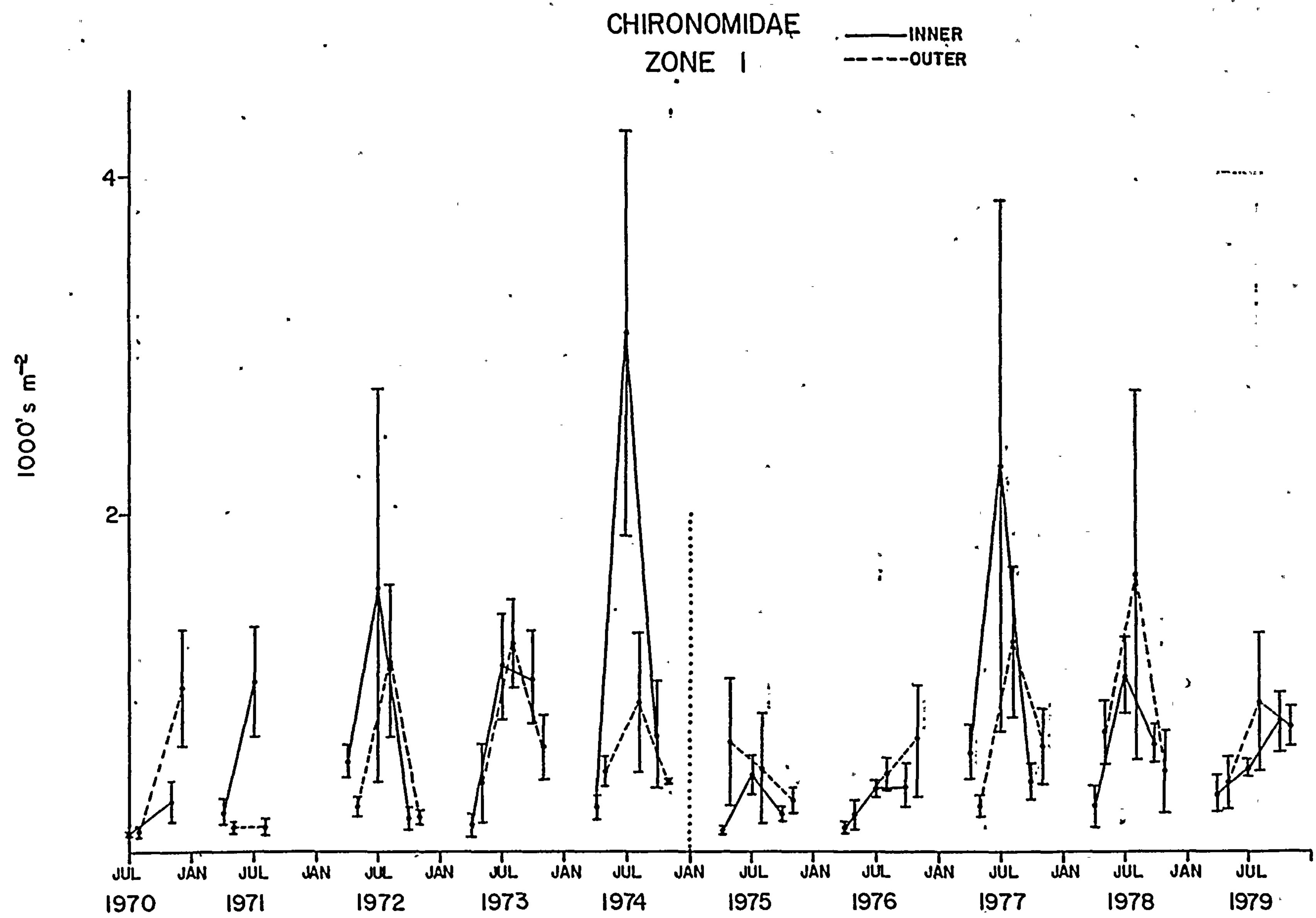

FIGURE 14. Density (animals m^{-2}) of Chironomidae in the Inner and Outer sections of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

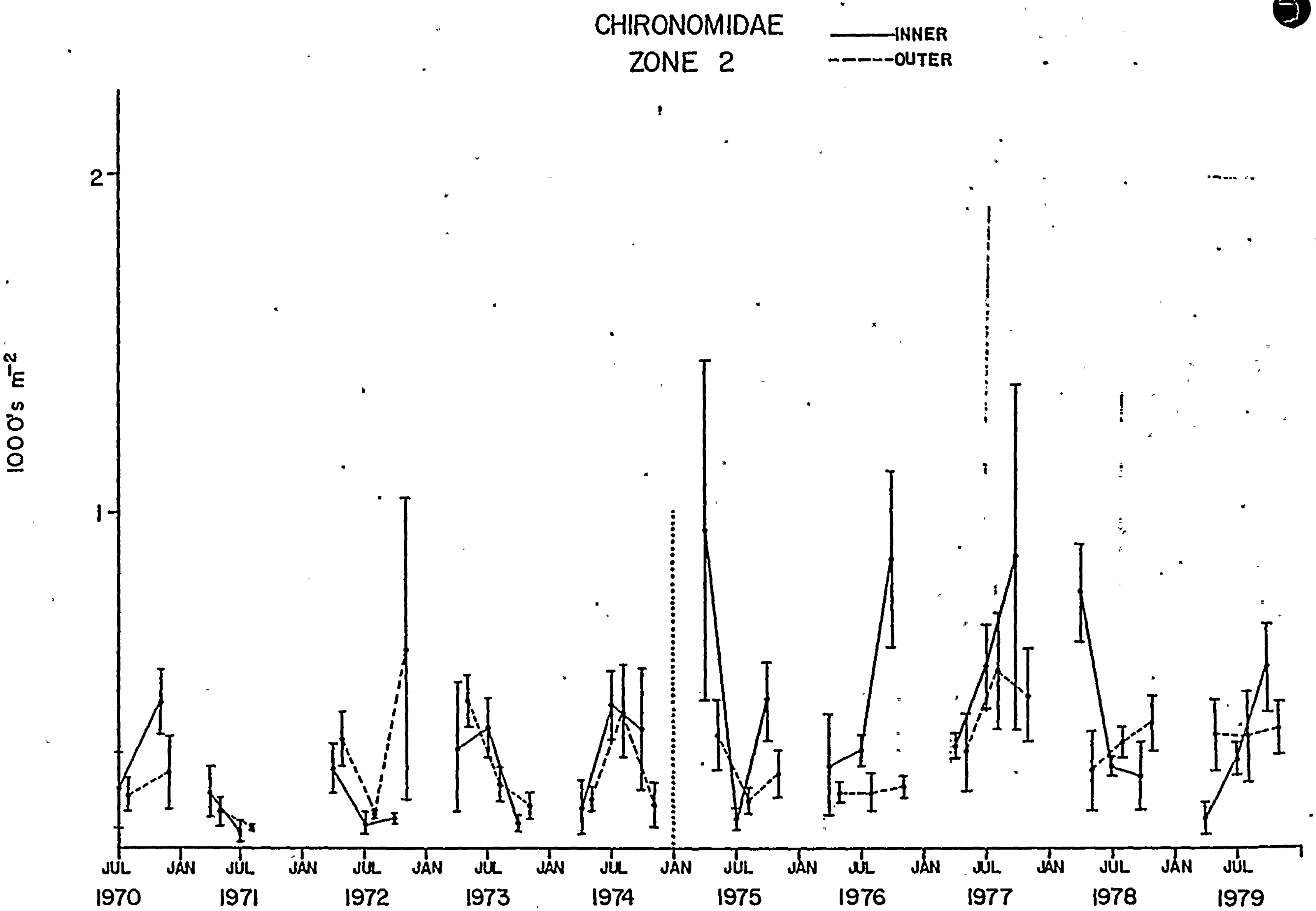

FIGURE 15. Density (animals m^{-2}) of Chironomidae in the Inner and Outer sections of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

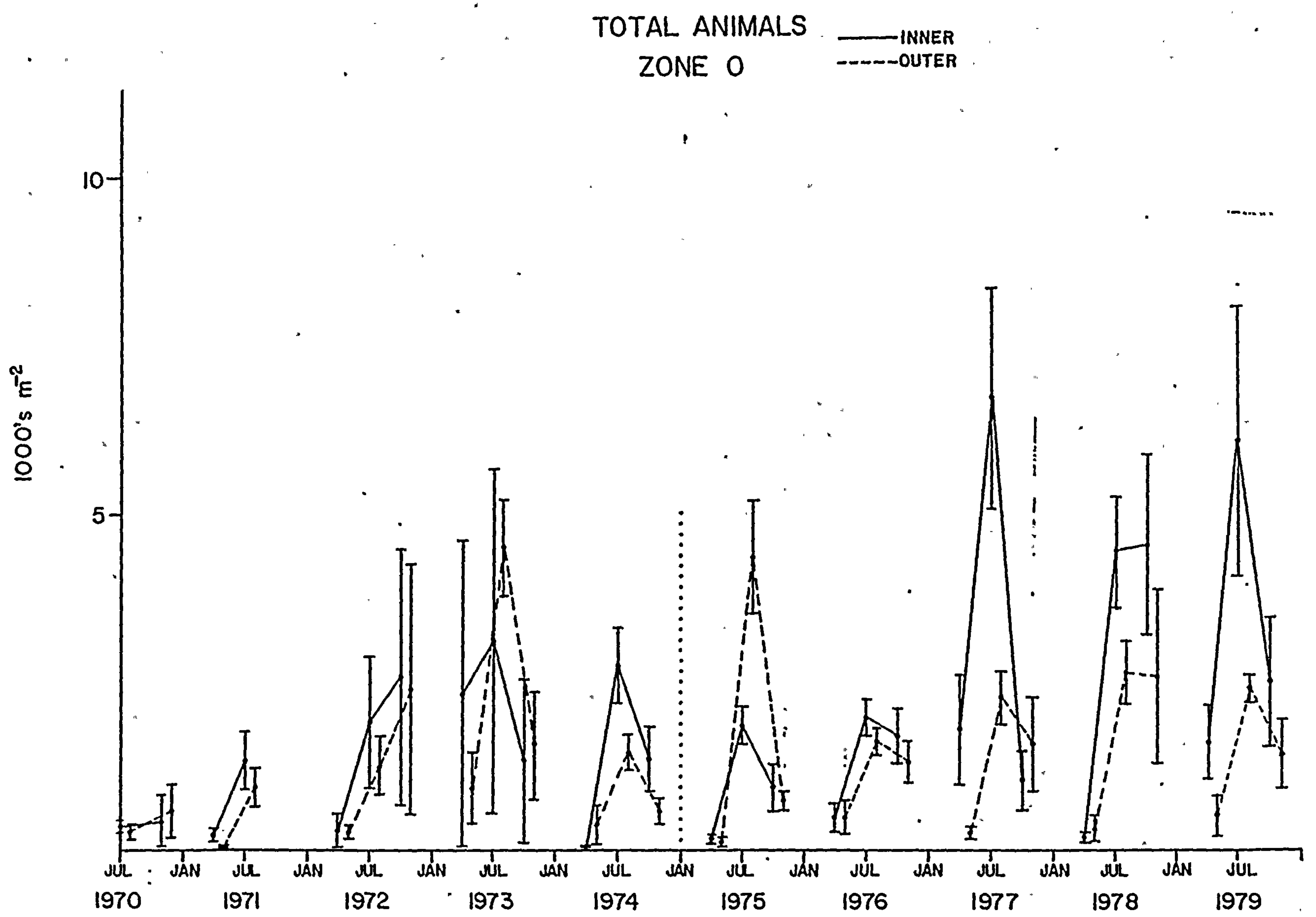

FIGURE 16. Density (animals m^{-2}) of Total Animals in the Inner and Outer sections of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

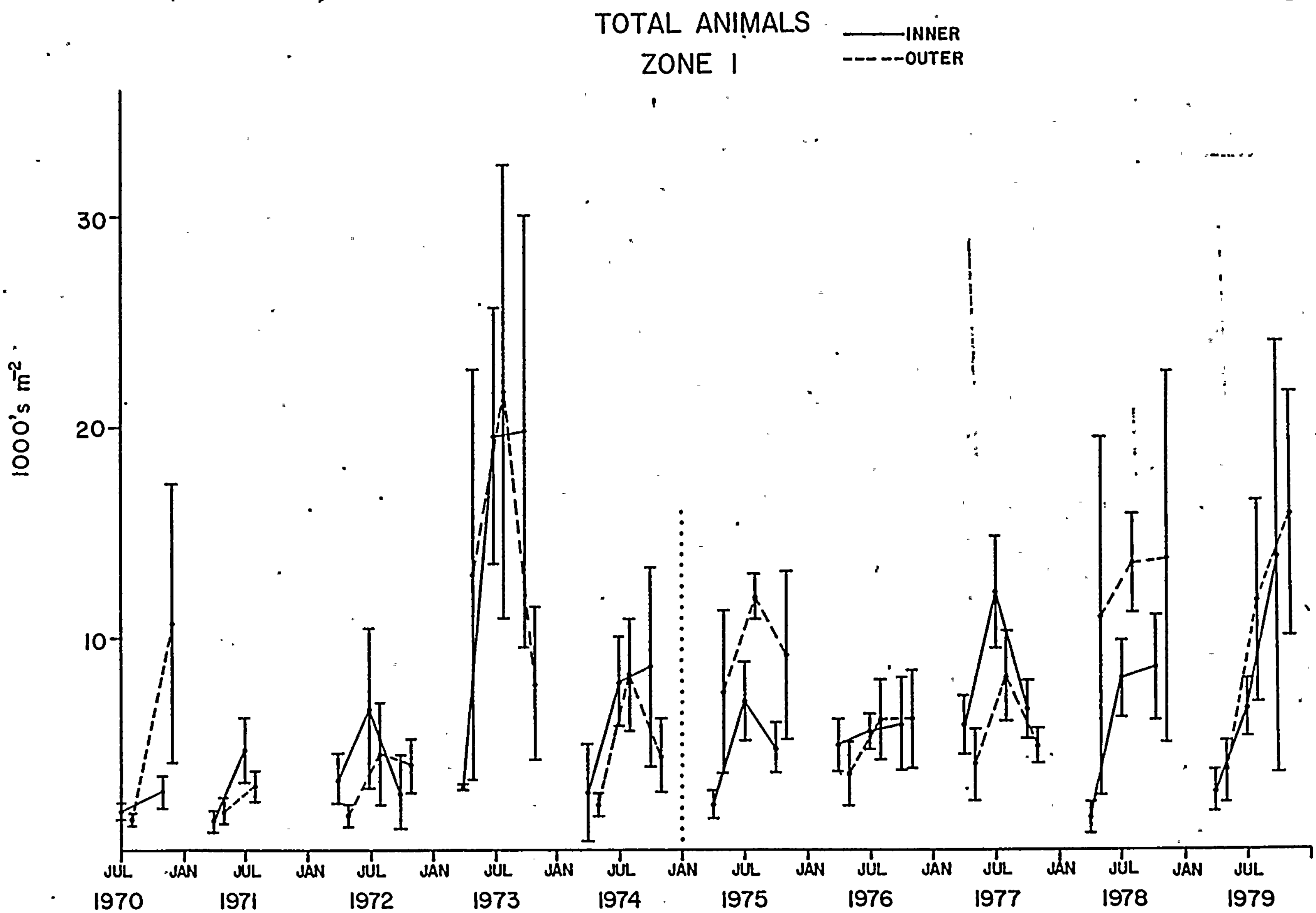

FIGURE 17. Density (animals m^{-2}) of Total Animals in the Inner and Outer sections of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

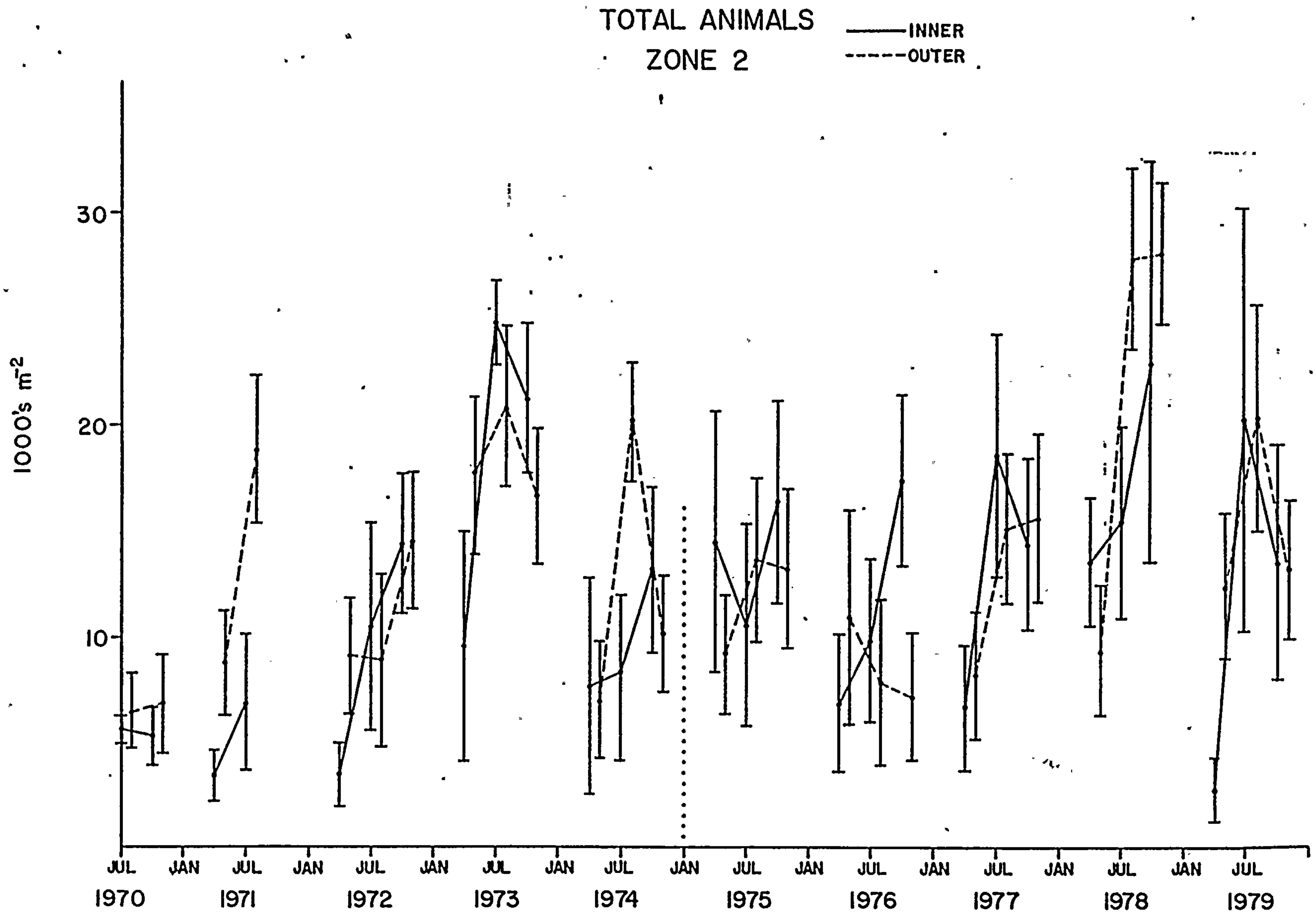

FIGURE 18. Density (animals m^{-2}) of total animals in the Inner and Outer sections of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

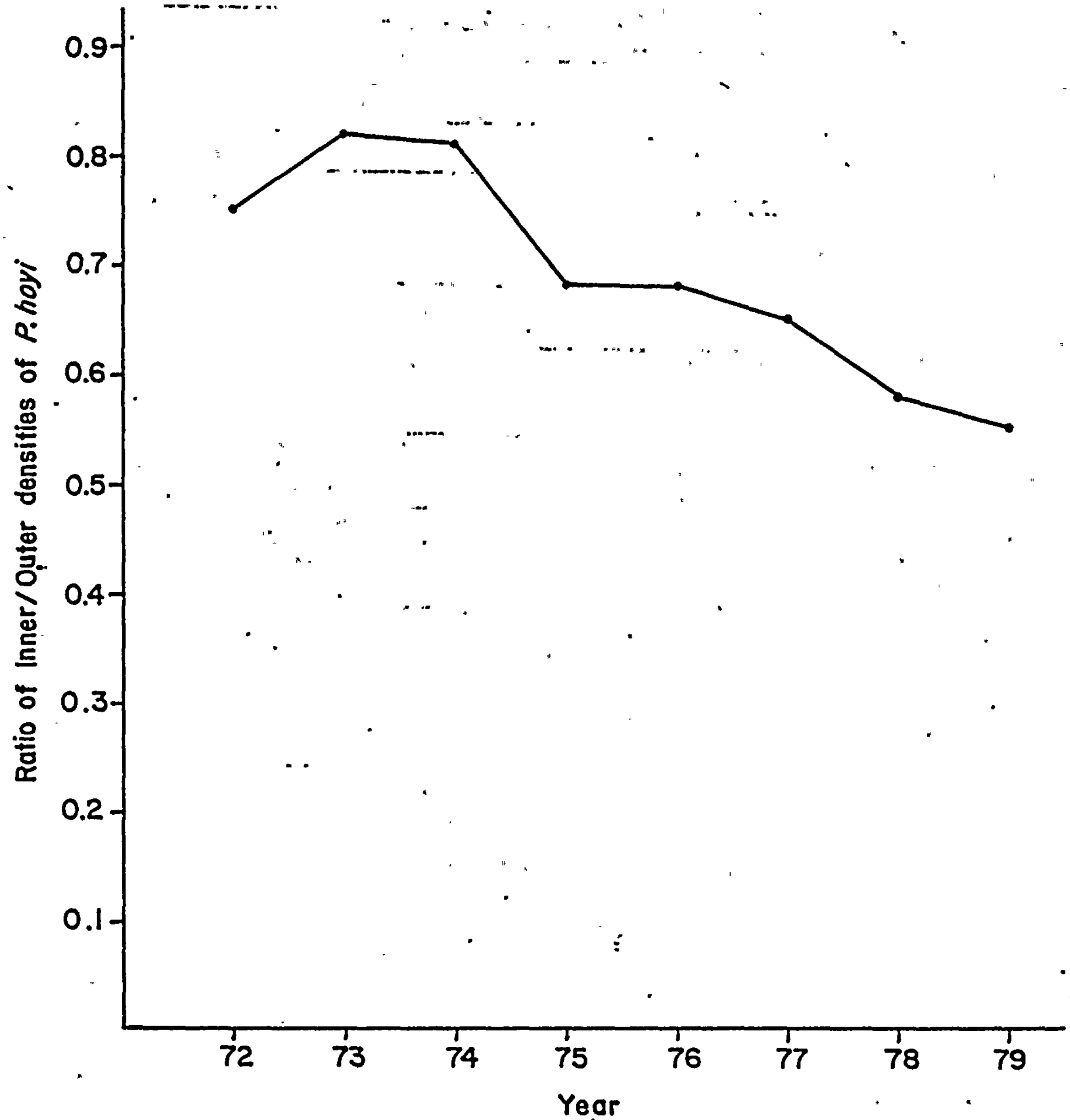

FIGURE 19. October Zone 2 Inner/Outer ratios of mean number m^{-2} for Pontoporeia hoyi for each year summed consecutively within the before and after construction time periods.

APPENDIX B-4

PERIPHYTON

Periphyton are attached algae growing upon solid substrates, and hence fixed in position. If their substrates are located where the plant discharge can reach them, the periphyton may respond by changes in abundance, population composition, diversity, or other population parameters. Significant differences between preoperational and operational population parameters are to be investigated as being possibly plant-caused.

Periphyton on the intake and discharge structures and the riprap are to be visually inspected and samples hand-collected during the months of April through October. The Specifications require that in each of these months a sample from the intake structure be examined in wet-mount for species identification; monthly samples from the intake and discharge structures and from the riprap around each are being wet-mount examined.

Monthly samples of entrained phytoplankton taken from the intake forebay of the screenhouse are to be examined for periphytic species and the abundances thereof obtained. Six replicates of entrained phytoplankton from the intake forebay are being examined each month.

Specification 4.1.2.1.4 (Visual Observation of the Intake and Discharge Structure Areas) provides that diving operations shall be dependent upon favorable weather conditions. Periphyton samples could not be taken due to bad weather in April and September 1975, October 1976, and October 1977. Samples of April 1977 were lost in the capsizing of a small boat; samples of May 1977 were accidentally omitted. Personnel changes in 1979 have resulted in the entrainment samples being worked up only through September 1978.

INTRODUCTION

Periphyton are algal organisms which require attachment to solid substrata during all or part of their life cycles. The plant's offshore riprap bed and submerged intake and discharge structures provide solid substrates in an area naturally devoid of them, and becoming inhabited by periphyton and animal organisms, they constitute a small ecosystem atypical of the surrounding area.

The discharge structures function in, and the riprap and intake structures are reasonably near, the discharge of the plant's waste heat. The algal and animal organisms supported by these installations are, then, presumably subject to temperature perturbations due to exposure to the plant's discharged heat. Study of the abundance and species composition of the periphyton, over time, becomes a means of telling whether plant operation has affected these resident, but not indigenous, populations.

Newly placed underwater installations undergo periods of surface modification (rusting, slime formation) before they become colonized by periphyton and subsequently by animal organisms. Our diving records show that 1974 was the first field season when the Cook Plant underwater installations were complete; at that time the installations were being colonized rapidly by periphyton, snails, bryozoa, freshwater sponges, and crayfish but the numbers of periphyton taxa taken in June and October were low (8 green algae, 1 blue-green, and 30 diatoms). We consider that the one preoperational year was insufficient for the new installations to become fully colonized, and that additional colonization after 1974 has rendered pre- vs post-operational comparisons of periphyton abundances and species compositions probably not valid.

TECHNIQUES

The strategy of the periphyton studies is that samples taken by divers from the underwater installations are analyzed to provide a yearly list of periphyton taxa present; to these, taxa taken in intake entrainment samples in the plant screenhouse are compared to assess the adequacy of the plant's intake water flow as a sampler of the periphyton. The diver-collected periphyton taxa list provides names of periphytes which may be taken in entrainment samples during November through March when the only sampling possible is that done by the intake flow entrainment.

Periphyton samples are collected underwater by scraping the substrate with a putty knife and gently transferring the scrapings into a widemouth plastic bottle. After surfacing, the diver disperses the scrapings by gentle stirring and preserves the sample with 5% buffered formalin.

In the laboratory a subsample from each sample of scrapings is removed for wet-mounting in water for species identification at 400-600X on a Leitz-Wetzlar Ortholux microscope. Species identified in the wet mounts of the diver-collected samples taken during April-October become the yearly list of periphyton taxa.

Entrainment sampling is carried out in the intake forebay of the plant screenhouse. Duplicate samples are pumped by nominal 80 gpm diaphragm pumps from 18 feet below the water surface at each of morning twilight, noon, and evening twilight. Samples are one liter each, taken in plastic bottles, preserved with Lugol's fixative, and taken to the laboratory where a permanent slide is made from each sample by the settle-freeze method used in our lake phytoplankton studies. Each sample is settled in a one liter graduated cylinder for two days, 900 ml of supernatant are then siphoned off and the remaining 100 ml swirled and gently shaken to resuspend the settled material. Eighteen ml of the suspension is pipetted to a plexiglass chamber clamped to a microscope slide and allowed two days of secondary settling. Each slide is precoated with Dessicote to provide a hydrophobic surface, and leakage of water at the chamber bottom is prevented by a light ring of stopcock grease. Groups of chambers and slides rest on an aluminum plate during settling. After the second day freezing is done by setting the plate on a flat block of dry ice until the bottom 1.5 mm is frozen; the supernatant is then decanted and the chamber removed, leaving a wafer of ice on the slide. The slide is placed for two days in an anhydrous alcohol vapor chamber for dehydration, and then for two days in a toluene vapor chamber to prepare for the toluene-based Permount mounting medium and a cover slip. Newly prepared slides are allowed to dry at least two days before identifications and counting are carried out under oil immersion at 1000X. A horizontal and a vertical row across each slide are counted and identified.

The author makes no apology for departing from scientific practice in the presentation of scientific names in the tables; to require the typist to switch to italics for each of the great mass of scientific names was adjudged an avoidable waste of time.

RESULTS AND DISCUSSIONS

Table 1 lists the algal taxa that were collected by our divers in periphyton samples from the Cook Plant underwater installations during the diving season of 1978 and gives the abundances in cells per ml of these taxa in intake entrainment samples each month. Personnel changes and the necessity for extensive training of new personnel have resulted in entrainment samples being worked up only through September 1978.

Ninety-seven periphyte taxa were diver-collected in each of 1975 and 1977, 67 were taken in 1976, and 117 were taken in 1978. These numbers are substantially higher than were collected in preoperational 1974, and are interpreted as indicating that the underwater structures did not become fully colonized during 1974.

The diver-collected periphyton show increasing diversity and decreasing numbers of dominant forms; of 117 taxa taken in 1978 only three occurred in 100% of the samples (compared to eight that occurred in all samples in 1977). These are expectable characteristics of ecological succession.

In the periphyton samples collected from the underwater structures there have been:

45 taxa which were present in each year of 1975, 1976, 1977, and 1978
15 taxa which were present in three of the four years
36 taxa which were present in two of the four years
20 taxa which were present in 1975 only
1 taxon that was present in 1976 only
34 taxa which were present in 1977 only
43 taxa which were present in 1978 only

In 1978 there were three taxa that were present in 100% of the diver-collected samples; they were the diatoms Fragilaria crotonensis, Stephanodiscus spp., and Tabellaria fenestrata v. intermedia. Thirteen other diatom taxa, the green alga Cladophora sp., and the blue-green Oscillatoria sp. were collected in each month of the diving season, though they did not occur in all samples

Table 1. Taxa taken in diver-collected periphyton samples, and their mean abundances in cells/ml in monthly intake entrainment samples during 1978. Abundance numbers are the means of six replicate samples (two each at dawn, noon, and sunset). Abundances have been computed as cells per liter and divided by 1000.

Taxa	Jan.	Feb.	Mar.	Apr.	May	Jun.
BACILLARIOPHYTA						
Achnanthes sp.	0.3	0	0	1.1	4.5	2.8
Amphipleura pellucida	0	0	0	0.1	2.2	2.8
Amphora calumetica	0	0	0	0	0	0
A. ovalis	0.7	0	0	0.3	0	0
A. sp.	14.3	0.6	0.4	0.6	6.1	10.5
Asterionella formosa	71.3	5.1	2.1	43.7	530.4	188.4
Cocconeis pediculus	0	0	0	0	0	0
C. sp.	0	0	0	0	0	0
Cyclotella comta	1.0	0.4	0	0.6	2.2	0.6
C. meneghiniana	1.7	0	0	0.8	34.6	18.3
C. stelligera	11.9	12.9	26.5	24.5	36.4	31.0
C. spp.	63.7	26.5	21.3	21.7	71.1	24.9
Cymatopleura elliptica	0	0	0	0	0	0
C. solea	0.7	0	0	0	1.7	5.0
Cymbella prostrata	0	0	0	0	0	0
C. prostrata v. auerswaldii	0	0	0	0	0	0
C. tumida	0	0	0	0	0	0
C. spp.	0.3	0	0	0	1.1	4.4
Diatoma tenue v. elongatum	18.2	2.0	0.7	12.3	92.6	56.9
D. vulgare	0.3	0	0	0.1	2.8	0.6
Diploneis sp.	0	0	0	0	0	0
Fragilaria capucina	4.0	0	0	2.5	34.3	43.1
F. construens	18.0	0	0	1.4	10.0	2.2
F. crotonensis	175.1	17.9	8.7	47.8	505.8	519.5
F. intermedia	9.3	0	0	6.8	36.5	0
F. intermedia v. falax	26.5	0	2.6	15.6	150.7	44.8
F. pinnata	23.2	0	0.6	0.8	13.3	29.8
F. sp.	5.3	0.1	0.1	0.6	11.8	24.3
Gomphonema olivaceum	0	0.1	0	0.6	2.3	3.3
G. spp.	3.3	0	0	0.4	2.2	3.9
Gyrosigma sp.	0.3	0	0	0	1.1	0
Melosira distans	1.0	0	0	0	0.6	0
M. granulata	17.6	0.3	2.1	17.1	518.7	470.3
M. granulata v. angustissima	0	0	0	1.1	1.1	1.1
M. islandica	6.3	5.7	16.2	46.0	68.0	60.8
M. italica	12.9	4.2	8.0	24.5	137.9	39.8
M. varians	0	0	0	0	0.6	3.3
M. spp.	5.3	0	2.2	0.8	8.9	9.4
Meridion circulare	0.3	0	0	0.6	2.2	0.6
Navicula anglica	0	0	0	0.1	0	0
N. aurora	0	0	0	0	0	0
N. capitata	1.7	0.1	0	0.3	0.6	4.4
N. cryptocephala	0.3	0	0	1.1	2.2	1.7
N. cuspidata	0	0	0	0	0	0
N. gastrum	0	0	0	0	0	1.7
N. menisculus	0.3	0	0	0	0.6	1.1
N. placentula v. rostrata	0	0	0	0	0	0
N. radiosa	0	0	0	0	1.1	0
N. radiosa v. tenella	0.3	0.1	0	0.3	0.6	2.2
N. tripunctata	0.7	0	0	0.3	1.7	5.5
N. viridula v. linearis	0	0	0	0.3	0	0
N. sp. #78	0	0	0	0	0	0
N. spp.	9.3	0.4	0.6	1.7	15.7	7.7
Neidium dubium	0.3	0	0	0	0	0.6
Nitzschia acicularis	1.3	2.4	2.0	2.4	21.2	51.4
N. dissipata	0.7	0.1	0.1	0.3	8.9	9.9
N. sp. #2	1.0	0.1	0	1.5	18.4	17.1
N. spp.	18.6	0.7	1.8	6.6	63.1	138.7
Pinnularia major	0	0	0	0	0	0
Rhizosolenia gracilis	0.7	1.7	2.2	7.3	53.3	11.6
Rhoicosphenia curvata	0.7	0	0	0.6	0	0.6
Stephanodiscus alpinus	10.9	2.5	11.1	15.2	85.4	80.2
S. tenuis	0	0.1	0.3	1.9	36.9	1.1
S. transilvanicus	0.3	0.1	1.3	2.8	16.2	1.1
S. spp.	76.9	36.6	225.2	180.3	383.1	237.7

Table 1. continued.

Taxa	Jan.	Feb.	Mar.	Apr.	May	Jun.
Surirella angusta	0	0.1	0.1	0.3	10.1	10.0
S. ovata	0	0	0.1	0	1.1	0
Synedra delicatissima v. angustissima	0.7	0.3	0.7	3.5	35.8	20.4
S. filiformis	11.9	12.0	11.8	8.7	202.6	89.6
S. ostenfeldii	5.0	6.3	3.5	22.8	181.8	41.5
S. parasitica	0.7	0	0	0.8	0	1.1
S. ulna	0.3	0	0	0.3	12.3	2.2
S. ulna v. chaseana	0.7	0.3	1.0	3.6	23.4	22.1
S. spp.	0.7	0.6	0.1	2.6	10.6	11.6
Tabellaria fenestrata v. intermedia	115.4	11.8	5.8	13.1	48.7	143.1
CHLOROPHYTA						
Ankistrodesmus falcatus	2.7	22.9	43.7	13.3	0	0
Binuclearia sp.	0	0	0	0	0	0
Cladophora sp.	0	0	0	0	0	0
Closterium sp.	0	0	0	0	0	0
Coelastrum sp.	0	0	0	0	0	0
Cosmarium sp.	1.0	0.5	0	0	0.6	0.6
Crucigenia quadrata	0	1.5	0	0	11.1	4.4
Gloeocystis planctonica	83.2	1.5	1.1	48.7	34.4	36.5
Golenkinia radiata	0	0	0	0	0	0
Kirchneriella ella	0	0	0	0	0	0
K. sp.	0	0	0	0	0	0
Mougeotia sp.	4.3	0.4	0.8	4.4	1.7	2.7
Oocystis sp.	0	0.6	0	0	0	4.4
Pediastrum boryanum	0	0	0	0	0	16.6
P. duplex	0	0	0	0	0	0
P. simplex	0	0	0	0	0	0
Scenedesmus acuminatus	2.7	0	0	0	4.5	28.7
S. acutus	0	0	0	0	0	0
S. armatus	0	0	0	0	0	0
S. bicellularis	2.0	20.6	17.9	12.4	34.7	118.3
S. quadricauda	4.0	0	0	0	2.3	0
S. quadricauda v. longispina	0	0.6	0	0	0	38.7
S. spinosus	0	0	0	0	1.1	17.7
S. spp.	2.6	9.0	2.5	5.2	19.5	82.9
Spirogyra sp.	0	0	0	0	0	0
Staurastrum paradoxum	0	0	0	0	0	0
Tetraedron caudatum	0	0	0	0	0	1.7
T. pentaedricum	0	0	0	0	0	0
Ulothrix sp.	0	0	0	0	0	0
CHRYSOPHYTA						
Dinobryon divergens	6.6	3.8	0.3	2.2	19.3	71.9
CYANOPHYTA						
Agmenellum quadruplicatum	0	0	0	0	0	0
Anabaena flos-aquae	0	4.7	0	0	0	45.3
A. sp.	0	0	0	0	0	0
Anacystis incerta	121.0	30.4	24.3	37.3	104.4	464.2
A. thermalis	48.4	4.4	1.1	1.1	2.3	0
Gomphosphaeria lacustris	0	6.9	0	0	64.9	265.3
Oscillatoria sp.	1.3	0.7	1.7	3.3	2.8	4.4
Phormidium sp.	0	0	0	0	0	0
Schizothrix calcicola	0.7	0.2	0	0.8	4.5	1.1
S. sp.	1.3	2.8	1.8	0.6	9.0	0
EUGLENOPHYTA						
Trachelomonas sp.	0	0	0	0	0	0
PYRROPHYTA						
Peridinium sp.	0	0	0	0	0	0

Table 1. continued.

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
BACILLARIOPHYTA						
Achnanthes sp.	2.8	0	0.8			
Amphipleura pellucida	11.6	0	0.1			
Amphora calumetica	0	0	0			
A. ovalis	0	0.3	0			
A. sp.	2.8	0	1.9			
Asterionella formosa	139.9	68.3	2.1			
Cocconeis pediculus	1.1	0	0			
C. sp.	0	0	0			
Cyclotella comta	1.1	1.1	0			
C. meneghiniana	6.7	5.3	3.0			
C. stelligera	32.6	5.2	5.2			
C. spp.	16.0	9.1	5.9			
Cymatopleura elliptica	0	0	0			
C. solea	0.6	0	0.1			
Cymbella prostrata	0	0	0			
C. prostrata v. auerswaldii	0	0	0			
C. tumida	0	0	0			
C. spp.	1.1	0	0			
Diatoma tenue v. elongatum	33.7	0.6	0.3			
D. vulgare	0	0	0			
Diploneis sp.	0	0	0			
Fragilaria capucina	0	0	0.6			
F. construens	8.9	0	4.6			
F. crotonensis	459.3	363.9	29.3			
F. intermedia	4.4	0	0.3			
F. intermedia v. fallax	14.9	0	2.0			
F. pinnata	0	0.6	1.8			
F. sp.	5.5	0	4.4			
Gomphonema olivaceum	0.6	0	0			
G. spp.	0.6	0	0			
Gyrosigma sp.	0	0	0			
Melosira distans	0	0	0			
M. granulata	274.7	54.4	111.4			
M. granulata v. angustissima	0	0	8.9			
M. islandica	63.6	0	0			
M. italica	50.9	0.6	0.6			
M. varians	0	0	0			
M. spp.	0	0	3.1			
Meridion circulare	0	0	0			
Navicula anglica	0	0	0			
N. aurora	0	0	0			
N. capitata	0.6	0	0.6			
N. cryptocephala	1.1	0	0.2			
N. cuspidata	0	0	0			
N. gastrum	0	0	0			
N. menisculus	0	0	0			
N. placentula v. rostrata	0	0	0			
N. radiosa	0	0	0			
N. radiosa v. tenella	0	0	0			
N. tripunctata	1.1	0	0.3			
N. viridula v. linearis	0	0	0			
N. sp. #78	0	0	0.2			
N. spp.	0.6	0.6	1.2			
Neidium dubium	0	0	0.1			
Nitzschia acicularis	26.5	0	1.1			
N. dissipata	14.4	0.3	0.2			
N. sp. #2	5.5	0.3	0			
N. spp.	85.6	1.9	11.7			
Pinnularia major	0	0	0			
Rhizosolenia gracilis	87.9	4.0	0.1			
Rhoicosphenia curvata	0	0	0			
Stephanodiscus alpinus	24.9	1.4	1.8			
S. tenuis	0.6	1.1	0.6			
S. transilvanicus	2.2	0.3	0			
S. spp.	159.2	11.1	8.4			

Table 1. continued.

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Surirella angusta	3.9	0	0.4			
S. ovata	0	0	0			
Synedra delicatissima v. angustissima	6.6	0	2.4			
S. filiformis	62.5	13.0	5.1			
S. ostenfeldii	117.2	3.1	1.0			
S. parasitica	2.2	0	0			
S. ulna	3.9	0	0			
S. ulna v. chaseana	23.8	1.1	0			
S. spp.	14.4	0.6	1.1			
Tabellaria fenestrata v. intermedia	214.5	80.4	5.5			
CHLOROPHYTA						
Ankistrodesmus falcatus	0	0	0			
Binuclearia sp.	0	0	0			
Cladophora sp.	0	0	0			
Closterium sp.	0	0	0			
Coelastrum sp.	0	0	2.5			
Cosmarium sp.	3.3	0.9	0			
Crucigenia quadrata	0	0	2.8			
Gloeocystis planctonica	118.3	75.7	34.9			
Golenkinia radiata	0	2.2	1.7			
Kirchneriella ella	0	0	0			
K. sp.	0	1.4	0.8			
Mougeotia sp.	19.3	8.0	0.6			
Oocystis sp.	7.7	5.5	2.2			
Pediastrum boryanum	0	0	0			
P. duplex	0	0	5.2			
P. simplex	0	0	1.1			
Scenedesmus acuminatus	5.5	2.2	0.8			
S. acutus	6.6	0	0.3			
S. armatus	2.2	0	0.1			
S. bicellularis	239.9	27.6	14.8			
S. quadricauda	15.5	6.6	9.1			
S. quadricauda v. longispina	16.6	7.2	7.7			
S. spinosus	14.4	5.0	5.2			
S. spp.	65.8	13.6	13.6			
Spirogyra sp.	0	0	0			
Staurastrum paradoxum	0	0	0			
Tetraedron caudatum	0	0	0.3			
T. pentaedricum	0	0	0			
Ulothrix sp.	0	0	0			
CHRYSOPHYTA						
Dinobryon divergens	3.3	22.4	0.3			
CYANOPHYTA						
Agmenellum quadruplicatum	0	0	8.9			
Anabaena flos-aquae	5.5	170.8	4.8			
A. sp.	0	0	0			
Anacystis incerta	181.3	54.2	697.8			
A. thermalis	0	0	46.2			
Gomphosphaeria lacustris	248.7	116.1	2.4			
Oscillatoria sp.	12.7	0.6	0.6			
Phormidium sp.	0	0	0			
Schizothrix calcicola	21.6	3.6	1.2			
S. sp.	0	0	0			
EUGLENOPHYTA						
Trachelomonas sp.	0	0	0			
PYRROPHYTA						
Peridinium sp.	0.6	3.3	0.7			

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On the basis of their frequencies of occurrence in the diver-collected periphyton samples, the dominant periphytes on the underwater installations in each year were:

1975
- Oscillatoria sp. (blue-green)
- Cladophora sp. (green)
- Diatoms of the genera Cymbella, Diatoma, Fragilaria, Navicula, Nitzschia, Stephanodiscus, Synedra, Tabellaria

1976
- Oscillatoria sp. (blue-green)
- Cladophora sp. (green)
- Diatoms of the genera Cymbella, Navicula, Tabellaria

1977
- Phormidium sp. (blue-green)
- Cladophora sp. (green)
- Dinobryon spp. (golden brown)
- Diatoms of the genera Asterionella, Amphora, Cymbella, Fragilaria, Melosira, Navicula, Nitzschia, Stephanodiscus, Synedra, Tabellaria

1978
- Oscillatoria sp. (blue-green)
- Cladophora sp. (green)
- Diatoms of the genera Asterionella, Fragilaria, Melosira, Navicula, Nitzschia, Stephanodiscus, Tabellaria

In the combined years 1975 and 1976, when the periphyte lists were fairly similar, intake entrainment sampling captured 89% of the taxa resident on the underwater installations. During 1977 with a rather different list of resident periphytes, intake entrainment sampling took 74% of the resident taxa. The 1978 intake entrainment samples contained all but 22 of the resident taxa, a capture percentage of 81%. Intake entrainment sampling is considered to be an adequate means of monitoring the periphyton community on the underwater structures during the months when diving is not possible.

CONCLUSIONS

The Cook Plant's underwater intake and discharge structures and the associated riprap field constitute an artificial reef, providing shelter and solid substrates in a region naturally devoid of them.

After their completion the underwater installations underwent a period of modifications of surfaces followed by colonization by periphytic algae and animal species. We consider that the single preoperational year, 1974, was insufficient for the installations to become fully colonized and that pre- vs post-operational comparisons of periphyton abundances and species compositions are probably not valid because of additional colonization and changes due to natural succession which took place after 1974.

This study uses diver-collected periphyton samples from the underwater installations to determine the taxa living on the installations, and examines intake entrainment samples for these taxa as a means of assessing the efficiency of entrainment as a monitor of the offshore periphyton community.

The numbers of periphyte taxa taken by the divers have been: 1975, 97; 1976, 67; 1977, 97; and 1978, 117. Forty-five taxa have been present in each of the four years, 15 in three of the four years, 36 in two of the four years, 20 were present in 1975 only, 1 was present in 1976 only, 34 were present in 1977 only, and 43 were present in 1978 only.

Dominant periphyte taxa in 1978 were: the blue-green, Oscillatoria sp., the green, Cladophora sp., and seven genera of diatoms. The numbers of dominant taxa were reduced from 1977. Increased numbers of taxa (diversity) and decreased dominants are characteristics of the post-pioneer stages of ecological succession.

With capture rates ranging from 74% to 89% of the resident periphytes, intake entrainment sampling is considered adequate to monitor the periphyte community in months when diving is not possible.

The changes observed in the periphyton community are consistent with advancing stages of the "artificial reef" ecological succession, not with any effect of Cook Plant operation.

APPENDIX B5

ENVIRONMENTAL OPERATING REPORT - 1979

FISHERIES STUDIES AT THE DONALD C. COOK NUCLEAR PLANT

INTRODUCTION

In a continuing effort to provide current information on what effect the Cook Plant is having on Lake Michigan fish populations, we have compiled data on the field abundance and distribution of larval, juvenile and adult fish as well as entrainment and impingement summaries. Field distributions of larval fish were evaluated for 1977 and 1978 for species, times and areas for which enough data were available. Area and preoperational vs. operational differences were stressed. Entrainment studies covered 1974-1978; estimates of species, magnitude and yearly rates are presented. For juvenile and adult fish, data were transformed and analyzed via ANOVA to ascertain whether any patterns in abundance related to plant operation were statistically detectable. Impingement effects were documented for 1978 to 1979 in light of Unit 2 operation which began in 1978.

FISH LARVAE - FIELD

Introduction

Fish larvae distribution differences in the vicinity of the Cook Plant were examined by expanding the analysis of variance (ANOVA) to include 1973 through 1978 data. Only three species - alewife, spottail shiner and yellow perch - were abundant enough in 1973-1978 catches to be used in the ANOVA's. Data sets for analyses were also limited to months which corresponded to the period, usually brief, of abundance of these larvae. In order to avoid excessive zero catches, only nighttime beach sampling results were analyzed for spottail shiners and only 1977 and 1978 open water data were analyzed for yellow perch.

Although rainbow smelt larvae were frequently found in early spring samples, they were not abundant enough in 1977 and 1978 to be included in the ANOVA's. Small numbers of other larval species were also captured. Prior to 1977, trout-perch, carp, johnny darters, burbot, slimy sculpins and one ninespine stickleback had been caught during field larvae sampling. A fourhorn sculpin and several unidentified members of the minnow, sculpin, sucker and herring families were added to the minor species larval list in 1977 and 1978.

Table 1 summarizes factors used in the ANOVA's for this report. All designs were Model 1 (fixed effect), full factorical, balanced ANOVA's calculated with statistical package BMD8V (Statistical Research Laboratory 1975). In order to meet the assumptions of the model for normality, larvae concentrations were transformed using a $\log_{10}$ (density in no./1000 m^3 + 1) formula, as recommended for count data (Green 1979). Because preliminary tests indicated no significant difference in larvae concentrations among depth strata (surface to near-bottom) for a particular sampling site and time, the series of samples from different depths at one station and time were treated as replicates in the ANOVA's for open water stations. Two replicate samples (depth strata = 0.5 m) were taken regularly at each beach station.

Some samples were missing from open water designs. Furthermore, only four depth strata (0 m, 2 m, 4 m, 5.5 m) were sampled at 6-m stations while five depth strata (0 m, 2 m, 4 m, 6 m, 8.5 m) were sampled at 9-m stations. The fifth stratum, not sampled at 6-m stations, was treated as a missing replicate. The unweighted means method for balancing designs (Fox 1973) was then applied to the open water data matrix; cell means were substituted for missing replicates. Treatment sums of squares were multiplied by the ratio of harmonic mean cell size to maximum cell size to adjust for the substitutions; the number of missing values was subtracted from degrees of freedom for the error term to adjust mean square error.

The following discussion will focus primarily on new information generated by the addition of 1977 and 1978 field fish larvae results to the 1973-1976 data base. Further discussion of the 1973-1976 results can be found in the 1978 Environmental Operating Report.

Alewife

Beach zone -- The ANOVA for larval alewife densities in the beach zone covered 6 yr (1973-1978), 3 mo (June, July and August), three stations (A, north Cook; B, south Cook; and F, Warren Dunes) and two time periods (day, night) with duplicate tows taken at each sampling. Zero catches comprised 16% of the data points.

Although alewives continued to be the most abundant fish larvae caught in the vicinity of the Cook Plant, mean densities in 1977 and 1978 were lower than in all previous years except 1974. Geometric means of alewife densities (no./1000 m^3) for 1973-1978 were respectively 3342, 182, 497, 326, 189 and 272. The significance of Year main effect (Table 2) was probably caused by high larval alewife densities in 1973.

Month was also a significant main effect when geometric mean densities for months were pooled over years; July (1095 larvae/1000 m^3) emerged as the overall peak month of alewife abundance, with June (453 larvae/1000 m^3) and August (143 larvae/1000 m^3) following in order of abundance. However, month of maximum larval abundance varied among years, causing a significant Year x Month interaction. Peak month of geometric mean density was June for 1974-1976 and July for 1973 and 1977. For 1978, densities were high, but similar during both July and August.

Although Station alone was not a significant main effect in the ANOVA, it did enter into a significant interaction with Year. This effect was caused primarily by increases in alewife larval density at stations B (south Cook) and F (Warren Dunes) in 1975, while density decreased at station A (north Cook), followed in 1976 by an increase in density at station A and a decline in density at stations B and F. These interactions do not appear to be caused by plant operation, since larval alewife densities at stations B (south Cook) and F (Warren Dunes) followed similar trends during 1973-1978. Therefore, differences in alewife larval densities between beach stations in Cook Plant study areas were not significant for the years 1973-1978.

Time (day or night) was not found to be a significant factor affecting abundance of alewife larvae at beach stations during 1973-1978. However, the interaction of Year with Time was significant, because more larvae were collected in day samples than in night samples in 1973 and 1977; whereas, more larvae were caught during the night in 1974, 1975, 1976 and 1978. The Month x Time interaction term was also significant, due to more alewife larvae being caught at night in June and August, but more during the day in July.

The other significant interactions -- Year x Month x Station and Year x Month x Time -- are difficult to interpret, but are at least partially caused by the significant second-order interactions of Year with Month, Station and Time.

Open water zone -- The ANOVA for alewife larvae caught in open water also covered 6 yr, 3 mo and two time periods, but stations were replaced by two areas (Cook, Warren Dunes) with sampling sites at two depths (6 m, 9 m). As described in the introduction, depth strata were used as replicates and cell means were substituted for missing values to balance the design where necessary. About 25% of the samples produced no alewife larvae.

Year, Month, Depth and Time all remained significant ($P < .001$) main effects with the addition of 1977 and 1978 data (Table 3). Area was not a significant main effect, but did enter into a significant third-order interaction with Year and Month. However, the F-statistic for this interaction was quite small when compared to F-values for all significant main effects; the Year x Month x Area interaction seems minor and appears to be caused by fluctuations in August alewife larval abundance that varied between the two Areas. Therefore, overall abundance of alewife larvae at open water stations was not significantly different between Cook Plant and Warren Dunes.

Open water abundance of alewife larvae at Cook and Warren Dunes has continued to decline since reaching a peak in 1974. Geometric means of alewife densities (no./1000 m^3) for 1973-1978 open water stations were respectively 116, 524, 211, 124, 31 and 5.

Alewife spawning typically reaches a peak when water temperatures become ideal, usually in June or July. The timing of this event determines the month of maximum larval abundance, thereby producing a significant Month effect. Geometric mean monthly density of alewife larvae pooled for 1973-1978 was highest for July (161/1000 m^3), lower for June (103/1000 m^3) and lowest for August (31/1000 m^3). This was the same pattern established in the beach zone.

Since the peak spawning period varied from year to year depending on water temperatures, the month of greatest alewife larval concentration also varied, causing a significant Year x Month interaction. June was the peak month of larval abundance in 1973 and 1974, while July took the lead in 1975 and 1976; August became the peak month in 1977 and 1978. These results suggest that the prime spawning period for alewife in southeastern Lake Michigan has been delayed somewhat, probably by weather conditions, in the last few years.

Depth was a significant main effect because more larvae were found at 6-m stations than were found at 9-m stations. This difference may be due to offshore movement of larger larvae which are less vulnerable to our sampling gear.

Overall geometric mean density of alewife larvae was significantly greater at night (120/1000 m^3) than during the day (51/1000 m^3), probably because more larvae were able to avoid the sampling net during the day. This pattern of greater night catches was consistent for all years except 1977, when the geometric mean for daytime abundance (47 larvae/1000 m^3) was greater than that for nighttime abundance (21 larvae/1000 m^3). This discrepancy in 1977 accounted for the significant Year x Time interaction.

The only other significant effect was the Year x Month x Time interaction. This third-order interaction seems to be caused primarily by inconsistencies already discussed: peak month of abundance varying with year, high nighttime catches for all years except 1977 and wide fluctuations in August larval densities.

Comparisons of open water alewife larvae results with those from the beach zone revealed generally similar factor effects. Year and Month were significant main effects in both ANOVA's, but neither beach Station nor open water Area had a significant first-order effect on larval alewife concentrations, indicating no observable plant effect. Larvae were usually more abundant at beach stations than open water stations. Time was a significant main effect in the openwater ANOVA -- more alewife larvae were caught at night than during the day -- but not in the beach zone ANOVA. Both ANOVA's showed significant effects due to Year x Month, Year x Time, Year x Month x Time and Year x Month x Station/Area interactions.

Spottail Shiner

Beach zone -- The data set used in the analysis of spottail shiner larvae in the beach zone included 6 yr (1973-1978), 3 mo (June, July and August) and three stations (A, north Cook; B, south Cook; and F, Warren Dunes) with duplicate tows taken at each station. Only nighttime sampling data were used because daytime samples too often contained no spottail shiner larvae. Nevertheless, zero catches comprised 27% of the data set.

Densities of spottail shiner larvae in Cook Plant study areas differed significantly among years (Table 4). Geometric mean densities (no./1000 m^3) for 1973-1978 were respectively 40, 1141, 517, 176, 40 and 35. These results indicate a significant decline in spottail shiner larvae at both Cook and Warren Dunes since 1974. However, it is also possible that the timing of our sampling efforts in recent years has not corresponded well with peak abundance periods of spottail shiner larvae.

The Month factor also had a significant effect on spottail shiner densities in the beach zone. This is to be expected since occurrence of optimal spawning conditions produces a peak month of larvae abundance. Furthermore, the Year x Month interaction term was significant because month of highest larval density varied among years. June samples had the greatest number of spottail shiner larvae in 1973, 1975, 1976 and 1978, while July was the peak month in 1974 and 1977.

Station was not a significant factor nor did it enter into any significant interactions in the ANOVA. Therefore, no meaningful differences could be detected between densities of spottail shiner larvae at Cook Plant and Warren Dunes beach stations.

Yellow Perch

Open water zone -- An ANOVA was performed for a limited subset of the open water yellow perch larval data set because low numbers were caught during most years. For the years considered in this report, 1973 through 1978, only in 1977 and 1978 were larval yellow perch caught in sufficient numbers to analyze via ANOVA. Therefore, the data set consisted of 2 yr (1977, 1978), 1 mo (June), two areas (Cook, Warren Dunes), two depth-stations (6 m, 9 m) and two times (day, night).

Results of this analysis (Table 5) showed that no factors or interactions were statistically significant. Differences between years almost attained significance (P = .0197). Geometric mean densities (no./1000 m^3) of yellow perch larvae in June for 1977 and 1978 were 15 and 3 respectively.

Lack of significance for the factor Area (Cook Plant vs. Warren Dunes) established that, for 1977 and 1978, there was no statistically significant difference in the open water densities of perch between the treatment and reference area. Thus, there was no buildup or depletion of larval yellow perch in the Cook Plant vicinity and therefore no demonstrated plant effect.

FISH LARVAE - ENTRAINMENT

Introduction

Using Lake Michigan water in once-through cooling system at the Cook Plant potentially represents an impact on the fish populations of Lake Michigan. One source of this impact could be entrainment of fish larvae and eggs. Since eggs and larvae of fish are very susceptible life stages, considerable effort must be made to determine species composition and the magnitude of entrainment. The purpose of this section, therefore, is to present estimates for fish larvae and eggs entrained by the Cook Plant during 1977 and 1978. Additional comments relating entrainment during 1977 and 1978 to 1974 through 1976 (see the 1978 Environmental Operating Report) will be made when appropriate so general trends may be noted.

Methods

Entrainment sampling for larval fish has been performed since 1974. The standard schedule involves sampling for 24 h at the intake and discharge forebays of the plant. Sampling, encompassing a 24-h period, was conducted twice per month during all months except June, July and August, when sampling was done once per week. Each 24-h period was divided into four sampling divisions which changed depending on day length. The four divisions were: sunrise-noon, noon-sunset, sunset-midnight and midnight-sunrise. The number of samples collected per 24-h period was usually 16, 4 replicates per division. Each division represented from 4 to 8 h depending on which division the samples came from and day length.

To obtain yearly estimates of entrained fish larvae and eggs, data from 24-h entrainment samples were pooled and an average density calculated. Next, non-overlapping time intervals (usually 1-2 wk) were established such that the sampling date was the approximate middle of the interval. Entrainment characteristics were assumed to be similar over that time interval. The average density of larvae and eggs was then multiplied by the volume of water pumped over that interval, assuming maximum Unit 1 flow rates (710,000 gpm) occurred over the time interval, to give the total number of larvae and eggs entrained. Finally, these estimates were totaled and values for the year computed. Standardized mean larval and egg density represents a simple conversion of number per volume sampled to number per standardized volume, 1000 m^3. Upper and lower 95% confidence limits, assuming normality, were also computed.

Results and Discussion

Eleven new categories of fish larvae have been observed since the 1978 Environmental Operating Report which included entrainment data through 1976. Five new taxa were entrained during 1977 and 1978. Six other groups, representing larvae which could not be identified to species, were identified to the lowest taxon possible. All numbers presented in this section are estimates. Due to the magnitude of the numbers involved and large expansion factors, it is difficult to compute precise entrainment numbers. Comments concerning 1974 data will generally be omitted due to sporadic sampling during 1974.

No fish larvae or eggs were found in entrainment samples during March or in October through December 1977, or April or December 1978 (Tables 6 and 7). Months of major larval and egg entrainment were June, July and August of both years. Similar results were noted during 1975 and 1976.

Approximately 80 million larvae, representing 14 species of fish were estimated to have been entrained during 1977-1978. In order of decreasing abundance, the species entrained were: alewife, spottail shiner, yellow perch, johnny darter, rainbow smelt, trout-perch, slimy sculpin, carp, fourhorn sculpin, white sucker, burbot, ninespine stickleback and logperch. Alewives accounted for nearly 80% of the estimated number of larvae entrained during the 2-yr period. By number, spottail shiner and yellow perch were the next two most important species entrained, representing 7 and 6%, respectively. Approximately 5% of all larvae collected during 1977 and 1978 could not be identified to species; most of these larvae were in poor condition.

Alewife was the most commonly entrained larval species, accounting for 79% of the estimated total entrainment during 1977 and 1978. Entrainment of this species during 1977 was twice as high as in 1978, 42.8×10^6 and 20.1×10^6, respectively (Table 8). Months in which entrainment was most common were June through August 1977 and May through October 1978 (Tables 6 and 7). Estimated alewife larval entrainment peaked in July of both years.

When examining data from 1975 through 1978, several general trends were apparent. Total estimated alewife entrainment decreased consistently from 1975 through 1978 (105, 61.2, 42.8 and 20 million respectively). Alewife relative abundance decreased over the 4-yr period from greater than 90% during 1975 and 1976 to 81% in 1977 and 75% in 1978. July was the month of greatest alewife entrainment.

The second most commonly entrained species of fish larvae during 1977 and 1978 was spottail shiner. Entrained during June and July of 1977 and from June through August of 1978 (Tables 6 and 7), this species constituted 7% of the total 2-yr entrainment estimate. Total annual entrainment for spottail shiners decreased over the 2-yr period, these values being 48.0×10^5 and 9.21×10^5 for 1977 and 1978, respectively (Table 8).

Similar to alewife entrainment, estimated entrainment of spottails decreased from a high in 1975. Estimated entrainment of this species over the 4-yr period from 1975 to 1978 was 49.6×10^5, 10.4×10^5, 48.0×10^5 and 9.21×10^5 per year. However, related to other species entrained, this decrease was not as drastic as it first appears. During 1974 to 1976, spottail shiners accounted for 3% of the total entrainment estimates, and were rated as the third-most common species entrained. During 1977 and 1978 spottail shiners were the second-most commonly entrained species, accounting for 7% of total entrainment.

The third-most abundant species entrained was yellow perch. Approximately 6% of the total estimated larval entrainment during 1977 and 1978 was yellow perch. Entrained from June through August in 1977 and May through August in 1978, 5 million larval yellow perch were estimated to have been entrained during 1977 and 1978, 2.5 million each year. June was the month of highest estimated entrainment both in 1977 and 1978 (Tables 6 and 7). During the 1974 to 1976 sample period, yellow perch entrainment was low, only 1.10×10^5. These data indicate yellow perch entrainment increased from 1974 to 1978.

When compared to 1974-1976 data, johnny darter estimated numbers and relative importance increased during 1977 and 1978. Total estimated entrainment for johnny darters during 1975-1978 was respectively 0.129×10^5, 2.08×10^5, 11.2×10^5 and 4.09×10^5 (Table 8). Johnny darter larvae were the fourth-most abundant larvae entrained during 1977-1978, while they were relatively insignificant during 1975-1976 and absent from 1974 samples. Johnny darter larvae were present in entrainment samples during late August 1975, mid-July 1976, June and July 1977 and June through August 1978 (Tables 6 and 7).

The remaining species entrained each represented less than 1% of the total estimated larval entrainment from 1977 to 1978. These minor species combined amounted to only 1.5% of the total 1977-1978 entrainment. Because of their relative insignificance to total entrainment, these species will be discussed only briefly.

Rainbow smelt, the second-most common species entrained during 1974-1976, was the fifth-most abundant species entrained during 1977-1978. Estimated smelt larvae entrainment decreased from 1974 to 1978, the estimates being 89.7×10^5, 12.2×10^5, 7.88×10^5, 2.56×10^5, respectively. Peak smelt larval entrainment during 1974-1976 occurred during early May, while in 1977 it occurred in July, and in 1978 in June.

Larval trout-perch entrainment was sporadic from 1974 to 1978, however, numbers of this species entrained have consistently decreased over the 5-yr period. Estimated entrainment of trout-perch per year from 1974 to 1978 was 41.7×10^5, 7.48×10^5, 2.35×10^5, 1.43×10^5 and 0.508×10^5, respectively. Trout-perch were entrained in May and November of 1974, June and September through October of 1975, February, July and November of 1976, June through August of 1977 and August of 1978.

Slimy sculpins were entrained during June, July and August of 1975 and 1976; May and June of 1977; and June of 1978. Since 1975, total estimated number of slimy sculpins entrained decreased through 1977 then increased in 1978. Estimates for 1975 through 1978 were 8.08×10^5, 3.00×10^5, 0.675×10^5 and 1.18×10^5. No slimy sculpins were found in entrainment samples in 1974.

Carp larvae were first observed in 1976 and persisted through 1978. This species was not observed to be entrained in 1974 or 1975. Estimated total entrainment per year from 1976 to 1978 was 1.43×10^5, 0.339×10^5 and 0.618×10^5.

Burbot larvae were collected in April 1976 and March 1978, with 5.22×10^6 larvae estimated entrained each year. Larvae of white sucker and logperch were entrained only during 1977. Fourhorn sculpin and ninespine stickleback were entrained only during 1978. In all five cases, one specimen per species was observed in entrainment samples. These species should be considered incidental.

Larvae which could not be accurately identified to species represented about 5% of the total estimated larval entrainment from 1977 to 1978. In four categories, specimens were identified to genus (Cottus, Coregonus, Etheostoma, and Lepomis); one category represents an entire family, Cyprinidae; and two groups could only be recognized as fish larvae. The most common category of unidentified fish larvae was larvae in poor condition.

Approximately 5.2×10^5 fish eggs, which include fertilized, unfertilized, and unviable eggs, were estimated to have been entrained from 1977 to 1978. The most common months of fish egg entrainment were June and July for both years. Estimates of total eggs entrained from 1975 to 1978 were 9.42×10^8, 27.4×10^8, 14.7×10^8 and 37.0×10^9 (Tables 6-8).

In evaluating entrainment of fish larvae from 1975 to 1978 at the Cook Plant, general comparisons were made with field larvae collections over the same period. Abundance trends noted in the field larvae section corresponded to general trends found in the entrainment data. Decline in alewife, spottail shiners, trout-perch and rainbow smelt numbers were noted in entrainment estimates. Sufficient data were present in field larvae collections to indicate general declines in alewife and spottail shiner larval abundance. A rise in yellow perch entrainment estimates over the 4-yr period, unfortunately, could neither be supported nor contradicted. Generally, it appears that entrainment composition reflects abundance of field larvae.

Johnny darters and sculpins were probably attracted to the riprap surrounding the intake structures, and consequently their larvae were entrained. Entrainment of these species will probably continue.

Adult carp have been found to concentrate around the discharge area and spawn, thus resulting in entrainment of carp larvae. Entrainment of carp larvae is expected to continue as long as warm water is being discharged.

FOREBAY VISUAL INSPECTION

Inspections to monitor the presence and behavior of fish in the intake forebay were conducted monthly during 1979 in accordance with technical specifications. No fish were observed in the forebay during 1979. Operation of Unit 2 and corresponding increases in water velocities at the intake and forebay since July 1978 may have (1) significantly reduced fish residence time in the forebay or (2) severely limited the investigator's ability to observe fish in the forebay (increased turbulence, surface reflections, etc.). Previous studies at Cook and other power generating stations (Cochran and Kitchel 1976; Wapora 1976) suggest that some fish species may experience extended residence time (up to 5 mo) in power plant forebays prior to impingement or even escapement. This is probably reduced or eliminated by increased water velocities from the simultaneous operation of both generating units at Cook.

ADULT AND JUVENILE FISH - FIELD

Introduction

Standard series trawl, gill net and seine catch data on abundant and common species of adult and juvenile fish are analyzed in this section. Major emphasis was placed on examination of January to October 1979 data and a comparison with 1973 to 1978 results. A factorial, balanced ANOVA (analysis of variance) model was used to determine statistical significance between geometric mean catches of the five most abundant species. The effects that 1979 data had on significance of Year and Area factors and their two-way interactions were examined in detail. Statistical analyses were not performed for common species, but 1979 data were examined for differences and similarities with previous year's results. Comparisons were also made of catches (1975-1979) at stations R and Q (6 m and 9 m, north Cook) with catches at standard series stations C and D (6 and 9 m, south Cook) and G and H (6 and 9 m, Warren Dunes).

All these analyses were an attempt to document plant operational effects on local fish populations. These examinations and interpretations are preliminary; more comprehensive analyses must await further examination of not only the catch data, but also limnological and meteorological data. These analyses will be treated in future special reports.

Statistical Procedures

Statistical analyses were performed on catch-per-unit-effort data for each of the five most abundant species. In this study one unit of effort was defined as a 10-min trawl, a 12-h gill net set, or a 61-m seine haul. Data from different gear were not directly compared because each gear has a unique bias (Ricker 1975).

As in the past (Environmental Operating Report 1978), log-transformed [($\log_{10}$ (catch + 1)] data for alewife, spottail shiner, rainbow smelt, yellow perch and trout-perch were analyzed using a MODEL I, full factorial, balanced analysis of variance. Where designs were unbalanced due to missing samples, output from the BMD8V program was modified to provide an unweighted means analysis for unbalanced data (Fox 1973). Unweighted means analysis involves multiplying mean squares by the ratio of harmonic mean cell size to maximum cell size and subtracting the number of missing observations from the error degrees of freedom. A summary of the factors of each model is given in Table 9. Levels of ANOVA factors were reduced or eliminated when excessive zero observations were present. Reduction of levels of ANOVA factors and use of log transformation insured that parametric assumptions of ANOVA were not severely violated.

Gill net data did not include replicate sampling, depriving the model of a specific term for within cell error. The highest order interaction term was assumed to be non-significant, and its mean square represented mean square error (MSE) from each gill net ANOVA. This procedure, based on an examination of 1973-1976 trawl and gill net data, appeared appropriate except for rainbow smelt gill net data. In that case, the highest order interaction mean square was much larger than many other interaction mean squares, indicating that the highest order interaction mean square was a poor estimate of MSE. ANOVA of rainbow smelt gill net data was excluded from this report, but may be presented in the future if an appropriate strategy for pooling interaction terms to estimate MSE is established.

Discussion of ANOVA results is largely restricted to examination of factors related to potential plant effects. Main factors Year and Area (station) and the Year x Area (Year x Station) interaction were examined to identify changes in fish abundance that might be ascribed to plant effects.

Sampling Methods

Adult and juvenile fish were collected at a number of standard series stations located north and south of the Cook Plant and at Warren Dunes State Park (reference area) (see Fig. 1). For details of materials and methods, see the 1978 Environmental Operating Report and Jude et al. (1979). To save space in some tables, common names of species were abbreviated and are presented in Table 10. For adult and juvenile fish, only data from January through October 1979 were presented.

Abundant Species

Alewife -- Alewife was the most common species caught by standard series sampling every year from 1973 to 1979. Annual alewife catch fluctuated from a high of 148,451 in 1973 to a low of 38,492 in 1978 (Tables 11-17). The 1979 catch (141,633) was the second largest since 1973. Standard series trawls, gill nets and seines contributed 2.4%, 2.0% and 95.6%, respectively, to 1979 total alewife catches (Tables 18, 19 and 20). All gear and area catches increased in 1979. Overall catch data suggest that, except for 1976 and 1979, alewife populations in southeastern Lake Michigan have suffered long-term declines.. However, preliminary analysis of length-frequency information indicated that a strong 1979 year class was partly responsible for this year's near record catch.

The history and ecology of alewives in the Great Lakes have been described in detail by Brown (1972), Colby (1971, 1973), Graham (1956, 1957), and Smith (1968, 1970). We will review only specifics related to populations in our study areas in southeastern Lake Michigan. Inshore alewife migrations begin as early as March with peak abundance of spawning adults usually reached in June (Jude et al. 1979). By August, spawning subsides and adults begin their return to deeper water. Most young-of-the-year alewives are first recruited to our gear in August. Total catch declines as movement to deeper water occurs in the fall. Graham (1956) noted that in winter, alewives in Lake Ontario may be found at depths to 91 m. However, alewives appear to remain in our study area all year since they are found in impingement samples thoughout winter months.

The multiplicity of significant ANOVA interactions identified in the following section reveals a complexity of behavioral and biological relationships that must be considered in our analyses of plant impacts on this species. Our preliminary analyses will concentrate on Area and Year effects, factors that may reveal Cook Plant impacts on localized alewife.populations.

ANOVA for trawl catches of alewives showed that all main effects (Year, Month, Depth, Time), except Area, were significant (Table 21). Most Year effects are ascribed to oscillations of abundance characteristic of alewife populations. Large catches in 1973, 1976 and 1979 were a major source of variation in our data. Additionally, in 1973-1979, abundance indices (geometric mean catches) indicated a long-term alewife decline. Significant Depth and Time effects were probably the result of behavioral variability. Differences in diel activity patterns between young-of-the-year and adults were major contributors to these effects (1978 Environmental Operating Report). Significant Year x Area interaction was the result of variable catches at both Warren Dunes and Cook during some years. No definite trend has been established; these periodic fluctuations occur at both areas. In most years catch fluctuations occurred simultaneously in both survey areas. Additionally, the most recent catch increase (1979) was noted at both Cook and Warren Dunes. The lack of significant Area effects suggests that alewife trawl catches were not influenced by plant operations. This is further supported by a lack of significance of the Area x Depth and Area x Time interactions.

Alewife gill net ANOVA showed significant main effects for Year, Month and Time (Table 22). Significant Year interactions were most likely caused by annual variation and a general alewife population decline over the period of record. Month effects can be linked to spawning migrations, upwellings, etc. (Jude et al. 1979). Significant time (Year x Time and Time) effects were probably the result of differences between the diel activity patterns of young and adult fish, and differential susceptibility to our survey gear (1978 Environmental Operating Report). Lack of significance of most Area interactions indicates the Cook plant has had little detectable effect on alewife populations sampled by this gear.

Analysis of seine ANOVA's yielded significant main effects for all factors except Station (Table 23). Contributors to variability in interactions of Year, Month and Time have been noted and are discussed in more detail in the 1978 Environmental Operating Report. Lack of significance for the main effect Station suggests that the Cook Plant does not impact alewife populations found within the beach zone. The significant Year x Station interaction is probably caused by periodic catch fluctuations at some stations. However, no trend is obvious when all survey years were considered.

We believe, at this stage of our analyses, that Cook Plant operations have had no long-term detectable effects on alewife populations in our study areas. Most significant statistical interactions noted were probably associated with the characteristic, often large, annual fluctuations in alewife populations (Smith 1968, 1970) which are evidenced by catch variability in our survey areas. Additionally, localized responses to the physical environment (upwellings, atmospheric conditions, currents, etc.) and biological factors (schooling, feeding and spawning activities, etc.) complicated our analyses. These factors will be dealt with in greater detail in future reports. Our data reveal a long-term alewife decline, a condition mirrored at both Cook and Warren Dunes. This decline coincided locally with modest increases in salmonid catches, especially coregonids. Increased salmon and trout populations may depress alewife numbers via predation. Coregonids were thought to be victims of interspecific alewife competition and thus an increase in our catch may also signal a reduction in alewife densities. However, closure of the commercial chub fishery in 1976 may also be a factor in coregonid increases.

The 1979 alewife catch at both Warren Dunes and Cook increased when the 1979 year class appeared in September and October as young-of-the-year. This strong year class may potentially stabilize alewife populations in our survey areas and signal a local population increase.

Spottail Shiner -- Spottail shiners were the second-most abundant fish collected in 1979 (Tables 11-17). This year's catch was the second largest for the species since surveillance began in 1973. The increased catch was probably the result of the strong 1977 year class being recruited to our gear as adults. During the 1979 survey, 65.6%, 23.7% and 10.7% of the total spottail catch were from seines, trawls and gill nets, respectively - a pattern that has been repeated for most of the past 7 yr.

Spottails were collected in almost every month surveyed and were the second-most abundant species taken in every survey year (Tables 11-17), underscoring their importance within the lake's inshore fish community. The relative abundance and distribution of spottails in our study areas follow a predictable seasonal pattern. During winter months, catches were minimal. Wells (1968) found that Lake Michigan spottails overwinter in moderately deep water

(9 to 37 m). Our winter impingement samples showed that they were common at the 9-m depths of the plant's intakes. Shoreward migration begins in March and field catches suggest that peak abundance of adults occurs in June or July. Spawning, as judged from gonad condition (Jude et al. 1979), begins in June and continues for an extended period (through August) as is typical in southeastern Lake Michigan (Wells 1968). Spawning in our study areas was also verified by SCUBA divers (Dorr 1974; Dorr and Miller 1975). Adult spottail catches usually decrease in late July and August as adults disperse from spawning areas. However, recruitment of YOY spottails to our gear results in increased catches starting in August. Numbers of both YOY and adults decline in the fall via mortality and a continuing dispersal from beach zones to deeper water.

Our preliminary review of the ANOVA treatment of 1973-1979 data will be primarily confined to Year, Area or Station effects, those that may reveal plant influences on local spottail populations. A more detailed analysis of these data will be conducted in future reports. Spottail ANOVA interactions were confounded by the ecology of the species. Behavior including spawning migrations, seasonal diel activity patterns, schooling, responses to varying thermal conditions and age-related activity patterns serve to complicate our analyses. Additionally, variable year class strength affects some Year interactions and strong spottail year classes in 1973 and 1974 also had significant effects on our catches. Further discussion of spottail biology and its effects on ANOVA interactions are reviewed by Jude et al. (1975) and Jude et al. (1979).

ANOVA for trawl spottail catches showed that Year, Month, Depth and Time were significant (P <0.001), while Area was not (Table 24). Significant Month, Depth and Time interactions were probably the result of a combination of gear selectivity, cold-water upwellings and seasonal behavior patterns. We ascribe the significance of the Year main effect to annual population fluctuations. The Year x Area interaction was not significant, implying that there were no detectable plant effects on spottail populations sampled by trawls. Other significant first- and second-order interactions were largely due to previously mentioned population variation. The significance of Month x Area interactions may indicate some differences between survey areas, but these are most likely behavioral rather than plant induced. This is additionally supported by lack of significance between Area x Depth, Year x Area x Depth and Month x Area x Depth interactions.

Gill net catch ANOVA indicates significant main effects of Month, Depth and Time, but not Area - a pattern similar to that of trawls. Lack of significant Area main effect and Year x Area interaction suggests that there were no detectable plant effects on the spottail population surveyed by this gear (Table 25). The significant Month x Area interaction has been previously mentioned (1978 Environmental Operating Report) as an indicator of seasonal differential distribution of age-groups between Cook and Warren Dunes. This relationship was not corroborated with 1979 data, but further analysis should be considered before definitive conclusions can be drawn.

The only significant main effect for seine ANOVA's was Month, an expected influence considering spottail shiner biology (Table 26). Lack of interaction between Year x Station supports our preliminary contention that spottail populations in the beach zone were not influenced by plant operations. Most other significant interactions with either year or station were, upon preliminary assesment, thought to be related to species biology.

In summary, our preliminary review of ANOVA's indicated that no detectable changes in the distribution and abundance of spottail shiners in our Lake Michigan study areas have occurred which were attributable to plant operation. In fact, the population appears healthy and periodically continues to produce large year classes, the most recent being in 1977. Data also indicate that a strong 1979 year class will maintain 1980-1981 spottail catches at relatively stable levels. Our analyses were complicated by the complex biological and behavioral variability associated with spottail populations. These problems will be dealt with in more detail in future reports.

Rainbow Smelt -- Rainbow smelt (*Osmerus mordax*) was the third-most abundant species collected in standard series fish nets during 1973-1979, comprising a yearly average of 4.7% of the total catch. Numbers of smelt netted varied widely during the study from a maximum catch of 16,294 in 1973 to only 1,265 in 1976 (Tables 11-17). These yearly variations are thought to primarily reflect natural population fluctuations. However, the coincidence of smelt spawning and our monthly sampling could also play a part since it was during spawning that the majority of adult smelt were netted in study areas. Adult smelt were only netted in association with upwellings at other times of the year.

Analysis of variance (ANOVA) of smelt data presented here cover only seine and trawl data. Gill net data were not presented because examination of F-statistics indicated that the highest-order interaction term was not a reasonable estimator of the error mean square (see Statistical Procedures). ANOVA of gill net data may be presented in the future if an appropriate strategy for pooling interaction terms to estimate mean square error can be established.

ANOVA of smelt seine data was performed for April and May 1973-1979 and on trawl data for April through October 1973-1979. Only April and May seine data were analyzed because these were the only months in which smelt were regularly seined every year.

Results of ANOVA on seined rainbow smelt showed significant effects for three out of four main effects and a number of interactions (Table 27). Significant main effects were Year, Month and Time. Station was not a significant main effect, but it did enter into several interactions. The Month x Time interaction which was significant ($P < .0001$) for the 1973-1978 ANOVA was not significant for the 1973-1979 ANOVA. Only the main effect Year and the Year x Station interaction were of interest in assessing plant effects.

The Year effect was apparently the result of a general decline in the smelt population in the study areas through time. This is evidenced by the geometric means (catch + 1) of 12.11, 3.15, 4.15, 3.34, 1.14, 1.41 and 3.03 for 1973-1979. Mean catch dropped sharply between 1973 and 1974 with a general decline continuing through 1978 which moderated during 1979. The years 1973, 1977 and 1978 were major contributors to the Year effect.

The Year x Station interaction ($P < .0001$) was the result of differences in the mean catches between Cook Plant and Warren Dunes stations in the years 1974 and 1979. The preoperational 1974 mean catches at Cook beach stations A and B were 2.51 and 1.62 respectively compared with 7.67 for Warren Dunes station F. Mean 1979 values for Cook Plant stations A and B were 2.06 and 2.16 respectively, compared with 6.20 for Warren Dunes station F. Reasons A and B are not clear, but are thought to reflect subtle differences in habitat between the two areas. There is a small creek which enters Lake Michigan near our Warren Dunes station. Plant effect has been ruled out as a factor because of the radical population decline observed in the areas during preoperational 1974.

The Month x Time interaction was not significant in the 1973-1979 ANOVA because of a decrease in the amount of variability between years.Variability decreased because the within cell errors for 1973-1978 (0.0784) and 1973 - 1979 (0.0821) remained relatively constant, while mean square for 1973 - 1979 (0.3903) decreased considerably compared with the mean square for 1973-1978 (1.5911).

The 1973-1979 ANOVA results for trawls (Table 28) showed generally the same significant main effects and interactions as in the 1973 - 1978 ANOVA. Only the main effects Year and Area and the Month x Area interaction will be examined for the purpose of assessing plant effects. The Year x Area interaction was not significant for 1973-1979 data.

Year effects were principally attributed to the large difference between mean catches of 1973 (29.07) and 1976 (2.68). However, an overall decline in mean catch for the period 1974-1977 (mean catch values of 9.06, 6.47, 2.68 and 4.72 respectively) was a compounding factor. Mean catches for 1978 (12.40) and 1979 (12.23) have since increased and appear to be stabilizing . Because of the variability in mean catch between preoperational years as well as the variability in mean catch among operational years, Year effects most likely reflect natural population fluctuations rather than plant effects. The nonsignificance of the Year x Area interaction supports this finding.

Area effects were attributable to consistently larger mean trawl catches at Warren Dunes (9.47) compared with Cook (6.68) during preoperational and operational years. No explanation was apparent for this phenomenon, other than that Warren Dunes may offer a preferable habitat for smelt compared with the Cook Plant area. The difference between 1973 mean catch at Warren Dunes (34.29) compared with mean trawl catch at Cook (24.65) was an especially significant factor.

The Month x Area interaction for the 1973 - 1979 trawl ANOVA was significant in large part as a result of the August data. Mean catch values of smelt for August were 8.96 for Cook and 21.88 for Warren Dunes. The interaction was the result of large catches of YOY smelt taken at Warren Dunes during 1973 as a result of an upwelling. The Month x Area interaction was also enhanced by larger overall mean catches of smelt at Warren Dunes trawling stations compared with Cook Plant trawling stations.

Smelt trawl and gill net catches for 1975-1979 at stations R and Q when compared with similar stations at Warren Dunes showed no variation in the overall abundance or distribution of smelt. Results of the 1973-1979 seine and trawl ANOVA's have not demonstrated any change in the abundance or distribution of rainbow smelt in the Cook Plant study areas attributable to Cook Plant operation. Additional 1979 data have not significantly changed ANOVA results for 1973 - 1979 compared with 1973 - 1978 ANOVA results. Only the Month x Time interaction for seines changed between the 1973-1978 and 1973-1979 seine ANOVA's. This change was not significant in terms of plant effects. Significant effects identified by statistical analyses were attributed to natural population fluctuations, sampling during periods of upwelling or natural selection of the Warren Dunes study area over the Cook Plant vicinity for undetermined reasons.

Yellow Perch-- The total standard series field catch of yellow perch (4,381 fish) from January to October 1979 was above the average catch (3,492 fish) for 1973 to 1979 (Tables 11-17). Although the 1979 gill net and seine catches were below average, the trawl catch of 3,241 perch was substantially above the 7-yr average of 1059 fish (Tables 18, 19, 20). Numerous young-of-the-year and yearlings were trawled in August and September 1979 and accounted for most of the increased catch. Some of the variation is the result of large year classes; the 1979 year class appears to be very strong.

The following preliminary examination of ANOVA results concentrates on how the addition of 1979 data to the 1973-1978 data affected the analysis. Also stressed are any changes in the significance of Area (Station)and Year and two-way interactions with Area and Year.

Significance of main effects in the trawl catch ANOVA did not change with addition of 1979 data (Table 29). The difference in Area mean catches and the Year x Area interaction continued to be nonsignificant, while differences in Year mean catches continued to be highly significant. Since the mean trawl catch for 1979 was the highest of the 6 yr, we can conclude that the plant did not have a detrimental effect on yellow perch abundances as indicated by trawl catches. This finding is substantiated by nonsignificance between Area mean catches.

Two interaction terms (Year x Time and Year x Station) that were not significant at the 0.01 probability level with 1973 to 1978 seine data, became significant with addition of 1979 seine data (Table 30). Examination of these terms involving Year did not show any preoperational/operational trends in the data which could be ascribed to plant operation. Part of the reason for significance of the Year x Time interaction was that during years when large seine catches occurred, the difference between day and night catches (night catches were greater than day catches) was considerably greater than the difference during years of small catches. But this trend occurred during both operational and preoperational years.

An interesting trend was highlighted by the Year x Station interaction data. During preoperational years mean seine catches were highest at station B (south Cook). However, during operational years no station had consistently large mean catches. It may be that during preoperational years the safe harbor, and debris left behind when it was removed, attracted perch to station B. Station B was approximately 0.5 km south of the safe harbor. After removal of the safe harbor (operational years) and much of the concrete, scrap iron, debris, etc., the shallow, protected nature of this station was changed due to storms and currents. Thus the physical habitat at station B more closely resembled that of the other two stations.

It was emphasized in the 1978 Environmental Operating Report that there may be a subtle day/night effect by the power plant on beach zone perch numbers. Lower mena night catches occurred at Warren Dunes, while at Cook, mena night catches were higher than mean day catches. However, in 1979 mean night catches were higher than mean day catches at both areas. This finding reduces our belief in a subtle effect on beach zone perch numbers caused by the power plant.

Addition of 1979 data to the gill net ANOVA caused one major change - the difference between Area mean catches became significant at the 0.01 probability level (Table 31). Obviously the large difference between Area mean catches in 1979 caused the significance. The geometric mean (catch + 1) at Warren Dunes was 13.43 while at Cook it was 17.24. The following yearly mean gill net catches between areas also showed a continually greater abundance at Cook:

Year	1973	1974	1975	1976	1977	1978	1979
Cook	19.62	8.94	23.68	24.44	22.73	10.81	18.15
Warren Dunes	19.47	8.16	22.68	17.34	13.19	8.37	11.35
Difference	.15	.78	1.00	7.10	9.54	2.44	6.80

Although abundance was greater at Cook in preoperational years 1973 and 1974, the difference between areas has become greater in operational years of 1975 to 1979. This trend and the following discusssion must be tempered with the finding that the Year x Area interaction was not significant.

Since perch are attracted to the riprap (SCUBA divers have consistently observed more perch over the riprap than over sandy areas) this is a partial reason for greater abundance at Cook. There may also be some attraction to the discharge plume. We have noted that during summer months perch fishermen frequently congregate in small boats off the Cook Plant's discharges, apparently successfully catching yellow perch. The good fishing success could be related to perch attracted to the riprap or to the effects of currents generated by the plant's high velocity discharge. It may be the physical effects of the currents or it may be that food organisms are dislodged by currents and therefore more available.

An interesting question becomes why did trawl and seine data show no significant difference between Areas (Stations)? While trawls and seines collected young-of-the-year and yearlings, few adults were sampled. Gill net catches are more reflective of yearling and especially adult fish abundance. Apparently larger perch are more attracted to the Cook area than smaller fish. This may be only a partial explanation of the discrepancy.

One consequence of the attraction of larger perch to the Cook area is that they will become more vulnerable to impingement. Perch are impinged in large numbers (see IMPINGEMENT Section). Whether impingement mortality is significantly affecting local perch abundance remains to be determined. It may be very difficult to ascertain because of: 1) the continual attraction to apparently both the riprap and the plume, 2) immigration of fish from other areas, 3) natural abundance and distribution changes in the local population, 4) continual recreational and scientific fishing mortality and 5) a lack of data before riprap placement (before 1973). Emphasis in future analyses will be directed to this problem.

Total gill net catches of perch at stations R and Q (6 and 9 m, north Cook) were similar to those at stations C and D (6 and 9 m, south Cook) during 1979. This finding was similar to 1975-1978 data. However, total gill net caches at Warren Dunes 6- and 9-m stations (G and H) were smaller for reasons given above. The total trawl catch at station R (6 m, north Cook) was smaller than at stations C and G (6 m, south Cook and Warren Dunes) during 1979.

We can conclude from this preliminary examination of ANOVA results of trawl and seine catches that the Cook Plant probably did not have an acute effect on the younger individuals of the yellow perch population during 1975-1979. However, gill net data, which reflect abundance of larger fish, did show a plant effect. Yellow perch are being attracted to the Cook Plant, because of the riprap and probably because of the discharge plume. Field data for 1979 showed local perch abundance to be greater than observed during most of the previous years. Much of this variation was due to large year classes, especially the 1979 year class.

<u>Trout-perch</u> -- Trout-perch dropped from fourth-most abundant species in 1976-1978 to fifth-most abundant species collected from Cook Plant study areas in 1979 (Tables 11-17). They were caught in every month of standard series fishing in 1979; trawl catches accounted for most (88%) of the total catch. As in previous years, trout-perch were least abundant in seine catches and were more often caught at night than day in both seines and gill nets, reflecting their nocturnal behavior patterns.

All five main factors -- Year, Month, Area, Depth and Time -- remained highly significant with the addition of 1979 data to the ANOVA for trawl catches (Table 32). The significance of both Year and Area raises the possibility of plant effects. However, no consistent trend was observed; geometric mean trawl catches of trout-perch increased from 1975-1978, but then decreased in 1979. More fish were trawled at Warrent Dunes than at the Cook Plant in all years except 1975, causing a significant Area effect. Year x Area interaction, however, was not significant and yearly changes in trout-perch catches at Cook Plant stations were similar to those at Warren Dunes stations. Therefore, the differences appear to be due to natural population fluctuations rather than plant effects.

The interactions Year x Month, Month x Area and Year x Depth all remained significant with the addition of 1979 data; these interactions were discussed in the 1978 Environmental Operating Report and most can be explained by a few unusually large catches occurring in some years. Although more trout-perch were trawled at night than during the day in all years, the difference was so great in 1979 that Year x Time interaction became significant. Area x Time interaction, however, was no longer significant after model variability was increased by the addition of 1979 data. There were no other changes in significant interactions. Most significant second-order interactions seem to reflect the patchy and highly variable distribution of trout-perch.

ANOVA for night gill nets showed a significant Month main effect and a significant Year x Month interaction (Table 33), as was shown in the 1978 analysis. With years pooled,mean catches of trout-perch were highest in July, but monthly differences varied among years because of upwellings and seasonal temperature differences. Mean catches were greater at Cook Plant than at Warren Dunes for the first time in 1979, causing a significant Year x Area interaction. No other effects or interactions were significant and therefore no differences in trout-perch catches due to plant operation could be demonstrated.

No changes in significant effects were seen with the addition of 1979 data to the ANOVA for night-seined trout-perch (Table 34). Year and Month were significant; station was not. Mean catch of trout-perch was slightly greater in 1979 than in 1978. Although September had the highest geometric mean catch, monthly variations in trout-perch abundance in the beach zone differed among years, causing a significant Year x Month interaction. Again, water temperature and changing seasonal patterns probably accounted for the variation. Month x Station interaction was also significant; however, catches at Stations A (north Cook) and F (Dunes) showed similar monthly trends while those at B (south Cook) were different.

Interpretation of trout-perch catch data continues to be complicated by many significant first and second order interactions. Most of these interactions were caused by a patchy distribution that seems to reflect schooling behavior, upwellings and natural population variability.

Common Species

Brown Trout -- Brown trout (Salmo trutta) comprised a small, but constant fraction of the standard series catch at Cook Plant study areas from 1973 to 1979 (Tables 11-17). Brown trout were caught throughout the field season with the majority of specimens collected in seines (61.4%) and gill nets (37.7%), but rarely in trawls (0.9%).

Comparison of brown trout standard series data for preoperational years (1973 and 1974) with data for 1979, did not indicate any change in the brown trout population in the study areas as a result of plant operations. Catches of brown trout at stations Q (9 m, north Cook) and R (6 m, north Cook) during 1975-1979 were compared with brown trout catches at standard series stations of equal depth over the same period. There were no demonstrable differences in brown trout distribution or abundance, other than that accountable by natural variation.

Carp -- Numbers of carp (Cyprinus carpio) netted at Cook Plant standard series stations increased during operational years while numbers netted at Warren Dunes standard series stations remained static. Mean catches during operational years showed a 2.5 increase in the number of carp netted over preoperational values. Examination of preoperational and operational data showed little difference in the number of carp seined, but a substantial increase in the number gillnetted (Tables 19 and 20). There was also a corresponding shift in the percentage of carp taken in seines and gill nets. During preoperational years 59% of all carp were seined and 37% were gillnetted. During operational years only 28% were seined while 69% were gillnetted. Percentages of carp trawled remained constant in preoperational and operational years (Table 18).

Comparison of Cook Plant standard series stations C and D with Cook Plant non-standard series stations R and Q showed that 6-m station nets consistently collected more carp (121 carp at C and 91 carp at R) than did 9-m stations gill nets (60 carp at D and 37 carp at Q). We feel these increases were the result of carp being attracted to the warm water plume of the discharge.

Carp spawning was not observed in the Cook Plant area during preoperational years, however carp larvae were common in the area during operational years. We suspect the plume and possible currents generated by the intakes and discharges were responsible for promoting spawning in the Cook Plant area. Corroborating evidence, that carp are attracted to the intake and discharge structures and the riprap around them, was supplied by SCUBA divers, who observed carp schooling in these areas (Dorr and Miller 1975).

Chinook Salmon -- Chinook salmon (Oncorhynchus tshawytscha), while not an abundant species, were regularly netted in Cook Plant study areas. During this study (1973-1979) chinook salmon have accounted for an average of 0.07% of the total number of fish netted. Chinook salmon were taken throughout the year with largest catches normally occurring during spring (April-June) and fall (September-November).

Numbers of chinook salmon netted at standard series stations have increased each year since 1973, with the exception of 1976 (Tables 11-17). However, these increases were relatively uniform at all stations and therefore not indicative of any plant effect. Comparison of 1979 gill net data with preoperational gill net data showed the same general pattern of temporal and spatial fish distribution. However, April 1979 catches were much larger than April catches for preoperational years. Examination of April 1979 gillnetting data by station showed these increases to be uniform at all stations, including Q and R (9- and 6-m stations north Cook). This apparently was the result of an overall increase in abundance rather than a plant effect.

The temporal distribution of chinook salmon taken during seining was generally the same at all beach stations (A, B and F) between preoperational and operational years. However, there was more variation between stations in the number of chinook salmon (primarily young-of-the-year) netted during 1975-1979 compared with 1973-1974. In April 1979, similar numbers of chinook salmon were seined at beach stations: 49, 38 and 35 at A, B and F respectively. However, more variation between stations was observed in May and June 1979. During May 50 chinook salmon were seined at station A with only 9 and 18 seined at stations B and F (Warren Dunes) respectively. During June seining, station F had the largest catch of chinook (26 fish) with catches at stations A and B, 17 and 15 respectively. Reasons for these variations in numbers of chinook netted may reflect the patchy distribution of chinook salmon as the stations with the largest catch varied from month to month and between years.

Comparison of the numbers of chinook salmon netted at stations Q and R (9 m and 6 m, north Cook) with those netted at other standard series stations of equal depth, were generally similar. However, chinook salmon were not always netted at stations Q and R when they were taken at other standard series gill net stations. The thermal plume was considered as a possible cause, but water temperatures at all gill net stations were within 1-2 C of each other. Reasons for the differences in the numbers of chinook salmon netted at gillnetting stations are not readily apparent, but attraction to the plume may be a possible reason.

Coho Salmon -- Coho salmon (*Oncorhynchus kisutch*) represented an average of 0.11% of the total number of fish sampled from 1973 to 1979 (Tables 11-17). Coho salmon were primarily collected in the spring and fall with largest catches occurring in spring. Coho were rarely taken during the summer except during upwellings when the fish moved inshore along with cold hypolimnion water.

Coho were collected almost exclusively in seines and gill nets from 1973 to 1979 (Tables 19 and 20). Seine catches accounted for 62% of the total coho catch, while gill nets contributed 37%. Trawl catches accounted for less than 1% (two fish) (Table 18).

Comparison of the mean number of coho collected during preoperational (91) and operational (118) years showed a slight increase in the number of coho taken in operational years. During June 1978, an exceptionally large seine catch occurred. Examination of water temperatures during June 1978 seining showed that day seining stations were subjected to an upwelling and had correspondingly larger catches of coho at all affected stations. Night water temperatures showed the upwelling had greatly receded with only station A (north Cook) still affected. Coho were captured only at station A during night seining. Jude et al. (1979) established that yearling coho use the beach zone in the study area as a nursery. Many of the coho taken in seines during spring sampling periods were undoubtedly juveniles as evidenced by their small size. In general, seine catches of coho salmon were similar between beach stations during 1973-1979.

Comparison of coho catch statistics for standard series gillnetting stations did not demonstrate any differences between stations within or between years. Comparison of catches at gillnetting stations Q (9 m, north Cook) and R (6 m, north Cook) with standard series gillnetting stations of equal depth within and between years failed to demonstrate any differences in the coho population attributable to plant operations.

Emerald Shiner -- Annual catches (1973-1979) of emerald shiners at Cook and Warren Dunes study areas have ranged from zero in 1976 to 49 in 1973, the first year of preoperational studies. Since that time, with the exception of 1976, catches have averaged approximately 12 fish per year (Tables 11-17). The 1979 catch (11 fish) fell within this range. Emerald shiners were taken only during seining and were most abundant at Cook Plant stations (A and B) in all survey years. Of the entire emerald shiner catch since 1973 (112 fish), only 8% (9 fish) were collected from Warren Dunes (Station F). A major catch increase in 1973 and subsequent decline during operational years are probably not directly related to plant effects. This increase may have been produced by either of the following two factors, acting alone or in concert. First, local emerald shiner populations are often characterized by instability that may produce substantial annual fluctuations (Fuchs 1967; Scott and Crossman 1973). And second, the 1973 catch may have been the result of a localized population increase noted at both Cook and Warren Dunes seine stations. However, a more detailed consideration of the biology of the species offers an alternative explanation. In 1973, emerald shiner catches increased most substantially from August to November at station B (south Cook) and accounted for 73.5% of the year's catch. These fish were probably attracted to the Cook Plant area by the presence of a safe harbor built during the early stages of plant construction. Attraction of emerald shiners to the safe harbor area corresponds with reports by Fuchs (1967) and Scott and Crossman (1973), who suggested that although the species is usually pelagic and remains offshore during most of the year, they may move inshore during late summer and fall and do congregate around nearshore structures (piers, docks, river mouths, etc.).

In summary, emerald shiners are not commonly taken in our study areas in southeastern Lake Michigan. Low population levels have been noted lakewide since the early 1960's (Wells and McLain 1972). Limited annual catch fluctuations occur, but are thought to be the result of localized population changes rather than a direct result of plant operation. Unfortunately a paucity of information concerning the age composition of this species in our study areas prevents the more detailed analysis necessary to clearly understand these population changes.

Because of the current low population levels of emerald shiners in the vicinity of the Cook Plant, impingement of the species is of minor concern. Since plant operation began in 1973, one emerald shiner was collected in 1975 and four in 1978 during routine impingement sampling. Since the area is probably not an important spawning area, nursery or preferred habitat of this species, little impact of plant operation can be forseen at this time.

Gizzard Shad -- The 151 gizzard shad collected from January to October 1979 was the second highest standard series field catch from 1973 to 1979 (Tables 11-17). Most of the 1979 catch were adults gillnetted in August and especially September, while some young-of-the-year and yearlings were seined in October (Tables 19 and 20). Larvae were not collected from 1973 to 1978, which indicates spawning did not occur in the study area.

Except for 1976, gizzard shad abundance was greater during operational years (1975-1979) than during 1973 and 1974 (Tables 11-17). We believe this increased abundance resulted from the attraction of shad to the warm-water discharge and possible attraction to Cladophora growth on the riprap and discharge and intake cribs. Gill net catches were usually much greater from 1975 to 1979 at Cook than at Warren Dunes, further evidence for the attraction of shad to the plume area. Gill net catches at the three 6-m stations were greater at both of the Cook stations compared to the Warren Dunes station. Gill net catches from 1975 to 1979 at the Cook 9-m stations (D and Q) were always greater than at the 9-m Warren Dunes station (H). In 1976, 1977 and 1978, catches at station Q (north Cook) were noticeably larger than at station D (south Cook). Some of the differences in catches at the four Cook stations may be related to direction the thermal plume was moving (future analysis of temperature-catch data may define these differences). Interestingly in preoperational 1974 (no shad were gillnetted in 1973) gill net catches of gizzard shad were larger at Warren Dunes (20 fish) than at Cook (11 fish). As in previous years, shad seined in 1979 showed no attraction to any one station.

Johnny Darter -- The January to October 1979 standard series catch of 226 johnny darters (Table 17) was somewhat below the average 1973-1979 catch (282 fish). The 1979 trawl catch of 168 fish was the second lowest catch; the 58 fish seined was the highest (Tables 18 and 19). These differences do not appear to be related to plant operation. As in previous years, no darters were gillnetted in 1979.

As in all previous study years, johnny darters were more abundant at Cook trawling stations than at Warren Dunes stations in 1979. In 1979, trawl catches at station R (6 m, north Cook) were similar to those at station C (6 m, south Cook), but still greater than at station G (6 m, Warren Dunes). This trend also occurred from 1975 to 1978. We believe this area difference is related to attraction of darters to the riprap around the discharge and intake structures. SCUBA diver observations and entrainment of darter larvae revealed that darters spawn on the riprap. Loss of darters through impingement and entrainment does not appear to have noticeably decreased their abundance at the Cook Plant, as evidenced by field catches.

Although trawl data showed more darters at Cook than at Warren Dunes, seine data for 1979 exhibited the reverse. In July and September 38 darters were seined at station F (Warren Dunes), but only 9 and 11 were seined at stations A (north Cook) and B (south Cook) respectively. A similar large catch (25 fish) at station F also occurred in August 1977 (only 4 were caught at A and 6 at B). Since most young-of-the-year and yearlings were seined, these occurrences may indicate that the Warren Dunes area serves more as a nursery area than Cook does. Johnny darter larvae have been collected at Warren Dunes.

How or even if plant operation was responsible for this difference could not be determined.

Lake Sturgeon -- Although lake sturgeons were not commonly caught, it is a threatened species in Lake Michigan. Four were caught from 1973 to 1979, none in 1979. No effect of plant operation on sturgeon numbers was discernible.

Lake Trout -- Lake trout (Salvelinus namaycush) represented an average of 0.13% of the total catch over the course of the study (1973-1979). They were caught almost exclusively in gill nets (94%), but only rarely in seines (3%) and trawls (3%). While lake trout were taken in the greatest abundance from September through November, it was not unusual to collect them throughout the year (Tables 11-17).

Numbers of lake trout collected varied over the study period (1973-1979). However, because these variations were observed both at Cook and Warren Dunes stations these fluctuations were not attributed to plant operation.

Lake trout gill net catches were generally larger at Cook Plant stations (C, 6 m and D, 9 m) than at Warren Dunes stations during preoperational and operational years. Lake trout gill net catches at Cook Plant stations Q (9 m, north Cook) and R (6 m, north Cook) closely paralleled those of stations C and D. The plume apparently had no effect on numbers of lake trout collected in the area.

Longnose Dace -- With the exception of 1979, longnose dace catches in our study areas remained relatively stable during preoperational and operational periods (Tables 11-17). Longnose dace catches substantially declined in 1979 (January through October only); only six fish were taken, three each from Cook and Warren Dunes. All fish collected during standard series netting were seined except for one individual caught by trawl in 1977. From 1973 to 1974 and 1975 to 1978, 90.5% (mean catch = 38) and 84.7% (mean catch = 28) of the longnose dace catch was from Cook stations (A and B). Additionally, except for 1977 and 1979, catches were greatest at station B (south Cook). Since 1973, most fish were collected at night (85.5%). The affinity of longnose dace for Cook Plant stations, especially B, may be related to the occurrence of gravel bottom sediments (Seibel et al. 1974) in this area and the species' preference for this type of substrate (Brazo et al. 1978; Scott and Crossman 1973).

Only 24 fish were impinged during plant operational years, 1975 to 1979. This is consistent with our observations that few dace inhabit depths corresponding to that of the intakes. Those individuals impinged were probably attracted to the riprap habitat.

In summary, reduced longnose dace catches at both Cook and Warren Dunes stations in 1979 suggest that this population is currently at low densities probably as a result of an overall population decline or a reduction in the availability of preferred habitat rather than a site-specific plant impact.

and H). Similarly, from 1975 to October 1979, 25% (3) of the total catch (12) was from Warren Dunes. These data suggest that the decline, while substantial, was not the result of Cook Plant operations, but rather an overall decrease in abundance of northern pike at both survey areas.

Rainbow trout -- Rainbow trout (Salmo gairdneri) were regularly taken in small numbers throughout the year during preoperational (1973-1974) and operational years (1975-1979) with largest catches generally occurring in spring and fall (Tables 11-17). Total numbers of rainbow trout collected each year were very similar with the exception of 1973. Exceptionally large seine catches during 1973 at all study area stations were responsible for this variation (Table 19). These unusually large catches were thought to be the result of local stocking of hatchery-reared fish. Comparison of the relative distribution of rainbow trout by station and gear type, however, did not demonstrate any change in the occurrence of rainbow trout among years.

Rainbow trout were collected only in seines and gill nets with the exception of one specimen trawled during September 1979. Seines accounted for 96% of the rainbow trout collected in 1973-1974 and for 73% of the catch in 1979. Making allowances for the unusually large catches of rainbow trout in 1973, total number of trout taken in preoperational years and in 1979 were in reasonable agreement. More importantly, the general pattern of occurrence and distribution of rainbow trout was similar between preoperational years and 1979. Comparison of preoperational and operational data do not substantiate any change in rainbow trout abundance or distribution attributable to Cook Plant operations.

Slimy Sculpin -- While numbers of slimy sculpin collected in standard series field catches declined from 1974 to 1978, the 1979 field catches showed an increase in abundance. The 1979 total (130 fish) was the largest field catch since 1974 (Tables 11-17). The 1979 seine catch (31) was the largest for the 7 yr of the study.

Trawl catches in 1979 increased at all standard series stations at Cook and Warren Dunes, and also the north Cook 6-m station, R. Catches at all stations were similar in 1979 (20-28 fish), to what they were in 1976 and 1977. Higher trawl catches of sculpins at Cook Plant stations during 1973 through 1975 may have been due to high population density on the plant riprap during initial colonizations; the population may have since stabilized at lower numbers. SCUBA divers noticed a decline in the sculpin population on the riprap in recent years.

Increased field catches of sculpins during 1979 was reflected in impingement data, which also revealed an increase in number of sculpins. Because slimy sculpin numbers first declined, then increased during operational years, and because all areas and gear (including impingement) showed similar fluctuations, we believe these abundance changes resulted from natural population fluctuations and therefore probably were not directly caused by plant operation. However, the effect of annual estimated impingement loss of 1,000 to 8,000 adult slimy sculpins in unknown, as is the loss of larval sculpins through entrainment.

Unidentified Coregonids -- All coregonids under approximately 300 mm could

Longnose Sucker -- Field catches of longnose suckers from 1973 to 1979 revealed a relatively stable population in the study area, only in 1976 did a relatively low catch occur (Tables 11-17). The 1979 total standard series catch of 96 fish was above the 7-yr average (82 fish), but very similar to catches in 1974, 1975 and 1977. Gill net catches at Warren Dunes were generally greater than at Cook, except in 1975 and 1976 when more were caught at Cook. From 1975 to 1979, gill net catches at north Cook stations were usually similar to those at south Cook stations.

One difference in 1979 catch data compared with previous years was the relatively large (25 fish) trawl catch (Table 18). Most of this increase resulted from a September catch of 13 juveniles at station C (6 m, south Cook). A cause for this high catch was not determined.

Plant operation did not appear to influence longnose sucker abundance in the study area during 1979. However, operation of Unit 2 has noticeably increased impingement mortality of longnose suckers. When only Unit 1 was operating from 1975 to 1977, an estimated 20 to 30 fish were impinged, but in 1978 and 1979 an estimated 156 and 149 fish respectively were impinged.

Ninespine Stickleback -- Standard series catches of ninespine sticklebacks declined in operational years compared with preoperational years (Table 11-17). Catches of ninespine sticklebacks were essentially constant at standard series stations during preoperational years and into 1975, the first year of plant operation. Commencing in 1976 numbers of ninespine sticklebacks collected at standard series stations declined compared with standard series catches during 1973-1975. Examination of operational standard series catch data across stations of equal depth and between Cook Plant and Warren Dunes stations showed these declines to be uniform. Therefore, we attributed the decline to natural population fluctuations.

Comparison of 1975-1979 standard series trawl catches from stations C (6 m, south Cook) and G (6 m, Warren Dunes) with catches from station R (6 m, north Cook) showed more were caught at Cook stations. Respective catches were two at Station R compared with seven and six trawled at stations C and G. As the thermal plume from the Unit 1 discharge is usually found in the station R vicinity, attraction of sticklebacks to the plume is a possibility.

Northern Pike -- Northern pike were infrequently caught during 1979 in our study area; four were collected, two by seines and two by gill nets (Tables 19 and 20). From 1973 to 1974, 46 northern pike were collected by standard series netting; 17.4% by seines, 6.5% by trawls and 76% by gill nets. All but two 100-mm individuals taken in 1974 were mature adults. Only 12 fish were collected from 1975 to 1979, 6 with gill nets and 6 with seines. From January 1975 to September 1979, we estimate that 17 northern pike were impinged at the Cook Plant.

From 1973 to the present, northern pike catches have suffered a continous long-term decline. However, the decrease has affected both Cook and Warren Dunes stations proportionately. From 1973 to 1974, 30.4% (14) of the total standard series northern pike catch (46) were collected at Warren Dunes stations (F, G, not be accurately identified to species because of recent morphometric changes in Lake Michigan populations and possible hybridization of some species (for a further discussion see Scott and Crossman 1973). We concluded that most small coregonids we caught were bloaters (Coregonus hoyi), but some of these fish may have been young lake herring (C. artedii).

The 1979 catch of bloaters (2,662 fish) was the largest yearly catch from 1973 to 1979 (Tables 11-17). We believe the increased abundance of bloaters in 1978 and 1979 was not the result of plant operation. Instead it reflects a natural population increase in southeastern Lake Michigan. Approximately 76% of the 1979 catch was yearlings, which indicates that the 1978 year class was large. The 1977 year class was also large (many yearlings were caught in 1978). Many young-of-the-year were caught during fall 1979, which suggests that the 1979 year class will also be large. These three strong year classes are probably related to closure of the Lake Michigan commercial chub (coregonids) fishery in 1976.

Bloater catches at Warren Dunes were similar to those at the Cook Plant during 1973 through 1977. However, in the summers of 1978 and 1979 (when large numbers of yearlings were trawled during upwellings) more fish were caught at Warren Dunes. Whether this area difference was the result of upwelling configuration and intensity or the result of plant operation, is unknown. Trawl catches from April to October 1979 at station R (6 m, north Cook) were similar to catches at station C (6 m, south Cook), but catches at station G (6 m, Warren Dunes) were usually larger. Since most bloaters in southeastern Lake Michigan are found between 18 and 90 m (Wells 1968) our data are indicative only of fringes of the bloater population.

White Sucker -- The 1979 standard series catch of 183 white suckers was the largest ever taken from 1973 to 1975 (Tables 11-17). However, the catch was not noticeably greater than those of 1973 and 1977. A large seine catch of 38 suckers in April (Table 19) accounted for most of the increased catch in 1979 (the largest April seine catch in previous years was only 3 fish). White suckers spawn in early spring. Seining in April 1979 may have coincided exactly with spawning activities, which we believe occur at a small stream near Warren Dunes (all of the April seine catch came from Warren Dunes). White suckers were more abundant at Warren Dunes from 1973 to 1979. From 1975 to 1978, gill net catches (few suckers were trawled) at north Cook stations were usually similar to those at south Cook stations. However, 1979 catches at stations R and Q (6 and 9 m, north Cook) were noticeably lower than at stations C and D (6 and 9 m, south Cook). Although there was some white sucker catch variation in 1979, we believe that plant operation did not have a noticeable effect on the white sucker population in 1979.

Impingement of white suckers changed substantially when the two units were operating in 1978 and 1979. Estimated numbers of white suckers impinged in 1975, 1976 and 1977 (only Unit 1 operating) were 16, 27 and 15 fish respectively. However, in 1978 and 1979 (two-unit operation) estimated numbers were 145 and 184 fish respectively. Apparently the increased volume of cooling water with two units operating has increased numbers of suckers impinged.

ADULT AND JUVENILE FISH - IMPINGEMENT

Introduction -- Monitoring of fish impinged on the Cook Plant traveling screens began in 1973 and continues through the present. The present sampling schedule, begun in April 1976, requires that fish collected over a 24-h period every fourth day be saved, sorted by species and counted. These samples were then used to estimate total monthly impingement (TMI) according to the formula:

$$TMI = \text{Number or weight of fish in samples} \times \frac{\text{Number of days in month}}{\text{Number of sampling days}}$$

Total weight of fish impinged on non-sampling days was recorded before fish were discarded. Impingement data for 1973 through September 1978 were presented and discussed in detail in the 1978 Environmental Operating Report and will be briefly summarized here. Data from November 1978 through September 1979 will be presented in this report and discussed in relation to Unit 2 operation.

1975-October 1978 -- From 1975 through October 1978 the greatest number of fish impinged in one year was over 400,000 fish which were impinged in 1978 (Tables 35-39). The second highest was over 200,000 fish impinged in 1975 and the lowest number was over 50,000 fish impinged in 1977. Numerically, the most abundant species collected from traveling screens were alewife, spottail shiner, yellow perch, trout-perch and rainbow smelt. Both yellow perch and lake trout were proportionately more important on a weight basis than numerically (Tables 40-44). Alewife dominated impingement numbers and also biomass, except in 1977, when more kilograms of yellow perch than alewife were impinged.

Numbers of fish impinged were explained more adequately by seasonal behavior of fish, water temperature and weather phenomena such as storms, than by total volume or rate of water pumped through the plant. No measurable effect on local fish populations in 1979 (as indicated by field catches) could be attributed to impingement.

November 1978-October 1979 -- Impingement since October 1978 was remarkable mostly because of the exceptionally large estimated impingement, over 500,000 fish, in September 1979 (Table 39). The two most abundant species in September were alewife (YOY) which accounted for 71% of the total number of fish impinged that month and 20% of the biomass (Table 44), and yellow perch which composed 14% of impingement totals by number and 65% by weight. Of the biomass of fish impinged in September, 52% was impinged during the early morning hours of 8 September. This large impingement collection was associated with a storm and a strong upwelling which may have been significant in causing such large numbers of fish to be impinged. Young-of-the-year alewives and young-of-the-year and yearling yellow perch were also very abundant in September field catches.

The main effect of Unit 2 operation on the magnitude and pattern of impingement was most clearly observed on a few days during certain months when extremely large numbers of fish were impinged. On most days, impingement was no higher or only slightly higher with both units operating than it was with one unit. The best explanation appears to be that under certain circumstances, i.e., storms, upwellings; large numbers of fish concentrate in the area of the intake. Under these conditions, abrupt water temperature changes or turbidity may compound the effect of increased intake velocity resulting in the extreme catches documented during operation of both units.

One problem of analyzing impingement data since Unit 2 began operation was the occurrence of extremely large samples on certain days of the month. The resulting large variability from day to day sometimes introduced an unusually large error into our estimates of monthly impingement based on fourth-day sampling. An estimate of the magnitude and direction (less or greater than the "actual" number impinged) of the error can be gleaned from comparing the estimated weight with the actual weight of fish impinged, which was included with our monthly impingement reports. Until we have an opportunity to study and compare other methods of estimating monthly impingement, we will continue to use values obtained by estimating impingement from fourth-day samples.

Species composition of impingement collections since both units began operating remained similar to what it had been in the past. Rank and relative abundance of major species varied, but not to a degree that would distinguish this period from the period of single-unit operation. In 1978, unusually large numbers of spottail shiners and trout-perch were impinged (Table 38), while alewives and yellow perch comprised the vast majority of fish impinged in 1979 (Table 39). In most instances these species were abundant in field catches during months when they were impinged most heavily; however, this was not true of trout-perch which in 1978 were impinged in large numbers, but were not comparably abundant in field catches.

Among less abundant species, salmonids (lake, brown and rainbow trout, chinook and coho salmon) were impinged in greater numbers in 1978 and 1979 than in previous years of the study. Most of the increased catch of lake trout occurred in November and December 1978 while unusually large numbers of yearling chinook were impinged in March 1979. These species also increased somewhat in abundance in 1978 and 1978 field catches, making it difficult to separate the effect of plant operation from the effect of greater abundance of these species in the area. Slimy sculpins also increased both in impingement collections and in field catches.

Several species of fish were impinged in higher numbers in 1979, but were not collected in higher numbers in field catches. Among these were white sucker, longnose sucker, burbot, carp and silver redhorse. All these species were impinged over several months in numbers larger than they had been impinged in the past, an increase probably attributable to increased circulation of water associated with Unit 2 operation.

Though Unit 2 more than doubled the rate at which water circulated through the plant, this seemed to have little effect on numbers of fish impinged when density of fish in the Cook Plant area was low to moderate and weather conditions were mild. When number of fish increased in the area or weather or water temperature was changing rapidly and was stressful to fish, they seemed to be more vulnerable to impingement than they were when only one unit was operating. So far, no decline in abundance in field catches of any species has been observed which could be attributed to impingement.

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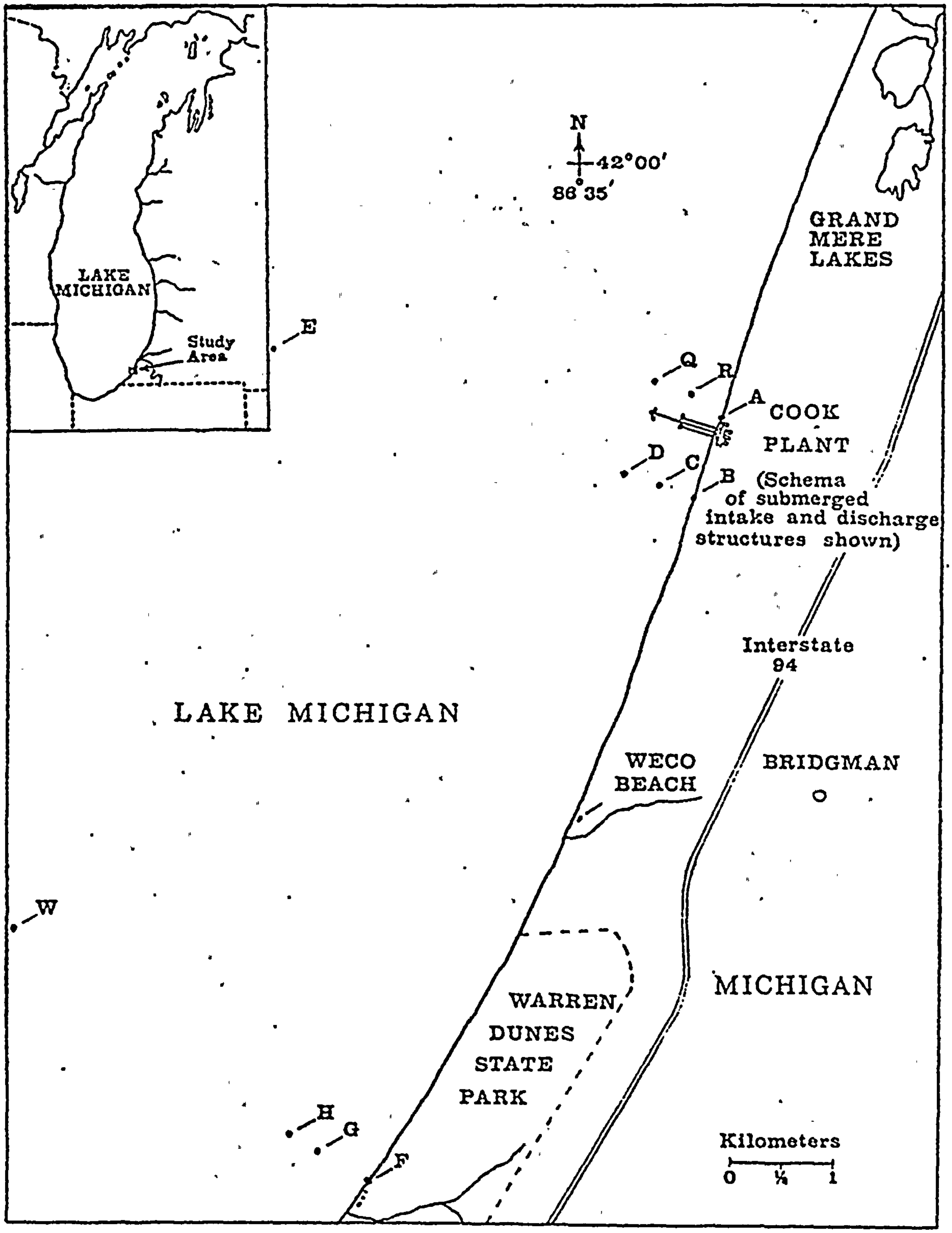


FIG. 1. Location of fish sampling stations at the Cook Plant and Warren Dunes study areas, southeastern Lake Michigan.

Table 1. Summary of factors used in analysis of variance applied to larval concentration data [$\log_{10}$ (density + 1)] from Cook Plant study areas, southeastern Lake Michigan.

		FACTORS				
BEACH						
Species	Year	Month	Station	Time		
Alewife	1973-1978	Jun-Aug	A, B, F	day, night		
Spottail shiner	1973-1978	Jun-Aug	A, B, F	night		
OPEN WATER						
Species	Year	Month		Area	Depth	Time
Alewife	1973-1978	Jun-Aug		Warren Dunes, Cook	6 m, 9 m	day, night
Yellow perch	1977, 1978	June		Warren Dunes, Cook	6 m, 9 m	day, night

Table 2. Summary of analysis of variance for $\log_{10}$ (density + 1) larval alewife in the beach zone (stations A, B and F) at Cook Plant study areas from June - August 1973-1978.

Source of variation[1]	df	Mean square	F-statistic	Attained significance level[2]
Year	5	8.0222	17.0198	.0000 **
Month	2	14.0450	29.7975	.0000 **
Station	2	0.6202	1.3159	.2725
Time	1	1.3873	2.9432	.0891
Y x M	10	10.1712	21.5791	.0000 **
Y x S	10	1.6514	3.5035	.0005 **
M x S	4	0.6628	1.4062	.2368
Y x T	5	1.7403	3.6922	.0040 *
M x T	2	5.7826	12.2682	.0000 **
S x T	2	2.0964	4.4476	.0139
Y x M x S	20	1.3124	2.7844	.0004 **
Y x M x T	10	2.6957	5.7191	.0000 **
Y x S x T	10	1.0505	2.2288	.0211
M x S x T	4	0.7672	1.6277	.1725
Y x M x S x T	20	0.7834	1.6621	.0513
Within cell error	108	0.4713		

[1]Day and night periods defined the Time factor.

[2]* denotes significance (P < .01). ** denotes significance (P < .001).

Table 3. Summary of analysis of variance for $\log_{10}$ (density + 1) larval alewife in the open water zone (6-m stations C and G; 9-m stations D and H) at Cook Plant study areas from June - August 1973-1978.

Source of variation[1]	df[2]	Adjusted mean square[3]	F-statistic	Attained significance level[4]
Year	5	50.2421	78.4380	.0000 **
Month	2	27.6552	43.1753	.0000 **
Area	1	0.8745	1.3653	.2432
Depth	1	17.7274	27.6760	.0000 **
Time	1	18.1047	28.2650	.0000 **
Y x M	10	21.6185	33.7509	.0000 **
Y x A	5	0.3562	0.5560	.7337
M x A	2	0.3279	0.5120	.5996
Y x D	5	0.5262	0.8215	.5347
M x D	2	0.1530	0.2389	.7876
A x D	1	0.4376	0.0001	.9934
Y x T	5	4.1464	6.4734	.0000 **
M x T	2	0.8756	1.3670	.2558
A x T	1	0.3675	0.5738	.4491
D x T	1	1.9265	3.0076	.0835
Y x M x A	10	2.0870	3.2583	.0004 **
Y x M x D	10	0.5829	0.9100	.5236
Y x A x D	5	0.1552	0.2423	.9435
M x A x D	2	0.5954	0.9296	.3954
Y x M x T	10	3.8814	6.0597	.0000 **
Y x A x T	5	0.5132	0.8012	.5492
M x A x T	2	0.8874	0.1385	.8707
Y x D x T	5	0.9313	1.4539	.2036
M x D x T	2	0.7312	1.1416	.3202
A x D x T	1	0.6238	0.9738	.3242
Y x M x A x D	10	0.8090	1.2630	.2487
Y x M x A x T	10	1.0395	1.6229	.0970
Y x M x D x T	10	0.9303	1.4524	.1543
Y x A x D x T	5	0.5504	0.8592	.5084
M x A x D x T	2	0.7777	1.2141	.2979
Y x M x A x D x T	10	0.6916	1.0797	.3760
Within cell error	485	0.6405		

[1]Area included Warren Dunes and Cook Plant stations; 6-m and 9-m stations comprised the Depth factor; day and night periods defined the Time factor.

[2]Ninety-one degrees of freedom were subtracted to correct for 91 missing observations where cell means were substituted.

[3]Mean squares were multiplied by harmonic cell size/maximum cell size (n_h/N = .8746) to correct for missing observations where cell means were substituted.

[4]** denotes significance ($P < .001$).

Sou:
var:

Table 4 . Summary of analysis of variance for $\log_{10}$ (density + 1) larval spottail shiner at night in the beach zone (stations A, B and F) at Cook Plant study areas from June-August 1973-1978.

Source of variation	df	Mean square	F-statistic	Attained significance level[1]
Year	5	7.4636	10.5239	.0000 **
Month	2	9.3455	13.1775	.0000 **
Station	2	0.1492	0.2103	.8110
Y x M	10	6.9298	9.7713	.0000 **
Y x S	10	1.3350	1.8824	.0681
M x S	4	0.5878	0.8288	.5127
Y x M x S	20	1.3632	1.9222	.0296
Within cell error	54	0.7092		

[1]**denotes significance ($P < .001$).

Table 5 . Summary of analysis of variance for $\log_{10}$ (density + 1) larval yellow perch in the open water zone (6-m stations C and G; 9-m stations D and H) at Cook Plant study areas during June 1977 and 1978.

Source of variation[1]	df[2]	Adjusted mean square[3]	F-statistic	Attained significance level
Year	1	5.9876	5.7650	.0197
Area	1	0.3313	0.3190	.5745
Depth	1	0.3330	0.3206	.5735
Time	1	1.0273	0.9891	.3242
Y x A	1	0.3045	0.2932	.5903
Y x D	1	0.5904	0.0001	.9940
A x D	1	0.8933	0.0086	.9264
Y x T	1	2.4486	2.3575	.1303
A x T	1	0.3741	0.0004	.9849
D x T	1	0.1904	0.0183	.8928
Y x A x D	1	1.3706	1.3196	.2555
Y x A x T	1	2.7199	2.6188	.1112
Y x D x T	1	0.7537	0.7257	.3979
A x D x T	1	1.8577	1.7886	.1865
Y x A x D x T	1	0.1061	0.0010	.9746
Within cell error	56	1.0386		

[1] Area included Warren Dunes and Cook Plant stations; 6-m and 9-m stations comprised the Depth factor; day and night periods defined the Time factor.

[2] Eight degrees of freedom were subtracted to correct for eight missing observations where cell means were substituted.

[3] Mean squares were multiplied by harmonic cell size/maximum cell size (n_h/N = .8888) to correct for missing observations where cell means were substituted.

Table 6. Entrainment loss estimates for various taxons of larval fish and fish eggs in 1977 at the D. C. Cook Nuclear Plant, southeastern Lake Michigan. Unit 1 flow rates were assumed over the year for all calculations.

TAXON	Time Interval: * 1 MAR - 4 APR	5 APR - 6 MAY	7 MAY - 28 MAY	29 MAY - 1 JUL	2 JUL - 31 JUL	1 AUG - 26 AUG	27 AUG - 30 SEP	Total No. Larvae	% of Total
Alewife		8.72×10^5	3.48×10^4	1.78×10^7	1.81×10^7	5.42×10^6	7.01×10^5	42.9×10^6	80.3
Spottail Shiner				3.52×10^6	1.28×10^6			4.80×10^6	9.0
Yellow Perch			5.08×10^4	2.41×10^6	3.92×10^4			2.50×10^6	4.7
Trout-perch				5.73×10^4	1.29×10^4	7.11×10^4		$.143 \times 10^6$	0.3
Rainbow Smelt		6.96×10^4		1.26×10^4	1.74×10^5			$.256 \times 10^6$	0.5
Slimy Sculpin			1.89×10^4	4.86×10^4				$.0675 \times 10^6$	0.1
Carp					3.39×10^4			$.0339 \times 10^6$	0.1
Johnny Darter				8.30×10^5	2.86×10^5			1.12×10^6	2.1
White Sucker		7.40×10^4						$.0740 \times 10^6$	0.1
Logperch				3.22×10^4				$.0322 \times 10^6$	0.1
Unidentified Cottid				1.32×10^5				$.132 \times 10^6$	0.2
Unidentified Coregonid		1.00×10^5						$.100 \times 10^6$	0.2
Unidentified Etheostomid				6.51×10^4				$.0651 \times 10^6$	0.1
Unidentified Cyprinid		6.09×10^4			2.71×10^4			$.0880 \times 10^6$	0.2
Unidentified *Lepomis*					1.15×10^5			$.115 \times 10^6$	0.2
Poor condition				1.89×10^5	2.13×10^5	1.06×10^5		$.508 \times 10^6$	1.0
Unidentified Pisces		1.04×10^5					5.42×10^4	$.158 \times 10^6$	0.3
Fish Eggs		6.97×10^6	1.63×10^7	1.20×10^9	2.42×10^8	5.51×10^5		1.46×10^9	----

* No sampling was performed in January and February 1977. No fish were caught between 1 October and 31 December 1977.

Table 7. Entrainment loss estimates for various taxons of larval fish and fish eggs in 1978 at the D. C. Cook Nuclear Plant, southeastern Lake Michigan. Unit 1 flow rates over the year were assumed for all calculations.

TAXON	Time Interval: 1 JAN-29 JAN	30 JAN-28 FEB	1 MAR-4 APR	5 APR-2 MAY	3 MAY-30 MAY	31 MAY-2 JUL	3 JUL-28 JUL	29 JUL-25 AUG	26 AUG-3 OCT	4 OCT-1 NOV	2 NOV-1 DEC	Total No.	% of Total
Alewife					1.87×10^6	3.60×10^6	7.90×10^6	1.94×10^6	1.21×10^6	3.22×10^6	1.38×10^5	20.1×10^6	75.1
Spottail Shiner						7.49×10^4	5.18×10^5	3.28×10^5				$.921 \times 10^6$	3.4
Yellow Perch					1.32×10^5	1.99×10^6	3.48×10^5	3.07×10^4				2.50×10^6	9.3
Trout-perch								5.08×10^4				$.0508 \times 10^6$	0.2
Rainbow Smelt					3.19×10^4	1.26×10^5		6.14×10^4				$.219 \times 10^6$	0.8
Slimy Sculpin						1.18×10^5						$.118 \times 10^6$	0.4
Carp								6.18×10^4				$.0618 \times 10^6$	0.2
Johnny Darter						2.52×10^5	5.78×10^4	9.93×10^4				$.409 \times 10^6$	1.5
Burbot			5.22×10^4									$.0522 \times 10^6$	0.2
Fourhorn Sculpin			8.71×10^4									$.0871 \times 10^6$	0.3
Ninespine Stickleback									4.64×10^4			$.0464 \times 10^6$	0.2
Unidentified Cottid						1.79×10^5						$.179 \times 10^6$	0.7
Unidentified Cyprinid					1.25×10^5		4.45×10^4					$.170 \times 10^6$	0.6
Poor Condition						5.10×10^5	4.41×10^5	3.77×10^5	1.33×10^5	2.52×10^5		1.71×10^6	6.4
Unidentified Pisces						7.55×10^4	5.66×10^4					$.132 \times 10^6$	0.5
Fish Eggs	7.62×10^7	6.37×10^4			4.80×10^5	1.47×10^9	2.10×10^9	5.18×10^7	1.16×10^5	3.19×10^4		3.70×10^9	----

* No fish were observed in entrainment samples collected between 2 December and 31 December 1978.

Table 8. Estimates of total entrainment losses per year for 21 categories of ichthyoplankton at the D. C. Cook Nuclear Plant, southeastern Lake Michigan, 1974-1978. Unit 1 flow rates were assumed for all calculations.

Year	Alewife	Spottail Shiner	Yellow Perch	Trout-perch	Rainbow Smelt	Slimy Sculpin	Carp	Johnny Darter	Burbot	Fourhorn Sculpin	Ninespine Stickleback	White Sucker	Log Perch	Unidentified Cottid	Unidentified Coregonid	Unidentified Etheostomid	Unidentified Cyprinid	Unidentified *Lepomis*	Poor Condition	Unidentified Pisces	Total No. Larvae	Total No. Fish Eggs
*1974[a]	6.46×10^7	1.28×10^6		4.17×10^6	8.97×10^6															9.56×10^5	8.00×10^7	6.49×10^8
1975[a]	1.05×10^8	4.96×10^6	7.63×10^4	7.48×10^5	1.22×10^6	8.08×10^5		1.29×10^4												9.59×10^5	1.14×10^8	9.42×10^8
1976	6.12×10^7	1.04×10^6	3.33×10^4	2.35×10^5	7.88×10^5	3.00×10^5	1.43×10^5	2.08×10^5	5.22×10^4											1.97×10^5	6.42×10^7	2.74×10^9
1977	4.29×10^7	4.80×10^6	2.50×10^6	1.43×10^5	2.56×10^5	6.75×10^4	3.39×10^4	1.12×10^6				7.40×10^4	3.22×10^4	1.32×10^5	1.00×10^5	6.51×10^4	8.80×10^4	1.15×10^5	5.08×10^4	1.58×10^5	5.34×10^7	1.46×10^9
1978	2.01×10^7	9.21×10^5	2.50×10^6	5.08×10^4	2.19×10^5	1.18×10^5	6.18×10^4	4.09×10^5	5.22×10^4	8.71×10^4	4.64×10^4			1.79×10^5			1.70×10^5		1.71×10^6	1.32×10^5	2.68×10^7	3.70×10^9

[a]Larvae in poor condition were assumed to be alewives

*Only intermittent plant pumping and therefore sampling were performed.

Table 9. Summary of factors used in analysis of variance applied to catch data from the Cook Plant study areas southeastern Lake Michigan.

SEINES

Species	FACTORS Year	Month	Station	Time
Spottail shiner	1973-1979	Apr-Oct	A, B, F	day, night
Alewife	1973-1979	Apr-Oct	A, B, F	day, night
Rainbow smelt	1973-1979	Apr-May	A, B, F	day, night
Yellow perch	1973-1979	Jun, Jul, Aug	A, B, F	day, night
Trout-perch	1973-1979	Apr-Oct	A, B, F	*

GILL NETS

Species	Year	Month	Area	Depth	Time
Spottail shiner	1973-1979	Apr-Sep	Warren Dunes, Cook	6 m, 9 m	day, night
Alewife	1973-1979	Apr-Sep	Warren Dunes, Cook	6 m, 9 m	day, night
Yellow perch	1973-1979	Jun-Sep	Warren Dunes, Cook	6 m, 9 m	day, night
Trout-perch	1973-1979	May-Sep	Warren Dunes, Cook	6 m, 9 m	*

TRAWLS

Species	Year	Month	Area	Depth	Time
Spottail shiner	1973-1979	Apr-Oct	Warren Dunes, Cook	6 m, 9 m	day, night
Alewife	1973-1979	Apr-Oct	Warren Dunes, Cook	6 m, 9 m	day, night
Rainbow smelt	1973-1979	Apr-Oct	Warren Dunes, Cook	6 m, 9 m	day, night
Yellow perch	1973-1979	Jun-Oct	Warren Dunes, Cook	6 m, 9 m	day, night
Trout-perch	1973-1979	Jun-Oct	Warren Dunes, Cook	6 m, 9 m	day, night

* Only night values were used; Time was not a factor.

Table 10. Scientific name, common name and abbreviations for all species of fish captured in plankton nets and standard series gear from Cook Plant study areas, southeastern Lake Michigan during 1973-1979. Names assigned according to Bailey et al. 1970.

Scientific and common name	Abbreviation
Acipenseridae	
Acipenser fulvescens Rafinesque Lake sturgeon	LG
Clupeidae	
Alosa pseudoharengus (Wilson) Alewife	AL
Dorosoma cepedianum (Lesueur) Gizzard shad	GS
Salmonidae	
Coregonus artedii Lesueur Lake herring or Cisco	LH
Coregonus clupeaformis (Mitchill) Lake whitefish	LW
Coregonus hoyi (Gill) Bloater	BL
Coregonid spp. Unidentified corregonid	XC
Oncorhynchus kisutch (Walbaum) Coho salmon	CM
Oncorhynchus tshawytscha (Walbaum) Chinook salmon	CH
Salmo gairdneri Richardson Rainbow trout	RT
Salmo trutta Linnaeus Brown trout	BT
Salvelinus namaycush (Walbaum) Lake trout	LT
Osmeridae	
Osmerus mordax (Mitchill) Rainbow smelt	SM
Esocidae	NP
Esox lucius Linnaeus Northern pike	

Table 10. continued.

Scientific and common name	Abbreviation
Cyprinidae	
Carassius auratus Goldfish	GF
Cyprinus carpio Linnaeus Carp	CP
Notemigonus crysoleucas (Mitchill) Golden shiner	GL
Notropis atherinoides Rafinesque Emerald shiner	ES
Notropis heterodon (Cope) Blackchin shiner	ND
Notropis hudsonius (Clinton) Spottail shiner	SP
Notropis spiloterus (Cope) Spotfin shiner	SF
Notropis stramineus (Cope) Sand shiner	SH
Pimephales notatus (Rafinesque) Bluntnose minnow	BM
Pimephales promelas Rafinesque Fathead minnow	PP
Pomoxis annularis White crappie	WC
Pomoxis nigromaculatus Black crappie	BC
Rhinichthys cataractae (Valenciennes) Longnose dace	LD
Catostomidae	
Carpiodes cyprinus (Lesueur) Quillback	QL
Catostomus catostomus (Forster) Longnose sucker	LS
Catostomus commersoni (Lacepede) White sucker	WS
Erimyzon sucetta Lake chubsucker	ER
Moxostoma anisurum (Rafinesque) Silver redhorse	MA
Moxostoma erythrurum (Rafinesque) Golden redhorse	GR
Moxostoma macrolepidotum (Lesueur) Shorthead redhorse	SR

Table 10. continued.

Scientific and common name	Abbreviation
Percopsidae	
Percopsis omiscomaycus (Walbaum) Trout-perch	TP
Gadidae	
Lota lota (Linnaeus) Burbot	BR
Antherinidae	
Labidesthes sicculus (Cope) Brook silverside	SV
Gasterosteidae	
Pungitius pungitius (Linnaeus) Ninespine stickleback	NS
Centrarchidae	
Ambloplites rupestris (Rafinesque) Rock bass	RB
Lepomis cyanellus Rafinesque Green sunfish	GN
Lepomis gibbosus (Linnaeus) Pumpkinseed	PS
Lepomis macrochirus Rafinesque Bluegill	BG
Micropterus dolomieui Lacepede Smallmouth bass	SB
Micropterus salmoides (Lacepede) Largemouth bass	LB
Percidae	
Etheostoma nigrum Rafinesque Johnny darter	JD
Percina caprodes (Rafinesque) Logperch	LP
Perca flavescens (Mitchill) Yellow perch	YP
Sciaenidae	
Aplodinotus grunniens (Rafinesque) Freshwater drum	FD

Table 10. continued.

Scientific and common name	Abbreviation
Cottidae	
Cottus bairdi Girard Mottled sculpin	MS
Cottus cognatus Richardson Slimy sculpin	SS
Ictaluridae	
Ictalurus melas (Rafinesque) Black bullhead	BB
Ictalurus nebulosus Brown bullhead	BN
Ictalurus punctatus (Rafinesque) Channel catfish	CC
Umbridae	
Umbra limi Central mudminnow	MM
Petromyzontidae	
Ichthyomyzon castaneus Chestnut lamprey	CL
Petromyzon marinus Sea lamprey	SL

Table 11. Number of fish caught in standard series nets (seines, gill nets and trawls) during 1973 at Cook Plant study areas, southeastern Lake Michigan.

SPECIES [1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
SP	-	17	439	2687	3374	7416	1819	2514	768	1435	121	1	20591	10.622
AL	-	0	1969	10286	3207	6792	13204	79934	765	32389	5	0	148451	76.576
SH	-	4	119	3926	823	957	294	8394	1425	338	14	0	16294	8.405
YP	-	6	35	15	41	1459	611	909	243	395	22	0	3735	1.927
TP	-	0	2	47	156	1567	703	515	150	330	21	0	3510	1.811
JO	-	0	0	13	47	58	17	31	11	30	0	0	207	0.107
HS	-	1	7	7	14	26	22	30	41	25	0	0	174	0.090
LS	-	1	4	9	15	14	27	1	1	1	0	0	73	0.038
LT	-	0	2	1	2	2	6	19	49	27	54	0	162	0.084
CH	-	0	1	2	5	6	2	2	3	2	0	0	23	0.012
RT	-	1	1	15	30	13	6	11	1	3	5	0	86	0.044
ES	-	1	2	1	6	1	2	11	15	8	2	0	49	0.025
LO	-	2	0	2	4	3	3	4	22	0	1	0	41	0.021
CP	-	0	0	2	2	14	1	2	0	5	0	0	27	0.014
MS	-	0	0	9	3	2	0	0	0	2	0	0	16	0.009
CH	-	0	5	3	9	7	0	0	3	2	0	0	29	0.015
BT	-	1	4	2	6	33	18	4	3	7	0	0	78	0.040
NS	-	0	1	1	12	5	0	0	0	0	0	0	19	0.010
SS	-	0	0	44	14	3	0	5	4	7	1	0	79	0.041
CC	-	1	0	0	0	1	0	2	0	2	4	0	10	0.005
NP	-	0	0	0	0	2	0	1	8	10	9	0	30	0.015
GS	-	0	0	0	0	0	0	0	0	1	22	0	23	0.012
XC	-	0	0	0	2	26	42	35	1	20	0	0	126	0.065
LW	-	0	0	0	1	1	0	0	0	0	0	0	2	0.001
BB	-	0	0	1	0	0	1	0	0	0	0	0	2	0.001
BG	-	0	0	0	1	3	0	1	0	0	5	0	10	0.005
BR	-	0	0	4	0	2	0	0	0	0	0	0	6	0.003
PP	-	0	0	0	1	0	1	0	0	0	0	0	2	0.001
LB	-	0	0	1	0	0	0	0	0	0	0	0	1	0.001
RB	-	0	0	0	0	1	0	0	0	0	1	0	2	0.001
GL	-	0	0	2	0	0	0	0	0	0	0	0	2	0.001
TOTALS	-	35	2491	17080	7775	18413	16779	92425	3523	35050	287	1	193860	

1 See Table 10 for definition of species abbreviations.

Table 12. Number of fish caught in standard series nets (seines, gill nets and trawls) during 1974 at Cook Plant study areas, southeastern Lake Michigan.

SPECIES[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	1	–	167	313	4111	6942	5884	6047	414	475	36	22	24413	21.413
AL	0	–	292	4932	13520	3789	4662	36669	8179	2977	724	0	76033	66.690
SM	0	–	55	701	794	59	385	3304	93	345	13	5	5754	5.047
YP	1	–	14	35	14	156	2581	1182	453	9	75	16	4536	3.979
TP	0	–	0	10	145	55	928	123	105	197	17	2	1578	1.384
JD	0	–	0	5	93	85	60	6	7	22	14	0	293	0.257
WS	2	–	2	3	16	19	29	13	16	13	5	8	126	0.111
LS	1	–	2	4	26	11	39	2	3	3	6	2	99	0.097
LT	0	–	1	1	17	9	0	0	0	12	85	0	125	0.110
CH	0	–	0	3	6	3	5	5	13	0	3	1	41	0.036
RT	0	–	5	2	0	0	0	0	0	0	1	0	8	0.007
ES	0	–	2	1	1	3	0	0	0	6	0	0	13	0.011
LD	0	–	2	1	3	8	2	1	0	20	6	0	43	0.038
CP	0	–	0	2	7	0	1	9	5	3	0	0	27	0.024
LH	0	–	0	0	0	0	0	0	0	0	0	1	1	0.001
CM	0	–	8	8	71	13	2	25	0	0	25	0	153	0.134
BT	0	–	3	5	14	13	6	5	2	1	2	0	51	0.045
NS	0	–	0	1	15	4	3	1	0	0	0	0	24	0.021
SS	0	–	2	155	19	15	14	23	2	13	19	0	272	0.239
CC	0	–	0	1	0	1	8	0	5	1	1	0	17	0.015
NP	1	–	3	3	1	2	0	1	0	5	0	0	16	0.014
GN	0	–	0	0	5	0	0	0	0	1	0	0	6	0.005
GS	0	–	5	4	44	1	0	1	20	9	0	0	84	0.074
XC	0	–	0	0	0	3	199	7	1	15	0	0	225	0.197
LW	0	–	0	0	0	0	0	1	0	0	0	0	1	0.001
BB	0	–	0	1	1	0	0	0	0	0	0	0	2	0.002
BG	0	–	1	0	40	5	0	0	0	0	0	0	46	0.040
BR	0	–	1	1	2	1	0	0	0	0	0	10	15	0.013
LB	0	–	0	0	0	1	0	0	0	0	0	0	1	0.001
GL	0	–	0	0	0	0	0	1	0	0	0	0	1	0.001
SB	0	–	0	0	0	0	0	0	0	3	1	0	4	0.004
BS	0	–	0	0	0	0	0	0	0	1	0	0	1	0.001
TOTALS	6	0	555	6392	19365	11198	14809	47433	9319	4127	1033	67	114009	

1 See Table10 for definition of species abbreviations.

Table 13. Number of fish caught in standard series nets (seines, gill nets and trawls) during 1975 at Cook Plant study areas, southeastern Lake Michigan.

SPECIES[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	1	–	12	103	1740	8483	3076	1583	2022	1535	428	831	19814	27.941
AL	0	–	797	176	6974	2718	1096	757	7740	21188	168	42	41656	58.742
SH	3	–	21	255	1233	1032	0	173	94	179	105	14	3109	4.384
YP	7	–	29	12	4	968	2143	560	280	151	103	80	4337	6.116
TP	0	–	0	14	151	221	68	114	150	108	51	28	905	1.276
JD	0	–	0	2	35	19	3	5	31	19	19	9	142	0.200
WS	1	–	7	3	6	37	9	0	17	2	2	5	89	0.126
LS	1	–	50	3	9	22	1	2	1	2	3	0	94	0.133
LT	0	–	1	3	8	21	0	0	0	4	47	1	85	0.120
CH	0	–	0	3	0	11	3	3	2	20	7	1	50	0.071
RT	0	–	1	2	0	0	1	0	1	6	3	1	15	0.021
ES	0	–	0	1	0	0	0	0	0	0	0	0	1	0.001
LD	0	–	0	0	0	1	0	2	2	7	6	0	18	0.025
CP	0	–	0	0	1	0	14	14	17	2	2	0	50	0.071
LH	0	–	0	1	0	0	0	0	0	0	0	0	1	0.001
CM	0	–	6	40	1	12	0	2	0	0	2	0	63	0.089
BT	0	–	7	2	1	1	1	1	1	1	10	1	26	0.037
NS	0	–	0	2	10	14	0	0	0	0	0	0	26	0.037
SS	0	–	0	38	48	12	0	1	1	2	5	4	111	0.157
CC	0	–	0	0	0	0	1	1	5	1	1	0	9	0.013
OL	0	–	0	0	0	1	0	0	0	0	0	0	1	0.001
LG	0	–	0	0	1	0	0	0	0	0	0	0	1	0.001
NP	1	–	0	1	0	1	0	0	0	0	3	0	6	0.008
GS	0	–	0	2	0	0	0	28	18	13	106	26	193	0.272
XC	0	–	0	0	2	34	0	11	1	1	0	0	49	0.069
PS	0	–	0	0	0	0	1	0	0	0	0	0	1	0.001
LW	0	–	0	1	0	1	0	0	0	0	0	0	2	0.003
BG	0	–	0	0	0	1	0	0	1	0	0	0	2	0.003
BR	1	–	0	0	0	0	0	0	0	1	0	13	15	0.021
LB	0	–	0	0	0	1	0	0	0	0	0	0	1	0.001
SR	0	–	0	0	0	0	0	0	4	0	0	0	4	0.006
SH	0	–	0	0	0	0	0	0	1	1	32	0	34	0.048
HA	0	–	0	0	0	0	0	0	0	1	0	0	1	0.001
LP	0	–	0	0	1	1	0	0	0	0	0	0	2	0.003
TOTALS	15	–	931	664	10225	13612	6417	3257	10389	23244	1103	1056	70913	

1 See Table 10 for definition of species abbreviations.

Table 14. Number of fish caught in standard series nets (seines, gill nets and trawls) during 1976 at Cook Plant study areas, southeastern Lake Michigan.

SPECIES [1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	–	47	49	967	1708	3307	5309	580	823	1178	147	–	14115	8.956
AL	–	0	204	2020	7446	3862	2852	43406	74708	2225	20	–	136743	86.767
SH	–	1	21	452	67	143	416	19	11	13	122	–	1265	0.803
YP	–	13	5	54	24	318	1242	386	422	30	4	–	2498	1.585
TP	–	2	1	25	118	115	1146	134	261	145	8	–	1955	1.240
JD	–	0	0	2	139	12	25	30	31	59	6	–	304	0.193
WS	–	4	0	6	24	5	18	5	18	8	1	–	89	0.056
LS	–	20	3	8	4	3	2	0	0	0	0	–	40	0.025
LT	–	0	3	6	8	7	2	0	0	11	0	–	37	0.023
CH	–	1	0	0	0	9	1	0	3	0	0	–	14	0.009
RT	–	2	0	2	2	1	1	0	4	2	0	–	14	0.009
LO	–	0	0	1	3	2	1	5	10	1	4	–	27	0.017
CP	–	0	0	0	10	2	1	14	4	1	0	–	32	0.020
CM	–	0	0	0	27	16	1	0	1	1	0	–	46	0.029
BT	–	6	0	2	32	18	10	1	17	4	0	–	90	0.057
NS	–	0	0	0	8	1	0	0	0	0	0	–	9	0.006
SS	–	0	0	55	12	1	0	6	2	5	3	–	84	0.053
CC	–	0	0	0	2	0	1	2	8	0	0	–	13	0.008
OL	–	0	0	0	0	1	1	0	0	0	0	–	2	0.001
LG	–	0	0	0	1	0	0	0	0	0	0	–	1	0.001
SB	–	0	0	0	0	0	0	1	0	0	0	–	1	0.001
GS	–	1	0	0	0	1	1	20	20	7	1	–	51	0.032
XC	–	0	0	3	2	26	76	0	0	0	0	–	107	0.068
LW	–	0	1	2	1	1	1	0	0	0	0	–	6	0.004
BG	–	0	0	0	1	0	1	0	0	0	1	–	3	0.002
BR	–	1	0	2	0	0	1	0	0	2	0	–	6	0.004
LB	–	0	0	0	0	0	0	1	0	0	0	–	1	0.001
GL	–	1	0	0	0	0	0	0	0	1	0	–	2	0.001
SH	–	0	0	1	0	0	0	7	0	31	0	–	39	0.025
PA	–	0	0	0	0	0	3	0	0	0	0	–	3	0.002
SV	–	0	0	1	0	0	0	0	0	0	0	–	1	0.001
TOTALS	–	99	287	3609	9639	7851	11112	44617	76343	3724	317	–	157598	

1 See Table10 for definition of species abbreviations.

Table 15. Number of fish caught in standard series nets (seines, gill nets and trawls) during 1977 at Cook Plant study areas, southeastern Lake Michigan.

SPECIES[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	—	0	54	20	2333	2190	2363	10098	3535	1564	398	0	22555	25.530
AL	—	0	66	34	1270	1607	3507	20151	12731	3017	13596	0	55979	63.363
SM	—	0	0	113	170	2	669	88	99	148	166	0	1455	1.647
YP	—	0	11	28	19	189	1300	897	470	47	416	1	3378	3.824
TP	—	0	1	4	193	317	1919	130	172	501	2	0	3239	3.666
JD	—	0	0	34	171	44	31	41	92	4	16	0	423	0.479
WS	—	0	0	8	29	18	68	13	23	8	5	1	173	0.196
LS	—	0	4	5	3	0	34	9	14	6	24	0	99	0.112
LT	—	0	4	10	6	6	6	0	9	27	119	0	187	0.212
CH	—	0	11	21	0	43	0	0	0	1	0	0	76	0.086
RT	—	0	0	2	1	0	1	0	6	0	2	0	12	0.014
ES	—	0	0	0	0	2	23	0	0	3	0	0	27	0.032
LD	—	0	0	1	0	3	1	0	9	38	8	0	60	0.068
CP	—	0	0	5	30	0	5	22	20	3	7	0	92	0.104
MS	—	0	0	0	0	0	0	0	0	3	0	0	3	0.003
CY	—	0	3	1	83	2	0	0	1	2	4	0	96	0.109
BT	—	0	5	9	8	13	5	0	5	1	9	6	61	0.069
NS	—	0	0	0	5	0	2	0	0	0	0	0	7	0.008
SS	—	0	0	15	0	0	7	1	2	0	5	0	30	0.034
CC	—	0	0	0	0	0	0	5	2	2	0	0	9	0.010
QL	—	0	0	0	0	0	0	1	2	0	0	0	3	0.003
LG	—	0	0	0	0	0	1	1	0	0	0	0	2	0.002
GS	—	0	0	0	0	0	1	15	39	41	8	0	104	0.118
XC	—	0	0	0	0	24	40	0	7	141	15	0	227	0.257
BG	—	0	0	0	0	1	0	0	1	0	0	0	2	0.002
BR	—	0	1	0	0	0	0	1	0	0	0	6	8	0.009
GR	—	0	0	0	0	0	0	6	3	0	0	0	9	0.010
RB	—	0	0	0	0	0	0	0	0	1	0	0	1	0.001
GL	—	0	0	0	0	0	0	0	1	0	0	0	1	0.001
SR	—	0	0	0	0	0	0	0	0	0	0	1	1	0.001
FD	—	0	0	0	0	0	0	0	0	1	0	0	1	0.001
SH	—	0	0	1	0	2	13	5	1	0	1	0	23	0.026
MA	—	0	0	0	0	0	0	0	1	0	0	0	1	0.001
BM	—	0	0	0	0	0	0	1	0	0	0	0	1	0.001
TOTALS	—	0	160	311	4321	4463	9996	31485	17235	5559	14801	15	88346	

1 See Table 10 for definition of species abbreviations.

Table 16. Number of fish caught in standard series nets (seines, gill nets and trawls) during 1978 at the Cook Plant study area, southeastern Lake Michigan.

SPECIES[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
ND	—	—	—	0	0	1	0	0	0	0	0	—	1	0.001
SP	—	—	—	108	414	6824	15913	6064	2298	4788	202	—	36601	39.732
AL	—	—	—	4	294	5498	641	1786	2686	26882	701	—	38492	41.785
SM	—	—	—	66	1580	59	1844	5446	89	109	68	—	9261	10.053
YP	—	—	—	50	4	181	379	206	609	57	90	—	1576	1.711
TP	—	—	—	5	80	194	610	310	254	1631	20	—	3104	3.370
JD	—	—	—	1	77	57	82	17	5	112	34	—	385	0.418
WS	—	—	—	1	6	9	15	9	36	31	11	—	119	0.128
LS	—	—	—	14	2	2	1	7	12	8	25	—	71	0.077
LT	—	—	—	9	34	31	18	11	89	53	41	—	286	0.310
CH	—	—	—	7	6	55	4	2	7	22	4	—	107	0.116
BT	—	—	—	4	1	2	2	5	1	5	1	—	21	0.023
ES	—	—	—	0	0	0	0	3	0	7	0	—	10	0.011
LO	—	—	—	3	3	2	0	0	5	8	5	—	26	0.028
CP	—	—	—	0	4	0	1	2	6	16	5	—	34	0.037
LH	—	—	—	1	0	0	0	0	0	0	0	—	1	0.001
CN	—	—	—	11	23	224	22	17	4	0	0	—	301	0.327
BT	—	—	—	63	12	9	10	11	30	17	10	—	162	0.176
NS	—	—	—	1	2	1	0	0	1	0	0	—	5	0.005
SS	—	—	—	5	6	1	1	0	0	1	0	—	14	0.015
CC	—	—	—	0	0	0	1	0	1	2	1	—	5	0.005
QL	—	—	—	0	0	0	0	0	0	2	0	—	2	0.002
LG	—	—	—	0	0	0	0	0	0	0	1	—	1	0.001
NP	—	—	—	0	0	0	0	0	0	2	0	—	2	0.002
GS	—	—	—	0	0	0	0	0	12	88	8	—	108	0.117
XC	—	—	—	0	1	117	269	868	29	52	56	—	1392	1.511
LW	—	—	—	0	1	3	0	2	2	0	1	—	9	0.010
BR	—	—	—	2	1	0	0	0	0	1	1	—	5	0.005
PP	—	—	—	0	0	0	0	0	1	0	0	—	1	0.001
GL	—	—	—	0	0	0	2	0	0	0	0	—	2	0.002
SP	—	—	—	0	0	0	0	0	2	0	0	—	2	0.002
SH	—	—	—	0	0	0	0	0	12	0	0	—	12	0.013
MA	—	—	—	0	0	0	0	0	0	1	0	—	1	0.001
SV	—	—	—	0	0	0	0	0	1	0	0	—	1	0.001
TOTALS	—	—	—	355	2551	13270	19815	14766	6182	33895	1285	—	92119	

[1] See Table 10 for definition of species abbreviations.

Table 17. Number of fish caught in standard series nets (seines, gill nets and trawls) during 1979 at the Cook Plant study area, southeastern Lake Michigan.

SPECIES [1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	—	—	—	711	834	3475	9796	2147	8582	2080	—	—	27625	14.991
AL	—	—	—	267	71	2248	1178	16700	66562	54607	—	—	41633	76.858
SM	—	—	—	788	2152	579	146	923	54	150	—	—	4792	2.600
YP	—	—	—	41	25	104	511	1031	2606	63	—	—	4381	2.377
TP	—	—	—	41	27	152	326	376	324	461	—	—	1707	0.926
JD	—	—	—	20	52	53	38	1	42	20	—	—	226	0.123
WS	—	—	—	40	19	31	4	41	30	18	—	—	183	0.099
LS	—	—	—	2	35	20	3	9	20	7	—	—	96	0.052
LT	—	—	—	15	3	4	0	2	0	55	—	—	79	0.043
CH	—	—	—	150	83	61	1	1	7	0	—	—	303	0.164
BT	—	—	—	3	1	1	1	1	2	2	—	—	11	0.006
ES	—	—	—	7	1	3	0	0	0	0	—	—	11	0.006
LD	—	—	—	3	0	0	0	0	1	2	—	—	6	0.003
CP	—	—	—	11	29	7	2	12	3	7	—	—	71	0.039
MS	—	—	—	2	0	0	0	0	0	0	—	—	2	0.001
CM	—	—	—	57	26	0	0	0	0	0	—	—	83	0.045
BT	—	—	—	20	10	9	11	0	1	4	—	—	55	0.030
NS	—	—	—	0	1	7	0	0	0	0	—	—	8	0.004
SS	—	—	—	89	28	7	1	0	0	5	—	—	130	0.071
CC	—	—	—	1	0	0	0	3	3	1	—	—	8	0.004
LC	—	—	—	1	0	0	0	0	0	0	—	—	1	0.001
NP	—	—	—	0	0	0	0	1	3	0	—	—	4	0.002
GN	—	—	—	0	0	1	0	0	0	0	—	—	1	0.001
GS	—	—	—	3	0	1	0	6	124	17	—	—	151	0.082
XC	—	—	—	0	4	68	1979	3	518	90	—	—	2662	1.445
MM	—	—	—	1	0	0	0	0	0	0	—	—	1	0.001
LW	—	—	—	3	3	1	0	0	0	0	—	—	7	0.004
BC	—	—	—	0	1	0	0	0	0	0	—	—	1	0.001
BG	—	—	—	0	0	1	0	0	0	0	—	—	1	0.001
BR	—	—	—	1	0	2	0	2	0	0	—	—	5	0.003
PP	—	—	—	0	0	1	0	1	0	0	—	—	2	0.001
GR	—	—	—	0	0	0	0	0	3	0	—	—	3	0.002
RW	—	—	—	1	0	0	0	0	0	1	—	—	2	0.001
SR	—	—	—	1	0	0	1	0	0	2	—	—	4	0.002
XX	—	—	—	0	0	0	6	0	0	0	—	—	6	0.003
SF	—	—	—	0	0	0	0	2	0	1	—	—	3	0.002
SH	—	—	—	0	0	0	0	0	0	3	—	—	3	0.002
MA	—	—	—	0	0	0	0	1	6	3	—	—	10	0.005
DM	—	—	—	0	1	0	0	0	0	0	—	—	1	0.001
TOTALS	—	—	—	2279	3406	6836	14004	21263	78891	57599	—	—	184278	

[1] See Table 10 for definition of species abbreviations.

Table 18. Number of fish caught in standard series trawls from 1973-1979 at the Cook Plant study areas, southeastern Lake Michigan.

1973

SPECIES[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
SP	–	–	–	729	563	167	266	504	632	273	–	–	3134	9.339
AL	–	–	–	2946	1627	1579	1963	2611	683	508	–	–	11917	35.513
SM	–	–	–	1358	722	953	292	8273	1360	325	–	–	13284	39.586
YP	–	–	–	5	25	360	264	486	209	315	–	–	1664	4.959
TP	–	–	–	46	90	1505	588	492	155	294	–	–	3170	9.447
JD	–	–	–	13	47	57	15	31	11	27	–	–	201	0.599
WS	–	–	–	0	0	3	1	4	3	0	–	–	11	0.033
LS	–	–	–	0	0	3	2	0	0	0	–	–	5	0.015
LT	–	–	–	0	1	2	0	1	0	0	–	–	4	0.012
CH	–	–	–	0	0	1	0	0	0	0	–	–	1	0.003
MS	–	–	–	6	2	2	0	0	0	2	–	–	12	0.036
BT	–	–	–	0	0	1	0	0	0	0	–	–	1	0.003
NS	–	–	–	0	6	5	0	0	0	0	–	–	11	0.033
SS	–	–	–	37	14	3	0	6	4	7	–	–	71	0.212
CC	–	–	–	0	0	1	0	0	0	0	–	–	1	0.003
NP	–	–	–	0	0	0	0	1	0	2	–	–	3	0.009
XC	–	–	–	0	0	14	9	21	0	19	–	–	63	0.198
LW	–	–	–	0	1	1	0	0	0	0	–	–	2	0.006
BG	–	–	–	0	1	0	0	0	0	0	–	–	1	0.003
BR	–	–	–	0	0	1	0	0	0	0	–	–	1	0.003
TOTALS	–	–	–	5140	3099	4658	3400	12430	3357	1773	–	–	33557	

1974

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
SP	–	–	–	112	1755	333	181	133	86	338	10	–	2948	11.388
AL	–	–	–	3928	7808	755	1149	131	166	765	723	–	15425	59.588
SM	–	–	–	308	738	59	373	3274	89	284	13	–	5138	19.849
YP	–	–	–	19	7	89	23	65	84	7	19	–	313	1.209
TP	–	–	–	8	123	53	786	108	83	137	12	–	1315	5.080
JD	–	–	–	5	93	82	60	6	7	22	14	–	289	1.116
WS	–	–	–	0	0	1	1	2	2	0	0	–	6	0.023
LS	–	–	–	0	0	0	1	0	0	1	0	–	2	0.008
LT	–	–	–	1	1	0	0	0	0	0	2	–	4	0.015
CH	–	–	–	0	0	0	1	3	0	0	0	–	4	0.015
CP	–	–	–	0	0	0	0	0	1	1	0	–	2	0.008
BT	–	–	–	0	0	0	2	0	0	0	0	–	2	0.008
NS	–	–	–	0	13	4	2	1	0	0	0	–	20	0.077
SS	–	–	–	137	19	14	14	28	2	17	17	–	248	0.958
CC	–	–	–	1	0	0	0	0	0	1	1	–	3	0.012
XC	–	–	–	0	0	3	140	5	0	15	0	–	163	0.630
BG	–	–	–	0	1	2	0	0	0	0	0	–	3	0.012
BR	–	–	–	0	1	0	0	0	0	0	0	–	1	0.004
TOTALS	–	–	–	4519	10559	1395	2733	3755	525	1588	811	–	25886	

1 See Table 10 for definition of species abbreviations.

Table 18.continued.

1975

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	-	-	-	39	631	342	185	451	749	116	156	797	3466	26.232
AL	-	-	-	9	1889	143	161	16	2119	404	100	32	4873	36.880
SM	-	-	-	159	1093	1026	0	171	92	171	105	13	2830	21.418
YP	-	-	-	4	2	108	573	132	24	19	4	77	943	7.137
TP	-	-	-	12	134	204	68	103	89	78	49	28	765	5.790
JD	-	-	-	2	35	16	3	3	31	19	10	9	128	0.969
WS	-	-	-	0	0	0	0	0	0	1	1	1	3	0.023
LS	-	-	-	0	1	2	1	2	0	0	0	0	6	0.045
LT	-	-	-	1	3	3	0	0	0	0	0	0	7	0.053
CH	-	-	-	0	0	0	1	0	0	0	0	0	1	0.008
CP	-	-	-	0	0	0	2	1	0	0	0	0	3	0.023
NS	-	-	-	0	5	14	0	0	0	0	0	0	19	0.144
SS	-	-	-	37	31	12	0	1	1	2	5	4	93	0.704
GS	-	-	-	0	0	0	0	0	1	0	0	26	27	0.204
IC	-	-	-	0	2	33	0	9	1	1	0	0	46	0.348
ER	-	-	-	0	0	0	0	0	0	1	0	0	1	0.008
LP	-	-	-	0	1	1	0	0	0	0	0	0	2	0.015
TOTALS	-	-	-	263	3827	1904	994	889	3107	812	430	987	13213	

1976

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	-	-	-	503	576	324	68	134	434	1144	146	-	3329	21.992
AL	-	-	-	748	4405	130	381	398	78	2164	20	-	8324	54.991
SM	-	-	-	136	37	0	415	14	3	12	121	-	738	4.875
YP	-	-	-	33	3	58	86	154	242	26	4	-	606	4.003
TP	-	-	-	15	106	62	1088	92	179	143	7	-	1692	11.178
JD	-	-	-	2	139	9	25	26	30	59	6	-	296	1.955
WS	-	-	-	0	0	0	1	0	1	0	0	-	2	0.013
LS	-	-	-	2	0	0	0	0	0	0	0	-	2	0.013
LT	-	-	-	1	1	0	2	0	0	0	0	-	4	0.026
CP	-	-	-	0	0	0	0	0	1	1	0	-	2	0.013
NS	-	-	-	0	7	0	0	0	0	0	0	-	7	0.046
SS	-	-	-	38	12	0	0	4	1	5	3	-	63	0.416
CC	-	-	-	0	1	0	0	0	0	0	0	-	1	0.007
GS	-	-	-	0	0	0	0	0	0	0	1	-	1	0.007
IC	-	-	-	3	1	1	60	0	0	0	0	-	65	0.429
LN	-	-	-	0	0	0	1	0	0	0	0	-	1	0.007
BG	-	-	-	0	1	0	0	0	0	0	0	-	1	0.007
ER	-	-	-	1	0	0	0	0	0	2	0	-	3	0.020
TOTALS	-	-	-	1482	5289	584	2127	822	969	3556	308	-	15137	

Table 18 continued.

1977

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	-	-	-	7	339	417	68	1437	3177	1157	25	-	6627	34.591
AL	-	-	-	2	364	249	134	37	1242	2794	1780	-	6602	34.461
SM	-	-	-	75	168	1	663	87	78	111	104	-	1287	6.718
YP	-	-	-	14	7	122	13	464	333	29	120	-	1102	5.752
TP	-	-	-	4	171	205	1861	118	75	493	1	-	2928	15.283
JD	-	-	-	34	167	44	26	6	81	4	15	-	377	1.968
WS	-	-	-	0	3	0	2	3	0	1	0	-	9	0.047
LS	-	-	-	0	0	0	0	8	9	0	1	-	18	0.094
CH	-	-	-	0	0	1	0	0	0	0	0	-	1	0.005
LO	-	-	-	0	0	0	0	0	0	1	0	-	1	0.005
KS	-	-	-	0	0	0	0	0	0	3	0	-	3	0.016
XS	-	-	-	0	5	0	2	0	0	0	0	-	7	0.037
SS	-	-	-	14	0	0	7	1	2	0	2	-	26	0.136
XC	-	-	-	0	0	3	11	0	2	141	12	-	169	0.882
DR	-	-	-	0	0	0	0	1	0	0	0	-	1	0.005
TOTALS	-	-	-	150	1224	1042	2787	2162	4999	4734	2060	-	19158	

1978

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	—	—	—	14	146	1361	3	30	916	4638	166	—	7274	23.836
AL	—	—	—	0	0	629	14	18	55	8018	694	—	9428	30.894
SM	—	—	—	47	1452	20	1532	5338	41	102	66	—	8598	28.174
YP	—	—	—	21	0	55	85	2	271	57	53	—	544	1.783
TP	—	—	—	3	54	129	573	300	230	1611	18	—	2918	9.562
JD	—	—	—	1	75	56	82	16	4	112	34	—	380	1.245
WS	—	—	—	0	0	3	0	0	0	10	0	—	13	0.043
LS	—	—	—	0	0	2	0	0	6	1	1	—	10	0.033
LT	—	—	—	0	0	0	1	1	0	1	2	—	5	0.016
CP	—	—	—	0	0	0	0	0	1	0	0	—	1	0.003
CH	—	—	—	2	0	0	0	0	0	0	0	—	2	0.007
BT	—	—	—	1	0	0	0	0	0	0	0	—	1	0.003
NS	—	—	—	1	1	1	0	0	1	0	0	—	4	0.013
SS	—	—	—	5	6	1	1	0	0	1	0	—	14	0.046
XC	—	—	—	0	0	106	257	826	27	52	56	—	1324	4.339
BA	—	—	—	1	0	0	0	0	0	0	0	—	1	0.003
TOTALS	—	—	—	96	1734	2363	2548	6531	1552	14603	1090	—	30517	

Table 18. continued.

1979

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	—	—	—	529	214	1738	343	1803	457	1463	—	—	6547	32.002
AL	—	—	—	22	20	618	226	129	629	1815	—	—	3459	16.908
SH	—	—	—	664	1868	576	146	915	48	65	—	—	4282	20.931
YP	—	—	—	29	7	76	41	613	1419	56	—	—	2241	10.954
TP	—	—	—	19	19	110	275	338	310	423	—	—	1494	7.303
JD	—	—	—	20	52	53	17	1	5	20	—	—	168	0.821
WS	—	—	—	0	1	4	1	2	1	1	—	—	10	0.049
LS	—	—	—	0	1	3	0	5	16	0	—	—	25	0.122
LT	—	—	—	0	0	2	0	0	0	0	—	—	2	0.010
CH	—	—	—	0	4	2	0	0	0	0	—	—	6	0.029
RT	—	—	—	0	0	0	0	0	1	0	—	—	1	0.005
CP	—	—	—	0	0	0	0	1	0	0	—	—	1	0.005
MS	—	—	—	2	0	0	0	0	0	0	—	—	2	0.010
BT	—	—	—	1	0	0	0	0	0	0	—	—	1	0.005
NS	—	—	—	0	1	6	0	0	0	0	—	—	7	0.034
SS	—	—	—	62	28	7	1	0	0	1	—	—	99	0.484
GS	—	—	—	0	0	0	0	0	0	1	—	—	1	0.005
XC	—	—	—	0	3	68	1933	2	36	65	—	—	2107	10.299
MM	—	—	—	1	0	0	0	0	0	0	—	—	1	0.005
LW	—	—	—	0	2	0	0	0	0	0	—	—	2	0.010
BR	—	—	—	1	0	1	0	0	0	0	—	—	2	0.010
TOTALS	—	—	—	1350	2220	3264	2983	3809	2922	3910	—	—	20458	

Table 19. Number of fish caught in standard series seines from 1973-1979 at the Cook Plant study areas, southeastern Lake Michigan.

<u>1973</u>

SPECIES[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	–	5	37	1044	2012	6401	1523	1710	32	1025	25	–	13819	9.674
AL	–	0	0	4658	489	1015	10387	77060	3	31813	5	–	125430	87.911
SH	–	3	1	2388	94	0	1	0	5	4	2	–	2498	1.749
YP	–	0	0	0	1	571	9	1	0	47	0	–	629	0.440
TP	–	0	0	1	59	0	1	4	0	14	1	–	80	0.056
JD	–	0	0	0	0	1	2	0	0	3	0	–	6	0.004
WS	–	0	5	1	4	12	8	0	0	0	0	–	30	0.021
LS	–	0	0	0	2	0	1	0	0	0	0	–	3	0.002
CH	–	0	1	0	3	5	1	0	0	0	0	–	10	0.007
RT	–	1	1	14	28	13	6	11	1	3	5	–	83	0.058
ES	–	1	2	1	6	1	2	11	15	8	2	–	49	0.034
LD	–	2	0	2	4	3	3	4	22	0	1	–	41	0.029
CP	–	0	0	2	2	14	1	1	0	0	0	–	20	0.014
MS	–	0	0	2	1	0	0	0	0	0	0	–	3	0.002
CM	–	0	0	3	0	6	0	0	0	0	0	–	9	0.006
BT	–	1	0	1	4	32	18	2	3	6	0	–	67	0.047
NS	–	0	1	1	6	0	0	0	0	0	0	–	8	0.006
SS	–	0	0	7	0	0	0	0	0	0	1	–	8	0.006
CC	–	1	0	0	0	0	0	2	0	0	0	–	3	0.002
NP	–	0	0	0	0	2	0	0	0	1	1	–	4	0.003
GS	–	0	0	0	0	0	0	0	0	1	22	–	23	0.016
XC	–	0	0	0	1	0	0	0	0	0	0	–	1	0.001
BR	–	0	0	1	0	0	1	0	0	0	0	–	2	0.001
BG	–	0	0	0	0	3	0	1	0	0	5	–	9	0.006
PP	–	0	0	0	1	0	1	0	0	0	0	–	2	0.001
LB	–	0	0	1	0	0	0	0	0	0	0	–	1	0.001
RB	–	0	0	0	0	0	0	0	0	0	1	–	1	0.001
GL	–	0	0	2	0	0	0	0	0	0	0	–	2	0.001
TOTALS	–	14	48	8129	2717	8079	11970	78807	81	32925	71	–	142841	

[1] See Table 10 for definition of species abbreviations.

Table 19. continued.

1974

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	0	–	69	39	1656	5274	5542	5875	252	61	9	–	18777	25.377
AL	0	–	3	13	4312	251	526	36187	7839	2052	0	–	51183	69.174
SM	0	–	37	224	39	0	2	10	1	2	0	–	315	0.426
YP	0	–	0	1	0	39	2508	802	10	0	0	–	3360	4.541
TP	0	–	0	1	1	0	2	3	12	0	2	–	21	0.029
JD	0	–	0	0	0	4	0	0	0	0	0	–	4	0.005
WS	0	–	1	0	1	0	3	1	1	0	0	–	7	0.009
LS	0	–	1	0	0	0	0	1	0	1	0	–	3	0.004
LT	0	–	1	0	0	0	0	0	0	0	0	–	1	0.001
CH	0	–	0	2	5	2	5	0	0	0	0	–	14	0.019
RT	0	–	4	2	0	0	0	0	0	0	1	–	7	0.009
ES	0	–	2	1	1	3	0	0	0	5	0	–	13	0.018
LD	0	–	2	1	3	8	2	1	0	20	6	–	43	0.058
CP	0	–	0	2	7	0	1	2	0	0	0	–	12	0.016
CN	0	–	0	4	31	13	2	0	0	0	0	–	50	0.068
BT	0	–	2	3	9	12	0	0	0	1	0	–	27	0.036
NS	0	–	0	1	2	0	1	0	0	0	0	–	4	0.005
SS	0	–	2	17	0	1	0	0	0	1	2	–	23	0.031
CC	0	–	0	0	0	1	8	0	1	0	0	–	10	0.014
NP	0	–	1	0	0	2	0	1	0	0	0	–	4	0.005
GN	0	–	0	0	5	0	0	0	0	1	0	–	6	0.008
GS	0	–	5	4	43	1	0	0	0	1	0	–	54	0.073
XC	0	–	0	0	0	0	0	2	0	0	0	–	2	0.003
BB	0	–	0	1	1	0	0	0	0	0	0	–	2	0.003
BG	0	–	1	0	39	3	0	0	0	0	0	–	43	0.058
LB	0	–	0	0	0	1	0	0	0	0	0	–	1	0.001
GL	0	–	0	0	0	0	0	1	0	0	0	–	1	0.001
SB	0	–	0	0	0	0	0	0	0	3	1	0	4	0.004
BA	0	–	0	0	0	0	0	0	0	1	0	0	1	0.001
TOTALS	0	–	131	316	6155	5615	8602	42886	8116	2150	21	–	73992	

Table 19. continued.

1975

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	–	–	–	52	976	7596	2679	927	1119	1311	251	–	14911	29.093
AL	–	–	–	0	4775	1708	424	540	5569	20740	18	–	33774	65.898
SM	–	–	–	84	127	0	0	0	2	1	0	–	214	0.418
YP	–	–	–	0	0	722	1209	62	1	0	12	–	2006	3.914
TP	–	–	–	1	5	0	0	4	41	15	0	–	66	0.129
JD	–	–	–	0	0	3	0	2	0	0	9	–	14	0.027
WS	–	–	–	2	2	0	1	0	0	0	0	–	5	0.010
CH	–	–	–	3	0	11	2	0	0	1	0	–	17	0.033
RT	–	–	–	2	0	0	1	0	0	6	3	–	12	0.023
ES	–	–	–	1	0	0	0	0	0	0	0	–	1	0.002
LD	–	–	–	0	0	1	0	2	2	7	6	–	18	0.035
CP	–	–	–	0	1	0	3	0	0	0	0	–	4	0.008
CB	–	–	–	0	0	7	0	0	0	0	1	–	8	0.016
BT	–	–	–	0	1	0	1	0	0	0	10	–	12	0.023
NS	–	–	–	2	5	0	0	0	0	0	0	–	7	0.014
SS	–	–	–	1	17	0	0	0	0	0	0	–	18	0.035
CC	–	–	–	0	0	0	0	0	1	0	0	–	1	0.002
QL	–	–	–	0	0	1	0	0	0	0	0	–	1	0.002
NP	–	–	–	1	0	0	0	0	0	0	3	–	4	0.008
GS	–	–	–	2	0	0	0	0	2	12	104	–	120	0.234
XC	–	–	–	0	0	0	0	1	0	0	0	–	1	0.002
PS	–	–	–	0	0	0	1	0	0	0	0	–	1	0.002
BG	–	–	–	0	0	1	0	0	1	0	0	–	2	0.004
LB	–	–	–	0	0	1	0	0	0	0	0	–	1	0.002
SH	–	–	–	0	0	0	0	0	1	1	32	–	34	0.066
TOTALS	–	–	–	151	5909	10051	4321	1538	6739	22094	449	–	51252	

Table 19. continued.

1976

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	–	7	–	122	873	2881	4857	343	250	3	1	–	9337	7.032
AL	–	0	–	5	1905	1654	824	42919	74554	49	0	–	121910	91.818
SM	–	0	–	300	13	0	0	5	7	0	1	–	326	0.246
YP	–	0	–	0	0	16	750	16	13	0	0	–	795	0.599
TP	–	2	–	9	9	1	32	38	25	0	1	–	117	0.088
JD	–	0	–	0	0	3	0	4	1	0	0	–	8	0.006
NS	–	1	–	1	13	2	3	0	0	1	1	–	22	0.017
LS	–	0	–	1	0	0	0	0	0	0	0	–	1	0.001
LT	–	0	–	1	0	0	0	0	0	9	0	–	10	0.008
CH	–	1	–	0	0	9	0	0	0	0	0	–	10	0.008
BT	–	1	–	2	2	1	1	0	4	2	0	–	13	0.010
LD	–	0	–	1	3	2	1	5	10	1	4	–	27	0.020
CP	–	0	–	0	10	2	0	0	0	0	0	–	12	0.009
CM	–	0	–	0	8	10	1	0	1	1	0	–	21	0.016
PT	–	4	–	1	31	17	8	0	16	3	0	–	80	0.060
MS	–	0	–	0	1	1	0	0	0	0	0	–	2	0.002
SS	–	0	–	17	0	1	0	2	1	0	0	–	21	0.016
CC	–	0	–	0	1	0	1	0	0	0	0	–	2	0.002
QL	–	0	–	0	0	1	1	0	0	0	0	–	2	0.002
SE	–	0	–	0	0	0	0	1	0	0	0	–	1	0.001
GS	–	1	–	0	0	1	0	0	2	1	0	–	5	0.004
XC	–	0	–	0	1	0	2	0	0	0	0	–	3	0.002
EG	–	0	–	0	0	0	1	0	0	0	1	–	2	0.002
LB	–	0	–	0	0	0	0	1	0	0	0	–	1	0.001
GL	–	1	–	0	0	0	0	0	0	1	0	–	2	0.002
SH	–	0	–	1	0	0	0	7	0	31	0	–	39	0.029
MA	–	0	–	0	0	0	3	0	0	0	0	–	3	0.002
SV	–	0	–	1	0	0	0	0	0	0	0	–	1	0.001
TOTALS	–	18	–	462	2870	4602	6485	43341	74884	102	9	–	132773	

Table 19. continued.

1977

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
SP	–	–	–	11	1310	960	2235	8453	239	274	356	–	13838	22.049
AL	–	–	–	6	298	573	2590	20022	11451	51	11812	–	46803	74.573
SM	–	–	–	3	2	1	0	0	15	20	62	–	103	0.164
YP	–	–	–	0	1	1	1004	25	3	0	285	–	1319	2.102
TP	–	–	–	0	7	99	4	9	91	3	1	–	214	0.341
JD	–	–	–	0	4	0	5	35	1	0	1	–	46	0.073
WS	–	–	–	3	5	14	16	0	2	2	2	–	44	0.070
LS	–	–	–	0	0	0	0	1	0	0	0	–	1	0.002
LT	–	–	–	0	0	0	0	0	0	0	1	–	1	0.002
CH	–	–	–	0	0	42	0	0	0	0	0	–	42	0.067
BT	–	–	–	2	1	0	0	0	6	0	0	–	9	0.014
ES	–	–	–	0	0	2	23	0	0	3	0	–	28	0.043
LD	–	–	–	1	0	3	1	0	9	37	8	–	59	0.094
CP	–	–	–	3	27	0	4	4	0	1	2	–	41	0.065
CM	–	–	–	1	83	2	0	0	0	0	3	–	89	0.142
BT	–	–	–	9	3	8	3	0	1	0	6	–	30	0.048
SS	–	–	–	1	0	0	0	0	0	0	3	–	4	0.006
CC	–	–	–	0	0	0	0	1	0	0	0	–	1	0.002
QL	–	–	–	0	0	0	0	1	1	0	0	–	2	0.003
GS	–	–	–	0	0	0	1	0	0	40	8	–	49	0.078
XC	–	–	–	0	0	1	0	0	5	0	3	–	9	0.014
BG	–	–	–	0	0	1	0	0	1	0	0	–	2	0.003
RB	–	–	–	0	0	0	0	0	0	1	0	–	1	0.002
GL	–	–	–	0	0	0	0	0	1	0	0	–	1	0.002
FD	–	–	–	0	0	0	0	0	0	1	0	–	1	0.002
SH	–	–	–	1	0	2	13	5	1	0	1	–	23	0.037
BS	–	–	–	0	0	0	0	1	0	0	0	–	1	0.002
TOTALS	–	–	–	41	1741	1709	5899	28557	11827	433	12554	–	62761	

Table 19. continued.

1978

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
ND	—	—	—	0	0	1	0	0	0	0	0	—	1	0.002
SP	—	—	—	33	24	5438	15905	5830	1246	2	12	—	28490	50.355
AL	—	—	—	0	0	3717	90	1630	2553	18839	6	—	26835	47.430
SM	—	—	—	0	81	12	283	0	0	2	1	—	379	0.670
YP	—	—	—	1	0	0	263	7	20	0	1	—	292	0.516
TP	—	—	—	1	3	39	32	0	5	0	0	—	80	0.141
JD	—	—	—	0	2	1	0	1	1	0	0	—	5	0.009
WS	—	—	—	1	2	1	14	1	0	0	2	—	21	0.037
LS	—	—	—	0	0	0	0	1	0	0	0	—	1	0.002
LT	—	—	—	1	0	0	0	0	0	1	0	—	2	0.004
CH	—	—	—	0	0	55	0	0	0	0	0	—	55	0.097
RT	—	—	—	3	1	2	2	4	1	4	1	—	18	0.032
ES	—	—	—	0	0	0	0	3	0	7	0	—	10	0.018
LD	—	—	—	3	3	2	0	0	5	8	5	—	26	0.046
CP	—	—	—	0	2	0	1	0	2	0	0	—	5	0.009
CM	—	—	—	2	15	220	11	0	0	0	0	—	248	0.438
BT	—	—	—	58	7	9	7	0	0	1	0	—	82	0.145
NS	—	—	—	0	1	0	0	0	0	0	0	—	1	0.002
CC	—	—	—	0	0	0	1	0	0	0	0	—	1	0.002
GS	—	—	—	0	0	0	0	0	0	0	1	—	1	0.002
YC	—	—	—	0	0	3	3	0	0	0	0	—	6	0.011
BR	—	—	—	1	0	0	0	0	0	0	0	—	1	0.002
PP	—	—	—	0	0	0	0	0	1	0	0	—	1	0.002
GL	—	—	—	0	0	0	2	0	0	0	0	—	2	0.004
SP	—	—	—	0	0	0	0	0	2	0	0	—	2	0.004
SH	—	—	—	0	0	0	0	0	12	0	0	—	12	0.021
SV	—	—	—	0	0	0	0	0	1	0	0	—	1	0.002
TOTALS	—	—	—	104	141	9500	16614	7477	3849	18864	29.	—	56578	

Table 19. continued.

1979

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	—	—	—	108	410	885	8271	163	7874	422	—	—	18133	11.617
AL	—	—	—	2	1	121	108	16381	65916	52792	—	—	135321	86.691
SM	—	—	—	26	236	1	0	3	3	67	—	—	336	0.215
YP	—	—	—	1	0	0	428	29	687	0	—	—	1145	0.734
TP	—	—	—	22	4	21	26	4	2	1	—	—	80	0.051
JD	—	—	—	0	0	0	21	0	37	0	—	—	58	0.037
WS	—	—	—	38	6	1	3	5	0	1	—	—	54	0.035
LS	—	—	—	0	1	1	0	0	1	0	—	—	3	0.002
LT	—	—	—	0	0	0	0	0	0	10	—	—	10	0.006
CH	—	—	—	122	77	58	1	0	0	0	—	—	258	0.165
RT	—	—	—	2	1	1	0	1	1	2	—	—	8	0.005
ES	—	—	—	7	1	3	0	0	0	0	—	—	11	0.007
LD	—	—	—	3	0	0	0	0	1	2	—	—	6	0.004
CP	—	—	—	10	2	3	2	0	0	0	—	—	17	0.011
CM	—	—	—	28	26	0	0	0	0	0	—	—	54	0.035
BT	—	—	—	5	4	3	8	0	0	3	—	—	23	0.015
NS	—	—	—	0	0	1	0	0	0	0	—	—	1	0.001
SS	—	—	—	27	0	0	0	0	0	4	—	—	31	0.020
LC	—	—	—	1	0	0	0	0	0	0	—	—	1	0.001
NP	—	—	—	0	0	0	0	0	2	0	—	—	2	0.001
GN	—	—	—	0	0	1	0	0	0	0	—	—	1	0.001
GS	—	—	—	3	0	1	0	0	0	10	—	—	14	0.009
XC	—	—	—	0	0	0	0	0	482	25	—	—	507	0.325
BC	—	—	—	0	1	0	0	0	0	0	—	—	1	0.001
BG	—	—	—	0	0	1	0	0	0	0	—	—	1	0.001
BR	—	—	—	0	0	1	0	2	0	0	—	—	3	0.002
PP	—	—	—	0	0	1	0	1	0	0	—	—	2	0.001
SR	—	—	—	1	0	0	0	0	0	0	—	—	1	0.001
XX	—	—	—	0	0	0	6	0	0	0	—	—	6	0.004
SF	—	—	—	0	0	0	0	2	0	1	—	—	3	0.002
SH	—	—	—	0	0	0	0	0	0	3	—	—	3	0.002
BM	—	—	—	0	1	0	0	0	0	0	—	—	1	0.001
TOTALS	—	—	—	406	771	1104	8874	16591	75006	53343	—	—	156095	

Table 20. Number of fish caught in standard series gill nets from 1973-1979 at the Cook Plant study areas, southeastern Lake Michigan.

1973

SPECIES[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
SP	—	12	402	914	799	848	25	300	104	137	95	1	3638	20.834
AL	—	0	1869	2682	1091	4198	854	263	79	68	0	0	11104	63.589
SM	—	1	118	180	7	4	1	121	60	8	12	0	512	2.932
YP	—	6	35	10	15	527	338	422	34	33	22	0	1442	8.258
TP	—	0	2	0	7	62	114	19	5	31	20	0	260	1.489
WS	—	1	2	6	10	11	13	25	38	25	0	0	133	0.762
LS	—	1	4	9	13	11	24	1	1	1	0	0	65	0.372
LT	—	0	2	1	1	0	5	13	49	27	54	0	158	0.905
CH	—	0	0	2	2	0	1	2	3	2	0	0	12	0.069
RT	—	0	0	1	2	0	0	0	0	0	0	0	3	0.017
CP	—	0	0	0	0	0	0	1	0	6	0	0	7	0.040
NS	—	0	0	1	0	0	0	0	0	0	0	0	1	0.006
CM	—	0	5	0	9	1	0	0	3	2	0	0	20	0.115
BT	—	0	4	1	2	0	0	2	0	1	0	0	10	0.057
CC	—	0	0	0	0	0	0	0	0	2	4	0	6	0.034
NP	—	0	0	0	0	0	0	0	8	7	8	0	23	0.132
XC	—	0	0	0	1	12	33	14	1	1	0	0	62	0.355
BR	—	0	0	4	0	1	0	0	0	0	0	0	5	0.029
RB	—	0	0	0	0	1	0	0	0	0	0	0	1	0.006
TOTALS	—	21	2443	3811	1959	5676	1409	1189	385	352	216	1	17462	

1974

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
SP	1	—	98	162	700	1335	161	39	76	77	17	22	2688	19.022
AL	0	—	279	891	1800	2782	2987	351	174	160	1	0	9425	66.697
SM	0	—	18	169	17	0	10	20	3	59	0	5	301	2.130
YP	1	—	14	15	7	28	50	315	359	2	56	16	863	6.107
TP	0	—	0	1	21	2	140	17	5	50	3	2	242	1.713
WS	2	—	1	3	15	18	25	10	13	13	5	8	113	0.800
LS	1	—	1	4	26	11	38	1	3	1	6	2	94	0.665
LT	0	—	0	0	16	9	0	0	0	12	83	0	120	0.849
CH	0	—	0	1	1	1	0	3	13	0	3	1	23	0.163
RT	0	—	1	0	0	0	0	0	0	0	0	0	1	0.007
CP	0	—	0	0	0	0	0	7	4	2	0	0	13	0.092
LH	0	—	0	0	0	0	0	0	0	0	0	1	1	0.007
CM	0	—	8	4	40	0	0	25	0	0	25	0	103	0.729
BT	0	—	1	2	5	1	4	5	2	0	2	0	22	0.156
SS	0	—	0	1	0	0	0	0	0	0	0	0	1	0.007
CC	0	—	0	0	0	0	0	0	4	0	0	0	4	0.028
NP	1	—	2	3	1	0	0	0	0	5	0	0	12	0.085
GS	0	—	0	0	1	0	0	1	20	8	0	0	30	0.212
XC	0	—	0	0	0	0	59	0	1	0	0	0	60	0.425
LW	0	—	0	0	0	0	0	1	0	0	0	0	1	0.007
BR	0	—	1	1	1	1	0	0	0	0	0	10	14	0.099
TOTALS	6	—	424	1257	2651	4188	3474	796	678	389	201	67	14131	

[1] See Table 10 for definition of species abbreviations.

Table 20. continued.

1975

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	1	–	12	12	133	545	212	205	154	108	21	34	1437	22.286
AL	0	–	797	167	310	867	511	201	52	44	50	10	3009	46.666
SM	3	–	21	12	13	6	0	2	0	7	0	1	65	1.008
YP	7	–	29	8	2	138	361	366	255	132	87	3	1388	21.526
TP	0	–	0	1	12	17	0	7	20	15	2	0	74	1.148
WS	1	–	7	1	4	37	8	0	17	1	1	4	81	1.256
LS	1	–	50	3	8	20	0	0	1	2	3	0	88	1.365
LT	0	–	1	2	5	18	0	0	0	4	47	1	78	1.210
CH	0	–	0	0	0	0	0	3	2	19	7	1	32	0.496
RT	0	–	1	0	0	0	0	0	1	0	0	1	3	0.047
CP	0	–	0	0	0	0	9	13	17	2	2	0	43	0.667
LH	0	–	0	1	0	0	0	0	0	0	0	0	1	0.016
CM	0	–	6	40	1	5	0	2	0	0	1	0	55	0.853
BT	0	–	7	2	0	1	0	1	1	1	0	1	14	0.217
CC	0	–	0	0	0	0	1	1	4	1	1	0	8	0.124
LG	0	–	0	0	1	0	0	0	0	0	0	0	1	0.016
NP	1	–	0	0	0	1	0	0	0	0	0	0	2	0.031
GS	0	–	0	0	0	0	0	28	15	1	2	0	46	0.713
XC	0	–	0	0	0	1	0	1	0	0	0	0	2	0.031
LW	0	–	0	1	0	1	0	0	0	0	0	0	2	0.031
BB	1	–	0	0	0	0	0	0	0	0	0	13	14	0.217
SR	0	–	0	0	0	0	0	0	4	0	0	0	4	0.062
MA	0	–	0	0	0	0	0	0	0	1	0	0	1	0.016
TOTALS	15	–	931	250	489	1657	1102	830	543	338	224	69	6448	

1976

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	–	40	49	342	259	102	384	103	139	31	–	–	1449	14.957
AL	–	0	204	1267	1136	2078	1647	89	76	12	–	–	6509	67.186
SM	–	1	21	16	17	143	1	0	1	1	–	–	201	2.075
YP	–	13	5	21	21	244	406	216	167	4	–	–	1097	11.323
TP	–	0	1	1	3	52	26	4	57	2	–	–	146	1.507
WS	–	3	0	5	11	3	14	5	17	7	–	–	65	0.671
LS	–	20	3	5	4	3	2	0	0	0	–	–	37	0.382
LT	–	0	3	4	7	7	0	0	0	2	–	–	23	0.237
CH	–	0	0	0	0	0	1	0	3	0	–	–	4	0.041
RT	–	1	0	0	0	0	0	0	0	0	–	–	1	0.010
CP	–	0	0	0	0	0	1	14	3	0	–	–	18	0.186
CM	–	0	0	0	19	6	0	0	0	0	–	–	25	0.258
BT	–	2	0	1	1	1	2	1	1	1	–	–	10	0.103
CC	–	0	0	0	0	0	0	2	8	0	–	–	10	0.103
IG	–	0	0	0	1	0	0	0	0	0	–	–	1	0.010
GS	–	0	0	0	0	0	1	20	18	6	–	–	45	0.464
XC	–	0	0	0	0	25	14	0	0	0	–	–	39	0.403
LW	–	0	1	2	1	1	0	0	0	0	–	–	5	0.052
RR	–	1	0	1	0	0	1	0	0	0	–	–	3	0.031
TOTALS	–	81	287	1665	1480	2665	2500	454	490	66	–	–	9688	

Table 20. continued.

1977

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	—	—	54	3	684	813	60	208	119	133	17	0	2090	32.519
AL	—	—	66	26	608	785	783	92	38	172	4	0	2574	40.050
SM	—	—	0	35	0	0	6	1	6	17	0	0	65	1.011
YP	—	—	11	14	11	66	283	408	134	18	11	1	957	14.890
TP	—	—	1	0	15	13	54	3	6	5	0	0	97	1.509
RS	—	—	0	5	21	4	50	10	21	5	3	1	120	1.867
LS	—	—	4	5	3	0	34	0	5	6	23	0	80	1.245
LT	—	—	4	10	6	6	6	0	9	27	118	0	186	2.894
CH	—	—	11	21	0	0	0	0	0	1	0	0	33	0.513
RT	—	—	0	0	0	0	1	0	0	0	2	0	3	0.047
CP	—	—	0	2	3	0	1	18	20	2	5	0	51	0.794
CR	—	—	3	0	0	0	0	0	1	2	1	0	7	0.109
BT	—	—	5	0	5	5	2	0	4	1	3	6	31	0.482
CC	—	—	0	0	0	0	0	4	2	2	0	0	8	0.124
QL	—	—	0	0	0	0	0	0	1	0	0	0	1	0.016
LG	—	—	0	0	0	0	1	1	0	0	0	0	2	0.031
GS	—	—	0	0	0	0	0	15	39	1	0	0	55	0.856
XC	—	—	0	0	0	20	29	0	0	0	0	0	49	0.762
BR	—	—	1	0	0	0	0	0	0	0	0	6	7	0.109
GB	—	—	0	0	0	0	0	6	3	0	0	0	9	0.140
SR	—	—	0	0	0	0	0	0	0	0	0	1	1	0.016
MA	—	—	0	0	0	0	0	0	1	0	0	0	1	0.016
TOTALS	—	—	160	120	1356	1712	1310	766	409	392	187	15	6427	

1978

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP				61	244	25	5	204	126	148	24		837	16.660
AL				4	294	1152	537	138	78	25	1		2229	44.367
SM				19	47	27	29	109	48	5	1		284	5.653
YP				28	4	126	11	197	318	0	36		740	14.729
TP				1	23	26	5	10	19	20	2		106	2.110
RS				0	4	5	1	8	36	21	9		84	1.672
LS				14	2	0	1	6	6	7	24		60	1.194
LT				8	34	31	17	10	89	51	39		279	5.553
CH				7	6	0	4	2	7	22	4		52	1.035
RT				1	0	0	0	1	0	1	0		3	0.060
CP				0	2	0	0	2	3	16	5		28	0.557
LN				1	0	0	0	0	0	0	0		1	0.020
CR				7	8	4	11	17	4	0	0		51	1.015
BT				4	5	0	3	11	30	16	10		79	1.572
CC				0	0	0	0	0	1	2	1		4	0.080
QL				0	0	0	0	0	0	2	0		2	0.040
LG				0	0	0	0	0	0	0	1		1	0.020
NP				0	0	0	0	0	0	2	0		2	0.040
GS				0	0	0	0	0	12	88	7		107	2.130
XC				0	1	8	9	42	2	0	0		62	1.234
LW				0	1	3	0	2	2	0	1		9	0.179
BR				0	1	0	0	0	0	1	1		3	0.060
MA				0	0	0	0	0	0	1	0		1	0.020
TOTALS				155	676	1407	653	758	781	428	166	—	5024	

Table 20.continued.

1979

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	—	—	—	74	210	852	1182	181	251	195	—	—	2945	38.123
AL	—	—	—	243	50	1509	844	190	17	0	—	—	2853	36.932
SM	—	—	—	98	48	2	0	5	3	18	—	—	174	2.252
YP	—	—	—	11	18	28	42	389	500	7	—	—	995	12.880
TP	—	—	—	0	4	21	25	34	12	37	—	—	133	1.722
WS	—	—	—	2	12	26	0	34	29	16	—	—	119	1.540
LS	—	—	—	2	33	16	3	4	3	7	—	—	68	0.880
LT	—	—	—	15	3	2	0	2	0	45	—	—	67	0.867
CH	—	—	—	28	2	1	0	1	7	0	—	—	39	0.505
RT	—	—	—	1	0	0	1	0	0	0	—	—	2	0.026
CP	—	—	—	1	27	4	0	11	3	7	—	—	53	0.686
CM	—	—	—	29	0	0	0	0	0	0	—	—	29	0.375
BT	—	—	—	14	6	6	3	0	1	1	—	—	31	0.401
CC	—	—	—	1	0	0	0	3	3	1	—	—	8	0.104
NP	—	—	—	0	0	0	0	1	1	0	—	—	2	0.026
GS	—	—	—	0	0	0	0	6	124	6	—	—	136	1.761
XC	—	—	—	0	1	0	46	1	0	0	—	—	48	0.621
LW	—	—	—	3	1	1	0	0	0	0	—	—	5	0.065
GR	—	—	—	0	0	0	0	0	3	0	—	—	3	0.039
RW	—	—	—	1	0	0	0	0	0	1	—	—	2	0.026
SR	—	—	—	0	0	0	1	0	0	2	—	—	3	0.039
MA	—	—	—	0	0	0	0	1	6	3	—	—	10	0.129
TOTALS	—	—	—	523	415	2468	2147	863	963	346	—	—	7725	

Table 21. Analysis of variance summary for log (catch + 1) of alewives. Fish were trawled from April through October 1973-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df#	Adjusted mean square†	F-statistic	Attained significance level
Year	6	11.5851	77.1353	0.0000**
Month	6	5.5757	37.1238	0.0000**
Area	1	0.4581	3.0506	0.0815
Depth	1	5.4129	36.0396	0.0000**
Time	1	5.7613	38.3594	0.0000**
Y x M	36	4.6699	31.0929	0.0000**
Y x A	6	1.2370	8.2361	0.0000**
M x A	6	0.4190	2.7895	0.0114
Y x D	6	0.4119	2.7425	0.0127
M x D	6	0.5905	3.9314	0.0008**
A x D	1	0.4085	2.7201	0.0999
Y x T	6	0.6606	4.3980	0.0003**
M x T	6	7.3088	48.6627	0.0000**
A x T	1	0.1051	0.6995	0.4035
D x T	1	0.7573	5.0420	0.0253
Y x M x A	36	0.5093	3.3907	0.0000**
Y x M x D	36	0.2657	1.7689	0.0051*
Y x A x D	6	0.1071	0.7131	0.6392
M x A x D	6	0.8071	5.3736	0.0000**
Y x M x T	36	2.6275	17.4944	0.0000**
Y x A x T	6	1.1779	7.8423	0.0000**
M x A x T	6	0.8517	5.6707	0.0000**
Y x D x T	6	0.2223	1.4799	0.1837
M x D x T	6	0.2080	1.3846	0.2195
A x D x T	1	0.4478	2.9814	0.0850
Y x M x A x D	36	0.3385	2.2540	0.0001**
Y x M x A x T	36	0.3996	2.6608	0.0000**
Y x M x D x T	36	0.3938	2.6220	0.0000**
Y x A x D x T	6	0.1084	0.7216	0.6325
M x A x D x T	6	0.3726	2.4808	0.0229
Y x M x A x D x T	36	0.2134	1.4205	0.0592
Within cell error	390	0.1502		

One degree of freedom was subtracted from the error term to correct for a missing observation where the cell mean was substituted.
† Mean squares were multiplied by harmonic mean cell size/maximum cell size ($n_h/n = 0.9966$) to correct for one missing observation where cell mean was substituted.
** Highly significant ($P < 0.001$).
* Significant ($P < 0.01$).

Table 22. Summary of analysis of variance for $\log_{10}$ (catch + 1) alewives caught in gill nets at Cook Plant study areas, southeastern Lake Michigan, from April through September, 1973-79.

Source of variation	df	Mean square	F-statistic	Attained significance level[1]
Year	6	5.4694	46.4513	.0000**
Month	5	13.8400	117.5430	.0000**
Area	1	.1428	1.2125	.2796
Depth	1	.2307	1.9592	.1785
Time	1	12.0963	102.7339	.0000**
Y x M	30	1.2335	10.4758	.0000**
Y x A	6	.2167	1.8402	.1247
M x A	5	.3615	3.0704	.0235
Y x D	6	.0841	.7142	.6410
M x D	5	.8482	7.2036	.0002**
A x D	1	.4451	3.7799	.0613
Y x T	6	1.5615	13.2615	.0000**
M x T	5	.4266	3.6230	.0111
A x T	1	.0653	.5546	.4622
D x T	1	.7788	6.6147	.0153
Y x M x A	30	.3342	2.8384	.0028*
Y x M x D	30	.4103	3.4843	.0005**
Y x A x D	6	.1051	.8924	.5129
M x A x D	5	.0124	.1057	.9902
Y x M x T	30	.4534	3.8511	.0002**
Y x A x T	6	.5121	4.3496	.0028*
M x A x T	5	.1274	1.0824	.3900
Y x D x T	6	.1205	1.0237	.4292
M x D x T	5	.0634	.5387	.7453
A x D x T	1	.1583	1.3440	.2555
Y x M x A x D	30	.1599	1.3588	.2030
Y x M x A x T	30	.1146	.9735	.5289
Y x M x D x T	30	.2973	2.5251	.0067*
Y x A x D x T	6	.0806	.6847	.6633
M x A x D x T	5	.1022	.8682	.5139
Y x M x A x D x T[2]	30	.1177		

[1] denotes significance (P < .01). ** denotes significance (P < .001).

[2] The Y x M x A x D x T interaction is assumed to be zero and its mean square is treated as the within cell error mean square.

Table 23. Summary of analysis of variance for $\log_{10}$ (catch + 1) alewives caught in seines at Cook Plant study areas, southeastern Lake Michigan, from April through October, 1973-79.

Source of variation	df[1]	Adjusted mean square[2]	F-statistic	Attained significance level[3]
Year	6	2.3869	16.1987	.0000**
Month	6	32.8084	222.6500	.0000**
Station	2	.3897	2.6447	.0727
Time of day	1	10.9881	74.5654	.0000**
Y x M	36	6.4367	43.6815	.0000**
Y x S	12	.8334	5.6557	.0000**
M x S	12	.4757	3.2285	.0002**
Y x T	6	1.8043	12.2448	.0000**
M x T	6	22.2994	151.3321	.0000**
S x T	2	.1015	0.6886	.3114
Y x M x S	72	.8461	5.7417	.0000**
Y x M x T	36	3.4841	23.6444	.0000**
Y x S x T	12	.9091	6.1697	.0000**
M x S x T	12	.2562	1.7386	.0583
Y x M x S x T	72	.5129	3.4806	.0000**
Within cell error	293	.1474		

[1]One degree of freedom was subtracted from the error term to correct for 1 missing observation where the cell mean was substituted.

[2]Mean squares were multiplied by harmonic cell size/maximum cell size ($n_h/N = .9966$) to correct for 1 missing observation where the cell mean was substituted.

[3]* denotes significance ($P < .01$). ** denotes significance ($P < .001$).

Table 24. Analysis of variance summary for log (catch + 1) of spottail shiners. Fish were trawled from April through October, 1973-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df#	Adjusted mean square†	F-statistic	Attained significance level
Year	6	2.4113	46.3651	0.0000**
Month	6	9.1380	175.7076	0.0000**
Area	1	0.0355	0.6819	0.4094
Depth	1	8.1633	156.9667	0.0000**
Time	1	87.1967	1676.6445	0.0000**
Y x M	36	3.1161	59.9176	0.0000**
Y x A	6	0.1258	2.4194	0.0262
M x A	6	0.8105	15.5853	0.0000**
Y x D	6	0.3899	7.4967	0.0000**
M x D	6	0.6492	12.4822	0.0000**
A x D	1	0.1259	2.4207	0.1205
Y x T	6	1.1873	22.8289	0.0000**
M x T	6	3.6983	71.1120	0.0000**
A x T	1	2.0953	40.2893	0.0000**
D x T	1	5.0876	97.8251	0.0000**
Y x M x A	36	0.3747	7.2046	0.0000**
Y x M x D	36	0.3590	6.9024	0.0000**
Y x A x D	6	0.1480	2.8458	0.0101
M x A x D	6	0.1261	2.4142	0.0159
Y x M x T	36	1.3747	26.4324	0.0000**
Y x A x T	6	0.4646	8.9339	0.0000**
M x A x T	6	0.6577	12.6466	0.0000**
Y x D x T	6	0.4759	9.1505	0.0000**
M x D x T	6	0.4074	7.8338	0.0000**
A x D x T	1	0.2632	5.0616	0.0250
Y x M x A x D	36	0.1571	3.0217	0.0000**
Y x M x A x T	36	0.3288	6.3227	0.0000**
Y x M x D x T	36	0.3328	6.3996	0.0000**
Y x A x D x T	6	0.2170	4.1729	0.0004**
M x A x D x T	6	0.2780	5.3458	0.0000**
Y x M x A x D x T	36	0.1330	2.5566	0.0000**
Within cell error	390	0.0520		

One degree of freedom was subtracted from the error term to correct for a missing observation where the cell mean was substituted.

† Mean squares were multiplied by harmonic mean cell size/maximum cell size (nh/n = 0.9966) to correct for one missing observation where cell mean was substituted.

** Highly significant ($P < 0.001$).

Table 25. Summary of analysis of variance for $\log_{10}$(catch + 1) spottail shiners caught in gill nets at Cook Plant study areas, southeastern Lake Michigan, from April through September, 1973-79.

Source of variation	df	Mean square	F-statistic	Attained significance level[1]
Year	6	2.8916	30.1998	.0000**
Month	5	2.3373	24.4105	.0000**
Area	1	.1493	1.5598	.2214
Depth	1	1.2296	13.5734	.0090*
Time	1	35.1110	366.6953	.0000**
Y x M	30	1.3194	13.7792	.0000**
Y x A	6	.0805	.8410	.5439
M x A	5	.3731	3.8971	.0077*
Y x D	6	.1003	1.0476	.4150
M x D	5	.3353	3.5019	.0130
A X D	1	.1351	1.4105	.2443
Y x T	6	.6163	6.4363	.0002**
M x T	5	.6059	6.3276	.0004**
A x T	1	.7894	8.2442	.0074*
D x T	1	4.6684	48.7571	.0000**
Y x M x A	30	.4356	4.5495	.0000**
Y x M x D	30	.3241	3.3853	.0006**
Y x A x D	6	.0284	.2964	.9338
M x A x D	5	.1500	1.5667	.1996
Y x M x T	30	.7437	7.7675	.0000**
Y x A x T	6	.3725	3.8907	.0054*
M x A x T	5	.1444	1.5080	.2169
Y x D x T	6	.0615	.6423	.6957
M x D x T	5	.1924	2.0094	.1059
A x D x T	1	.0129	.1344	.7165
Y x M x A x D	30	.0740	.7733	.7572
Y x M x A x T	30	.2087	2.1798	.0183
Y x M x D x T	30	.1795	1.8746	.0452
Y x A x D x T	6	.0923	.9640	.4660
M x A x D x T	5	.1533	1.6008	.1902
Y x M x A x D x T[2]	30	.0957		

[1]* denotes significance ($P < .01$). ** denotes significance ($P < .001$).

[2]The Y x M x A x D x T interaction is assumed to be zero and its mean square is treated as the within cell error mean square.

Table 26. Summary of analysis of variance for $\log_{10}$ (catch + 1) spottail shiners caught in seines at Cook Plant study areas, southeastern Lake Michigan from April through October 1973-79.

Source of variance	df [1]	Adjusted mean square [2]	F-statistic	Attained significance level [3]
Year	6	.3835	1.7443	.1105
Month	6	30.0643	136.7366	.0000**
Station	2	.0220	.1002	.9047
Time of day	1	.1850	.8414	.3598
Y x M	36	2.8204	12.8277	.0000**
Y x S	12	.4020	1.8284	.0433
M x S	12	.9778	4.4468	.0000**
Y x T	6	1.3858	6.3027	.0000**
M x T	6	3.5737	16.2535	.0000**
S x T	2	.1764	.8026	.4492
Y x M x S	72	.4130	1.8785	.0001**
Y x M x T	36	1.9295	8.7758	.0000**
Y x S x T	12	.3136	1.4263	.1528
M x S x T	12	.6746	3.0681	.0004**
Y x M x S x T	72	.4499	2.0463	.0000**
Within cell error	293	.2199		

[1] One degree of freedom was subtracted from the error term to correct for 1 missing observation where the cell mean was substituted.

[2] Mean squares were multiplied by harmonic cell size/maximum cell size (n_h/N = .9966) to correct for 1 missing observation where the cell mean was substituted.

[3] * denotes significance ($P < .01$). ** denotes significance ($P < .001$).

Table 27. Summary of analysis of variance for $\log_{10}$ (catch + 1) rainbow smelt caught in seines at Cook Plant study areas, southeastern Lake Michigan, during April and May 1973-79.

Source of variance	df	Mean square	F-statistic	Attained significance level[1]
Year	6	2.6953	32.8359	.0000**
Month	1	.8797	10.7175	.0015*
Station	2	.1707	2.0795	.1314
Time	1	13.5623	165.2242	.0000**
Y x M	6	1.4091	17.1663	.0000**
Y x S	12	.2724	3.3180	.0006**
M x S	2	.0719	.8760	.4202
Y x T	6	.6385	7.7791	.0000**
M x T	1	.3703	4.5118	.0366
S x T	2	.3199	3.8976	.0241
Y x M x S	12	.1867	2.2742	.0149
Y x M x T	6	1.4243	17.3522	.0000**
Y x S x T	12	.5396	6.5736	.0000**
M x S x T	2	.4561	5.5563	.0054*
Y x M x S x T	12	.5822	7.0928	.0000**
Within cell error	84	.0821		

1 * denotes significance ($P < .01$). ** denotes significance ($P < .001$).

Table 28. Analysis of variance summary for log (catch + 1) of rainbow smelt. Fish were trawled from April through October, 1973-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df#	Adjusted mean square†	F-statistic	Attained significance level
Year	6	12.4019	187.8836	0.0000**
Month	6	9.4430	143.0578	0.0000**
Area	1	1.6127	24.4320	0.0000**
Depth	1	9.4161	142.6495	0.0000**
Time	1	0.0173	0.2617	0.6092
Y x M	36	4.4678	67.6847	0.0000**
Y x A	6	0.1327	2.0108	0.0633
M x A	6	0.6410	9.7107	0.0000**
Y x D	6	1.1242	17.0306	0.0000**
M x D	6	0.1007	1.5250	0.1686
A x D	1	0.1418	2.1485	0.1435
Y x T	6	0.8548	12.9503	0.0000**
M x T	6	1.8350	27.7990	0.0000**
A x T	1	0.0054	0.0819	0.7749
D x T	1	2.8323	42.9081	0.0000**
Y x M x A	36	0.5014	7.5956	0.0000**
Y x M x D	36	0.6020	9.1195	0.0000**
Y x A x D	6	0.4058	6.1480	0.0000**
M x A x D	6	0.2882	4.3658	0.0003**
Y x M x T	36	1.2223	18.5177	0.0000**
Y x A x T	6	0.1275	1.9314	0.0747
M x A x T	6	0.2609	3.9530	0.0008**
Y x D x T	6	0.1269	1.9223	0.0761
M x D x T	6	0.4590	6.9532	0.0000**
A x D x T	1	0.0423	0.6403	0.4241
Y x M x A x D	36	0.1865	2.8259	0.0000**
Y x M x A x T	36	0.2076	3.1452	0.0000**
Y x M x D x T	36	0.2178	3.3000	0.0000**
Y x A x D x T	6	0.0676	1.0236	0.4094
M x A x D x T	6	0.0484	0.7332	0.6231
Y x M x A x D x T	36	0.2270	3.4394	0.0000**
Within cell error	390	0.0660		

One degree of freedom was subtracted from the error term to correct for a missing observation where the cell mean was substituted.
† Mean squares were multiplied by harmonic mean cell size/maximum cell size (nh/h = 0.9966) to correct for one missing observation where cell mean was substituted.
** Highly significant ($P < 0.001$).

Table 29. Analysis of variance summary for log (catch + 1) of yellow perch. Fish were trawled from June through October, 1973-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df#	Adjusted mean square†	F-statistic	Attained significance level
Year	6	4.0716	38.1754	0.0000**
Month	4	6.3990	59.9971	0.0000**
Area	1	0.1871	1.7541	0.1865
Depth	1	0.0991	0.9294	0.3359
Time	1	6.5437	61.3539	0.0000**
Y x M	24	2.0669	19.3790	0.0000**
Y x A	6	0.2649	2.4835	0.0234
M x A	4	0.1272	1.1927	0.3142
Y x D	6	0.3385	3.1735	0.0050*
M x D	4	1.0447	9.7953	0.0000**
A x D	1	0.0071	0.0669	0.7961
Y x T	6	0.3943	3.6973	0.0015*
M x T	4	0.9740	9.1323	0.0000**
A x T	1	0.1975	1.8516	0.1747
D x T	1	0.0003	0.0028	0.9580
Y x M x A	24	0.2108	1.9761	0.0051*
Y x M x D	24	0.3816	3.5775	0.0000**
Y x A x D	6	0.1027	0.9628	0.4507
M x A x D	4	0.0551	0.5169	0.7234
Y x M x T	24	0.6870	6.4411	0.0000**
Y x A x T	6	0.1686	1.5806	0.1527
M x A x T	4	0.1119	1.0492	0.3822
Y x D x T	6	0.2150	2.0157	0.0637
M x D x T	4	0.4164	3.9040	0.0042*
A x D x T	1	0.0643	0.6028	0.4382
Y x M x A x D	24	0.1671	1.5666	0.0475
Y x M x A x T	24	0.1757	1.6473	0.0315
Y x M x D x T	24	0.2693	2.5253	0.0002**
Y x A x D x T	6	0.1445	1.3544	0.2332
M x A x D x T	4	0.1350	1.2653	0.2838
Y x M x A x D x T	24	0.0968	0.9078	0.5915
Within cell error	279	0.1067		

One degree of freedom was subtracted from the error term to correct for a missing observation where the cell mean was substituted.

† Mean squares were multiplied by harmonic mean cell size/maximum cell size (nh/n = 0.9966) to correct for one missing observation where cell mean was substituted.

** Highly significant ($P < 0.001$).

* Significant ($P < 0.01$).

Table 30. Summary of analysis of variance for $\log_{10}$ (catch + 1) yellow perch caught in seines at Cook Plant study areas, southeastern Lake Michigan, from June through August, 1973-1979.

Source of variation	df [1]	Adjusted mean square [2]	F-statistic	Attained significance level [3]
Year	6	3.8216	36.5629	.0000**
Month	2	17.0149	162.7908	.0000**
Station	2	.1515	1.4492	.2387
Time	1	3.4290	32.8070	.0000**
Y x M	12	3.9480	37.7725	.0000**
Y x S	12	.2663	2.5475	.0048*
M x S	4	.1514	1.4486	.2220
Y x T	6	.3195	3.0564	.0080*
M x T	2	3.5987	34.4304	.0000**
S x T	2	.8180	7.8261	.0006**
Y x M x S	24	.2235	2.1384	.0037*
Y x M x T	12	.9249	8.8486	.0000**
Y x S x T	12	.2284	2.1854	.0161
M x S x T	4	.3306	3.1627	.0163
Y x M x S x T	24	.3156	3.0196	.0000**
Within cell error	125	.1045		

[1]One degree of freedom was subtracted from the error term to correct for 1 missing observation where the cell mean was substituted.

[2]Mean squares were multiplied by harmonic cell size/maximum cell size (n_h/N = .99921) to correct for 1 missing observation where the cell mean was substituted.

[3]* denotes significance ($P < .01$). ** denotes significance ($P < .001$).

Table 31. Summary of analysis of variance for $\log_{10}$ (catch + 1) yellow perch caught in gill nets at Cook Plant study areas, southeastern Lake Michigan, from June through September, 1973-79.

Source of variation	df	Mean square	F-statistic	Attained significance level[1]
Year	6	.9101	12.8644	.0000**
Month	3	2.0465	28.9273	.0000**
Area	1	.6639	9.3848	.0067*
Depth	1	.0136	.1923	.6662
Time	1	.2497	3.5300	.0766
Y x M	18	1.2956	18.3131	.0000**
Y x A	6	.0680	.9610	.4783
M x A	3	.0640	.9041	.4585
Y x D	6	.3406	4.8142	.0043*
M x D	3	1.3954	19.7240	.0000**
A x D	1	.0078	.1105	.7435
Y x T	6	.6912	9.7702	.0001**
M x T	3	.2870	4.0575	.0229
A x T	1	.0218	.3088	.5853
D x T	1	.9798	13.8509	.0016*
Y x M x A	18	.1755	2.4808	.0307
Y x M x D	18	.4054	5.7297	.0003**
Y x A x D	6	.0632	.8929	.5207
M x A x D	3	.0417	.5888	.6302
Y x M x T	18	.4194	5.9283	.0002**
Y x A x T	6	.0463	.6553	.6859
M x A x T	3	.1306	1.8463	.1750
Y x D x T	6	.0922	1.3026	.3058
M x D x T	3	.1538	2.1740	.1265
A x D x T	1	.0143	.2023	.6582
Y x M x A x D	18	.0579	.8188	.6620
Y x M x A x T	18	.1296	1.8330	.1041
Y x M x D x T	18	.1431	2.0228	.0723
Y x A x D x T	6	.1493	2.1099	.1027
M x A x D x T	3	.0820	1.1597	.3524
Y x M x A x D x T[2]	18	.0707		

[1]* denotes significance ($P \leq .01$). ** denotes significance ($P < .001$).

[2]The Y x M x A x D x T interaction is assumed to be zero and its mean square is treated as the within cell error mean square.

Table 32. Analysis of variance summary for log (catch + 1) of trout-perch. Fish were trawled from June through October, 1973-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df#	Adjusted mean square†	F-statistic	Attained significance level
Year	6	3.5194	61.1300	0.0000**
Month	4	5.2101	90.4972	0.0000**
Area	1	0.7336	12.7419	0.0004**
Depth	1	1.1150	19.3673	0.0000**
Time	1	71.0224	1233.6238	0.0000**
Y x M	24	1.6981	29.4947	0.0000**
Y x A	6	0.1431	2.4864	0.0233
M x A	4	0.2644	4.5924	0.0013*
Y x D	6	0.7412	12.8750	0.0000**
M x D	4	1.3613	23.6443	0.0000**
A x D	1	0.0637	1.1067	0.2937
Y x T	6	0.8853	15.3769	0.0000**
M x T	4	2.1448	37.2541	0.0000**
A x T	1	0.3090	5.3679	0.0212
D x T	1	1.0173	17.6706	0.0000**
Y x M x A	24	0.2424	4.2096	0.0000**
Y x M x D	24	0.3885	6.7479	0.0000**
Y x A x D	6	0.1975	3.4307	0.0028*
M x A x D	4	0.0771	1.3387	0.2557
Y x M x T	24	0.8733	15.1694	0.0000**
Y x A x T	6	0.2689	4.6703	0.0002**
M x A x T	4	0.9955	17.2915	0.0000**
Y x D x T	6	0.7060	12.2625	0.0000**
M x D x T	4	0.1809	3.1415	0.0150
A x D x T	1	0.3024	5.2519	0.0227
Y x M x A x D	24	0.1526	2.6511	0.0001**
Y x M x A x T	24	0.2082	3.6165	0.0000**
Y x M x D x T	24	0.2006	3.4851	0.0000**
Y x A x D x T	6	0.0861	1.4957	0.1795
M x A x D x T	4	0.1333	2.3147	0.0577
Y x M x A x D x T	24	0.0874	1.5176	0.0605
Within cell error	279	0.0576		

One degree of freedom was subtracted from the error term to correct for a missing observation where the cell mean was substituted.

† Mean squares were multiplied by harmonic mean cell size/maximum cell size (nh/n = 0.9966) to correct for one missing observation where cell mean was substituted.

** Highly significant (P < 0.001).

* Significant (P < 0.01).

Table 33. Summary of analysis of variance for $\log_{10}$ (catch + 1) trout-perch caught in night gill nets at Cook Plant study areas, southeastern Lake Michigan, from May through September, 1973-79.

Source of variation	df	Mean square	F-statistic	Attained significance limit[1]
Year	6	.0971	1.7728	.1475
Month	4	.6640	12.1278	.0000**
Area	1	.0824	1.5051	.2318
Depth	1	.4082	7.4560	.0117
Y x M	24	.5192	9.4833	.0000**
Y x A	6	.2074	3.7877	.0085*
M x A	4	.1422	2.5971	.0618
Y x D	6	.1093	1.9956	.1060
M x D	4	.2127	3.8853	.0143
A x D	1	.0160	.2927	.5935
Y x M x A	24	.0868	1.5870	.1325
Y x M x D	24	.1410	2.5763	.0121
Y x A x D	6	.1198	2.1888	.0797
M x A x D	4	.0564	1.0306	.4118
Y x M x A x D[2]	24	.0547		

[1]* denotes significance (P < .01). ** denotes significance (P < .001).

[2]The Y x M x A x D interaction is assumed to be zero, and its mean square is treated as the within cell error mean square.

Table 34. Summary of analysis of variance for $\log_{10}$ (catch + 1) trout-perch caught in night seines at Cook Plant study areas, southeastern Lake Michigan, from April through October, 1973-79.

Source of variation	df	Mean square	F-statistic	Attained significance level[1]
Year	6	.4836	14.2144	.0000**
Month	6	.5476	16.0967	.0000**
Station	2	.0552	1.6215	.2011
Y x M	36	.6328	18.6001	.0000**
Y x S	12	.5159	1.5165	.1241
M x S	12	.1301	3.8241	.0000**
Y x M x S	72	.0921	2.7099	.0000**
Within cell error	147	.0340		

[1]* denotes significance (P < .01). ** denotes siginificance (P < .001).

Table 35. Summary of all fish species impinged at the Donald C. Cook Nuclear Plant in Bridgman, Michigan, 1975. See Table 10 for definition of species abbreviations.

1975

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	86	261	345	931	749	701	117	44	318	1880	1980	2544	10008	4.429
AL	193	1	1620	48997	22811	82838	11230	1910	458	2533	1016	1732	175339	77.670
SM	8	11	75	873	1041	158	49	229	39	842	198	222	3745	1.659
YP	228	154	245	1195	45	313	399	492	414	4539	1816	2164	12004	5.318
TP	7	10	22	120	261	376	129	107	517	7327	5620	877	15373	6.810
JD	1	0	0	1	30	90	17	16	11	2	10	2	180	0.080
WS	0	0	1	2	3	7	1	0	1	0	0	1	16	0.007
LS	0	1	0	2	2	6	1	4	1	2	4	0	23	0.010
LT	4	0	1	39	4	7	5	0	1	0	17	23	101	0.045
CH	0	0	0	3	0	0	3	1	0	0	0	0	7	0.003
RT	0	1	0	0	0	1	0	1	0	0	0	1	4	0.002
ES	0	0	1	0	0	0	0	0	0	0	0	0	1	0.000
ID	0	0	0	1	0	0	0	0	0	1	4	0	6	0.003
CP	0	0	0	0	0	0	0	2	0	0	0	0	2	0.001
CM	0	0	0	3	4	0	0	0	0	0	0	1	8	0.004
NS	1	0	9	69	86	20	2	0	1	3	0	3	194	0.086
SS	116	120	340	2960	1494	1171	437	321	357	261	294	268	8139	3.600
CC	16	4	10	12	0	3	1	1	1	0	0	2	50	0.022
CL	0	1	0	0	0	0	0	0	0	0	1	0	2	0.001
SB	1	0	0	0	0	0	0	0	2	0	1	1	5	0.002
NP	0	0	0	1	1	0	0	1	0	0	0	0	3	0.001
GN	0	0	0	0	0	0	0	0	0	1	1	11	13	0.006
GS	1	13	10	33	0	0	0	0	0	4	64	153	278	0.123
XC	0	0	2	5	2	4	9	5	6	9	5	2	49	0.022
PS	0	0	0	0	0	1	0	0	0	2	4	16	23	0.010
MM	1	2	2	2	0	0	0	0	0	0	1	1	9	0.004
LW	0	0	0	1	0	0	0	0	0	0	0	0	1	0.000
DB	6	1	4	12	9	0	0	1	0	1	0	1	35	0.016
EC	0	0	0	0	0	0	0	0	0	1	2	8	11	0.005
BG	0	0	0	6	6	5	1	1	2	0	9	18	48	0.021
RB	2	1	3	5	4	6	1	4	2	4	2	3	37	0.016
IB	0	0	0	0	0	0	0	2	2	1	1	7	13	0.006
BB	0	0	0	2	0	0	0	0	0	0	1	0	3	0.001
FS	0	0	0	1	0	0	0	0	0	0	0	0	1	0.000
GL	0	0	1	3	0	0	0	0	0	0	1	0	5	0.002
XX	0	0	0	0	1	0	0	0	0	0	0	0	1	0.000
YB	0	1	0	0	0	0	0	0	0	0	3	1	5	0.002
GP	0	0	0	1	1	0	0	0	0	0	0	0	2	0.001
WC	1	0	0	0	0	0	0	0	0	1	0	4	6	0.003
CL	0	0	0	2	1	0	0	1	0	0	0	0	4	0.002
PR	0	0	0	1	0	0	0	0	0	0	0	0	1	0.000
ME	0	0	0	0	0	0	0	0	0	0	0	1	1	0.000
LP	0	0	0	0	1	0	0	0	0	0	0	0	1	0.000
UB	0	0	1	0	0	0	0	0	0	0	0	0	1	0.000
TOTALS	672	582	2692	55314	26556	85707	12402	3143	2133	17414	11055	8067	225737	

Table 36. Estimated numbers of impinged fish at the D.C. Cook Plant during 1976. See Table 10 for definition of species abbreviations.

1976

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	2330	1872	11683	889	708	188	426	275	1864	2953	1071	1833	26092	15.987
AL	186	3	16159	1946	7140	31489	28028	3844	3694	2360	4303	171	99323	60.857
SM	240	75	411	270	615	45	194	84	9	116	43	101	2203	1.350
YP	1663	111	461	146	300	330	2019	1541	6077	4127	99	1194	18068	11.071
TP	145	34	171	8	852	281	2073	536	4209	682	77	81	9149	5.606
JD	0	1	0	8	139	15	23	4	103	19	9	4	325	0.199
WS	4	2	0	0	0	8	4	0	9	0	0	0	27	0.017
LS	2	4	8	4	0	0	0	9	0	0	0	0	27	0.017
LT	8	10	62	0	26	11	0	0	0	0	4	16	137	0.084
CH	0	0	4	0	5	0	0	0	0	0	0	0	9	0.006
PT	0	1	0	0	5	0	4	0	0	0	0	4	14	0.009
LD	3	1	0	0	0	0	0	0	0	4	0	0	8	0.005
CP	4	0	4	0	0	0	0	0	0	0	0	0	8	0.005
CM	1	2	8	0	5	4	0	0	0	0	4	4	28	0.017
BT	0	0	0	4	5	0	0	0	0	0	4	8	21	0.013
NS	5	3	12	0	77	0	0	0	0	4	9	0	110	0.067
SS	252	106	1031	1001	1803	289	271	182	403	151	56	93	5638	3.455
CC	22	12	23	0	0	4	0	0	0	4	0	12	77	0.047
LC	0	1	0	0	0	0	0	0	4	0	0	0	5	0.003
SB	0	0	0	0	0	0	0	0	0	0	4	8	12	0.007
NP	2	0	0	0	0	4	0	4	0	0	0	0	10	0.006
GM	2	0	0	0	0	4	0	0	0	0	0	0	6	0.004
GS	1161	72	132	0	0	0	0	0	9	27	154	93	1648	1.010
XC	7	0	4	0	10	0	19	0	0	8	4	0	52	0.032
PS	2	2	8	0	0	0	0	0	0	16	4	0	32	0.020
MM	0	0	19	0	0	0	0	0	0	0	0	0	19	0.012
BB	2	1	16	4	5	0	0	0	0	4	4	4	40	0.025
BC	2	0	4	0	0	0	0	0	0	0	0	0	6	0.004
BG	2	0	0	0	0	4	0	0	0	8	4	0	18	0.011
BR	5	7	16	4	5	4	4	0	9	0	9	4	67	0.041
LB	0	0	0	0	0	0	0	0	4	0	0	0	4	0.002
PB	0	1	0	0	0	0	0	0	0	0	0	0	1	0.001
FS	0	0	0	0	5	0	0	0	0	0	0	0	5	0.003
GP	0	1	0	0	0	0	0	0	0	0	0	0	1	0.001
XX	0	0	0	0	0	0	4	0	0	0	0	0	4	0.002
YB	0	1	0	0	0	0	0	0	0	0	0	0	1	0.001
HB	0	0	8	0	0	0	0	0	0	0	0	0	8	0.005
MT	0	0	0	0	0	0	4	0	0	0	0	0	4	0.002
TOTALS	6050	2323	30244	4284	11705	32680	33073	6479	16394	10483	5862	3630	163207	

Table 37. Estimated numbers of impinged fish at the D.C. Cook Plant during 1977. See Table 10 for definition of species abbreviations.

1977

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	4	109	2201	1166	167	77	465	21	45	492	263	210	5220	10.411
AL	7	0	567	1946	2949	9583	2499	124	578	6421	345	448	25467	50.792
SM	8	109	124	225	85	73	469	5	11	465	64	45	1683	3.357
YP	10	126	1156	469	39	77	5510	186	94	558	484	403	9112	18.173
TP	1	21	27	109	35	137	1845	67	135	3166	210	96	5849	11.665
JD	0	0	0	11	39	17	8	0	0	4	0	0	79	0.158
WS	0	0	0	0	0	0	0	0	4	0	8	3	15	0.030
LS	0	0	0	0	0	0	31	0	0	0	0	0	31	0.062
LT	5	4	9	8	12	0	0	0	0	9	49	38	134	0.267
LD	0	0	0	0	0	0	0	0	0	4	0	14	18	0.036
MS	0	0	0	0	0	0	0	0	0	0	4	10	14	0.028
CN	2	4	4	4	0	0	0	0	0	0	4	7	25	0.050
BT	9	7	0	8	0	0	0	0	0	0	4	0	28	0.056
NS	1	0	9	30	27	4	0	0	0	4	0	0	75	0.150
SS	6	7	204	1024	275	124	70	5	19	35	23	21	1813	3.616
CC	7	11	13	0	0	0	0	0	0	4	0	0	35	0.070
LC	0	0	0	0	0	0	0	0	0	0	4	3	7	0.014
SB	0	0	4	0	0	0	0	0	0	0	4	3	11	0.022
GN	0	0	4	0	0	0	0	0	0	0	0	0	4	0.008
GS	5	0	0	0	0	0	0	0	0	13	19	7	44	0.088
XC	0	4	0	0	0	9	19	0	0	288	15	24	359	0.716
PS	0	0	0	0	0	0	0	0	0	0	4	0	4	0.008
BB	0	0	18	0	0	0	0	0	0	0	0	0	18	0.036
BC	0	0	0	0	0	0	0	0	0	9	0	0	9	0.018
BG	0	0	0	0	0	0	0	0	0	0	4	7	11	0.022
BR	0	4	0	0	8	9	8	5	4	0	11	0	49	0.098
LB	1	0	0	0	0	0	4	0	0	4	0	0	9	0.018
RB	0	0	0	0	0	0	0	0	0	4	0	0	4	0.008
SR	0	4	0	0	0	0	0	0	0	0	0	3	7	0.014
YB	2	0	0	0	0	0	0	0	0	0	0	0	2	0.004
ER	0	0	4	0	0	0	0	0	0	0	0	0	4	0.008
TOTALS	68	410	4344	5000	3636	10110	10928	413	890	11480	1519	1342	50140	

Table 38. Estimated numbers of fish impinged at the D.C. Cook Plant during 1978. See Table 10 for definition of species abbreviations.

1978

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
SP	2573	316	1166	3549	661	1080	104935	5499	2900	3821	683	1842	129025	27.894
AL	0	0	0	13	4810	49746	109669	8653	2240	4673	3698	1391	184893	39.972
SM	105	32	1360	86	3720	1032	19588	13640	365	39	0	66	40033	8.655
YP	488	56	442	540	62	222	14433	4352	1055	461	3308	239	25658	5.547
TP	105	12	43	30	517	1242	55711	2348	1170	1697	45	142	63062	13.633
JD	0	0	4	0	10	18	40	16	0	0	0	0	88	0.019
WS	4	0	4	0	5	0	22	16	0	81	0	13	145	0.031
LS	12	8	16	21	5	30	18	4	10	8	15	9	156	0.034
LT	0	16	12	4	10	6	0	4	5	27	98	84	266	0.058
CH	0	0	0	4	0	6	4	0	0	0	8	31	53	0.011
RT	0	0	8	0	0	0	0	0	0	0	0	0	8	0.002
ES	0	0	0	0	0	0	0	0	0	0	0	4	4	0.001
LD	16	0	0	0	0	0	0	0	0	0	0	18	34	0.007
CP	0	0	0	0	0	0	0	0	0	0	0	4	4	0.001
MS	54	12	4	0	36	18	4	19	50	39	0	71	307	0.066
CM	4	12	23	21	10	6	13	0	0	4	0	0	93	0.020
BT	4	4	4	0	0	0	0	0	5	0	0	40	57	0.012
NS	8	0	58	9	150	48	13	4	0	0	0	9	299	0.065
SS	31	24	27	206	449	54	93	35	10	16	0	133	1078	0.233
CC	8	0	0	4	0	0	0	0	0	8	0	0	20	0.004
LC	4	0	0	0	0	0	0	0	0	0	0	0	4	0.001
SB	0	0	0	4	0	0	0	0	0	0	0	0	4	0.001
NP	0	0	0	0	0	0	0	0	0	0	0	4	4	0.001
GN	0	0	0	0	0	0	4	0	0	0	0	0	4	0.001
GS	12	0	4	0	0	0	4	0	0	171	113	350	654	0.141
XC	4	0	0	0	0	36	15451	636	10	105	45	102	16389	3.543
PS	0	0	0	0	0	0	4	0	5	0	0	0	9	0.002
BB	0	0	0	4	0	0	0	0	0	0	0	9	13	0.003
BC	0	4	0	0	0	0	0	0	0	0	0	0	4	0.001
BG	0	0	0	0	0	0	4	0	0	4	0	0	8	0.002
BR	4	16	16	13	5	0	4	12	5	23	0	9	107	0.023
RB	4	4	0	0	0	0	0	0	0	0	0	0	8	0.002
SR	0	0	4	0	0	0	0	0	0	0	0	27	31	0.007
FD	0	0	0	0	0	0	0	0	10	0	0	0	10	0.002
WC	0	0	0	0	0	0	4	0	0	4	0	0	8	0.002
CL	0	0	0	0	0	0	0	0	0	0	0	4	4	0.001
MA	0	0	0	0	0	0	0	0	0	4	0	0	4	0.001
BN	0	0	0	0	0	6	0	0	0	0	0	4	10	0.002
TOTALS	3440	516	3195	4508	10450	53550	320018	35238	7840	11185	8013	4605	462558	

Table 39. Estimated numbers of fish impinged at the D.C. Cook Power Plant January - September, 1979. See Table 10 for definition of species abbreviations.

Species	Jan	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum	% of Total
SP	4375	303	488	9184	31		4320	2874	33780	55355	7.6
AL	8		3	900	22	60	128717	18303	372702	520715	71.6
SM	323	28	356	3415	13		7572	2347	39034	53088	7.3
YP	1107	158	441	317	17		690	1204	72120	76054	10.5
TP	265	37	27	278	4		4260	1120	8305	14296	2.0
JD							8	13	17	38	0.0
WS	44	32	34	34	8	15	4	13		184	0.0
LS	13	9	38	30	13		21	8	17	149	0.0
LT	31	14			4			13	34	96	0.0
CH	8	9	480	17			8	13	8	543	0.1
RT			7	4						11	0.0
CP			11		4			4		19	0.0
MS	155	18	11				34	57	47	322	0.0
CM	13		62	60	17					152	0.0
NS	8		3	47			4			62	0.0
SS	128	42	189	1834	22		180	31	38	2464	0.3
CC	17	9	3	8					12	49	0.0
GS	39	4	3					4	4	54	0.0
XC	26		3				2670	13	141	2853	0.4
LW	4		3							7	0.0
BB				4						4	0.0
BC	4									4	0.0
BR	194	56	96	38	26		21	4	34	469	0.1
RB			3							3	0.0
GF		4								4	0.0
WC									4	4	0.0
SR	31	14	11							56	0.0
SL			3							3	0.0
BN				4						4	0.0
FD									4	4	0.0
BT	22	14	27	17						80	0.0
SB			3							3	0.0
MM			3							3	0.0
ER				4						4	0.0
TOTAL	6815	751	2308	16195	181	75	148509	26021	526301	727156	

Table 40. Weights (kg.) of fish impinged at the D.C. Cook Power Plant during 1975.

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
Spottail shiner	0.98	3.37	3.91	12.28	7.20	7.54	1.10	0.48	2.63	15.44	15.19	18.23	88.35	1.44
Alewife	7.67	0.01	64.06	1834.06	797.80	2062.24	278.75	46.64	6.91	12.80	23.43	71.32	5205.68	84.76
Rainbow smelt	0.15	0.20	0.68	12.65	17.45	1.76	0.43	0.98	0.24	1.30	1.41	2.37	39.63	0.65
Yellow perch	2.97	7.70	13.91	71.78	2.05	39.38	60.04	48.18	14.72	63.19	51.00	19.91	394.84	6.43
Trout perch	0.05	0.16	0.24	1.22	2.69	3.24	1.14	1.10	3.48	71.53	71.42	11.86	168.13	2.74
Johnny darter	0.00	0.0	0.0	0.00	0.10	0.26	0.04	0.04	0.03	0.00	0.03	0.01	0.51	0.01
White sucker	0.0	0.0	0.91	1.40	2.84	8.99	1.31	0.0	0.90	0.0	0.0	0.02	16.38	0.27
Longnose sucker	0.0	1.77	0.0	2.86	3.03	8.87	0.92	3.62	1.07	1.02	5.95	0.0	29.11	0.47
Lake trout	13.35	0.0	0.02	0.80	3.88	0.08	0.11	0.0	0.02	0.0	25.04	43.09	86.39	1.41
Chinook salmon	0.0	0.0	0.0	0.46	0.0	0.0	0.01	0.02	0.0	0.0	0.0	0.0	0.49	0.01
Rainbow trout	0.0	0.15	0.0	0.0	0.0	0.07	0.0	0.03	0.0	0.0	0.0	0.12	0.38	0.01
Emerald shiner	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00
Longnose dace	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.01	0.03	0.0	0.04	0.00
Carp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.00	0.00
Coho salmon	0.0	0.0	0.0	2.09	2.83	0.0	0.0	0.0	0.0	0.0	0.0	0.47	5.39	0.09
Ninespine stickleback	0.00	0.0	0.02	0.16	0.20	0.04	0.00	0.0	0.00	0.01	0.0	0.01	0.45	0.01
Slimy sculpin	0.78	1.13	2.55	28.40	8.26	6.48	2.62	1.71	1.94	1.46	2.34	2.00	59.68	0.97
Channel catfish	0.05	0.04	0.16	0.49	0.0	0.03	0.10	0.21	1.46	0.0	0.0	0.01	2.55	0.04
Quillback	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	1.00	0.02
Smallmouth bass	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.00	0.02	0.17	0.00
Northern pike	0.0	0.0	0.0	1.45	2.00	0.0	0.0	0.01	0.0	0.0	0.0	0.0	3.46	0.06
Green sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.05	0.06	0.00
Gizzard shad	0.01	0.45	0.81	6.69	0.0	0.0	0.0	0.0	0.0	0.02	0.39	1.69	10.07	0.16
Unidentified coregonid	0.0	0.0	0.01	0.02	0.01	0.04	0.10	0.04	0.04	0.09	0.05	0.01	0.42	0.01
Pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.07	0.0	0.0	0.0	0.00	0.08	0.08	0.23	0.00
Central mudminnow	0.01	0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00	0.05	0.00
Lake whitefish	0.0	0.0	0.0	2.74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.74	0.04
Black bullhead	0.24	0.01	0.30	0.75	0.63	0.0	0.0	0.06	0.0	0.08	0.0	0.05	2.12	0.03
Black crappie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.01	0.02	0.03	0.00
Bluegill	0.0	0.0	0.0	0.04	0.03	0.01	0.00	0.00	0.01	0.0	0.05	0.06	0.20	0.00
Burbot	0.86	0.85	2.35	3.23	2.47	4.60	0.25	2.25	0.84	3.25	0.67	0.89	22.51	0.37
Largemouth bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.01	0.00	0.05	0.09	0.00
Rock bass	0.0	0.0	0.0	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.09	0.00
Fourhorn sculpin	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.00
Golden shiner	0.0	0.0	0.02	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.04	0.00
Unidentified pisces	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00
Yellow bullhead	0.0	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.11	0.00
Goldfish	0.0	0.0	0.0	0.03	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.00
White crappie	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.02	0.03	0.00
Chestnut lamprey	0.0	0.0	0.0	0.07	0.05	0.0	0.0	0.03	0.0	0.0	0.0	0.0	0.16	0.00
Pirate perch	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00
Spotted sucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.01	0.00
Logperch	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00
Hybrid sunfish	0.0	0.0	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.00
TOTALS	27.29	15.95	90.03	1983.82	853.54	2143.72	346.91	105.40	34.33	170.24	198.12	172.38	6141.72	

Table 41. Estimated weights (kg.) of fish impinged at the D.C. Cook Power Plant during 1976.

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
Spottail shiner	18.09	17.04	109.99	9.45	5.85	2.04	3.82	2.49	16.38	30.53	9.82	21.06	246.57	5.86
Alewife shiner	9.56	0.11	701.18	79.00	216.05	761.86	713.12	90.57	27.06	12.28	99.80	4.39	2714.98	64.54
Rainbow smelt	2.57	1.27	5.36	7.78	5.34	0.54	2.36	1.73	0.14	0.59	0.59	1.39	29.66	0.71
Yellow perch	14.01	8.21	17.18	4.54	8.61	33.95	234.02	149.76	129.08	81.64	3.25	71.83	756.08	17.97
Trout perch	2.15	0.46	1.91	0.09	5.74	2.32	17.21	4.68	15.53	10.73	1.03	1.54	63.40	1.51
Johnny darter	0.0	0.00	0.0	0.03	0.45	0.04	0.05	0.01	0.20	0.05	0.01	0.01	0.85	0.02
White sucker	1.26	0.05	0.0	0.0	0.0	9.23	5.62	0.0	7.76	0.0	0.0	0.0	23.92	0.57
Longnose sucker	2.42	6.18	5.96	6.19	0.0	0.0	0.0	0.08	0.0	0.0	0.0	0.0	20.84	0.50
Lake trout	19.25	9.02	15.57	0.0	44.35	18.80	0.0	0.0	0.0	0.0	11.79	50.96	169.72	4.03
Chinook salmon	0.0	0.0	0.57	0.0	0.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90	0.02
Rainbow trout	0.0	0.13	0.0	0.0	0.06	0.0	0.13	0.0	0.0	0.0	0.0	0.36	0.67	0.02
Longnose dace	0.04	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.0	0.0	0.10	0.00
Carp	0.10	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12	0.00
Coho salmon	0.65	0.98	2.64	0.0	0.02	0.02	0.0	0.0	0.0	0.0	0.64	3.88	8.82	0.21
Brown trout	0.0	0.0	0.0	2.29	0.14	0.0	0.0	0.0	0.0	0.0	0.06	0.36	2.85	0.07
Ninespine stickleback	0.01	0.01	0.03	0.0	0.18	0.0	0.0	0.0	0.0	0.01	0.02	0.0	0.26	0.01
Slimy sculpin	2.11	0.76	7.47	5.09	8.44	1.95	1.76	1.05	1.94	1.09	0.41	0.92	32.98	0.78
Channel catfish	0.45	1.02	0.10	0.0	0.0	0.02	0.0	0.0	0.0	0.01	0.0	0.19	1.78	0.04
Lake chub tfish	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.02	0.00
Smallmouth bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.34	0.41	0.01
Northern pike	0.66	0.0	0.0	0.0	0.0	2.00	0.0	8.64	0.0	0.0	0.0	0.0	11.30	0.27
Green sunfish	0.02	0.0	0.0	0.0	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.00
Gizzard shad	31.53	23.87	3.69	0.0	0.0	0.0	0.0	0.0	2.51	0.26	1.48	15.75	79.09	1.88
Unidentified coregonid	0.05	0.0	0.06	0.0	0.49	0.0	0.79	0.0	0.0	0.03	0.02	0.0	1.44	0.03
Pumpkinseed	0.00	0.00	0.84	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.18	0.0	0.25	0.01
Central mudminnow	0.0	0.0	0.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.11	0.00
Black bullhead	0.02	0.08	0.92	0.06	0.05	0.0	0.0	0.0	0.0	0.16	0.77	1.55	3.61	0.09
Black crappie	0.49	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.51	0.01
Bluegill	0.01	0.0	0.0	0.0	0.0	0.07	0.0	0.0	0.0	0.09	0.02	0.0	0.19	0.00
Burbot	2.15	3.76	14.12	3.60	2.58	0.19	1.80	0.0	1.79	0.0	3.65	1.28	34.94	0.83
Largemouth bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.0	0.0	0.0	0.06	0.00
Rock bass	0.0	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.15	0.00
Fourhorn sculpin	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00
Grass pickerel	0.0	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.00
Unidentified pisces	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.02	0.00
Yellow bullhead	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00
Hybrid sunfish	0.0	0.0	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.18	0.00
Tadpole madtom	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.02	0.00
TOTALS	107.59	73.21	887.11	118.13	298.72	833.05	980.72	259.01	202.46	137.54	133.61	175.80	4206.95	

Table 42. Estimated weights (kg.) of impinged fish collected at the D.C. Cook Power Plant during 1977.

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
Spottail shiner	0.06	1.71	28.99	15.15	1.94	6.67	4.44	0.27	0.36	3.68	2.58	1.82	67.67	3.69
Alewife	0.14	0.0	23.08	72.02	94.32	245.43	62.12	3.60	6.49	39.33	3.33	17.50	567.36	30.97
Rainbow smelt	0.13	1.11	0.81	2.44	0.62	0.72	1.86	0.03	0.03	3.77	0.81	0.58	12.90	0.70
Yellow perch	2.59	6.78	22.12	27.77	1.76	13.62	507.74	20.53	6.35	7.59	16.51	8.70	642.07	35.04
Trout perch	0.01	0.28	0.30	1.07	0.36	0.95	8.11	0.48	1.43	25.33	2.31	1.00	41.64	2.27
Johnny darter	0.0	0.0	0.0	0.05	0.14	0.04	0.02	0.0	0.0	0.02	0.0	0.0	0.25	0.01
White sucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.09	0.0	4.76	0.12	7.97	0.44
Longnose sucker	0.0	0.0	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	0.0	0.19	0.01
Lake trout	17.50	10.50	7.37	21.19	40.14	0.0	0.0	0.0	0.0	34.23	172.48	131.87	435.29	23.76
Longnose dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.11	0.13	0.01
Mottled sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.10	0.14	0.01
Coho salmon	1.25	2.59	2.98	1.69	0.0	0.0	0.0	0.0	0.0	0.0	0.86	4.68	14.06	0.77
Brown trout	0.45	0.39	0.0	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.18	0.0	1.14	0.06
Ninespine stickleback	0.00	0.0	0.03	0.08	0.07	0.01	0.0	0.0	0.0	0.01	0.0	0.0	0.20	0.01
Slimy sculpin	0.06	0.09	2.07	6.62	1.41	0.68	0.44	0.05	0.18	0.38	0.19	0.20	12.36	0.67
Channel catfish	0.17	0.20	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.0	0.44	0.02
Lake chub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.02	0.04	0.00
Smallmouth bass	0.0	0.0	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.13	0.22	0.01
Green sunfish	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00
Gizzard shad	1.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.25	0.26	2.00	0.11
Unidentified coregonid	0.0	0.02	0.0	0.0	0.0	0.13	0.21	0.0	0.0	1.15	0.09	0.22	1.81	0.10
Pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.01	0.00
Black bullhead	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.01
Black crappie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.0	0.0	0.03	0.00
Bluegill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.01	0.01	0.00
Burbot	0.0	2.94	0.0	0.0	4.09	2.15	2.88	1.24	1.42	0.0	7.99	0.0	22.72	1.24
Largemouth bass	0.03	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.01	0.0	0.0	0.05	0.00
Rock bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.0	0.0	0.10	0.01
Shorthead redhorse	0.0	0.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.53	1.05	0.06
Yellow bullhead	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.00
Lake chubsucker	0.0	0.0	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08	0.00
TOTALS	23.85	27.14	88.18	148.19	144.86	270.38	588.00	26.21	19.35	115.73	212.45	167.84	1832.19	

Table 43. Estimated weights (kg.) of fish impinged at the D.C. Cook Power Plant during 1978.

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
Spottail shiner	31.18	3.19	15.45	52.92	6.75	7.68	327.95	38.18	20.28	32.55	5.54	17.44	561.10	6.54
Alewife	0.0	0.0	0.0	0.62	188.61	1220.42	2674.47	199.52	30.83	59.19	128.86	62.30	4564.80	53.20
Rainbow smelt	1.95	0.80	23.98	1.85	24.33	4.63	65.22	65.52	2.91	1.16	0.0	0.31	192.67	2.25
Yellow perch	26.06	7.27	56.34	69.46	5.06	10.48	451.67	345.58	62.60	45.71	58.48	16.45	1155.16	13.46
Trout perch	0.80	0.11	0.33	0.24	4.01	9.04	274.87	16.22	8.29	17.83	0.50	1.42	333.66	3.89
Johnny darter	0.0	0.0	0.02	0.0	0.02	0.05	0.10	0.04	0.0	0.0	0.0	0.0	0.23	0.00
White sucker	0.14	0.0	7.75	0.0	5.68	0.0	24.57	12.83	0.0	38.37	0.0	9.83	99.17	1.16
Longnose sucker	10.79	13.40	31.43	39.06	6.59	29.45	25.28	2.72	1.65	13.56	20.06	15.63	209.63	2.44
Lake trout	0.0	56.84	31.93	13.71	34.10	19.80	0.0	20.54	16.63	106.15	341.44	296.36	936.49	10.91
Chinook salmon	0.0	0.0	0.0	1.06	0.0	0.04	0.04	0.0	0.0	0.0	72.00	5.56	78.70	0.92
Rainbow trout	0.0	0.0	1.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.41	0.02
Emerald shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.06	0.00
Longnose dace	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.16	0.33	0.00
Carp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.18	17.18	0.20
Mottled sculpin	0.80	0.09	0.07	0.0	0.71	0.14	0.04	0.12	0.61	0.32	0.0	0.95	3.87	0.05
Coho salmon	3.20	7.92	14.62	18.19	10.24	6.00	0.61	0.0	0.0	1.30	0.0	0.0	62.07	0.72
Brown trout	0.35	0.39	0.40	0.0	0.0	0.0	0.0	0.0	27.50	0.0	0.0	3.18	31.90	0.37
Ninespine stickleback	0.02	0.0	0.19	0.02	0.46	0.11	0.02	0.01	0.0	0.0	0.0	0.03	0.83	0.01
Slimy sculpin	0.49	0.20	0.22	1.88	2.55	0.31	0.53	0.12	0.10	0.16	0.0	1.31	7.86	0.09
Channel catfish	0.33	0.0	0.0	2.86	0.0	0.0	0.0	0.0	0.0	15.51	0.0	0.0	18.70	0.22
Lake chub	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.00
Smallmouth bass	0.0	0.0	0.0	2.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.16	0.03
Northern pike	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.36	1.36	0.02
Green sunfish	0.0	0.0	0.0	0.0	0.0	0.0	0.06	0.0	0.0	0.0	0.0	0.0	0.06	0.00
Gizzard shad	0.69	0.0	2.03	0.0	0.0	0.0	3.57	0.0	0.0	12.71	2.49	36.16	57.65	0.67
Unidentified coregonid	0.02	0.0	0.0	0.0	0.0	0.18	165.46	7.15	0.05	0.51	0.24	0.51	174.10	2.03
Pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.06	0.0	0.0	0.0	0.06	0.00
Black bullhead	0.0	0.0	0.0	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.32	0.56	0.01
Black crappie	0.0	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.00
Bluegill	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.0	0.0	0.02	0.0	0.0	0.07	0.00
Burbot	1.07	8.43	8.42	5.11	2.19	0.0	2.79	5.49	4.75	9.65	0.0	0.52	48.41	0.56
Rock bass	0.04	0.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.01
Shorthead redhorse	0.0	0.0	0.81	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.87	7.67	0.09
Freshwater drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.50	0.0	0.0	0.0	5.50	0.06
White crappie	0.0	0.0	0.0	0.0	0.0	0.0	0.34	0.0	0.0	0.09	0.0	0.0	0.43	0.01
Chestnut lamprey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.29	0.29	0.00
Silver redhorse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.42	0.0	0.0	5.42	0.06
Brown bullhead	0.0	0.0	0.0	0.0	0.0	0.59	0.0	0.0	0.0	0.0	0.0	0.09	0.69	0.01
TOTALS	78.12	99.29	195.47	209.37	291.31	1308.93	4017.62	714.04	181.75	359.21	629.61	496.29	8581.01	

Table 44. Estimated weights (kg.) of fish impinged at the D.C. Cook Power Plant January - September 1979. T = trace. See Table 10 for definition of species abbreviations.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum	% of Total
SP.	49.5	3.7	58.2	99.2	0.4		27.3	20.2	268.8	527.3	5.2
AL	0.1		0.2	42.7	1.0	2.4	2981.6	398.3	944.6	4370.9	42.7
SM	3.4	0.5	7.5	20.7	0.2		26.6	16.2	250.7	325.8	3.2
YP	36.6	13.2	47.5	28.2	3.9		63.7	71.8	3118.7	3383.6	33.1
TP	3.4	0.6	0.4	2.9	T		21.0	10.0	59.9	98.2	1.0
JD							T	T	T	<0.1	0.0
WS	68.9	54.6	57.6	37.4	8.7	13.1	3.6	7.8		251.7	2.5
LS	37.0	16.0	65.3	39.5	19.6		23.1	4.6	16.0	221.1	2.2
LT	75.0	58.5			13.2			31.4	106.7	284.8	2.8
CH	1.4	2.1	149.7	3.0			0.1	0.2	1.0	157.5	1.5
RT			9.7	9.9						19.6	0.2
CP			26.3		43.6			T		69.9	0.7
MS	1.5	0.2	6.9				0.3	0.6	0.3	9.8	0.1
CM	4.8		42.1	40.8	9.9					97.6	0.9
NS	T		T	0.1			T			0.2	0.0
SS	1.3	0.4	1.6	14.3	0.2		0.8	0.2	0.3	19.1	0.2
CC	5.2	6.3	19.6	2.3					10.3	43.7	0.4
GS	16.8	2.1	1.4					3.0	4.7	28.0	0.3
XC	0.1		T				21.5	0.1	1.2	22.9	0.2
LW	2.0		1.7							3.7	0.0
BB				T						<0.1	0.0
BC	0.2									0.2	0.0
BR	84.1	28.8	70.3	23.2	20.6		6.7	0.2	2.7	236.6	2.3
RB			0.4							0.4	0.0
GF		0.8								0.8	0.0
WC									0.6	0.6	0.0
SR	7.9	3.6	3.0							14.5	0.1
SL			0.6							0.6	0.0
BN				0.1						0.1	0.0
FD									3.2	3.2	0.0
BT	4.9	1.6	11.5	13.2						31.2	0.3
SB			1.3							1.3	0.0
MM			T							<0.1	0.0
ER				0.1						0.1	0.0
TOTAL	404.2	193.2	582.8	377.6	121.3	15.5	3176.3	564.5	4789.6	10225.0	

APPENDIX C
ENVIRONMENTAL OPERATING REPORT 1979
GROUNDWATER MONITORING

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

GROUND WATER WELL 1A

Chemical Analysis Parameters

Date	2/6/79	3/26/79	9/4/79
Sodium (Na), mg/L	8.8	8.8	15.4
Sulfate (SO_4), mg/L	0	0	0
Phosphate (PO_4), mg/L	0	0	3.8
pH, standard units	6.3	6.8	6.6
Conductivity, μmho	225	235	276
Nitrate (NO_3), mg/L	0.21	0.20	0.41
Iron (Fe), mg/L	9.0	4.3	4.9
Copper (CU), mg/L	0	0	0
Ground water elevation ft.	601.74	607.99	605.74

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

GROUND WATER WELL 8

Chemical Analysis Parameters

Date	2/6/79	3/26/79	9/4/79
Sodium (Na), mg/L	460.0	45.5	26.8
Sulfate (SO_4), mg/L	0	0	0
Phosphate (PO_4), mg/L	0.1	0	6.5
pH, standard units	6.6	6.9	6.8
Conductivity, µmho	900	665	521
Nitrate (NO_3), mg/L	0.52	0.01	0.32
Iron (Fe), mg/L	1.5	1.1	3.0
Copper (CU), mg/L	0	0	0
Groundwater elevation (ft.)	608.87	609.28	608.20

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

GROUND WATER WELL 11

Chemical Analysis Parameters

Date	2/6/79	3/26/79	9/4/79
Sodium (Na), mg/L	495.0	97.5	94.8
Sulfate (SO_4), mg/L	247.0	172.8	216.0
Phosphate (PO_4), mg/L	0	0	6.0
pH, standard units	7.2	7.0	7.1
Conductivity, µmho	938	875	826
Nitrate (NO_3), mg/L	0.41	0.50	0.17
Iron (Fe), mg/L	1.2	0.3	2.3
Copper (CU), mg/L	0	0	0
Groundwater elevation (ft.)	605.47	606.30	606.17

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

GROUND WATER WELL 12

Chemical Analysis Parameters

Date	2/6/79	3/26/79	9/4/79
Sodium (Na), mg/L	388.0	137.5	83.1
Sulfate (SO_4), mg/L	257.0	233.7	111.0
Phosphate (PO_4), mg/L	0	0	0
pH, standard units	7.2	6.9	7.2
Conductivity, µmho	1075	1075	797
Nitrate (NO_3), mg/L	0.11	0.06	0.63
Iron (Fe), mg/L	1.6	0.4	1.4
Copper (CU), mg/L	0	0	0
Groundwater elevation (ft)	592.70	598.53	596.95

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

CIRC. WATER I

Chemical Analysis Parameters

Date	3/26/79	9/4/79
Sodium (Na), mg/L	5.0	67.0
Sulfate (SO_4), mg/L	0	0
Phosphate (PO_4), mg/L	0	0.8
pH, standard units	6.9	7.0
Conductivity, µmho	355	311
Nitrate (NO_3), mg/L	0.33	0.70
Iron (Fe), mg/L	0.5	0.2
Copper (CU), mg/L	0	0

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

CIRC. WATER II

Chemical Analysis Parameters

Date	3/26/79	9/4/79
Sodium (Na), mg/L	4.3	67.0
Sulfate (SO_4), mg/L	0	0
Phosphate (PO_4), mg/L	0	0.5
pH, standard units	7.5	7.5
Conductivity, μmho	355	305
Nitrate (NO_3), mg/L	0.41	0.80
Iron (Fe), mg/L	0.3	0.2
Copper (CU), mg/L	0	0

B. Specification 4.1.1.5 Groundwater Movement Analysis

Groundwater movement was determined by calculating the velocity and direction of flow from data acquired during flow drawdown hydraulic pumping tests of the monitoring wells, as described in the following report:

SUBJECT: Determine the direction of flow and velocity of groundwater near the infiltration basin and sanitary waste ponds.

PROCEDURE: In written form is the step by step methods along with references to sketch maps, work sheets, pumping test data used to mathematically solve for velocity flow of the groundwater along with vector directions.

COMPUTATIONS: The gradient determination was computed by simple arithmetic, ie. distance vs. difference in elevations. The straight line graphical solution of T was computed to aid in the evaluation of T found by the type curve solution, ie. T - 39193 gpd/ft, S-.00872 & P -4676.96 gpd/ft^2.

SKETCHES: Site locations of monitor wells & distances between them plus the construction diagrams were prepared by Tom Kriesel, Cook Nuclear Plant.

REFERENCES USED: THEORY OF AQUIFER TESTS, Geological Survey water-supply paper 1536-E.

GROUND WATER & WELLS, Edward E. Johnson, Inc.

SELECTED ANLAYTICAL METHODS FOR WELL & AQUIFER EVALUATIONS, William C. Walton; Illinois State Water Survey.

PREPARED BY:

Robert J. Cole, Consulting Geologist

GEORGE B. COLE & SONE INC.

&

GREAT LAKES GEOPHYSICAL SERVICE

Between 5 & 17 July '79' the four monitor wells in this report were test pumped for 24 hrs each with a record kept of drawdown vs. discharge capacity, & time. The static water level (SWL) was taken on all the monitor wells & the pond observation well. Sketch #1 shows the relationships of the monitor wells to the infiltration and sanitary waste ponds. Sketch #2 contains the SWL for this years report, for '77's & '76's report for rapid comparisons. It is readily seen that the SWL varies from year to year but due to these formations being shallow water table aquifers they also vary season to season. The level of Lake Michigan also affect-s the slope of the water table. Sketch #3 is included inorder to show the various well constructions.

It appears that the gradient of the water table in the region of well #8 westward toward the area of the ponds is appx. .0018'/ft., See Sketch # 4. The gradient from the pond area (Induced recharge area) westward towards well #12 is appx. .012'/ft., See Sketch #4.

Velocity is computed by multiplying Permeability times gradient times a conversion factor (.134).

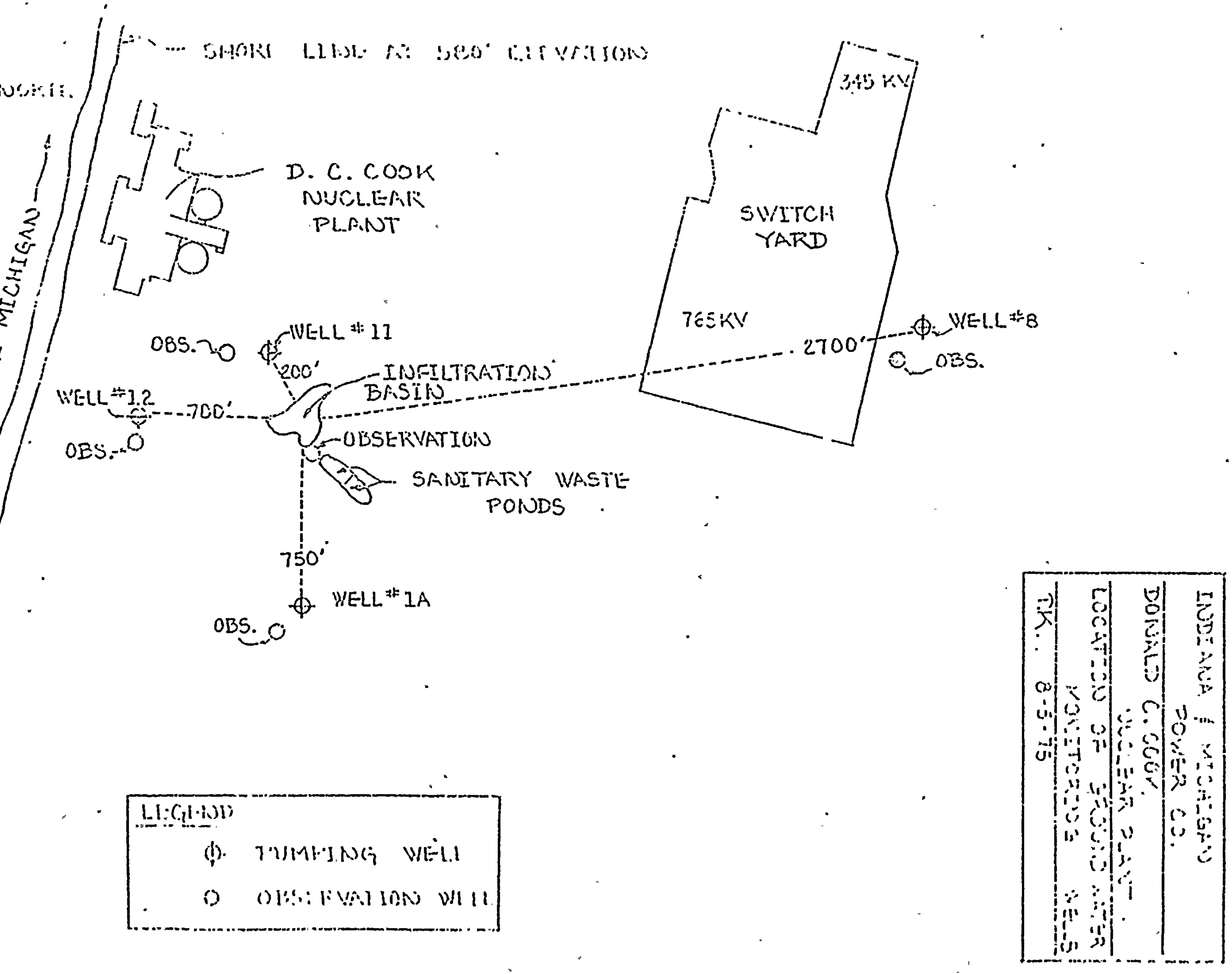
The velocity of ground-water flow in the area of well #8 is westward towards the lake at appx. 1.13ft/day. And the velocity of ground-water flow in the area of the ponds is west to northwest towards the lake at appx. 7.52ft/day. These velocities are a little lower than two years ago & are what one would expect with the differences in the SWL. Yearly & seasonal fluctions are the norm rather than the exception.

I feel that it is safe to assume an average velocity for the areas in question and that it isn't necessary to go through the mechanics necessary for this report morecthen every 5 years or so. If there are any large changes in wastewater disposal then this may be reason to run these tests moreoften.

Respectifully Submitted,

Robert j Cole

Robert j Cole, Consulting Geologist
17 December '79'


SHORE LINE AT 580' ELEVATION
NORTH
LAKE MICHIGAN
D. C. COOK NUCLEAR PLANT
SWITCH YARD
345 KV
765 KV
WELL #8
2700'
OBS.
WELL #11
OBS.
200'
INFILTRATION BASIN
WELL #12
700'
OBS.
OBSERVATION
SANITARY WASTE PONDS
750'
WELL #1A
OBS.
LEGEND
PUMPING WELL
OBSERVATION WELL
INDIANA & MICHIGAN POWER CO.
DONALD C. COOK NUCLEAR PLANT
LOCATION OF GROUND WATER MONITORING WELLS
T.K. 8-5-75

K&E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS

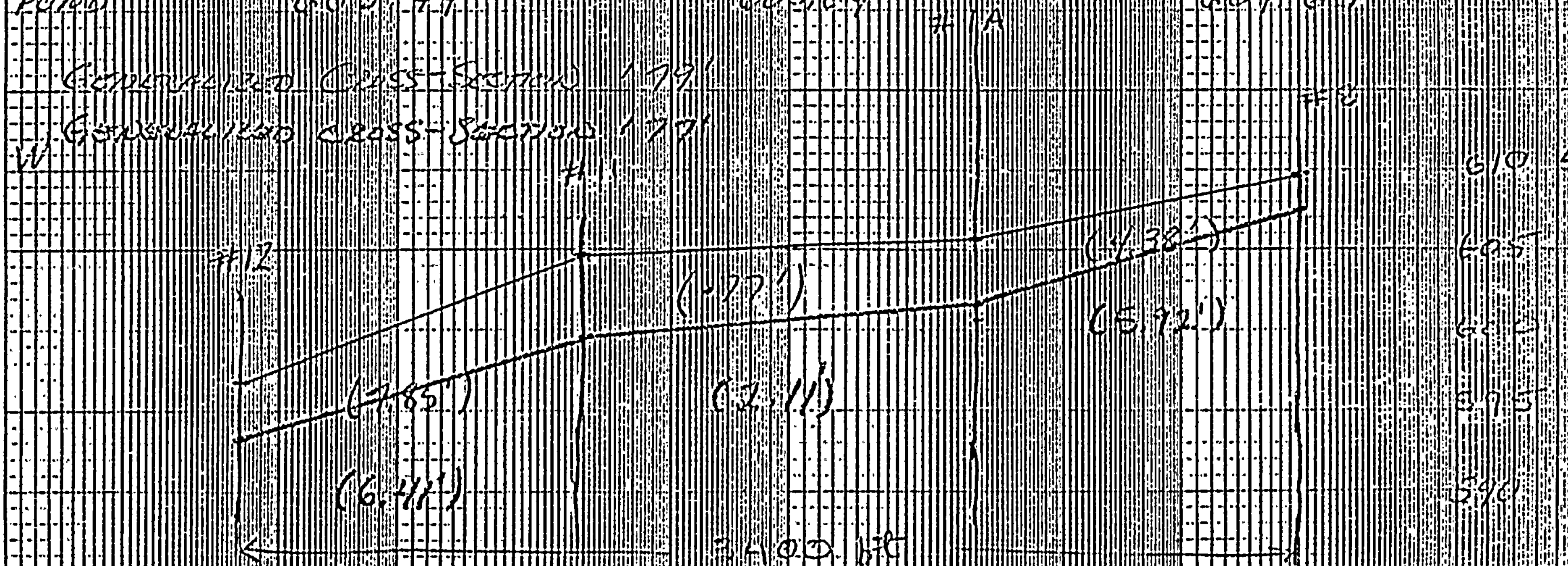
'79'

SKETCH #II

S.W.L. OF WELLS BY DATE TESTED

	'79'	'77'	'76'
WELL 8	609.87'	607.62'	609.16'
WELL 1A	605.47'	601.70'	605.96'
WELL 11	604.72'	599.59'	601.68'
WELL 12	596.87'	593.18'	594.76'
POND	606.44'	603.09'	604.63'

GENERALIZED CROSS-SECTION '79'
GENERALIZED CROSS-SECTION '77'



INDIANA / MICHIGAN POWER CO.
DONALD C. COOK NUCLEAR PLANT
GROUND WATER MONITORING
WELL CONSTRUCTION DIAGRAM
T.K. 8-5-75

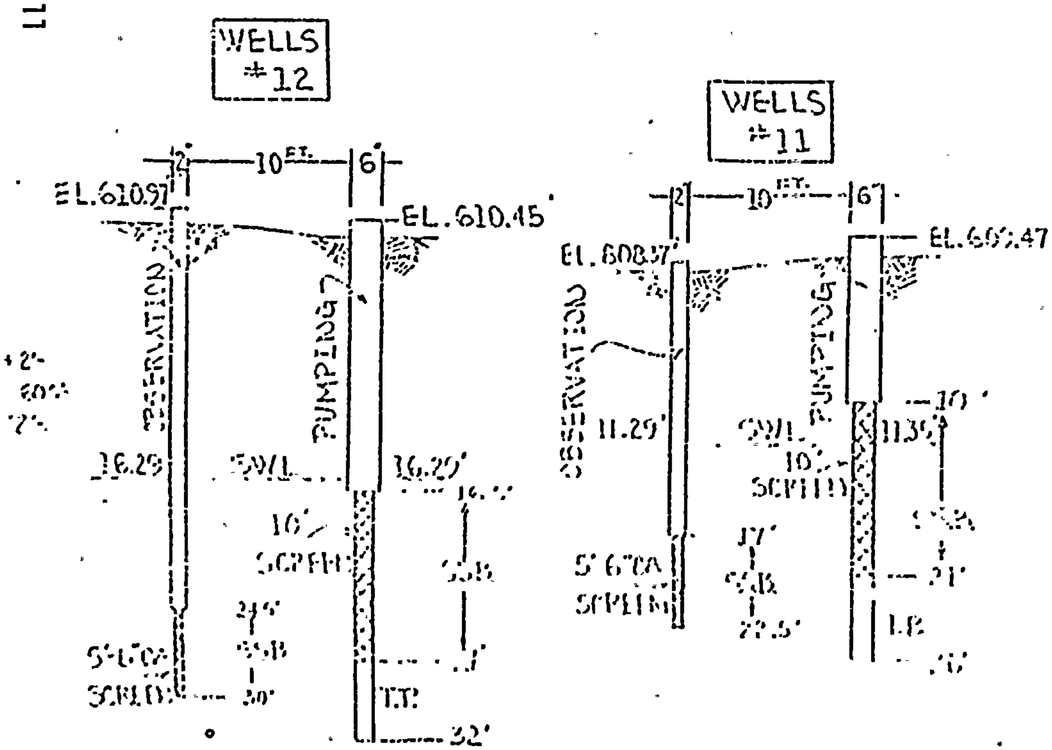
LEGEND

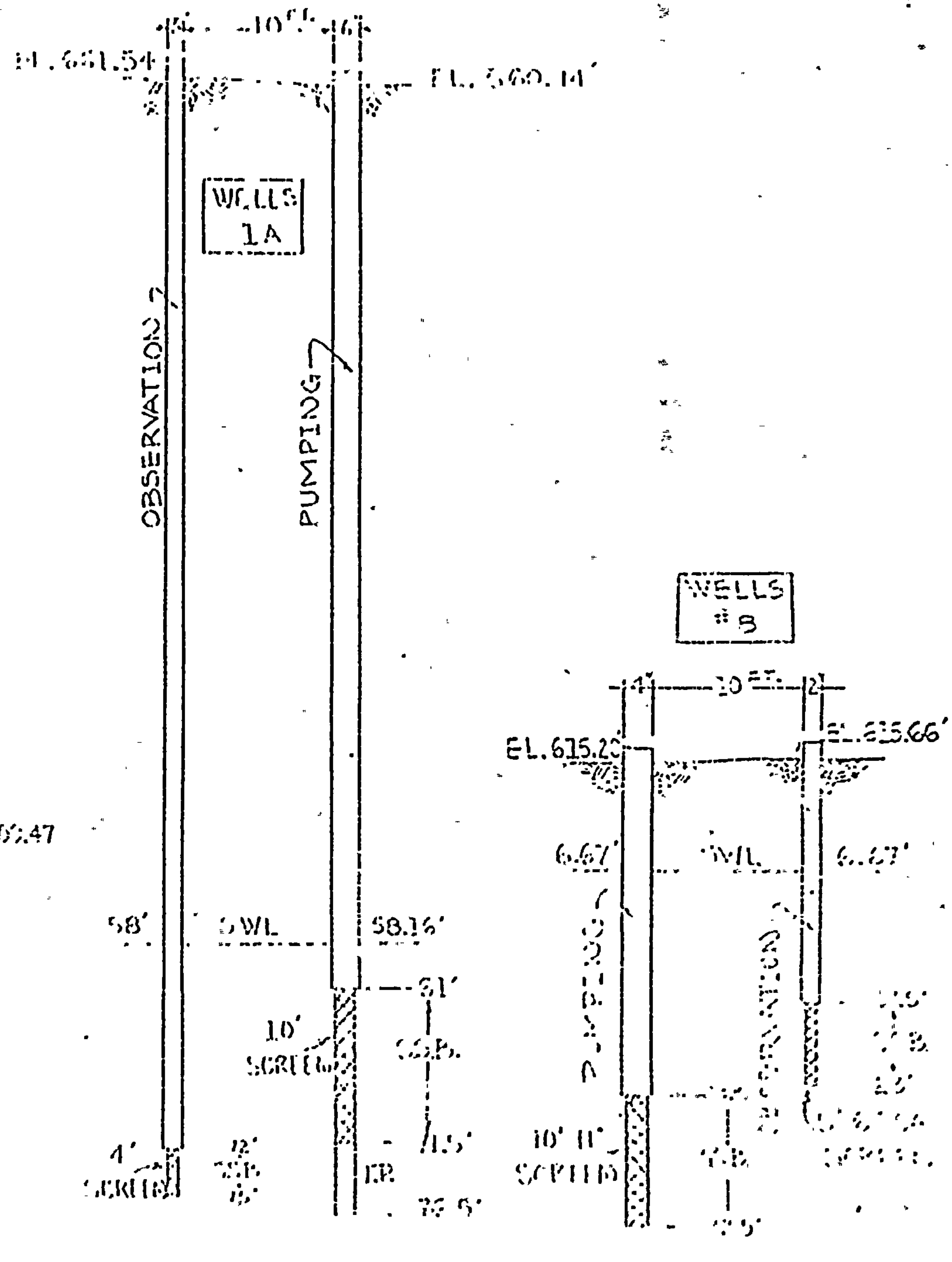
-----SWL – STATIC WATER LEVEL BELOW TOP OF CASING

S.S.B. – SCREEN SET BETWEEN

EL. – ELEVATIONS (FT.) REFER TO MEAN SEA LEVEL

T.P. – TAIL PIPE





SKETCH 3

SKETCH #4

1791

SKETCH #4

GRADIENT CHANGES BY VARIOUS CONTROL DATA

WEST FROM WELL 8 TO WELL #12 OVERALL GRADIENT = .00382'/ft.

$\left(\frac{13'}{3400'} = .00382' /ft \text{ gradient} \right)$

THE GRADIENT FROM THE POND WEST TOWARDS WELL 12 = .012 '/ft.

$\left(\frac{8.57'}{711'} = .01204' /ft \text{ gradient} \right)$

THE NATURAL GRADIENT FROM WELL 1-A IS NORTH NORTHWEST TOWARDS WELL #11 @ .0008 '/ft

$\left(\frac{.77'}{920'} = .000836 \right)$

THE NATURAL GRADIENT FROM WELL 11 TOWARDS WELL 12 .0115 '/ft

$\frac{7.85'}{680'} = .01154$

THE GRADIENT FROM WELL 8 TOWARDS THE POND AVERAGES .0018 '/ft

$\left(\frac{4.87'}{2750'} = .00177 \right)$

K+E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS

'79'

WELL 8 (4" WELL)

S.W.L. @ START OF TEST 609.87'

PUMPING RATE 30 GPM

S.W.L. '77 607.62'

AN INCREASE OF 2.25'

OVER '77

ELEV @ TOP OF PITLESS 615.20'

5.33'

609.87'

WELL 8 OB WELL (2" WELL)

S.W.L. @ START OF TEST 610.00'

ELEV @ TOP CSG 615.66'

5.66'

610.00'

GEORGE B. COLE & SON
Drilling Contractor
3946 Evergreen Lane
Benton Harbor, Mich. 49022

PUMPING TEST RECORD

5 July 79
date

GREAT LAKES GEOPHYSICAL SERVICE
3946 Evergreen Lane
Benton Harbor, Mich. 49022

Project Monitor Well Pump Test Well No. 8

Depth 32½' Diameter 4" Static Level 5'4" TOP PITLESS CAP OFF Pumping Rate 30 GPM

Static Pilot Well No. 1 5'-8" TOP 2" CSG. Distance from Pumped Well 10

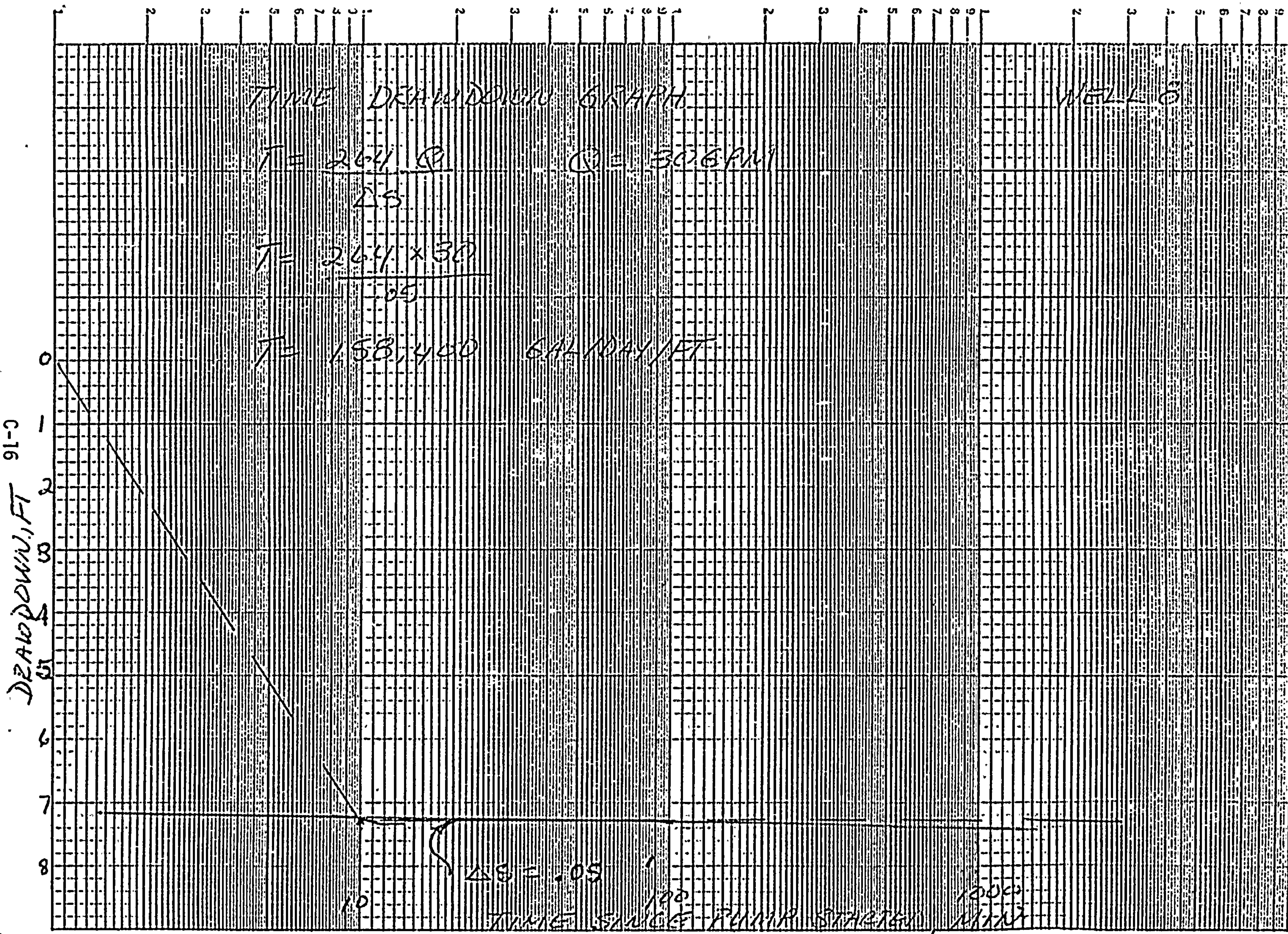
Static Pilot Well No. 2 ______ Distance from Pumped Well ______

Time since pump started			Drawdown in well	Drawdown in Pilot No. 1	Drawdown in Pilot No. 2
		1min	7'	1.72'	
		2min	7.20'	1.80'	
		3min	7.24'	1.95'	
		4min	7.28	2.10'	
		5min	7.30	2.20'	
		6min	7.34'		
		7min	7.33'		
		8min			
		9min			
		10min			
		12min			
		14min			
		16min			
		18min			
		20min			
		30min			
		40min			
		50min			
1.0	hr	60min			
1.5	hr	90min			
2.0	hr	120min			
2.5	hr	150min			
3.0	hr	180min			
3.5	hr	210min			
4.0	hr	240min			
4.5	hr	270min			
5.0	hr	300min			
5.5	hr	330min			
6.0	hr	360min			
6.5	hr	390min			
7.0	hr	420min			
7.5	hr	450min			
8.0	hr	480min			
8.5	hr	510min			
9.0	hr	540min	7.35'		
9.5	hr	570min	7.35'		
10.0	hr	600min			
10.5	hr	630min			
11.0	hr	660min		7.25'	
11.5	hr	690min			
12.0	hr	720min			
12.5	hr	750min			
13.0	hr	780min			
13.5	hr	810min			
14.0	hr	840min			
14.5	hr	870min			
15.0	hr	900min	7.35'	2.25'	

Time since pump started			Drawdown in well	Drawdown in Pilot No. 1	Drawdown in Pilot No. 2
15.5	hr	930min	7.35'	2.25'	
16.0	hr	960min	↓	↓	
16.5	hr	990min			
17.0	hr	1020min			
17.5	hr	1050min			
18.0	hr	1080min			
18.5	hr	1110min			
19.0	hr	1140min			
19.5	hr	1170min			
20.0	hr	1200min			
20.5	hr	1230min			
21.0	hr	1260min			
21.5	hr	1290min			
22.0	hr	1320min			
22.5	hr	1350min			
23.0	hr	1380min			
23.5	hr	1410min	↓	↓	
24.0	hr	1440min	7.35'	2.75'	

COMMENTS:

K&E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS



C-16

K&E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS

WELL 1-A (6" WELL)

S.W.L. @ START OF TEST 605.49'

PUMPING RATE 30 GPM

S.W.L. 177' 601.70'

AN INCREASE OF 3.79'

IN WELL 177'

ELEV. TOP 6" CSG. 660.74'
55.25'
605.49

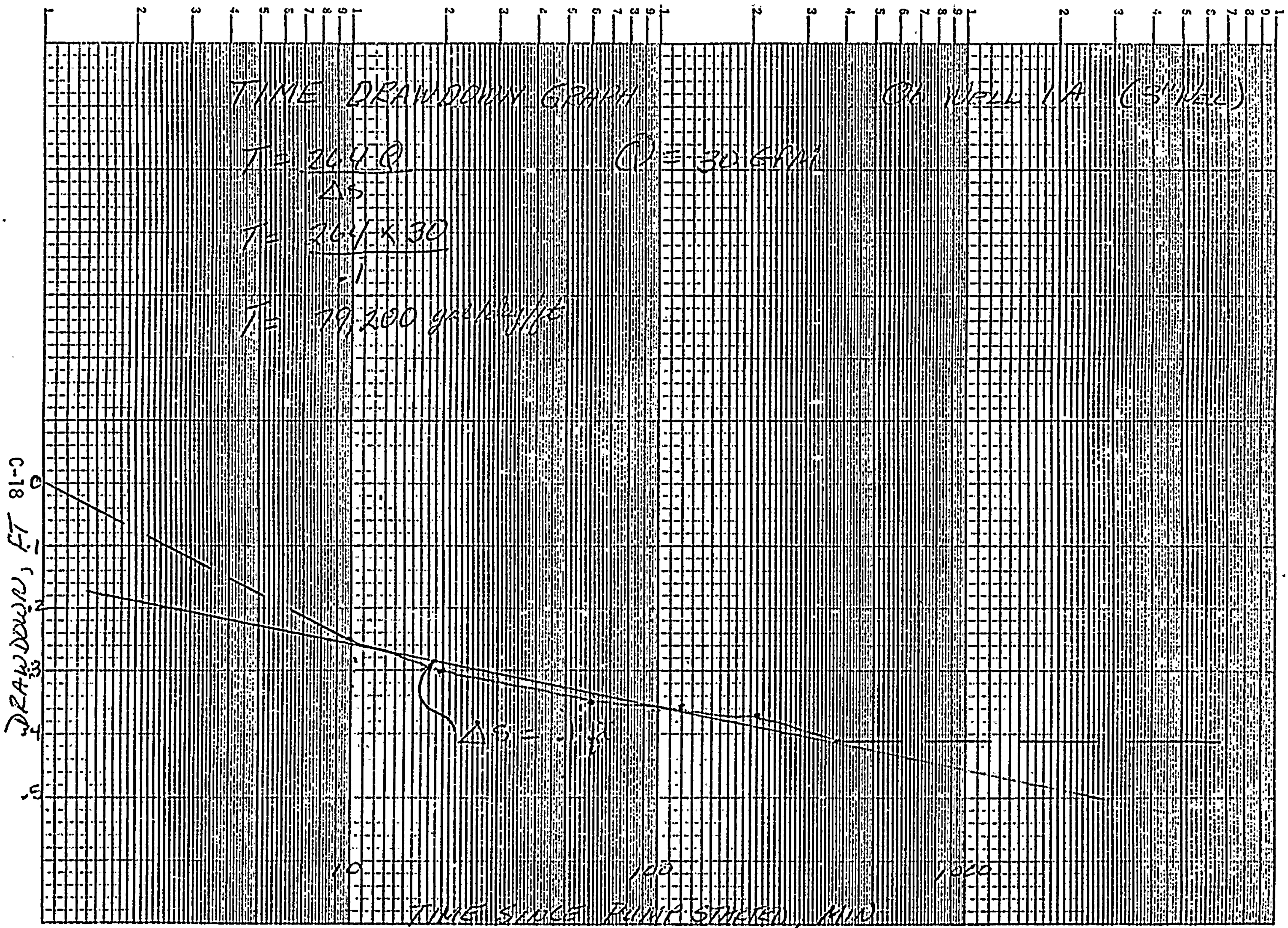
WELL 1-A OB WELL (3" WELL)

S.W.L. @ START OF TEST 606.04'

ELEV. TOP OF 3" CSG 661.54'
55.50'
606.04'

'79'

SEMI LOGARITHMIC 359 31
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES X 70 DIVISIONS



GEORGE B. COLE & SON
Drilling Contractor
3946 Evergreen Lane
Benton Harbor, Mich. 49022

PUMPING TEST RECORD

10 July 79
date

GREAT LAKES GEOPHYSICAL SERVICE
3946 Evergreen Lane
Benton Harbor, Mich. 49022

Project Monitor Well Pumping Test Well No. 1-A

Depth 76½' Diameter 6" Static Level 55'-3" Top Csg. Pumping Rate 306 GPM

Static Pilot Well No. 1 55'-6" Top Coupl. Distance from Pumped Well 10'

Static Pilot Well No. 2 ________ Distance from Pumped Well ________

Time since pump started			Drawdown in well	Drawdown in Pilot No. 1	Drawdown in Pilot No. 2
		1min	4.79'	.250'	
		2min	5.42'	.250'	
		3min	5.46'	.250'	
		4min	6.00'	.250'	
		5min	6.12'	.250'	
		6min	6.25'	.250'	
		7min	6.28'	.250'	
		8min	6.33'	.250	
		9min	6.33'	.250'	
		10min	6.34'	.250'	
		12min	6.35'	.290'	
		14min	6.36'	.290'	
		16min	6.37'	.290'	
		18min	6.38'	.290'	
		20min	6.39'	.300	
		30min	6.40'	.330	
		40min	6.41'	.333'	
		50min	6.42'	.340'	
1.0	hr	60min	6.43'	.345'	
1.5	hr	90min	6.45'	.350'	
2.0	hr	120min	6.47'	.355'	
2.5	hr	150min	6.48'	.360'	
3.0	hr	180min	6.50'	.365'	
3.5	hr	210min	6.52'	.370'	
4.0	hr	240min	6.54'	.390'	
4.5	hr	270min	6.56'	.400	
5.0	hr	300min	6.57'	.410'	
5.5	hr	330min	6.58'	.414'	
6.0	hr	360min	6.60'	.415'	
6.5	hr	390min	6.61'	.415'	
7.0	hr	420min	6.63'	.416'	
7.5	hr	450min	6.65'	.416'	
8.0	hr	480min	6.66'	.416'	
8.5	hr	510min	6.66'	.416'	
9.0	hr	540min	6.66'	.416'	
9.5	hr	570min	6.66'	.416'	
10.0	hr	600min	6.66'	.416'	
10.5	hr	630min	6.66'	.416'	
11.0	hr	660min	6.66'	.416'	
11.5	hr	690min	6.66'	.416'	
12.0	hr	720min	6.66'	.416'	
12.5	hr	750min	6.66'	.416'	
13.0	hr	780min	6.66'	.416'	
13.5	hr	810min	6.66'	.416'	
14.0	hr	840min	6.66'	.416'	
14.5	hr	870min	6.66'	.416'	
15.0	hr	900min	6.66'	.416'	

Time since pump started			Drawdown in well	Drawdown in Pilot No. 1	Drawdown in Pilot No. 2
15.5	hr	930min	6.67'	.417'	
16.0	hr	960min	6.67'	.417'	
16.5	hr	990min	6.67'	.417'	
17.0	hr	1020min	6.67'	.417'	
17.5	hr	1050min	6.67'	.417'	
18.0	hr	1080min	6.67'	.417'	
18.5	hr	1110min	6.67'	.417'	
19.0	hr	1140min	6.67'	.417'	
19.5	hr	1170min	6.67'	.417'	
20.0	hr	1200min	6.67'	.417'	
20.5	hr	1230min	6.67'	.417'	
21.0	hr	1260min	6.67'	.417'	
21.5	hr	1290min	6.67'	.417'	
22.0	hr	1320min	6.67'	.417'	
22.5	hr	1350min	6.67'	.417'	
23.0	hr	1380min	6.67'	.417'	
23.5	hr	1410min	6.67'	.417'	
24.0	hr	1440min	6.67'	.417	

COMMENTS:

K&E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS

'79'

WELL 11 (GILLILAND)

SWL @ START OF TEST 604.72'

Pumping Rate 25 GPM

Elev. @ Top Csg. 609.47'
4.75'
604.72'

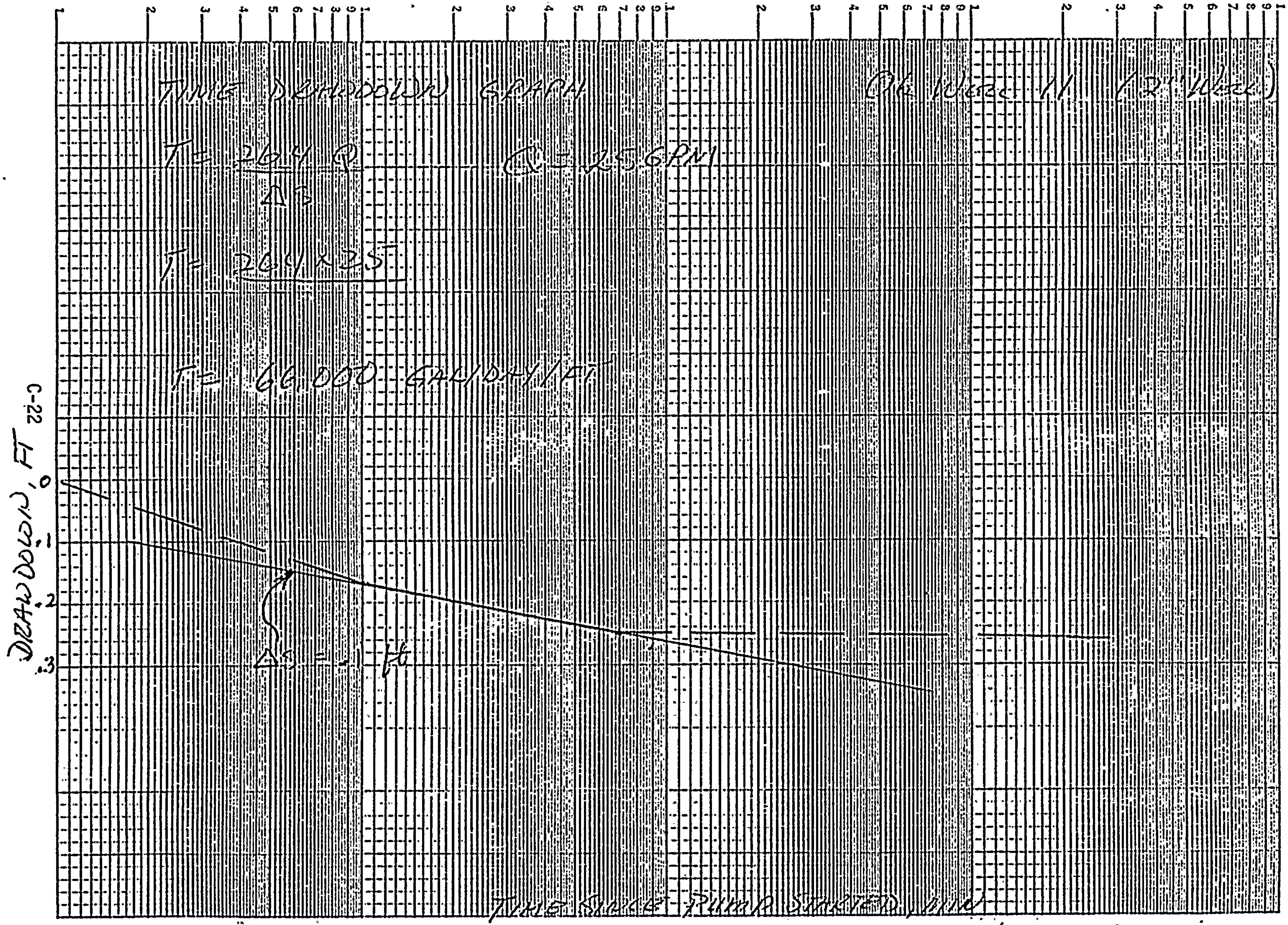
SWL 1771 599.59'

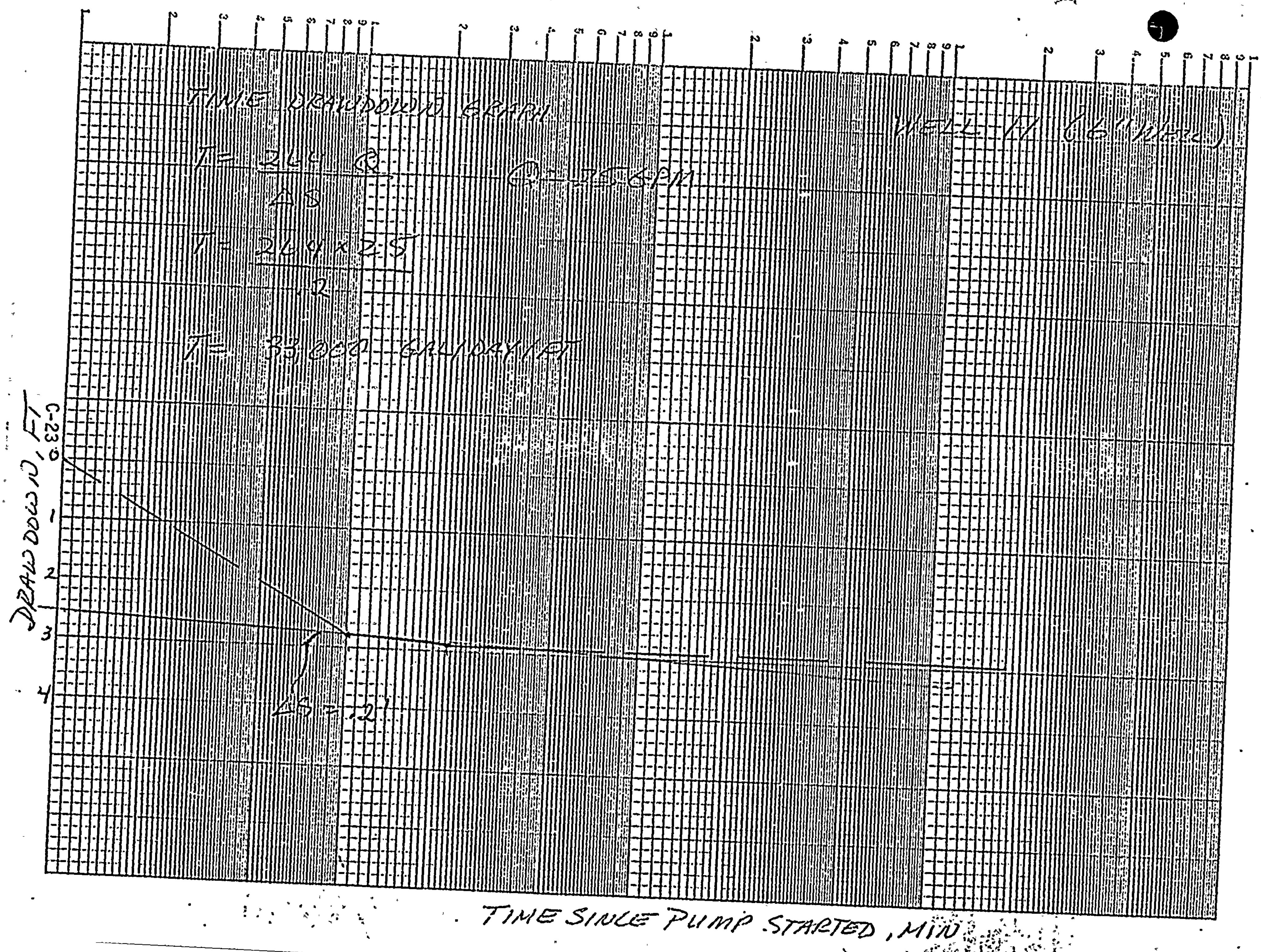
AN INCREASE OF 5.13'

DURING 1771

C-21

K&E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS




TIME DRAWDOWN GRAPH
WELL 11
T = 264 Q / ΔS
Q = 25 GPM
T = 264 x 25 / .2
T = 33 000 GAL/DAY/FT
ΔS = .2'
C-23
DRAWDOWN, FT
0
1
2
3
4
TIME SINCE PUMP STARTED, MIN

GEORGE B. COLE & SON
Drilling Contractor
3946 Evergreen Lane
Benton Harbor, Mich. 49022

PUMPING TEST RECORD

12 July 79
date

GREAT LAKES GEOPHYSICAL SERVICE
3946 Evergreen Lane
Benton Harbor, Mich. 49022

Project Monitor Well Pumping Test Well No. 11

Depth 25'-9½" Diameter 6 Static Level 4'-9" TOP CSG Pumping Rate 25GPM

Static Pilot Well No. 1 3'-9" TOP CSG Distance from Pumped Well 9'-6"

Static Pilot Well No. 2 ______ Distance from Pumped Well ______

Time since pump started			Drawdown in well	Drawdown in Pilot No. 1	Drawdown in Pilot No. 2 (CORRECTED FOR DRAINAGE)
		1min	2.75'	.166'	.165'
		2min	2.75'		
		3min	2.75'		
		4min	2.75'		
		5min	2.75'		
		6min	2.75'		
		7min	2.79'		
		8min	2.79'		
		9min	2.79'	.166'	.165'
		10min	2.83'	.170'	.169'
		12min	2.83'		
		14min	2.83'		
		16min	2.83'		
		18min	2.87'		
		20min			
		30min			
		40min		.170'	.169'
		50min		.250'	.247'
1.0	hr	60min			
1.5	hr	90min			
2.0	hr	120min			
2.5	hr	150min			
3.0	hr	180min			
3.5	hr	210min			
4.0	hr	240min			
4.5	hr	270min			
5.0	hr	300min			
5.5	hr	330min			
6.0	hr	360min			
6.5	hr	390min			
7.0	hr	420min			
7.5	hr	450min			
8.0	hr	480min			
8.5	hr	510min			
9.0	hr	540min			
9.5	hr	570min			
10.0	hr	600min			
10.5	hr	630min			
11.0	hr	660min			
11.5	hr	690min			
12.0	hr	720min			
12.5	hr	750min			
13.0	hr	780min			
13.5	hr	810min			
14.0	hr	840min			
14.5	hr	870min			
15.0	hr	900min	2.87'	.250	

Time since pump started			Drawdown in well	Drawdown in Pilot No. 1	Drawdown in Pilot No. 2
15.5	hr	930min	2.87'	.250'	
16.0	hr	960min			
16.5	hr	990min			
17.0	hr	1020min			
17.5	hr	1050min			
18.0	hr	1080min			
18.5	hr	1110min			
19.0	hr	1140min			
19.5	hr	1170min			
20.0	hr	1200min			
20.5	hr	1230min			
21.0	hr	1260min			
21.5	hr	1290min			
22.0	hr	1320min			
22.5	hr	1350min			
23.0	hr	1380min			
23.5	hr	1410min			
24.0	hr	1440min	2.87'	.250'	

COMMENTS:

K&E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO. MADE IN U.S.A.
4 CYCLES x 70 DIVISIONS

WELL 12 (6" Well)

S.W.L. @ START OF TEST 596.87'

Pumping Rate 25 GPM

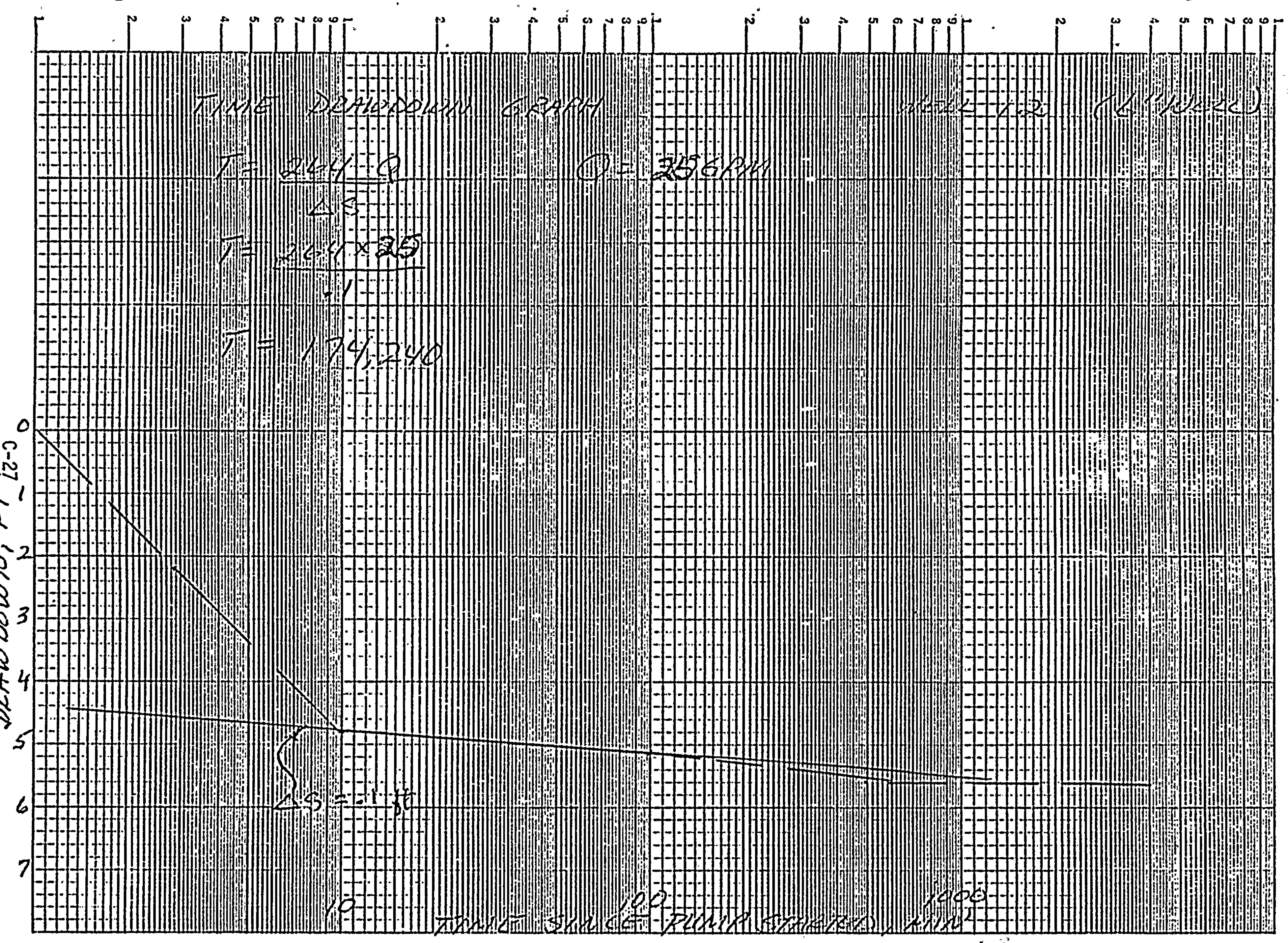
Elev @ Top 6" CSG 610.45'
13.58'
596.87'

S.W.L. 1977' 599.18'

AN INCREASE OF 3.49'

SINCE 1977'

K+E SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS



GEORGE B. COLE & SON
Drilling Contractor
3946 Evergreen Lane
Benton Harbor, Mich. 49022

PUMPING TEST RECORD

GREAT LAKES GEOPHYSICAL SERVICE
3946 Evergreen Lane
Benton Harbor, Mich. 49022

16 July
date

Project Monitor Well Pumping Test Well No. 12

Depth 32' Diameter 6" Static Level 13'-7" TOP CSG. Pumping Rate 25GPM

Static Pilot Well No. 1 14'-2¼" TOP CSG Distance from Pumped Well 10'

Static Pilot Well No. 2 ________ Distance from Pumped Well ________

Time since pump started			Drawdown in well	Drawdown in Pilot No. 1	Drawdown in Pilot No. 2
		1min	4.33'	.36'	
		2min	4.67'	.61'	
		3min	4.70'	.63'	
		4min	4.70'	.64'	
		5min	4.70'	.65'	
		6min	4.70'	.65'	
		7min	4.70'	.65'	
		8min	4.70'	.65'	
		9min	4.70'	.65'	
		10min	4.79'	.66'	
		12min	4.79'	.68'	
		14min	4.79'	.70'	
		16min	4.79'	.72'	
		18min	4.79'	.74'	
		20min	4.79'	.75'	
		30min	4.83'	.77'	
		40min	5.08'	.796	
		50min	5.08'	.81'	
1.0	hr	60min	5.08'	.82'	
1.5	hr	90min	5.14'	.83'	
2.0	hr	120min	5.17'	.86'	
2.5	hr	150min	5.21'	.87'	
3.0	hr	180min	5.25'	.90'	
3.5	hr	210min	5.27'	.91'	
4.0	hr	240min	5.29'	.92'	
4.5	hr	270min	5.31'	.94'	
5.0	hr	300min	5.33'	.96'	
5.5	hr	330min	5.42'	.98'	
6.0	hr	360min	5.50'	.99'	
6.5	hr	390min	5.50'	1.02'	
7.0	hr	420min	5.54'	1.02'	
7.5	hr	450min	5.54'	1.03'	
8.0	hr	480min	5.54'	1.04'	
8.5	hr	510min	5.54'	1.04'	
9.0	hr	540min	5.58'	1.04'	
9.5	hr	570min	5.60'	1.05'	
10.0	hr	600min	5.60'	1.05'	
10.5	hr	630min	5.60'	1.06	
11.0	hr	660min	5.60'	1.06'	
11.5	hr	690min	5.60'	1.06'	
12.0	hr	720min	5.60'	1.07'	
12.5	hr	750min	5.60'	1.07'	
13.0	hr	780min	5.60'	1.07'	
13.5	hr	810min	5.60'	1.07'	
14.0	hr	840min	5.60'	1.07'	
14.5	hr	870min	5.60'	1.07'	
15.0	hr	900min	5.60'	1.07'	

Time since pump started			Drawdown in well	Drawdown in Pilot No. 1	Drawdown in Pilot No. 2
15.5	hr	930min	5.60'	1.07'	
16.0	hr	960min	5.60'	1.07'	
16.5	hr	990min	5.60'	1.07'	
17.0	hr	1020min	5.60'	1.07'	
17.5	hr	1050min	5.60'	1.07'	
18.0	hr	1080min	5.60'	1.07'	
18.5	hr	1110min	5.60'	1.07'	
19.0	hr	1140min	5.60'	1.07'	
19.5	hr	1170min	5.60'	1.07'	
20.0	hr	1200min	5.60'	1.07'	
20.5	hr	1230min	5.60'	1.07'	
21.0	hr	1260min	5.60'	1.07'	
21.5	hr	1290min	5.60'	1.07'	
22.0	hr	1320min	5.60'	1.07'	
22.5	hr	1350min	5.60'	1.07'	
23.0	hr	1380min	5.60'	1.07'	
23.5	hr	1410min	5.60'	1.07'	
24.0	hr	1440min	5.60'	1.07'	

COMMENTS:

APPENDIX D
ICE CONDITIONS AT THE DONALD C. COOK NUCLEAR PLANT

ICE CONDITIONS AT THE DONALD C. COOK NUCLEAR PLANT IN SOUTHEASTERN LAKE MICHIGAN DURING THE WINTER OF 1978-1979.

Although the winter of 1978-79 was a severe one, it did not start until late December to form shore ice in the vicinity of the Cook Plant. An icefoot formed on the beach north of the plant on 20 December and underwent reductions and re-formations until 2 January. On 2 January there began a heavy snowstorm that continued until the afternoon of 4 January. At that time clearing occurred, revealing a complex of icefoot, first lagoon, first ice ridge, second lagoon, second ice ridge, and an outer ice field extending to the horizon.

West-Looking Camera Monitor, Daily Ice Conditions.

The west-looking camera was established to monitor conditions in the melthole resulting from the plant's discharges of waste heat. Because of its orientation some of the late afternoon pictures were of reduced quality from sunlight entering its lens. The ice conditions recorded by this monitor are summarized day by day in Table 1.

In front of the plant an icefoot formed on the beach on 25 December. A first ice ridge, just off the beach, formed on 26 December and on 28 December grew to join the icefoot. This ridge began melting on 29 December and was gone on 30 and 31 December, leaving only the icefoot on the beach.

During the snowstorm of 2-4 January the outer ice field pushed in to the beach and underwent compression shoreward. By 4 January there were established a first lagoon, a first ice ridge (farther off shore than the one formed 26 December), a second lagoon, a second ice ridge, a third lagoon, and a partial third ice ridge. The partial third ridge and the third lagoon melted during 5 January but re-formed during the night of 8-9 January and melted during 9 January.

During 10 January the second ridge was augmented with iceballs. On 13 January the outer ice field almost completely filled in the melthole. On both the 13th and 14th the second ridge was increased by iceballs from the melthole. During the night of 18-19 January the second ridge was augmented again, this time apparently with slush ice. During 21-22 January the melthole became completely filled with floe ice; the same happened on 24-25 January; and by 25 January the second ridge was augmented and a partial third ridge formed. Over the night of 25-26 January the partial third ridge was augmented with sandy ice. On 28 and 29 January the second ridge was again augmented with brash ice and/or small iceballs. The partial third ridge first seen on 25 January finished melting completely on 28 January. The second ridge received some augmentation with iceballs on 30 January.

By 1 February melting in the first lagoon (which began on 19 January and increased intermittently) had breached the second ridge. On 6 and 7 February the melthole was filled with floe ice. Progressive melting of the first lagoon and of the second ridge went on until the second ridge was completely gone from in front of the plant on 18 February, leaving only the icefoot on the beach.

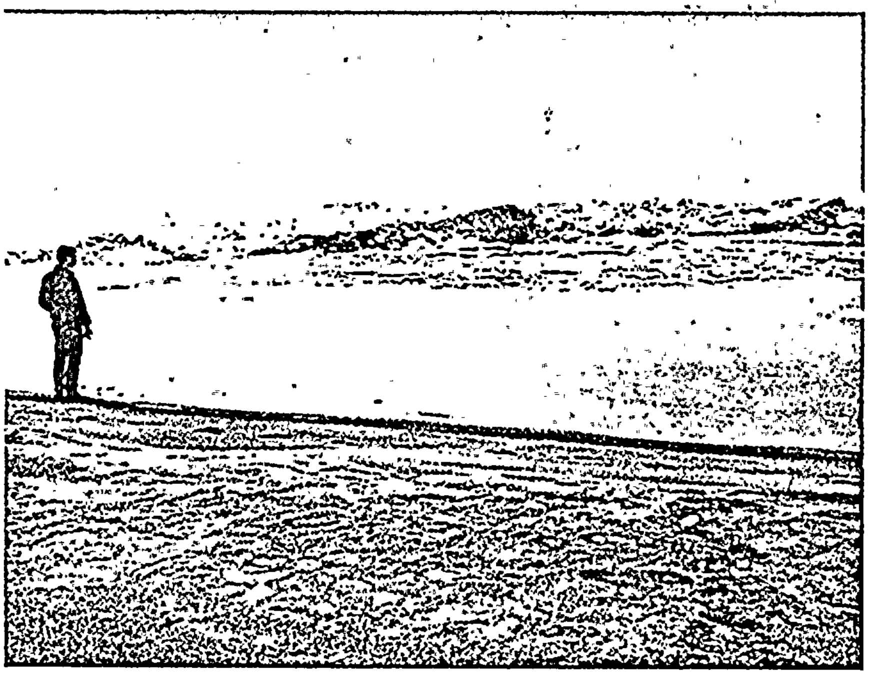


FIG. 1. Cross-section of the spring wreckage-ice structure showing its sandy nature and new white brash ice accreted to its top on 28 March. View is of the south side of the breach produced by leakage from the south discharge pipe. Slide #30, 29 March 1979.

FIG. 2. View lakeward through the breach caused by the leaking south discharge pipe. Width of the breach estimated to be about 60 feet. Slide #24, 29 March 1979.

From 8 February through 28 February the characteristic condition was that of a large melthole surrounded by an extensive ice field. The overflights of 1 February, 17 February, and 12 March showed that the melthole could change shape and orientation. During the first two overflights there could be no doubt that the outer ice field was composed of floes, slabs, and brash ice all solidly frozen into clear blue ice; under easterly winds this field would crack and create leads of open water, but the field would stay in sight. On 1 March the outer ice field was not visible; on 2 March it returned during the day; and on 3 March it receded from view again. It appears that about 1 March the outer field began losing its matrix of clear blue ice and converting to a more mobile field of progressively looser floes and slabs. The month of March featured more or less regular alternation of disappearance of the outer field and influxes of brash ice and floes which filled the melthole. Influxes of the outer field resulted in varying degrees of re-establishment of the second and third ice ridges in the plant vicinity; the re-establishments were always temporary. Given loose ice and wind onto shore, the ice-building processes were operative despite the presence of the plant's waste heat.

On 3 March the icefoot on the beach in front of the plant melted rapidly; it was gone by 4 March and did not re-form. The north-south extent of icefoot melting appeared to be associated with the north-south extent of melting in the first lagoon. The cause of the icefoot melting cannot be given, but at present a near-shore leak in the south discharge pipe appears apt to have been the causal agent, for icefoot melting was not observed in previous years when only road-salt run-off from the plant parking lots was reaching the first lagoon. The leaking pipe inserted warmed water into the first lagoon where it resulted in extra melting of the ice complex in front of the plant. It appears possible that warmed water in the lagoon might have warmed the interstitial water of the beach enough to have caused the icefoot melt (since the sheet-piling along much of the property front cuts off or materially reduces the natural ground water flow).

On 24 and 25 March breaking waves were present in the camera's field of view for the first time since freezeup; they probably indicated the demise of the outer ice field. On 25 March ice coming to shore formed two small ice ridges off the beach; these were strongly augmented during a heavy influx of ice pieces on 26 March. Further augmentation, elevation, and compression of the ice near shore was evident on 28 March and nearly all the ice showed incorporated sand coming to the surface as a lag concentrate from sun-melting. The surface sandiness was more pronounced on 29 March when Figure 1 was photographed. This aberrant shore-ice structure occurs in spring when wreckage from the outer ice field and the more normal ice complex is brought to shore by spring winds; this is the usual spring feature, although there are some springs when winds do not occur at the right time and the normal ice complex quietly melts in place. In the spring of 1979 the aberrant shore ice structure began melting on 1 April and was completely gone by 8 April.

Figure 1 shows a cross-section of the spring wreckage-ice structure where the leakage from the south discharge pipe had cut a breach. Sand incorporated in the ice and the rather homogeneous sizes of the component brash ice pieces are typical of this type of spring ice structure.

Figure 2, also taken on 29 march, shows the breach cut through the wreakage-ice structure by the leakage from the south discharge pipe. Estimating from the height of the man, the breach is about 60 feet wide and the ice stands 6 to 8 feet above the water surface. Except for this breach, this ice structure extended for miles on either side of the plant.

Overflights.

Overflights of the Cook Plant vicinity were made on 1 February, 17 February, and 12 March 1979.

The overflight of 1 February was made in severe cold and in the presence of many snow squalls. The flight was made under Instrument Flight Rules which handicapped us by requiring that we remain at sufficient altitude to be kept in the radar field of the South Bend, Indiana, airport. It was necessary to wait until mid-afternoon before even this limited permission could be obtained. A break in the snow squall pattern was utilized to overfly the region from St. Joseph to Cook Plant and return.

On 1 February the melthole of Cook units 1 and 2 was surrounded by an extensive outer icefield. The melthole disrupted the third ice ridge for a distance estimated (from the 712 foot length of the turbine building) to be about 2800 feet in front of the plant. The estimated dimensions of the melthole were: north-south 2800 feet and lakeward 5700 feet. Melting in the first lagoon extended from about the north range pole to about halfway to Livingston Road. In front of the plant the second ice ridge was breached in two places; each breach being fairly narrow. Conditions of the melthole and the shore ice structures are shown in Figures 3, 4, and 5.

The overflight of 17 February was in clear, but subzero, weather and under an east wind. There was an extensive offshore ice field of ice cakes and slabs frozen into clear blue ice; under the influence of the east wind the outer field had begun to move away from shore, creating openwater leads which were producing sea smoke in the bitter air temperature. Steam was visible over the melthole.

On 17 February the melthole of Cook Plant's discharges had its primary orientation lakeward and was estimated to be about 1800 feet north-south and about 5000 feet east-west. The melthole on this day extended to the beach, and for about 1400 feet in front of the plant the beach edge was exposed. Melting in the first lagoon extended from about the north range pole to about halfway to Livingston Road. Ice floes were forming from the outer ice field at the lakeward edge of the melthole but were being held there by the east wind. Figures 6 and 7 show these conditions.

The overflight on 12 March was made in more seasonable, but still subfreezing, weather. The sky was fairly clear and there was some wind from the east which had opened some leads in the outer icefield. The outer field was composed of ice cakes and slabs.

During this overflight the melthole had its largest dimension (about 4600 feet) in the north-south direction and was about 2100 feet east to west. The melted first lagoon extended from about the north range pole to about Livingston Road, but on this day there was no icefoot on the beach from about the north range pole to beyond Livingston Road. Normal-looking ice ridges were present off the length of the company property except in the melthole itself.

There apparently had been a recent push of the outer ice field into the melthole, for a substantial belt of floes lay along the shoreward side of the melthole at the positions of the second ice ridge and second lagoon. Some reconstruction of the second and third ridges had taken place. There were numerous ice floes in the melthole. Conditions on 12 March are shown in Figures 8 and 9.

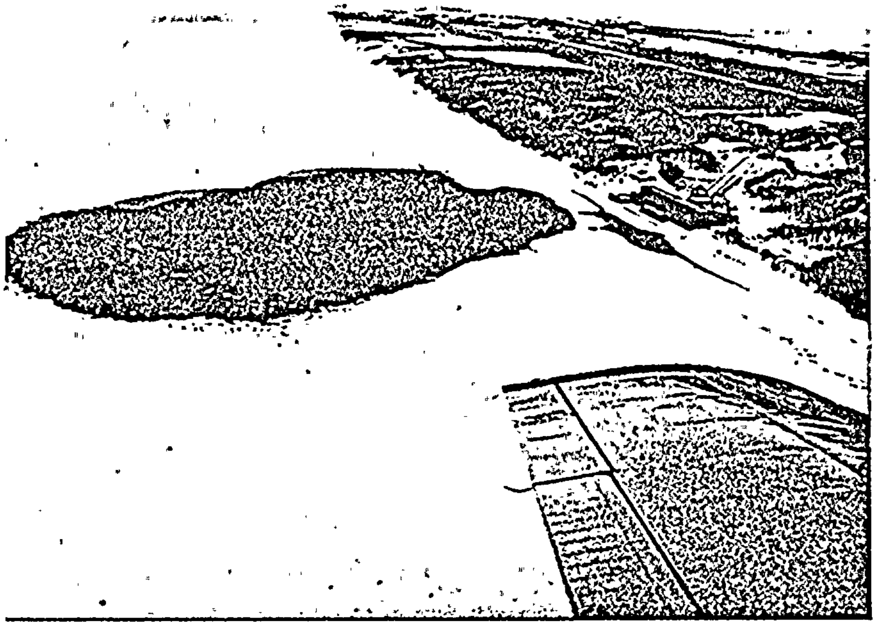


FIG. 3. The ice surrounded melthole of Cook Plant units 1 and 2 on 1 February 1979. Melting in the first lagoon and two breaches through the second ice ridge are visible in front of the plant. Slide #12.

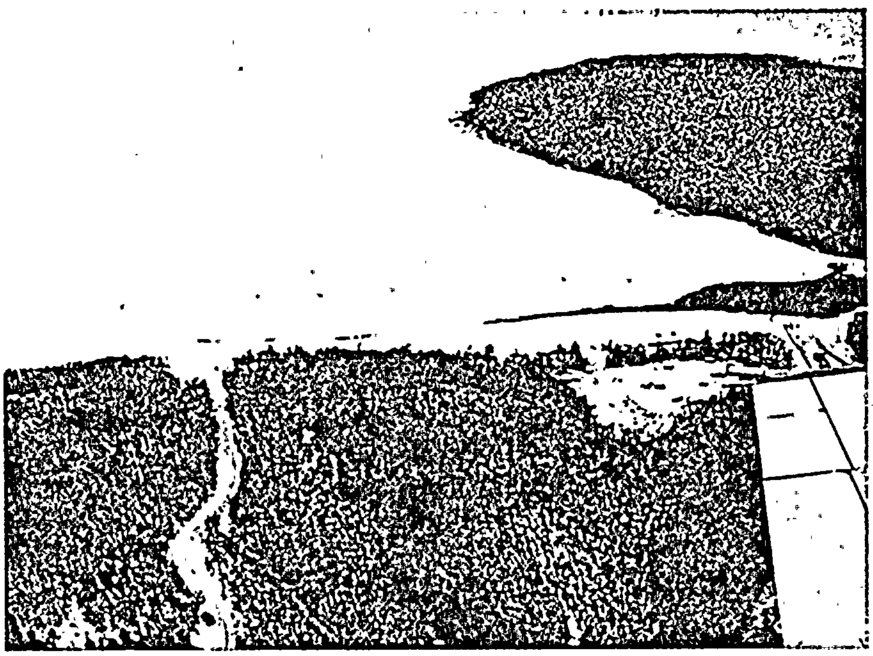


FIG. 4. View westward from inland the south edges of the melthole and of the melting in the first lagoon show on the right of center. Livingston Road, the south edge of the plant property, shows at the left of center. Slide #13, 1 February 1979.

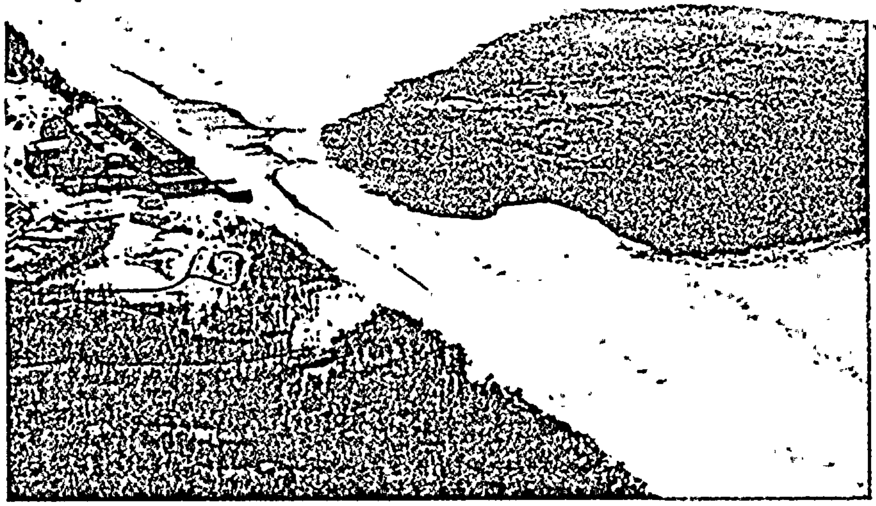


FIG. 5. View southwestward from inland. The north edges of the melthole and of the melting in the first lagoon show just below horizontal center of the picture. The visitors' center is just below horizontal center and near the left side. Slide #25, 1 February 1979.

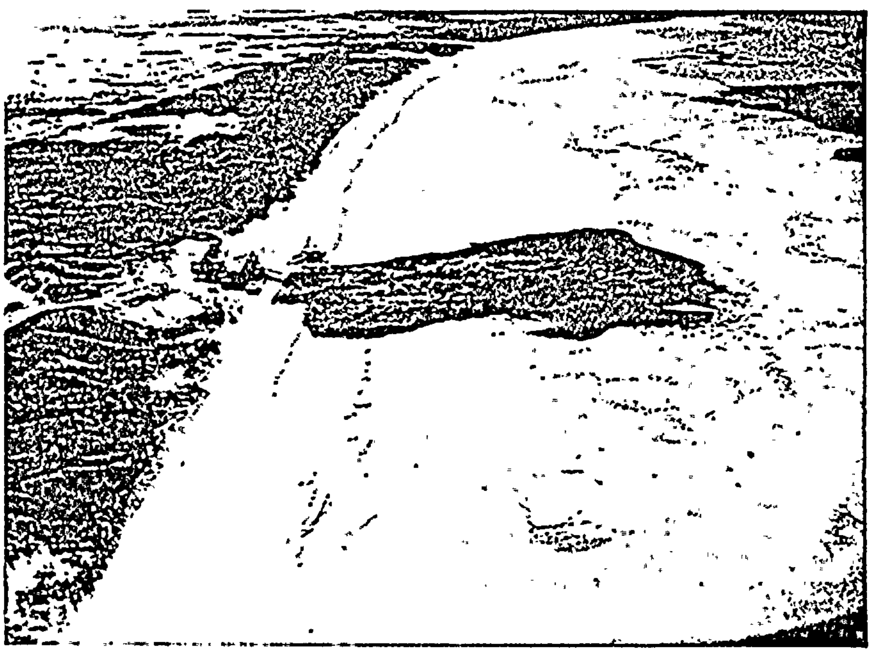


FIG. 6. The ice-surrounded melthole of Cook Plant units 1 and 2 on 17 February 1979. In front of the plant melting extends shoreward to the beach. Steam shows over the melthole water. An openwater lead in upper right has formed under the east wind of the day. Slide #2-9.

FIG. 7. View generally northward, showing melting to the beach. Melting in the first lagoon extends from about the north range pole southward to about halfway to Livingston Road. Slide #7-5, 17 February 1979.

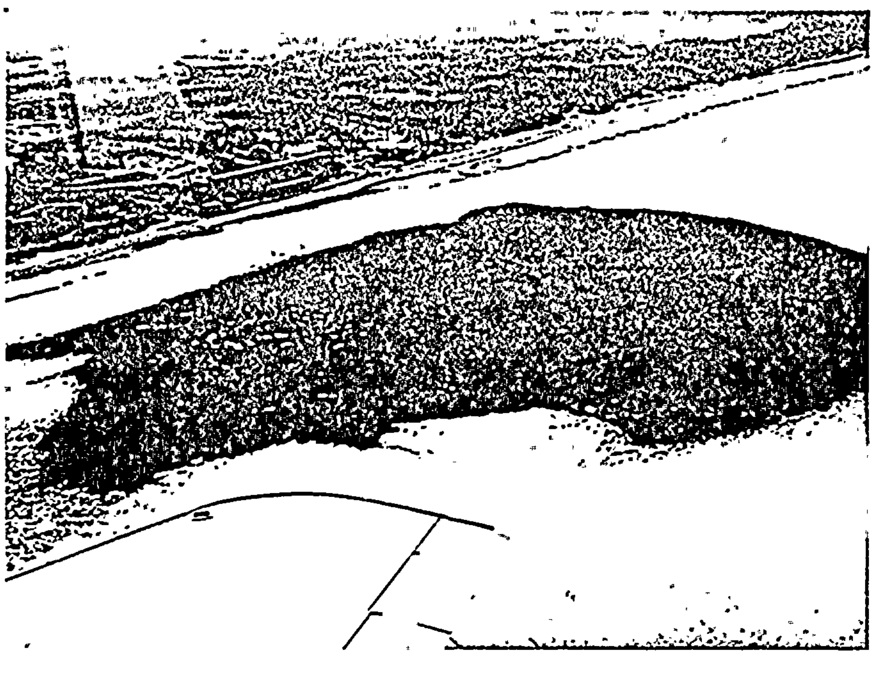


FIG. 8. The ice-surrounded melthole of Cook Plant units 1 and 2 on 12 March 1979. Floes coming from the outer ice field have crossed the melthole and made a re-formed ice cover along the shore. Slide B-16.

FIG. 9. View generally southward from near the north edge of the plant property; the north range pole shows to the right of the trailing edge of the wing-tip. Melting in the first lagoon extends from near the north range pole to about half-way to Livingston Road; runoff from the plant parking lots crosses the beach in a dark channel on this side of the plant. Beach devoid of icefoot extends from near the north range pole to beyond Livingston Road. In front of the plant there has been partial reconstruction of the second ice ridge (at the lakeward edge of the melted first lagoon); floes fill the second lagoon; and some reconstruction of the dark third ice ridge extends from south to north to end in front of the north end of the plant buildings. The reconstructions of both ice ridges are of white ice. Slide 1-34, 12 March 1979.

The overflights of 17 February and 12 March covered the shoreline from Indiana Harbor, Indiana, to Grand Haven, Michigan, to provide comparative data on ice conditions in other areas.

Effects of Two-Unit Operation on the Local Shore Ice.

Effects of two-unit operation on the local shore ice was probably supramaximal during the winter of 1978-1979. In addition to full two-unit operation, there was a leak in the south discharge pipe near the shoreline. Warmed water from this leak induced nearshore melting of the ice complex; this melting was, to an unknown degree, in excess of what would have taken place had the discharge pipe been intact.

During a visit to the plant on 25 January 1979 there was, over the south discharge pipe, a strip estimated to be 30-40 feet wide, completely melted from the beach out to the main melthole. During the overflight of 1 February there were two rather narrow breaches through the second ice ridge and an expanded area of melting in the first lagoon. We believe that water from the leaking pipe ponded in the first lagoon and melted the northern of the breaches through the ice ridge. During the overflight of 17 February the ice was melted from beach to melthole along a stretch estimated to be about 1400 feet long in front of the plant. The overflight of 12 March showed a belt of brash ice between the melthole and the shore; though the brash ice near shore was probably the result of an invasion of the melthole by the outer ice field, we consider that the condition seen on 12 March would have been typical (or more typical) were the discharge pipe not leaking.

Although the plant's waste heat produced a large melthole in the ice complex during the winter of 1978-1979 (the first winter of two-unit operation), the melthole did not extend north-south to the limits of the plant site. In front of the plant the third ice ridge was disrupted and the second ridge underwent varying degrees of melting and re-formation. To the north and south of the melthole the normal ice complex of ridges and lagoons was present within the limits of the plant property and continued for miles in either direction.

Melting in the first lagoon was first observed during construction of Unit 1 and has been a characteristic feature of the shoreice complex since then. It is attributed to road-salt-containing runoff from the plant's parking lots. During the winter of 1978-1979 this melting was more extensive than previously, evidently as a result of warmed water from the leaking discharge pipe. The winter of 1978-1979 was the first in which melting of the icefoot on the beach was observed. Whether this would be a regular feature of two-unit operation with intact discharge pipes cannot now be determined.

Except for the area in front of the plant, the melted first lagoon and bared beach were protected from erosion by ice ridges.

TABLE 1. WEST-LOOKING CAMERA, DAILY ICE CONDITIONS.

24 December 1978. No ice visible.

25 December. Icefoot developed on the beach slightly back from water's edge.

26 December. Small first ridge built of slush balls has formed just lakeward of water's edge.

27 December. No change.

28 December. Ice ridge in water has accreted and joined to the icefoot.

29 December. Melting has separated the first ridge from the icefoot and both are smaller.

30 December. First ice ridge has disappeared, slush balls at water's edge.

31 December. As on 30 December.

1 January 1979. Storm. Rapid accretion of iceballs from the beach across the first lagoon to a new first ridge further off shore than that of 26 December.

2 January. Ice field extends nearly to the horizon beyond the lagoon and first ridge formed on 1 January. Snow.

3 January. Snow, compression of ice field toward shore.

4 January. Overnight there formed a second lagoon, a pressure ridge in the position of second ridge, a third lagoon and a part of a third ridge. Some snow.

5 January. A large melthole enclosed by floe ice has formed outside the second ridge from shore. Water in the melthole steams. Third lagoon and third ridge have disappeared.

6 January. As on 5 January.

7 January. As on 5 January.

8 January. As on 5 January.

9 January. A third lagoon and partial third ridge formed overnight but melted during the day.

10 January. Shoreward edge of melthole is nearer to shore and iceballs have been thrown up onto second ridge. Melthole larger than on 9th with an ice field outside it.

11 January. Static, no change from 10 January.

12 January. All pictures too dark.

TABLE 1 continued.

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13 January. Onshore movement of ice field has almost completely filled up the melthole.

14 January. Melthole redeveloping along its previous lakeward edge. Second ridge accreted by iceballs.

15 January. Shoreward edge of melthole reaches the second ridge and melts it during the day.

16 January. Very large melthole extends shoreward through the second ridge and into the second lagoon. Ice cakes in the melthole.

17 January. No pictures taken.

18 January. As on 16 January.

19 January. Second ridge has been augmented overnight. No outer ice field visible. Melting beginning in the first lagoon.

20 January. As on 19 January except that melting in the first lagoon has progressed.

21 January. Progressive arrival of a floe ice field to fill in the melthole. Melting in the first lagoon has progressed further.

22 January. Melthole completely filled with floe ice which extends to the horizon by the end of the day. Still further melting in the first lagoon.

23 January. Large melt hole has developed. Ice cakes in the shoreward edge of the melthole and an ice field in the far distance. More melting in the first lagoon.

24 January. No outer ice field visible. Floes moving into the melthole all day. Continued melting in the first lagoon.

25 January. Melthole full of floes in morning but hole was redeveloping along its lakeward edge by day's end. Second ridge somewhat augmented and a partial third ridge formed overnight. Slow melting in the first lagoon. Outer field returned.

26 January. Outer ice field present. Progressive melting of floes in the melthole. Some augmentation of the partial thrid ridge by sandy floes. Melting in the first lagoon is static.

27 January. Large melthole with outer ice field. Melting of floes in the melthole. Melting of the third ridge going on. Melt in the first lagoon is static.

28 January. Large melthole with outer ice field. Only a block of the third ridge is left. Second ridge is more continuous and is augmented with brash ice. Melt in the first lagoon is static.

TABLE 1 continued.

---

29 January. Outer ice field present. Floes in the melthole and the last block of the third ridge are gone. Second ridge has been augmented with white brash ice. Melt in the first lagoon is static.

30 January. As on 29 January.

31 January. Large melthole with outer ice field. Second ridge is less high. Increased melting in the first lagoon has begun to reach into the second ridge.

1 February. Large melthole with outer ice field. Melting in the first lagoon has increased and breached the second ridge. OVERFLIGHT THIS DAY.

2 February. Large melthole with outer ice field. Breach in second ridge is wider. Melting in the first lagoon. Shoreward edge of second ridge collapsing into first lagoon.

3 February. As on 2 February except that the breach through the second ridge is somewhat wider.

4 February. Snow until last picture of the day. Slush in the first lagoon water and in the breach through the second ridge. Melthole steams in the last picture.

5 February. As on 4 February.

6 February. Outer floe field encroaches into melthole, temporarily filling it. Breach in second ridge temporarily filled with brash. Slush in first lagoon.

7 February. Melthole full of floes. Breach in second ridge reopened. Edge collapse from second ridge into first lagoon. Slush gone from first lagoon.

8 February. Large melthole with outer ice field. Melthole open and steaming. Second ridge lower than on 7 February. Melting in first lagoon and in breach through second ridge. No left edge of breach visible.

9 February. Large melthole with outer ice field. Melthole open and steaming. Further melting in first lagoon and calving from second ridge into first lagoon.

10 February. Large melthole with outer ice field. Floes from outer field reached second ridge in morning but melted during the day. Second ridge is lower than on 9th.

11 February. No change from afternoon of 10 February.

12 February. Large melthole with outer ice field. Snow. Slush in first lagoon. Otherwise static as on 10th.

TABLE 1 continued.

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13 February. As on 10 February.

14 February. As on 10 February.

15 February. As on 10 February.

16 February. Essentially static. Some reduction in size of second ridge.

17 February. Snow in the morning. Melthole open and steaming. Substantial increase in width of open first lagoon. Second ridge is reduced to a single block. OVERFLIGHT THIS DAY.

18 February. Large melthole with outer ice field. Melthole open, steaming, and free of floes. Last block of second ridge has melted.

19 February. Large melthole with outer ice field. Snow. Slush present in the melthole, but it melts rapidly during the day.

20 February. Melthole large but surrounded by ice. Lake bottom visible in slide 2W197 just lakeward of the icefoot.

21 February. Large melthole with outer ice field. A few floes in the melthole during the day.

22 February. As on 21 February.

NOTE: On 22 February the west-looking camera was substituted for the one which looked northwest, while the stereo-camera system was overhauled. The camera was returned to looking west on 26 February.

26 February. Numerous large ice floes in the melthole. An extensive outer ice field is present beyond the melthole.

27 February. Unchanged from 26 February.

28 February. Floes in the melthole have melted except for a single row apparently grounded on the second sand bar. These melted progressively during the day. The outer ice field is present but distant.

1 March. No outer ice field visible. The last of the floes on the second sand bar melts during the day. Small amount of brash ice near shore late in the day.

2 March. Outer ice field returned during the day. A few floes in the melthole.

3 March. The outer ice field receded from view during the day. The icefoot on the beach decreased rapidly during the day.

4 March. Icefoot completely gone from the beach. A small amount of brash ice accumulated near shore during the day.

TABLE 1 continued.

5 March. Heavy influx of brash ice, filling the melthole. No outer ice field was visible. Melting in the first lagoon has begun.

6 March. Melthole partially re-formed in the brash ice field. Brash ice being compressed onto the second sand bar, re-forming a partial second ice ridge. Melting in the first lagoon.

7 March. Partial second ice ridge with brash ice and floes outside it.

8 March. Fog, no visibility.

9 March. As on 7 March. Melting in the first lagoon only little more than on 6th.

10 March. Influx of brash ice, filling the melthole. Second ice ridge diminishing.

11 March. Melthole re-establishing in the brash ice field. Second ice ridge still diminishing. Melting in the first lagoon appears static. Outer ice field evident.

12 March. Large melthole inside an outer ice field. Second ice ridge present but broken, with brash ice outside it. OVERFLIGHT THIS DAY.

13 March. Second ice ridge diminished further, became more broken, and was almost gone at the end of the day. Outer ice field was only a thin rim around the melthole.

14 March. Influx of ice cakes and brash ice, filling the melthole.

15 March. Melthole beginning to re-establish in an extensive field of floes and brash ice. Melting in the first lagoon has re-begun.

16 March. Melthole further developed in an extensive field of floes and brash ice. Further melting in the first lagoon.

17 March. Large melthole in an extensive field of floes and brash ice. Progressive melting in the first lagoon. Rapid melting of all ice during the day.

18 March. The only ice visible is the outer ice field in the far distance.

19 March. Poor visibility. Outer ice field in the far distance. A few floes in the melthole.

20 March. Poor visibility. Conditions apparently as on 19 March.

21 March. A few floes are the only ice visible.

22 March. Outer ice field in the far distance. A few floes in the melthole.

TABLE 1 continued.

23 March. Outer ice field possibly present in the far distance. A few floes in the melthole.

24 March. Moderate amount of floes, iceballs, and brash ice in the water near the beach. No outer ice field visible. Breaking waves outside the loose ice near shore, probably indicating the absence of an outer ice field.

25 March. Further accumulation of ice near shore, and compression of that ice to form two small ice ridges. Breaking waves outside the ice near shore.

26 March. Heavy influx of brash ice with further compression and elevation of the ice ridges. No outer ice field visible. No melthole. Melting in first lagoon beginning. No ice on the beach.

27 March. As on 26 March.

28 March. Ice near shore has been further compressed and elevated. Sand now evident in the ice, except in some new white ice along the outer edge.

29 March. As on 28 March, with further melting in the first lagoon.

30 March. As on 29 March.

31 March. As on 29 March.

1 April. White outer ice accreted on 28 March progressively melted during the day. Somewhat more melting in the first lagoon.

2 April. The sandy ice near shore has begun to melt on the lakeward side.

3 April. Progressive melting of both sides of the sandy ice near shore, forming brash on the lakeward side and a few pieces of brash in the melted first lagoon.

4 April. Further melting of the sandy ice near shore. White brash has been thrown onto the outer edge of the sandy ice. Inner edge of the ice has calved pieces into the first lagoon.

5 April. Continued melting of the sandy ice and calving of pieces into the first lagoon. Pieces of white brash in the first lagoon suggest that the sandy ice ridge has been breached outside of the field of view.

6 April. Breaching and continued melting of the sandy ice, with contribution of white brash into the first lagoon.

7 April. Final melting of the sandy ice ridge, leaving small amount of brash in the water along the beach.

8 April. Complete disappearance of ice.

9 April. No ice.

10 April. No ice. Camera removed.

APPENDIX E

ENVIRONMENTAL RADIATION DATA

TABLE OF CONTENTS

SUMMARY

During 1979, environmental media samples and analyzed in the Donald C. Cook environmental radiological monitoring program revealed the presence of radioactivity of natural and fallout origin. While levels of some radionuclides in several media were slightly higher than usual, with one exception none of the samples contained radioactivity clearly attributable to operation of the Cook Plant.

Findings for individual media are discussed below.

AIRBORNE RADIOACTIVITY

During the year gross beta concentrations in air particulates ranged from less than 0.01 to 0.16 pCi/m^3. There was no statistically significant difference in concentrations between indicator and background stations. Data are given on pages 20-23.

Airborne iodine-131 concentration was less than 0.1 pCi/m^3 for all samples analyzed.

Gamma spectrometry of monthly composites of air particulate filters indicated that the concentration of gamma emitters were less than 0.01 pCi/m^3 for both indicator and background stations. Data are presented on page 24.

Quarterly composites of air particulate filters were analyzed for Sr-89 and Sr-90. Strontium-89 concentrations were less than 0.002 pCi/m^3 for indicator and background locations. Strontium-90 concentrations ranged from less than 0.001 to 0.001 pCi/m^3 for indicator and background stations. These were generally in the range to be expected from measurements of the nuclides in this medium.

PRECIPITATION

Gamma isotopic analyses of monthly precipitation samples from indicator and background stations indicate the presence of no gamma emitters in concentrations exceeding 10 pCi/l (<3000 pCi/m^2). Strontium-89 and strontium-90 were less than 2 pCi/l and 1 pCi/l respectively in semiannual composites of precipitation samples from the indicator and background stations during the year, but traces of Sr-90 attributable to long term fallout were detected during the second half of the year. Data are given on page 30.

WATER SAMPLES

Samples of water from Lake Michigan are composited by indicator and background locations are analyzed for gamma emitters on a monthly basis. Gamma emitters were measured to be less than 10 pCi/l per nuclide for all samples. Quarterly composites of the monthly composites were analyzed for tritium. The tritium concentrations were in the range of 100 to 400 pCi/l for indicator stations, and 180 to 340 pCi/l for background stations. The tritium concentrations measured the usual ranges for environmental surface water in the Midwest. Data are presented on page 31.

WELL WATER

Well water is collected from seven on-site locations at 18 week intervals and analyzed for tritium and gamma emitters. In late 1977, one well was found to contain low, but easily measurable concentrations of tritium and a special program of monthly sampling was begun at five wells and the Lake Township water intake from Lake Michigan. Tritium in varying concentrations were found in many of the well water samples throughout the year, but gamma emitters were below detection sensitivities in all samples analyzed.

The tritium concentrations in the Lake Township intake ranged from less than 1.0 to 1.4 pCi/ml. The tritium concentrations in the other special samples ranged from less than 1.0 to 21.0 pCi/ml. Two samples collected in February and March at location 5 showed unusually high levels of tritium (300 and 1400 pCi/ml respectively). But these results may not be quantitative or indicate high levels of tritium, due to interference from large amounts of hydrocarbons in the liquid scintillation counting techniques. Modified sample collection techniques by the station personnel appear to have eliminated the presence of hydrocarbons in the water samples collected during April through December.

It is possible that the tritium found in these special samples is a result of plant operations and the matter is being investigated. Data for well water samples is given on pages 28 and 29.

MILK

Strontium-90 concentrations in milk samples continued to display considerable variation which is typical for this type of sample. This nuclide is attributable to worldwide fallout from both recent and older nuclear test programs. Data are given on page 26.

Iodine-131 and Sr-89 measured below the detection limits of the program. Data are presented on page 26.

Gamma emitters other than those which occur in nature were not detected in any samples at a measurement sensitivity of 10 pCi/l. Data are given on page 27.

FISH

Fish samples from areas north and south of the plant, both on- and off-site, were analyzed for gamma emitters, strontium-89, and strontium-90. No gamma emitters were detected at a sensitivity of 1 pCi/gram. Strontium-89 was below the detection limit of 0.05. Strontium-90 was below detection sensitivities for most samples and ranged to about 0.1 pCi/gram for those samples that did contain detectable concentrations of this nuclide. The concentrations observed were well within the range attributable to worldwide fallout. Data are given on page 32.

GAMMA RADIATION

Gamma radiation is measured with thermoluminescent dosimeters (TLD). Throughout the year, no significant differences were observed between indicator and background stations. The ambient levels of gamma radiation measured quarterly are presented on page 25. There was no statistically significant difference in dose rates between indicator and background locations, nor do they differ significantly from dose rates measured in previous years.

INTRODUCTION

The Donald C. Cook Nuclear Plant utilizes a pressurized water reactor with a radwaste hold-up and treatment system that has been designed to keep radioactive realeases to as low as is practical levels. However, small quantities of noble gases and radioiodine may be released to Lake Michigan. The quantities of radionuclides released to the environment are expected to be miniscule and insignificant as a source of potential exposure to flora and fauna in the area. However, direct radiation exposure to man and radionuclide accumulations in various components of food chains to man will be carefully monitored.

The environmental radiological monitoring program is intended to serve the following purposes:

a) To yield average values of radiation levels and concentrations of radioactive material in various media of the environment.

b) To identify sample locations and/or types of samples that deviate from the averages.

c) To document seasonal variations that could be erroneously interpreted when the power station is operating.

d) To indicate the range of values that should be considered "background" for various types of samples.

The basic approach for the Donald C. Cook Nuclear Plant is to control the release of radioactive material at levels far below that which would be expected to cause detrimental impact on the environment. The environmental radioactivity surveillance program will be closely coordinated with conditions of plant operation and subject to periodic review.

Levels of environmental radioactivity are subject to change for reasons in no way related to the operation of the D. C. Cook Nuclear Plant. Therefore, the radioactivity surveillance program has been designed to include reference or "background" stations as well as "indicator" stations. The program is summarized in Table I.

This report contains a compilation of the results of analyses of various types of samples collected during the period January 1979 through December 1979.

TABLE I

ENVIRONMENTAL MONITORING PROGRAM

DONALD C. COOK NUCLEAR PLANT

Sample Type	No. Station Ind.	No. Station Bkg.	Collection Frequency	Analysis Frequency	Type Analysis	Remarks
Air Particulate	6	4	Weekly	Weekly	Gross Beta	
				Monthly	Gamma Isotopic Composite, 2 Samples	By indicator and background samples.
				Quarterly	Sr-89, Sr-90	
Airborne I-131	6	4	Weekly	Weekly	Gamma Isotopic	
Precipitation	6	4	Monthly	Monthly	Gamma Isotopic Composite, 2 Samples	By indicator and background samples.
				Semi-annual	Sr-89, Sr-90 Composite, 2 Samples	By indicator and background samples.
Lake Water	3	4	Monthly	Monthly	Gamma Isotopic Composite, 2 Samples	By indicator and background samples.
				Quarterly	Tritium Composite, 2 Samples	By indicator and background samples.
Well Water	7	0	Every 18 wks.	Every 18 wks.	Gamma Isotopic Tritium	
Fish	2	2	2 per year	2 per year	Gamma Isotopic Sr-89, Sr-90	Edible portion only.

TABLE I (Cont'd)

ENVIRONMENTAL MONITORING PROGRAM

DONALD C. COOK NUCLEAR PLANT

Sample Type	No. Stations Ind.	- Bkg.	Collection Frequency	Analysis Frequency	Type Analysis	Remarks
Aquatic	2	2	2 per year	2 per year	Gamma Isotopic Sr-89, Sr-90	When available
Milk	4	3	Monthly	Monthly	Gamma Isotopic Sr-89, Sr-90 I-131	
Sediment	2	2	2x per year	2x per year	Gamma Isotopic Sr-89, Sr-90	
TLD	6	4	Quarterly	Quarterly	Total Dose	
Food Crops	1	1	Annually	Annually	Gamma Isotopic	

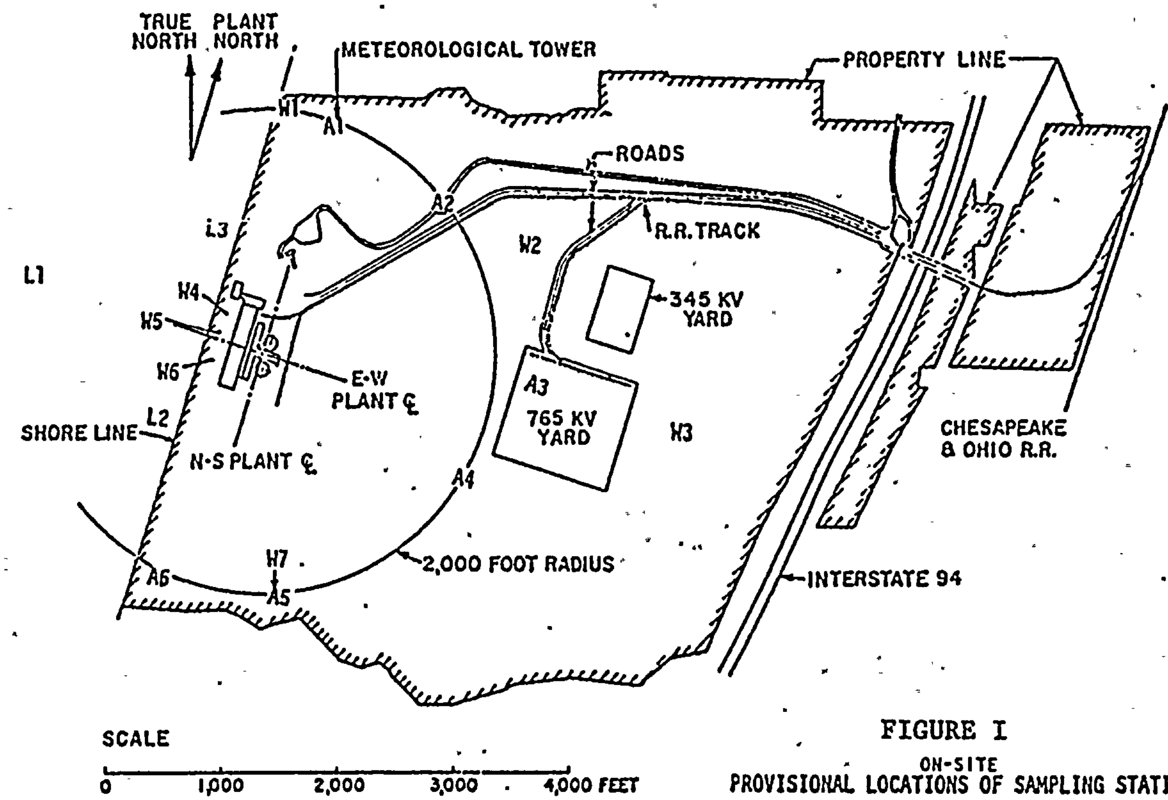

FIGURE I

ON-SITE
PROVISIONAL LOCATIONS OF SAMPLING STATIONS

A - Air, Precipitation, TLD Stations
W - Well Water Sample Stations
L - Lake Water Sample Stations

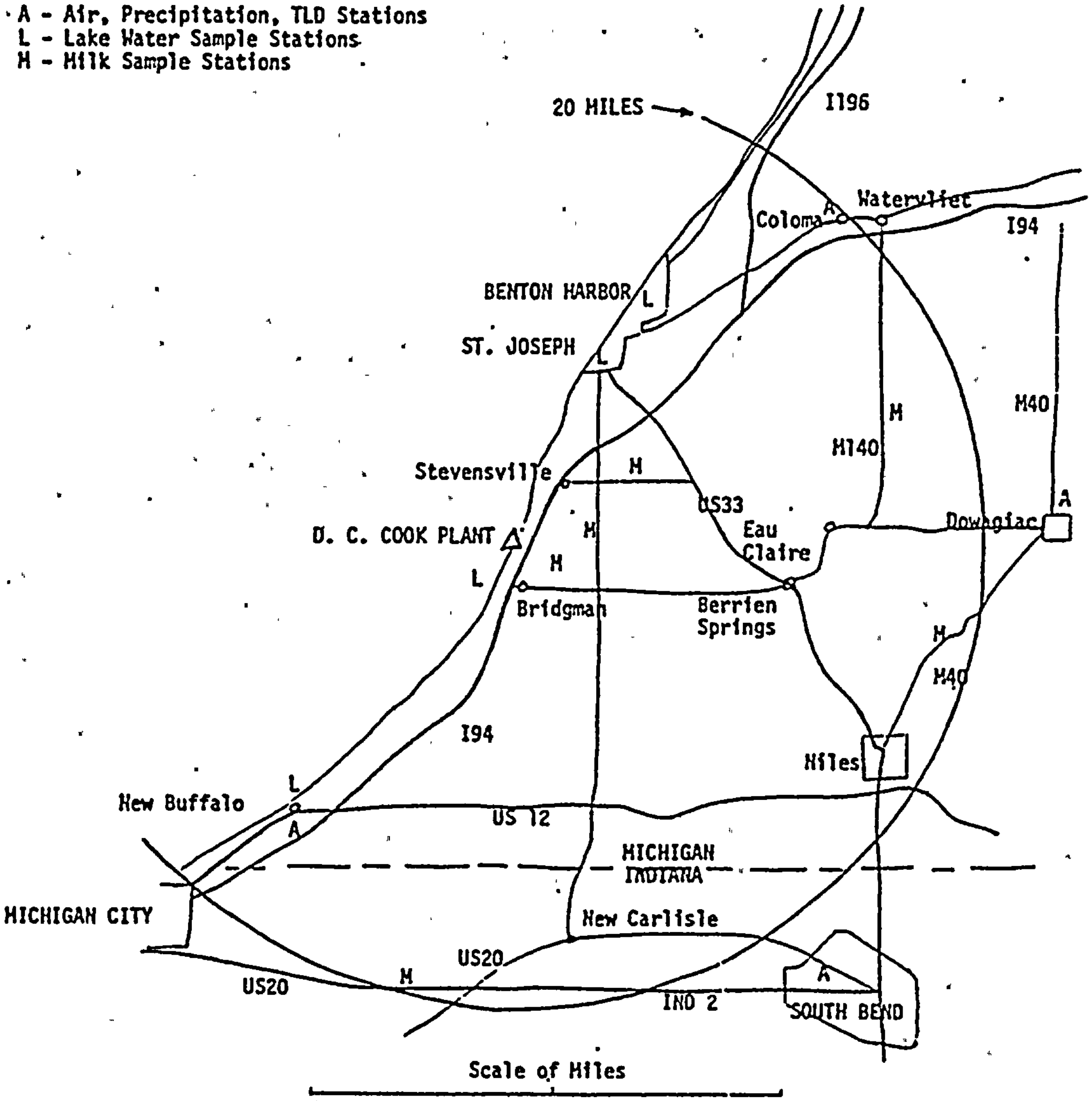

FIGURE II
OFF-SITE
PROVISIONAL LOCATIONS OF SAMPLING STATIONS

ANALYTICAL PROCEDURES

Analytical procedures employed are those followed by the U. S. Nuclear Regulatory Commission[1], E.P.A.[2] and H.E.W.[3]. Deviation from these procedures are instituted only when the revisions have been carefully researched and demonstrated to be superior to previously established procedures. Brief outlines of these methods may be found in the semi-annual report for the period 01 January through June 1972 with exceptions as noted below.

1. Tritium in lake water is measured by electrolytic enrichment followed by liquid scintillation counting. Well water samples were analyzed by liquid scintillation counting.
2. Potassium-40 in milk is determined by gamma spectrum (GeLi) analysis rather than atomic absorption spectrometry.
3. Gamma Isotopic analyses of all types of samples are made using a GeLi crystal and 4096 channel pulse height analyzer. Samples are counted in a uniform geometry of either a 550 ml Marinelli beaker or 10 cm diameter petri dish.

References

(1) HASL Procedures Manual, edited by John H. Harley, Health and Safety Laboratory, U. S. Atomic Energy Commission, 1972 edition, revised annually.

(2) National Environmental Research Center, Environmental Protection Agency; Handbook of Radiochemical Analytical Methods. Program Element 1HA 325. Office of Research and Development, Las Vegas, Nevada 89114.

(3) Radionuclide Analysis of Environmental Samples, A Laboratory Manual of Methodology, edited by H. L. Krieger, Richard J. Velten and Frantz J. Burmann, U.S. Department of Health, Education and Welfare, Division of Radiological Health, revised February 1966.

COLLECTION PROCEDURES

Collection procedures remained the same as those detailed in the semi-annual report for the period 01 January through 30 June 1973.

ANALYTICAL QUALITY CONTROL/QUALITY ASSURANCE PROGRAM

Approximately 20 percent of the analyses performed in the analtyical laboratory are for quality control purposes. Background, standards and check samples are counted at least once for each ten samples. Typical check samples are:

1. Split samples - Samples which are divided into two or more aliquots.
2. Blank samples - Samples which are known not to contain radioactivity.
3. Spiked samples - Samples to which known amounts of radioactivity have been added.

Data from check samples normally fall within the ranges to be expected from statistical considerations. When data fall outside these limits, an investigation is undertaken to determine the cause of the problem, and corrective action taken.

The Midwest Facility participates in intercalibration programs on a regular basis with the Federal E.P.A., U.S.D.O.E., International Atomic Energy Agency and other agencies. A summary of the quality control data is forwarded to the station on a monthly basis. These reports summarize all quality control data for the month, not only data associated with the D. C. Cook environmental radiological program. Table B summarizes data from the EPA intercalibration program as available for the period.

TLD Intercomparison Badges
Irradiated by Battelle Northwest Labs

1979

Badge	1st Qtr Known	1st Qtr Measured	2nd Qtr Known	2nd Qtr Measured	3rd Qtr Known	3rd Qtr Measured	4th Qtr Known	4th Qtr Measured
	Total mR less transportation control							
A	39	39±4	Not		54	44±12	100	94±10
B	82	80±8	Available		48	44±12	75	73±16
C	25	24±2			42	36±8	50	51±10
D	73	72±7			36	35±7	25	25±8
E	50	47±5			27	26±7	90	88±17
F	96	91±9			66	61±16	65	58±7
G	9	8±1			72	69±8	40	38±8
H	57	59±6			84	77±8	60	55±6
J	16	14±1			100	93±16	25	23±1
K	64	62±6			59	57±8	100	98±22

QUALITY CONTROL ANALYSES SUMMARY

1979

The tables below summarize results of samples run for process quality control purposes during the subject year. These listings are in addition to such measurements as detector backgrounds, check source values, radiometric-gravimetric comparisons, system calibrations, etc. Detailed listings of each measurement are maintained at the laboratory and are available for inspection if required.

BLANK SAMPLES

Nuclide Analyzed	Number of Determinations	Number of analyses exceeding the LLD for that analysis *
Gross Beta	80	1
Gross Alpha	52	0
Iodine-131	144	0
Strontium-89	199	0
Strontium-90	204	1
Gamma Emitters	44	0
Tritium H-3	45	0
Calcium-45	2	0
Uranium	9	0

SPLIT SAMPLES

Nuclide Analyzed	Number of Det'ns	No. agreeing within 2σ	No. agreeing within 3σ	No. differing by > 3σ *
Gross Beta	91	87	3	1
Gross Alpha	7	7	0	0
Iodine-131	23	23	0	0
Strontium-89	74	73	0	1
Strontium-90	88	83	4	1
Gamma Emitters	69	69	0	0
Tritium H-3	69	68	1	0
Calcium-45	6	6	0	0

SPIKED SAMPLES

Nuclide Analyzed	No. of Det'ns	Within 2σ of known	Within 3σ of known	differing from known by > 3σ *
Gross Beta	55	48	5	2
Iodine-131	17	16	1	0
Strontium-89	1	1	0	0
Strontium-90	60	54	4	2
Gamma Emitters	29	29	0	0
Tritium H-3	28	27	1	0
Calcium-45	3	3	0	0
Uranium	5	5	0	0

* Corrective actions were taken.

EPA INTERCOMPARISON RESULTS

1979

Sample Type	Analysis	Agency Value	Control Limits (3σ,n=1)	MWF Measured ±2σ error	Units
Air Filter	Gross α	5	15	3±1	pCi/filter
Air Filter	Gross β	18	15	20±2	pCi/filter
Air Filter	Sr-90	6	4.5	7±2	pCi/filter
Air Filter	Cs-137	6	15	9±1	pCi/filter
Water	Gross α	6	15	7±2	pCi/1
Water	Gross α	10	15	13±1	pCi/1
Water	Gross β	16	15	14±2	pCi/1
Water	Gross β	16	15	18±3	pCi/1
Water	H-3	1280	993	1230±300	pCi/1
Water	H-3	2270	1047	2300±200	pCi/1
Water	Sr-89	14	15	9±1	pCi/1
Water	Sr-90	6	4.5	6±1	pCi/1
Water	I-131	40	12	43±4	pCi/1
Air Filter	Gross α	14	15	13±1	pCi/filter
Air Filter	Gross β	63	15	72±7	pCi/filter
Air Filter	Sr-90	21	4.5	21±2	pCi/filter
Air Filter	Cs-137	21	15	19±2	pCi/filter
Water	H-3	1540	1010	1400±400	pCi/1
Water	Gross α	9	15	1±1	pCi/1
Water	Gross β	12	15	5±2	pCi/1
Milk	Sr-89	42	5	24±15	pCi/1
Milk	Sr-90	54	3	54±6	pCi/1
Milk	I-131	96	5	107±17	pCi/1
Milk	Cs-137	154	8	150±27	pCi/1
Milk	Ba-140	0	0	<10	pCi/1
Milk	Sr-89	23	5	34±7	pCi/1
Milk	Sr-90	30	1.5	31±5	pCi/1
Water	Gross α	18	5	18±4	pCi/1
Water	Gross β	22	5	27±6	pCi/1
Air Filter	Gross α	9	15	10±1	pCi/filter
Air Filter	Gross β	30	15	37±4	pCi/filter
Air Filter	Sr-90	10	5	11±1	pCi/filter
Air Filter	Cs-137	10	15	11±1	pCi/filter
Milk	Sr-89	5	15	<10	pCi/1
Milk	Sr-90	11	5	11±5	pCi/1
Milk	I-131	17	15	5±3	pCi/1
Milk	Cs-137	12	15	17±3	pCi/1
Milk	Ba-140	0	0	<30	pCi/1
Milk	K-40	1630	250	2300±300	pCi/1

USDOE QUALITY ASSESSMENT PROGRAM

1979

Sample Type	Nuclide	Known	Measured ±2σ error	Units
Air	Co-57	0.116 E+03	0.131±0.013 E+03	pCi/filter
Air	Sr-90	0.135 E+02	0.155±0.025 E+02	pCi/filter
Air	Ru-106	0.174 E+03	0.167±0.020 E+03	pCi/filter
Air	Sb-125	0.749 E+03	0.823±0.082 E+03	pCi/filter
Air	Cs-134	0.985 E+02	0.947±0.095 E+02	pCi/filter
Air	Ca-45	0.134 E+03	0.230±0.023 E+03	pCi/filter
Soil	K-40	0.216 E+02	0.235±0.024 E+02	pCi/g
Soil	Sr-90	0.200 E+00	0.200±0.080 E+00	pCi/g
Soil	Cs-137	0.240 E+00	0.266±0.027 E+00	pCi/g
Tissue	K-40	0.840 E+01	0.900±0.090 E+01	pCi/g
Tissue	Sr-90	0.440 E-02	<0.200 E+00	pCi/g
Tissue	Cs-137	0.230 E-01	0.120±0.030 E-01	pCi/g
Vegetation	K-40	0.225 E+03	0.220±0.022 E+03	pCi/g
Vegetation	Sr-90	0.573 E+01	0.593±0.059 E+01	pCi/g
Vegetation	Cs-137	0.256 E+00	0.280±0.030 E+00	pCi/g
Water	H-3	0.124 E+02	0.130±0.013 E+02	pCi/ml
Water	Na-22	0.843 E+00	0.907±0.091 E+00	pCi/ml
Water	Mn-54	0.737 E+00	0.800±0.096 E+00	pCi/ml
Water	Co-60	0.871 E+00	0.970±0.097 E+00	pCi/ml
Water	Cs-137	0.980 E+00	0.117±0.012 E+01	pCi/ml
Air	Be-7	0.147 E+04	0.140±0.020 E+04	pCi/filter
Air	Ca-45	0.115 E+03	0.133±0.030 E+03*	pCi/filter
Air	Mn-54	0.540 E+02	0.490±0.070 E+02	pCi/filter
Air	Co-60	0.135 E+03	0.150±0.030 E+03	pCi/filter
Air	Sr-90	0.101 E+02	0.107±0.050 E+02	pCi/filter
Air	Zr-95	0.252 E+03	0.210±0.030 E+03	pCi/filter
Air	Sb-125	0.146 E+04	0.160±0.030 E+04	pCi/filter
Air	Cs-137	0.130 E+03	0.125±0.014 E+03	pCi/filter
Air	Ce-144	0.294 E+04	0.240±0.041 E+04	pCi/filter
Air	K-40	0.793 E+01	1.267±0.307 E+01	pCi/filter
Soil	Cs-137	0.225 E-01	0.183±0.038 E-01	pCi/g
Soil	U	0.188 E+01	0.420±0.150 E 00	pCi/g
Vegetation	K-40	0.215 E+03	0.300±0.030 E+03	pCi/g
Vegetation	Sr-90	0.337 E+01	0.250±0.045 E+01	pCi/g
Vegetation	Cs-137	0.270 E 00	0.317±0.070 E 00	pCi/g

*correction for a calculation error was made.

Sample Type	Nuclide	Known	Measured ±2σ error	Units
Water	H-3	0.134 E+02	0.130±0.018 E+02	pCi/ml
Water	Na-22	0.153 E+01	0.130±0.020 E+01	pCi/ml
Water	Co-57	0.676 E 00	0.113±0.020 E+01	pCi/ml
Water	Co-60	0.124 E+01	0.120±0.015 E+01	pCi/ml
Water	Sr-89	0.342 E 00	0.340±0.030 E 00	pCi/ml
Water	Cs-137	0.124 E+01	0.103±0.020 E+01	pCi/ml
Water	U	0.356 E-01	0.400±0.141 E-01	pCi/ml
Air	Co-58	0.279 E+03	0.180±0.031 E+03	pCi/filter
Air	Sr-89	0.473 E+02	0.380±0.076 E+02	pCi/filter
Air	Sr-90	0.164 E+02	0.210±0.042 E+02	pCi/filter
Air	Ru-106	0.500 E+03	0.570±0.060 E+03	pCi/filter
Air	Cs-134	0.288 E+03	0.255±0.037 E+03	pCi/filter
Air	Cs-137	0.347 E+03	0.275±0.042 E+03	pCi/filter
Soil	K-40	0.245 E+01	0.460±0.092 E+01	pCi/g
Soil	Co-60	0.668 E 00	0.500±0.283 E 00	pCi/g
Soil	Sr-90	0.251 E+01	0.120±0.028 E+01	pCi/g
Soil	Cs-137	0.608 E+02	0.390±0.255 E+02	pCi/g
Tissue	Sr-90	0.233 E+01	0.258±0.030 E+01	pCi/g
Water	H-3	0.304 E+02	0.293±0.029 E+02	pCi/ml
Water	Ca-45	0.940 E 00	0.867±0.116 E 00	pCi/ml
Water	Zn-65	0.232 E+01	0.220±0.022 E+01	pCi/ml
Water	Sr-90	0.135 E 00	0.190±0.035 E 00	pCi/ml
Water	Cs-134	0.113 E+01	0.120±0.012 E+01	pCi/ml
Water	Cs-137	0.152 E+01	0.155±0.016 E+01	pCi/ml

DATA TABLES

COMMENTS ON, AND TERMS USED IN DATA TABLES

Wet Weight	a reporting unit used with organic tissue samples such as vegetation and animal samples in which the amount of sample is taken to be the weight as received from the field with no moisture removed.
Dry Weight	a reporting unit used for soil and sediment in which the amount of sample is taken to be the weight of the sample after removal of moisture by drying in an oven at about 110°C for about 15 hours.
pCi/m^3	a reporting unit used with air particulate and radioiodine data which refers to the radioactivity content expressed in picocuries of the volume of air expressed in cubic meters passed through the filter and/or the charcoal trap. Note that the volumes are not corrected to standard conditions.
Gamma Emitters or Gamma Isotopic	samples were analyzed by high resolution (GeLi) gamma spectrometry. The resulting spectrum is analyzed by a computer program which scans from about 50 to 2000 kev and lists the energy peaks of any nuclides present in concentrations exceeding the sensitivity limits set for that particular experiment.
NA, NS, NR	used in place of a concentration value when a sample was not available (NS), or when a sample was not analyzed for some specific measurement (NA), or when an analysis is not required (NR).
Error Terms	figures following "±" are error terms based on counting uncertainties at the 2σ (95% confidence) level. Values preceded by the "<" symbol were below the stated concentration at the 3σ (99% confidence) level.
Sensitivity	In general, all analyses meet the sensitivity requirements of the program as given in Table II. For the few samples that do not (because of inadequate sample quantities, analytical interferences, etc.) the sensitivity actually obtained in the analysis is given.
Comment	when all analyses of a particular type during the period resulted in concentrations below the sensitivity limits, a statement is made on the appropriate table rather than presenting a whole page of "<" data. If all but one or two data points are below the sensitivity limits, the previously mentioned convention is followed and the finite data are given as footnotes.

DONALD C. COOK

LISTING OF MISSED SAMPLES
1979

Sample Type	Location	Expected Collection Date	Reason
Air Particulate	ONS-1,4	01/03	Snow conditions
Milk	South Bend	01/06	No milk left when collector arrived
Air Particulate	ONS-4,5, South Bend, Dowagic, Coloma	01/17	Snow conditions
Lake Water	All stations	Jan., Feb.	Lake frozen
Lake Water	Indicators	March	Lake frozen
Lake Water	Composites	1st.Qtr.	No samples due to frozen lake
Milk	Scottsdale	02/03	No longer participating; looking for new station
Air Particulate	ONS-4	03/21 04/03,10,17,24 05/08,15,22,29	Area flooded
Milk	South Bend	04/14	Not available
Special Well Water	4,5,6	April, August, December	-
Air Particulate	ONS-6	05/29, 06/05	Unable to remove lock
Special Well Water	11	06/12	Loss of electrical power
Air Particulate	All stations	06/12	Lost in shipment through mails
Air Particulate	ONS-4	07/03	Area flooded
Air Particulate	ONS-4	12/03	Road blocked with snow

DONALD C. COOK

AIRBORNE IODINE-131* and GROSS BETA in AIR PARTICULATE FILTERS
(Weekly Collections)

Gross Beta 10^{-2} pCi/m³

Collection Date	ON-SITE 1 Volume (m³)	ON-SITE 1 Gross β	ON-SITE 2 Volume (m³)	ON-SITE 2 Gross β	ON-SITE 3 Volume (m³)	ON-SITE 3 Gross β	ON-SITE 4 Volume (m³)	ON-SITE 4 Gross β	ON-SITE 5 Volume (m³)	ON-SITE 5 Gross β
01/03/79	(a)		405	1±1	330	6±1	(a)		310	7±1
01/10/79	630	6±1	390	1±1	350	2±1	670	6±1	290	7±1
01/17/79	295	2±1	315	1±1	285	6±1	(a)		(a)	
01/24/79	400	1±1	425	1±1	400	8±1	600	6±1	560	7±1
01/31/79	320	5±1	335	3±1	330	5±1	365	4±1	360	5±1
02/07/79	375	6±1	275	7±1	215	11±1	325	7±1	300	8±1
02/14/79	410	6±1	330	2±1	340	8±1	345	5±1	340	1±1
02/21/79	380	5±1	305	4±1	360	1±1	380	6±1	290	5±1
02/28/79	450	6±1	425	3±1	345	9±1	400	6±1	335	3±1
03/07/79	435	5±1	330	2±1	370	4±1	470	5±1	340	5±1
03/14/79	395	6±1	320	2±1	360	6±1	365	8±1	340	6±1
03/21/79	310	5±1	355	<1	410	<1	(a)		400	5±1
03/27/79	270	1±1	315	4±1	310	4±1	645	4±1	310	5±1
04/03/79	335	4±1	395	4±1	360	5±1	(a)		380	<1
04/10/79	330	5±1	370	5±1	350	6±1	(a)		395	6±1
04/17/79	345	3±1	385	3±1	380	4±1	(a)		375	3±1
04/24/79	360	1±1	415	<1	365	4±1	(a)		390	5±1
05/01/79	345	3±1	375	1±1	370	4±1	1525	4±1	390	4±1
05/08/79	370	4±1	355	4±1	365	4±1	(a)		390	4±1
05/15/79	405	1±1	370	2±1	395	4±1	(a)		405	4±1
05/22/79	270	3±1	340	1±1	275	3±1	(a)		290	3±1
05/29/79	305	3±1	300	3±1	280	5±1	(a)		285	4±1
06/05/79	335	4±1	340	<1	305	1±1	1105	5±1	290	5±1
06/19/79(a)	355	6±1	365	6±1	305	7±1	345	6±1	315	6±1
06/26/79	350	3±1	360	4±1	315	5±1	350	4±1	345	4±1

* Iodine cartridges are sampled weekly. Concentrations are <0.10 pCi/m³ unless otherwise noted.

(a) See Listing of Missed Samples.

DONALD C. COOK

AIRBORNE IODINE-131* and GROSS BETA in AIR PARTICULATE FILTERS
(Weekly Collections)

Collection Date	Gross Beta 10^{-2} pCi/m³ ON-SITE 1 Volume (m³)	ON-SITE 1 Gross β	ON-SITE 2 Volume (m³)	ON-SITE 2 Gross β	ON-SITE 3 Volume (m³)	ON-SITE 3 Gross β	ON-SITE 4 Volume (m³)	ON-SITE 4 Gross β	ON-SITE 5 Volume (m³)	ON-SITE 5 Gross β
07/03/79	330	4±1	350	4±1	310	5±1	(a)		340	5±1
07/10/79	375	4±1	365	4±1	340	4±1	760	4±1	350	6±1
07/17/79	375	2±1	275	5±1	335	4±1	330	6±1	260	6±1
07/24/79	360	6±1	320	5±1	350	5±1	360(b)	6±1	240	7±1
07/31/79	375	3±1	340	3±1	375	3±1	300	3±1	290	4±1
08/07/79	360	4±1	355	4±1	355	4±1	320	4±1	290	4±1
08/14/79	370	3±1	380	4±1	370	4±1	330	4±1	290	4±1
08/21/79	380	3±1	395	3±1	385	3±1	330	4±1	280	3±1
08/27/79	335	4±1	345	4±1	345	4±1	290	5±1	255	5±1
09/03/79	385	5±1	380	5±1	390	6±1	325	6±1	310	6±1
09/10/79	390	2±1	420	4±1	420	4±1	350	4±1	380	3±1
09/17/79	415	4±1	395	3±1	340	4±1	330	4±1	385	4±1
09/24/79	405	2±1	400	2±1	400	2±1	350	3±1	375	3±1
10/01/79	395	5±1	385	6±1	385	6±1	320	7±1	375	7±1
10/08/79	425	1±1	415	2±1	445	3±1	360	2±1	325	2±1
10/15/79	390	2±1	385	2±1	405	2±1	365	2±1	320	2±1
10/22/79	390	3±1	390	5±1	410	4±1	350	5±1	365	4±1
10/29/79	400	3±1	350	4±1	400	3±1	345	2±1	285	3±1
11/05/79	405	3±1	285	4±1	395	3±1	325	4±1	155	8±1
11/12/79	405	4±1	275	4±1	395	4±1	395	3±1	65	16±4(c)
11/19/79	405	6±1	300	7±1	390	7±1	340	5±1	260	7±1
11/26/79	405	6±1	270	7±1	400	4±1	330	6±1	330	7±1
12/03/79	400	3±1	340	4±1	395	4±1	(a)		325	5±1
12/10/79	295	3±1	410	4±1	385	4±1	670	4±1	330	3±1
12/17/79	400	3±1	420	3±1	390	3±1	345	3±1	320	3±1
12/24/79	380	4±1	395	5±1	350	5±1	325	5±1	315	5±1
12/31/79	415	2±1	445	3±1	400	3±1	355	3±1	330	3±1

(c) Low sample volume for unknown reasons.
(a) See Listing of Missed Samples. (b) Pump shut from 0932-0935 to change vacuum gauge.
* Iodine cartidges are sampled weekly. Concentrations are <0.10 pCi/m³ unless otherwise noted.

DONALD C. COOK

AIRBORNE IODINE-131* and GROSS BETA in AIR PARTICULATE FILTERS
(Weekly Collections)

Gross Beta 10^{-2} pCi/m^3

Collection Date	ON-SITE 6 Volume (m^3)	ON-SITE 6 Gross Beta	Collection Date	NEW BUFFALO Volume (m^3)	NEW BUFFALO Gross Beta	SOUTH BEND Volume (m^3)	SOUTH BEND Gross Beta	DOWAGIAC Volume (m^3)	DOWAGIAC Gross Beta	COLOMA Volume (m^3)	COLOMA Gross Beta
01/03/79	325	7±1	12/30/79	370	10±1	350	9±1	415	9±1	350	9±1
01/10/79	330	<1	01/06/79	370	7±1	395	7±1	405	2±1	340	1±1
01/17/79	245	8±1	01/17/79	395	4±1	(a)		(a)		(a)	
01/24/79	285	1±1	01/24/79	410	2±1	920	1±1	805	4±1	660	7±1
01/31/79	230	3±1	01/27/79	360	8±1	340	6±1	385	6±1	325	7±1
02/07/79	205	4±1	02/03/79	390	3±1	370	5±1	385	<1	330	3±1
02/14/79	335	5±1	02/10/79	335	12±1	420	1±1	370	1±1	330	2±1
02/21/79	380	<1	02/17/79	385	<1	380	1±1	405	6±1	315	7±1
02/28/79	350	3±1	02/24/79	345	3±1	380	3±1	360	1±1	300	<1
03/07/79	355	5±1	03/03/79	405	3±1	420	6±1	385	6±1	320	7±1
03/14/79	360	1±1	03/10/79	390	7±1	405	6±1	345	7±1	340	6±1
03/21/79	355	2±1	03/17/79	370	1±1	325	5±1	400	1±1	490	1±1
03/27/79	290	4±1	03/24/79	375	6±1	315	1±1	365	6±1	545	1±1
04/03/79	60	5±2	03/31/79	365	4±1	350	4±1	350	4±1	445	3±1
04/10/79	355	7±1	04/07/79	450	<1	390	5±1	395	6±1	370	6±1
04/17/79	225(b)	<1	04/14/79	365	5±1	350	<1	370	4±1	330	4±1
04/24/79	290	2±1	04/22/79	400	4±1	340	4±1	375	4±1	425	1±1
05/01/79	290	<1	04/29/79	420	4±1	385	3±1	420	5±1	485	1±1
05/08/79	305	4±1	05/08/79	375	3±1	340	3±1	365	3±1	320	2±1
05/15/79	330	3±1	05/13/79	390	4±1	425	1±1	365	5±1	320	3±1
05/22/79	280	2±1	05/20/79	390	6±1	370	5±1	360	5±1	295	5±1
05/29/79	(a)		05/27/79	415	4±1	390	2±1	285	2±1	325	2±1
06/05/79	(a)		06/05/79	430	3±1	380	4±1	370	3±1	290	4±1
06/19/79	315	6±1	06/17/79	450	8±1	375	6±1	340	7±1	280	8±1
06/26/79	310	4±1	06/24/79	420	4±1	460	3±1	340	4±1	300	4±1

* Iodine cartridges are sampled weekly. Concentrations are <0.10 pCi/m^3 unless otherwise noted.

(a) See Listing of Missed Samples. (b) Power off during week; new meter installed 04/14/79.

DONALD C. COOK

AIRBORNE IODINE-131* and GROSS BETA in AIR PARTICULATE FILTERS
(Weekly Collections)

Gross Beta 10^{-2} pCi/m^3

	ON-SITE 6			NEW BUFFALO		SOUTH BEND		DOWAGIAC		COLOMA	
Collection Date	Volume (m^3)	Gross Beta	Collection Date	Volume (m^3)	Gross Beta	Volume (m^3)	Gross Beta	Volume (m^3)	Gross Beta	Volume (m^3)	Gross Beta
07/03/79	300	5±1	07/01/79	390	5±1	475	4±1	365	4±1	295	6±1
07/10/79	315	4±1	07/08/79	375	4±1	440	5±1	330	4±1	315	3±1
07/17/79	280	5±1	07/15/79	340	9±1	335	7±1	335	6±1	300	6±1
07/24/79	295	6±1	07/22/79	355	6±1	485	6±1	355	5±1	320	6±1
07/31/79	340	4±1	07/29/79	415	3±1	420	3±1	345	2±1	315	3±1
08/07/79	325	3±1	08/07/79	420	4±1	410	3±1	350	4±1	305	5±1
08/14/79	340	4±1	08/12/79	420	5±1	440	5±1	370	5±1	340	4±1
08/21/79	360	1±1	08/19/79	295	3±1	340	2±1	350	2±1	305	2±1
08/27/79	295	3±1	08/26/79	320	3±1	315	6±1	390	4±1	270	5±1
09/03/79	355	4±1	09/02/79	330	5±1	350	5±1	395	5±1	365	6±1
09/10/79	360	2±1	09/09/79	330	5±1	320	1±1	380	2±1	315	1±1
09/17/79	375	4±1	09/16/79	375	4±1	335	5±1	350	4±1	330	1±1
09/24/79	285	3±1	09/23/79	350	3±1	350	3±1	380	3±1	345	2±1
10/01/79	275	7±1	09/30/79	360	4±1	355	5±1	375	5±1	315	6±1
10/08/79	300	2±1	10/07/79	345	2±1	360	3±1	375	3±1	370	3±1
10/15/79	305	2±1	10/14/79	375	2±1	365	2±1	375	2±1	370	2±1
10/22/79	310	4±1	10/21/79	395	2±1	375	4±1	380	4±1	315	5±1
10/29/79	330	3±1	10/28/79	385	1±1	370	1±1	390	2±1	45	8±2
11/05/79	285	3±1	11/04/79	360	4±1	365	4±1	370	3±1	315	3±1
11/12/79	305	4±1	11/12/79	400	3±1	405	4±1	410	3±1	340	3±1
11/19/79	310	7±1	11/18/79	460	3±1	350	4±1	380	6±1	325	5±1
11/26/79	315	5±1	11/25/79	220	9±1	275	6±1	355	5±1	310	9±1
12/03/79	300	4±1	11/02/79	310	3±1	270	3±1	150	5±1	305	3±1
12/10/79	360	4±1	12/09/79	320	3±1	235	5±1	280	3±1	375	3±1
12/17/79	350	4±1	12/16/79	300	3±1	285	3±1	260	3±1	325	4±1
12/24/79	345	5±1	12/22/79	300	4±1	270	4±1	250	6±1	355	6±1
12/31/79	375	3±1	12/29/79	330	2±1	315	<1	355	3±1	385	2±1

* Iodine cartridges are sampled weekly. Concentrations are <0.10 pCi/m^3 unless otherwise noted.

DONALD C. COOK

GAMMA ISOTOPIC ANALYSIS OF MONTHLY AIR PARTICULATE COMPOSITES

Month	Indicator Stations	Background Stations
	Gamma Emitters pCi/m³	
January	<0.01	<0.01
February	<0.01	<0.01
March	<0.01	<0.01
April	<0.01	<0.01
May	<0.01	<0.01
June	<0.01	<0.01
July	<0.01	<0.01
August	<0.01	<0.01
September	<0.01	<0.01
October	<0.01	<0.01
November	<0.01	<0.01
December	<0.01	<0.01

STRONTIUM 89 AND STRONTIUM 90 ANALYSIS OF QUARTERLY AIR PARTICULATE COMPOSITES

Collection Period	Indicator Stations pCi/m³		Background Stations pCi/m³	
	Sr-89	Sr-90	Sr-89	Sr-90
1st Qtr.	<0.002	<0.001	<0.002	<0.001
2nd Qtr.	<0.002	0.001±0.001	<0.002	0.001±0.001
3rd Qtr.	<0.002	<0.001	<0.002	<0.001
4th Qtr.	<0.002	<0.001	<0.002	<0.001

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GAMMA RADIATION
(Quarterly)

(Measured using Thermoluminescent Dosimeters)

Date Annealed:	12/18/78	03/22/79	06/25/79	09/21/79
Date Read:	04/04/79	07/16/79	10/16/79	01/11/80
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Location	Measured mR/Week			
Indicator Stations				
On-Site 1	0.94±0.15	0.90±0.08	0.76±0.08	0.97±0.10
On-Site 2	1.01±0.19	0.89±0.11	0.76±0.08	0.99±0.10
On-Site 3	0.93±0.11	0.88±0.10	0.69±0.09	0.91±0.09
On-Site 4	0.96±0.14	0.72±0.08	0.65±0.08	0.94±0.09
On-Site 5	0.98±0.14	0.86±0.09	0.75±0.08	0.98±0.10
On-Site 6	0.96±0.19	0.85±0.09	0.72±0.07	0.96±0.12
Background Stations				
Coloma	0.91±0.15	0.70±0.11	0.72±0.11	0.95±0.11
Dowagiac	0.92±0.13	0.86±0.09	0.66±0.08	0.90±0.09
New Buffalo	1.00±0.20	0.86±0.16	0.64±0.06	0.94±0.09
South Bend	1.02±0.14	0.98±0.14	0.76±0.08	1.05±0.13

DONALD C. COOK

STRONTIUM 89*-90 and I-131 CONCENTRATIONS IN MILK SAMPLES
(Monthly Collections)

Collection Site:	Indicator Stations				Background Stations	
	Bridgman K2	Scottsdale K1	Stevensville K2	Galien	Dowagiac K1	South Bend K1
Collection Date	**I-131 pCi/l**					
01/06/79	<0.5	<0.5	<0.5	<0.5	<0.5	(a)
02/03/79	<0.5	(a)	<0.5	<0.5	<0.5	<0.5
03/03/79	<0.5		<0.5	<0.5	<0.5	<0.5
04/14/79	<0.5		<0.5	<0.5	<0.5	(a)
05/05/79	<0.5		<0.5	<0.5	<0.5	<0.5
06/02/79	<0.5		<0.5	<0.5	<0.5	<0.5
07/07/79	<0.5		<0.8(b)	<0.5	<0.5	<0.7(b)
08/04/79	<0.5		<0.5	<0.5	<0.5	<0.5
09/08/79	<0.5		<0.5	<0.5	<0.5	<0.5
10/06/79	<0.5		<0.5	<0.5	<0.5	<0.5
11/03/79	<0.5		<0.5	<0.5	<0.5	<0.5
12/01/79	<0.5		<0.5	<0.5	<0.5	<0.5
	Sr-90 pCi/l					
01/06/79	3±1	5±3	3±2	3±1	3±1	(a)
02/03/79	3±3	(a)	4±2	3±2	9±2	5±2
03/03/79	2±2		3±2	3±2	3±2	2±2
04/14/79	2±2		4±3	2±1	11±2	(a)
05/05/79	5±2		6±2	3±2	3±1	6±3
06/02/79	6±1		3±1	6±1	7±1	6±1
07/07/79	3±1		3±2	3±1	8±2	6±2
08/04/79	11±4		<1	5±3	11±3	6±5
09/08/79	3±1		6±3	3±1	7±4	4±1
10/06/79	8±3		<5(d)	4±1	3±3(c)	8±2
11/03/79	7±2		5±3	1±1	5±2	7±1
12/01/79	4±1		2±1	3±1	12±2	4±1

*Strontium-89 was determined on each sample and was <5 pCi/l unless otherwise noted.

(a) See Listing of Missed Samples. (b)Lower sensitivity due to delay in sample shipment.
(c) Sr-89 = <8 due to low chemical yield. (d) Lower sensitivity due to low chemical yeild.

DONALD C. COOK

RADIONUCLIDES IN MILK SAMPLES
(Monthly Collections)

	Indicator Stations				Background Stations	
Collection Site:	Bridgman K2	Scottsdale K1	Stevensville K2	Galien	Dowagiac K1	South Bend K1
Collection Date	Cs-137 pCi/l					
01/06/79	<10	<10	<10	<10	<10	(a)
02/03/79	<10	(a)	<10	<10	<10	<10
03/03/79	<10		<10	<10	<10	<10
04/14/79	<10		<10	<10	<10	(a)
05/05/79	<10		<10	<10	<10	<10
06/02/79	<10		<10	<10	<10	<10
07/07/79	<10		<10	<10	<10	<10
08/04/79	<10		<10	<10	<10	<10
09/08/79	<10		<10	<10	<10	<10
10/06/79	<10		<10	<10	<10	<10
11/03/79	<10		<10	<10	<10	<10
12/01/79	13±7		<10	<10	<10	<10
	Other Gamma Emitters pCi/l					
01/06/79	<10	<10	<10	<10	<10	(a)
02/03/79	<10	(a)	<10	<10	<10	<10
03/03/79	<10		<10	<10	<10	<10
04/14/79	<10		<10	<10	<10	(a)
05/05/79	<10		<10	<10	<10	<10
06/02/79	<10		<10	<10	<10	<10
07/07/79	<10		<10	<10	<10	<10
08/04/79	<10		<10	<10	<10	<10
09/08/79	<10		<10	<10	<10	<10
10/06/79	<10		<10	<10	<10	<10
11/03/79	<10		<10	<10	<10	<10
12/01/79	<10		<10	<10	<10	<10

(a) See Listing of Missed Samples.

DONALD C. COOK

RADIONUCLIDES IN WELL WATER SAMPLES
(18-week Interval Collections)

Collection Site:	ONS 1	ONS 2	ONS 3	ONS 4	ONS 5	ONS 6	ONS 7
Collection Date	Tritium pCi/l						
04/17/79	<1000	<1000	<1000	17000±2000	12000±1000	<1000	<1000
08/21/79	700±470	850±410	<1000	5100±500	2100±400	2100±400	2500±400
12/26/79	<1000	<1000	<1000	3600±400	3500±400	<1000	<1000
	Gamma Emitters pCi/l						
04/17/79	<10	<10	<10	<20(a)	<20(a)	<20(a)	<20(a)
08/21/79	<10	<10	<10	<10	<40(a)	<10	<10
12/26/79	<10	<10	<10	<10	<10	<10	<10

(a)Insufficient sample for more sensitive analysis.

TRITIUM CONCENTRATION IN WELL WATER SAMPLES
SPECIAL COLLECTION PROGRAM

Collection Date	pCi/ml (±2σ)					
	LTI (1)	No. 4	No. 5	No. 6	No. 11	No. 12
01/11/79(a)	<1	8.0±0.8	1.4±0.3	<1	7.8±0.8	<1
02/12/79	1.4±0.3	21±2	300±30(b)	<1	1.4±0.3	5.0±0.5
03/13/79	<1	21±2(b)	1400±100(b)	<1	<1	16±2(b)
04/17/79	0.32±0.11	(c)	(c)	(c)	0.91±0.12	1.2±0.10
05/15/79	<0.5	1.1±0.4	4.4±0.4	0.7±0.3	0.8 ±0.4	1.0±0.4
06/12/79	<1	9.2±0.9	<1	.68±.35	(c)	1.6±0.4
07/17/79	<0.2	5.72±0.26(d)	<0.2(d)	1.07±0.12(d)	<0.2	<0.2
08/21/79	.25±.10	(c)	(c)	(c)	.33±.10	.46±.10
09/21/79	.24±.09	3.5±0.4	1.4±0.3	0.66±0.10	.41±.11	1.20±0.1
10/16/79	.20±.10	2.6±0.4	2.2±0.4	1.50±0.20	.77±.10	.38±.09
11/79	.32±.12	2.3±0.2	2.9±0.4	2.3±0.2	.63±.11	.61±.11
12/26/79	.29±.07	(c)	(c)	(c)	.19±.07	.33±.07

(1) Lake Township Intake - Lake Water Sample
(a) Absorption Pond = 0.8±0.3 pCi/ml.
(b) Data may not be quantitative due to interference from hydrocarbons.
(c) See Listing of Missing Samples page.
(d) Sample contained oil.

DONALD C. COOK

GAMMA ISOTOPIC ANALYSIS OF PRECIPITATION SAMPLES
(Monthly Collections)

Collection Site:	Indicator	Background
Collection Period	Gamma Emitters nCi/m^2	
02/03-07/79 (Jan)	<0.5	<0.5
03/03-14/79 (Feb)	<0.5	<0.5
04/10-14/79 (Mar)	<4.0	<3.0
05/08/79 (Apr)	<5.0	<2.0
06/03-05/79 (May)	<0.2	<0.2
07/03-08/79 (June)	<0.1	<0.1
08/05-07/79 (July)	<0.2	<0.2
09/09-10/79 (August)	<0.6	<0.4
10/07-08/79 (Sept)	<0.8	<0.7
11/04-05/79 (Oct)	<0.1	<0.1
12/02-03/79 (Nov)	<0.1	<0.1
01/05-07/80 (Dec)	<0.1	<0.1

RADIOSTRONTIUM CONCENTRATIONS IN PRECIPITATION SAMPLES
(Semiannual Analysis on Composites of Monthlys)

	Indicator pCi/l		Background pCi/l	
Collection Period	Sr-89	Sr-90	Sr-89	Sr-90
January-June	<2	<1	<2	<1
July - December	<2	2±1	<2	<1

DONALD C. COOK

GAMMA EMITTERS IN LAKE WATER SAMPLES
(Monthly Composites of Indicator and Background Stations)

Month	Gamma Emitters pCi/l/nuclide Indicator Composite	Background Composite
January	(a)	(a)
February	(a)	(a)
March	(a)	<10
April	<10	<10
May	<10	<10
June	<10	<10
July	<10	<10
August	<10	<10
September	<10	<10
October	<10	<10
November	<10	<10
December	<10	<10

TRITIUM IN LAKE WATER SAMPLES
(Quarterly Composites of Monthly Samples)

Quarter	Tritium pCi/l Indicator Stations	Background Stations
1st	Lake frozen - - - -	No samples
2nd	400±130	340±120
3rd	300±110	180±120
4th	100±100	180±100

RADIONUCLIDES IN AQUATIC ORGANISMS
(Semiannual Collections when Available)

Location		Collection Date	pCi/g (wet) Sr-89	Sr-90	γ Emitters	-
North Onsite	ONS N	07/20/79	<0.05	0.026±0.008	<1	
St Joe Intake	OFS N	07/20/79	<0.05	0.016±0.002	<1	
South Onsite	ONS S	07/20/79	<0.05	0.036±0.009	<1	
Bridgman Intake	OFS S	07/20/79	<0.05	0.028±0.007	<1	
North Onsite	ONS N	09/20/79	<0.05	0.009±0.003	<1	
St Joe Intake	OFS N	09/20/79	<0.05	<0.02(c)	<1	
South Onsite	ONS S	09/20/79	<0.05	0.012±0.005	<1	
Bridgman Intake	OFS S	09/20/79	<0.05	<0.005	<1	

(a) See Listing of Missed Samples Page.
(b) Low sensitivity due to low tracer yield.
(c) Insufficient sample for more sensitive analysis.

DONALD C. COOK

RADIONUCLIDES IN SEDIMENT SAMPLES
(Semiannual Collections)

Collection Site	Collection Date	pCi/g (dry) Gamma Emitters	Sr-89	Sr-90
ONS N	05/29/79	<1	<.05	<.02(a)
ONS S	05/29/79	<1	<.05	<.03(a)
OFS N	05/29/79	<1	<.05	<.03(a)
OFS S	05/29/79	<1	<.05	<.03(a)
ONS N	09/17/79	<1	<0.5	<.01(b)
ONS S	09/17/79	<1	<.05	.15±.02
OFS N	09/17/79	<1	<.05	<.01(b)
OFS S	09/17/79	<1	<.05	.018±.013

RADIONUCLIDES IN FISH SAMPLES
(Semiannual Collections)

Collection Site	Collection Date	pCi/g (wet) Gamma Emitters	Sr-89	Sr-90
ONS N	10/18/79	<1	<0.05	0.010±0.009
ONS S	10/18/79	<1	<0.05	0.14±0.01
OFS N	10/18/79	<1	<0.05	<0.02(a)
OFS S	10/18/79	<1	<0.05	<0.005
ONS N	11/12/79 (c)	<1	<0.05	0.029±0.011
ONS S	11/12/79	<1	<0.05	0.032±0.007
OFS N	11/12/79	<1	<0.05	0.086±0.015
OFS S	11/12/79	<1	<0.05	0.060±0.009

RADIONUCLIDES IN FOOD CROPS
(Annual Fall Harvest Collection)

Collection Date	Collection Site: Sample Type	ON Site pCi/g (wet) Gamma Emitters	OFF Site
09/20/79	Grapes	<1	<1
09/20/79	Grape Leaves	<1	<1

(a) Lower sensitivity due to low chemical yield.
(b) Analytical detection limit not enough to meet sensitivity requirement.
(c) Fish samples were collected in late spring, sent and received by Eberline, and subsequently lost in the lab resulting in two (2) collections in the late fall.

Radiological Environmental Monitoring

Water Samples

Samples of water from Lake Michigan are composited by indicator and background stations and analyzed for gamma emitters on a monthly basis. All samples throughout the year 1979 for the five indicator stations and two background stations are analyzed for gamma emitters on a monthly basis. All samples throughout the year 1979 for the five indicator stations and two background stations show analysis results less than the concentration levels for each isotope listed in Table I.

Quarterly composites of the lake water composites are analyzed for Sr-89, Sr-90, and H-3. Results of these anlayses are listed in Table II.

TABLE I

DONALD C. COOK NUCLEAR PLANT

1979 LAKE WATER MONTHLY COMPOSITE GAMMA ISOTOPIC ANALYSIS

ISOTOPE	CONCENTRATION (µCi/cc)
I-131	< 5.660 E-8
Cs-137	< 3.342 E-8
Cs-134	< 2.482 E-8
Co-60	< 4.779 E-8
Co-58	< 3.205 E-8
Mn-54	< 2.246 E-8
Zn-65	< 6.260 E-8
Nb-95	< 2.977 E-8
Zr-95	< 4.986 E-8
Cr-51	< 2.353 E-7

TABLE II

DONALD C. COOK NUCLEAR PLANT
QUARTERLY LAKE WATER COMPOSITE SR-89, Sr-90, H-3 ANALYSIS

Location	Quarter	Concentration (μCi/cc) Sr-89	Sr-90	H-3
North Lake	1	<1.0 E-9	<1.0 E-9	<7.71 E-7
South Lake	1	<3.0 E-9	(2.8 ± 1.4) E-9	<7.71 E-7
Benton Harbor	1	<2.0 E-9	<1.0 E-9	<7.71 E-7
Bridgman	1	<2.0 E-9	<1.0 E-9	<7.71 E-7
Lake Township	1	<2.0 E-9	<1.0 E-9	<7.71 E-7
New Buffalo	1	<2.0 E-9	<1.0 E-9	<7.71 E-7
St. Joseph	1	<5.0 E-9	(4.0 ± 1.0) E-9	<7.71 E-7
North Lake	2	<3.0 E-9	<3.0 E-9	<7.71 E-7
South Lake	2	<4.0 E-9	<4.0 E-9	<7.71 E-7
Benton Harbor	2	<2.0 E-9	<2.0 E-9	<7.71 E-7
Bridgman	2	<2.0 E-9	(2.0 ± 2.0) E-9	<7.71 E-7
Lake Township	2	<1.0 E-9	(2.0 ± 2.0) E-9	<7.71 E-7
New Buffalo	2	<2.0 E-9	(2.0 ± 2.0) E-9	<7.71 E-7
St. Joseph	2	<2.0 E-9	<2.0 E-9	<7.71 E-7
North Lake	3	<8.0 E-9	(1.9 ± 0.9) E-8	<7.71 E-7
South Lake	3	(7.0 ± 5.0) E-9	<4.0 E-9	<7.71 E-7
Benton Harbor	3	<4.0 E-9	(8.0 ± 4.0) E-9	<7.71 E-7
Bridgman	3	<5.0 E-9	<5.0 E-9	<7.71 E-7
Lake Township	3	<5.0 E-9	<5.0 E-9	<7.71 E-7
New Buffalo	3	(3.6 ± 0.6) E-8	<8.0 E-9	<7.71 E-7
St. Joseph	3	<3.0 E-9	<9.0 E-9	<7.71 E-7
North Lake	4	<2.0 E-9	<2.0 E-9	<7.71 E-7
South Lake	4	<2.0 E-9	<1.0 E-9	<7.71 E-7
Benton Harbor	4	<2.0 E-9	<2.0 E-9	<7.71 E-7
Bridgman	4	<2.0 E-9	<2.0 E-9	<7.71 E-7
Lake Township	4	<2.0 E-9	<2.0 E-9	<7.71 E-7
New Buffalo	4	<2.0 E-9	<2.0 E-9	<7.71 E-7
St. Joseph	4	<2.0 E-9	<2.0 E-9	<7.71 E-7

APPENDIX F
TERRESTRIAL ECOLOGY STUDIES

Terrestrial Ecology Studies

Since May, 1973, periodic terrestrial studies have been conducted and reported for the Cook Nuclear Plant site. These investigations were conducted under the direction of Dr. Francis C. Evans, University of Michigan.

In continuation of these studies, American Electric Power Service Corporation staff biologists conducted a field investigation September 5-7, 1978.

Study Sites

Fourteen study sites, representing the open water, shallow marsh, herbaceous-grass, herbaceous-brush, upland hardwoods, lowland hardwoods, and mixed mesophytic forest types were investigated. These sites correspond to the areas utilized in the University of Michigan studies. A brief description of the study sites is found under Results of Investigations.

Faunal Studies

Investigations consisted of transversing each site twice and recording any sightings of birds, reptiles or mammals. Indirect evidence such as tracks and scats were recorded also.

Several of the sites, especially those in the swampy, wetland areas were examined twice. This was mainly conducted to observe early morning activity of birds.

No methods were utilized which involved capture or taking of specimens.

General Summary

The general habitat found within the Cook Nuclear Plant environs consists mostly of dry mixed forest in various stages of succession. Much of this dry habitat has good to excellent cover which also provides good habitat for small ground mammals, reptiles and numerous invertebrates. The forest associations provide habitat and food for those segments of the animal community which utilize this portion of the plant community for their existence.

Due to the sandy soil most of the study area consists of dry plant associations. Around those three sites which had moist conditions, observations during this study indicated high faunal populations. This is a common observation that inland water bodies (eq. swamps) normally do have high animal numbers because of marginal ecotones and generally a greater diversity of available habitats.

This study gave no indication of diverging from the more detailed studies conducted by the University of Michigan from 1973 through 1977.

In summary there may be some faunal successional changes in the future as young mixed oak stands mature and the shrub-herbaceous areas are taken over by other successional associations. As mentioned since studies have been conducted at Cook Nuclear site few changes from earlier observations have been noted.

Results of Investigations

Site 1:

This site is located at 600' elevation, on an abandoned field in the northeast corner of the plant property near Lakeway Drive. The sandy soil has a dense cover of low vegetation with sapling sassafras, oak and aspen invading this old field.

The site appeared good to excellent for moles, field mice, and rabbits. The amount of trails and paths in the field indicate a moderate population now exists there.

Site 2:

Open glade at the west end of site 1. Scattered trees form an open canopy above a heavy cover of a bracken fern and blueberry. The elevation is approximately 600'.

With the open trees this site was active with birds and appeared, as site 1, to support a moderate population of moles, field mice, etc.

Site 3:

This site is a dry, mixed oak forest lying approximately 500 feet west of site 2 and is situated on top of an east-west ridge dune at an elevation of 635. The crown cover is about 90% and the underlying community consists of blueberry, greenbrier, bracken fern, and winter green.

This site did not appear to be a good site for small mammal activity from the evidence noted. There was bird activity in the upper canopy of the trees.

Site 4:

Young mixed oak site on dune overlooking Lake Michigan and in the extreme northwest corner of the plant site, at an elevation of 650'.

From a faunal ecological view this site appeared to be the least productive of the 14 studied.

Site 5:

Mixed mature oak forest in the southwest corner of the plant property. The highest point on this dune ridge 690" descending to 610'. Ground cover was characteristic of a mature forest.

Two fox squirrels were seen along with deer tracks, and diggings (probably striped skunk). There was bird activity at all levels from the top canopy to the ground.

Site 6:

This site is a mixed oak forest bordering the absorption pond.

The canopy is relatively dense (80 to 90% complete) and ground cover was similar to the other dry forest sites.

Due to the presence of water, the site was very active with birds. Mammal signs were also numerous (deer, raccoon, fox tracks).

Site 7:

This site is a depression about 200 yards south of visitors entrance and west of Thornton Road. Its depth was approximately 20 feet. The vegetation surrounding this site was almost impenetrable. Many small wild cherry trees were in fruit at the time of this study, making the site very active with birds which were eating the fruit.

The dense vegetation made this an ideal area for smaller mammals and birds.

Site 8:

This site consists of a young mixed forest with numerous sassafrass trees present. The site is paralleled by a drainage ditch.

Very few birds were noted at this site, however, due to its close proximity to site 7 (400 feet) it is likely that site 7 was more attractive due to the ripe cherry trees.

This site closely paralleled the other dry forest areas observed in this study.

Site 9:

This site consisted of a shallow marsh bordered by herbs and shrubs around the margins and in close proximity to dry mixed oak forest.

The site was the most productive site observed. This was due to so many diverse habitats available over a small area.

Site 10:

The site consisted of a young mixed oak community on a dune hill which rose to an elevation of approximately 660 ft. There was a fairly dense ground cover of blueberry and wintergreen.

Due to the fairly heavy ground cover this site appeared to be good habitat for small mammals.

Site 11:

Another mixed oak forest habitat located near the center of the plant property. It reaches a maximum elevation of approximately 650'. As in site 10 this site has a heavy ground cover of blueberry and appeared to be good habitat for small mammals.

Site 12:

A high dry site consisting of mature mixed oak community and a fairly dense ground cover. This site did not appear to be as productive as sites 10 and 11.

Site 13:

This was a swampy site with standing water. This was an extremely productive site probably second only to site 9 which was a larger swamp.

Site 14:

This was a site consisting of shrubs, scattered trees, and a heavy ground cover. This site would be very productive for small mammals.

Attachment I

Table 1
Avian Observations

Species	Sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Robin													X	
Mourning Dove							X		X				X	X
Blue Jay	X		X	X	X		X	X		X	X	X	X	
Black-Capped Chickadee	X				X				X					X
E. Wood Peewee													X	
Olive-sided Thrush						X								
Cardinal						X			X					
White-eyed Vireo		X			X				X					
Red Tail Hawk										X				
Downy Woodpecker													X	
Red-headed Woodpecker									X					
Chimney swift		X												
Mourning Warbler													X	
Yellowthroat									X					
Black throated Green Warbler		X												
Redstart						X							X	
Catbird							X		X					
Magnolia Warbler									X					
Eastern Phoebe							X							
Goldfinch													X	

Table 2

Mammalian Observations (Tracks and scats included)

Mammals	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Eastern Chipmunk										X	X			X
Groundhog								X				X		
Raccoon											X		X	X
Striped Skunk					X						X			
Fox Squirrel				X	X									
White-tail Deer			X		X						X		X	
Fox (Gray or Red)?					X	X								
Muskrat									X				X	

Reptiles	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Midland Painted Turtle									X					
Fowler's Toad						X			X				X	

On September 5 - 7, Messrs Gary Crawford and Ray Showman were on the Cook Plant site. The purpose of this visit was to make a brief terrestrial survey and collect data for comparison with Dr. Evans' earlier work. All 15 of Dr. Evans' study pilots were located, and at each plot a floral list was compiled. Comparison of these lists with Dr. Evans' data revealed 7 additional lichen species and 2 additional higher plant species for the Cook Plant site. These are listed on the attached sheet. Notes on the successional stage, community type, and any anomolies or disturbances were also made at each plot. A summary for each plot is listed below.

Site 1. This is a typical old field community with a woody component of sumac, hawthorn, black oak seedlings and trembling aspen seedlings. The herbaceous component is composed of grasses, goldenrod, St. John's wort, bracken fern, Queen Ann's lace and other summer-flowering species. Nothing unusual was observed here.

Site 2. This is a woods edge community composed of blueberry, small sassafras trees, black and white oak seedlings, bracken fern and several species of summer-flowering weeds. Nothing unusual was seen at this site.

Site 3. This is a typical mixed oak forest with a canopy of medium-sized black, red, and white oak trees and an understory of sassafras and witch hazel. No anomolies were seen here.

Site 4. This is a mixed hardwood forest composed of red, and white and black oaks, basewood, wild cherry, sassofras, dogwood and maple-leafed viburnum. The community composition indicates that this site is more mesic than Site 3. The blow-out area just south of this site was also observed and found to be stabilized. The dune grass which was planted here is now well-established.

Site 5. This mixed hardwood community contains black and white oaks, wild cheerry, and sugar maple. The herbaceous layer is more diverse than in the mixed oak community. Several spring-flowering species such as hepatica and bellwort were seen. Except for a few early spring-flowering plants (eg. trillium and wood betony), I found essentially the same flora that Dr. Evans reported.

Site 6. This is a mixed hardwood forest on the north-facing slope just south of the absorption pond. This site contains a more diverse flora than any other site. In addition to many of the species reported by Dr. Evans, I also found Jack-in-the-pulpit (<u>Arisaema atrorubens</u>) and Indiana pipes(Monotropa uniflora), new additions to the Cook site flora. The Allegheny vine reported by Dr. Evans was not seen. However, I was unsure of its exact location. Several trees at the edge of the absorption pond were dead. This was almost certainly caused by standing water covering the roots for an extended time. Herbaceous plants at the absorption pond margin appeared to be healthy .

Site 7. This is an old sand mine which supports a grass and herb community. In addition, I found oak seedlings which apparently have invaded since Dr. Evans surveyed this site.

Site 8. This is a fairly young mixed oak community composed of black and white oaks, sassafras, and silver maple. Witch hazel, greenbriar, wild grape, and blueberry are also present. Nothing unusual was seen here.

Site 9. This is a marsh composed primarily of rushes with willow, trembling aspen and wild cherry around the edge. Other hydrophytic species such as cattail, boneset, sensitive fern, and steeple bush were also seen. Most of the marsh was too wet to walk through without boots.

Site 10. This is a mixed oak community similar in composition to Site 3. No anomolies were seen here.

Site 11. This is another mixed oak community like the above The mixed oak community is found on the dry sides (south-or west-facing) and tops of dunes throughout the Cook Plant site.

Site 12. Another mixed oak community typical to the area. Nothing unusual was seen here.

Site 13. This is a swamp with standing water in the center and willows and ashes around the edge. Ash samplings in the center have been killed by standing water. Horsetail, boneset, steeple bush and other hydrophytic plants were also seen.

Site 14. This is an open area with a dense cover of bracken fern. Summer and fall flowering weeds are also present. No anomolies were seen here.

Site 15. This is a dense stand of Jack Pine with an occassional white pine, sassafras, or black oak. Very few herbaceous plants are present here. This is typical of a dense pine grove.

In conclusion, Dr Evans' study plots were visited and other than a few trees killed by standing water, nothing unusual was seen.

Additional palnts recorded at the Cook Plant:

		Study Plot No.
Lichens:	Cladonia Cristatella	1
	Parmelia Rudecta	12
	P. Sulcata	9
	Physcia Adscendens	9
	P. Millegrana	9,12
	P. Orbicularis	9,12
	P. Sulcata	9
Higher :	Arisaema Atrorubens (Jack-in-the-pulpit)	6
	Monotropa Uniflora (Indian pipes)	6