DONALD C. COOK NUCLEAR PLANT
UNIT NOS. 1 AND 2
INDIANA & MICHIGAN ELECTRIC COMPANY
ANNUAL ENVIRONMENTAL OPERATING REPORT
JANUARY 1 THROUGH DECEMBER 31, 1980

DOCKET NOS. 50-315 AND 50-316
LICENSE NOS. DPR-58 AND DPR-74

TABLE OF CONTENTS

I. Introduction

Section 5.4 of the Appendix B Environmental Technical Specifications requires that an annual report be submitted to the NRC which details the results and findings of ongoing environmental radiological and non - radiological surveillance programs. This report serves to fulfill these requirements and represents the Annual Environmental Operating Report for Unit Nos. 1 and 2 of the Donald C. Cook Nuclear Plant for the reporting period ending December 31, 1980.

During this reporting period Unit No. 1 generated 6,698,320 (Mwh) gross of electrical energy. Monthly Operating Reports indicate that this unit was operating at a Unit Service Factor of 73.7%, at an average Unit Capacity Factor of 70.5%.

Unit No. 2 generated a total of 6,937,420 (Mwh) gross of electrical energy. Monthly Operating Reports indicate that this unit was operating at a Unit Service Factor of 74.4%, at an average Unit Capacity Factor of 70.4%

II. Abnormal Environmental Occurrences

The following abnormal occurrences were reported during the year 1980:

Date	Docket No.	AEO No.	Occurrence
2/26/80	50-316	80-001/04X-0	Unplanned release of radioactive steam from #4 steam generator on Unit #2.
2/27/80	50-315 & 50-316	80-001/04X-0	During the preparation of the 1979 Annual Environmental Operating Report, it was discovered that the maximum quantity of detergent discharged to the lake, Specification 4.1.1.7.2, Table 4.1-1 of 5,000 lbs. per year, was exceeded by 360 lbs.
3/24/80	50-315 & 50-316	80-002/04X-0	Unplanned release of radioactive gas from the Unit #1 vent stack.

III. Changes to the Environmental Technical Specifications

On August 29, 1980, the NRC issued Amendments 40 and 23 to Operating Licenses for Units 1 and 2 respectively making the following changes to the Appendix B Environmental Technical Specifications:

1. Section 4.1.1.2 was deleted since all the requirements under this section have been completed.

2. Section 4.1.1.4 was revised to reflect the recent modifications to the discharge scour bed.

IV. NON-RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

1. PHYSICAL OBSERVATIONS

A. Specification 4.1.2.1.4 - Visual Observation of the Intake and Discharge Structure Areas

Thirty-four dives were performed during the reporting period: four during April and May, five during June and July, six during August, four during September, and six during October.

Placement of the concrete scour pads in front of the discharges appears to have alleviated scour adjacent to the structures. Examination of the scour pads revealed no significant pitting, scoring or disintegration of the structures. The riprap surrounding the south intake structure was undisturbed; the sand/riprap interface surrounding the intake structures appeared stable. Accumulations of floc typically ranged from 1 to 5 mm thick. Large depressions in the bottom (10 m across by 1 m deep and containing a silt overburden 20-40 cm thick) that were encountered occasionally during previous years were not observed during 1980.

Both uni-directional and eddy current patterns were detectable throughout the water column within 100 m of the discharges; at stations more than 300 m from the discharges weak currents were occasionally noted, but no directional pattern was established. Variable current speeds were encountered at the south intake structure, but current was strongest adjacent to the base of the structure on the north and east sides. Increased current and possible recirculation of water were noted at the south intake structure during 7-pump operation.

Trash (primarily from fishermen) was observed in decreasing quantities during 1979-1980. Reduction in numbers of beverage containers was particularly noticeable. Relative to concentrations in control (sand substrate) areas, organic debris (algae and terrestrial vegetation) was concentrated in the riprap

zone by the trapping action of the uneven substrate, but appreciable accumulations were not noted. Dead fish (alewives and perch discarded by fishermen) and fecal pellets were seen occasionally, but accumulations of dead alewives on the bottom, even during the annual die-off period, have never been observed.

In 1980, periphyton growth remained reduced on top of the south intake structure, relative to earlier years. During 1979, periphyton growth was quite luxuriant within 5 m of the base, but growth was reduced during 1980. Peak lengths of periphyton were attained during June-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. During 1980, the rate of decline in numbers of sponge colonies appeared to slow somewhat. Hydra remained extremely abundant. Numbers (concentrations) of snails decreased dramatically during 1977-1978; snails were not observed during 1979-1980. Density of crayfish in the riprap area during 1978-1980 was less than one-half that estimated during 1975 (the year of maximum abundance). 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, perch and possibly spottail shiner and/or carp eggs were noted during 1980 (as in previous years), documenting continued minor (excluding alewife) spawning in the vicinity of Cook Plant. Eggs were observed attached to periphyton, entangled in loose algae and lying loose on the sand.

Twelve species of fish were observed during the reporting period. Listed in descending frequency of observation they were: sculpin (Cottus spp.),

johnny darter, alewife, yellow perch, rainbow smelt, spottail shiner, trout-perch, carp, burbot, brown trout, lake trout and sucker (Catostomus spp.). Carp were observed almost exclusively in the discharge area (nowhere else in 1980). Young-of-the-year alewife were very abundant during April and October in 1980, a pattern previously documented. Relative to numbers observed in control areas, fish congregated near the structures (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. The majority of fish species impinged and field-caught at Cook Plant were not observed by divers which was partly a reflection of the relatively incidental occurrence (low numbers) of many species in the study area. But, abundance and seasonal observation of major species (e.g., alewife, perch, etc.) and YOY fish documented by divers usually paralleled occurrence in the study area documented by fishery studies.

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. Barring a large change in Cook Plant operation, future diver observation of major or significant ecological changes in the study area are not anticipated.

For further details, see Appendix A.

B. SPECIFICATION 4.1.1.4 - SCOUR STUDIES

Concrete scour bed pads were constructed in front of the Unit #1 and Unit #2 discharges. The Unit #1 scour bed pour was completed in May of 1979 and Unit #2's completed in July of 1980. Due to a change in this specification, stating that scour studies will be performed at approximately six month intervals for at least one full year after major repairs or modifications to the scour bed, the first of two planned scour studies was completed on 11/7/80 to meet the above requirement. Given below are the details of the required scour studies:

The first of two lake bottom contour measurements was completed November 7th 1980. The second contour measurement is scheduled to be completed in April of 1981. The November 7th contour was taken in an East-West pattern beginning approximately 500 meters north of the East-West plant axis and proceeding south at approximately 50 meter increments until 500 meters south of the East-West plant axis.

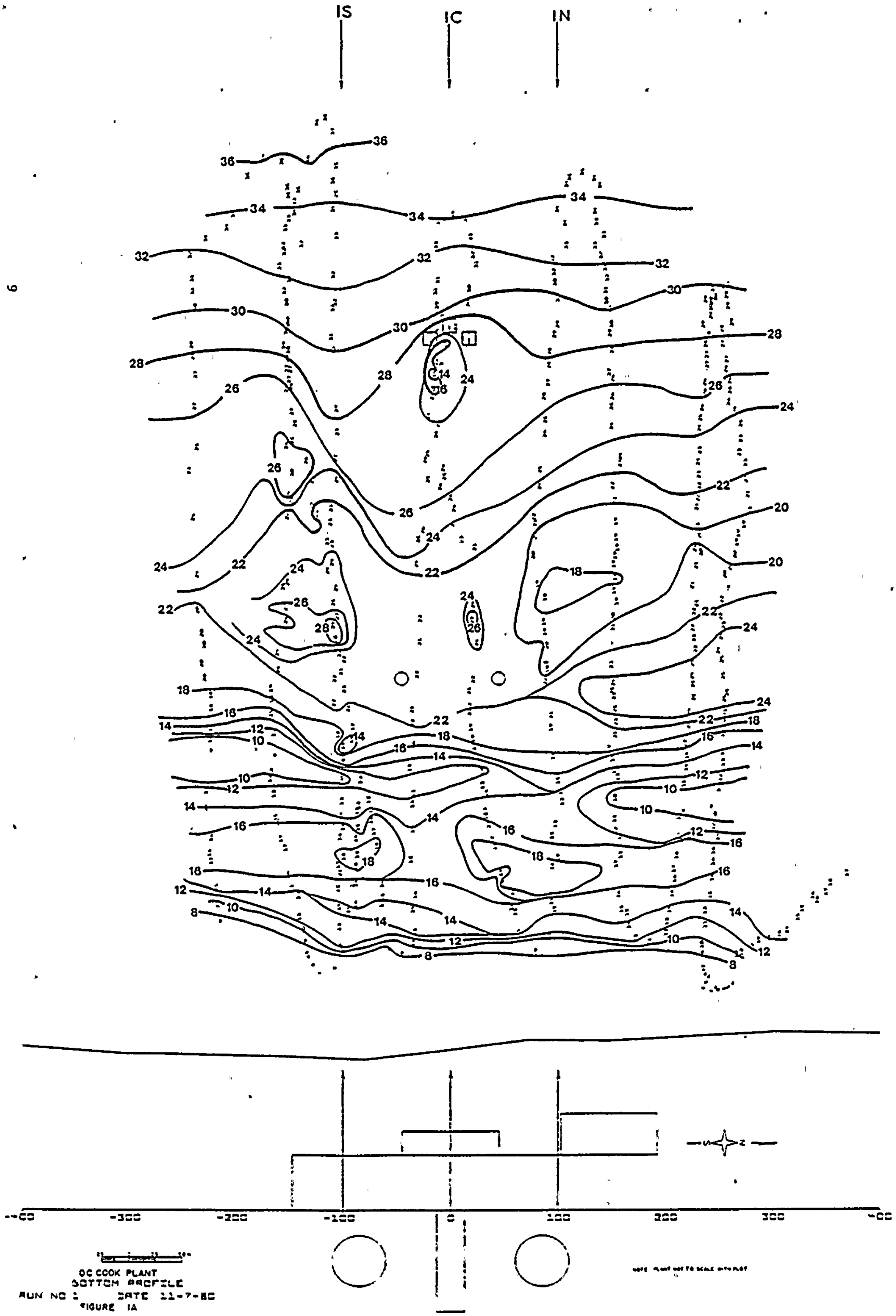
The contour data was reduced and plotted by computer into a topographical representation (Figure 1A). Three sections were taken from the plot to show graphically on Figure 2 the lake bottom topography for this survey. Figure 2 was compared with the Figure 2 sections made from previous surveys completed June 20th and October 20th of 1978 and July 7th and September 22nd of 1977. There has been little change in the three sections since 1977.

Data Acquisition

The system used to acquire the lake bottom contour data consisted of the Vidar Autodata Eight data acquisition device, the Signet Mk71 D3D digital depth sounder and the Motorola Mini-Ranger III system with two fixed transponders on shore to provide a triangulated location of the boat. The Vidar would poll the Signet for a depth reading and the Min-Ranger for location coordinates. This combined information was recorded on the Facit Paper Tape unit and printed on the Vidar tape for monitoring and verification of meaningful data.

Data Reduction

The computer program developed for plotting the temperature measurements during the thermal plume study was utilized for reduction of the depth data. The program converted the Mini-Ranger readings to x-y coordinates and the corresponding depth measurements were corrected for the depth sounder transducer depth. The computer plotted the depth on a diagram of the plant discharge and intake structures and the lines of constant depth were drawn by hand on these plots. Cross sections of the lake bottom profile were then prepared for the three transects near the discharge and intake structures.



DC COOK PLANT
BOTTOM PROFILE
RUN NO 1 DATE 11-7-80
FIGURE 1A

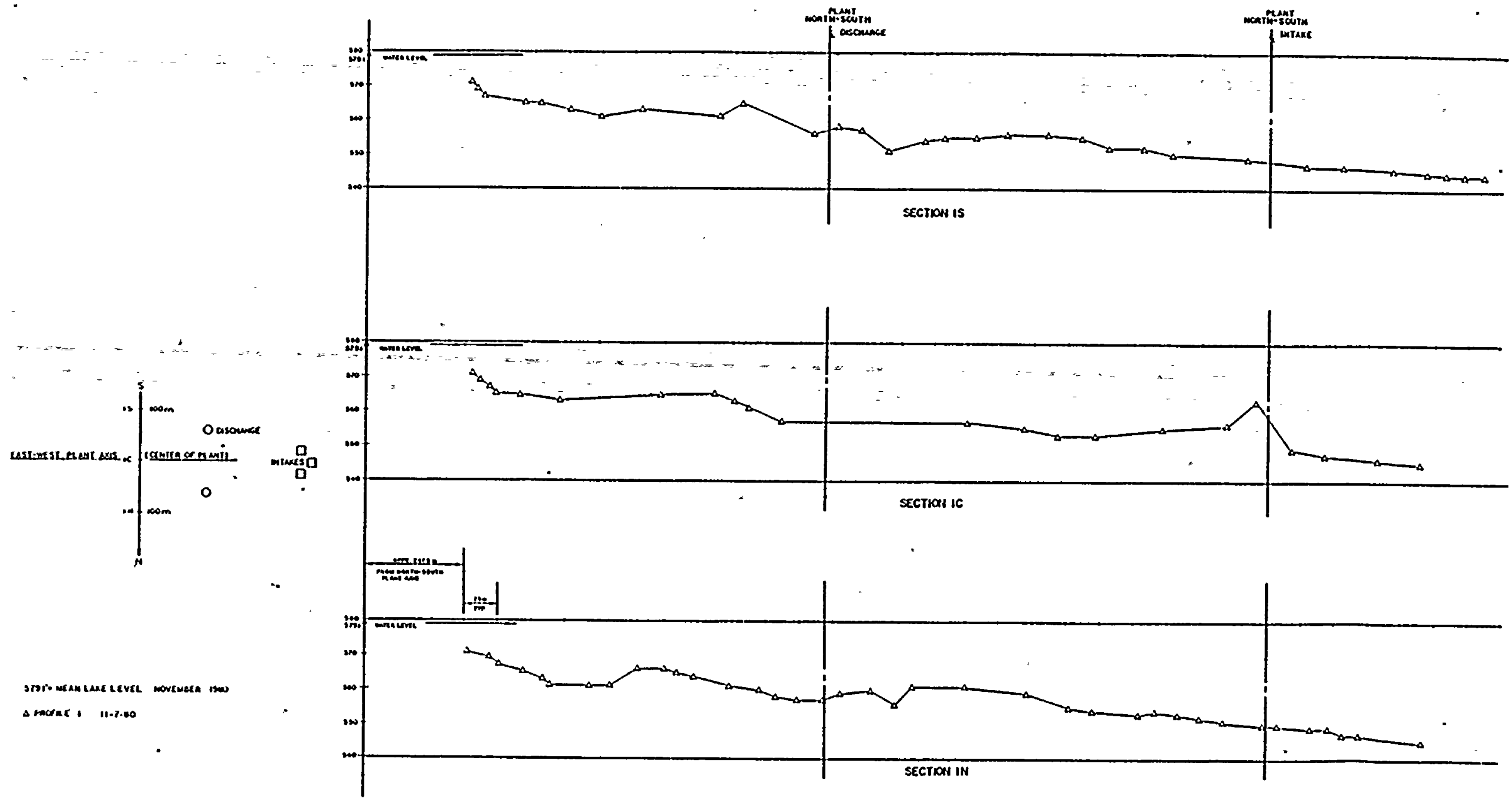


FIGURE 2 D.C. COOK BOTTOM PROFILE

C. SPECIFICATION 4.1.1.5 - Groundwater Monitoring

Groundwater movement or the hydraulic properties of groundwater studies were not required in 1980. The last groundwater movement study was performed in 1979, (see Annual Environmental Operating Report for 1979) therefore, this once every two year study requirement was not performed in 1980.

As required by Specification 4.1.1.5, chemical analyses of groundwater samples taken from shallow groundwater wells in the vicinity of the on-site absorption pond were performed in 1980 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 March and September and the results of the analyses are as follows:

IV.2.A. CHEMICAL DISCHARGE

Actual quantities of chemical released to the lake or absorption field during 1980 are listed below arranged according to the relevant Technical Specification:

i. 4.1.1.6.2 Corrosion and Deposition Inhibitors

Amount discharged - lbs.

a. Phosphate 79.2 (heating boiler blowdown)

b. Ammonium hydroxide 235.1

ii. 4.1.1.7.2 Other Chemical Discharges to Lake and Absorption Field

	Amt. Discharged	Discharged To
a. Sodium Sulfate	212.5 tons	absorption field
b. Boron	293.5 lbs.	Lake
c. Detergent - decontamination	4505.0 lbs.	Lake
d. Detergent - condenser leaks	495.0 lbs.	Lake

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 used in 1980 were 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 brilliant 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

iii. 4.1.1.7.2 Other Chemical Discharges to Absorption Field

a. Turbine Room Sump composite data

Sodium	186,533.0	lbs.
Calcium	44,938.2	lbs.
Magnesium	19,162.8	lbs.
Sulfate	287,487.2	lbs.
Chloride	15,888.3	lbs.
Total Solids	720,679.6	lbs.

b. pH values on sump discharge

Low	High
5.6	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. Four pounds were used in 1980.

IV.2.B. Circulating Water Chlorination

Specification 2.2.1.2

No chlorination of the circulating water system was done during 1980. No periods of chlorine experimentations took place in 1980.

IV.3. AQUATIC STUDIES

A. Specification 4.1.2.1.1.1 - Zooplankton Studies

i. Lake Surveys

Lake survey data from August to November 1978 and April and May 1979 are discussed in this report. Normal temporal succession patterns were observed for the numerically dominant taxa. There was no strong evidence suggesting that power plant operation had an ecologically significant disruptive effect on zooplankton populations in the vicinity of the power plant.

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. Five years of operational October data (1975 to 1979) and six years of operational April data (1975 to 1980) were used in these analyses. For each cruise-month analysis, several taxa occurred in statistically significant (α =.05) different preoperational and operational zone mean concentrations. Differences in the two plume zones (zones 2 and 5) were of most interest. In October, total zooplankton, immature cyclopoid copepods, Bosmina longirostris and Eubosmina coregoni were significantly more abundant in zone 2 while adult Cyclops spp. and Daphnia spp. were significantly less abundant in the operational than in the preoperational period. In zone 5, immature cyclopoid copepods were significantly more abundant in the operational period than in the preoperational period. Most differences were about a factor of two. In April in zone 2, total zooplankton, nauplii, adult Diaptomus spp. and Limnocalanus macrurus copepodites were significantly more abundant in the operational period than in the preoperational period. In zone 5, Limnocalanus macrurus were also more abundant in the operational period. Preoperational-operational differences ranged from a factor of two for total zooplankton to more than twenty for Limnocalanus macrurus. In zone 2, immature cyclopoid copepods were significantly less abundant (by a factor of less than two) in the operational period in comparison to their abundance in the preoperational period.

Zooplankton tended to be more abundant over the survey area in the operational period than in the preoperational period. These differences probably are associated with increased eutrophication of the southern basin. Daphnia pulex, a cladoceran which was observed in the survey area for the first time in autumn 1978 was again observed a year later. Mesocyclops edax, while not as abundant as in autumn 1978, was more common in the autumn 1979 than in previous years. Increased occurrences of these species may be related to eutrophication or to alterations in the standing stock of planktivorous fish.

Preliminary studies have investigated the filtering

effectiveness of the #10 (156 μm) mesh net used in the lake studies. As suspected, a significant number of the smaller copepods and cladocerans are lost through the meshes of the net, producing underestimates in population size. We have also conducted some baseline studies of rotifers to determine abundance and composition. Preliminary information indicates that rotifers account for up to 50% of the zooplankton collected by a 76 μm mesh net.

The effects of the thermal plume on the epibenthic and benthic microcrustacean community were investigated in July 1980. Preliminary data workup indicates that an area of high densities of epibenthic copepods and cladocerans is located offshore of the power plant. The significance of this observation has not been fully evaluated.

A study was conducted to investigate the possibility that fish in the vicinity of the power plant feed selectively on larger organisms killed by plant passage and/or entrained in the plume. This study was not successful (not enough fish were collected) and no further sample workup is planned.

ii. Condenser Passage Studies

This report discusses data collected from August 1979 to July 1980.

Zooplankton mortalities were generally low, averaging 14.4% in the intake waters, 15.5% in the discharge waters of Unit 2 and 17.8% in the discharge waters of Unit 1. Average mortalities were higher than in previous years. One period of particularly high mortality was August 1979 when the temperature of the discharge waters of Unit 1 approached 35°C. As we demonstrated in the last report, these high temperatures approach the upper lethal limit for short-term exposures (minutes) for most zooplankton. Other periods of high mortality could not be associated with any particular operating characteristic of the power plant.

Numbers of zooplankton entrained ranged from a low of 400 billion in February 1980 to a high of 15,000 billion in October 1979. The monthly biomass entrained ranged from a low of 2,000 kg dry weight in January 1980 to a high of 21,000 kg dry weight in October 1979. Estimated maximum biomass loss ranged from a February 1980 low of 613 kg dry weight to an October 1979 high of 2,300 kg dry weight. Estimated maximum losses were similar to those observed in previous years with both units operating.

For further information see Appendix B-1.

B. Specification 4.1.2.1.1.2 - Phytoplankton Studies

i. Lake Phytoplankton

Of the ten categories of phytoplankton, four (desmids, filamentous greens, coccoid greens, and "other algae") have shown essentially no changes in abundances during the ten years of the study.

Four other categories (flagellates, pennate diatoms, centric diatoms, and total algae) have in shallow zone 0 exhibited steadily increasing trends since 1970. These categories, in zones 1 and 2, showed increasing trends from 1970 through 1978 but had lower abundances in 1979. The abundance changes took place in both inner and outer stations.

Blue-green algae have increased in abundance during the period of the study. First indications of increase were minor rises in 1972 with substantially higher levels of coccoid blue-greens appearing in the fall of 1974 and being an autumn characteristic in later years. Occurring in all three depth zones and in both inner and outer station groups the fall increases are attributed to late summer-autumn depletions of silica in the epilimnetic water. Filamentous blue-greens exhibiting summer peak abundances have increased since 1974; occurring in all three depth zones and in both inner and outer stations the cause of these abundance variations is adjudged to be something in the lake.

In the ten years of the study, there have been 767 paired comparisons of inner vs. outer station group cell density means. These have been compared by a two-sample t-test for significant differences of the means. During the entire period there have been 42 cases of significant differences between the means; these amount to 5.5% of the comparisons. The cases of differences are spread through nine of the ten categories of phytoplankton and fall within the natural range of variation; the significant differences are attributed to normal accidents of sampling, no evidence of plant operation effects are shown by these analyses.

Phytoplankton diversities, as indicated by diversity indices, were not quite so high in zones 0 and 1 in 1979 as they had been in earlier operational years; in zone 2 the diversities for 1979 were not noticeably different from those of preceding years. In all zones diversities remain higher than in preoperational years prior to 1974. There is no evidence that operation of Cook Plant has simplified (lowered the diversity of) the phytoplankton community.

Phytoplankton redundancy is a measure of the dominance of one or a few species within a given population. Redundancy values range from 0 to 1, with a value of 1 implying that one species dominates the community. In 1979 redundancy values rose to the levels of preoperational years after a period of steady or slowly diminishing values from 1973 through 1978. We tentatively ascribe the 1979 condition to increased relative dominance of blue-green algae when flagellates and diatoms decreased in abundance in that year.

ii. Entrained Phytoplankton

During the period of November 1979 through October 1980, most samples for both enumeration and viability studies were collected. During viability analysis, one November 1979 evening replicate from the unit #1 discharge, one November 1979 incubated evening replicate from the discharge of unit #1, one November 1979 morning twilight replicate from the unit #1 discharge, one January 1980 evening twilight replicate from the discharge of unit #1, one March 1979 noon replicate from both the discharger of unit #2 and the intake, one April 1980 evening replicate from both discharges, one April 1980 evening incubated replicate from the discharge at unit #2, one April 1980 morning twilight relicate from the unit #2 discharge, one April 1980 noon replicate from unit #2 discharge, one May 1980 incubated evening replicate from the intake, one July 1980 noon replicate from the intake, one August 1980 evening replicate from the unit #2 discharge, one August 1980 morning twilight replicate from the unit #2 discharge, one September 1980 evening replicate from the unit #1 discharge and, one October 1979 noon replicate from both 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 1978 gave the following general observations: 1) coccoid blue-green algae and desmids were least abundant during 1976; 2) flagellates were most abundant during 1977; 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 long-term viability increase or decrease has been observed that can be attributed to the plant.

For further information see Appendix B-2.

C. Specification 4.1.2.1.1.3 - Benthos Studies

i. Lake Surveys

In 1980, 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 1971-1980 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.

ii. Entrainment Studies

Concentrations of the four major species of malacostracans, 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 samples 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 1980 concentrations of the four major crustaceans in entrainment samples were at levels similar to one or more of the previous operational years, with the exceptions of P. hoyi densities which were slightly greater than those recorded for previous years. Although the seasonal entrainment pattern was most similar to that of 1978, M. relicta densities were somewhat lower than during 1978. Densities of Gammarus were most similar to levels recorded during 1979 and lower than the peak year of 1977. Asellus occurred in such small numbers that year to year comparisons were difficult; however, consistently fewer have been

entrained from 1978-1980 than in years prior to 1978. No effect of plant operation has been detected on lake populations of P. hoyi. The causes of yearly fluctuations of M. relicta, Gammarus, and Asellus populations are not known as our collection methods are not designed to sample their lake populations with assurance.

iii. Impingement Studies

The projected total impingement of the crayfish Orconectes propinquus for 1980 (57 kg) is greater than the impingement level for the revised 1979 estimate (17 kg) and 1978 (33 kg) but considerably less than previous operational years (1975, 90 kg; 1976, 92 kg, and 1977, 70 kg). The average weight per specimen in 1979 (6.7 gm remained unchanged from the projected average weight and along with the 1980 projected average weight (6.8 gm) were slightly greater than observed for previous years 1975-1978 (5.5-6.5 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.

For further details see Appendix B-3.

D. Specification 4.1.2.1.1.4 - Periphyton Studies

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

After their completion the 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 not valid due to additional colonization and to natural succession which took place after 1974.

This study uses diver-collected periphyton samples from the underwater installations to determine the taxa living there, 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; 1978, 117; and 1979, 131. Of the taxa taken in 1978, 40 (29 diatoms, 10 green algae, and 1 blue-green) have been taken in every year of the study. Another 16 (10 diatoms, 3 greens, 1 chrysophyte, and 2 blue-greens were taken in four of the five years. It appears safe to consider that these 56 taxa, with the addition of Cladophora which is almost never entrained, probably constitute the basic periphyte community that is embroidered with about 60 rarer taxa that are taken much less frequently.

On the basis of samples through September 1979, the dominant periphytes

were: diatoms of the genera Asterionella, Cyclotella, Cymbella, Diatoma, Fragilaria, Melosira, Navicula, Nitzschia, Stephanodiscus, Synedra, and Tabellaria all of which occurred in more than 50% of the samples; the green algae, Scenedesmus quadricauda, which occurred in 47% of the samples; and blue-green algae of the genus Schizothriz occurred in 42%. There were 48 rare taxa that were present in 1979 only.

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.

For further information see Appendix B-4.

E. Specification 4.1.2.1.1.5 - Fish Studies

Data on field distributions of larval, juvenile and adult fish were evaluated to detect any possible effect of operation of the D. C. Cook Plant on these life forms. Entrainment and impingement data provide estimates of direct impact of the plant on fish populations.

Results of field larvae ANOVAs showed alewives were most abundant in 1973 (3342/1000 m^3) and least abundant in 1979 (39/1000 m^3). Alewife larvae appear to be declining in the study area. However, in 1979, adults were abundant during the spawning season, young-of-the-year were abundant in the fall and larvae were entrained in large numbers. Thus we feel we missed peak 1979 larval abundance in larval field sampling. Highest monthly field larvae abundance of alewives for all years combined was in July. No plant impact on beach zone alewives was observed. A similar result, no differences in densities between Cook and Warren Dunes, was found for open water larval alewives.

For larval spottail ANOVAs, Month and Year were significant, showing the variable nature of spottail recruitment. No plant effects, however, were documented. Yellow perch in open water (1977-1979) were equally distributed at Cook and Warren Dunes showing no Area effect. A number of other species were collected including carp, which were only observed at Cook Plant stations. Results of larval fish sampling as well as adult sampling have documented carp reproduction and attraction exclusively to the Cook Plant area.

In 1979, the estimated rate of fish larvae entrainment reached the highest level since monitoring began in 1974. Almost all ichthyoplankton categories experienced dramatic increases. A full year of two-unit operation in 1979, when cooling water volume doubled over previous years, accounted for some of the increased larvae entrainment. Additionally, substantial 1979 year classes of alewives, spottail shiners and smelt probably resulted in their increased abundance in entrainment samples.

No fish were observed in the plant's forebay from January to May and during August 1980. However, on 21-22 June many spottail shiners, a few yellow perch and many unidentified small fish were swimming in the forebay. On 25-26 June one unidentified salmonid and many unidentified small fish were also observed. On 17 July, 35 dead alewives, 10 dead yellow perch and 2 dead white suckers were floating in forebay surface waters.

ANOVAs have already been calculated for field catch data on abundant adult and juvenile fish for the years 1973-1979 and discussed in the 1978 and 1979 Environmental Operating Reports. Since only April through August 1980 data were available for this report, ANOVAs were not recalculated with 1980 data, which were subjectively compared with previous years' data to determine possible plant effects.

Analyses showed the Cook Plant has had no long-term detectable effects on southeastern Lake Michigan alewife populations. Most significant statistical interactions can be associated with the characteristic, large annual oscillations in alewife population densities. Data indicate that the long-term decline is continuing in 1980.

Bloaters have exhibited a spectacular increase in our catches starting in 1978; they are now one of our abundant species. Trawl catches were similar at Cook and reference stations from 1973 to 1977. In 1978 and 1979 more were caught at Warren Dunes than Cook; in 1980 this pattern was similar at 6-m stations, but reversed at 9-m stations. A plant effect is possible, since large numbers were impinged during 1978-1980.

The 1980 trawl and seine catches revealed increased abundance of young-of-the-year and yearling rainbow smelt, indicating that 1979 and 1980 spawnings were quite successful, which continues a trend of increasing smelt abundance since 1976-1977. Numbers of adult smelt caught in gill nets in 1980 were comparable to numbers taken in 1979. Changes in spatial distribution of smelt over the years appear to be unrelated to plant operation and are most likely due to natural shifts in smelt abundance and patchy distribution of smelt in the study areas.

Spottail shiner populations in southeastern Lake Michigan appear robust. They periodically produce large year classes (1977, 1979 and possibly 1980), which will maintain spottail catches at high levels for the next several years. Year class variability and the behavioral characteristics of this species appear to be the main reasons for distributional patterns, rather than any effect of plant operation.

Trout-perch were the sixth-most abundant species collected in 1980. Trawl and seine catches were large, portending a peak year for trout-perch populations in 1980. Trawl ANOVAs for 1973-1979 data resulted in a highly significant Area main effect, with more caught at Warren Dunes, even in preoperational years. In 1980, the trend was reversed, which may cause a significant Year x Area interaction. Gill net ANOVA for 1973-1979 revealed no significant differences between Areas, although higher catches at the Cook Plant in 1979 contributed to a significant Year x Area interaction. Cook Plant gill net catches exceeded Warren Dunes catches again in 1980. It is felt these findings were reflective of natural changes in trout-perch populations, rather than plant effects.

Yellow perch had a good year class in 1979 which resulted in very high catches in 1980. The ANOVA applied to 1973-1979 trawl data showed Year, Month and Time were significant; factors of interest to detect impact (Area and Year x Area) were not significant. In 1979 we found that the plume and riprap were probably attracting large yellow perch to Cook Plant stations. The 1980 data confounded this conclusion since more perch were gillnetted at the Warren Dunes 6-m station than at Cook 6-m stations.

Among common species, carp were definitely attracted to Cook Plant stations as shown by field catches of adults and larvae and SCUBA observations. Johnny darters and sculpins were apparently attracted to Cook Plant riprap, as they were

caught in larger numbers at Cook than at reference stations. Gizzard shad also appear to be attracted to the Cook Plant's thermal plume and discharge currents and possibly the <u>Cladophora</u> growth on the underwater structures and riprap. More longnose dace were caught at Cook than Warren Dunes, but we felt that was related to more gravel near Cook beach stations. Longnose and white suckers also showed a preoperational and operational proclivity for Warren Dunes stations which we felt was a natural preference.

Impingement of fish at the Cook Plant increased dramatically in 1980. From 1975 to 1979, number of fish impinged varied from 50,080 in 1977 to 735,334 in 1979. In 1980 (January-August) an estimated 3,522,989 fish were impinged by the plant. Alewives were the most frequently impinged fish; trout-perch, yellow perch, spottail shiner and rainbow smelt were other species comprising most of the total impingement collections. Lake trout made up a significant portion of the total weight of fish impinged, especially from 1977 to 1979. Large numbers of yellow perch and alewives were impinged in September 1979 which was attributed to an upwelling and storm which apparently affected fish behavior. Another impingement event was documented in April 1980. Warm inshore water, which caused alewives to concentrate inshore, was thought to be the major reason for the high rate of impingement recorded. The number of chinook salmon impinged has also increased in 1979 and 1980.

For further information see Appendix B-5.

SPECIFICATION 2.1.3 - ICE STUDIES

A. Ice Conditions

Ice conditions during the past winter were studied by airplane overflights on 18 February and 12 March, by personal visits (16 January, 23 January, 15 February, 20 March, 21 March, and 2 April), by stereo time lapse photography looking north from the office building, and by single-camera time lapse photography looking west from the office building toward the melthole resulting from the plant's waste heat.

Our program of stereo time lapse photography of ice condition was almost completely negated because one of the cameras suffered a series of mostly non-recurrent mechanical and electrical failures which resulted in very few usable pictures in its output. Judging from the output of the second camera, this series of failures is not considered disastrous because the positions of breaking wave zones and ice ridges appear to be the same as found in previous years.

The winter of 1979-1980 was slow in developing a shore-ice complex. A small complex formed temporarily on 8 January; substantial ice formed on 24 January and lasted until 30 March when it was wrecked by surf. The last ice melted on 4 April.

The aerial overflights and the more extensive of our shore visits showed normal shore ice extending for miles north and south of the plant. This ice and the extensive lake icefield protected the beach from winter wave erosion. Even in front of the plant, loose floes from the lake icefield drifting across the melthole repeatedly re-established protective nearshore ice formations that prevented erosion.

Our ice studies during the past winter showed no clear effect of a leak in

the south discharge pipe which was evident during the preceding winter, although the fact that melting in the first ice lagoon was more extensive in front of the plant and south of the plant would be consistent with some leakage from the pipe.
For further information, see Appendix d.

B. Deicing Operation - Specification 2.1.1.2.3

i. Circulating Water Pump #13 was removed from service during the period from 11/18/80 to 11/27/80 due to malfunction.
Circulating Water Pump #21 was removed from service during the period 12/27/80 to 1/4/81 due to malfunction.

Specification 2.1.3.2.2

ii. The deicing mode of operation was utilized from 2/25/80 to 2/27/80.

V. RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

(SEE APPENDIX E)

VI. CONCLUSIONS

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 during 1980.

Data from the environmental radiological monitoring program during this year were within their respective expected normal ranges. None of the samples contained radioactivity that could be attributed 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.

APPENDIX A

ENVIRONMENTAL OPERATING REPORT

UNDERWATER OBSERVATIONS AT THE DONALD C. COOK NUCLEAR PLANT

VISUAL INSPECTIONS

The underwater observation program has been designed to facilitate visual monitoring of the study area. The program enables divers to assess macroscopic physical and biological conditions of locations within one half kilometer 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 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 9 m (30 ft) to compare day and night observations, and two day dives in control areas outside the plume. As a result of seven circulation pump operation, dangerously strong currents were produced in the discharge area. Safe diver-entry into the discharge area was not possible except during periods when one or both units were shut-down. During periods of circulation pump shut-down, dives were made to examine the areas surrounding the discharge structures. A total of 34 dives were performed during 1980 in the vicinity of the study area (Tables 1 and 2); 31 required dives and seven supplementary dives. Required dives completed (Table 3) were: four in April and May, five in June and July, four in August and September, and five in October. Dangerous currents prohibited dives in April, May, August, and September in the discharge area. 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 preceding years with 1980 observations, notes significant preoperational/operational changes (if any) and describes any diver-observed plant effects.

Scour

Examination of riprap areas directly in the flowpath of high velocity water discharge has been limited (1975 - one dive, 1978 - one dive, 1979 - one dive, 1980 - three dives) because of diver inability to enter the areas during pumping. Displacement of some riprap immediately adjacent to the north discharge structure prior to placement of the concrete scour pad in 1979 has been discussed previously. The north scour pad was examined twice (June and July) during 1980 and appeared relatively free of sediment, periphyton and invertebrates. The top and sides of the pad were intact and evidenced little pitting, scoring or disintegration - no change in its appearance was noted between 1979 and 1980. Riprap scour adjacent to the south discharge structure was noted and discussed previously. In 1980, the concrete scour pad placed in the flowpath of the south discharge structure was examined during October. Visibility was poor and observations were limited to the top of the pad. Sediment, periphyton and invertebrates were not observed on the pad. No evidence of scour or pad disintegration was noted, nor was extensive scour

noted adjacent to the sides and back of the structure. Diving and observations in other areas of the discharge zone were not conducted during 1980. Scour has never been observed in the vicinity of the intake structures and observations made during 1978-1980 indicate that the southwest sand/riprap interface is relatively stable. Ice or wave scour has never been observed, but extensive ice damage to all three intake structure ice guards has been noted periodically during 1977-1980.

Sediment

Encroachment of sand onto the riprap in the discharge area has been documented previously. Limited observations during 1980 in the vicinity of the discharge structures revealed no noticeable changes in sand encroachment in this area. Some observations in the riprap area between the intake and discharge structures and surrounding the intake structures were made - noticeable encroachment of sand over riprap was not observed. 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 during 1974-1980 usually ranged from a trace (discernible, but not measurable to 5 mm in thickness; 2-3 mm was typical. Depressions (e.g., ripple mark troughs and riprap interstices contained more floc than did elevated surfaces (e.g., ripple mark crests, tops of structure). Reference stations south of Cook Plant typically were relatively free of floc. Discharge areas examined were devoid of floc.

During previous years, depressions 5-10 m across containing silt 20-40 cm thick overlying sand were occasionally encountered; none was encountered during 1980. A few 5-10 cm diameter lumps of clay were noted about 100 m south of the

discharge riprap field; their occurrence was noted during 1979 north of the discharge riprap field and remains unexplained.

As in previous years, 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 1974-1980. These large ripple marks were observed exclusively in very coarse sand; pebbles were often present in the troughs. Large ripple marks were observed primarily north of Cook. Ripple marks in areas observed south of Cook were usually small or assymetric in shape and pattern.

Current

During 1980, dives were made in the discharge area only when one of the units was not circulating water and currents were minimal. At reference (control) stations 100 m north and south of the discharges, currents (about 30 cm/sec) were noticeable but were variable in direction; occasionally, current was directed toward the discharges. At stations more than 300 m from the discharges, weak currents were occasionally noted, but no directional pattern was established.

At the south intake structure, current was noticeably stronger during 7-pump circulation than when fewer pumps were operating during a unit outage. Current was most evident along the top edge of the structure. Intake current was directed toward the south intake structure from all directions at 5 m or less from the structure base. But the strength of the current varied depending upon (compass) position. Currents were strongest at the base on the north and

east sides and weakest on the south side. Intake current was usually discernible 40 m southwest of the south structure. As previously noted, fish in the vicinity of the south intake often exhibited pronounced positive rheotaxis and some position-holding.

Inorganic debris

Input of debris by fishermen continued to be observed. But most debris was tackle or related fishing and boating gear. Less trash (i.e., primarily food and beverage packaging materials) was observed during 1980 than in 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 1980, as in previous years. Appreciable accumulations or patterns of distribution were not evident. Fewer large sections of trees (branches, logs, trunks) were noted in the riprap area during 1980. Comparison of observations within and outside the riprap area suggested that the rough substrate tends to trap organic detritus to a certain extent. Large sections of trees were also encountered during swims in the reference (control) areas. Occasionally, fecal pellets of fish (alewife and carp) were observed in great abundance, primarily during the summer on sand substrate areas. Surprisingly few dead fish were observed during 1980; dead alewives were occasionally seen in riprap and sand bottom areas. An occasional dead perch was noted but usually appeared to have been caught by fishermen and returned to the lake.

Turbidity

Reduced visibility within the Cook Plant plumes was not encountered during 1980. As reported in 1979, regions of reduced visibility (i.e., turbid water masses) were encountered immediate to the south intake structure and at the southwest edge of the sand/riprap interface. Visibility was often reduced 25-50%. Abrupt changes (decreases) in temperature were often associated with these turbid water masses. These observations suggest some possible recirculation of water, particularly 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 length of periphyton on the structure top was 30-40 mm (June-August). About 25-50% of the structure top surface area supported periphyton. Mechanical (buoy line, construction divers) and ice-scouring reduced periphytic growth during the summer and winter, respectively. Occurrence of scour was evidenced in that maximum length of Cladophora on top of the structure occurred in protected areas (crevices, oblique surfaces). Maximum length of Cladophora on riprap surrounding the south intake structure was 60 mm during July; about 50% of the upper surfaces of the riprap supported periphyton. Periphytic growth on riprap appeared to be less extensive during 1980 compared with maximum length (150 mm) and percentage (nearly 100) of riprap supporting periphyton in 1979. As previously noted, luxurant 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 (a cleaning or silt removal mechanism).

Limited observations during 1980 at the north and south discharge structures revealed that periphyton grew on top of the structure to lengths of 10-20 mm. But riprap adjacent to the structure was devoid of noticeable periphytic growth.

Since 1973, periphyton growing on the intake structures and riprap have provided a substrate for fish spawning (alewife and spottail shiner). Periphyton have provided 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 zero to 10 clumps/m^2) and less frequently in riprapped areas. Loose algae appeared to be concentrated along the edge of the sand/riprap interface, particularly in the vicinity of the intake structures. The observed concentration of algae along this interface was probably the result of trapping action of the rough substrate acting upon algae in transport along the lake bottom. Large accumulations (i.e., masses or mats) of algae were not observed. Random occurrence of algae clumps has been observed regularly during 1974-1980. Dead algae appeared to be the major consituent of most clumps, and fish eggs were often entangled in them. Macrophytes have never been observed during underwater observations 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. During 1980, numbers of bryozoan colonies observed remained low, but there appeared to be a slightly noticeable increase in numbers of sponge colonies attached to riprap. For the first time, finger-like extensions (1 cm long) of sponge were observed occasionally. Hydra continued to be observed in tremendous numbers, particularly on riprap lateral and undersides where algal growth was reduced. Heavy algal growth may preclude growth of attached invertebrates; the slight reduction in algal growth observed on the riprap in 1980 may have permitted increased growth (size and numbers) of sponge colonies.

Unattached invertebrates were also present during 1980, but numbers remained greatly reduced relative to earlier years (1973-1975). Live snails were not observed during 1979-1980. 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 except in sandy areas immediately adjacent to the discharge structures where shells appeared to have accumulated perhaps as a result of (eddy) current transport.

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 $m^2 \pm$ S.E.) of crayfish attained during July in the intake area was 27 ± 15. During 1980 crayfish were observed every month;

one in April and May, two in June, five in July, one in August, five in September, and one in October. Crayfish were observed exclusively at night except during September. Numbers of crayfish (and density) seen in 1980 paralleled numbers seen in 1979, reflecting the continued depressed population size relative to earlier years. Decline in crayfish abundance has been further documented by pronounced reduction in numbers of crayfish impinged during 1979-1980 (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. Ageing of the riprap "reef" has resulted in increased periphytic growth (primarily Cladophora) and accumulation of flocculent material. Plugging of interstices by algae or flocculent material may have reduced water circulation and/or increased biological oxygen demand at the substrate/water interface. Changes in microenvironmental conditions may have resulted in a shift in diversity and abundance of biota associated with the riprap area. Initially high exploitation followed by subsequent successional decline in species "richness" have been documented for marine artificial reefs (Smith 1978), possibly as a result of competition and/or a decline in available resources (e.g., food and suitable habitat).

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 1980, eggs of alewife and possibly spottail shiner and/or carp were observed attached to periphyton growing on the south intake structure and surrounding riprap and to periphyton growing on the top of

the north discharge structure. Eggs were noted loose and entangled in algae at reference stations north and south of Cook Plant during June. Numbers and densities of observed eggs were high, but not noticeably different from numbers and densities noted during previous years. But eggs were seen over a shorter (one month) period during 1980 than in some previous years. Five strands of yellow perch eggs were seen and sampled on riprap near the south intake structure on June 1 (during a non-project dive); most of the eggs were viable, and a few of the eyed eggs hatched during subsequent laboratory incubation.

Fish

Twelve species of fish were observed during 1980 and listed in descending frequency of sightings (measured as presence or absence, not as numbers of fish) within and across dives were: sculpin (*Cottus* spp.), johnny darter, alewife, yellow perch, rainbow smelt, spottail shiner, trout-perch, carp, burbot, brown trout, lake trout and sucker (*Catostomus* spp.). As in previous years, multiple sightings of the first five species often occurred during a dive; numbers seen were usually less than ten. But adult alewife and perch were observed commonly in schools (10 - perch, 10-50 - alewife) during early summer, and schools of hundreds of YOY alewife were seen during April and October. Only one fish each of the last four species was seen during 1980.

Several generalizations related to fish may be made based upon observations made over the period 1974-1980: alewife, spottail shiner, yellow perch, sculpin and johnny darter were the most frequently (occasions and numbers) observed species. Trout-perch, smelt and carp (in the discharge area only) were often but not regularly observed. Alewife, spottail shiner, and (in particular) yellow perch were sighted primarily during warm-water months (late

May through October). Thousands of adult alewives, sighted in previous years during spawning season (May-June), were not observed in 1980. In general, fewer alewives were seen in 1980 than in previous years. 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 but appeared to increase slightly during 1980. Observations of alewife, spottail shiner, and yellow perch generally followed patterns documented in the 1978 Environmental Operating Report. Dorr and Jude (1980) presented additional analysis and discussion of fish abundance and behavior in the vicinity of Cook Plant during 1975-1978.

The majority of fish species impinged and field-caught at Cook Plant were not observed by divers. This is partly a reflection of the generally incidental occurrence (low numbers) of these species in the study area. But species of fish commonly field-caught (alewife, spottail shiner, yellow perch, rainbow smelt, and trout-perch) and impinged (previous species plus sculpin and darters) were also frequently observed by divers. Seasonal occurrence of YOY fish in field and impingement catches was paralleled by diver observations. Demersal fish (sculpin and darters) concentrated in the riprap area (relative to the surrounding sand-bottom areas) and consequently were observed and impinged in relatively high numbers.

The remaining species were observed infrequently during 1980; little can be inferred from data related to the incidental sightings of these species. Large fish (salmonids, burbot and suckers) were rarely seen in the study area, probably because they detect diver presence and flee the area unnoticed.

Carp were observed in June (about 50 fish) and October (10-50 fish) 1980 during dives in the vicinity of the discharge structures, but not during July.

They were not observed in other areas. Comparison of preoperational and operational data (1974-1980) indicate that carp are attracted to and are more abundant in the vicinity of the discharge structures. An explanation for the attraction of carp to the discharge area was not readily available. 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 but outside the area of noticeably elevated temperature. But Cook Plant was never at full circulation capacity (i.e., maximum discharge of heated water) during dives in the area. Elevated concentrations of macroinvertebrates (prey or potential food items) were not observed within the plume. Carp appeared to concentrate in the discharge area and wander to neighboring areas. Gill net data also suggest concentration of carp near the discharges 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. As in previous years, fish abundance and diversity was highest during June. Activity levels were also higher at night (only perch appeared to be consistently less active at night) with fish concentrating near the bottom or absent in the area during daytime. Numbers of fish observed within riprap areas were much higher than numbers observed in control areas. Daytime observations of fish in sand-bottom reference areas were very infrequent, often equalling less than five sightings per year and usually as schools of adult or YOY alewives or a solitary darter or sculpin. During 1978-1980, a night station was examined in a sand area near the intake structures; fish (sculpin, spottail shiner, alewife, trout-perch, johnny darter, smelt and burbot) were sighted in numbers much larger than numbers observed at daytime reference

stations but far less than numbers observed within the riprap area. Species observed at the night sand station were also observed in riprapped areas.

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

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 Operation Report that were observed again during 1979 and 1980.

Shifts (declines) in numbers and/or frequency of observations of various invertebrates (snails, crayfish, bryozoans, freshwater sponge) indicate continued, but stabilizing ecological succession in the riprapped area. Species richness and abundance of invertebrates appears to have peaked prior to 1978 and subsequently declined. Operations of Cook Plant during 1980 have had no major diver-observed physical or biological effects that have not been noted in previous reports. Data analysis to date suggests that, barring a major change in Cook Plant operation, future changes in study area ecology may occur on a small scale, relative to changes observed immediately following deposition

of riprap. But these changes will probably be too small and variable to be reliably detected and defined through diver observations. Also, the interaction of plant effects and natural variation and change will confound interpretation of ecological change in the area.

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Table 1. Summary of 1980 diving activities near the Donald C. Cook Nuclear Plant. January through November.

Dive no.	Date	Location	Depth (m)	Day or night	Start time	Under time	No. of divers
1	Apr 21	N. reference stations	4-6	D	1430	17	2
2	Apr 21	S. reference stations	4-6	D	1500	10	2
3	Apr 21	S. intake structure	3-9	D	1608	37	2
4	Apr 21	S. intake structure	3-9	N	2300	45	2
5	May 28	S. intake structure	3-9	D	1559	80	2
6	May 28	S. reference stations	4-6	D	1804	20	2
7	May 28	N. reference stations	4-6	D	1842	15	2
8	May 28	S. intake structure	3-9	N	2045	45	2
9	Jun 24	N. reference stations	4-6	D	1605	15	2
10	June 24	S. reference stations	4-6	D	1632	15	2
11	Jun 24	S. intake structure	3-9	D	1710	45	2
12	Jun 24	N. discharge structure	6	D	1923	30	2
13	Jun 24	S. intake structure	3-9	N	2045	45	2
14	Jul 28	S. intake structure	3-9	N	0400	30	2
15	Jul 28	S. intake structure	3-9	D	0615	30	2
16	Jul 28	S. reference stations	4-6	D	0715	20	2
17	Jul 28	N. reference stations	4-6	D	0800	20	2
18	Jul 28	N. discharge structure	6	D	0900	20	2
19	Aug 18	S. intake structure	3-9	D	1806	45	2
20	Aug 18	S. intake structure	3-9	N	2020	30	2
21	Aug 19	N. reference stations	4-6	D	1120	25	2
22	Aug 19	S. reference stations	4-6	D	1150	25	2
23*	Aug 19	S. intake structure	9	D	1220	30	2
24*	Aug 19	3 km N. of Cook	6	D	1330	22	2
25	Sep 11	N. reference stations	4-6	D	1630	15	2
26	Sep 11	S. reference stations	4-6	D	1700	16	2
27	Sep 11	S. intake structure	3-9	D	1730	32	3
28	Sep 11	S. intake structure	3-9	N	2045	75	5
29	Oct 20	S. intake structure	3-9	N	1935	40	2
30	Oct 22	S. intake structure	3-9	D	1030	25	2
31	Oct 22	S. discharge structure	6	D	1112	13	2
32	Oct 22	N. reference stations	4-6	D	1135	10	1
33	Oct 22	S. reference stations	4-6	D	1205	10	1
34*	Oct 22	New Buffalo Shoals	15	D	1300	5	1

* Supplementary dive not required by the technical specifications.

Table 2. Summary of underwater time accrued during 1980 diving activities near the Donald C. Cook Nuclear Plant. January through November.

	Daylight		Night		Total	
Month	No. dives	Time (min)	No. dives	Time (min)	No. dives	Time (min)
April	3	64	1	45	4	109
May	3	115	1	45	4	160
June	4	105	1	45	5	150
July	4	90	1	30	5	120
August	5	147	1	30	6	177
September	3	63	1	75	4	138
October	5	63	1	40	6	103
Total	27	647	7	310	34	957

Table 3. Record of completion of 1980 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	9 m (30 ft)
April	3	*	1	2	4
May	5	*	7	6	8
June	11	12	9	10	13
July	15	18	17	16	14
August	19	*	21	22	20
September	27	*	25	26	28
October	30	31	32	33	29

* Strong currents did not permit safe diver-entry into the discharge area.

APPENDIX B-1

ZOOPLANKTON COLLECTED AT THE DONALD C. COOK NUCLEAR PLANT

Introduction

Lake surveys are conducted April through November once a month. 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 km² 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 1980, a total of 320 of the required 320 samples were collected. Samples up to and including May have been examined at the time of this writing. In addition, samples collected in 1979 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, for these analyses, the survey grid has been divided in eight zones: three inner, three middle and two outer zones (Fig.1). Preoperational versus operational zone mean comparisons for the major taxa during each major survey cruise continue to be performed using the Mann-Whitney U test. Such comparisons have been made for five years of operational October data (1975 to 1979) and six years of operational April data (1975 to 1980). Examination of long-term seasonal trends in the abundance of major zooplankton in the inshore plume zone (zone 2) is continuing. 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 dominant taxa.

Physical Data (April to November 1980)

April 10 surface water temperatures ranged from 2 to 6 °C. The thermal bar was located within 1.5 kilometers of shore. Temperatures on May 14 had increased to 11 to 16 °C while June 12 surface temperatures were 15 to 18 °C. Surface temperatures continued to increase through July 9 (18 to 21 °C) and reached 21 to 22 °C by August 13. There was some evidence of an upwelling on September 12 as surface temperatures ranged from 15°C to 20°C and were lowest closest to shore. Surface temperatures declined to 12 to 15°C on October 15 and 7 to 9 °C on November 12. The lake was thermally stratified from May to October.

The thermal plume was generally small and located within a kilometer of the discharge jets. Temperatures measured over the discharge jets averaged 2 to 3 C° above ambient lake temperatures.

Secchi disc depths followed the typical seasonal pattern but were slightly lower than 1979 depths. Depths ranged from 1 m to just under 6 m in April, 1 to 5 m in May, 2 to 6 m in June, 3 to 7 m in July, 2 to 6 m in August, 2 to 5 m in September, 1 to 5 m in October, and 1 to 6 m in November. Secchi disc depths were similar in the plume and in control stations suggesting that the suspended particulates were similar in the plume and ambient water.

August to November 1979 Zooplankton Data

The August inshore zooplankton population was numerically dominated by the cladoceran *Bosmina longirostris*. Copepod nauplii were secondary in abundance. Immature *Cyclops* spp. copepodites, immature *Diaptomus* spp. copepodites and *Daphnia* spp. (mainly *D retrocurva*) were also common inshore. In the offshore regions, the zooplankton population was composed mainly of immature *Diaptomus* spp., *Cyclops* spp. copepodites and *Daphnia* spp. (primarily *D. galeata mendotae*). There was no evidence of gross alterations in the zooplankton distribution in the plume area.

In September, the zooplankton community in the middle and inshore areas was numerically dominated by *Bosmina longirostris*. Immature *Cyclops* spp. and immature *Diaptomus* spp. copepodites were the dominant taxa offshore and were of secondary abundance inshore. *Daphnia* spp. were numerous at several stations throughout the survey area. There were no indications of gross disruptions in zooplankton distributions in the vicinity of the plume.

The October zooplankton community was dominated by *Bosmina longirostris*, immature *Cyclops* spp. copepodites, immature *Diaptomus* copepodites, and *Daphnia* spp. (primarily *D. retrocurva*). *B. longirostris* was especially abundant in the middle and inshore areas where it generally made up 40 to 77% of the zooplankton. *Daphnia pulex*, which was first observed in the survey area in October 1977, was again found at several stations in low concentrations (less than 50/m^3). *Mesocyclops edax* was also common at several stations. Prior to 1978, this species was extremely rare. As discussed in the previous report, increased occurrences of *Daphnia pulex* and *Mesocyclops edax* may be related to eutrophication and/or a decline in planktivorous fish standing stocks. There was no evidence of gross alterations in zooplankton distributions in the plume area.

In November, the dominant zooplankton in the middle and inshore zones were immature *Cyclops* spp. copepodites and *Bosmina longirostris*. Immature *Diaptomus* spp. were of secondary

abundance in these areas. In the offshore zones, immature *Cyclops* spp. and immature *Diaptomus* spp. copepodites dominated. There was no evidence of unusual occurrences in the plume area.

April to May 1980 Zooplankton Data

The April zooplankton population was dominated by copepod nauplii which were between 40 and 60% of the zooplankton in the survey area. Adult *Diaptomus* spp. (especially *D. ashlandi*) and adult *Limnocalanus macrurus* copepodites were also important. Zooplankton concentrations were lower than in April 1979. There were no indications of changes in zooplankton distributions in the immediate vicinity of the power plant.

In May, copepod nauplii again dominated the zooplankton community, especially in the inshore areas where they were 50 to 75% of the zooplankton. Immature *Diaptomus* spp. copepodites were of secondary abundance, while immature *Cyclops* spp. and immature *Limnocalanus macrurus* were also abundant. There was no evidence of gross alterations in the zooplankton distributions in the vicinity of the plume.

Statistical Comparison of October Preoperational with Operational (1975-1979) Abundances

The preoperational and operational abundances of twelve 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 during the operational period (by less than 50%) in all zones (Fig. 2) except the outer offshore zone. These differences were significant (α=0.05) for the plume inshore zone, the north and south middle zones, and the inner offshore zone. Copepod nauplii were more abundant (by less than 50%) during the operational period in all zones with the only statistically significant difference in the southern inshore zone.

Cyclopoid copepodites were also more abundant (by approximately 30%) during operational years in all zones. These differences were significant for the southern inshore zone and the three middle zones. Immature cyclopoid copepodites were significantly more abundant (a factor of up to two) in all zones except the outer offshore zone and the northern middle zone. On the other hand, adult cyclopoids had statistically similar preoperational and operational densities in all zones except the plume inshore zone where operational abundances were significantly higher (by a factor of two) than the preoperational values.

Calanoid copepodites had statistically similar densities during preoperational and operational periods in all zones except

the southern inshore zone, where operational abundances were higher by a factor of two. Immature Diaptomus spp. copepodites had higher operational densities in all zones except the outer offshore zone. These differences were significant for only the northern middle and the inner offshore zones. Adult Diaptomus spp. were also generally more abundant during the operational period but this trend was significant only in the southern middle and inner offshore zones.

Cladocerans were significantly more abundant (by factors of more than two) during the operational period in the northern middle and inner offshore zones and had higher operational mean densities in all other zones as well. Bosmina longirostris had higher operational densities in all zones, but only the two-fold difference in density displayed in the plume inshore zone was statistically significant. Eubosmina coregoni was significantly more abundant during the operational period in the plume and northern inshore zones and was significantly less abundant during the same period in the outer offshore zone. Daphnia spp. had significantly lower operational densities in the plume inshore zone and significantly higher abundances in the northern inshore zone for the same period.

Statistical Comparisons of April Preoperational with Operational (1975-1980) 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 significantly (α=0.05) different concentrations (Table 2) between the preoperational and operational periods in at least one zone.

Total zooplankton mean densities (Fig. 3) were higher during the operational period in the inner and middle zones. The only statistically significant (α=0.05) difference in mean densities was for the inshore plume zone. April preoperational mean densities for all three inshore zones were about one half the operational densities.

Mean densities of copepod nauplii were higher (by factors of up to two) during the operational period in all zones, but these differences were statistically significant in only the southern and plume inshore zones.

Cyclopoid copepodites were generally less abundant during the operational years. Operational mean densities were significantly lower for all three middle zones and for the two offshore zones. Immature cyclopoid copepodites were significantly less abundant (by fractions as small as 1/3) during operational years in all zones except the southern inshore zone. Adult cyclopoids had higher operational mean densities (by factors up to 5) in the inshore and middle zones but had significantly lower (by fractions of 1/2) operational densities

in the two offshore zones.

Calanoid copepodites had higher operational mean densities in all eight zones. These differences were statistically significant in the three inshore zones and the plume and northern middle zones. Preoperational and operational mean densities of immature Diaptomus copepodites were statistically similar in all zones. In contrast, Diaptomus spp. adults were more abundant during operational years in all zones except the outer offshore zone. These differences were significant (α=0.05) for the three inshore zones, where densities were up to five times greater during the operational period, and for the northern middle zone. Limnocalanus copepodites were significantly more abundant during operational years in all six inshore and middle zones. Limnocalanus was from seven to over 100 times more abundant in the inner and middle zones during the operational years.

Seasonal Cycles of Zooplankton in the Inshore Plume Zone

Seasonal plots of zooplankton abundances in the inshore plume zone (Fig. 4) 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.

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

Estimates of Net Collection Effectiveness and Rotifer Distribution

Prior to 1979, we collected three replicate samples at each lake station, examining the first two replicates and saving the third as a spare. This spare was to be used if a sample were lost or if there were poor agreement between the first and second replicates. In practice, this occurred on less than two occasions each year.

In 1979, we began collecting the third sample (not in the current Technical Specifications) with a finer-meshed (76 µm versus 156 µm) net. We initiated these collections for two reasons:

1) We were concerned about the loss of small copepods and cladocerans through the meshes of our 156 µm mesh net. Such a loss produces an underestimate in zooplankton biomass and abundance. We believe that it was necessary to obtain an indication of the magnitude of the loss, particularly in view of the fact that a reviewer of one

of our recent publications required such a statement concerning net loss.

2) We were concerned that our study has obtained no information on rotifers, a group of small zooplankton which, with the exception of <u>Asplanchna</u>, are not effectively captured by the 156 μm mesh net. Since most surveillance studies on the Great Lakes include rotifers, we believe that it was essential to obtain at least some information on this group of organisms.

Beginning in May 1979, a single sample was collected at each station with a 76 μm mesh net in addition to the required two samples with the 156 μm mesh net. A subset of these samples has been examined. Preliminary data indicate that up to 50% of the smaller nauplii and immature copepodites are lost through the 156 m mesh net. Losses for the larger zooplankton are neglible.

Rotifers have been identified at a similar subset of stations. Preliminary analyses indicate that rotifers account for up to 50% of the zooplankton on a numerical basis. Data have not been further analyzed to interpret the spatial and temporal distribution characteristics of these organisms.

<u>Epibenthic and Benthic Microcrustacean Study</u>

In July 1980, we conducted a study to investigate the distribution of epibenthic and benthic microcrustaceans in the vicinity of the power plant. In addition, we studied the macrobenthos. This study in the operational period provides a contrast to a study conducted in the preoperational period (Evans and Stewart 1976). The purpose of this study was to investigate whether or not plant operation produced localized alterations in the abundances of epibenthic and benthic organisms. Of particular interest was the possibility that dead organisms settling from the plume provide an additional food source to the benthic community.

Preliminary data on the epibenthic community (organisms living above the sediments) suggest that an area of high animal density occurs directly offshore of the power plant (Fig. 5). Further interpretation of the data is required. The most valuable information on sediment type, quantitative measures of detritus, etc. will be obtained from the examination of the sediment samples.

<u>Fish-feeding Study</u>

In August 1980, we conducted a study to test the hypothesis that fish in the vicinity of the plume are selectively feeding on large organisms killed by plant passage and/or entrained in the plume. An insufficient number of fish were collected, possibly because the study was conducted too late in the year. The study is considered to have been unsuccessful and no further workup of the samples is planned.

Discussion

The results of the 1979 and 1980 studies are similar to those of previous years. Differences were observed between preoperational and operational abundances for the numerically dominant zooplankton in the immediate vicinity of the power plant (inshore plume zone, zone 2): many of these differences were statistically significant at the $\alpha=0.05$ level. However, we do not interpret these differences as resulting from localized, direct, and environmentally significant effects of power plant activity. The reasons are as follows:

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 control zones.
3) Results of our entrainment studies (next section) indicate that plant passage is lethal only to a small percentage of zooplankton. Mortality in the plume has not been measured but, on the basis of literature reviews, is expected to be low. We have no basis for predicting that power plant operation will provide detectable losses in the zooplankton community given the small percentage of dead zooplankton and the physical nature of the plume.

It is evident that zooplankton populations are changing over the survey area. Zooplankton tend to be more abundant in the operational period than in the preoperational period. There is continued evidence of change in zooplankton populations at the species level. As was discussed in the previous report, Daphnia pulex was first observed in the survey area in the autumn of 1978. We again observed this species in the autumn of 1979. Mesocyclops edax has been more common in the autumn plankton both in 1978 and 1979. This suggests that this species is increasing in abundance in the survey area.

Increased abundances of zooplankton and increased occurrences of particular species could occur for several reasons. One factor could be related to increased phytoplankton standing stocks in the survey area: zooplankton standing stocks typically increase with increased standing stocks of phytoplankton (Patalas 1972). Mesocyclops edax and Daphnia pulex are both common species in the eutrophic waters of Green Bay (Gannon 1972). Some changes at the species level also could be related to declines in planktivorous fish stocks. It previously has been shown that both D. pulex and M. edax can be eliminated or severely reduced in numbers in certain waters by planktivorous fish (Galbraith 1967 ; Wells 1970). A decline in planktivorous fish abundances in the southern basin could lead to increased abundances of their prey. Further research is required to

investigate these alternate mechanisms.

CONDENSER PASSAGE STUDIES

Introduction

Mechanical and thermal stresses can kill up to 100% of the zooplankton passing through the condensers. Mortality studies are conducted to evaluate the severity of these stresses.

Zooplankton are collected monthly from the intake and discharge forebays of the power plant in compliance with the Technical Specifications. Zooplankton mortality due to plant condenser passage must be estimated at both Unit 1 and Unit 2 discharges since they have different operating characteristics (water temperature, flow rate, ΔT). Four samples are collected from each location within an hour or two of sunrise. Sample duration is two minutes. Each sample is divided into subsamples, each containing a few hundred organisms. The subsamples are visually examined for dead zooplankton at 0, 6, and 24 hours after collection.

For the January to November 1980 period, 124 samples were collected and 372 subsamples were examined. If both units had been running at all times it would have been possible to collect 132 samples. However, in June and July 1980, Unit 1 discharge was not operating and in November 1980, Unit 2 was in an outage. Due to equipment failure in January 1980, Units 1 and 2 were not sampled simultaneously. The intake and Unit 1 discharge were sampled the week of January 21, and the sampling series was repeated with Unit 2 the following week. Data up to and including July 1980 have been examined and are included in this report. In addition, data collected from August to December 1979 which were not included in the last report are presented here.

Results

Temperature

Intake temperatures ranged from a low of 0.3 °C on January 22, 1980 to a high of 24.0 °C in July 1980. High intake temperatures in February (5.8 °C) indicate that the plant was recirculating water through the intake. Unit 1 discharge water temperatures ranged from a high of 34.9 °C in August 1979 to a low of 9.2 °C in April 1980. The ΔT's for Unit 1 averaged 9.9 C° and ranged from 2.5 C° in April 1980 to 12.5 C° in December 1979. Flow rates for Unit 1 ranged from a high of 4.69 x 10^7 km^3/day in October 1979 to a low of 3.54 x 10^7 km^3/day in December 1979 and averaged 4.38 x 10^7 km^3/day. Discharge water temperatures for Unit 2 ranged from 10.1 °C in April 1980 to 31.8 °C in July 1980. The ΔT's ranged from 3.4 C° in April 1980 to 9.5 C° in June 1980 and averaged 8.6 C°. Flow rates averaged 5.81 x 10^7 km^3/day and ranged from 5.23 x 10^7 km^3/day in July 1980 to 6.15 x 10^7 km^3/day in September 1979.

Mortalities

Total zooplankton mortalities were generally low at initial collection times (Fig. 6), averaging 14.4% in the intake water, 17.8% for Unit 1 discharge water, and 15.5% for Unit 2 discharge water. Intake mortalities ranged from a low of 4.3% in July 1980 to a high of 34.6% in May 1980. Mortalities for Unit 1 ranged from 6.1% in April 1980 to 31.8% in August 1979. Unit 2 mortalities ranged from 7.4% in July 1980 to 32.8% on January 28, 1980. The numerically dominant taxa accounted for most of the dead zooplankton in these months. These included immature *Diaptomus* spp. copepodites , immature *Cyclops* spp. copepodites and adult *Limnocalanus macrurus* (Fig. 7).

There were several periods when discharge mortalities were several percent greater than intake mortalities. In August 1979, when discharge Unit 1 water temperature approached 35 °C, discharge mortalities were more than twice intake mortalities (31.8% versus 12.8%). It has been previously reported that 35 °C is an upper critical temperature for short-term exposure to high temperature. There were four other periods of high relative mortality. High mortalities occurred in the discharge waters of Unit 1 in September 1979 (mainly immature *Diaptomus* spp. copepodites) and on January 22, 1980 (primarily immature *Cyclops* copepodites). High mortalities in the discharge waters of Unit 2 occurred on January 29, 1980 (mainly immature *Cyclops* spp. copepodites) and in March 1980 (primarily adult *Limnocalanus macrurus*). During these periods water temperatures did not approach the upper critical temperature and ΔT's were moderate. Flow rates were moderate and water was not recirculated. The reasons for these relatively high mortalities are unknown.

Entrainment Abundance

Zooplankton samples were collected monthly from the intake and discharge forebays of the power plant. Generally, samples 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 passing through the power plant. Further, mortality data allow the estimation of the maximum loss of zooplankton due to plant passage.

A total of 248 samples were collected for the period January to November 1980. No samples were collected from the Unit 1 discharge in November, and no samples were collected from the Unit 2 discharge during June and July.

The concentration of zooplankton in the cooling waters peaked at 73,000/m^3 in October 1979 and declined to a winter low

of 2,000/m³ in February 1980. Numbers of zooplankton passing through the plant (Fig. 8) were a function of zooplankton concentration and pumping rates and ranged from a high of 15,000 billion in October to a low of 400 billion in February 1980. Relatively low values in November and December reflect the fact that Unit 2 was in an outage for most of these two months. Maximum estimated numerical loss generally followed the numbers entrained curve. The maximum estimated loss value for August does not include losses due to Unit 2 operation because mortality data are not available for that unit and month. If Unit 2 mortalities were similar to Unit 1 in August, the maximum loss value for Unit 2 would be expected to be 1.5 times the Unit 1 loss, as the total volume of water pumped by Unit 2 was approximately 1.5 times that of Unit 1 in August.

Biomass

The seasonal cycle of zooplankton biomass passing through the plant (Fig. 9) was not always similar to the seasonal cycle of zooplankton numbers passing through the plant. This is because the summer zooplankton, while numerous, tend to be dominated by relatively small animals (mean dry weights of 1 to 2 µg/individual). On the other hand, the winter zooplankton are less abundant but are dominated by animals that average dry weights of 3 to 6 µg/individual. The monthly biomass of zooplankton entrained ranged from an October high of 21,000 kg dry weight to a January low of 2,000 kg dry weight. Maximum biomass loss ranged from an October high of 2,300 kg dry weight to a low of 613 kg in February.

Discussion

Results of the entrainment studies indicate that mortalities averaged 14.4% in the intake waters, 15.5% in the discharge waters of Unit 2, and 17.8% in the discharge waters of Unit 1. As has been discussed in previous reports, intake mortalities do not reflect true mortalities in inflowing lake waters but rather mortalities after sample collection. Most of the observed mortality probably is due to mechanical stresses inflicted on the zooplankton during sample collection. Mortalities due to plant passage are a result of thermal and mechanical stresses. We have no evidence that mortalities due to mechanical stresses in sample collection and plant passage are additive. Consequently, we have used mortality estimates in the discharge waters to estimate the maximum loss during plant passage. We estimate their losses as ranging from 15.5% for Unit 2 to 17.8% for Unit 1.

A more conservative estimate for mortality losses is based on the unproven assumption that mortalities due to the two mechanical stresses are additive. In this case, we estimate mortality due to plant passage (Mp) as:

$$Mp = \frac{Md - Mi}{100 - Mi}$$

where:

Md = percent mortality in discharge
Mi = percent mortality in intake

A conservative estimate for average mortality due to plant passage is 1.29% for Unit 2 and 3.97% for Unit 1.

Exact causes of mortality during plant passage are not known but are the result of a combination of thermal and mechanical stresses. Mechanical stresses probably are the major cause of mortality under current operating conditions. We have noted only two occasions when high discharge mortalities could be directly attributed to thermal effects. Both occasions occurred when the power plant heated discharge waters to 35°C. On the basis of a previous zooplankton literature review, we concluded that 35°C approaches the upper lethal temperature for short-term exposures (minutes). This has been confirmed by actual observation. Thus, if discharge water temperatures remain below 35°C and the ΔT's do not rise substantially above 10-12C°, it is expected that zooplankton mortalities will remain low.

The ecological significance of the loss of zooplankton due to plant passage is unknown. Such losses cannot be detected in the lake and not enough is known about the zooplankton production dynamics to predict effects. It is possible that detrital zooplankton settling from the thermal plume will alter the benthic community by providing additional food material. We designed a study to investigate this possibility and, in the previous section, reported on preliminary results.

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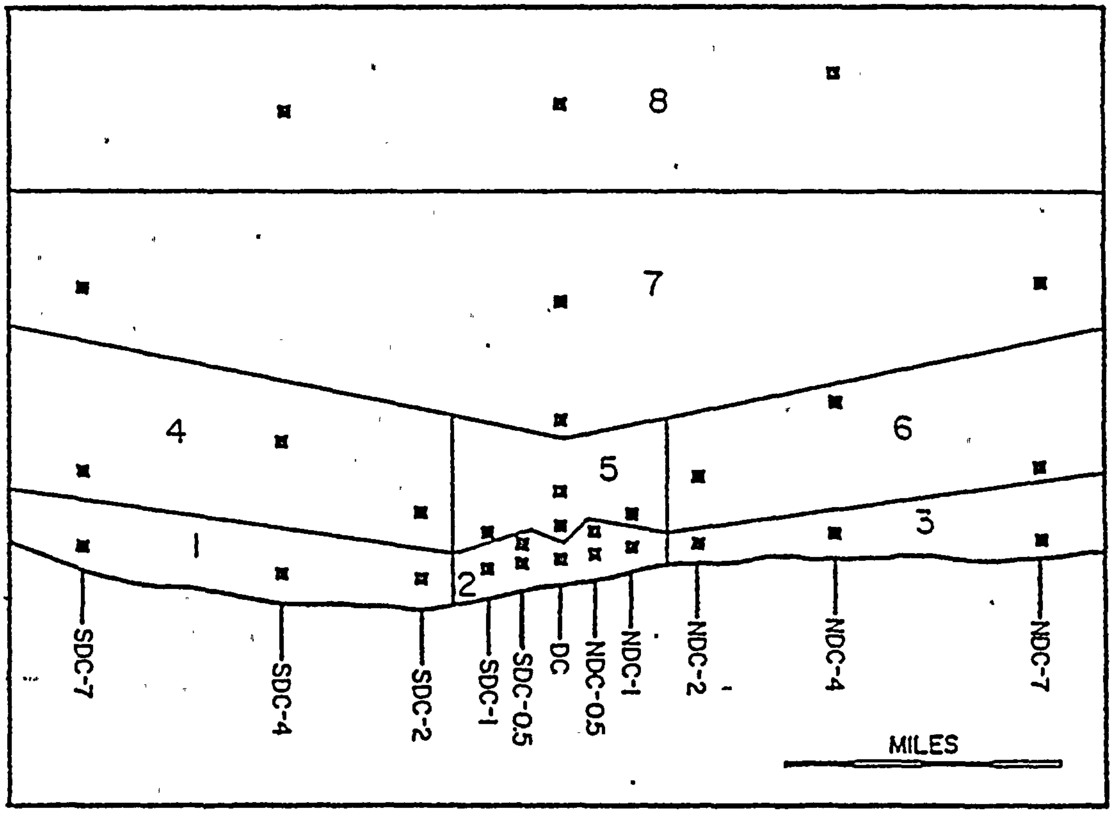
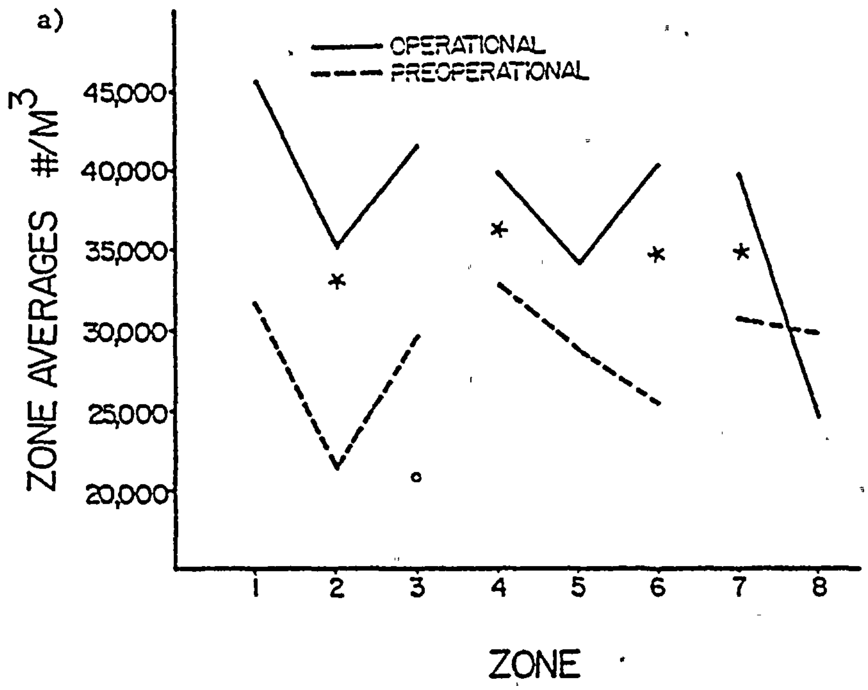


Figure 1. The survey grid divided into eight zones. Squares indicate major survey stations. The zones are: 1) southern inshore, 2) plume inshore, 3) northern inshore, 4) southern middle, 5) plume middle, 6) northern middle, 7) inner offshore, and 8) outer offshore.



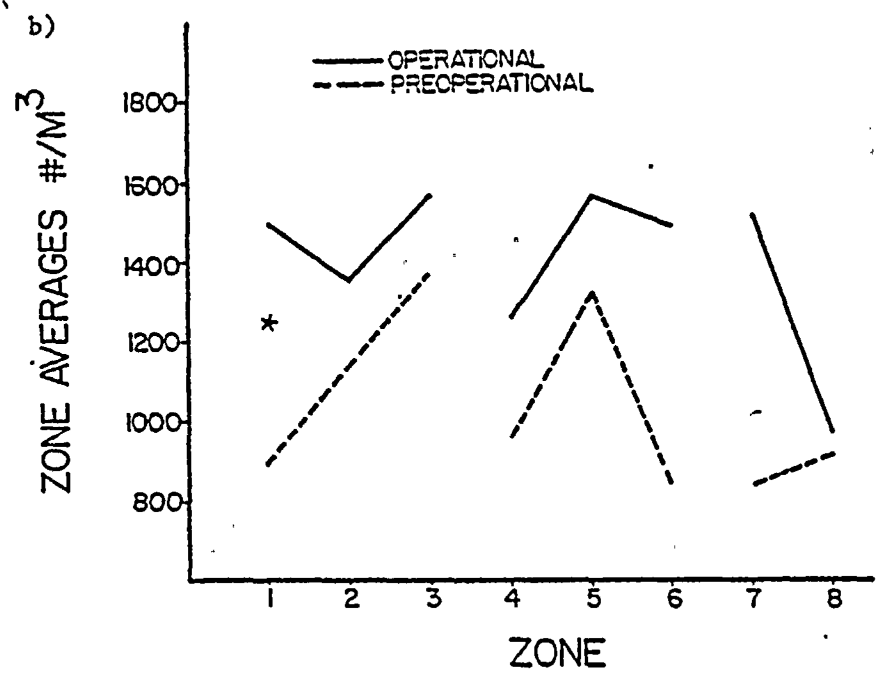


Figure 2. Mean zooplankton densities in October for each zone (dashed lines = preoperational periods, solid lines = operational period). Stars indicate zones with significant differences between the preoperational and operational periods (Mann Whitney U test, α = 0.05). Lines connect zones in the same 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 1975-79. b) Copepod nauplii 1972-74 and 1975-79.

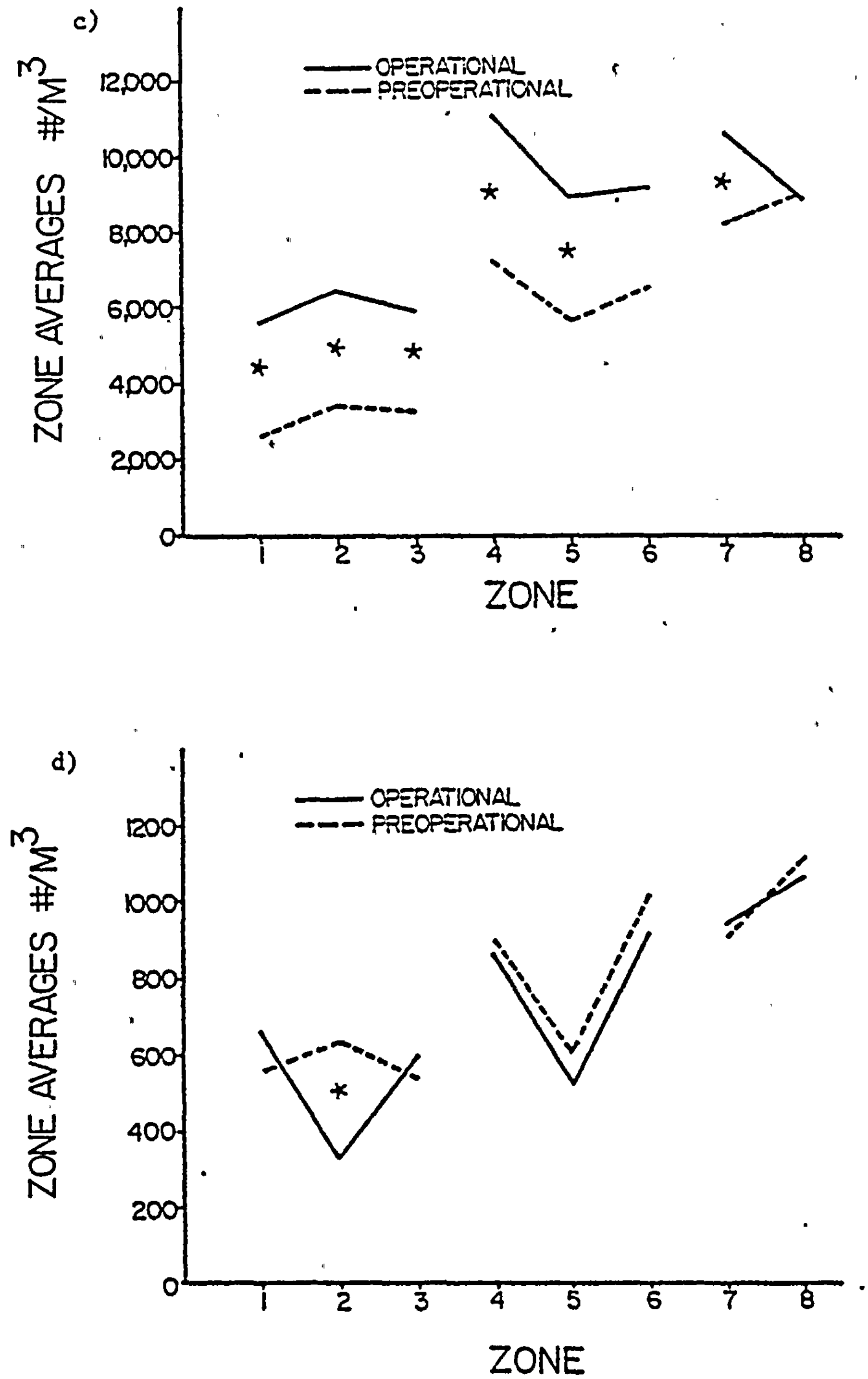
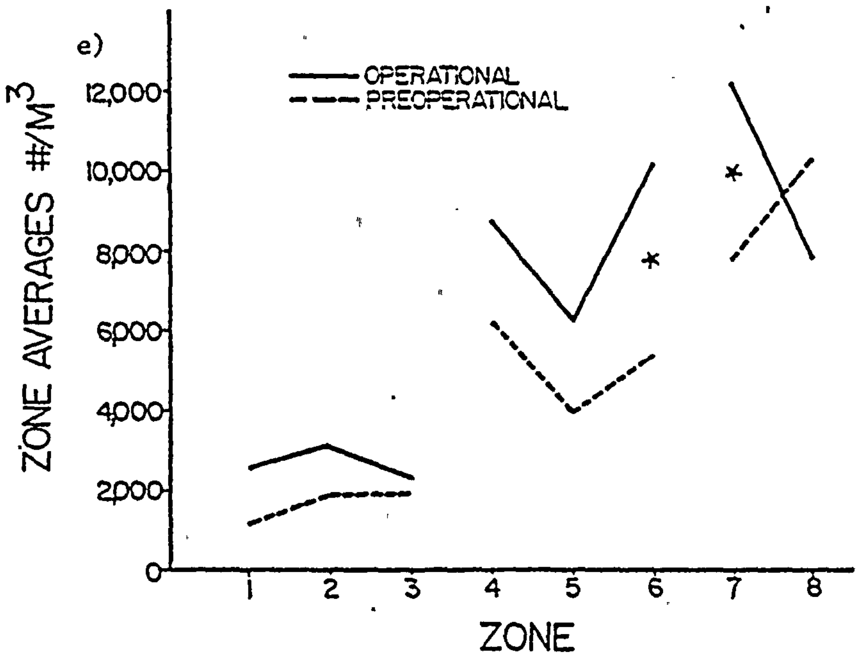


Figure 2 continued. c) Cyclopoid C1-C5 1973-74 and 1975-79. d) Cyclops spp. C6 1973-74 and 1975-79.



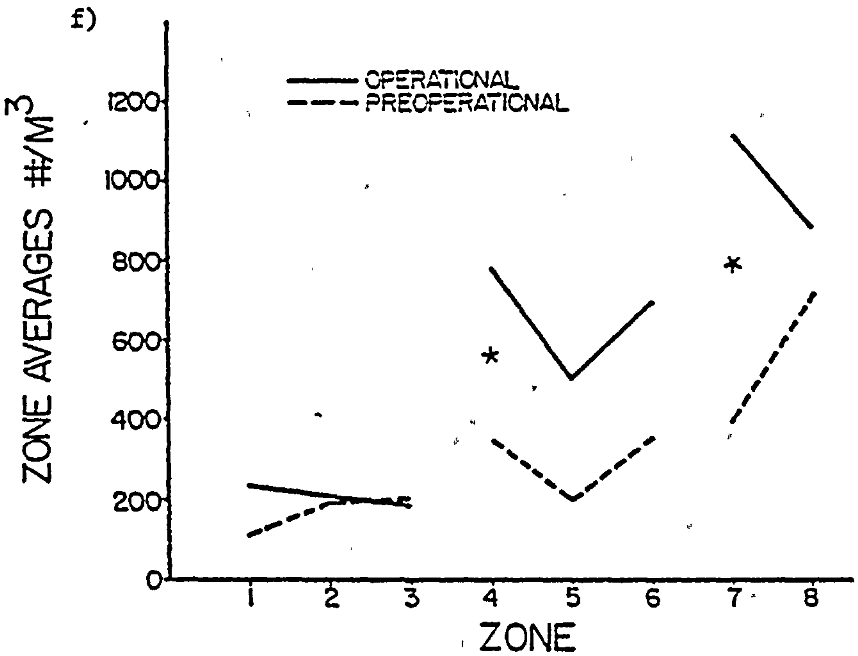


Figure 2 continued. e) Diaptomus spp. C1-C5 1973-74 and 1975-79. f) Diaptomus spp. C6 1973-74 and 1975-79.

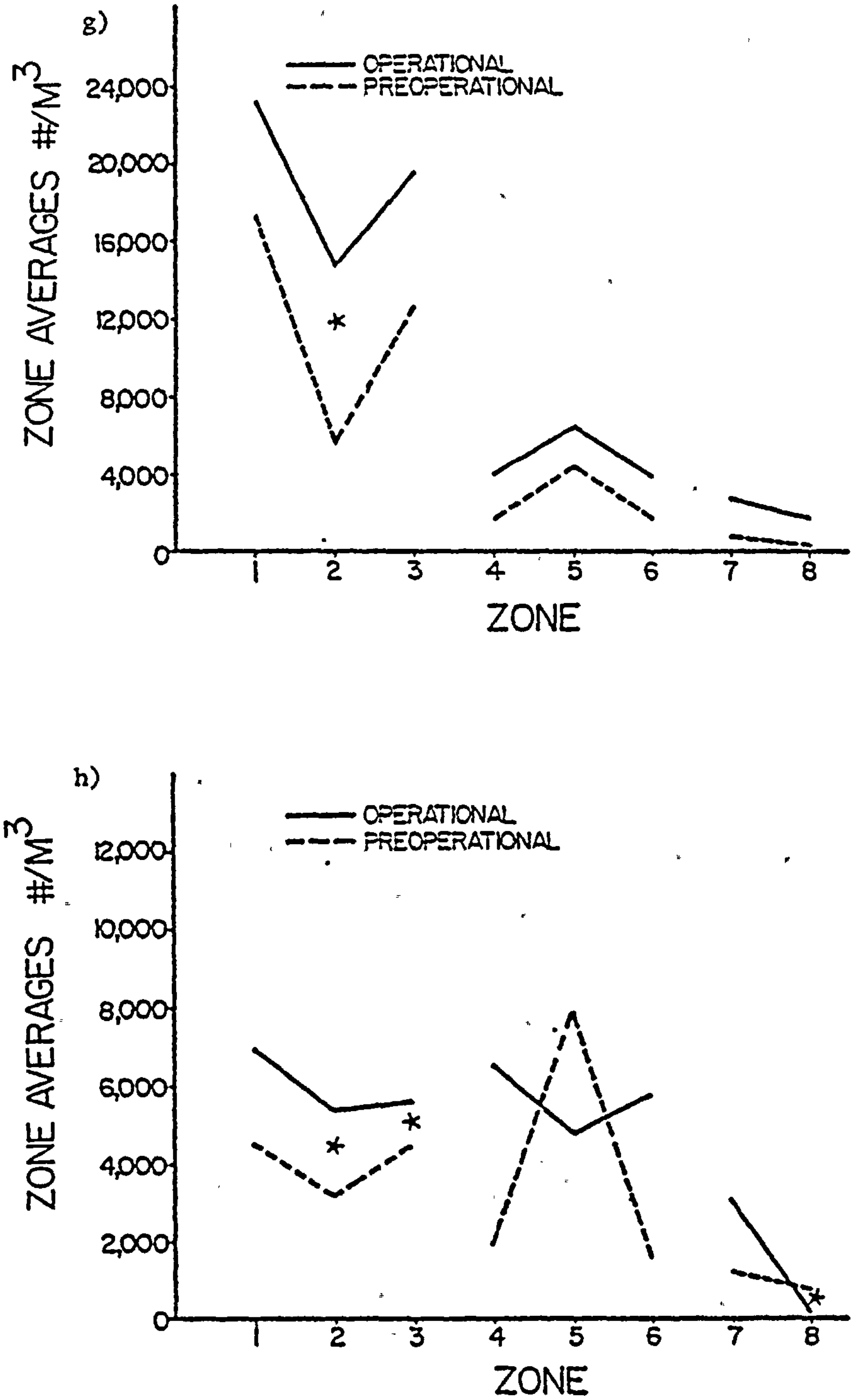


Figure 2 continued. g) <u>Bosmina longirostris</u> 1972-74 and 1975-79. h) <u>Eubosmina coregoni</u> 1972-74 and 1975-79.

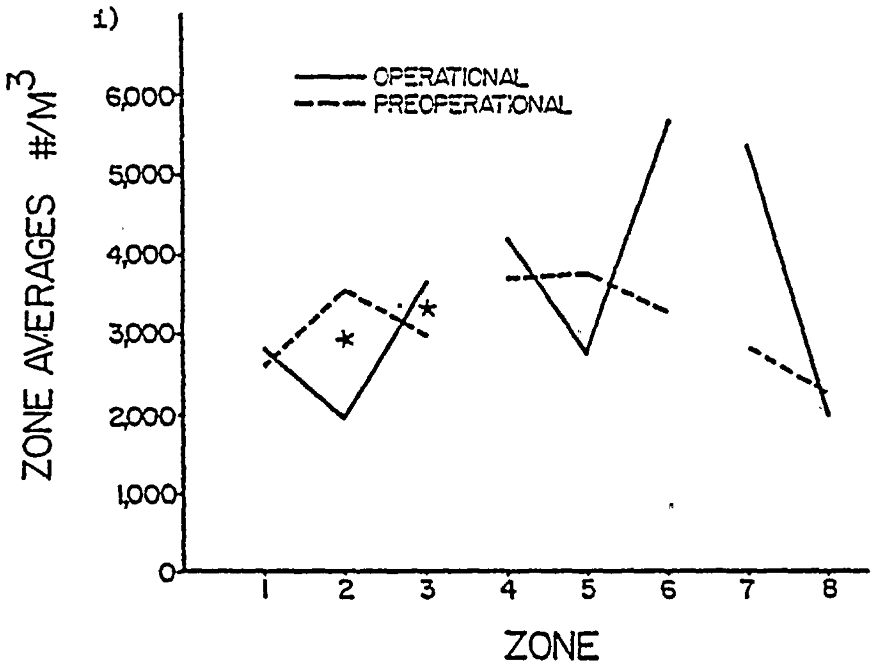
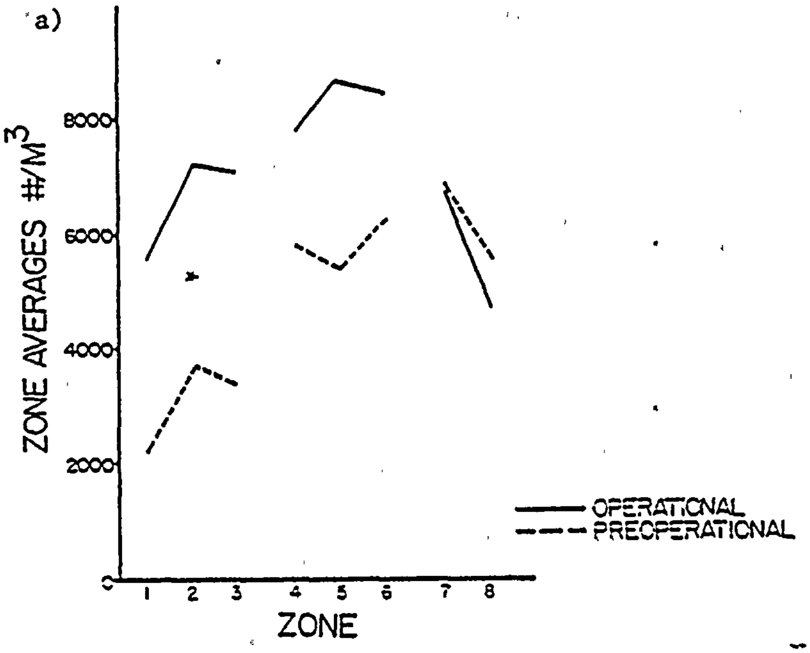


Figure 2 continued. i)<u>Daphnia</u> spp. 1972-74 and 1975-79.



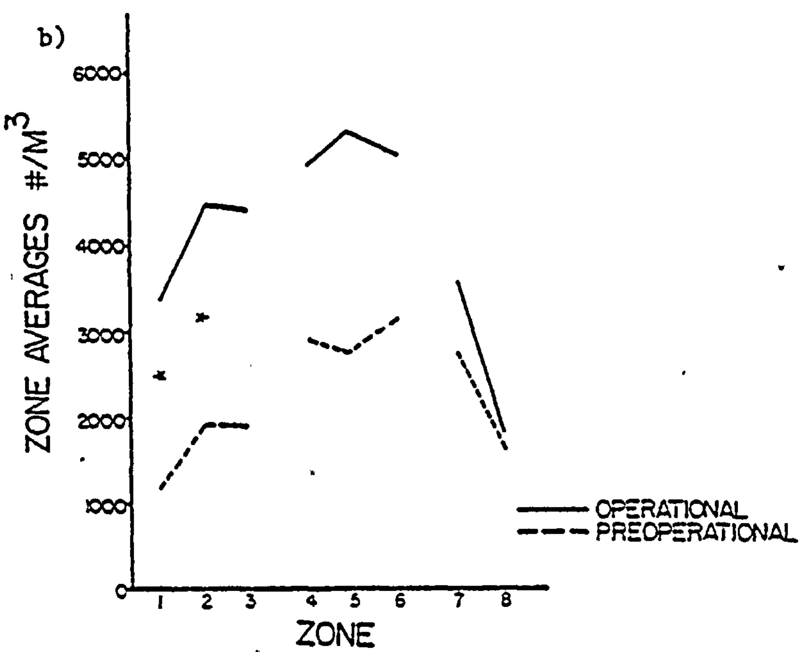
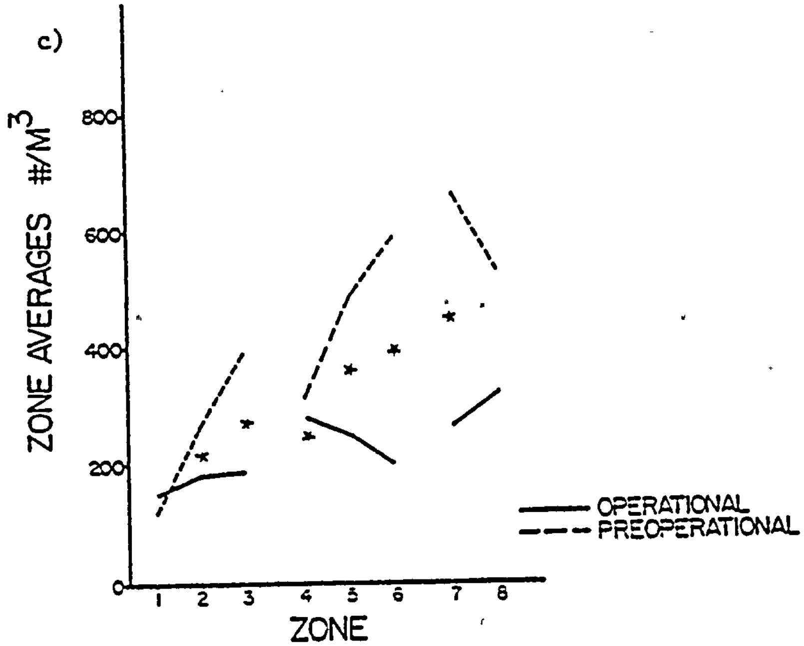


Figure 3. Mean zooplankton densities in April for each zone (dashed lines = preoperational period, solid lines = postoperational period). Stars indicate zones with significant differences between the preoperational and post operational periods (Mann-Whitney U test, α = 0.05). Lines connect zones in the 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 1975-80. b) Copepod nauplii 1972-1974 and 1975-1980.



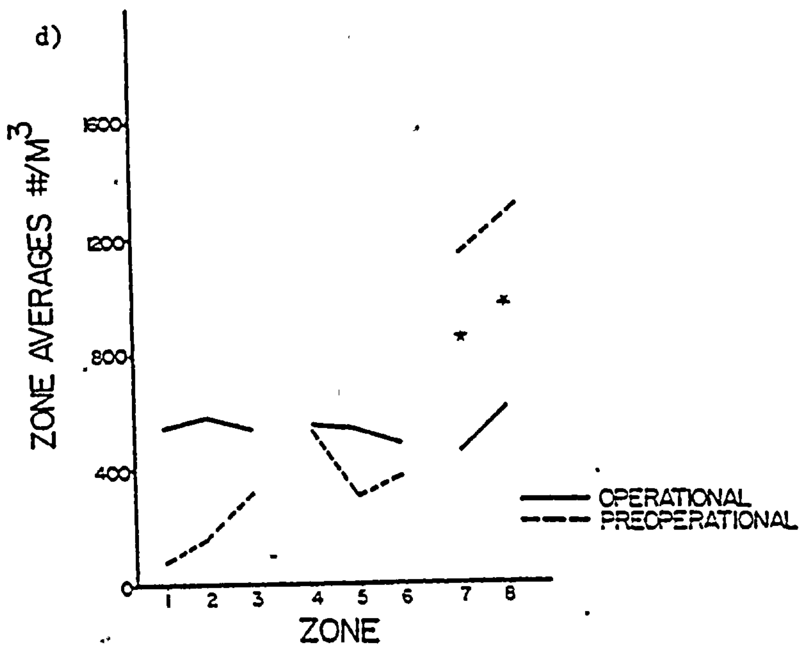
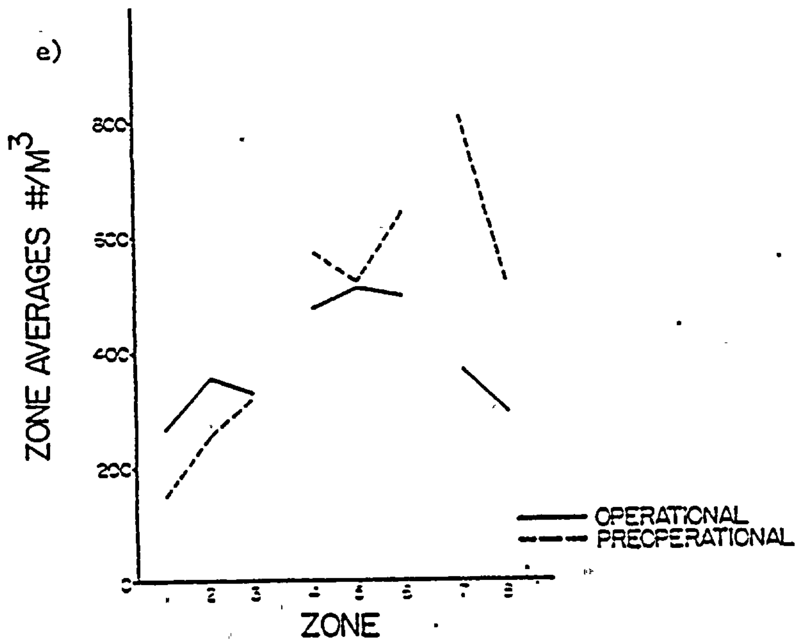


Figure 3 continued. c) Cyclopoid C1-5 1973-74 and 1975-80. d) Cyclops spp. C6 1973-74 and 1975-80.

e)



f)

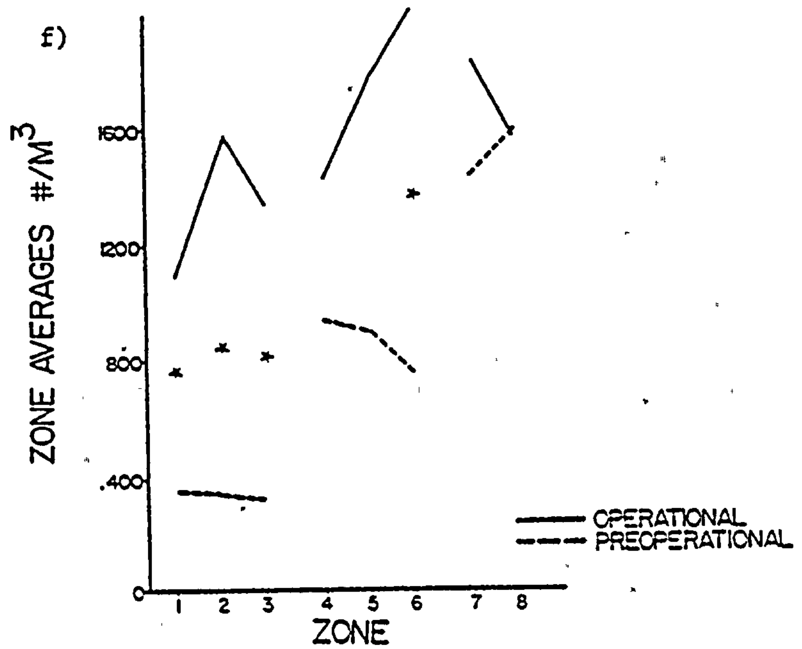


Figure 3 continued. e) <u>Diaptomus</u> spp. C1-C5 1973-74 and 1975-80. f) <u>Diaptomus</u> spp. C6 1973-74 and 1975-80.

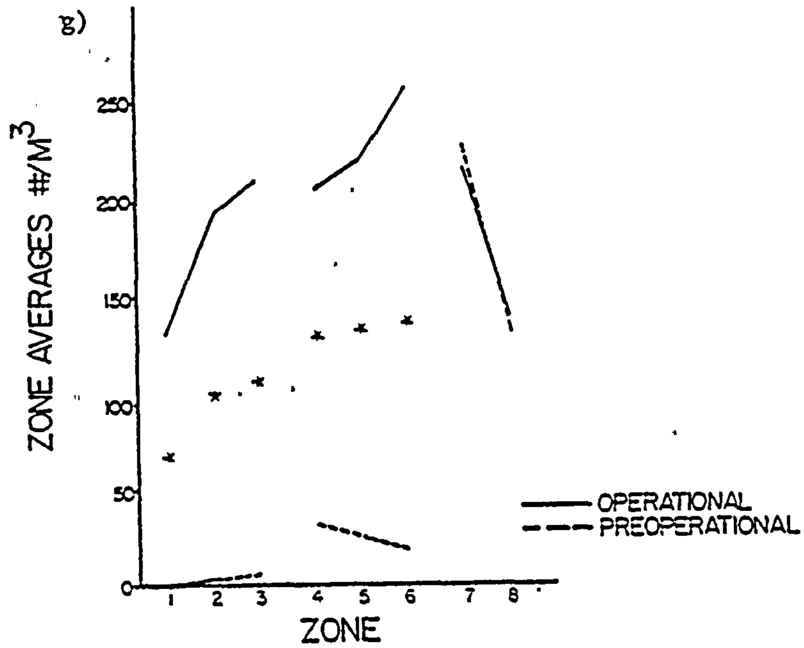
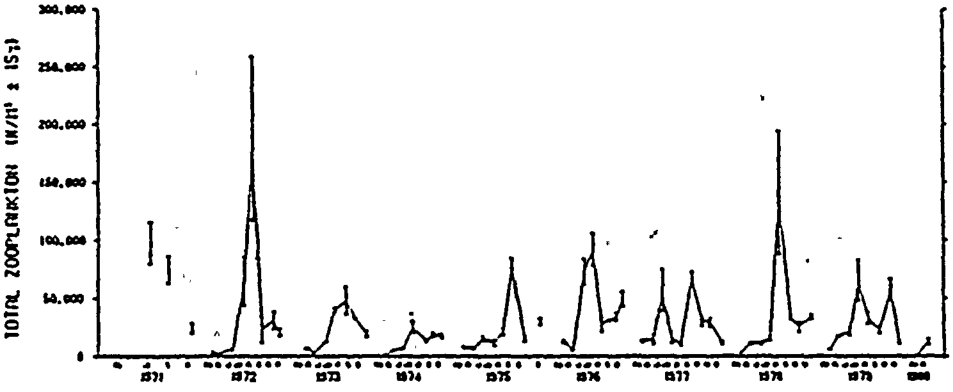


Figure 3 continued. g) Limnocalanus macrurus C1-6 1973-74 and 1975-80.

a)



b)

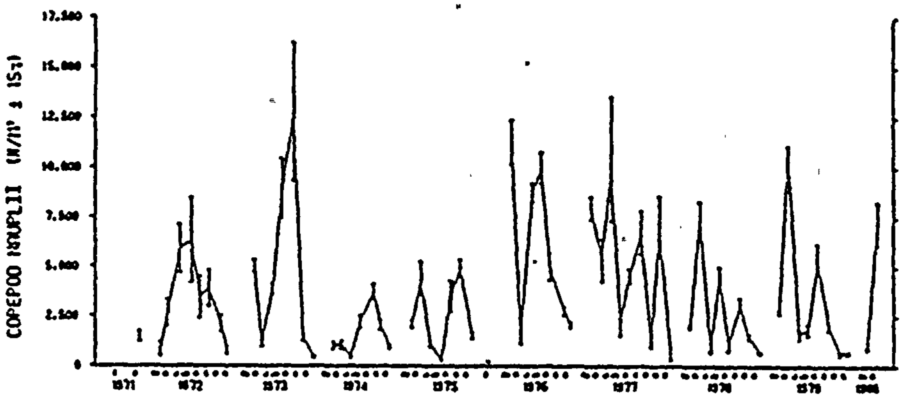
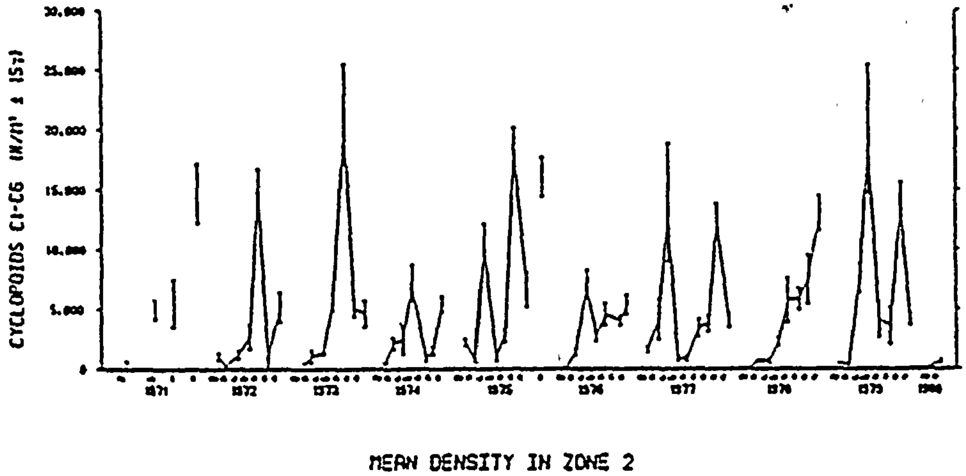


Figure 4. The monthly abundance of zooplankton in the inshore plume zone (zone 2) between 1971 and July 1980. a) Total zooplankton; b) copepod nauplii.

c)



d)

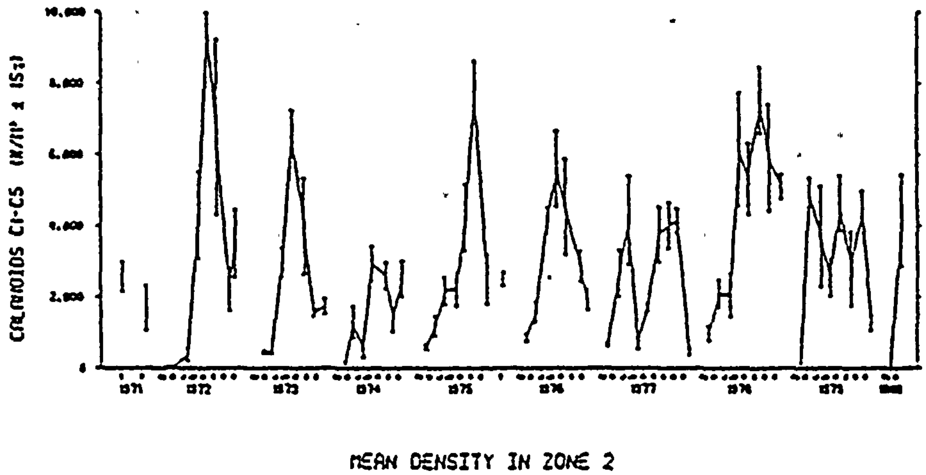
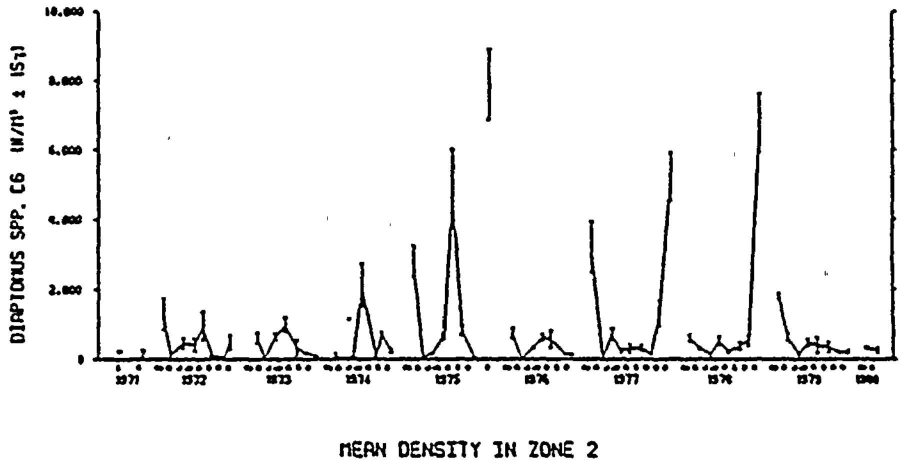


Figure 4 continued. c) cyclopoid copepodites; d) immature calanoid copepodites.

e)



f)

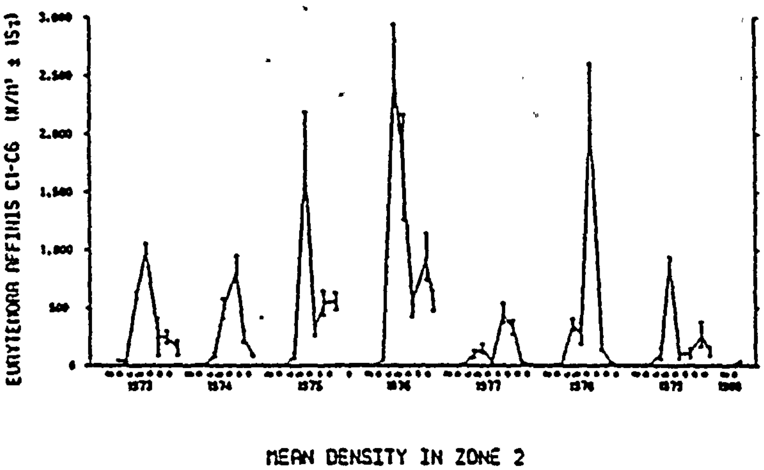
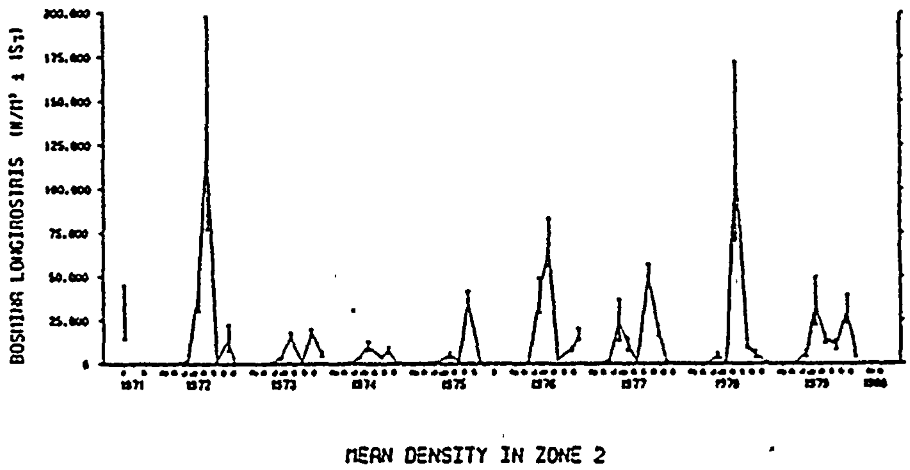


Figure 4 continued. e) Diaptomus spp. adults; f) Eurytemora affinis copepodites.

g)



h)

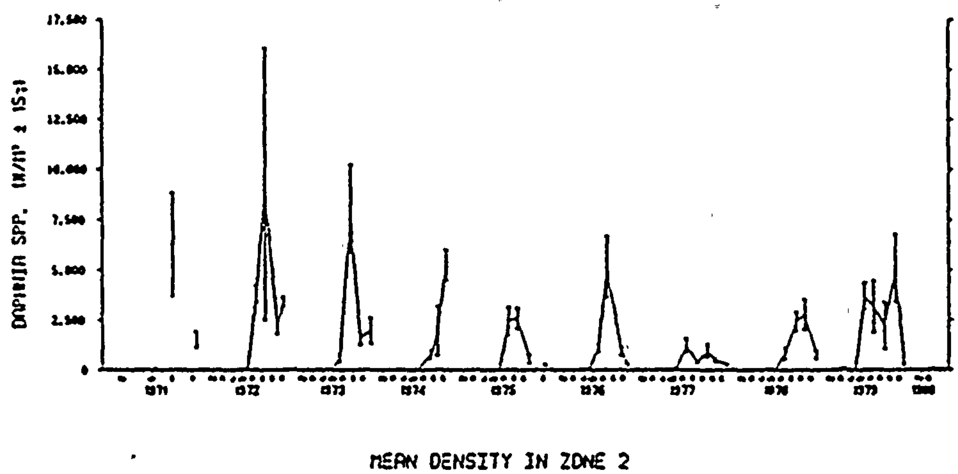
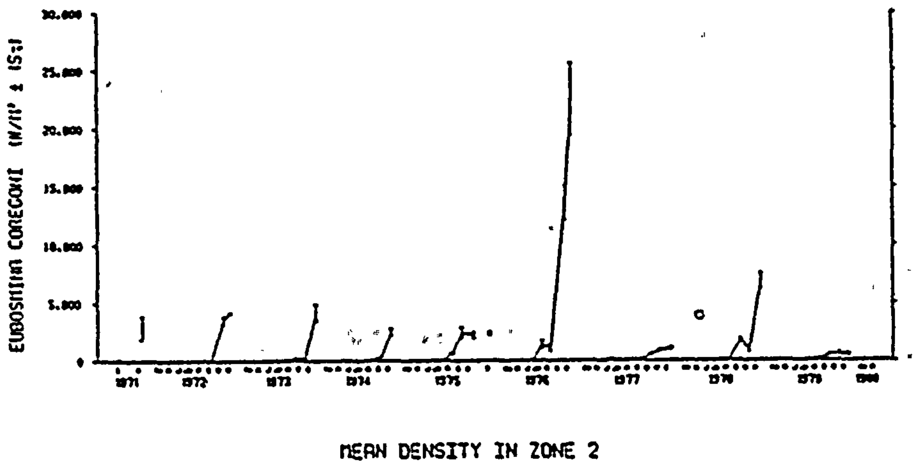


Figure 4 continued. g) Bosmina longirostris; h) Daphnia spp.

i)



j)

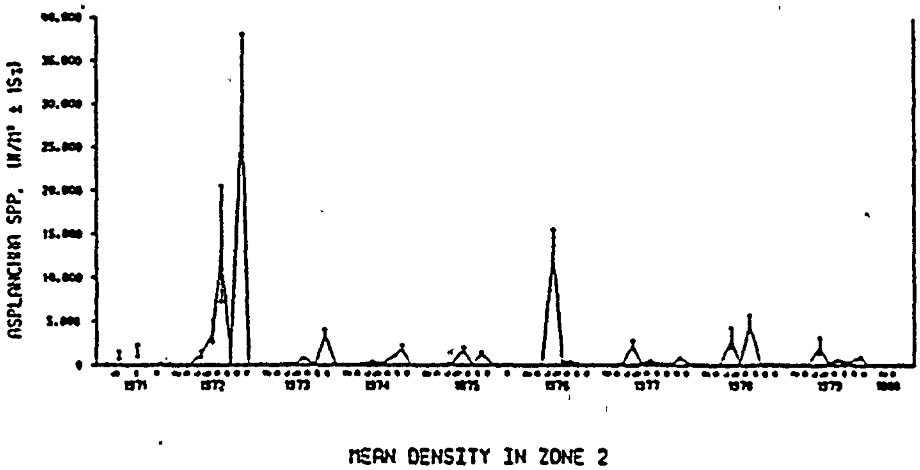


Figure 4 continued. i) Eubosmina coregoni; j) Asplanchna spp.

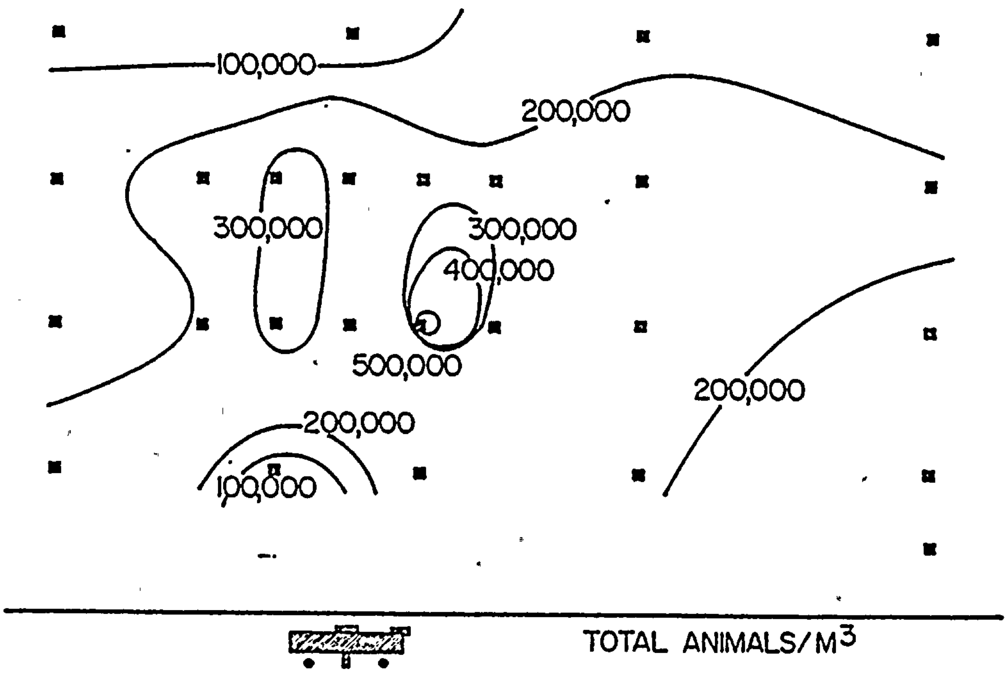


Figure 5. Mean concentrations (number/ M^3) of epibenthic organisms (organisms living above the sediments) on July 29-30, 1980, in the vicinity of the Donald C. Cook Nuclear Plant. The station grid extends 1 km south and 2 km north of the plant.

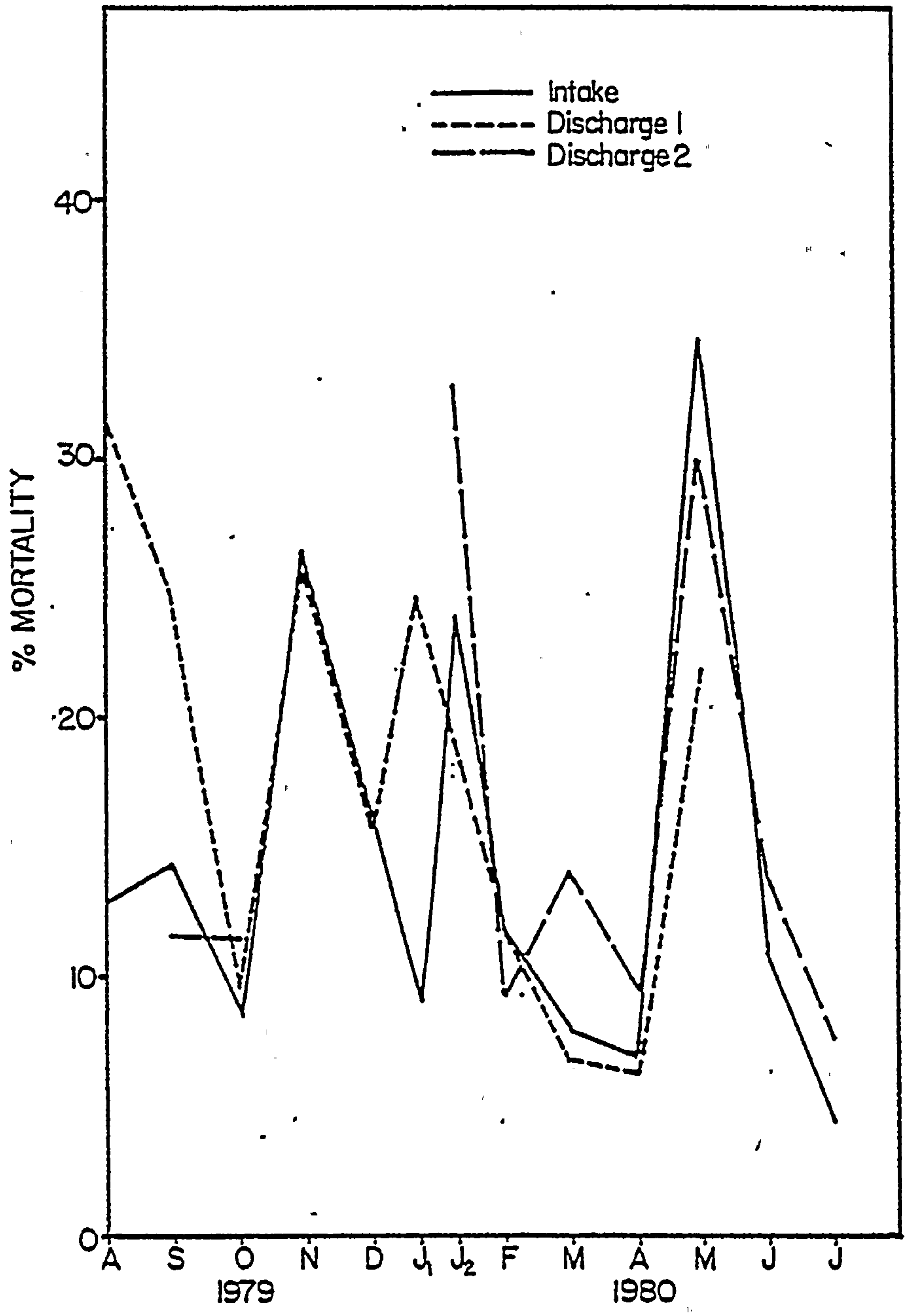


Figure 6. Total zooplankton mean mortality (%) immediately following collection (0 hour count) for zooplankton collected in the intake forebay (MTR1-5) and both Unit 1 and Unit 2 discharge bays.

a)

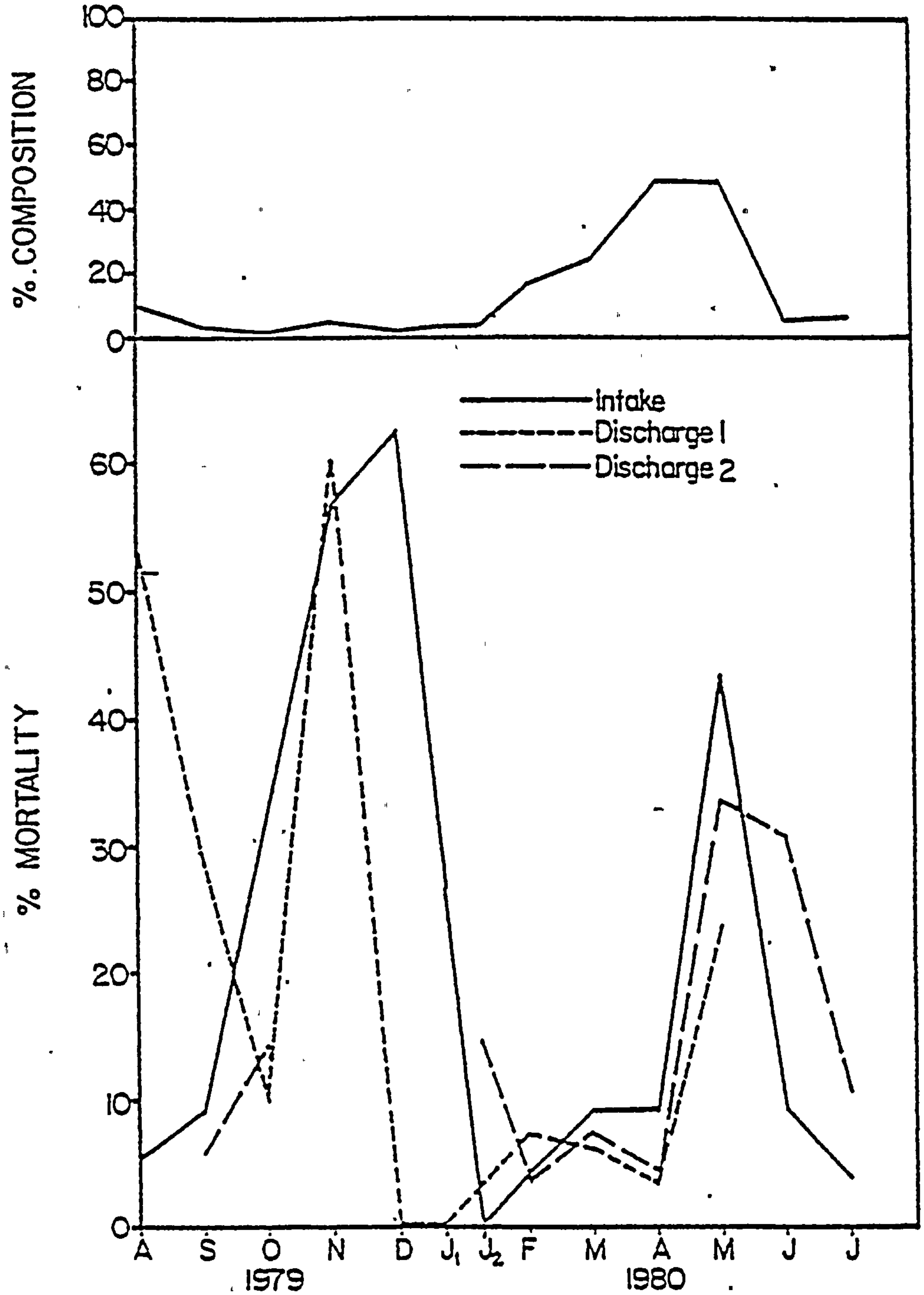


Figure 7. The mean mortality (% dead) immediately following collection (0 hour count) and relative density (% composition) for zooplankton collected in the intake forebay (MTR1-5) and both Unit 1 and Unit 2 discharge bays. a) Copepod nauplii.

b)

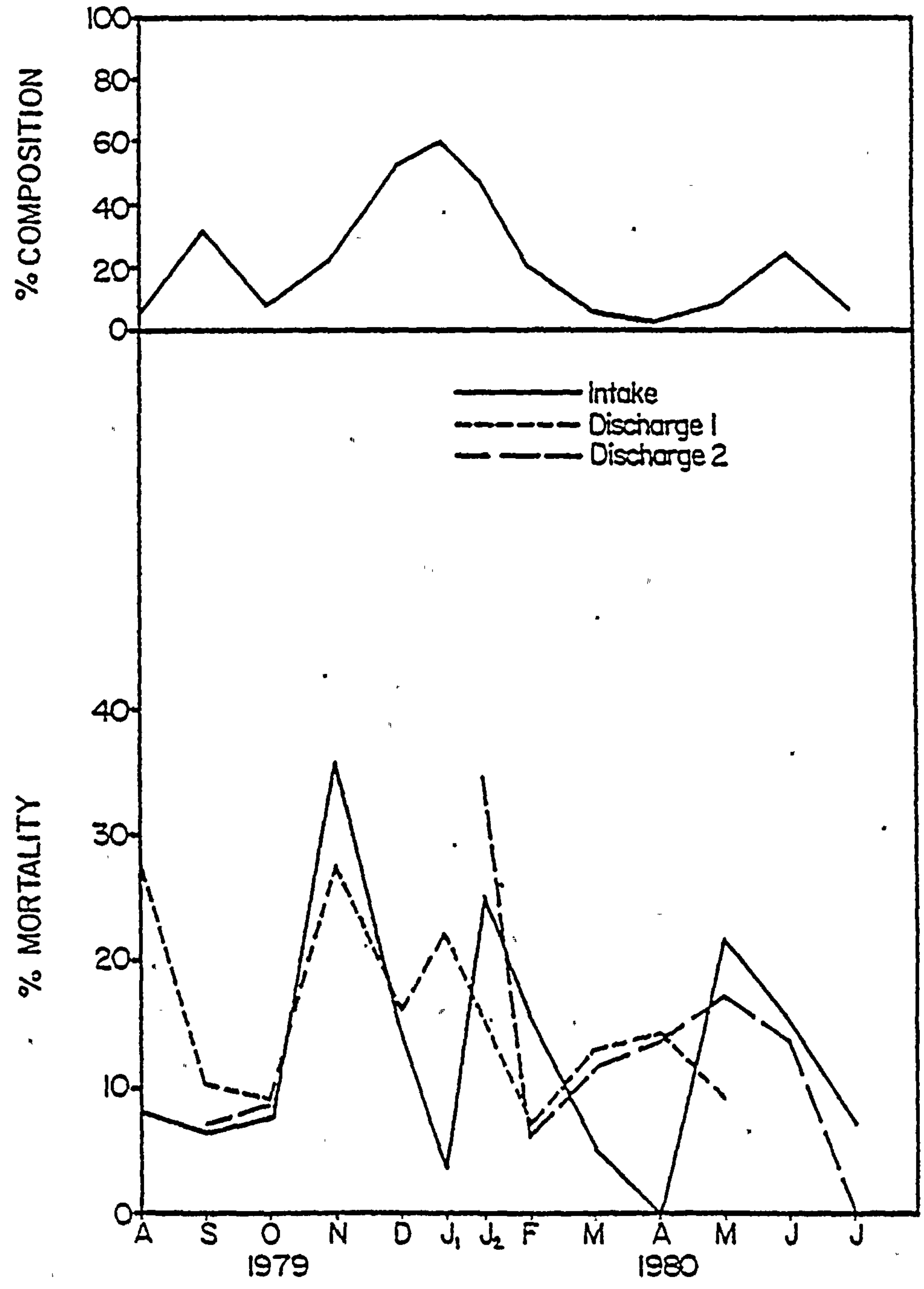


Figure 7 continued. b) Cyclops spp. C1-C5.

c)

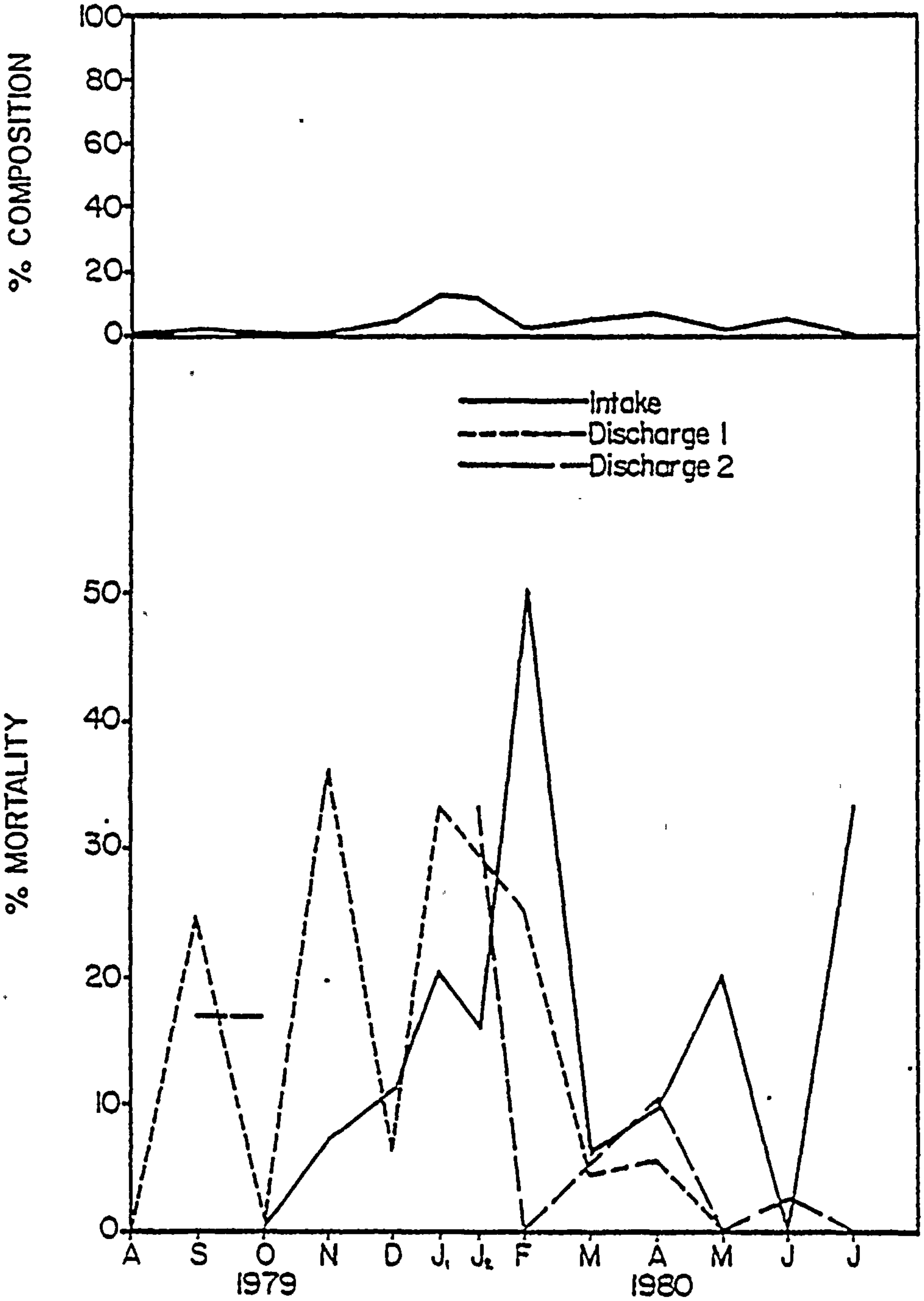


Figure 7 continued. c) Cyclops bicuspidatus C6.

d)

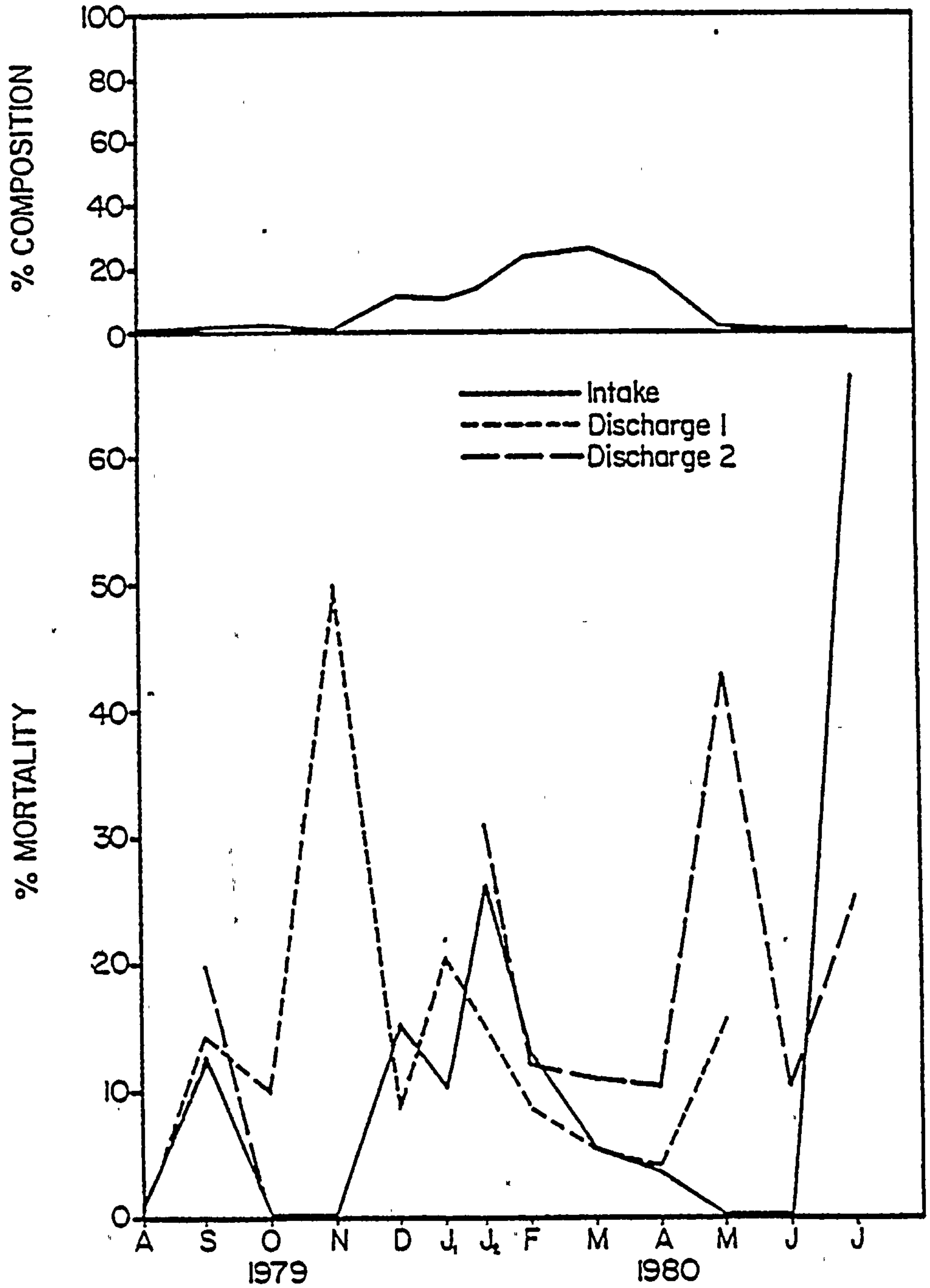


Figure 7 continued. d) Diaptomus spp. C1-C5.

e)

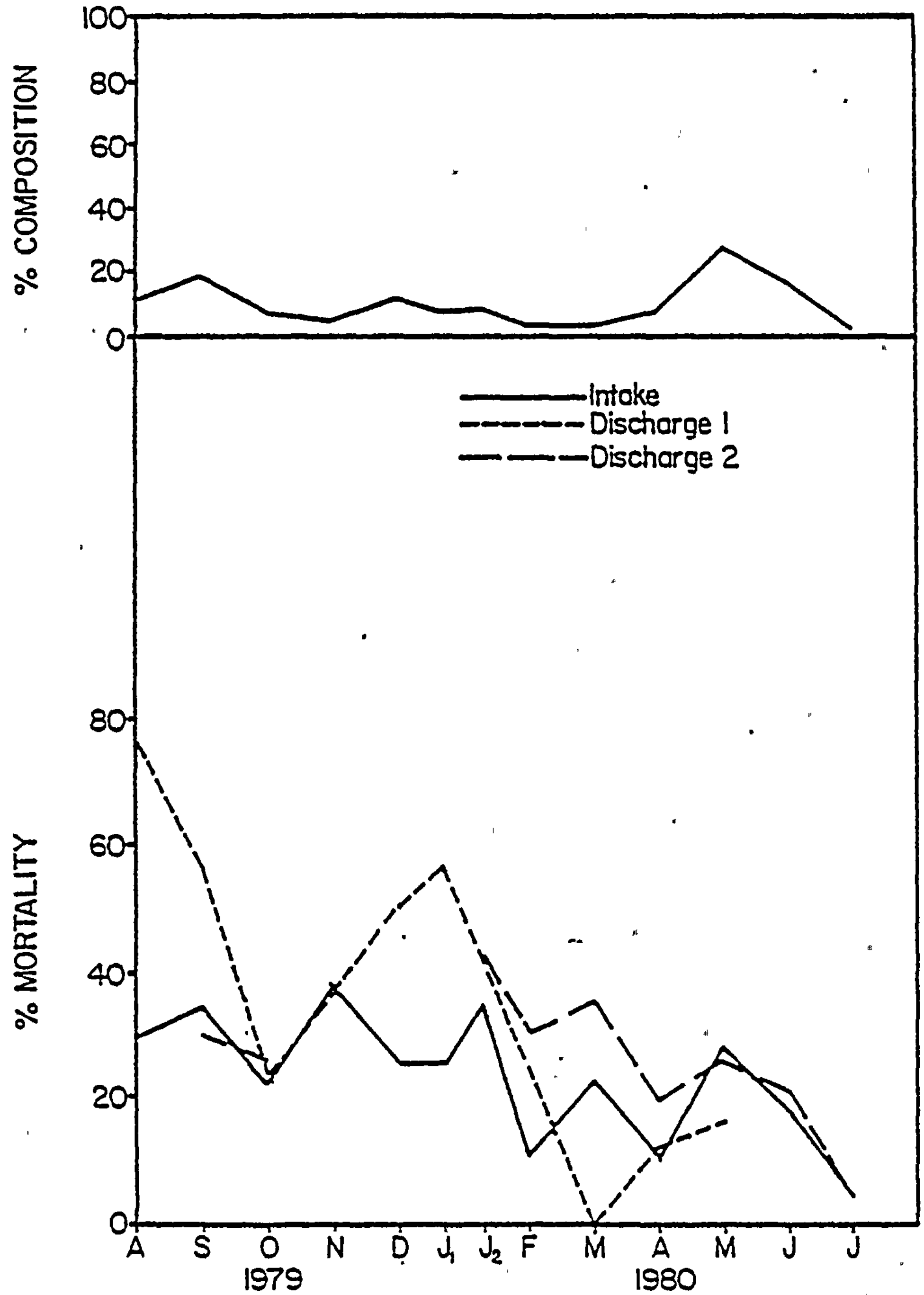


Figure 7 continued. e) <u>Diaptomus</u> spp. C6.

f)

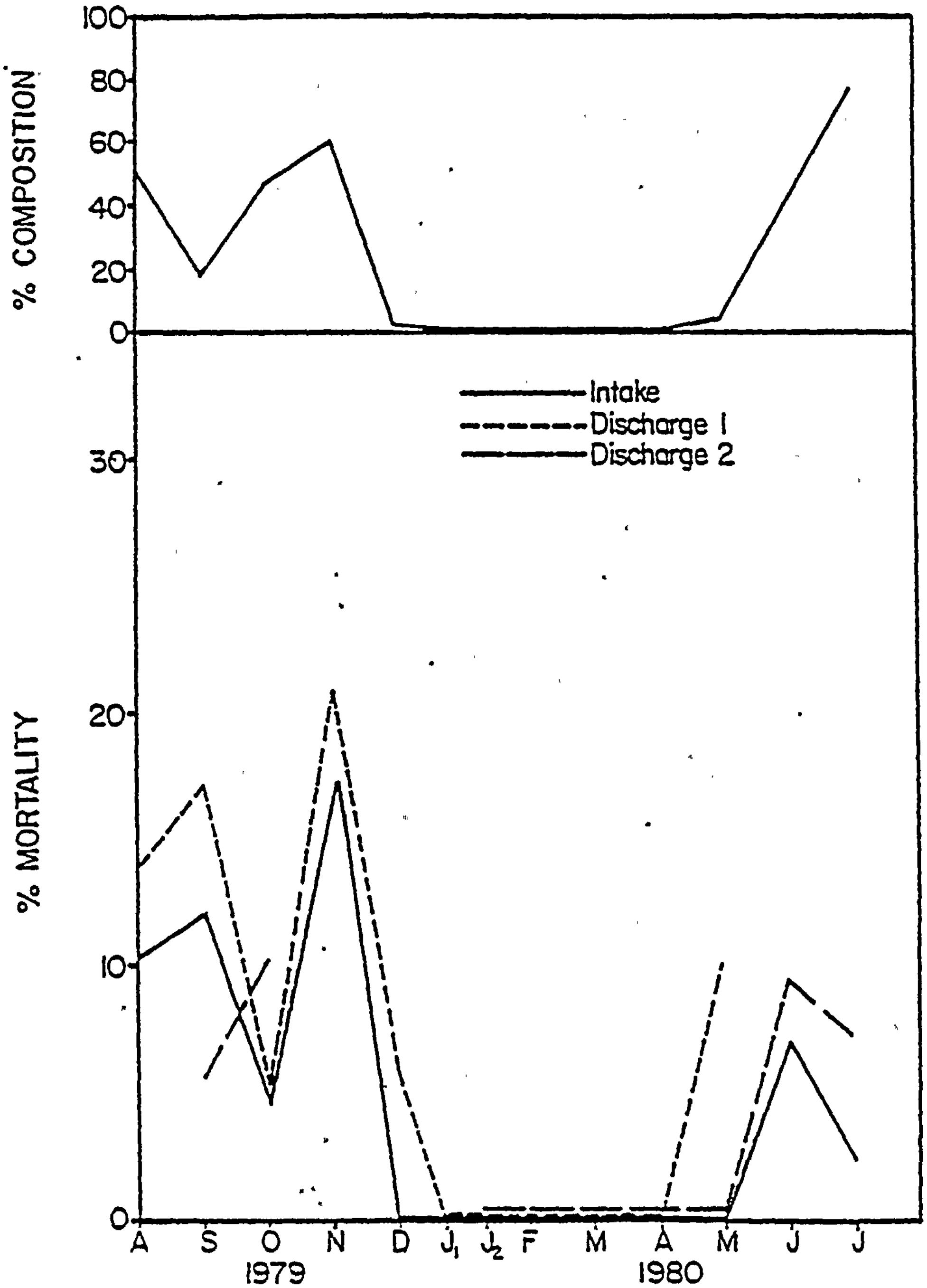


Figure 7 continued. f) <u>Bosmina</u> <u>longirostris</u>.

g)

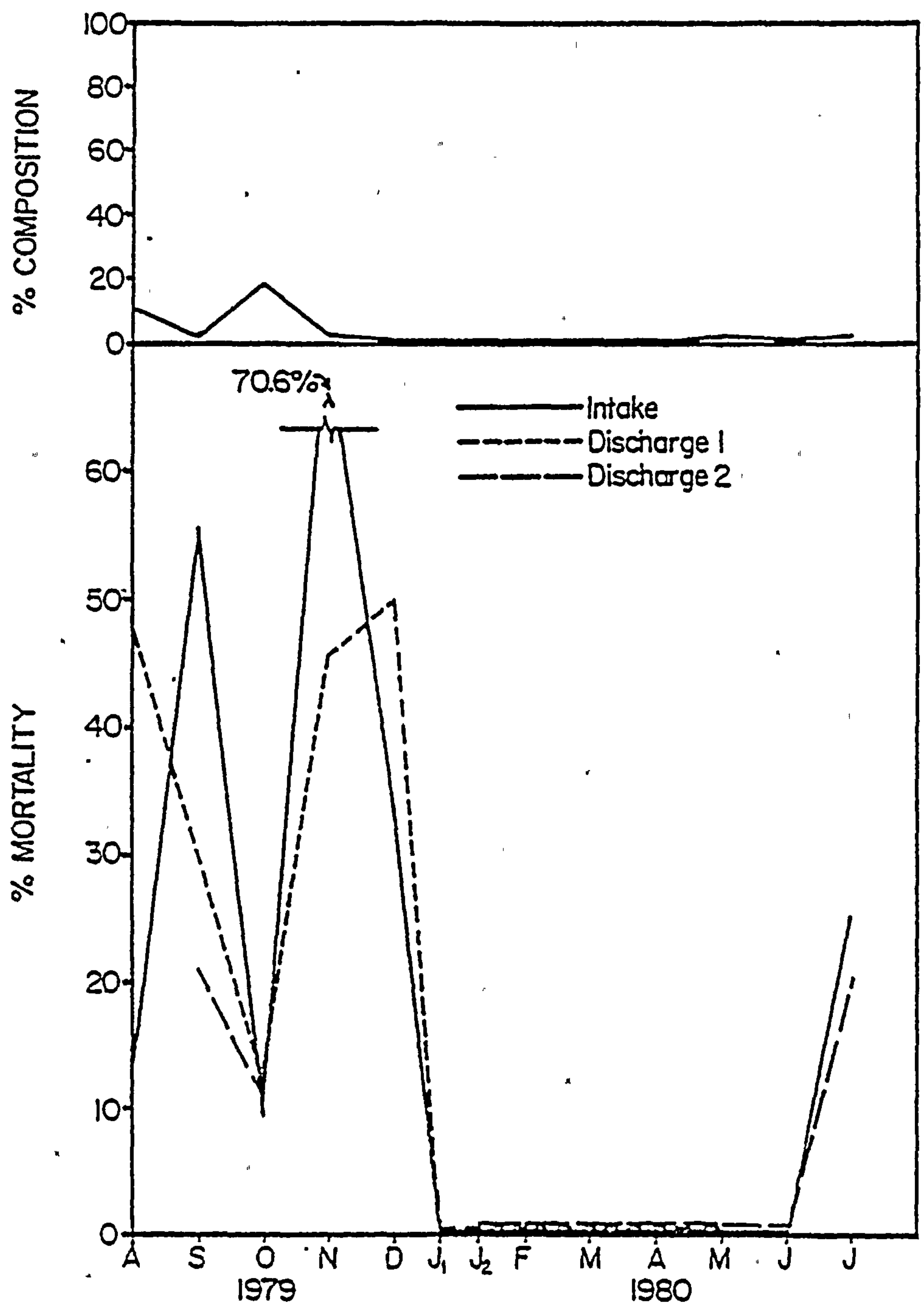


Figure 7 continued. g) Daphnia retrocurva.

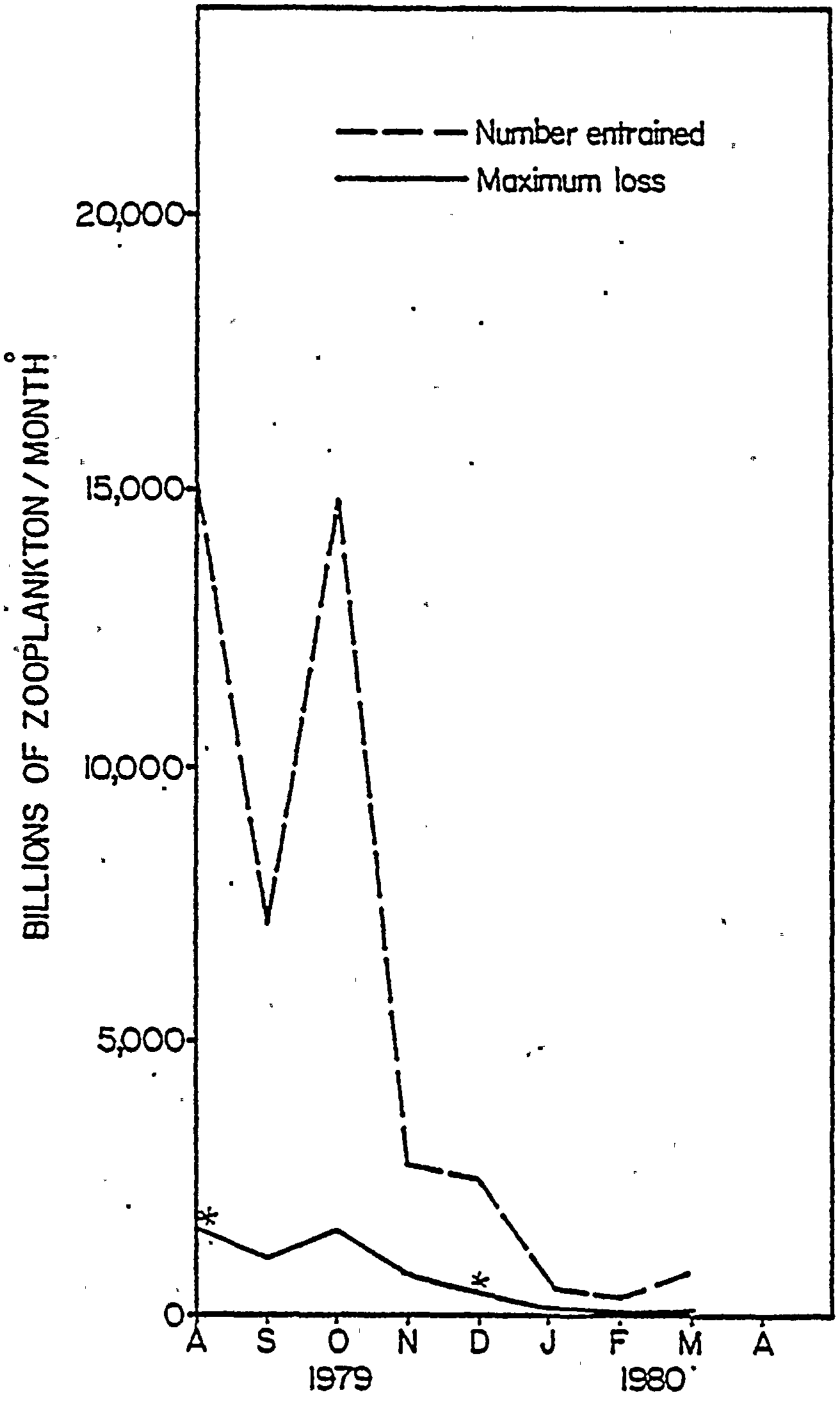


Figure 8. Estimates of zooplankton numbers entrained and maximum numbers lost from August 1979 to March 1980. The two starred maximum loss values are estimates for Unit 1 only.

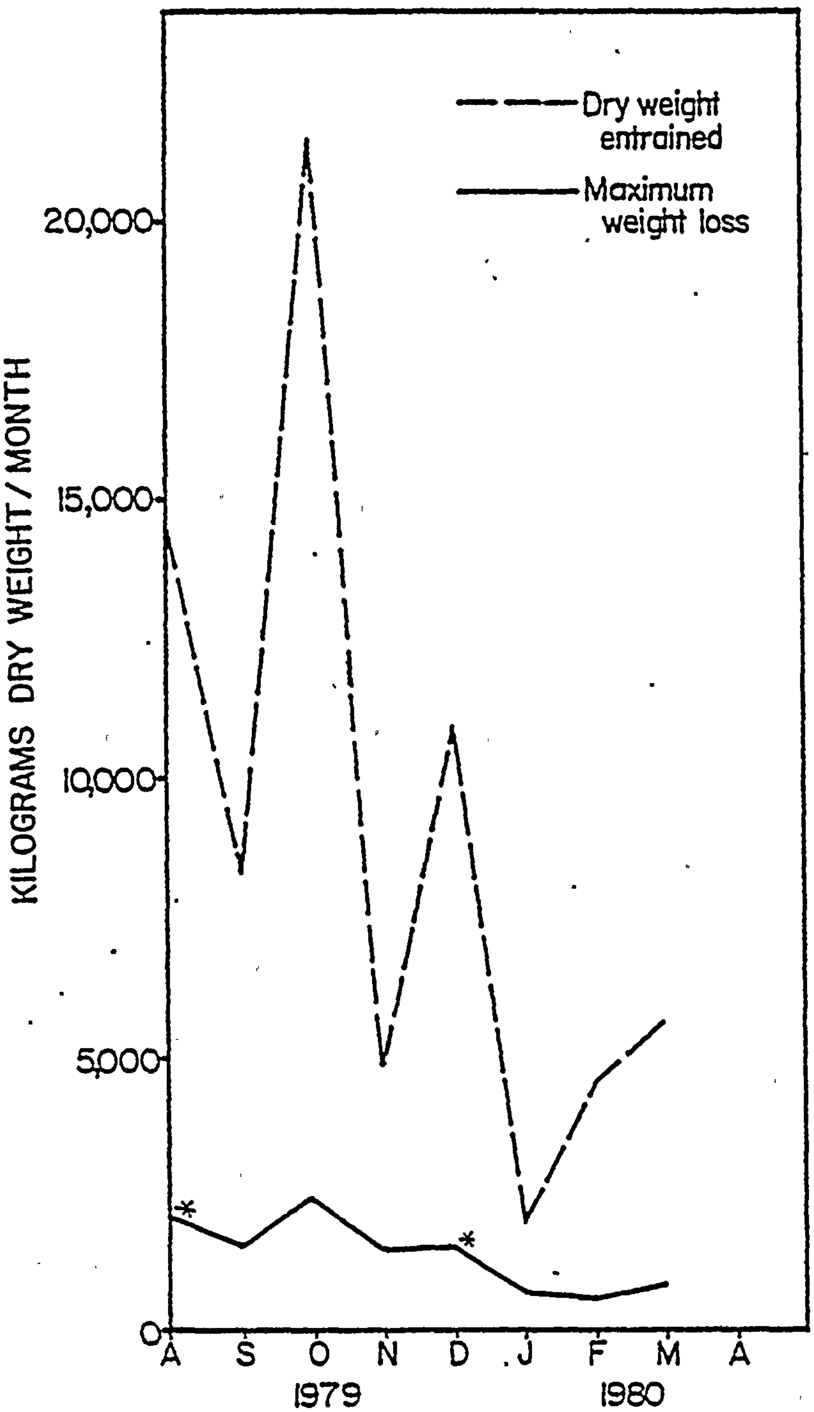


Figure 9. Estimates of entrained zooplankton dry weights and maximum losses from August 1979 to March 1980. The two starred maximum loss values are estimates for Unit 1 only.

Table 1. Results of Mann-Whitney U tests comparing October 1972-1979 preoperational and operational densities of 12 taxa in each of 8 zones. The preoperational period is 1972-74 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 categories									
Cyclopoid C1-C6	*	ns	ns	*	*	*	ns	ns	1972-79
Calanoid C1-C6	*	ns	ns	ns	ns	ns	ns	ns	1972-79
Cladoceran	ns	ns	ns	ns	ns	*	*	ns	1972-79
Total zooplankton	ns	*	ns	*	ns	*	*	ns	1972-79
Genus, species, or developmental stage									
Copepod nauplii	*	ns	ns	ns	ns	ns	ns	ns	1972-79
Cyclopoid C1-C5	*	*	*	*	*	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	1973-79
Diaptomus spp. C6	ns	ns	ns	*	ns	ns	*	ns	1973-79
Bosmina longirostris	ns	*	ns	ns	ns	ns	ns	ns	1972-79
Eubosmina coregoni	ns	*	*	ns	ns	ns	ns	*	1972-79
Daphnia spp.	ns	*	*	ns	ns	ns	ns	ns	1972-79

Table 2. Results of Mann-Whitney U tests comparing April 1971-1980 preoperational and operational densities of 9 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 1975-80. Stars indicate significant differences ($\alpha=0.05$).

Taxa	Zone 1	2	3	4	5	6	7	8	Period
Composite categories									
Cyclopoid C1-C6	ns	ns	ns	*	*	*	*	*	1971-80
Calanoid C1-C6	*	*	*	ns	*	*	ns	ns	1971-80
Total zooplankton	ns	*	ns	ns	ns	ns	ns	ns	1972-80
Genus, species, or developmental stage									
Copepod nauplii	*	*	ns	ns	ns	ns	ns	ns	1972-80
Cyclopoid C1-C5	ns	*	*	*	*	*	*	ns	1973-80
Cyclops spp. C6	ns	ns	ns	ns	ns	ns	*	*	1973-80
Diaptomus spp. C1-C5	ns	ns	ns	ns	ns	ns	ns	ns	1973-80
Diaptomus spp. C6	*	*	*	ns	ns	*	ns	ns	1973-80
Limnocalanus macrurus C1-C6	*	*	*	*	*	*	ns	ns	1973-80

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 1980 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 1979. The phytoplankton surveys of previous years are given by Ayers et. al. (1979), Ayers, Mozley, and Roth (1973), Ayers, Mozley, and Stewart (1974), Ayers (1975), Ayers, Southwick, and Robinson (1977), 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 1979 are not presented here; they are given in Ayers, Feldt, 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 comparison 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 1979 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: 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 1979. 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 it is justifiable on the basis that members of each category have more or less similar functions in the ecosystem.

Table 1 presents, for the seasonal surveys of 1979, the means, standard errors, and numbers of observations of abundances of toal 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 1.

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 1 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. 1A) have shown almost no variation in abundance over the entire ten years of the study.

Filamentous green algae (Fig. 1B), 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. 1C) increased in abundance in all depth zones and both station groups in 1976 and 1977, but similar abundances had been observed in preoperational years. In 1978 this category exhibited, in both station groups of zone 0, increases to numbers higher than previously found. In zones 1 and 2 high densities of this category were present only in summer, with fall abundances falling back to the range of numbers found in earlier years. In 1979 this category, in both station groups and all zones, returned to the range of numbers previously observed.

Filamentous blue-green algae (Fig. 1D) have in general been more abundant in the study area since plant startup in 1975 than they were in preoperational years. In zone 0 during the ten years of study their abundances at inner and outer stations have been closely similar. Except in 1978, zone 1 July densities of these algae were higher at the inner stations in 1976, 1977, and 1979. No reason for the 1978 reversal in summer abundances in zones 1 and 2 can be given.

Coccoid blue-greens (Fig. 1E), 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. 1F) 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 off-shore stations where the plant plume is not expected, the high of that month is attributed to some lake effect, not plant operation.

Flagellates (Fig. 1G) in both station groups of zone 0 continued in 1979 the trend of steadily increasing abundances that had been going on since 1971. In zones 1 and 2, however, these organisms decreased in abundance, in both inner and outer stations, to about the levels they had occupied in 1976. At present we can give no reason for the declines in 1979.

Pennate diatoms (Fig. 1H), like flagellates, in both station groups of zones 1 and 2, decreased in abundance in 1979 to about the levels of 1976. In zone 0 a summer increase to 2270 ± 764 cells per ml at the inner stations was not matched at the outer stations (788 ± 317 cells per ml); the reason for this is not known at present.

Centric diatoms (Figs. 1I, 1J, 1K) 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 minima of numbers did not occur in any zone in 1977 nor in zones 0 or 1 in 1973; these are attributed to temporary nutrient enrichments by upwellings of hypolimnion water. There was no

summer minimum in zone 0 in 1978, probably for the same reason. Cell densities in zones 1 and 2 in 1979 had the same shapes of annual curves and abundance levels as in 1975.

Total algae (Figs. 1L, 1M, 1N) had, with the exception of zone 2 inner stations in 1978, exhibited steadily rising trends of abundance since 1974. These trends were not continued in 1979; although abundances remained high they were below those of 1978. Declines in abundances of flagellates, pennate diatoms, and centric diatoms not completely offset by continuing increases in blue-green algae are considered the reason for lower abundances in 1979.

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

In the Environmental Operating Report for 1977 we reported statistical tests for significant differences in abundances of ten algal categories at inner vs. outer stations in three depth zones during three seasons of each year from 1971 through 1977; the two availble seasons of 1970 were also reported. The EOR for 1978 extended the testing through 1978; this section extends the tests through 1979.

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 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.

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 2 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 1979.

During the period from July 1970 through October 1979, 767 paired comparisons of inner vs. outer station group cell density means have been possible; of these 350 were from preoperational years and 417 were from operational years. During the entire period there have been a total of 42 cases of significant differences of mean densities between inner and outer station groups; these amount to 5.5% 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	79,Z0,Sp,0	
Filamentous blue-greens	75,Z1,Su,0	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,0	72,Z2,Sp,0	73,Z1,Fa,0	74,Z2,Fa,0
	76,Z2,Fa,I	77,Z1,Su,0	77,Z1,Fa,0	79,Z2,Fa,0
Centric diatoms	72,Z1,Sp,0	72,Z1,Fa,I	75,Z1,Fa,I	75,Z2,Fa,I
Pennate diatoms	70,Z1,Su,0	71,Z2,Su,01	73,Z1,Sp,0	75,Z2,Fa,I
	79,Z1,Fa,I			
Desmids	71,Z1,Su,0	71,Z2,Su,I		
Other algae	71,Z1,Sp,0	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,0	72,Z2,Sp,0	76,Z1,Sp,0	77,Z2,Su,I
	78,Z2,Su,0	79,Z2,Su,I		

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	1979	4

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 fours in operational 1976 and 1979 are less than the fives 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.

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 + 0	Inner greater 0 + 3	Inner greater 6 + 13
Outer greater 1 + 1	Outer greater 7 + 4	Outer greater 4 + 2

In zone 0 the cases of significant difference in abundances at inner and outer stations have been almost equally divided between 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 14 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 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 13 of 15 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 further, it is unlikely that waste heat from the plant has caused the higher densities in the inner stations of this zone.

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) estended them to include 1970 and 1976, and Ayers and Wiley (1979) added 1977. This section extends the previous summaries and interpretations to include the major seasonal surveys of 1979.

As was done in the reports cited above, the diversity index data for 1979 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):

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

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.

Mean diversity indices and associated standard errors for each depth-zone-station-group combination in the major surveys of 1979 are given in Table 3. In Figure 2 the surveys of 1979 have been added at the end of the time plots of diversity indices and standard errors which were presented previously.

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 and 1979. With the exceptions of zone 2 in July 1977 and October 1979, the parallelism of curves for inner and outer station groups in the operational years has been as good or better than in the preoperational years.

The placement on the graphs of annual curves for inner and outer station groups indicates that in zones 0 and 1 the diversities for 1979 were lower than in the preceding operational years; in zone 2 the diversities for 1979 were not noticeably different from those of preceding years. In all zones diversities remain higher than 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 $\bar{d}_{min}$ is the minimum possible diversity for a particular community. $\bar{d}_{max}$ 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 collections of 1970 - 1976 have been reported by Ayers (1978); those for 1977 by Ayers and Wiley (1979); and those for 1978 and 1979 will be reported by Ayers, Feldt, 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 seasonal surveys of 1979. The means and standard errors for the years 1970 through 1979 are plotted on a time axis in Figure 3.

In 1979 redundancy values rose to the levels of preoperational years, after a period of steady or slowly diminishing values from 1973 through 1978. We tentatively ascribe the 1979 condition to increased relative dominance of blue-green algae when flagellates and diatoms decreased in abundance in that year.

Except for October 1979 in zone 2, parallelism between annual curves of redundancies at inner and outer stations has been far better in later years than in preoperational years before 1972. Having begun in preoperational years and continued in the operational years, the trend for parallel changes in redundancy is attributed to some cause in the lake itself. There is nothing in this analysis of phytoplankton redundancies to indicate that operation of Cook Plant has had any adverse impact on the local phytoplankton community.

CONCLUSIONS

Of the ten categories of phytoplankton, four (desmids, filamentous greens, coccoid greens, and "other algae") have shown essentially no changes in abundances during the ten years of the study.

Four other categories (flagellates, pennate diatoms, centric diatoms, and total algae) have in shallow zone 0 exhibited steadily increasing trends since 1970. These categories, in zones 1 and 2, showed increasing trends from 1970 through 1978 but had lower abundances in 1979. The abundance changes took place in both inner and outer stations.

Blue-green algae have increased in abundance during the period of the study. First indications of increase were minor rises in 1972 with substantially higher levels of coccoid blue-greens appearing in the fall of 1974 and being an autumn characteristic in later years. Occurring in all three depth zones and in both inner and outer station groups, the fall increases are attributed to late summer-autumn depletions of silica in the epilimnetic water. Filamentous blue-greens exhibiting summer peak abundances have increased since 1974; occurring in all three depth zones and in both inner and outer stations the cause of these abundance variations is adjudged to be something in the lake.

In the ten years of the study there have been 767 paired comparisons of inner vs. outer station group cell density means. These have been compared by a two-sample t-test for significant differences of the means. During the entire period there have been 42 cases of significant differences between the means; these amount to 5.5% of the comparisons. The cases of differences are spread through nine of the ten categories of phytoplankton and fall within the natural range of variation; the significant differences are attributed to normal

accidents of sampling, no evidence of plant operation effects are shown by these analyses.

Phytoplankton diversities, as indicated by diversity indices, were not quite so high in zones 0 and 1 in 1979 as they had been in earlier operational years; in zone 2 the diversities for 1979 were not noticeably different from those of preceding years. In all zones diversities remain higher than in pre-operational years prior to 1974. There is no evidence that operation of Cook Plant has simplified (lowered the diversity of) the phytoplankton community.

Phytoplankton redundancy is a measure of the dominance of one or a few species within a given population. Redundancy values range from 0 to 1, with a value of 1 implying that one species dominates the community. In 1979 redundancy values rose to the levels of preoperational years after a period of steady or slowly diminishing values from 1973 through 1978. We tentatively ascribe the 1979 condition to increased relative dominance of blue-green algae when flagellates and diatoms decreased in abundance in that year.

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Wilhm, J. L., and T. C. Dorris. 1968. Biological parameters for water quality criteria. Bioscience 18 (6): 447-481.

* BHPPLS = Benton Harbor Power Plant Limnological Studies.

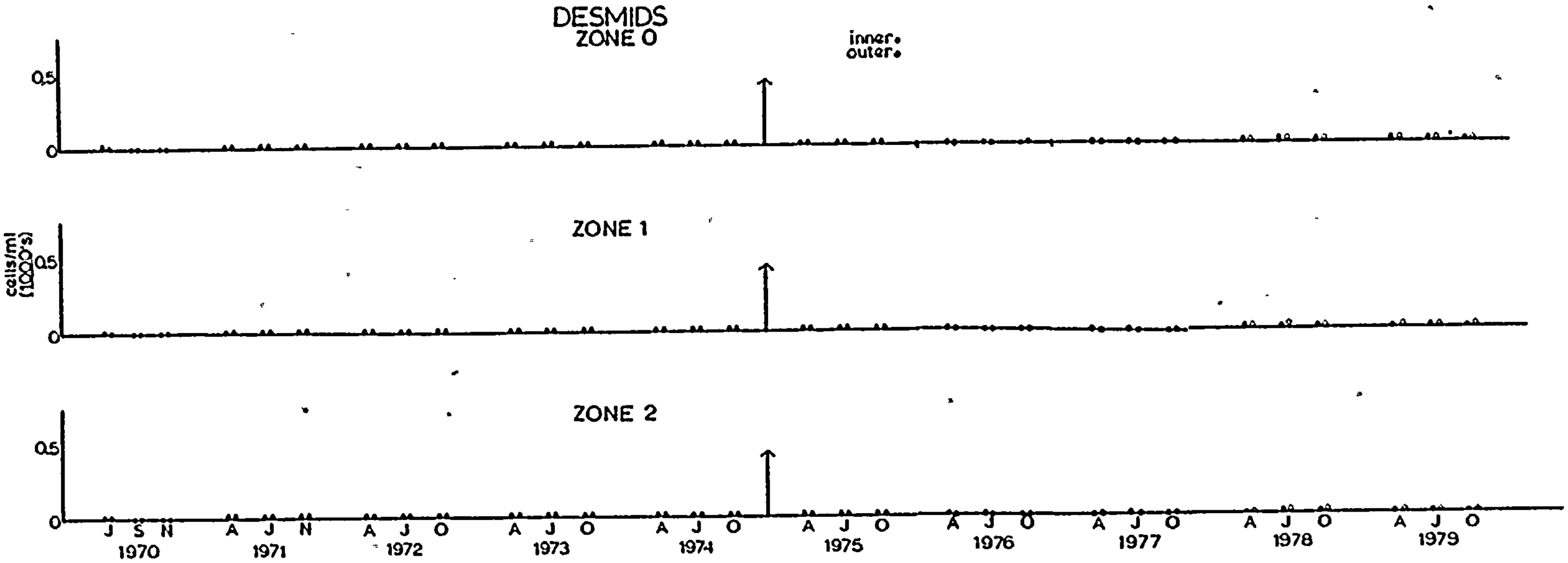

Fig. 1A. Mean abundances of desmids in zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. Space does not permit the drawing of standard error bars. See Table 1 for standard errors and numbers of observations.

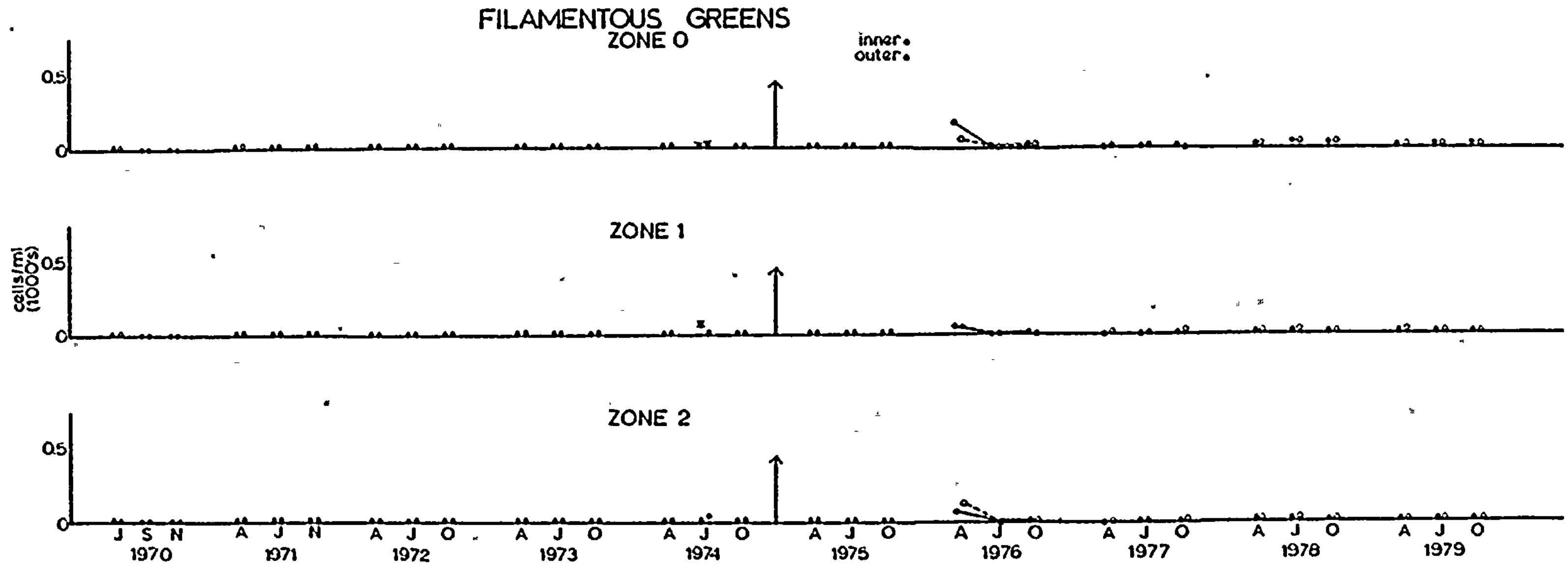

Fig. 1B. Mean abundances of filamentous green algae in zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. Space does not permit the drawing of standard error bars. See Table 1 for standard errors and numbers of observations.

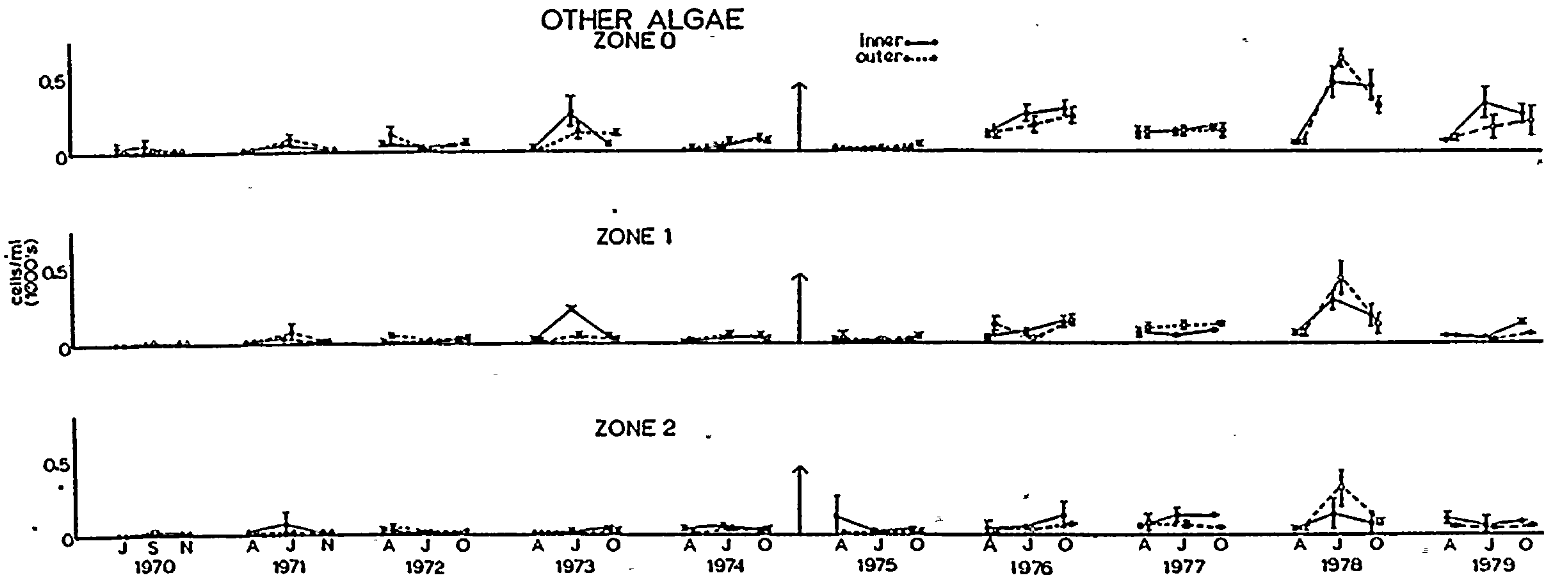

Fig. 1C. Mean abundances of "other algae" in zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

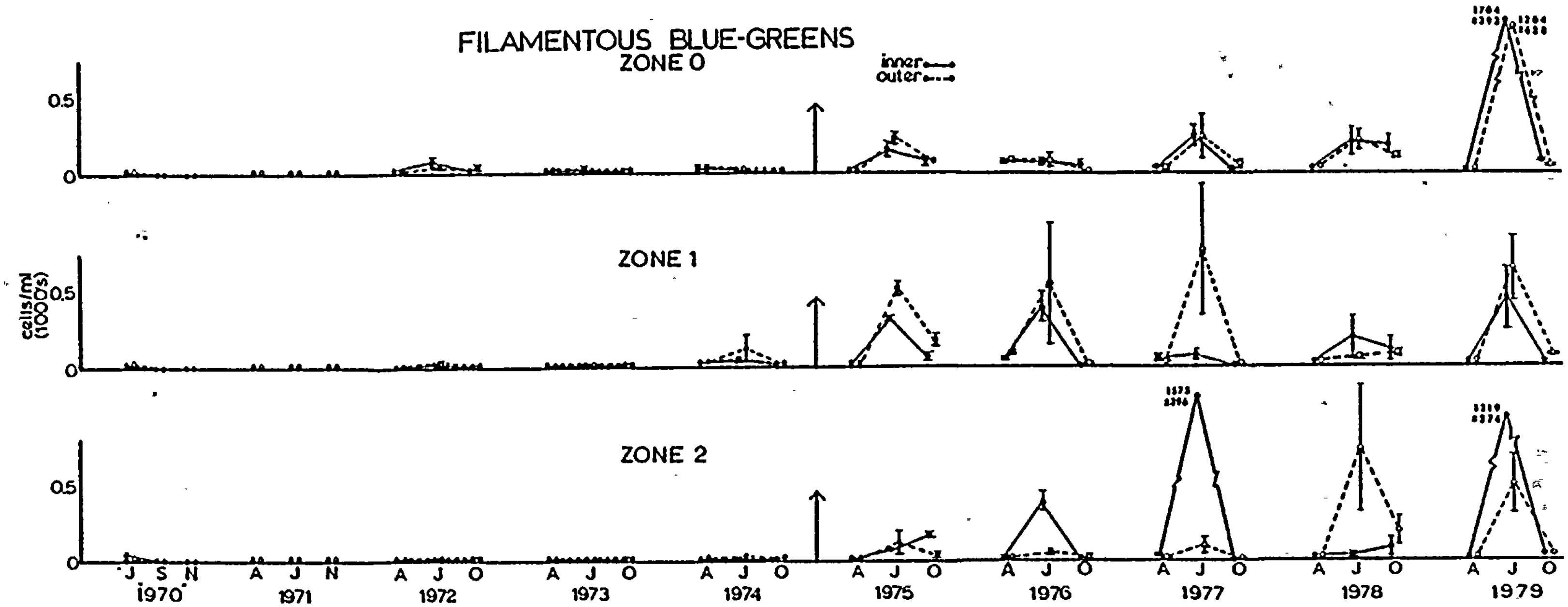

Fig. 1D. Mean abundances of filamentous blue-green algae in zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. Where space permits, vertical bars show the standard errors. See Table 1 for other standard errors and for numbers of observations.

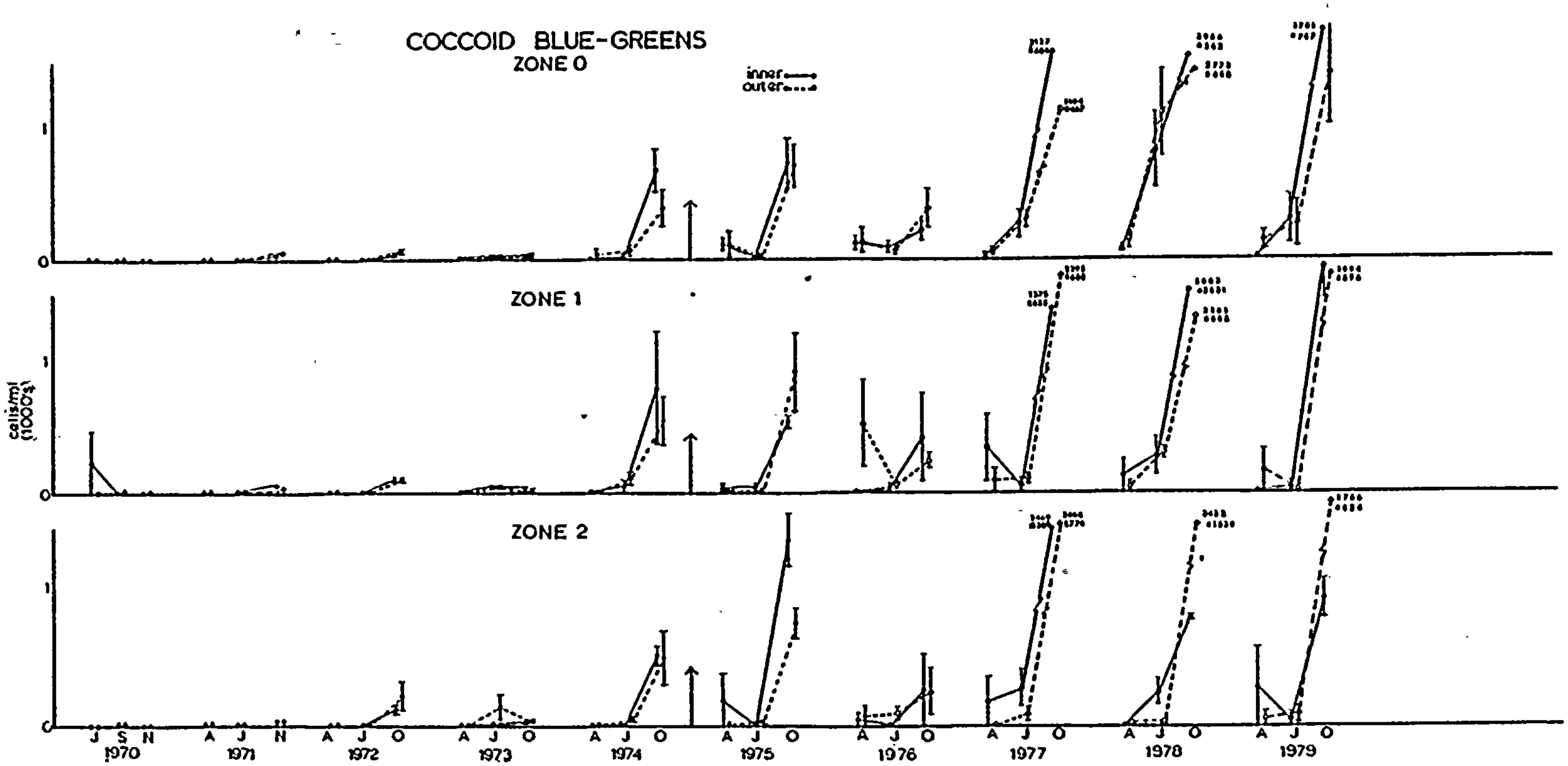

Fig. 1E. Mean abundances of coccoid blue-green algae in zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. Vertical bars show the standard errors. See Table 1 for numbers of observations.

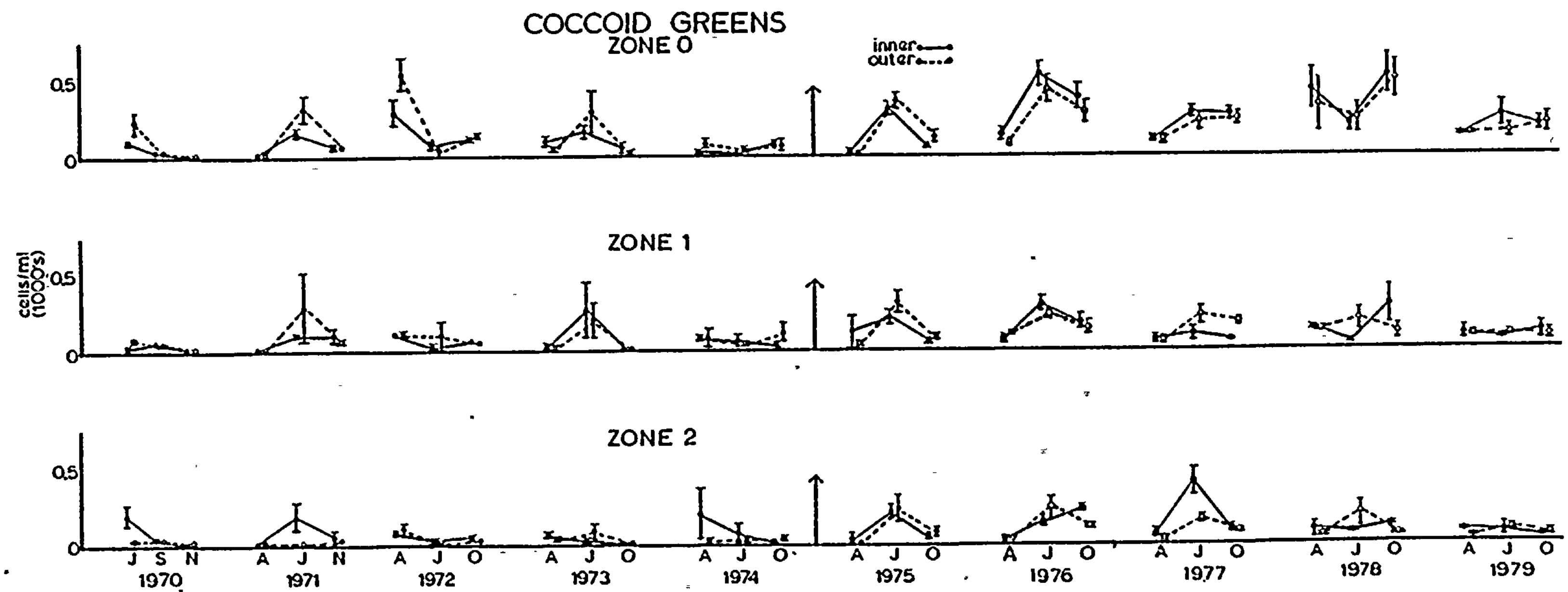

Fig. 1F. Mean abundances of coccoid green algae in zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

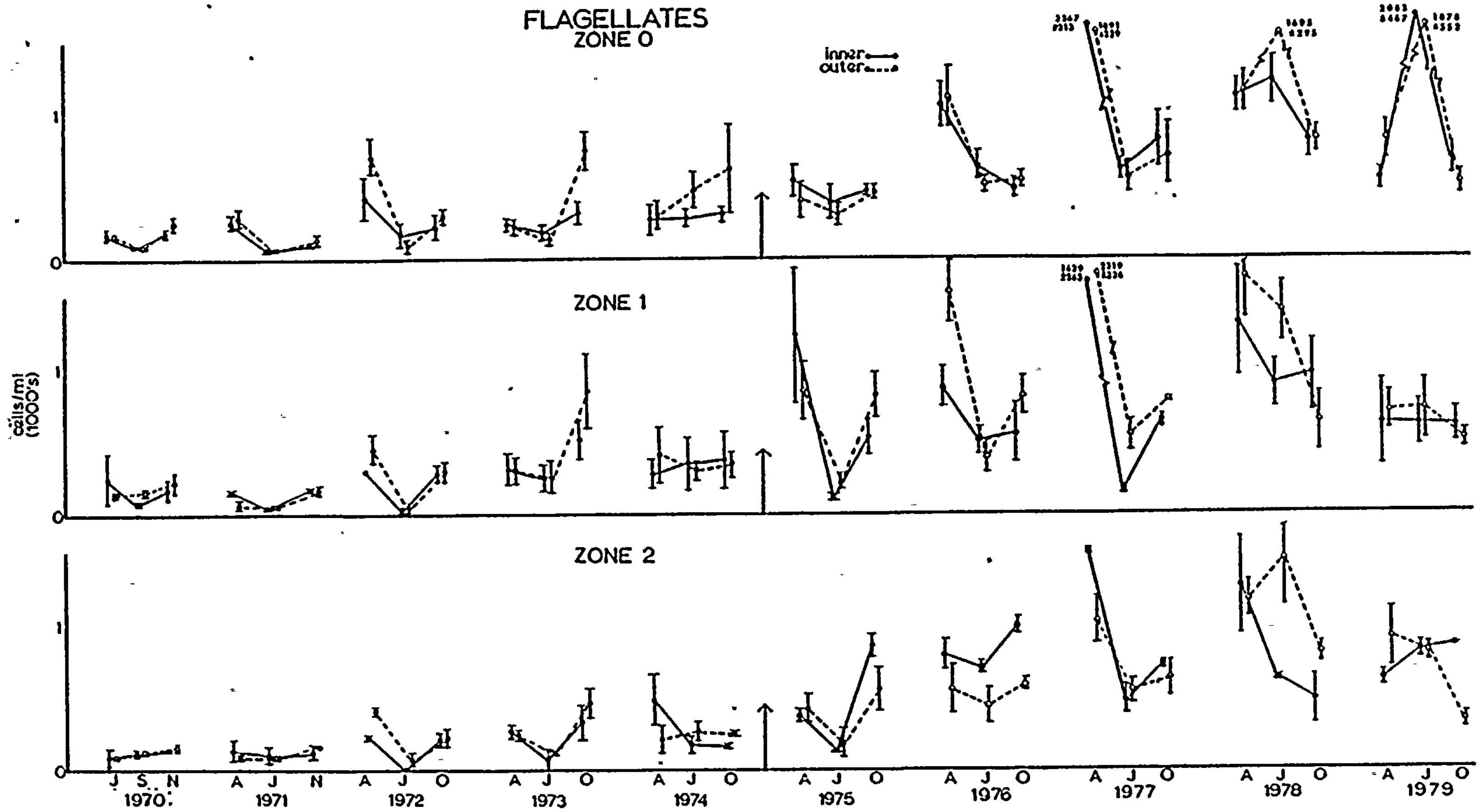

Fig. 1G. Mean abundances of flagellates in zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

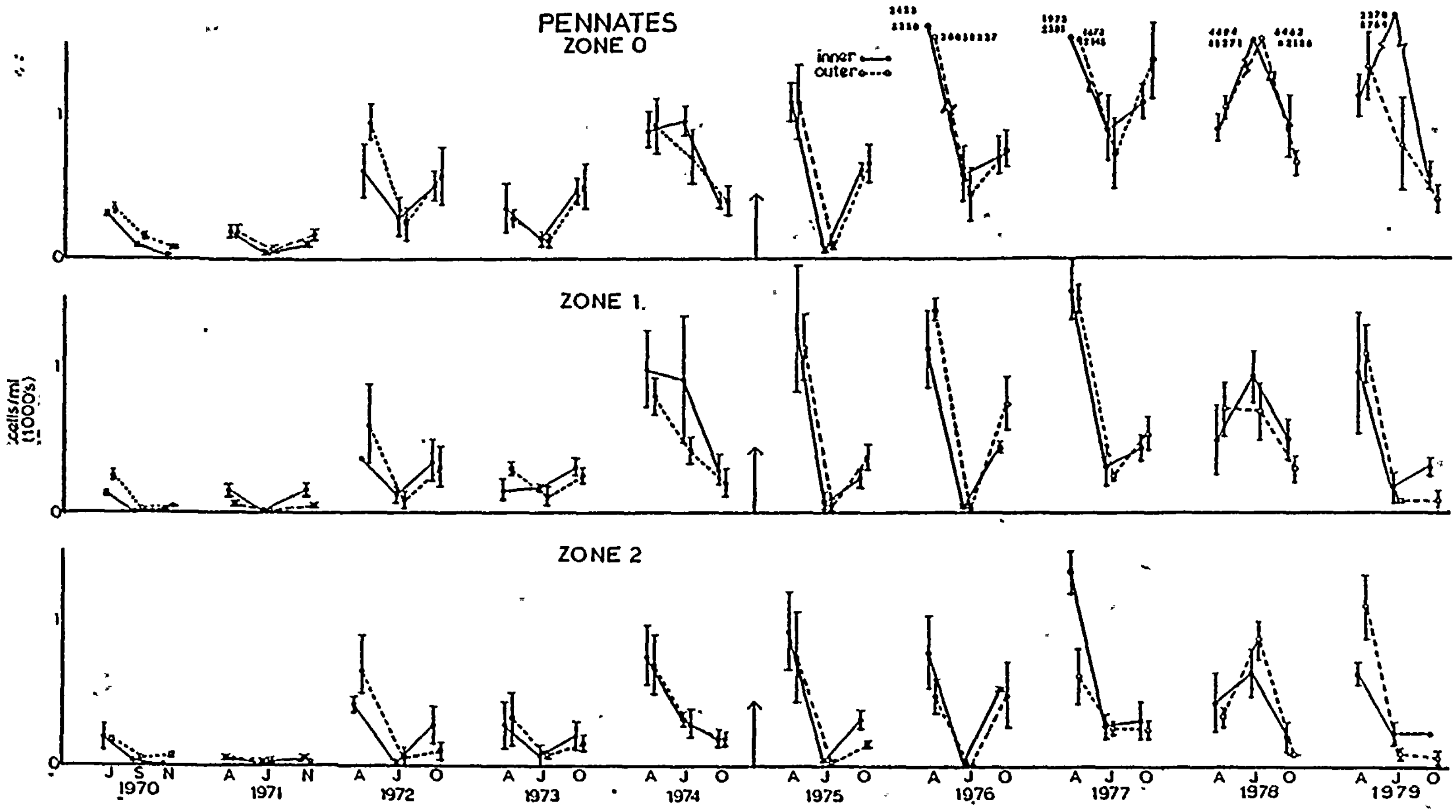

Fig. 1H. Mean abundances of pennate diatoms in zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

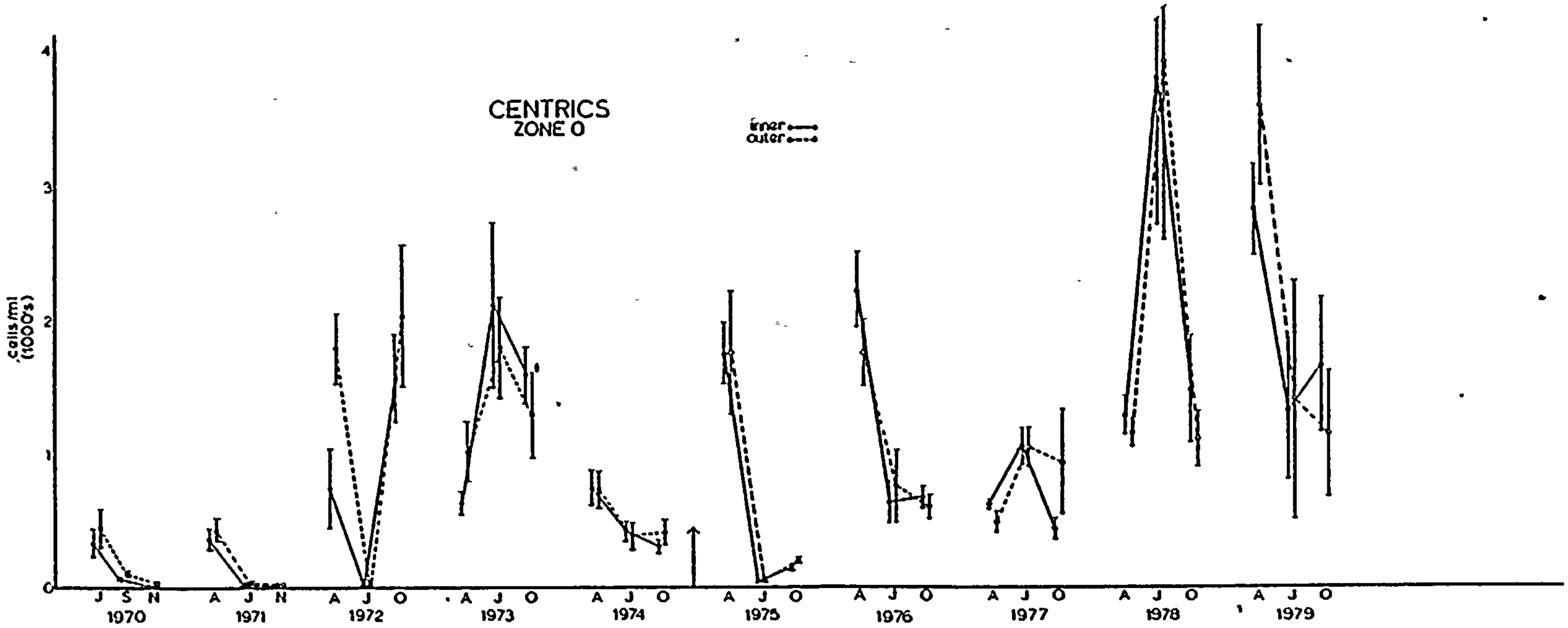

Fig. 11. Mean abundances of centric diatoms in zone 0 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

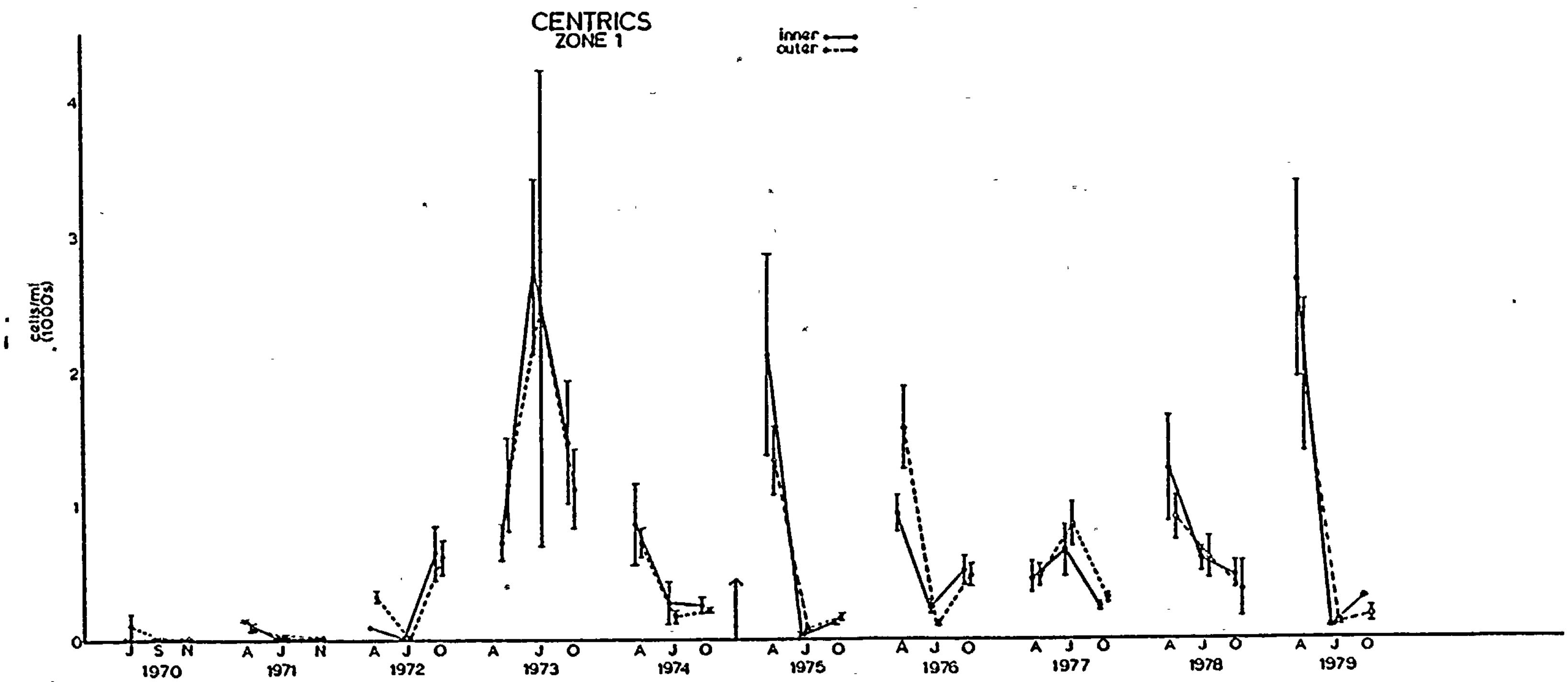

Fig. 1J. Mean abundances of centric diatoms in zone 1 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

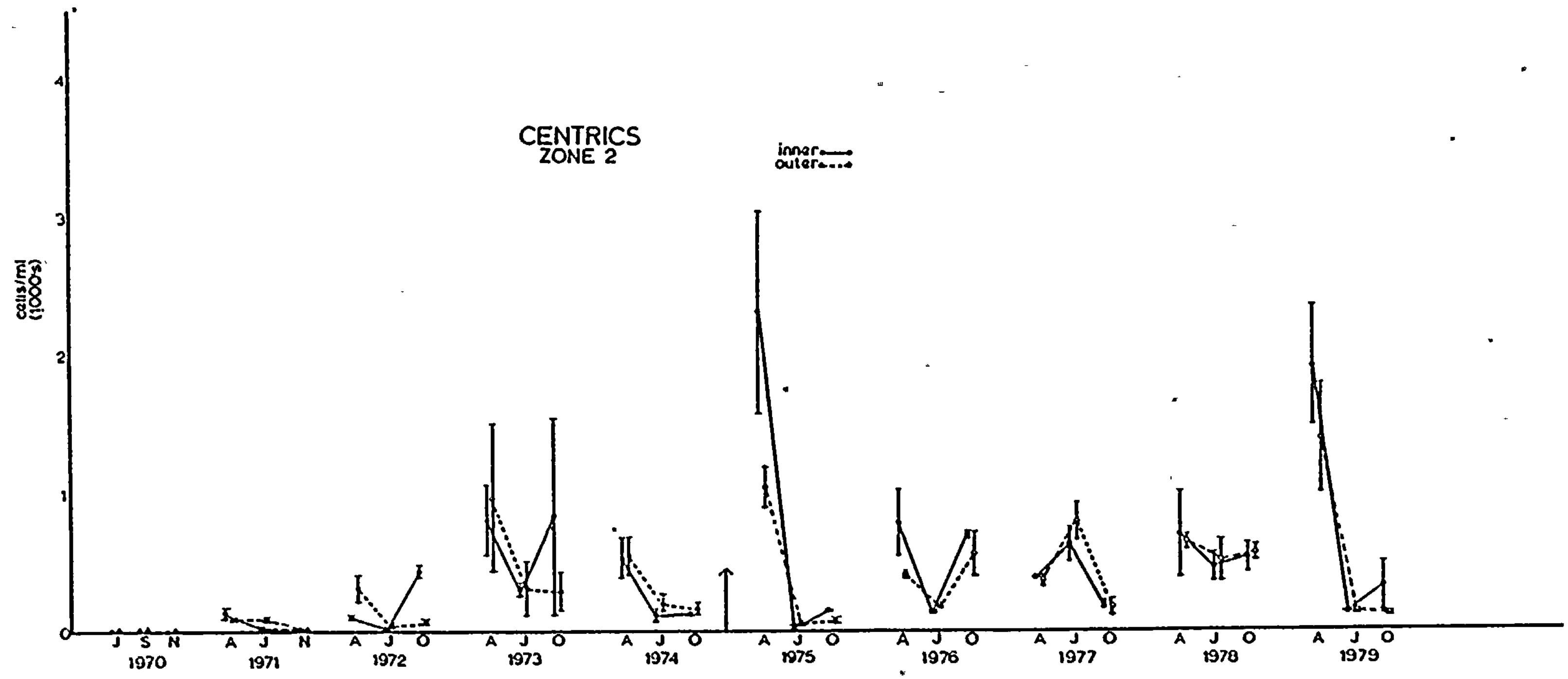

Fig. 1K. Mean abundances of centric diatoms in zone 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

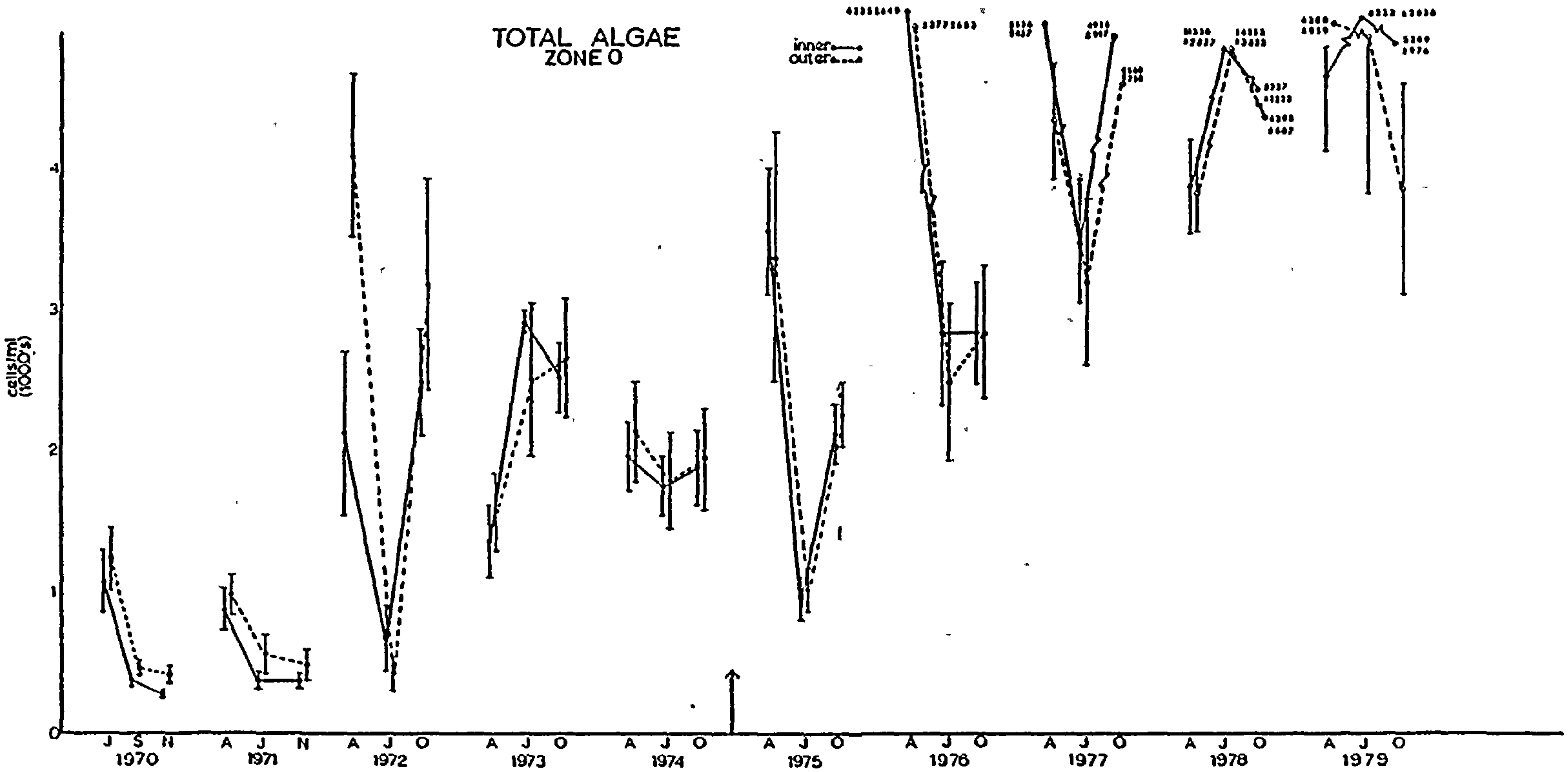

Fig. 1L. Mean abundances of total algae in zone 0 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

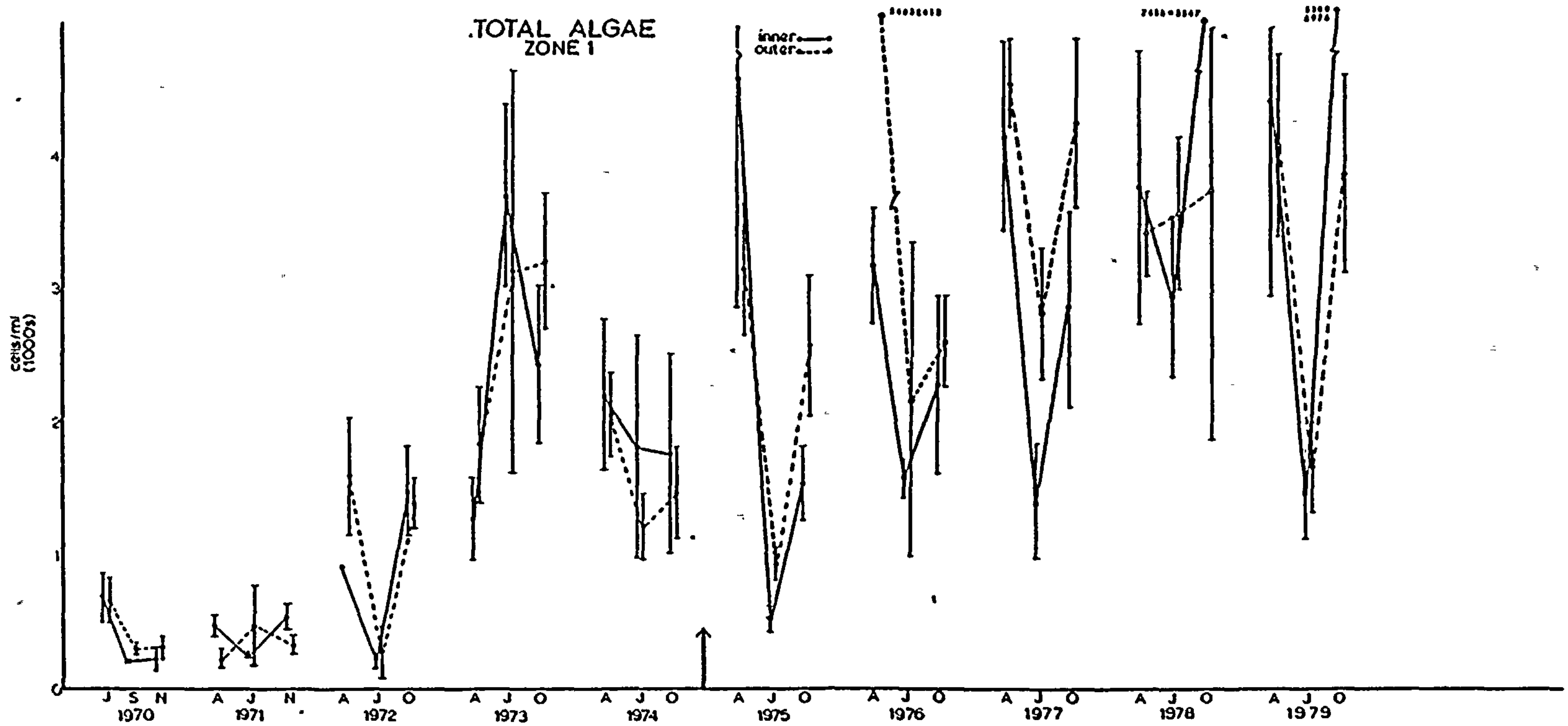

Fig. 1M. Mean abundances of total algae in zone 1 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

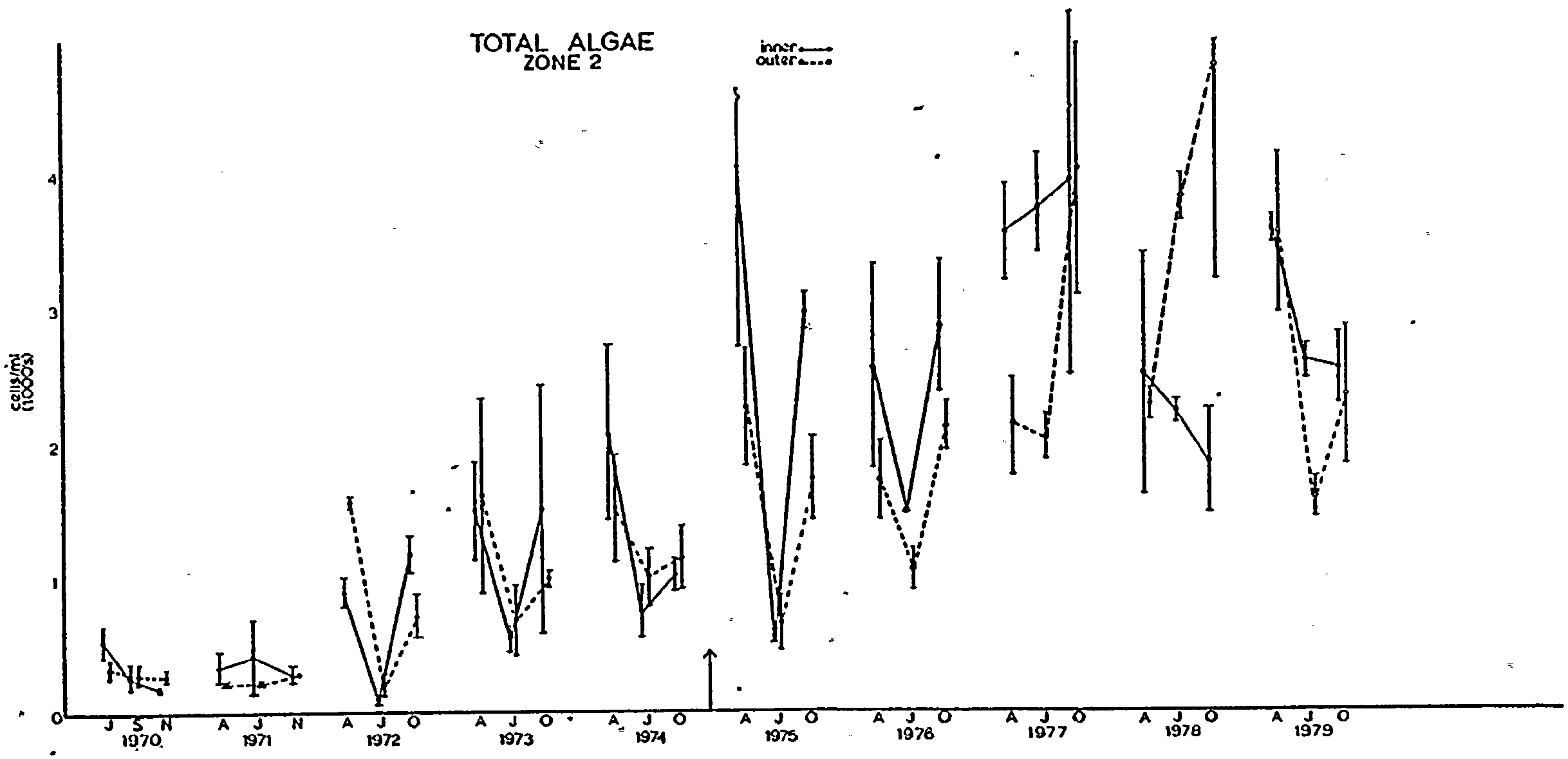

Fig. 1N. Mean abundances of total algae in zone 2 in the spring, summer, and fall seasonal surveys of 1970 through 1979. The vertical bars show the standard errors. See Table 1 for numbers of observations.

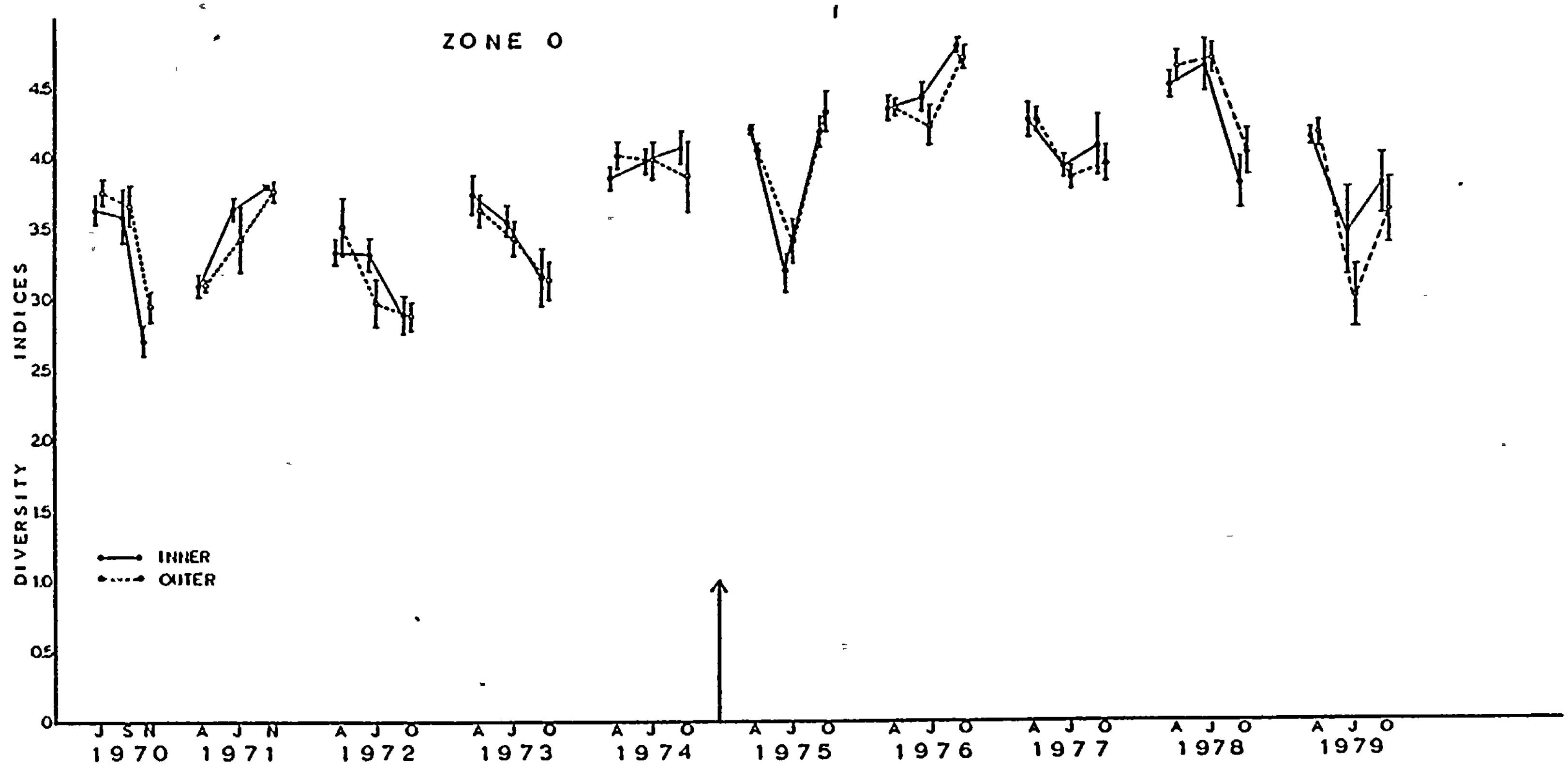

Fig. 2A. Mean diversity indices in zone 0 by spring, summer, and fall seasons and inner and outer station groups in 1970 through 1979. The vertical bars show the standard errors. See Table 3 for numbers of observations.

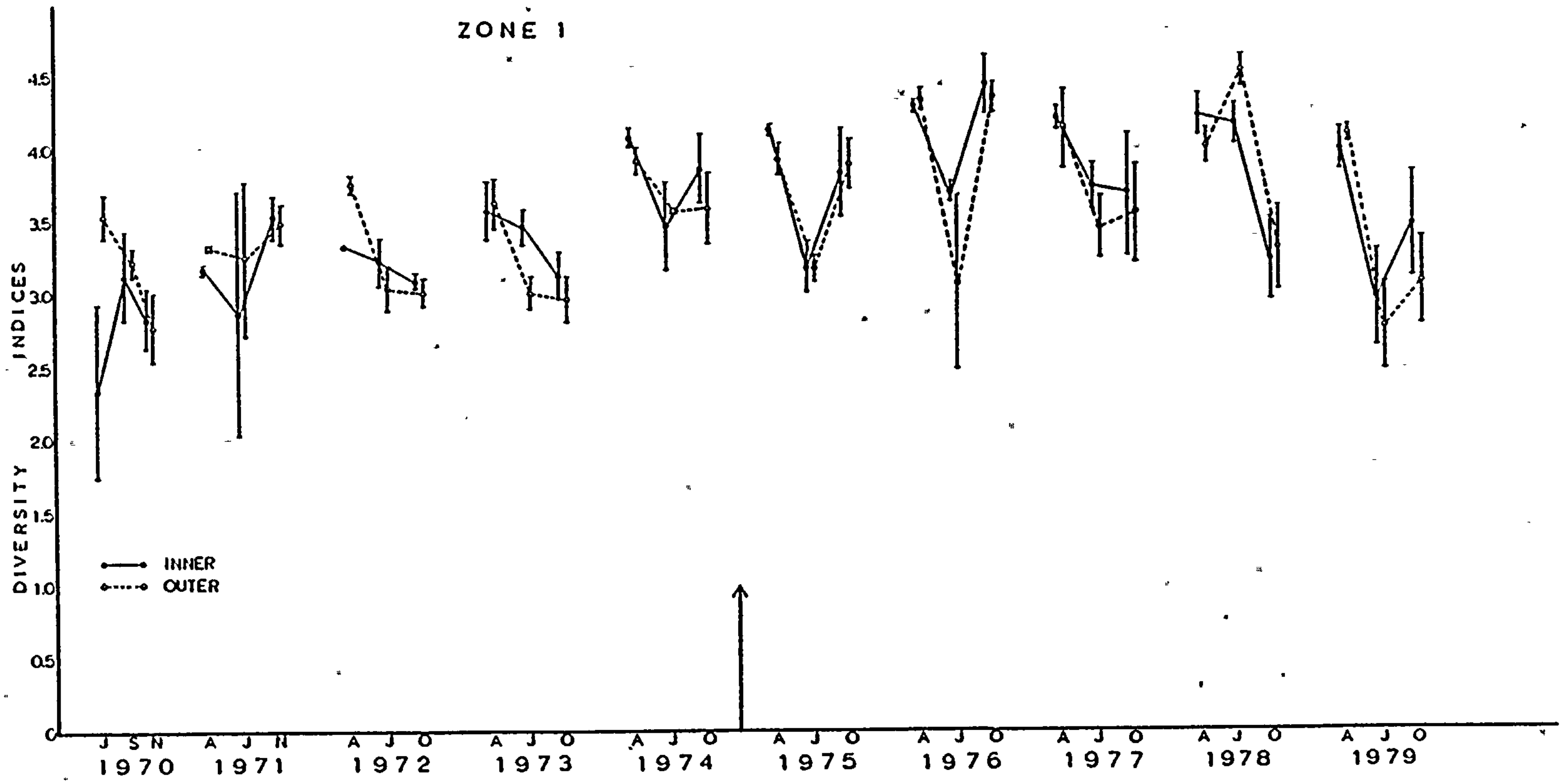

Fig. 2B. Mean diversity indices in zone 1 by spring, summer, and fall seasons and inner and outer station groups in 1970 through 1979. The vertical bars show the standard errors. See Table 3 for numbers of observations.

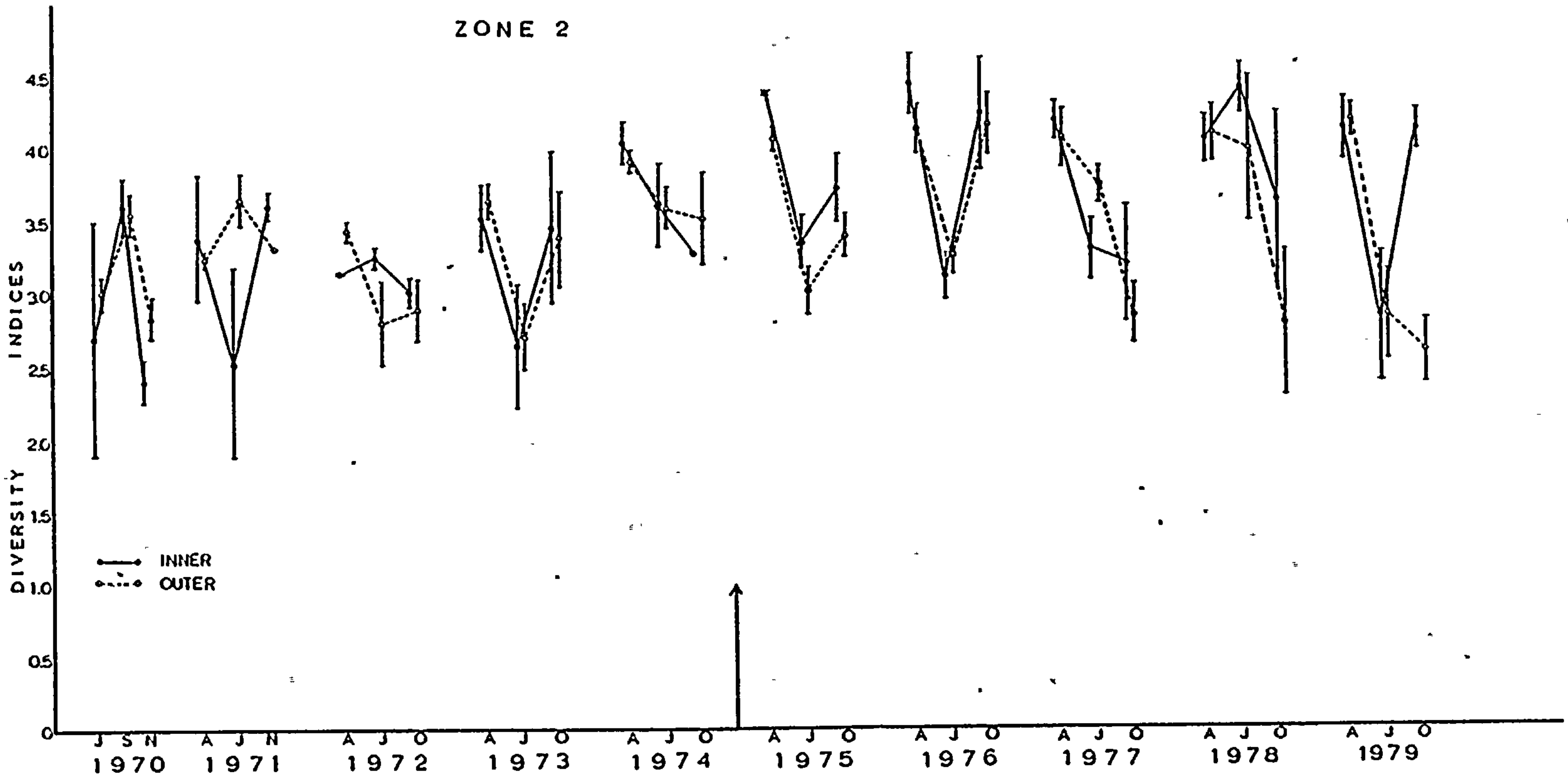

Fig. 2C. Mean diversity indices in zone 2 by spring, summer, and fall seasons and inner and outer station groups in 1970 through 1979. The vertical bars show the standard errors. See Table 3 for numbers of observations.

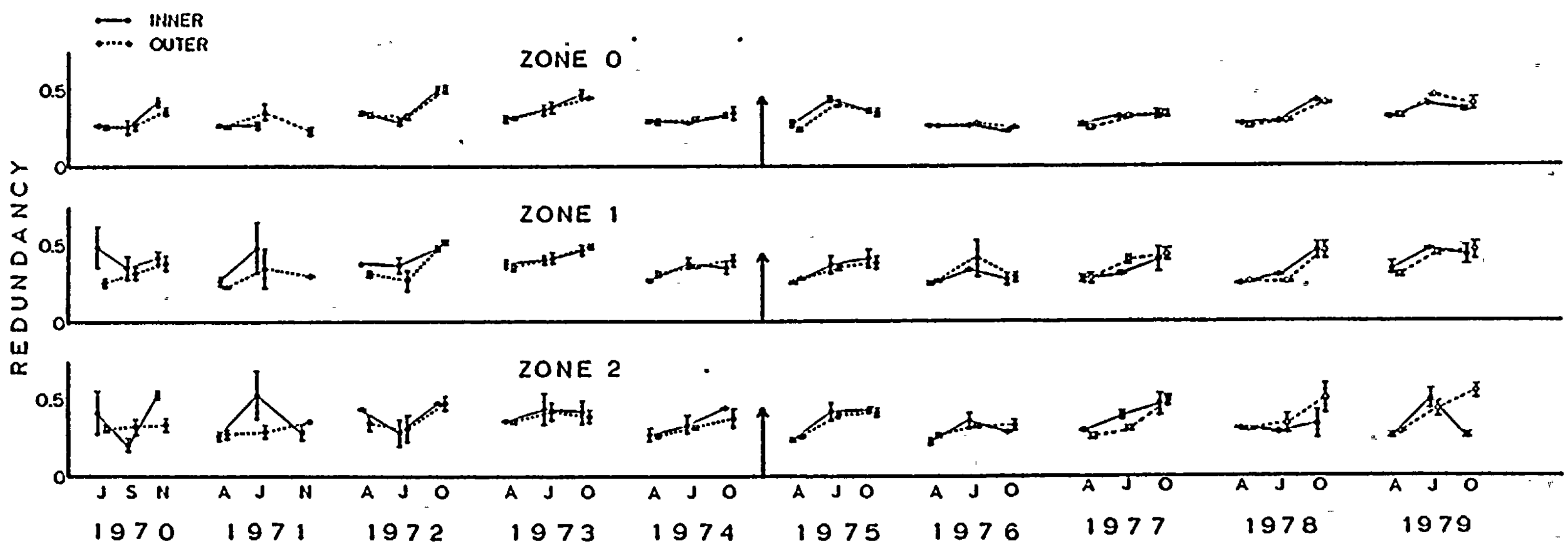

Fig. 3. Mean redundancies of phytoplankton collections from three depth zones in the Cook Plant area, by spring, summer, and fall seasons and inner and outer station groups in 1970 through 1979. The vertical bars show the standard errors. See Table 4 for numbers of observations.

TABLE 1. 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 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
12 APRIL 1979											
0	Inner										
	Mean	14.37	2.48	130.71	11.88	522.30	2822.10	1082.71	1.66	63.00	4651.98
	S. E.	11.00	1.09	34.89	10.69	79.07	345.47	138.13	1.19	13.63	527.25
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	141.28	3.30	136.14	4.48	785.10	3581.08	1567.55	1.32	79.42	6299.64
	S. E.	63.89	1.20	28.52	2.04	132.96	580.65	245.34	0.73	16.18	958.57
	N	10	10	10	10	10	10	10	10	10	10
1	Inner										
	Mean	0.0	0.0	91.7[illegible]	1.10	636.67	2627.47	959.47	0.0	77.40	4393.87
	S. E.	0.0	0.0	32.97	1.10	294.18	724.57	420.15	0.0	30.54	1478.06
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	165.80	4.13	88.70	9.95	693.08	1935.05	1086.03	2.48	72.95	4058.10
	S. E.	165.80	1.58	20.59	9.95	129.02	549.07	181.13	1.58	22.77	674.37
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	285.20	0.0	72.95	0.0	623.45	1880.25	686.40	0.0	82.90	3631.15
	S. E.	285.20	0.0	13.25	0.0	33.15	427.75	63.00	0.0	36.50	96.15
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	56.38	5.80	42.70	0.0	895.35	1354.65	1111.33	0.43	48.93	3515.50
	S. E.	47.95	3.69	12.26	0.0	184.66	371.23	230.50	0.43	17.31	585.98
	N	4	4	4	4	4	4	4	4	4	4

TABLE 1 continued.

Zone	Inner, Outer	Coccoid B-G	Filam. greens	Coccoid greens	Filam. greens	Flagel-lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total
11 JULY 1979											
0	Inner										
	Mean	301.91	1704.49	245.12	2.08	2082.67	1314.43	2269.62	6.49	305.51	8232.28
	S. E.	174.41	393.27	86.17	1.80	467.11	531.67	763.51	1.33	102.52	2029.71
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	261.14	1204.41	139.70	8.63	1877.60	1396.77	788.20	5.65	141.03	4911.45
	S. E.	162.01	428.45	42.50	4.03	552.47	886.98	317.18	2.27	66.17	1116.51
	N	10	10	10	10	10	10	10	10	10	10
1	Inner										
	Mean	40.90	442.70	54.13	1.10	623.73	84.57	171.07	0.27	32.33	1450.80
	S. E.	30.06	206.04	16.85	1.10	148.23	19.79	92.43	0.27	9.07	324.10
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	29.03	610.40	74.00	4.98	733.50	104.03	87.90	1.25	21.15	1666.13
	S. E.	29.03	201.08	16.49	2.95	197.77	24.12	27.67	0.79	5.75	283.58
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	58.05	1219.50	81.25	3.30	795.85	112.75	241.25	0.0	62.15	2574.15
	S. E.	58.05	274.40	38.15	3.30	56.35	8.25	82.05	0.0	38.95	118.55
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	91.18	484.15	72.95	0.0	693.08	118.95	67.98	0.85	31.08	1560.25
	S. E.	56.42	176.92	31.65	0.0	51.80	15.90	24.95	0.49	4.76	140.26
	N	4	4	4	4	4	4	4	4	4	4

TABLE 1 continued.

Zone	Inner Outer	Coccoid B-G	Filam. B-G	Coccoid greens	Filam. greens	Flagel-lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total
18 OCTOBER 1979											
0	Inner										
	Mean	1781.38	66.88	182.45	33.44	667.08	1649.57	586.68	0.0	241.59	5209.10
	S. E.	747.22	23.62	33.49	15.57	106.80	494.68	84.22	0.0	63.22	975.87
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	1370.89	34.82	177.07	6.80	490.44	1131.05	426.20	1.57	211.73	3850.61
	S. E.	377.51	10.23	55.87	3.13	71.07	462.57	95.27	0.86	83.41	746.12
	N	10	10	10	10	10	10	10	10	10	10
1	Inner.										
	Mean	1729.27	22.67	120.50	0.0	603.00	302.33	303.97	0.57	140.40	3242.63
	S. E.	244.42	11.43	52.45	0.0	105.67	16.12	58.72	0.57	33.98	325.50
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	1993.80	64.23	70.68	0.0	505.90	165.40	85.18	0.0	55.75	2941.00
	S. E.	895.90	13.01	23.89	0.0	49.20	45.03	41.32	0.0	16.34	984.63
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	960.05	48.10	24.85	0.0	847.25	331.65	232.10	0.0	74.60	2518.60
	S. E.	140.95	48.10	4.95	0.0	1.65	155.85	0.0	0.0	8.30	263.60
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	1766.15	47.05	56.40	0.0	272.73	92.41	55.40	0.0	44.48	2330.28
	S. E.	424.13	9.07	10.62	0.0	33.94	30.55	40.14	0.0	16.78	511.66
	N	4	4	4	4	4	4	4	4	4	4

TABLE 2. 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 1979. 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	Variances	N	t-test	Means	Variances	N	t-test	Means	Variances	N	t-test
COCCOID BLUE-GREEN ALGAE													
Spring	Inner	14.367	1453.2	12	0.0448*	0	0	3		285.20	0.16268×10^6	2	0.2924 n.s.
	Outer	141.28	40825.0	10		165.80	0.10996×10^6	4		56.375	9196.9	4	
Summer	Inner	301.91	0.36504×10^6	12	0.8678 n.s.	40.900	2710.0	3	0.7914 n.s.	58.050	6739.6	2	0.7365 n.s.
	Outer	261.14	0.26248×10^6	10		29.025	3369.8	4		91.175	12734.0	4	
Fall	Inner	1781.4	0.67001×10^7	12	0.6500 n.s.	1749.3	0.17921×10^6	3	0.8398 n.s.	960.05	39734.0	2	0.2776 n.s.
	Outer	1370.9	0.14371×10^7	10		1993.8	0.32105×10^7	4		1766.1	0.71953×10^6	4	
FILAMENTOUS BLUE-GREEN ALGAE													
Spring	Inner	2.4750	14.107	12	0.6159 n.s.	0	0	3		0	0	2	
	Outer	3.3000	14.520	10		4.1250	9.9825	4		5.8000	54.260	4	
Summer	Inner	1704.5	0.18559×10^7	12	0.4003 n.s.	442.70	0.12735×10^6	3	0.5928 n.s.	1219.5	0.15059×10^6	2	0.0793 n.s.
	Outer	1204.4	0.18357×10^7	10		610.40	0.16172×10^6	4		484.15	0.12520×10^6	4	
Fall	Inner	66.883	9828.9	12	0.3403 n.s.	22.667	391.58	3	0.0703 n.s.	48.100	4627.2	2	0.9757 n.s.
	Outer	34.820	1046.7	10		64.225	677.13	4		47.050	328.70	4	
COCCOID GREEN ALGAE													
Spring	Inner	130.71	14604.0	12	0.9078 n.s.	91.767	3261.7	3	0.9368 n.s.	72.950	351.13	2	0.2067 n.s.
	Outer	136.14	8135.7	10		88.700	1695.3	4		42.700	600.92	4	
Summer	Inner	245.12	89101.0	12	0.3153 n.s.	54.133	852.21	3	0.4468 n.s.	81.250	2910.8	2	0.8830 n.s.
	Outer	139.70	18060.0	10		74.000	1087.9	4		72.950	4007.5	4	
Fall	Inner	182.45	13459.0	12	0.9325 n.s.	120.50	8254.2	3	0.3837 n.s.	24.850	49.005	2	0.1236 n.s.
	Outer	177.07	31217.0	10		70.675	2282.9	4		56.400	451.11	4	
FILAMENTOUS GREEN ALGAE													
Spring	Inner	11.875	1372.0	12	0.5416 n.s.	1.1000	3.6300	3	0.4873 n.s.	0	0	2	
	Outer	4.4800	41.640	10		9.9500	396.01	4		0	0	4	
Summer	Inner	2.0750	38.707	12	0.1308 n.s.	1.1000	3.6300	3	0.3321 n.s.	3.3000	21.780	2	
	Outer	8.6300	162.43	10		4.9750	34.816	4		0	0	4	
Fall	Inner	33.442	2908.1	12	0.1408 n.s.	0	0	3		0	0	2	
	Outer	6.8000	97.960	10		0	0	4		0	0	4	
FLAGELLATES													
Spring	Inner	522.80	75028.0	12	0.0927 n.s.	636.67	0.25963×10^6	3	0.8532 n.s.	623.45	2197.8	2	0.3830 n.s
	Outer	785.10	0.17679×10^6	10		693.07	66586.0	4		895.35	0.13639×10^6	4	
Summer	Inner	2082.7	0.26183×10^7	12	0.7782 n.s.	623.73	65914.0	3	0.6957 n.s.	795.85	6350.6	2	0.2933 n.s.
	Outer	1877.6	0.30522×10^7	10		733.50	0.15644×10^6	4		693.07	10733.0	4	
Fall	Inner	667.08	0.13688×10^6	12	0.2025 n.s.	603.00	33496.0	3	0.4010 n.s.	847.25	5.4450	2	0.0003**
	Outer	490.44	50506.0	10		505.90	9680.3	4		272.97	4542.0	4	

TABLE 2 continued.

Survey	Station group	Zone 0 (0-8m) Means	Variances	N	t-test	Zone 1 (8-16m) Means	Variances	N	t-test	Zone 2 (16-24m) Means	Variances	N	t-test
CENTRIC DIATOMS													
Spring	Inner	2822.8	0.14347×10^{7}	12	0.2573 n.s.	2627.5	0.15750×10^{7}	3	0.4710 n.s.	1880.3	0.36594×10^{6}	2	0.4412 n.s.
	Outer	3581.1	0.33715×10^{7}	10		1934.9	0.12057×10^{7}	4		1354.6	0.55124×10^{6}	4	
Summer	Inner	1314.4	0.33921×10^{7}	12	0.1885 n.s.	84.567	1174.3	3	0.5810 n.s.	112.75	136.13	2	0.8118 n.s.
	Outer	485.16	0.35159×10^{6}	10		104.02	2327.5	4		118.95	1011.3	4	
Fall	Inner	1649.6	0.29365×10^{7}	12	0.4595 n.s.	302.33	787.26	3	0.0551 n.s.	331.65	48578.0	2	0.0867 n.s.
	Outer	1131.0	0.21397×10^{7}	10		165.40	8110.2	4		92.425	3732.4	4	
PENNATE DIATOMS													
Spring	Inner	1082.7	0.22897×10^{6}	12	0.0874 n.s.	959.47	0.52958×10^{6}	3	0.7709 n.s.	686.40	7938.0	2	0.2890 n.s.
	Outer	1567.5	0.60192×10^{6}	10		1086.0	0.13123×10^{6}	4		1111.3	0.21251×10^{6}	4	
Summer	Inner	2269.6	0.69953×10^{7}	12	0.1108 n.s.	171.07	25629.0	3	0.3675 n.s.	241.25	13464.0	2	0.5050 n.s.
	Outer	788.17	0.10061×10^{7}	10		87.900	3062.3	4		67.975	2488.8	4	
Fall	Inner	586.67	85114.0	12	0.2201 n.s.	303.97	10344.0	3	0.0252*	232.10	0	2	
	Outer	426.20	90760.0	10		85.175	6826.9	4		50.900	5082.5	4	
DESMIDS													
Spring	Inner	1.6583	17.041	12	0.8202 n.s.	0	0	3		0	0	2	
	Outer	1.3200	5.3240	10		2.4750	9.9825	4		0.4250	0.72250	4	
Summer	Inner	6.4917	21.343	12	0.7427 n.s.	0.2667	0.2133	3	0.3543 n.s.	0	0	2	
	Outer	5.6500	51.403	10		1.2500	2.5100	4		0.8500	0.96333	4	
Fall	Inner	0	0	12		0.5667	0.9633	3		0	0	2	
	Outer	1.5700	7.3334	10		0	0	4		0	0	4	
OTHER ALGAE													
Spring	Inner	63.000	2228.9	12	0.4433 n.s.	77.400	2797.5	3	0.9093 n.s	82.900	2664.5	2	0.3774 n.s.
	Outer	79.420	2617.3	10		72.950	2073.3	4		48.925	1197.9	4	
Summer	Inner	305.49	0.12614×10^{6}	12	0.2128 n.s.	32.333	246.90	3	0.3226 n.s.	62.150	3034.2	2	0.2800 n.s.
	Outer	141.03	43789.0	10		21.150	132.26	4		31.075	90.429	4	
Fall	Inner	241.59	47966.0	12	0.7745 n.s.	140.40	3463.8	3	0.0571 n.s.	74.600	137.78	2	0.3057 n.s.
	Outer	211.73	69572.0	10		55.750	1067.8	4		44.475	1125.5	4	
TOTAL ALGAE													
Spring	Inner	4652.0	0.33360×10^{7}	12	0.1309 n.s.	4393.9	0.65540×10^{7}	3	0.8286 n.s.	3631.1	18490.0	2	0.9019 n.s.
	Outer	6299.6	0.91886×10^{7}	10		4058.1	0.18191×10^{7}	4		3515.5	0.13735×10^{7}	4	
Summer	Inner	8232.3	0.49436×10^{8}	12	0.1908 n.s.	1450.8	0.31511×10^{6}	3	0.6389 n.s.	2574.1	28108.0	2	0.0104*
	Outer	4911.4	0.12466×10^{8}	10		1666.1	0.32167×10^{6}	4		1560.2	78964.0	4	
Fall	Inner	5209.1	0.11428×10^{8}	12	0.2973 n.s.	3242.6	0.31786×10^{6}	3	0.8110 n.s.	2518.6	0.13897×10^{6}	2	0.8220 n.s.
	Outer	3850.6	0.55669×10^{7}	10		2941.0	0.38779×10^{6}	4		2330.3	0.10472×10^{7}	4	

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 1979. 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.

1979

		12 April	11 July	18 October
Zone 0	Inner			
	Mean	4.10	3.43	3.79
	S. E.	0.06	0.27	0.18
	N	12	12	12
	Outer			
	Mean	4.13	2.96	3.58
	S. E.	0.08	0.21	0.23
	N	10	10	10
Zone 1	Inner			
	Mean	3.95	2.94	3.43
	S. E.	0.13	0.33	0.36
	N	3	3	3
	Outer			
	Mean	4.07	2.74	3.03
	S. E.	0.05	0.29	0.29
	N	4	4	4
Zone 2	Inner			
	Mean	4.08	2.77	4.09
	S. E.	0.21	0.44	0.13
	N			
	Outer			
	Mean	4.14	2.82	2.56
	S. E.	0.11	0.30	0.22
	N	4	4	4

TABLE 4. Means, standard errors, and numbers of observations of phytoplankton redundancies by seasons, depth zones, and inner or outer station groups in Cook Plant major surveys during operational 1979. Standard errors are computed only when the number of observations is 2 or more.

1979

		12 April	11 July	18 October
Zone 0	Inner			
	Mean	0.310	0.380	0.351
	S. E.	0.011	0.038	0.028
	N	12	12	12
	Outer			
	Mean	0.319	0.457	0.390
	S. E.	0.012	0.028	0.031
	N	10	10	10
Zone 1	Inner			
	Mean	0.326	0.458	0.417
	S. E.	0.034	0.060	0.065
	N	3	3	3
	Outer			
	Mean	0.299	0.443	0.451
	S. E.	0.010	0.035	0.061
	N	4	4	4
Zone 2	Inner			
	Mean	0.267	0.484	0.258
	S. E.	0.032	0.065	0.020
	N	2	2	2
	Outer			
	Mean	0.291	0.434	0.543
	S. E.	0.005	0.060	0.040
	N	4	4	4

APPENDIX B-2

PART II

PHYTOPLANKTON ENTRAINED AT THE DONALD C. COOK NUCLEAR PLANT

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INTRODUCTION

Technical Specification Requirements

The Environmental Technical Specifications for the Donald C. Cook Nuclear Plant require an assessment of phytoplankton abundance, viability, and species composition to be made on a monthly basis on samples collected in early morning, at mid-day, and in late evening. To this end, samples are collected at morning twilight, noon, and evening twilight from the intake and discharge forebays. Samples for microscopic counting are collected in duplicate and those for viability studies in quintuplicate. This report contains a discussion of the results of microscopic counting for September 1978 through April 1979 and of viability studies for November 1979 through October 1980. For the reader's information and the sake of presenting complete data sets, all of the viability data for 1979 are included in the tables.

Disposition of Samples Collected

In the Environmental Operating Report for 1979, a table which listed the disposition of all samples for microscopic counting was included. Table 1 is a continuation of that table. Of the 192 required samples for the period November 1979 through October 1980, all were collected. All samples through May 1979 have been counted. Since the plant was down during June 1979, no samples were collected.

Of the 640 samples required for viability analysis, 635 were collected for the period of November 1979 through October 1980. These include samples collected to give five replicates rather than the three required replicates. These additional samples were collected to decrease the detectable difference between intake and discharge that can be measured at the 0.05 level of significance. Five samples were accidentally not collected from the discharge in December 1979. These were to be the incubated samples. Thus a comparison between intake and discharge incubated samples was not possible. At the time of preparation of this report, analyses of all samples were complete.

During the period of November 1979 through October 1980, most samples for both enumeration and viability studies were collected. During viability analysis, one November 1979 evening replicate from the unit #1 discharge, one November 1979 incubated evening replicate from the discharge of unit #1, one November 1979 morning twilight replicate from the unit #1 discharge, one January 1980 evening twilight replicate from the discharge of unit #1, one March 1979 noon replicate from both the discharge of unit #2 and the intake, one April 1980 evening replicate from both discharges, one April 1980 evening incubated replicate from the discharge of unit #2, one April 1980 morning twilight relicate from the unit #2 discharge, one April 1980 noon replicate

from unit #2 discharge, one May 1980 incubated evening replicate from the intake, one July 1980 noon replicate from the intake, one August 1980 evening replicate from the unit #2 discharge, one August 1980 morning twilight replicate from the unit #2 discharge, one September 1980 evening replicate from the unit #1 discharge, and one October 1979 noon replicate from both 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, July 1978, October 1979, July 1980, August 1980, and September 1980, 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 preceding the June 1978, August 1978, September 1979, June 1980, August 1980, and September 1980 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 hypolimnetic and epilimnetic waters yields a water mass having characteristics of each and results in increased sampling variability. The increased heterogeneity is particularly important if upwelling occurs during sampling periods.

Filamentous green algae were more abundant during 1976 than in 1975, 1977, or 1978 (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 marked variation in abundance from 1975 to 1977 (Table 7), but they exhibited a slight increase in abundance in 1978. Peak abundances generally occurred during late spring or summer. An unusually high maximum and an unusually low minimum abundance were observed in 1978 compared to the previous years.

Centric diatoms showed a marked reduction in population density during 1977 compared to the previous years (Table 8) but increased during 1978 compared to 1977. The 1978 monthly increase was largest in May and June, 1978 as compared to those months in the preceding 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 or winter.

Desmid numbers were somewhat lower in 1976 relative to 1975, 1977, and 1978 (Table 10). Peak abundances generally occurred in the late spring or summer.

The group of other algae was least abundant in 1975 (Table 11), but they showed a slight increase in abundance in 1978 compared to 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, 1976, and 1978 (Table 12). The exact reason for these changes is unknown but is probably related to the natural variability in population in the nearshore of Lake Michigan. 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

The quantitative measures of the number of species (forms), the diversity index, and redundancy were used to evaluate various assemblages of phytoplankton which appeared in entrainment samples. 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 assemblages. 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 minimum 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 1978 relative to 1975, 1976, and 1977. 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, 1977, and 1978 (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 slightly lower than 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 dominance in Chrysophycean flagellates.

Redundancy variation during 1975 through 1978 shows no distinct trend. Though highest in 1977, the difference between the 1978 and 1977 redundancies does not vary greatly from the difference between the 1975 and 1976 redundancies or from that between the 1977 and 1975 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 are presented as in the reports on the 1975, 1976, and 1977 data (Rossmann et al. 1977; Rossmann et al. 1979; Rossmann et al. 1980). Chlorophyll a is the most sensitive of all the variables for detecting any change in viability.

During 1979 and 1980, changes in viability resembled those noted for 1975, 1976, and 1978 (Table 16). The higher rate of occurrence of changes during 1979 and possibly 1980 were similar to that of 1978 and 1977 and higher than those of 1975 and 1976. The increased occurrence of statistically significant differences at the 0.05 level of significance during 1977 through 1980 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.

Since chlorophyll a is the most sensitive of the variables for detecting any change in viability, it will be discussed in detail. Table 17 summarizes the percent occurrence of statistically significant (0.05 level of significance) decreases and increases in viability (chlorophyll a) between the intake and discharge. The table lists those percent occurrences for both non-incubated and incubated samples. The data are derived from Tables 18-27 which present all of the comparisons between intake and discharge. Little plant impact on the phytoplankton was noted during 1975 or 1976. Beginning in 1977, improved sampling design and analytical technique plus the character of the entrained phytoplankton community resulted in a high occurrence of decreases in chlorophyll a concentrations between intake and discharge. The higher occurrence of these decreases in the incubated samples suggests that the phytoplankton were incapable of recovering from the shock of entrainment. Apparently something happened in the lake to the phytoplankton which made them more susceptible to the rigors of entrainment. In 1978, two unit operation began at the plant. The higher rate of occurrences of chlorophyll a differences between intake and discharge from 1977 through 1978 most likely reflect our improved methodology. This higher rate of occurrences does not coincide with two unit operation. The phytoplankton population apparently improved in 1978. Though susceptible to a plant impact, the occurrence of changes in phytoplankton viability in incubated samples increased and decreased equally. The fact that the occurrences of decrease were less for incubated than non-incubated suggest that the phytoplankton were capable of partial recovery from the rigors of entrainment. In the instances of increased viability, the phytoplankton appear to actually have been stimulated by entrainment. During 1979, the impact of entrainment was very similar to that

of 1978. In 1980, the nature of the phytoplankton community apparently was such that though non-incubated samples showed a decrease in viability similar to that of 1978 and 1979, the phytoplankton were capable of a full recovery as evidenced by no occurrences of decreases in chlorophyll a concentration between intake and discharge in the incubated samples. Stimulation of the phytoplankton during 1980 appears to be minor and apparently temporary.

With the exception of 1977 when the character of the entrained phytoplankton community was such that a negative impact was noted, no consistent long-term 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 1978 gave the following general observations: 1) coccoid blue-green algae and desmids were least abundant during 1976; 2) flagellates were most abundant during 1977; 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 long-term 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
June 1978					
Evening Twilight					IA IB D2A D2B
Morning Twilight					IA IB D2A D2B
Noon					IA D2A D2B
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 DIA D1B D2A D2B
October 1978					
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
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 D2A D2B
Morning Twilight					IA IB D2A D2B
Noon					IA IB D2A D2B
May 1978					
Evening Twilight					IA IB D2A D2B
Morning Twilight					IA IB D2A D2B
Noon					IA IB D2A D2B
June 1979			Plant not Operational		
July 1979					
Evening Twilight			IA IB D2A D2B		
Morning Twilight			IA IB D2A D2B		
Noon			IA IB 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		

(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
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		
November 1979					
Evening Twilight			IA IB D1A D1B		
Morning Twilight			IA IB D1A D1B		
Noon			IA IB D1A D1B		
December 1979					
Evening Twilight			IA IB D1A D1B		
Morning Twilight			IA IB D1A D1B		
Noon			IA IB D1A D1B		
January 1980					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
February 1980					
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
March 1980					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
April 1980					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
May 1980					
Evening Twilight			IA IB DIA D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
June 1980					
Evening Twilight			IA IB D2A D2B		
Morning Twilight			IA IB D2A D2B		
Noon			IA IB 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
July 1980					
Evening Twilight			IA IB D2A D2B		
Morning Twilight			IA IB D2A D2B		
Noon			IA IB D2A D2B		
August 1980					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
September 1980					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		
October 1980					
Evening Twilight			IA IB D1A D1B D2A D2B		
Morning Twilight			IA IB D1A D1B D2A D2B		
Noon			IA IB D1A D1B D2A D2B		

[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 through 1980.

Date	Time	Intake, °C	Discharge #1, °C	Discharge #2, °C
January 10, 1978	Morning Twilight	3.0	13.5	–[1]
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)

[1] Dashes appear when a unit was not operating. Blanks are for missing data.

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, 1979	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
November 12, 1979	Evening Twilight	9.5	19.8	-
13	Morning Twilight	9.3	19.9	-
13	Noon	9.3	20.2	-
December 10, 1979	Evening Twilight	4.0	18.0	-
11	Morning Twilight	4.1	17.5	-
11	Noon	4.1	17.2	-

(continued)

1 Dashes appear when a unit was not operating. Blanks are for missing data.

TABLE 2 (continued)

Date	Time	Intake, °C	Discharge #1, °C	Discharge #2, °C
January 21, 1980	Evening Twilight	-0.2	12.0	6.6
22	Morning Twilight	-0.3	12.0	6.5
22	Noon	-0.3	12.0	6.5
February 4, 1980	Evening Twilight	0.6	12.2	12.4
5	Morning Twilight	3.2	14.5	11.9
5	Noon	2.4	14.5	14.3
March 10, 1980	Evening Twilight	5.5	17.2	14.0
11	Morning Twilight	6.3	17.8	15.1
11	Noon	6.0	17.2	14.0
April 7, 1980	Evening Twilight	3.8	15.6	13.2
8	Morning Twilight	7.3	8.3	15.4
8	Noon	6.1	7.6	15.2
May 12, 1980	Evening Twilight	11.9	23.0	21.4
13	Morning Twilight	12.5	23.8	22.2
13	Noon	12.5	24.0	22.4
June 9, 1980	Evening Twilight	14.7	-	24.1
10	Morning Twilight	14.0	-	25.5
10	Noon	13.9	-	23.1
July 14, 1980	Evening Twilight	22.5	-	31.3
15	Morning Twilight	22.3	-	31.8
15	Noon	23.6	-	32.8
August 11, 1980	Evening Twilight	23.8	31.1	33.5
12	Morning Twilight	24.2	31.9	34.0
12	Noon	23.0	31.1	33.0
September 8, 1980	Evening Twilight	20.1	29.3	29.5
9	Morning Twilight	22.9	31.5	31.0
9	Noon	22.5	33.2	32.2
October 13, 1980	Evening Twilight	16.0	26.2	24.6
14	Morning Twilight	14.0	25.1	22.9
14	Noon	15.2	25.4	23.7

[1] Dashes appear when a unit was not operating. Blanks are for missing data.

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 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 least abundant in 1976 (Table 3). Since then, an increase in the occurrences and abundance of coccoid blue-green algae has been observed. This trend may be attributed to the eutrophication in the nearshore of Lake Michigan (Chang and Rossmann, submitted). 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 1978 than 1975 or 1976, but they were more abundant than in 1977 (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 1978 than in 1975 and 1976, but they were more abundant than in 1977 (Table 5). This may be attributed to the natural variability in the phytoplankton population in the nearshore of Lake Michigan. Peak concentrations occurred during the summer and fall.

TABLE 3. Monthly variation of coccoid blue-green algae during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		461.(149.)		296.(91.9)	275.(44.5)
February	109.(59.7)	254.(71.7)		95.0(50.0)	120.(24.3)
March	257.(186.)	347.(110.)	137.(57.2)	28.7(12.6)	209.(43.8)
April	312.(125.)	143.(63.6)	110.(76.2)	78.8(30.7)	30.(27.6)
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)	660.(80.4)	
October	945.(212.)	560.(196.)	727.(145.)	2353.(365.)	
November	600.(166.)	422.(121.)	1320.(289.)	1992.(278)	
December	176.(106.)	275.(73.4)	872.(124.)	3642.(363.)	
Yearly Mean	535.(117.)	285.(50.1)	599.(159.)	850.(134.)	

'Mean is followed by the standard error.

TABLE 4. Monthly variation of filamentous blue-green algae during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		22.0(8.06)		15.2(5.61)	7.91(1.33)
February	28.2(8.10)	16.4(3.53)		6.22(2.46)	3.78(0.60)
March	59.7(17.6)	13.4(2.53)	16.7(3.19)	3.60(.921)	4.57(0.86)
April	27.6(5.40)	57.9(5.16)	110.(76.2)	2.63(.919)	3.58(1.71)
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.(26.5)	
September	17.3(9.20)	46.8(15.8)	25.0(8.84)	8.89(2.68)	
October	98.8(34.0)	45.9(23.8)	21.4(7.61)	87.0(18.9)	
November	21.6(17.8)	6.35(4.31)	12.7(3.13)	82.9(18.7)	
December	15.4(7.70)	74.5(44.3)	45.2(18.6)	67.9(13.5)	
Yearly Mean	71.8(26.5)	75.2(35.6)	35.0(9.54)	48.0(13.3)	

'Mean is followed by the standard error.

TABLE 5. Monthly variation of coccoid green algae during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		42.2(12.2)		56.8(17.4)	39.6(4.87)
February	39.3(14.2)	29.5(11.1)		10.7(2.57)	18.5(3.53)
March	55.2(24.7)	22.9(7.63)	21.1(4.43)	16.6(4.54)	79.4(43.5)
April	49.7(14.8)	57.9(12.3)	51.4(8.31)	108.(25.2)	69.9(22.5)
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)	174.(24.1)	
October	116.(16.1)	242.(37.1)	232.(85.4)	256.(26.9)	
November	138.(66.9)	134.(36.1)	65.1(18.2)	159.(18.1)	
December	110.(47.8)	240.(54.4)	49.5(11.4)	194.(15.1)	
Yearly Mean	188.(82.8)	246.(74.6)	79.5(21.5)	128.(22.6)	

'Mean is followed by the standard error.

TABLE 6. Monthly variation of filamentous green algae during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		31.6(17.4)		2.26(1.35)	2.49(0.89)
February	18.0(9.70)	2.00(1.20)		.350(.241)	0.278(0.280)
March	34.8(12.6)	16.4(6.62)	6.63(4.37)	3.04(1.82)	0.600(0.330)
April	0.0(0.0)	18.1(10.5)	18.2(12.3)	2.21(1.70)	0.00(0.00)
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)	1.12(.401)	
October	2.8(1.1)	9.67(2.47)	6.63(4.02)	8.19(2.16)	
November	1.5(1.2)	6.35(5.48)	26.8(6.92)	18.4(4.37)	
December	14.4(7.3))	5.52(2.39)	14.0(6.97)	35.4(4.55)	
Yearly Mean	9.44(3.87)	21.5(5.64)	10.2(3.06)	7.92(2.03)	

'Mean is followed by the standard error.

TABLE 7. Monthly variation of flagellated algae during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		110.(18.7)		156.(44.0)	277.(53.2)
February	90.8(20.8)	252.(32.1)		109.(21.7)	242.(46.7)
March	272.(56.6)	268.(25.5)	628.(60.2)	97.5(24.6)	392.(37.1)
April	857.(190.)	351.(36.6)	1010.(116.)	435.(69.9)	379.(44.4)
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.(18.9)	
September	587.(71.6)	426.(70.3)	302.(57.8)	75.7(11.5)	
October	696.(85.4)	559.(91.7)	550.(91.8)	108.(15.9)	
November	417.(51.9)	524.(47.6)	754.(156.)	52.0(12.4)	
December	368.(59.9)	415.(84.2)	78.9(19.3)	261.(88.0)	
Yearly Mean	527.(69.0)	485.(89.0)	540.(114.)	454.(68.9)	

'Mean is followed by the standard error.

TABLE 8. Monthly variation of centric diatoms during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		1810.(191.)		310.(46.7)	193.(11.8)
February	1040.(130.)	560.(45.0)		125.(12.8)	169.(8.96)
March	1290.(111.)	807.(56.8)	463.(57.7)	423.(37.8)	352.(22.2)
April	2550.(427.)	930.(51.1)	779.(83.9)	592.(74.5)	2590.(199.)
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)	225.(40.5)	
October	286.(21.2)	644.(50.9)	140.(18.1)	904.(88.7)	
November	404.(64.5)	1090.(69.4)	194.(24.2)	195.(21.3)	
December	1700.(132.)	503.(58.8)	165.(18.5)	160.(9.63)	
Yearly Mean	945.(224.)	1050.(249.)	366.(93.7)	623.(64.0)	

'Mean is followed by the standard error.

TABLE 9. Monthly variation of pennate diatoms during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		991.(186.)		598.(79.0)	213.(16.4)
February	1640.(196.)	265.(43.0)		62.2(8.27)	43.8(4.30)
March	1340.(146.)	329.(46.3)	1210.(90.6)	41.7(4.68)	200.(17.9)
April	1160.(306.)	1340.(123.)	1710.(187.)	226.(37.1)	748.(67.9)
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)	120.(23.2)	
October	295.(34.6)	498.(36.6)	822.(45.2)	570.(63.1)	
November	501.(74.2)	842.(100.)	724.(100.)	963.(107.)	
December	333.(43.4)	1320.(148.)	548.(50.2)	572.(45.5)	
Yearly Mean	907.(271.)	1070.(220.)	685.(155.)	731.(74.6)	

'Mean is followed by the standard error.

TABLE 10. Monthly variation of desmids during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		0.0(0.0)		1.05(.640)	0.461(0.290)
February	0.8(0.5)	.238(.191)		.275(.207)	0.339(0.120)
March	0.8(0.5)	.417(.298)	.142(.142)	.208(.151)	0.322(0.140)
April	1.2(1.2)	.825(.592)	.275(.275)	0.0(0.0)	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)	0.022(0.022)	
October	0.8(0.4)	0.0(0.0)	0.0(0.0)	1.20(0.439)	
November	0.5(0.3)	0.0(0.0)	.825(.431)	1.94(0.561)	
December	0.0(0.0)	.447(.298)	1.38(.604)	1.98(0.397)	
Yearly Mean	1.14(.298)	.484(.150)	.804(.197)	0.935(0.329)	

'Mean is followed by the standard error.

TABLE 11. Monthly variation of other algae during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		62.4(18.1)		50.8(11.2)	84.4(9.25)
February	7.0(3.2)	58.3(30.4)		53.9(8.07)	94.4(9.4)
March	29.4(4.4)	39.9(5.93)	16.7(5.49)	66.2(7.79)	92.0(13.9)
April	70.0(16.9)	91.1(42.8)	167.(20.8)	57.6(10.9)	29.8(6.58)
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)	86.6(10.3)	
October	44.0(5.0)	166.(23.7)	183.(21.4)	245.(23.7)	
November	65.7(13.0)	84.7(14.5)	119.(15.6)	112.(18.5)	
December	71.0(13.1)	42.0(7.67)	63.4(15.1)	124.(13.0)	
Yearly Mean	98.7(39.7)	153.(39.5)	110.(22.6)	161.(20.3)	

'Mean is followed by the standard error.

TABLE 12. Monthly variation of total algae during 1975, 1976, 1977, 1978, and 1979 (cells/ml).

Month	1975'	1976'	1977'	1978'	1979'
January		3530.(429.)		1490.(210.)	1090.(92.5)
February	2970.(318.)	1410.(147.)		465.(81.7)	691.(62.9)
March	3340.(421.)	1840.(182.)	2500.(206.)	681.(63.9)	1330.(121.5)
April	5020.(816.)	2990.(200.)	3890.(336.)	1500.(170.)	3850.(243.)
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.)	1350.(113.)	
October	2490.(286.)	2720.(291.)	2680.(285.)	4530.(450.)	
November	2150.(259.)	3090.(237.)	3210.(428.)	3580.(407.)	
December	2790.(170.)	2870.(312.)	1840.(189.)	5060.(414.)	
Yearly Mean	3280.(399.)	3390.(519.)	2380.(228.)	3000.(272.)	

'Mean is followed by the standard error.

TABLE 13. Comparison of the number of forms of phytoplankton for the years 1975, 1976, 1977, 1978, and 1979. Standard errors are included in the first set of parentheses and sample size is shown in the second set of parentheses.

Month	1975	1976	1977	1978	1979
January	---[1]	59.4(2.79) (11)	---[1]	62.9(2.47) (11)	59.7(3.03) (18)
February	51.1(1.90) (9)	57.3(1.64) (12)	---	48.9(1.01) (12)	46.6(1.37) (18)
March	51.7(1.89) (9)	59.3(1.59) (12)	52.9(2.36) (12)	40.3(1.16) (12)	56.7(1.80) (18)
April	48.3(1.38) (9)	56.1(1.43) (12)	55.5(3.37) (12)	55.1(3.24) (12)	44.8(1.97) (12)
May	47.4(1.78) (9)	60.3(2.84) (12)	46.4(2.91) (12)	81.9(2.07) (12)	
June	49.2(1.77) (12)	65.8(1.77) (12)	64.1(3.59) (12)	85.3(4.17) (12)	
July	51.6(.892) (12)	87.3(3.78) (12)	57.7(2.64) (12)	69.7(2.73) (18)	
August	44.5(2.32) (12)	53.4(3.31) (12)	46.9(2.26) (12)	49.9(1.93) (18)	
September	44.1(3.12) (10)	84.8(4.30) (12)	60.3(2.75) (12)	67.1(2.53) (18)	
October	54.9(2.18) (12)	58.8(2.77) (12)	52.3(2.60) (12)	78.2(3.02) (18)	
November	50.3(2.11) (12)	57.2(1.74) (12)	46.6(1.85) (12)	72.6(3.47) (18)	
December	50.8(1.74) (11)	56.5(1.81) (12)	56.4(2.52) (12)	55.1(2.19) (18)	
Yearly Mean	49.4(.969)	63.1(3.25)	53.9(1.92)	63.9(2.50)	

[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, 1978, and 1979. Standard errors are included in the first set of parentheses and sample size is shown in the second set of parentheses.

Month	1975	1976	1977	1978	1979
January	--- [1]	4.29(.0547) (11)	--- [1]	4.53(.0918) (11)	4.29(0.102) (18)
February	4.35(.0473) (9)	4.47(.0591) (12)	---	4.37(.103) (12)	3.96(0.112) (18)
March	4.30(.0544) (9)	4.34(.0633) (12)	3.85(.0680) (12)	3.69(.108) (12)	4.24(0.0643) (18)
April	4.21(0.569) (9)	4.30(.0466) (12)	4.36(.0872) (12)	4.21(.119) (12)	3.75(0.0774) (12)
May	3.76(.228) (9)	4.37(.112) (12)	2.98(.186) (12)	4.96(0.03) (12)	
June	4.17(.0809) (12)	4.67(.0616) (12)	4.62(.0836) (12)	4.31(0.10) (12)	
July	3.93(.0654) (12)	5.08(.0380) (12)	4.00(.0564) (12)	4.86(0.05) (18)	
August	3.58(.163) (12)	3.50(.114) (12)	3.29(.161) (12)	4.07(0.97) (18)	
September	3.36(.189) (10)	4.92(.0973) (12)	3.29(.109) (12)	4.40(0.15) (18)	
October	3.96(.138) (12)	4.48(.0823) (12)	4.00(.0764) (12)	3.77(0.11) (18)	
November	4.02(.119) (12)	3.97(.0608) (12)	3.69(.0945) (12)	3.58(0.11) (18)	
December	3.83(.0982) (11)	3.96(.0963) (12)	3.82(.113) (12)	2.91(0.08) (18)	
Yearly Mean	3.95(.0924)	4.36(.124)	3.79(.159)	4.15(0.09)	

[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, 1978, and 1979. Standard errors are included in the first set of parentheses and sample size is shown in the second set of parentheses.

Month	1975	1976	1977	1978	1979
January	---[1]	.270(.0114) (11)	---[1]	.238(.0163) (11)	.262(0.0147) (18)
February	.230(.00916) (9)	.231(.0111) (12)	---	.207(.0238) (12)	.278(0.0195) (18)
March	.243(.00781) (9)	.263(.0106) (12)	.329(.00821) (12)	.317(.0212) (12)	.261(0.0103) (18)
April	.246(.00879) (9)	.260(.00667) (12)	.244(.00581) (12)	.272(.0134) (12)	.303(0.0122) (12)
May	.327(.0540) (9)	.259(.0150) (12)	.474(.0304) (12)	.217(.007) (12)	
June	.258(.00973) (12)	.223(.0101) (12)	.223(.0105) (12)	.329(.013) (12)	
July	.310(.0114) (12)	.210(.00759) (12)	.318(.0115) (12)	.201(.006) (18)	
August	.353(.0262) (12)	.393(.0172) (12)	.411(.0336) (12)	.280(.009) (18)	
September	.389(.0290) (10)	.227(.0127) (12)	.457(.0215) (12)	.447(.026) (18)	
October	.317(.0212) (12)	.232(.0141) (12)	.299(.0112) (12)	.405(.017) (18)	
November	.289(.0196) (12)	.322(.0106) (12)	.335(.0154) (12)	.427(.019) (18)	
December	.325(.0173) (11)	.322(.0175) (12)	.348(.0194) (12)	.502(.017) (18)	
Yearly Mean	299(.0152)	.268(.0154)	.344(.0262)	.320(0.030)	

[1] Samples were not collected where dàshes 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	9	5
1980 (through Oct.)	4	6

TABLE 17. Percent Occurrence of Statistically Significant (0.05 level of significance) changes in Viability (Chlorophyll a) between the Intake and Discharge.

	Decrease		Increase	
Year	Non-incubated	Incubated	Non-incubated	Incubated
1975	0	5	0	0
1976	8	8	6	0
1977	30	60	0	0
1978	22	17	5	17
1979	15	12	16	30
1980 (through Oct.)	18	0	5	3

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
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	0.159E+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	0620	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	0.308E+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	0.260E+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=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	0.200E+01	0.107E+00			
08/07/79	0335	D1 0	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 0	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 0	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			
09/11/79	0520	D1 28	4	0.274E+01	0.190E+00			
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			
09/11/70	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	1210	I5 0	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	0552	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
11/12/79	1903	I5 0	5	0.397E+01	0.863E-01			
11/12/79	1903	D1 0	4	0.451E+01	0.137E+00	INTAKE VS DISCHARGE	0.123E+02	0.109E-01
11/12/79	1903	I5 38	5	0.440E+01	0.687E-01			
11/12/79	1903	D1 38	4	0.424E+01	0.174E+00	INTAKE VS DISCHARGE	0.814E+00	0.400E+00

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/79	0604	I5 0	5	0.429E+01	0.767E-01			
11/13/79	0603	D1 0	4	0.402E+01	0.603E-01	INTAKE VS DISCHARGE	0.737E+01	0.307E-01
11/13/79	1235	I5 0	5	0.456E+01	0.114E+00			
11/13/79	1226	D1 0	5	0.445E+01	0.133E+00	INTAKE VS DISCHARGE	0.366E+00	0.565E+00
12/10/79	1854	I5 0	5	0.115E+02	0.246E+00			
12/10/79	1905	D1 0	5	0.111E+02	0.121E+00	INTAKE VS DISCHARGE	0.282E+01	0.131E+00
12/11/79	0622	I5 0	5	0.114E+02	0.150E+00			
12/11/79	0626	D1 0	5	0.111E+02	0.490E-01	INTAKE VS DISCHARGE	0.410E+01	0.775E-01
12/11/79	1200	I5 0	5	0.112E+02	0.143E+00			
12/11/79	1200	D1 0	5	0.110E+02	0.107E+00	INTAKE VS DISCHARGE	0.181E+01	0.215E+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
01/21/80	1940	I5 0	5	0.481E+01	0.134E+00			
01/21/80	1922	D1 0	4	0.487E+01	0.766E-01			
01/21/80	2002	D2 0	5	0.496E+01	0.524E-01	INTAKE VS DISCHARGE	0.626E+00	0.555E+00
01/21/80	1940	I5 38	5	0.526E+01	0.196E+00			
01/21/80	1922	D1 40	5	0.522E+01	0.939E-01			
01/21/80	2002	D2 41	5	0.562E+01	0.595E-01	INTAKE VS DISCHARGE	0.296E+01	0.911E-01
01/22/80	0632	I5 0	5	0.516E+01	0.800E-01			
01/22/80	0620	D1 0	5	0.509E+01	0.701E-01			
01/22/80	0646	D2 0	5	0.509E+01	0.573E-01	INTAKE VS DISCHARGE	0.328E+00	0.726E+00
01/22/80	1202	I5 0	5	0.533E+01	0.562E-01			
01/22/80	1150	D1 0	5	0.494E+01	0.133E+00			
01/22/80	1215	D2 0	5	0.494E+01	0.123E+00	INTAKE VS DISCHARGE	0.416E+01	0.435E-01
02/04/80	2014	I5 0	5	0.320E+01	0.170E+00			
02/04/80	1959	D1 0	5	0.327E+01	0.821E-01			
02/04/80	1944	D2 0	5	0.346E+01	0.109E+00	INTAKE VS DISCHARGE	0.747E+00	0.497E+00
02/04/80	2014	I5 37	5	0.359E+01	0.103E+00			
02/04/80	1959	D1 37	5	0.363E+01	0.140E+00			
02/04/80	1944	D2 37	5	0.400E+01	0.266E+00	INTAKE VS DISCHARGE	0.150E+01	0.264E+00
02/05/80	0652	I5 0	5	0.349E+01	0.552E-01			
02/05/80	0639	D1 0	5	0.341E+01	0.451E-01			
02/05/80	0635	D2 0	5	0.334E+01	0.917E-01	INTAKE VS DISCHARGE	0.126E+01	0.320E+00
02/05/80	1239	I5 0	5	0.375E+01	0.156E+00			
02/05/80	1226	D1 0	5	0.389E+01	0.155E+00			
02/05/80	1210	D2 0	5	0.370E+01	0.148E+00	INTAKE VS DISCHARGE	0.396E+00	0.603E+00
03/10/80	2023	I5 0	5	0.354E+01	0.577E-01			
03/10/80	2022	D1 0	5	0.322E+01	0.108E+00			
03/10/80	2033	D2 0	5	0.325E+01	0.203E+00	INTAKE VS DISCHARGE	0.175E+01	0.217E+00
03/10/80	2021	I5 37	5	0.375E+01	0.129E+00			
03/10/80	2022	D1 37	5	0.372E+01	0.104E+00			
03/10/80	2033	D2 38	5	0.353E+01	0.138E+00	INTAKE VS DISCHARGE	0.878E+00	0.443E+00
03/11/80	0530	I5 0	5	0.335E+01	0.348E-01			
03/11/80	0519	D1 0	5	0.322E+01	0.426E-01			
03/11/80	0520	D2 0	5	0.318E+01	0.179E+00	INTAKE VS DISCHARGE	0.673E+00	0.531E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/11/80	1204	I5	0	4	0.345E+01	0.140E+00			
03/11/80	1156	D1	0	5	0.323E+01	0.634E-01			
03/11/80	1157	D2	0	4	0.375E+01	0.300E+00	INTAKE VS DISCHARGE	0.210E+01	0.174E+00
04/07/80	2125	I5	0	5	0.470E+01	0.104E+00			
04/07/80	2107	D1	0	4	0.453E+01	0.110E+00			
04/07/80	2107	D2	0	4	0.479E+01	0.277E+00	INTAKE VS DISCHARGE	0.575E+00	0.583E+00
04/07/80	2123	I5	36	5	0.347E+01	0.628E+00			
04/07/80	2107	D1	36	5	0.356E+01	0.342E+00			
04/07/80	2117	D2	36	4	0.300E+01	0.975E+00	INTAKE VS DISCHARGE	0.194E+00	0.823E+00
04/08/80	0515	I5	0	5	0.475E+01	0.630E-01			
04/08/80	0510	D1	0	4	0.471E+01	0.395E-01			
04/08/80	0509	D2	0	5	0.452E+01	0.132E+00	INTAKE VS DISCHARGE	0.276E+01	0.108E+00
04/08/80	1212	I5	0	5	0.526E+01	0.110E+00			
04/08/80	1215	D1	0	5	0.503E+01	0.224E+00			
04/08/80	1205	D2	0	4	0.421E+01	0.187E+00	INTAKE VS DISCHARGE	0.879E+01	0.600E-02
05/12/80	2130	I5	0	5	0.158E+02	0.299E+00			
05/12/80	2120	D1	0	5	0.149E+02	0.788E+00			
05/12/80	2120	D2	0	5	0.157E+02	0.271E+00	INTAKE VS DISCHARGE	0.889E+00	0.439E+00
05/12/80	2130	I5	36	4	0.177E+02	0.364E+00			
05/12/80	2120	D1	36	5	0.190E+02	0.350E+00			
05/12/80	2120	D2	36	5	0.179E+02	0.277E+00	INTAKE VS DISCHARGE	0.405E+01	0.492E-01
05/13/80	0333	I5	0	5	0.159E+02	0.159E+00			
05/13/80	0328	D1	0	5	0.154E+02	0.302E+00			
05/13/80	0326	D2	0	5	0.152E+02	0.513E+00	INTAKE VS DISCHARGE	0.116E+01	0.349E+00
05/13/80	1200	I5	0	5	0.141E+02	0.247E+00			
05/13/80	1155	D1	0	5	0.138E+02	0.186E+00			
05/13/80	1153	D2	0	5	0.140E+02	0.183E+00	INTAKE VS DISCHARGE	0.678E+00	0.528E+00
06/09/80	2302	I5	0	5	0.112E+02	0.146E+00			
06/09/80	2302	D2	0	5	0.109E+02	0.276E+00	INTAKE VS DISCHARGE	0.114E+01	0.317E+00
06/09/80	2302	I5	36	5	0.112E+02	0.260E+00			
06/09/80	2302	D2	36	5	0.110E+02	0.208E+00	INTAKE VS DISCHARGE	0.346E+01	0.996E-01
06/10/80	0229	I5	0	5	0.979E+01	0.170E+00			
06/10/80	0229	D2	0	5	0.871E+01	0.168E+00	INTAKE VS DISCHARGE	0.200E+02	0.276E-02

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
06/10/80	1200	I5 0	5	0.106E+02	0.315E+00			
06/10/80	1200	D2 0	5	0.103E+02	0.249E+00	INTAKE VS DISCHARGE	0.700E+00	0.428E+00
07/14/80	2225	I5 0	5	0.220E+01	0.105E+00			
07/14/80	2230	D2 0	5	0.219E+01	0.117E+00	INTAKE VS DISCHARGE	0.286E+00	0.609E+00
07/14/80	2225	I5 38	5	0.210E+01	0.115E+00			
07/14/80	2230	D2 38	5	0.214E+01	0.966E-01	INTAKE VS DISCHARGE	0.779E-01	0.777E+00
07/15/80	0323	I5 0	5	0.229E+01	0.697E-01			
07/15/80	0314	D2 0	5	0.221E+01	0.908E-01	INTAKE VS DISCHARGE	0.465E+00	0.518E+00
07/15/80	1212	I5 0	4	0.289E+01	0.102E+00			
07/15/80	1204	D2 0	5	0.238E+01	0.143E+00	INTAKE VS DISCHARGE	0.764E+01	0.286E-01
08/11/80	2205	I5 0	5	0.224E+01	0.610E-01			
08/11/80	2153	D1 0	5	0.199E+01	0.722E-01			
08/11/80	2156	D2 0	4	0.193E+01	0.735E-01	INTAKE VS DISCHARGE	0.570E+01	0.203E-01
08/11/80	2205	I5 35	5	0.181E+01	0.118E+00			
08/11/80	2153	D1 35	5	0.188E+01	0.779E-01			
08/11/80	2156	D2 35	5	0.173E+01	0.965E-01	INTAKE VS DISCHARGE	0.577E+00	0.579E+00
08/12/80	0428	I5 0	5	0.558E+01	0.133E+00			
08/12/80	0416	D1 0	5	0.552E+01	0.119E+00			
08/12/80	0421	D2 0	4	0.471E+01	0.786E-01	INTAKE VS DISCHARGE	0.155E+02	0.105E-02
08/12/80	1122	I5 0	5	0.529E+01	0.563E-01			
08/12/80	1126	D1 0	5	0.543E+01	0.131E+00			
08/12/80	1104	D2 0	5	0.479E+01	0.109E+00	INTAKE VS DISCHARGE	0.106E+02	0.289E-02
09/08/80	2109	I5 0	5	0.877E+01	0.163E+00			
09/08/80	2054	D1 0	4	0.928E+01	0.196E+00			
09/08/80	2050	D2 0	5	0.855E+01	0.245E+00	INTAKE VS DISCHARGE	0.303E+01	0.908E-01
09/08/80	2109	I5 38	5	0.866E+01	0.306E+00			
09/08/80	2054	D1 38	5	0.848E+01	0.201E+00			
09/08/80	2050	D2 38	5	0.836E+01	0.128E+00	INTAKE VS DISCHARGE	0.913E+00	0.430E+00
09/09/80	0459	I5 0	5	0.760E+01	0.540E+00			
09/09/80	0455	D1 0	5	0.910E+01	0.168E+00			
09/90/80	0456	D2 0	5	0.753E+01	0.190E+00	INTAKE VS DISCHARGE	0.664E+01	0.124E-01

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
09/09/80	1217	I5 0	5	0.600E+01	0.805E-01			
09/09/80	1205	D1 0	5	0.580E+01	0.574E-01			
09/09/80	1257	D2 0	5	0.582E+01	0.614E-01	INTAKE VS DISCHARGE	0.272E+01	0.107E+00
10/13/80	1943	I5 0	5	0.108E+02	0.220E+00			
10/13/80	1949	D1 0	5	0.109E+02	0.678E-01			
10/13/80	1953	D2 0	5	0.104E+02	0.678E-01	INTAKE VS DISCHARGE	0.280E+01	0.102E+00
10/13/80	1943	I5 37	5	0.104E+02	0.167E+00			
10/13/80	1949	D1 37	5	0.103E+02	0.153E+00			
10/13/80	1953	D2 37	5	0.103E+02	0.299E+00	INTAKE VS DISCHARGE	0.159E+00	0.851E+00
10/14/80	0533	I5 0	5	0.102E+02	0.152E+00			
10/14/80	0542	D1 0	5	0.100E+02	0.263E+00			
10/14/80	0528	D2 0	5	0.983E+01	0.196E+00	INTAKE VS DISCHARGE	0.520E+01	0.246E-01
10/14/80	1206	I5 0	5	0.854E+01	0.127E+00			
10/14/80	1207	D1 0	4	0.830E+01	0.762E-01			
10/14/80	1212	D2 0	4	0.838E+01	0.998E-01	INTAKE VS DISCHARGE	0.129E+01	0.319E+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

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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	1210	D2	0	4	0.401E-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	0.382E-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			
05/08/79	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	0.288E-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			
09/11/79	0520	D1	28	4	0.887E-02	0.888E-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	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	0	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
11/12/79	1903	I5	0	5	0.200E-04	0.200E-04			
11/12/79	1903	D1	0	4	0.0	0.0	INTAKE VS DISCHARGE	0.778E+00	0.410E+00
11/12/79	1903	I5	38	5	0.0	0.0			
11/12/79	1903	D1	38	4	0.800E-04	0.800E-04	INTAKE VS DISCHARGE	0.130E+01	0.293E+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
11/13/79	0604	I5	0	5	0.185E-02	0.185E-02			
11/13/79	0603	D1	0	4	0.0	0.0	INTAKE VS DISCHARGE	0.778E+00	0.410E+00
11/13/79	1235	I5	0	5	0.695E-02	0.500E-02			
11/13/79	1226	D1	0	5	0.457E-01	0.257E-01	INTAKE VS DISCHARGE	0.219E+01	0.177E+00
12/10/79	1854	I5	0	5	0.268E-01	0.268E-01			
12/10/79	1905	D1	0	5	0.679E-01	0.523E-01	INTAKE VS DISCHARGE	0.489E+00	0.508E+00
12/11/79	0622	I5	0	5	0.916E-03	0.916E-03			
12/11/79	0626	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.956E+00	0.359E+00
12/11/79	1200	I5	0	5	0.200E-04	0.200E-04			
12/11/79	1200	D1	0	5	0.866E-02	0.864E-02	INTAKE VS DISCHARGE	0.100E+01	0.348E+00

TABLE 21. 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
01/21/80	1940	I5	0	5	0.850E-02	0.522E-02			
01/21/80	1922	D1	0	4	0.225E-02	0.225E-02			
01/21/80	2002	D2	0	5	0.184E-01	0.129E-01	INTAKE VS DISCHARGE	0.840E+00	0.460E+00
01/21/80	1940	I5	38	5	0.200E-04	0.200E-04			
01/21/80	1922	D1	40	5	0.0	0.0			
01/21/80	2002	D2	41	5	0.0	0.0	INTAKE VS DISCHARGE	0.100E+01	0.399E+00
01/22/80	0632	I5	0	5	0.264E-01	0.264E-01			
01/22/80	0620	D1	0	5	0.0	0.0			
01/22/80	0646	D2	0	5	0.436E-02	0.436E-02	INTAKE VS DISCHARGE	0.839E+00	0.459E+00
01/22/80	1202	I5	0	5	0.200E-06	0.200E-06			
01/22/80	1150	D1	0	5	0.175E-02	0.175E-02			
01/22/80	1215	D2	0	5	0.260E-02	0.260E-02	INTAKE VS DISCHARGE	0.536E+00	0.601E+00
02/04/80	2014	I5	0	5	0.110E-01	0.612E-02			
02/04/80	1959	D1	0	5	0.325E-01	0.200E-01			
02/04/80	1944	D2	0	5	0.800E-03	0.800E-03	INTAKE VS DISCHARGE	0.179E+01	0.209E+00
02/04/80	2014	I5	37	5	0.479E-01	0.249E-01			
02/04/80	1959	D1	37	5	0.746E-01	0.275E-01			
02/04/80	1944	D2	37	5	0.464E-01	0.159E-01	INTAKE VS DISCHARGE	0.463E+00	0.642E+00
02/05/80	0652	I5	0	5	0.255E-01	0.167E-01			
02/05/80	0639	D1	0	5	0.101E-01	0.673E-02			
02/05/80	0635	D2	0	5	0.617E-01	0.325E-01	INTAKE VS DISCHARGE	0.152E+01	0.258E+00
02/05/80	1239	I5	0	5	0.110E-01	0.595E-02			
02/05/80	1226	D1	0	5	0.460E-01	0.144E-01			
02/05/80	1210	D2	0	5	0.102E-01	0.707E-02	INTAKE VS DISCHARGE	0.417E+01	0.432E-01
03/10/80	2023	I5	0	5	0.207E-01	0.930E-02			
03/10/80	2022	D1	0	5	0.351E-01	0.151E-01			
03/10/80	2033	D2	0	5	0.351E-01	0.127E-01	INTAKE VS DISCHARGE	0.433E+00	0.660E+00
03/10/80	2023	I5	37	5	0.372E-01	0.156E-01			
03/10/80	2022	D1	37	5	0.725E-01	0.210E-01			
03/10/80	2033	D2	38	5	0.514E-01	0.204E-01	INTAKE VS DISCHARGE	0.862E+00	0.449E+00
03/11/80	0530	I5	0	5	0.311E-01	0.208E-01			
03/11/80	0519	D1	0	5	0.789E-01	0.152E-01			
03/11/80	0520	D2	0	5	0.527E-01	0.240E-01	INTAKE VS DISCHARGE	0.130E+01	0.289E+00

TABLE 21. 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
03/11/80	1204	I5	0	4	0.695E-01	0.246E-01			
03/11/80	1156	D1	0	5	0.469E-01	0.191E-01			
03/11/80	1157	D2	0	4	0.346E-01	0.236E-01	INTAKE VS DISCHARGE	0.593E+00	0.573E+00
04/07/80	2125	I5	0	5	0.281E-01	0.260E-01			
04/07/80	2107	D1	0	4	0.686E-01	0.263E-01			
04/07/80	2107	D2	0	4	0.300E-01	0.174E-01	INTAKE VS DISCHARGE	0.858E+00	0.456E+00
04/07/80	2123	I5	36	5	0.430E-01	0.224E-01			
04/07/80	2107	D1	36	5	0.103E-01	0.553E-02			
04/07/80	2117	D2	36	4	0.320E-01	0.320E-01	INTAKE VS DISCHARGE	0.662E+00	0.537E+00
04/08/80	0515	I5	0	5	0.136E+00	0.308E-01			
04/08/80	0510	D1	0	4	0.816E-01	0.287E-01			
04/08/80	0509	D2	0	5	0.950E-01	0.393E-01	INTAKE VS DISCHARGE	0.694E+00	0.523E+00
04/08/80	1212	I5	0	5	0.102E+00	0.981E-02			
04/08/80	1215	D1	0	5	0.259E+00	0.836E-01			
04/08/80	1205	D2	0	4	0.146E+00	0.510E-01	INTAKE VS DISCHARGE	0.188E+01	0.199E+00
05/12/80	2130	I5	0	5	0.109E-02	0.109E-02			
05/12/80	2120	D1	0	5	0.200E-04	0.200E-04			
05/12/80	2120	D2	0	5	0.198E-01	0.198E-01	INTAKE VS DISCHARGE	0.944E+00	0.418E+00
05/12/80	2130	I5	36	4	0.250E-04	0.250E-04			
05/12/80	2120	D1	36	5	0.200E-04	0.200E-04			
05/12/80	2120	D2	36	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.167E-01	0.981E+00
05/13/80	0333	I5	0	5	0.200E-04	0.200E-04			
05/13/80	0328	D1	0	5	0.200E-04	0.200E-04			
05/13/80	0326	D2	0	5	0.140E-01	0.139E-01	INTAKE VS DISCHARGE	0.100E+01	0.398E+00
05/13/80	1200	I5	0	5	0.200E-04	0.200E-04			
05/13/80	1155	D1	0	5	0.200E-04	0.200E-04			
05/13/80	1153	D2	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
06/09/80	2302	I5	0	5	0.559E-01	0.251E-01			
06/09/80	2302	D2	0	5	0.325E-01	0.107E-01	INTAKE VS DISCHARGE	0.732E+00	0.421E+00
06/09/80	2302	I5	36	5	0.332E-02	0.332E-02			
06/09/80	2302	D2	36	5	0.740E-02	0.436E-02	INTAKE VS DISCHARGE	0.467E+00	0.517E+00
06/10/80	0229	I5	0	5	0.510E-01	0.178E-01			
06/10/80	0229	D2	0	5	0.112E+00	0.509E-01	INTAKE VS DISCHARGE	0.129E+01	0.289E+00

TABLE 21. 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
06/10/80	1200	I5	0	5	0.327E-01	0.188E-01			
06/10/80	1200	D2	0	5	0.110E+00	0.508E-01	INTAKE VS DISCHARGE	0.205E+01	0.190E+00
07/14/80	2225	I5	0	5	0.661E-01	0.257E-01			
07/14/80	2230	D2	0	5	0.141E-01	0.701E-02	INTAKE VS DISCHARGE	0.382E+01	0.864E-01
07/14/80	2225	I5	38	5	0.368E-01	0.265E-01			
07/14/80	2230	D2	38	5	0.736E-01	0.223E-01	INTAKE VS DISCHARGE	0.113E+01	0.321E+00
07/15/80	0323	I5	0	5	0.460E-01	0.793E-02			
07/15/80	0314	D2	0	5	0.563E-01	0.165E-01	INTAKE VS DISCHARGE	0.318E+00	0.591E+00
07/15/80	1212	I5	0	4	0.114E+00	0.263E-01			
07/15/80	1204	D2	0	5	0.533E-01	0.243E-01	INTAKE VS DISCHARGE	0.285E+01	0.135E+00
08/11/80	2205	I5	0	5	0.909E-02	0.505E-02			
08/11/80	2153	D1	0	5	0.187E-01	0.762E-02			
08/11/80	2156	D2	0	4	0.368E-01	0.155E-01	INTAKE VS DISCHARGE	0.211E+01	0.169E+00
08/11/80	2205	I5	35	5	0.214E-01	0.179E-01			
08/11/80	2153	D1	35	5	0.208E-01	0.132E-01			
08/11/80	2156	D2	35	5	0.205E-01	0.787E-02	INTAKE VS DISCHARGE	0.119E-02	0.998E+00
08/12/80	0420	I5	0	5	0.143E+00	0.422E-01			
08/12/80	0416	D1	0	5	0.163E+00	0.457E-01			
08/12/80	0421	D2	0	4	0.992E-01	0.414E-01	INTAKE VS DISCHARGE	0.515E+00	0.614E+00
08/12/80	1122	I5	0	5	0.992E-01	0.186E-01			
08/12/80	1126	D1	0	5	0.179E+00	0.147E-01			
08/12/80	1104	D2	0	5	0.133E+00	0.362E-01	INTAKE VS DISCHARGE	0.258E+01	0.118E+00
09/08/80	2109	I5	0	5	0.179E+00	0.309E-01			
09/08/80	2054	D1	0	4	0.880E-01	0.525E-01			
09/08/80	2050	D2	0	5	0.135E+00	0.406E-01	INTAKE VS DISCHARGE	0.120E+01	0.339E+00
09/08/80	2109	I5	38	5	0.570E-01	0.251E-01			
09/08/80	2054	D1	38	5	0.148E+00	0.436E-01			
09/08/80	2050	D2	38	5	0.527E-01	0.218E-01	INTAKE VS DISCHARGE	0.290E+01	0.948E-01
09/09/80	0459	I5	0	5	0.107E+00	0.381E-01			
09/09/80	0455	D1	0	5	0.215E+00	0.361E-01			
09/90/80	0456	D2	0	5	0.896E-01	0.185E-01	INTAKE VS DISCHARGE	0.448E+01	0.361E-01

TABLE 21. 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
09/09/80	1217	I5	0	5	0.163E-01	0.839E-02			
09/09/80	1205	D1	0	5	0.102E-01	0.632E-02			
09/09/80	1257	D2	0	5	0.145E+00	0.381E-01	INTAKE VS DISCHARGE	0.112E+02	0.242E-02
10/13/80	1943	I5	0	5	0.0	0.0			
10/13/80	1949	D1	0	5	0.0	0.0			
10/13/80	1953	D2	0	5	0.530E-02	0.530E-02	INTAKE VS DISCHARGE	0.100E+01	0.399E+00
10/13/80	1943	I5	37	5	0.0	0.0			
10/13/80	1949	D1	37	5	0.134E-01	0.134E-01			
10/13/80	1953	D2	37	5	0.566E-01	0.347E-01	INTAKE VS DISCHARGE	0.190E+01	0.193E+00
10/14/80	0533	I5	0	5	0.466E-01	0.269E-01			
10/14/80	0542	D1	0	5	0.755E-01	0.461E-01			
10/14/80	0528	D2	0	5	0.708E-01	0.197E-01	INTAKE VS DISCHARGE	0.269E+00	0.767E+00
10/14/80	1206	I5	0	5	0.254E-01	0.151E-01			
10/14/80	1207	D1	0	4	0.663E-02	0.663E-02			
10/14/80	1212	D2	0	4	0.336E-01	0.174E-01	INTAKE VS DISCHARGE	0.086E+00	0.445E+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	0.878E-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	0.530E+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	0628	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	2048	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	0.240E+00

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5 0	3	0.404E+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			
09/11/79	0520	D1 28	4	0.234E+00	0.549E-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	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
11/12/79	1903	I5 0	5	0.579E+00	0.391E-01			
11/12/79	1903	D1 0	4	0.726E+00	0.637E-01	INTAKE VS DISCHARGE	0.423E+01	0.789E-01
11/12/79	1903	I5 38	5	0.843E+00	0.785E-01			
11/12/79	1903	D1 38	4	0.882E+00	0.772E-01	INTAKE VS DISCHARGE	0.126E+00	0.727E+00

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/79	0604	I5 0	5	0.912E+00	0.827E-01			
11/13/79	0603	D1 0	4	0.731E+00	0.144E-01	INTAKE VS DISCHARGE	0.365E+01	0.977E-01
11/13/79	1235	I5 0	5	0.922E+00	0.905E-01			
11/13/79	1226	D1 0	5	0.903E+00	0.492E-01	INTAKE VS DISCHARGE	0.347E-01	0.843E+00
12/10/79	1854	I5 0	5	0.186E+01	0.232E+00			
12/10/79	1905	D1 0	5	0.188E+01	0.166E+00	INTAKE VS DISCHARGE	0.398E-02	0.940E+00
12/11/79	0622	I5 0	5	0.172E+01	0.801E-01			
12/11/79	0626	D1 0	5	0.152E+01	0.175E+00	INTAKE VS DISCHARGE	0.101E+01	0.345E+00
12/11/79	1200	I5 0	5	0.181E+01	0.140E+00			
12/11/79	1200	D1 0	5	0.163E+01	0.710E-01	INTAKE VS DISCHARGE	0.135E+01	0.280E+00

TABLE 23. 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
01/21/80	1940	I5 0	5	0.102E+01	0.705E-01			
01/21/80	1922	D1 0	4	0.932E+00	0.152E+00			
01/21/80	2002	D2 0	5	0.901E+00	0.628E-01	INTAKE VS DISCHARGE	0.440E+00	0.657E+00
01/21/80	1940	I5 38	5	0.859E+00	0.654E-01			
01/21/80	1922	D1 40	5	0.821E+00	0.333E-01			
01/21/80	2002	D2 41	5	0.857E+00	0.564E-01	INTAKE VS DISCHARGE	0.540E+00	0.599E+00
01/22/80	0632	I5 0	5	0.844E+00	0.257E-01			
01/22/80	0620	D1 0	5	0.957E+00	0.303E-01			
01/22/80	0646	D2 0	5	0.773E+00	0.594E-01	INTAKE VS DISCHARGE	0.503E+01	0.270E-01
01/22/80	1202	I5 0	5	0.585E+00	0.678E-01			
01/22/80	1150	D1 0	5	0.710E+00	0.698E-01			
01/22/80	1215	D2 0	5	0.699E+00	0.312E-01	INTAKE VS DISCHARGE	0.137E+01	0.293E+00
02/04/80	2014	I5 0	5	0.486E+00	0.503E-01			
02/04/80	1959	D1 0	5	0.311E+00	0.259E-01			
02/04/80	1944	D2 0	5	0.356E+00	0.694E-01	INTAKE VS DISCHARGE	0.311E+01	0.828E-01
02/04/80	2014	I5 37	5	0.631E+00	0.836E-01			
02/04/80	1959	D1 37	5	0.583E+00	0.407E-01			
02/04/80	1944	D2 37	5	0.658E+00	0.722E-01	INTAKE VS DISCHARGE	0.310E+00	0.739E+00
02/05/80	0652	I5 0	5	0.596E+00	0.503E-01			
02/05/80	0639	D1 0	5	0.549E+00	0.566E-01			
02/05/80	0635	D2 0	5	0.487E+00	0.133E+00	INTAKE VS DISCHARGE	0.383E+00	0.691E+00
02/05/80	1239	I5 0	5	0.570E+00	0.620E-01			
02/05/80	1226	D1 0	5	0.663E+00	0.522E-01			
02/05/80	1210	D2 0	5	0.619E+00	0.602E-01	INTAKE VS DISCHARGE	0.643E+00	0.546E+00
03/10/80	2023	I5 0	5	0.583E+00	0.225E-01			
03/10/80	2022	D1 0	5	0.547E+00	0.310E-01			
03/10/80	2033	D2 0	5	0.575E+00	0.660E-01	INTAKE VS DISCHARGE	0.189E+00	0.826E+00
03/10/80	2023	I5 37	5	0.730E+00	0.255E-01			
03/10/80	2022	D1 37	5	0.643E+00	0.656E-01			
03/10/80	2033	D2 38	5	0.681E+00	0.687E-01	INTAKE VS DISCHARGE	0.593E+00	0.570E+00
03/11/80	0530	I5 0	5	0.644E+00	0.503E-01			
03/11/80	0519	D1 0	5	0.634E+00	0.195E-01			
03/11/80	0520	D2 0	5	0.661E+00	0.776E-01	INTAKE VS DISCHARGE	0.614E-01	0.936E+00

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DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/11/80	1204	I5	0	4	0.687E+00	0.325E-01			
03/11/80	1156	D1	0	5	0.713E+00	0.204E-01			
03/11/80	1157	D2	0	4	0.715E+00	0.796E-01	INTAKE VS DISCHARGE	0.104E+00	0.897E+00
04/07/80	2125	I5	0	5	0.672E+00	0.260E-01			
04/07/80	2107	D1	0	4	0.746E+00	0.980E-01			
04/07/80	2107	D2	0	4	0.715E+00	0.160E-01	INTAKE VS DISCHARGE	0.481E+00	0.634E+00
04/07/80	2123	I5	36	5	0.535E+00	0.839E-01			
04/07/80	2107	D1	36	5	0.539E+00	0.409E-01			
04/07/80	2117	D2	36	4	0.567E+00	0.956E-01	INTAKE VS DISCHARGE	0.508E-01	0.946E+00
04/08/80	0515	I5	0	5	0.114E+01	0.980E-01			
04/08/80	0510	D1	0	4	0.919E+00	0.190E+00			
04/08/80	0509	D2	0	5	0.755E+00	0.105E+00	INTAKE VS DISCHARGE	0.234E+01	0.143E+00
04/08/80	1212	I5	0	5	0.129E+01	0.811E-01			
04/08/80	1215	D1	0	5	0.129E+01	0.174E+00			
04/08/80	1205	D2	0	4	0.994E+00	0.117E+00	INTAKE VS DISCHARGE	0.152E+01	0.262E+00
05/12/80	2130	I5	0	5	0.211E+01	0.145E+00			
05/12/80	2120	D1	0	5	0.187E+01	0.108E+00			
05/12/80	2120	D2	0	5	0.189E+01	0.104E+00	INTAKE VS DISCHARGE	0.125E+01	0.321E+00
05/12/80	2130	I5	36	4	0.135E+01	0.414E+00			
05/12/80	2120	D1	36	5	0.124E+01	0.289E+00			
05/12/80	2120	D2	36	5	0.152E+01	0.334E+00	INTAKE VS DISCHARGE	0.179E+00	0.834E+00
05/13/80	0333	I5	0	5	0.154E+01	0.356E+00			
05/13/80	0328	D1	0	5	0.162E+01	0.402E+00			
05/13/80	0326	D2	0	5	0.113E+01	0.262E+00	INTAKE VS DISCHARGE	0.581E+00	0.577E+00
05/13/80	1200	I5	0	5	0.141E+01	0.324E+00			
05/13/80	1155	D1	0	5	0.148E+01	0.342E+00			
05/13/80	1153	D2	0	5	0.150E+01	0.332E+00	INTAKE VS DISCHARGE	0.181E-01	0.980E+00
06/09/80	2302	I5	0	5	0.174E+01	0.105E+00			
06/09/80	2302	D2	0	5	0.145E+01	0.100E+00	INTAKE VS DISCHARGE	0.405E+01	0.789E-01
06/09/80	2302	I5	36	5	0.163E+01	0.974E-01			
06/09/80	2302	D2	36	5	0.177E+01	0.129E+00	INTAKE VS DISCHARGE	0.754E+00	0.414E+00
06/10/80	0229	I5	0	5	0.129E+01	0.627E-01			
06/10/80	0229	D2	0	5	0.130E+01	0.544E-01	INTAKE VS DISCHARGE	0.929E-02	0.913E+00

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DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
06/10/80	1200	I5 0	5	0.174E+01	0.820E-01			
06/10/80	1200	D2 0	5	0.160E+01	0.898E-01	INTAKE VS DISCHARGE	0.131E+01	0.286E+00
07/14/80	2225	I5 0	5	0.490E+00	0.506E-01			
07/14/80	2230	D2 0	5	0.425E+00	0.375E-01	INTAKE VS DISCHARGE	0.104E+01	0.339E+00
07/14/80	2225	I5 38	5	0.401E+00	0.750E-01			
07/14/80	2230	D2 38	5	0.334E+00	0.532E-01	INTAKE VS DISCHARGE	0.519E+00	0.496E+00
07/15/80	0323	I5 0	5	0.463E+00	0.706E-01			
07/15/80	0314	D2 0	5	0.418E+00	0.383E-01	INTAKE VS DISCHARGE	0.306E+00	0.597E+00
07/15/80	1212	I5 0	4	0.613E+00	0.321E-01			
07/15/80	1204	D2 0	5	0.438E+00	0.744E-01	INTAKE VS DISCHARGE	0.390E+01	0.890E-01
08/11/80	2205	I5 0	5	0.430E+00	0.233E-01			
08/11/80	2153	D1 0	5	0.411E+00	0.324E-01			
08/11/80	2156	D2 0	4	0.440E+00	0.401E-01	INTAKE VS DISCHARGE	0.241E+00	0.788E+00
08/11/80	2205	I5 35	5	0.303E+00	0.737E-01			
08/11/80	2153	D1 35	5	0.310E+00	0.496E-01			
08/11/80	2156	D2 35	5	0.287E+00	0.275E-01	INTAKE VS DISCHARGE	0.844E+00	0.456E+00
08/12/80	0428	I5 0	5	0.457E+00	0.559E-01			
08/12/80	0416	D1 0	5	0.607E+00	0.645E-01			
08/12/80	0421	D2 0	4	0.509E+00	0.294E-01	INTAKE VS DISCHARGE	0.204E+01	0.178E+00
08/12/80	1122	I5 0	5	0.619E+00	0.452E-01			
08/12/80	1126	D1 0	5	0.616E+00	0.497E-01			
08/12/80	1104	D2 0	5	0.559E+00	0.106E+00	INTAKE VS DISCHARGE	0.220E+00	0.803E+00
09/08/80	2109	I5 0	5	0.780E+00	0.544E-01			
09/08/80	2054	D1 0	4	0.952E+00	0.959E-01			
09/08/80	2050	D2 0	5	0.799E+00	0.110E+00	INTAKE VS DISCHARGE	0.970E+00	0.411E+00
09/08/80	2109	I5 38	5	0.709E+00	0.113E+00			
09/08/80	2054	D1 38	5	0.741E+00	0.101E+00			
09/08/80	2050	D2 38	5	0.700E+00	0.627E-01	INTAKE VS DISCHARGE	0.525E-01	0.945E+00
09/09/80	0459	I5 0	5	0.735E+00	0.615E-01			
09/09/80	0455	D1 0	5	0.930E+00	0.306E-01			
09/90/80	0456	D2 0	5	0.760E+00	0.737E-01	INTAKE VS DISCHARGE	0.333E+01	0.720E-01

TABLE 23. 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
09/09/80	1217	I5 0	5	0.560E+00	0.473E-01			
09/09/80	1205	D1 0	5	0.659E+00	0.368E-01			
09/09/80	1257	D2 0	5	0.647E+00	0.650E-01	INTAKE VS DISCHARGE	0.168E+01	0.229E+00
10/13/80	1943	I5 0	5	0.135E+01	0.109E+00			
10/13/80	1949	D1 0	5	0.172E+01	0.164E+00			
10/13/80	1953	D2 0	5	0.124E+01	0.559E-01	INTAKE VS DISCHARGE	0.439E+01	0.301E-01
10/13/80	1943	I5 37	5	0.139E+01	0.151E+00			
10/13/80	1949	D1 37	5	0.122E+01	0.353E-01			
10/13/80	1953	D2 37	5	0.129E+01	0.775E-01	INTAKE VS DISCHARGE	0.734E+00	0.503E+00
10/14/80	0533	I5 0	5	0.121E+01	0.780E-01			
10/14/80	0542	D1 0	5	0.135E+01	0.113E+00			
10/14/80	0528	D2 0	5	0.111E+01	0.104E+00	INTAKE VS DISCHARGE	0.145E+01	0.273E+00
10/14/80	1206	I5 0	5	0.990E+00	0.758E-01			
10/14/80	1207	D1 0	4	0.127E+01	0.320E-01			
10/14/80	1212	D2 0	4	0.940E+00	0.746E-01	INTAKE VS DISCHARGE	0.657E+01	0.161E-01

TABLE 24. 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
01/08/79	1930	I5 0	5	0.200E+00	0.967E-01			
01/08/79	1916	D1 0	5	0.116E+00	0.402E-01			
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+00			
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+00			
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+00			
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+00			
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+00			
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 0	5	0.256E+00	0.152E+00			
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+00			
03/05/79	2048	D1 0	5	0.439E+00	0.127E+00			
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+00			
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	0.108E+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

TABLE 24. 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
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	0.888E+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

TABLE 24. 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
08/07/79	0347	I5 0	3	0.694E-01	0.373E-01			
08/07/79	0335	D1 0	4	0.100E+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			
09/11/79	0520	D1 28	4	0.175E+00	0.116E+00			
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	0.240E+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	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	0.138E+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
11/12/79	1903	I5 0	5	0.535E+00	0.108E+00			
11/12/79	1903	D1 0	4	0.136E+00	0.785E-01	INTAKE VS DISCHARGE	0.804E+01	0.260E-01
11/12/79	1903	I5 38	5	0.704E-01	0.704E-01			
11/12/79	1903	D1 38	4	0.250E+00	0.709E-01	INTAKE VS DISCHARGE	0.313E+01	0.120E+00

TABLE 24. 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
11/13/79	0604	I5	0	5	0.780E-01	0.610E-01			
11/13/79	0603	D1	0	4	0.108E+00	0.440E-01	INTAKE VS DISCHARGE	0.146E+00	0.708E+00
11/13/79	1235	I5	0	5	0.994E-01	0.840E-01			
11/13/79	1226	D1	0	5	0.104E+00	0.104E+00	INTAKE VS DISCHARGE	0.982E-03	0.965E+00
12/10/79	1854	I5	0	5	0.200E-04	0.200E-04			
12/10/79	1905	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/11/79	0622	I5	0	5	0.200E-04	0.200E-04			
12/11/79	0626	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/11/79	1200	I5	0	5	0.200E-04	0.200E-04			
12/11/79	1200	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01

TABLE 25. MEAN PHAEOPHYTIN 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
01/21/80	1940	I5 0	5	0.423E+00	0.115E+00			
01/21/80	1922	D1 0	4	0.370E+00	0.643E-01			
01/21/80	2002	D2 0	5	0.210E+00	0.639E-01	INTAKE VS DISCHARGE	0.168E+01	0.232E+00
01/21/80	1940	I5 38	5	0.401E+00	0.102E+00			
01/21/80	1922	D1 40	5	0.856E-02	0.524E-02			
01/21/80	2002	D2 41	5	0.394E-01	0.265E-01	INTAKE VS DISCHARGE	0.128E+02	0.156E-02
01/22/80	0632	I5 0	5	0.480E-01	0.231E-01			
01/22/80	0620	D1 0	5	0.480E-01	0.400E-01			
01/22/80	0646	D2 0	5	0.876E-01	0.549E-01	INTAKE VS DISCHARGE	0.260E+00	0.768E+00
01/22/80	1202	I5 0	5	0.0	0.0			
01/22/80	1150	D1 0	5	0.183E+00	0.123E+00			
01/22/80	1215	D2 0	5	0.112E+00	0.690E-01	INTAKE VS DISCHARGE	0.120E+01	0.315E+00
02/04/80	2014	I5 0	5	0.125E+00	0.768E-01			
02/04/80	1959	D1 0	5	0.854E-02	0.854E-02			
02/04/80	1944	D2 0	5	0.0	0.0	INTAKE VS DISCHARGE	0.245E+01	0.129E+00
02/04/80	2014	I5 37	5	0.450E-01	0.287E-01			
02/04/80	1959	D1 37	5	0.544E-01	0.544E-01			
02/04/80	1944	D2 37	5	0.662E-01	0.662E-01	INTAKE VS DISCHARGE	0.385E-01	0.959E+00
02/05/80	0652	I5 0	5	0.267E-01	0.254E-01			
02/05/80	0639	D1 0	5	0.191E+00	0.774E-01			
02/05/80	0635	D2 0	5	0.217E+00	0.131E+00	INTAKE VS DISCHARGE	0.134E+01	0.300E+00
02/05/80	1239	I5 0	5	0.240E+00	0.150E+00			
02/05/80	1226	D1 0	5	0.740E-01	0.740E-01			
02/05/80	1210	D2 0	5	0.136E+00	0.114E+00	INTAKE VS DISCHARGE	0.482E+00	0.631E+00
03/10/80	2023	I5 0	5	0.865E-01	0.496E-01			
03/10/80	2022	D1 0	5	0.394E+00	0.157E+00			
03/10/80	2033	D2 0	5	0.284E+00	0.154E+00	INTAKE VS DISCHARGE	0.180E+01	0.208E+00
03/10/80	2023	I5 37	5	0.110E+00	0.706E-01			
03/10/80	2022	D1 37	5	0.104E+00	0.994E-01			
03/10/80	2033	D2 38	5	0.276E+00	0.810E-01	INTAKE VS DISCHARGE	0.135E+01	0.298E+00
03/11/80	0530	I5 0	5	0.139E+00	0.714E-01			
03/11/80	0519	D1 0	5	0.170E+00	0.118E+00			
03/11/80	0520	D2 0	5	0.336E+00	0.108E+00	INTAKE VS DISCHARGE	0.614E+00	0.560E+00

TABLE 25. 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
03/11/80	1204	I5	0	4	0.535E-02	0.535E-02			
03/11/80	1156	D1	0	5	0.534E-01	0.313E-01			
03/11/80	1157	D2	0	4	0.175E+00	0.175E+00	INTAKE VS DISCHARGE	0.796E+00	0.480E+00
04/07/80	2125	I5	0	5	0.750E+00	0.142E+00			
04/07/80	2107	D1	0	4	0.614E+00	0.111E+00			
04/07/80	2107	D2	0	4	0.665E+00	0.848E-01	INTAKE VS DISCHARGE	0.334E+00	0.724E+00
04/07/80	2123	I5	36	5	0.746E+00	0.243E+00			
04/07/80	2107	D1	36	5	0.104E+01	0.237E+00			
04/07/80	2117	D2	36	4	0.174E+01	0.114E+01	INTAKE VS DISCHARGE	0.701E+00	0.519E+00
04/08/80	0515	I5	0	5	0.947E+00	0.931E-01			
04/08/80	0510	D1	0	4	0.865E+00	0.128E+00			
04/08/80	0509	D2	0	5	0.805E+00	0.145E+00	INTAKE VS DISCHARGE	0.608E-01	0.936E+00
04/08/80	1212	I5	0	5	0.686E+00	0.105E+00			
04/08/80	1215	D1	0	5	0.562E+00	0.203E+00			
04/08/80	1205	D2	0	4	0.163E+01	0.186E+00	INTAKE VS DISCHARGE	0.109E+02	0.313E-02
05/12/80	2130	I5	0	5	0.885E+00	0.217E+00			
05/12/80	2120	D1	0	5	0.162E+01	0.102E+01			
05/12/80	2120	D2	0	5	0.104E+01	0.220E+00	INTAKE VS DISCHARGE	0.398E+00	0.682E+00
05/12/80	2130	I5	36	4	0.250E+06	0.250E+06			
05/12/80	2120	D1	36	5	0.200E+06	0.200E+06			
05/12/80	2120	D2	36	5	0.200E+06	0.200E+06	INTAKE VS DISCHARGE	0.167E-01	0.981E+00
05/13/80	0333	I5	0	5	0.200E+06	0.200E+06			
05/13/80	0328	D1	0	5	0.200E+06	0.200E+06			
05/13/80	0326	D2	0	5	0.200E+06	0.200E+06	INTAKE VS DISCHARGE	0.264E-11	0.999E+00
05/13/80	1200	I5	0	5	0.200E+06	0.200E+06			
05/13/80	1155	D1	0	5	0.200E+06	0.200E+06			
05/13/80	1153	D2	0	5	0.200E+06	0.200E+06	INTAKE VS DISCHARGE	0.244E-12	0.998E+00
06/09/80	2302	I5	0	5	0.208E+00	0.714E-01			
06/09/80	2302	D2	0	5	0.676E+00	0.234E+00	INTAKE VS DISCHARGE	0.366E+01	0.919E-01
06/09/80	2302	I5	36	5	0.445E+00	0.163E+00			
06/09/80	2302	D2	36	5	0.472E+00	0.235E+00	INTAKE VS DISCHARGE	0.879E-02	0.915E+00
06/10/80	0229	I5	0	5	0.504E+00	0.241E+00			
06/10/80	0229	D2	0	5	0.697E+00	0.204E+00	INTAKE VS DISCHARGE	0.370E+00	0.563E+00

TABLE 25. 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
06/10/80	1200	I5 0	5	0.583E+00	0.105E+00			
06/10/80	1200	D2 0	5	0.549E+00	0.219E+00	INTAKE VS DISCHARGE	0.203E-01	0.876E+00
07/14/80	2225	I5 0	5	0.640E-01	0.415E-01			
07/14/80	2230	D2 0	5	0.608E-01	0.436E-01	INTAKE VS DISCHARGE	0.279E-02	0.948E+00
07/14/80	2225	I5 38	5	0.400E-06	0.245E-06			
07/14/80	2230	D2 38	5	0.200E-06	0.200E-06	INTAKE VS DISCHARGE	0.400E+00	0.548E+00
07/15/80	0323	I5 0	5	0.640E-02	0.640E-02			
07/15/80	0314	D2 0	5	0.866E-01	0.866E-01	INTAKE VS DISCHARGE	0.853E+00	0.385E+00
07/15/80	1212	I5 0	4	0.0	0.0			
07/15/80	1204	D2 0	5	0.121E+00	0.744E-01	INTAKE VS DISCHARGE	0.204E+01	0.196E+00
08/11/80	2205	I5 0	5	0.502E-01	0.255E-01			
08/11/80	2153	D1 0	5	0.133E+00	0.819E-01			
08/11/80	2156	D2 0	4	0.827E-01	0.486E-01	INTAKE VS DISCHARGE	0.550E+00	0.595E+00
08/11/80	2205	I5 35	5	0.0	0.0			
08/11/80	2153	D1 35	5	0.278E-01	0.278E-01			
08/11/80	2156	D2 35	5	0.135E+00	0.898E-01	INTAKE VS DISCHARGE	0.172E+01	0.222E+00
08/12/80	0428	I5 0	5	0.354E+00	0.153E+00			
08/12/80	0416	D1 0	5	0.347E+00	0.111E+00			
08/12/80	0421	D2 0	4	0.281E+00	0.133E+00	INTAKE VS DISCHARGE	0.808E-01	0.918E+00
08/12/80	1122	I5 0	5	0.350E+00	0.129E+00			
08/12/80	1126	D1 0	5	0.238E+00	0.839E-01			
08/12/80	1104	D2 0	5	0.940E-01	0.544E-01	INTAKE VS DISCHARGE	0.186E+01	0.198E+00
09/08/80	2109	I5 0	5	0.240E+00	0.812E-01			
09/08/80	2054	D1 0	4	0.516E+00	0.235E+00			
09/08/80	2050	D2 0	5	0.617E+00	0.207E+00	INTAKE VS DISCHARGE	0.126E+01	0.324E+00
09/08/80	2109	I5 38	5	0.616E+00	0.230E+00			
09/08/80	2054	D1 38	5	0.123E+00	0.701E-01			
09/08/80	2050	D2 38	5	0.239E+00	0.196E+00	INTAKE VS DISCHARGE	0.204E+01	0.174E+00
09/09/80	0459	I5 0	5	0.144E+00	0.109E+00			
09/09/80	0455	D1 0	5	0.576E-01	0.576E-01			
09/90/80	0456	D2 0	5	0.760E-01	0.470E-01	INTAKE VS DISCHARGE	0.358E+00	0.707E+00

TABLE 25. 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
09/09/80	1217	I5 0	5	0.273E+00	0.101E+00			
09/09/80	1205	D1 0	5	0.555E+00	0.124E+00			
09/09/80	1257	D2 0	5	0.598E-01	0.598E-01	INTAKE VS DISCHARGE	0.633E+01	0.142E-01
10/13/80	1943	I5 0	5	0.325E+00	0.207E+00			
10/13/80	1949	D1 0	5	0.191E+00	0.629E-01			
10/13/80	1953	D2 0	5	0.283E+00	0.655E-01	INTAKE VS DISCHARGE	0.155E+00	0.854E+00
10/13/80	1943	I5 37	5	0.267E+00	0.246E+00			
10/13/80	1949	D1 37	5	0.748E-01	0.748E-01			
10/13/80	1953	D2 37	5	0.312E+00	0.151E+00	INTAKE VS DISCHARGE	0.534E+00	0.602E+00
10/14/80	0533	I5 0	5	0.120E+00	0.873E-01			
10/14/80	0542	D1 0	5	0.313E+00	0.193E+00			
10/14/80	0528	D2 0	5	0.773E+00	0.171E+00	INTAKE VS DISCHARGE	0.456E+01	0.347E-01
10/14/80	1206	I5 0	5	0.225E+00	0.577E-01			
10/14/80	1207	D1 0	4	0.121E+00	0.108E+00			
10/14/80	1212	D2 0	4	0.260E+00	0.893E-01	INTAKE VS DISCHARGE	0.702E+00	0.521E+00

TABLE 26. 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
01/08/79	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	1948	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

TABLE 26. 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
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 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
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			
09/11/79	0520	D1	28	4	0.717E-01	0.493E-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			
09/11/70	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	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
11/12/79	1903	I5	0	5	0.137E+00	0.303E-01			
11/12/79	1903	D1	0	4	0.315E-01	0.182E-01	INTAKE VS DISCHARGE	0.777E+01	0.278E-01
11/12/79	1903	I5	38	5	0.159E-01	0.159E-01			
11/12/79	1903	D1	38	4	0.594E-01	0.172E-01	INTAKE VS DISCHARGE	0.342E+01	0.107E+00

TABLE 26. 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=MTB1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.		SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/79	0604	I5	0	5	0.189E-01	0.150E-01			
11/13/79	0603	D1	0	4	0.268E-01	0.107E-01	INTAKE VS DISCHARGE	0.166E+00	0.692E+00
11/13/79	1235	I5	0	5	0.237E-01	0.202E-01			
11/13/79	1226	D1	0	5	0.258E-01	0.258E-01	INTAKE VS DISCHARGE	0.429E-02	0.938E+00
12/10/79	1854	I5	0	5	0.200E-04	0.200E-04			
12/10/79	1905	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/11/79	0622	I5	0	5	0.200E-04	0.200E-04			
12/11/79	0626	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/11/79	1200	I5	0	5	0.200E-04	0.200E-04			
12/11/79	1200	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01

TABLE 27. 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
01/21/80	1940	I5 0	5	0.904E-01	0.249E-01			
01/21/80	1922	D1 0	4	0.764E-01	0.142E-01			
01/21/80	2002	D2 0	5	0.430E-01	0.135E-01	INTAKE VS DISCHARGE	0.176E+01	0.218E+00
01/21/80	1940	I5 38	5	0.781E-01	0.210E-01			
01/21/80	1922	D1 40	5	0.168E-02	0.103E-02			
01/21/80	2002	D2 41	5	0.710E-02	0.473E-02	INTAKE VS DISCHARGE	0.109E+02	0.263E-02
01/22/80	0632	I5 0	5	0.955E-02	0.466E-02			
01/22/80	0620	D1 0	5	0.100E-01	0.100E-01			
01/22/80	0646	D2 0	5	0.171E-01	0.107E-01	INTAKE VS DISCHARGE	0.226E+00	0.798E+00
01/22/80	1202	I5 0	5	0.0	0.0			
01/22/80	1150	D1 0	5	0.396E-01	0.269E-01			
01/22/80	1215	D2 0	5	0.240E-01	0.149E-01	INTAKE VS DISCHARGE	0.126E+01	0.319E+00
02/04/80	2014	I5 0	5	0.434E-01	0.267E-01			
02/04/80	1959	D1 0	5	0.276E-02	0.276E-02			
02/04/80	1944	D2 0	5	0.0	0.0	INTAKE VS DISCHARGE	0.247E+01	0.128E+00
02/04/80	2014	I5 37	5	0.134E-01	0.841E-02			
02/04/80	1959	D1 37	5	0.170E-01	0.170E-01			
02/04/80	1944	D2 37	5	0.204E-01	0.204E-01	INTAKE VS DISCHARGE	0.468E-01	0.950E+00
02/05/80	0652	I5 0	5	0.805E-02	0.767E-02			
02/05/80	0639	D1 0	5	0.564E-01	0.226E-01			
02/05/80	0635	D2 0	5	0.688E-01	0.426E-01	INTAKE VS DISCHARGE	0.130E+01	0.310E+00
02/05/80	1239	I5 0	5	0.714E-01	0.488E-01			
02/05/80	1226	D1 0	5	0.222E-01	0.222E-01			
02/05/80	1210	D2 0	5	0.421E-01	0.363E-01	INTAKE VS DISCHARGE	0.438E+00	0.657E+00
03/10/80	2023	I5 0	5	0.249E-01	0.144E-01			
03/10/80	2022	D1 0	5	0.129E+00	0.532E-01			
03/10/80	2033	D2 0	5	0.131E+00	0.555E-01	INTAKE VS DISCHARGE	0.180E+01	0.208E+00
03/10/80	2023	I5 37	5	0.319E-01	0.204E-01			
03/10/80	2022	D1 37	5	0.264E-01	0.249E-01			
03/10/80	2033	D2 38	5	0.804E-01	0.236E-01	INTAKE VS DISCHARGE	0.166E+01	0.232E+00
03/11/80	0530	I5 0	5	0.414E-01	0.216E-01			
03/11/80	0519	D1 0	5	0.535E-01	0.369E-01			
03/11/80	0520	D2 0	5	0.121E+00	0.722E-01	INTAKE VS DISCHARGE	0.780E+00	0.483E+00

TABLE 27. 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
03/11/80	1204	I5	0	4	0.176E-02	0.175E-02			
03/11/80	1156	D1	0	5	0.172E-01	0.103E-01			
03/11/80	1157	D2	0	4	0.378E-01	0.378E-01	INTAKE VS DISCHARGE	0.678E+00	0.532E+00
04/07/80	2125	I5	0	5	0.162E+00	0.330E-01			
04/07/80	2107	D1	0	4	0.138E+00	0.276E-01			
04/07/80	2107	D2	0	4	0.142E+00	0.237E-01	INTAKE VS DISCHARGE	0.202E+00	0.817E+00
04/07/80	2123	I5	36	5	0.255E+00	0.963E-01			
04/07/80	2107	D1	36	5	0.255E+00	0.767E-01			
04/07/80	2117	D2	36	4	0.186E+01	0.160E+01	INTAKE VS DISCHARGE	0.116E+01	0.352E+00
04/08/80	0515	I5	0	5	0.178E+00	0.195E-01			
04/08/80	0510	D1	0	4	0.184E+00	0.207E-01			
04/08/80	0509	D2	0	5	0.181E+00	0.375E-01	INTAKE VS DISCHARGE	0.920E-02	0.989E+00
04/08/80	1212	I5	0	5	0.132E+00	0.225E-01			
04/08/80	1215	D1	0	5	0.122E+00	0.440E-01			
04/08/80	1205	D2	0	4	0.394E+00	0.581E-01	INTAKE VS DISCHARGE	0.125E+02	0.205E-02
05/12/80	2130	I5	0	5	0.566E-01	0.141E-01			
05/12/80	2120	D1	0	5	0.125E+00	0.830E-01			
05/12/80	2120	D2	0	5	0.673E-01	0.150E-01	INTAKE VS DISCHARGE	0.550E+00	0.593E+00
05/12/80	2130	I5	36	4	0.226E+00	0.191E+00			
05/12/80	2120	D1	36	5	0.161E-01	0.997E-02			
05/12/80	2120	D2	36	5	0.924E-02	0.749E-02	INTAKE VS DISCHARGE	0.161E+01	0.244E+00
05/13/80	0333	I5	0	5	0.448E-01	0.275E-01			
05/13/80	0320	D1	0	5	0.223E-01	0.182E-01			
05/13/80	0326	D2	0	5	0.156E+00	0.981E-01	INTAKE VS DISCHARGE	0.144E+01	0.276E+00
05/13/80	1200	I5	0	5	0.200E+06	0.200E+06			
05/13/80	1155	D1	0	5	0.145E+00	0.519E-01			
05/13/80	1153	D2	0	5	0.200E+06	0.200E+06	INTAKE VS DISCHARGE	0.500E+00	0.621E+00
06/09/80	2302	I5	0	5	0.109E-01	0.660E-02			
06/09/80	2302	D2	0	5	0.643E-01	0.237E-01	INTAKE VS DISCHARGE	0.339E+01	0.103E+00
06/09/80	2302	I5	36	5	0.411E-01	0.153E-01			
06/09/80	2302	D2	36	5	0.408E-01	0.204E-01	INTAKE VS DISCHARGE	0.120E-03	0.979E+00
06/10/80	0229	I5	0	5	0.529E-01	0.261E-01			
06/10/80	0229	D2	0	5	0.318E-01	0.255E-01	INTAKE VS DISCHARGE	0.626E+00	0.456E+00

TABLE 27. 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
06/10/80	1200	I5	0	5	0.552E-01	0.988E-02			
06/10/80	1200	D2	0	5	0.545E-01	0.215E-01	INTAKE VS DISCHARGE	0.927E-03	0.965E+00
07/14/80	2225	I5	0	5	0.304E-01	0.194E-01			
07/14/80	2230	D2	0	5	0.321E-01	0.233E-01	INTAKE VS DISCHARGE	0.300E-02	0.947E+00
07/14/80	2225	I5	38	5	0.400E-03	0.245E-03			
07/14/80	2230	D2	38	5	0.200E-03	0.200E-03	INTAKE VS DISCHARGE	0.400E+00	0.548E+00
07/15/80	0323	I5	0	5	0.300E-02	0.300E-02			
07/15/80	0314	D2	0	5	0.452E-01	0.450E-01	INTAKE VS DISCHARGE	0.877E+00	0.379E+00
07/15/80	1212	I5	0	4	0.0	0.0			
07/15/80	1204	D2	0	5	0.572E-01	0.352E-01	INTAKE VS DISCHARGE	0.205E+01	0.195E+00
08/11/80	2205	I5	0	5	0.237E-01	0.125E-01			
08/11/80	2153	D1	0	5	0.736E-01	0.452E-01			
08/11/80	2156	D2	0	4	0.455E-01	0.265E-01	INTAKE VS DISCHARGE	0.657E+00	0.540E+00
08/11/80	2205	I5	35	5	0.0	0.0			
08/11/80	2153	D1	35	5	0.168E-01	0.168E-01			
08/11/80	2156	D2	35	5	0.900E-01	0.600E-01	INTAKE VS DISCHARGE	0.177E+01	0.213E+00
08/12/80	0428	I5	0	5	0.659E-01	0.306E-01			
08/12/80	0416	D1	0	5	0.647E-01	0.221E-01			
08/12/80	0421	D2	0	4	0.604E-01	0.282E-01	INTAKE VS DISCHARGE	0.107E-01	0.988E+00
08/12/80	1122	I5	0	5	0.670E-01	0.247E-01			
08/12/80	1126	D1	0	5	0.451E-01	0.161E-01			
08/12/80	1104	D2	0	5	0.207E-01	0.120E-01	INTAKE VS DISCHARGE	0.159E+01	0.245E+00
09/08/80	2109	I5	0	5	0.275E-01	0.911E-02			
09/08/80	2054	D1	0	4	0.560E-01	0.253E-01			
09/08/80	2050	D2	0	5	0.745E-01	0.256E-01	INTAKE VS DISCHARGE	0.137E+01	0.295E+00
09/08/80	2109	I5	38	5	0.788E-01	0.317E-01			
09/08/80	2054	D1	38	5	0.145E-01	0.905E-02			
09/08/80	2050	D2	38	5	0.301E-01	0.249E-01	INTAKE VS DISCHARGE	0.197E+01	0.183E+00
09/09/80	0459	I5	0	5	0.213E-01	0.161E-01			
09/09/80	0455	D1	0	5	0.658E-02	0.658E-02			
09/90/80	0456	D2	0	5	0.107E-01	0.654E-02	INTAKE VS DISCHARGE	0.498E+00	0.622E+00

TABLE 27. 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
09/09/80	1217	I5 0	5	0.462E-01	0.174E-01			
09/09/80	1205	D1 0	5	0.961E-01	0.221E-01			
09/09/80	1257	D2 0	5	0.100E-01	0.100E-01	INTAKE VS DISCHARGE	0.629E+01	0.145E-01
10/13/80	1943	I5 0	5	0.322E-01	0.280E-01			
10/13/80	1949	D1 0	5	0.176E-01	0.577E-02			
10/13/80	1953	D2 0	5	0.270E-01	0.624E-02	INTAKE VS DISCHARGE	0.184E+00	0.830E+00
10/13/80	1943	I5 37	5	0.247E-01	0.226E-01			
10/13/80	1949	D1 37	5	0.740E-02	0.740E-02			
10/13/80	1953	D2 37	5	0.317E-01	0.154E-01	INTAKE VS DISCHARGE	0.584E+00	0.575E+00
10/14/80	0533	I5 0	5	0.121E-01	0.896E-02			
10/14/80	0542	D1 0	5	0.305E-01	0.192E-01			
10/14/80	0520	D2 0	5	0.792E-01	0.178E-01	INTAKE VS DISCHARGE	0.471E+01	0.320E-01
10/14/80	1206	I5 0	5	0.260E-01	0.690E-02			
10/14/80	1207	D1 0	4	0.149E-01	0.133E-01			
10/14/80	1212	D2 0	4	0.314E-01	0.109E-01	INTAKE VS DISCHARGE	0.649E+00	0.545E+00

APPENDIX B-3

BENTHOS COLLECTED AT THE DONALD C. COOK NUCLEAR PLANT

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 area acting as a reference. The depths encompassed are Zone 0 (0-8 m), 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 Ponar 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.

This report contains April, July, and October of 1980 data and comparisons of these data with those of the 1971-1979 surveys. A summary of the 1980 data is presented in Table 1-3, and Inner and Outer comparisons of the major

taxa from 1971-1980 are shown in Figures 1-19. Six 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 1-18. All means are transformed by the equation

$$y=\log10(x)$$

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

$$y=\log10(x+1)$$

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 1980. The pre-operational ratios for each season, 1971-1974, are compared with operational year ratios, 1975-1980. 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 1971-1980 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).

Pre-operational and operational Inner/Outer ratios for Pontoporeia hoyi occurring 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 in October Zone 2. Following the first operational year (1975), the mean October densities in the Outer region generally have increased by 118% while densities in the Inner region have decreased by 23% (Figure 3). The differences have resulted in a slowly decreasing Inner/Outer ratio (Figure 19). In all the pre-operational years averaged for October, Inner densities were 3202 m^{-2} and Outer 3982 m^{-2}. For all operational years in October, Inner densities averaged 2471 m^{-2} and Outer 4684 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.

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 one sample be collected from the intake and discharge during each of three consecutive 8-hr 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 is designed to determine 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 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 future comparisons with similar studies and other sources of data.

Included in this report are the entrainment data for November through December 1979 and January through October 1980. November and December 1980 will be included in the

next operating report. Because the plant was not operational during the first week of July, only three of four 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 P. hoyi entrained during this reporting period were slightly greater than those reported during previous years. Seasonally, numbers are consistently greatest in December and January during the lake-wide inshore reproductive migrations. Similar to 1979, the number of P. hoyi entrained during June and July 1980 was higher compared with previous years, including 1979. Densities entrained during most other 1980 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 P. hoyi populations in the immediate vicinity of the plant.

Entrainment of Mysis relicta in 1980 was greatest early in the year and again in late summer to early autumn. This pattern more closely approximated the 1978 M. relicta entrainment data than any other year. Greatest observed density of M. relicta in 1980 samples was 0.414 m^{-3} (Table 11). It is not possible to assess the effects of entrainment of M. relicta 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 through October 1980 *M. relicta* entrainment data, there appeared to be no uniquely different trends when compared with previous years.

Entrainment of *Gammarus* (Table 12) in 1980 followed a pattern similar to that of all previous years in that the majority of entrained individuals occurred in late summer through early winter (August through December). Entrainment of *Asellus* always is sporadic but has been nonetheless consistently less frequent from 1978-1980 when compared with 1975-1977. 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 hoyi*, *Mysis relicta*, *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.

IMPINGEMENT STUDIES

Although impingement studies of benthic macroinvertebrates are not required by Technical

Specifications, we have been maintaining records of the species, numbers, and weights of crayfish (Astacidae) collected on travelling screens at the Cook Plant. By virtue of their small size, other benthic macroinvertebrates 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.

October, November, and December 1979 data were not available for the last report but have been included here (Table 14). Data for January through October 1980 are presented in Table 15. All specimens recovered in 1978, 1979 and 1980 were *Orconectes propinquus*, with the exception of a single *Cambarus diogenes*. 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 February 15-28, May 17-31, and all of the months June, November, and December 1979, it is assumed that no crayfish were impinged during those periods. Similarly, when the 1980 crayfish data are completed in early 1981 with the inclusion of November and December data, any periods left blank in this report (Table 15) will assume the value of zero.

Inclusion of the October, November, and December data for 1979 brings that year's impingement totals to 2487 specimens and 16.71 kg (Table 14). This is less than the 4210 specimens and 28.30 kg projected for 1979 given in the last report. Crayfish impinged in 1980 have been processed through October (Table 15). The only month during 1980 in which no crayfish were impinged was January. The projected total for impinged crayfish in 1980 is 8376 individuals and 56.62 kg.

Through the first five years that the plant has been operational, there has been a general decrease in numbers and total mass of impinged crayfish: 1975 = 90 kg, 1976 = 92 kg, 1977 = 70 kg, 1978 = 33 kg, and 1979 = 17 kg. The average weights per crayfish impinged in 1975-1979 were 6.0,

5.8, 6.5, 5.5, and 6.7 g, respectively. However, in 1980, the average projected weight per specimen attained the highest average weight observed at 6.8 g and projected total weight impinged increased to 57 kg. 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

One *t*-test had a probability less than 0.05: *Pontoporeia hoyi* in the October survey of Zone 2. Observed trends indicated that October Outer Zone 2 means for *P. hoyi* always were greater than Inner Zone 2 means. However, this trend appears to be becoming more extreme. Results are likely 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.

Entrainment studies

In 1980, entrainment of *Pontoporeia hoyi* was slightly greater than that recorded during previous years. Although

density was less, seasonal entrainment pattern of Mysis relicta was most similar to that observed during 1978. Gammarus density in 1980 was similar to that of 1979, but less than the peak year of 1977. Asellus occurred much less frequently and abundantly in 1978-1980 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 adequately sample their lake populations.

Impingement studies

Projected impingement of the crayfish Orconectes propinquus for 1980 increased when compared to 1978 and 1979 but was lower than that observed prior to 1978. In addition, the average weight per individual was the greatest observed over the years 1975-1979. 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.

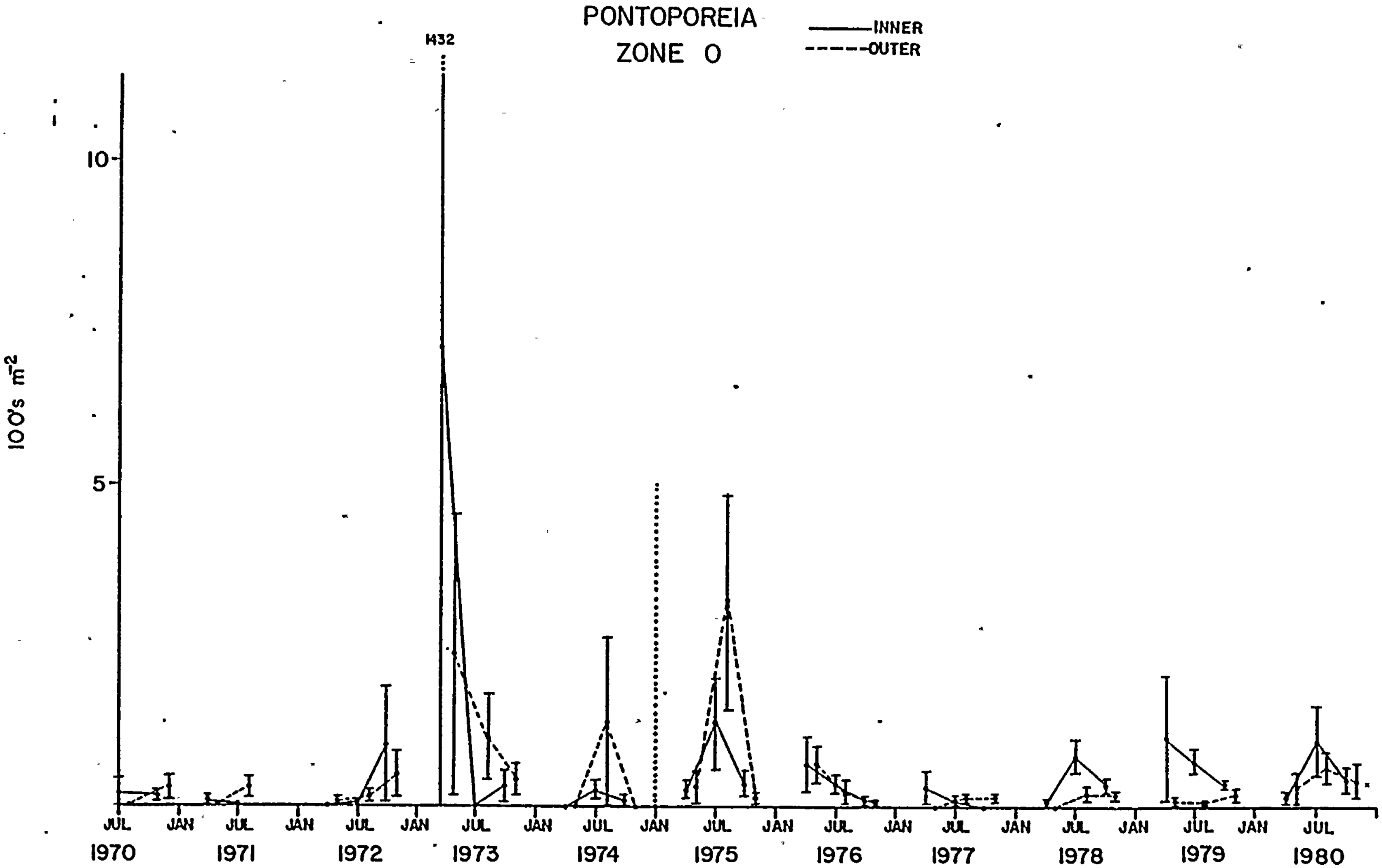

FIGURE 1. Density (animals m^{-2}) of Pontoporeia hoyi in the Inner and Outer regions of Zone (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

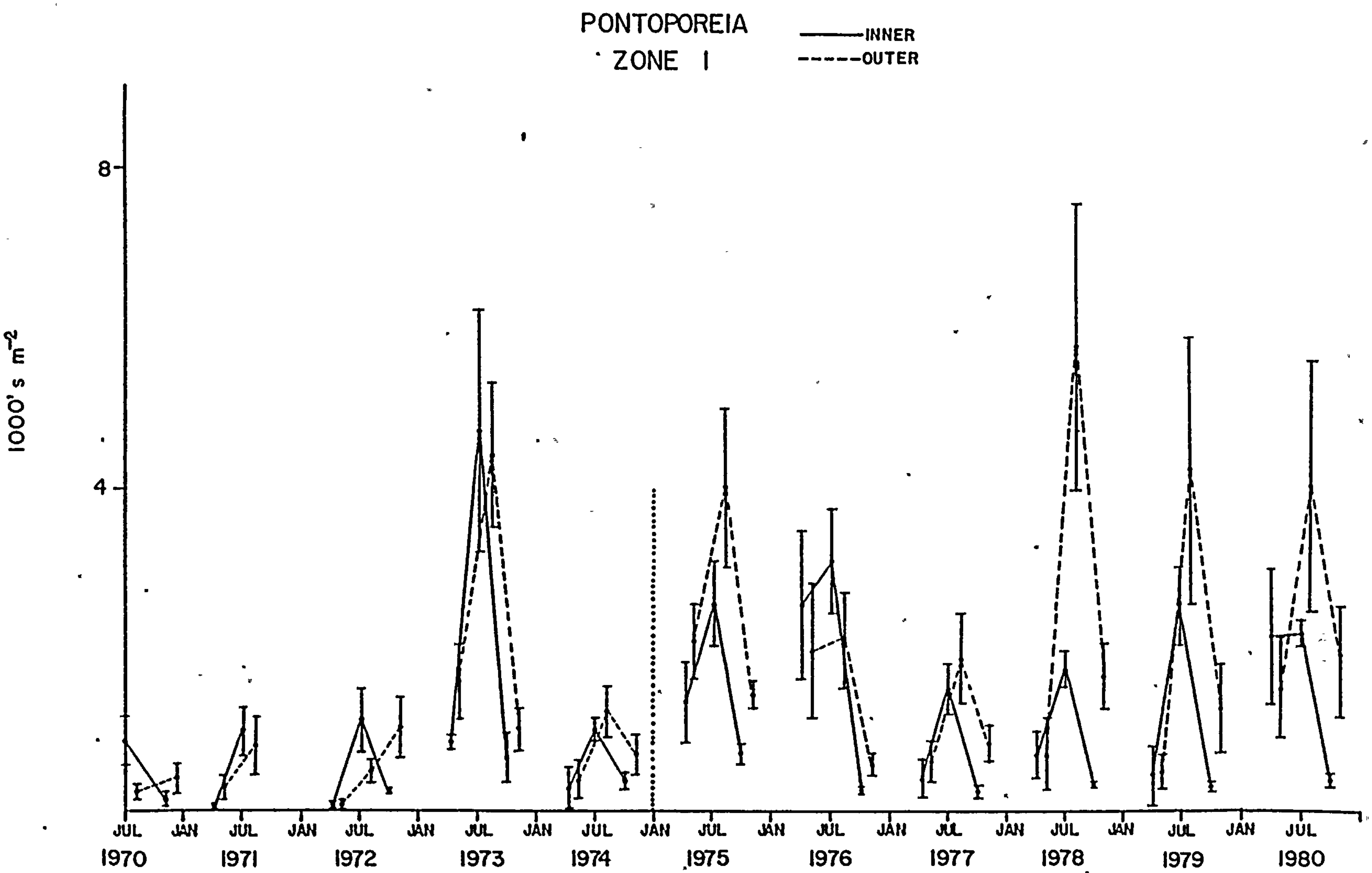

FIGURE 2. Density (animals m^{-2}) of Pontoporeia hoyi in the Inner and Outer regions of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

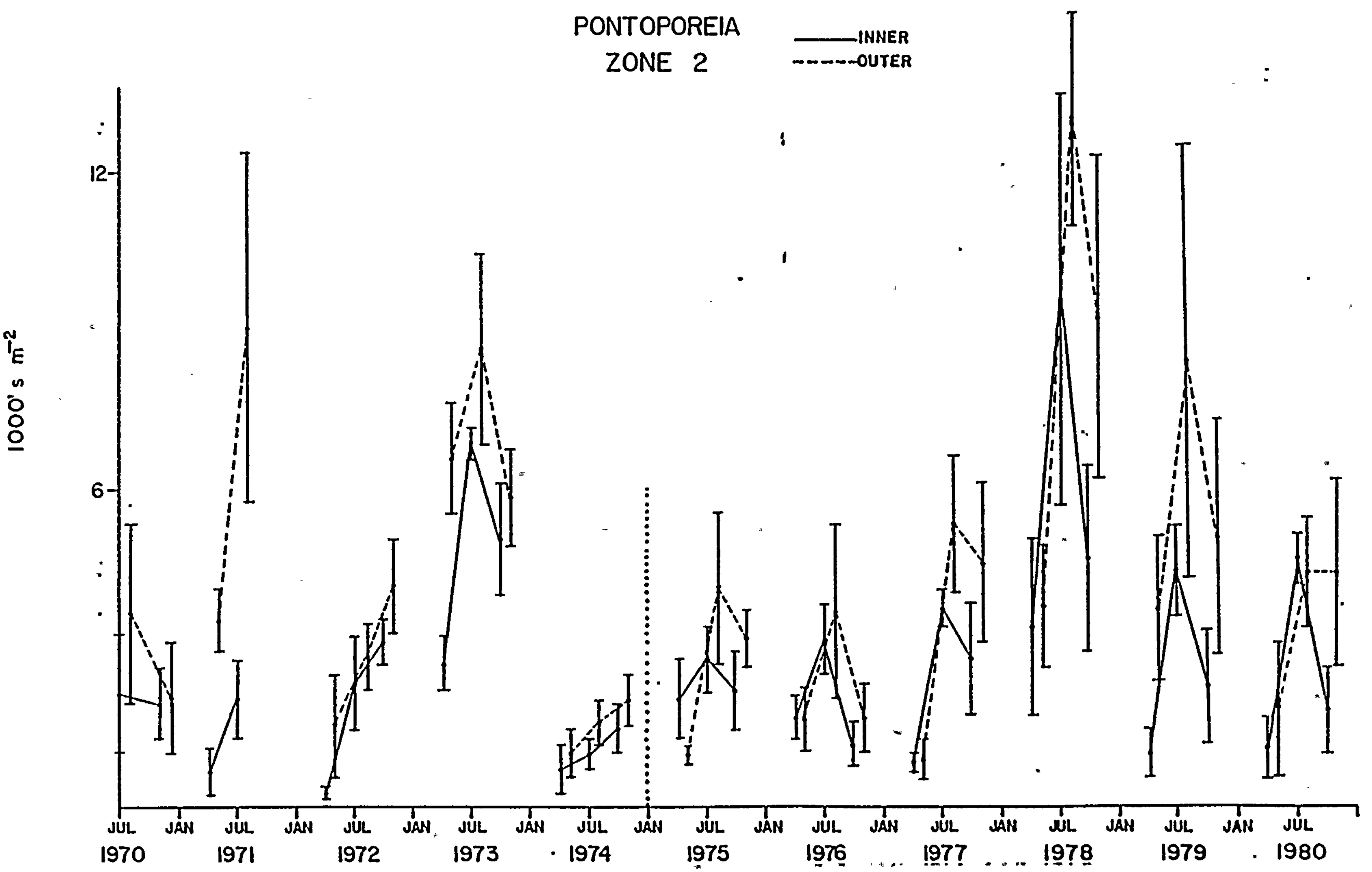

FIGURE 3. Density (animals m^{-2}) of Pontoporeia hoyi in the Inner and Outer regions of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

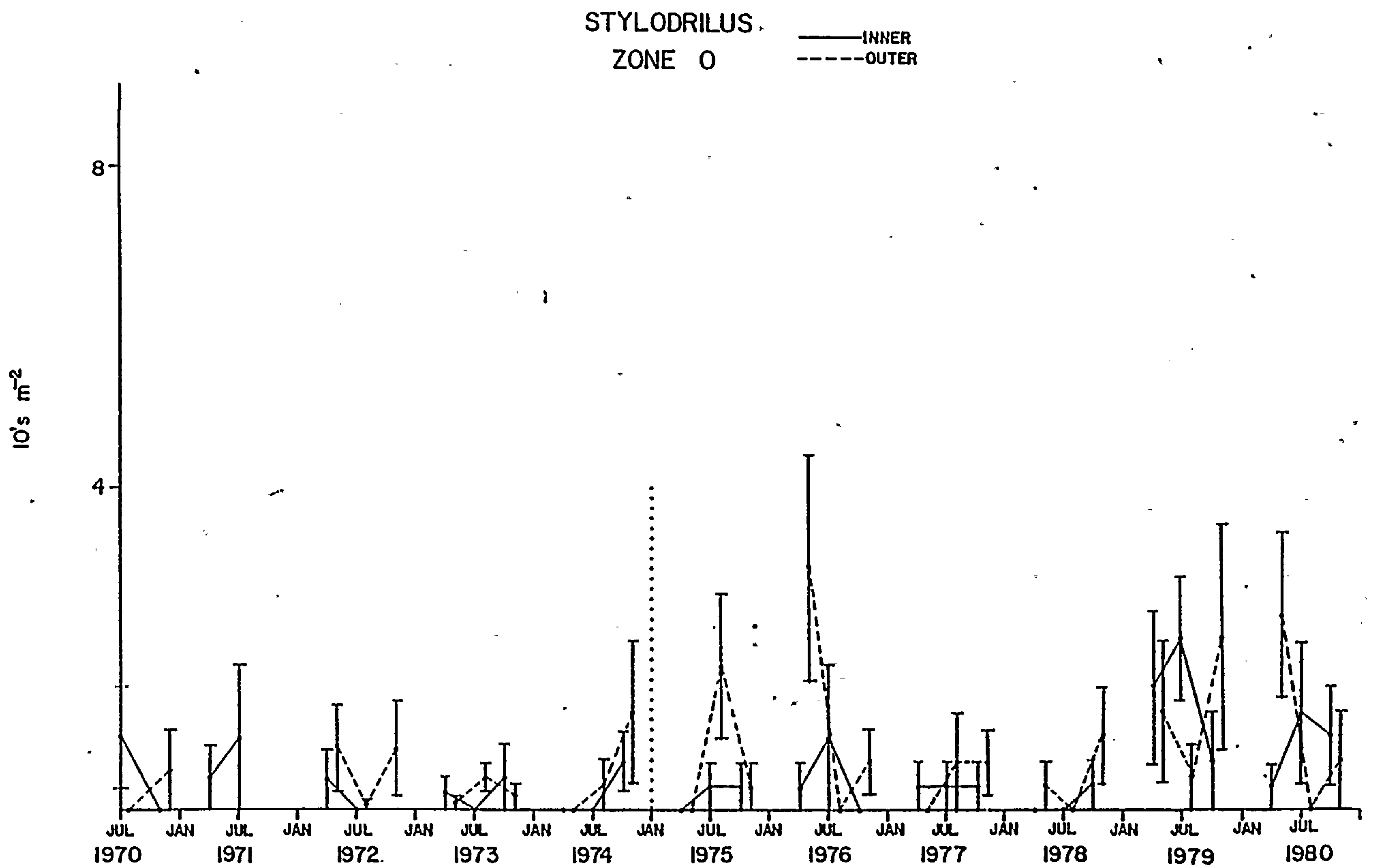

FIGURE 4. Density (animals m^{-2}) of Stylodrilus heringianus in the Inner and Outer regions of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

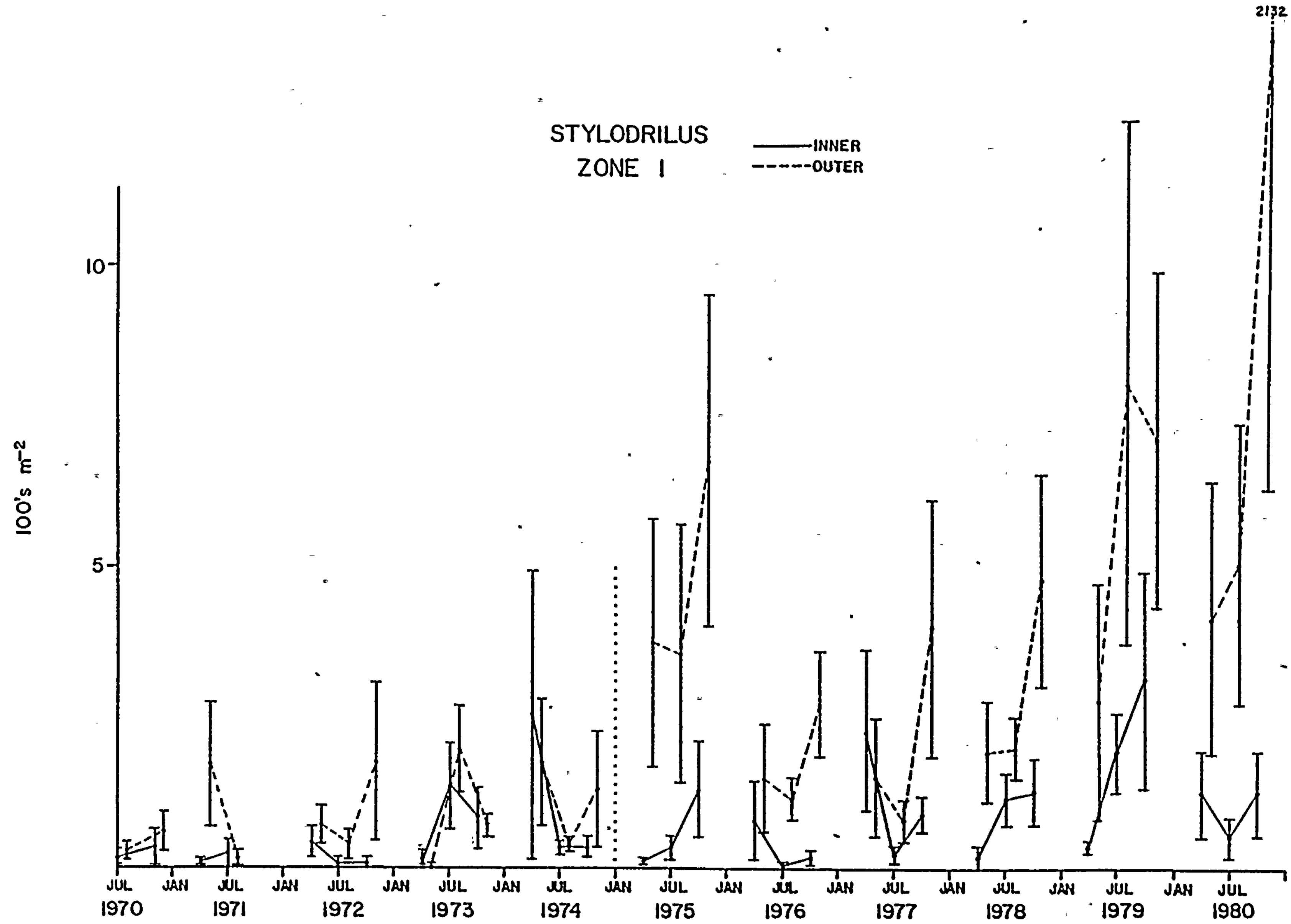

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FIGURE 5. Density (animals m^{-2}) of Stylodrilus heringianus in the Inner and Outer regions of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

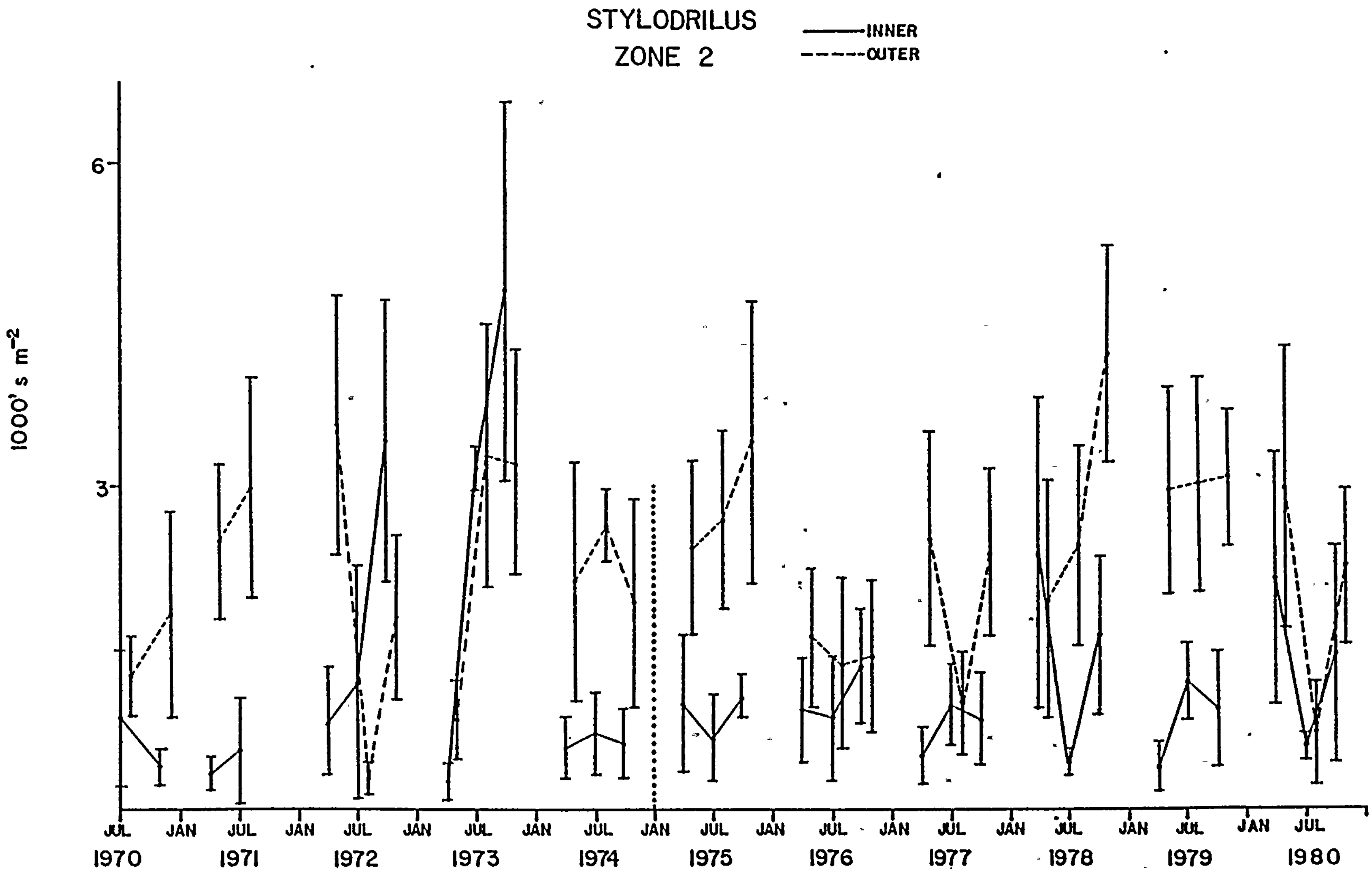

FIGURE 6. Density (animals m^{-2}) of Stylodrilus heringianus in the Inner and Outer regions of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

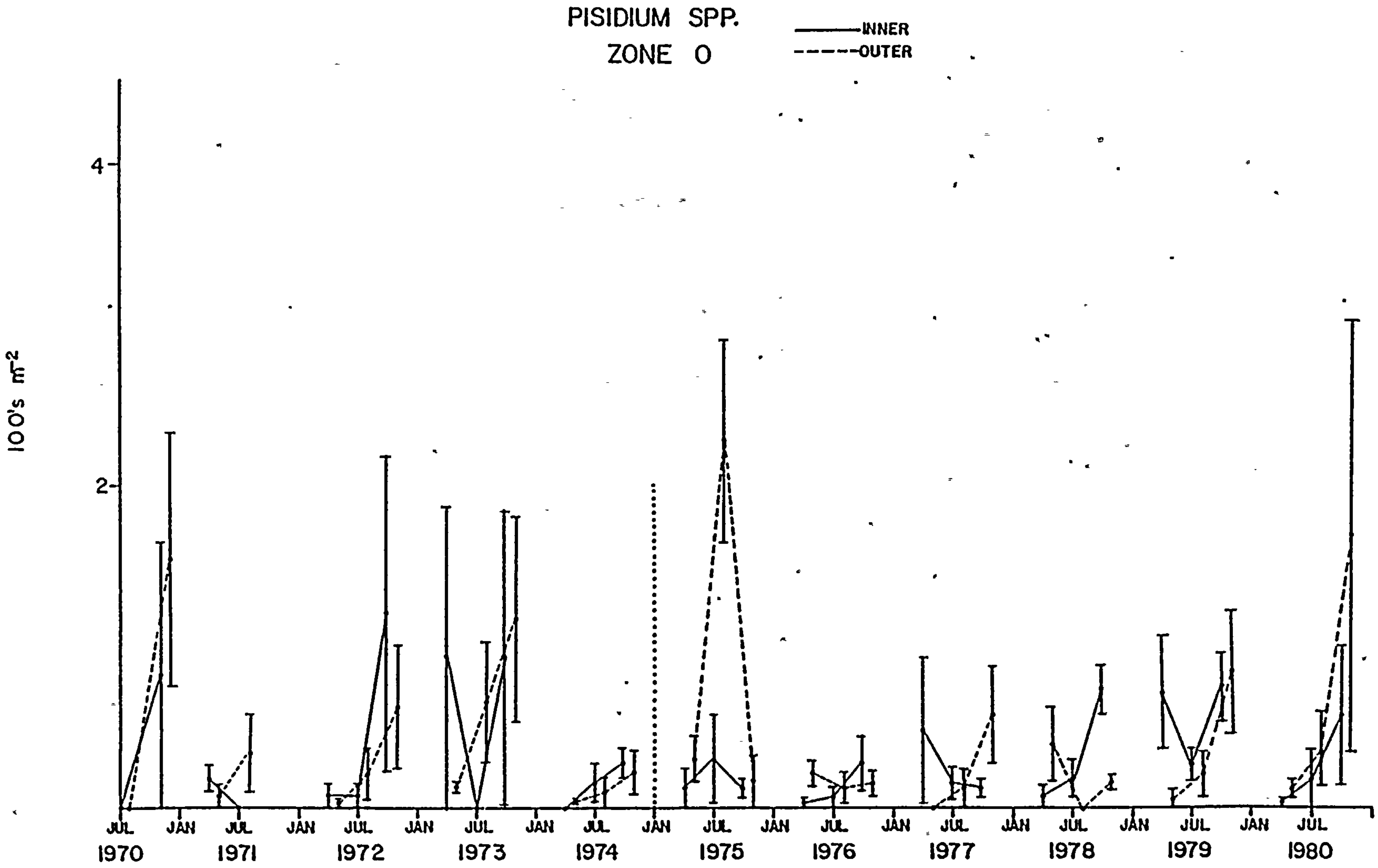

FIGURE 7. Density (animals m^{-2}) of Pisidium spp. in the Inner and Outer regions of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

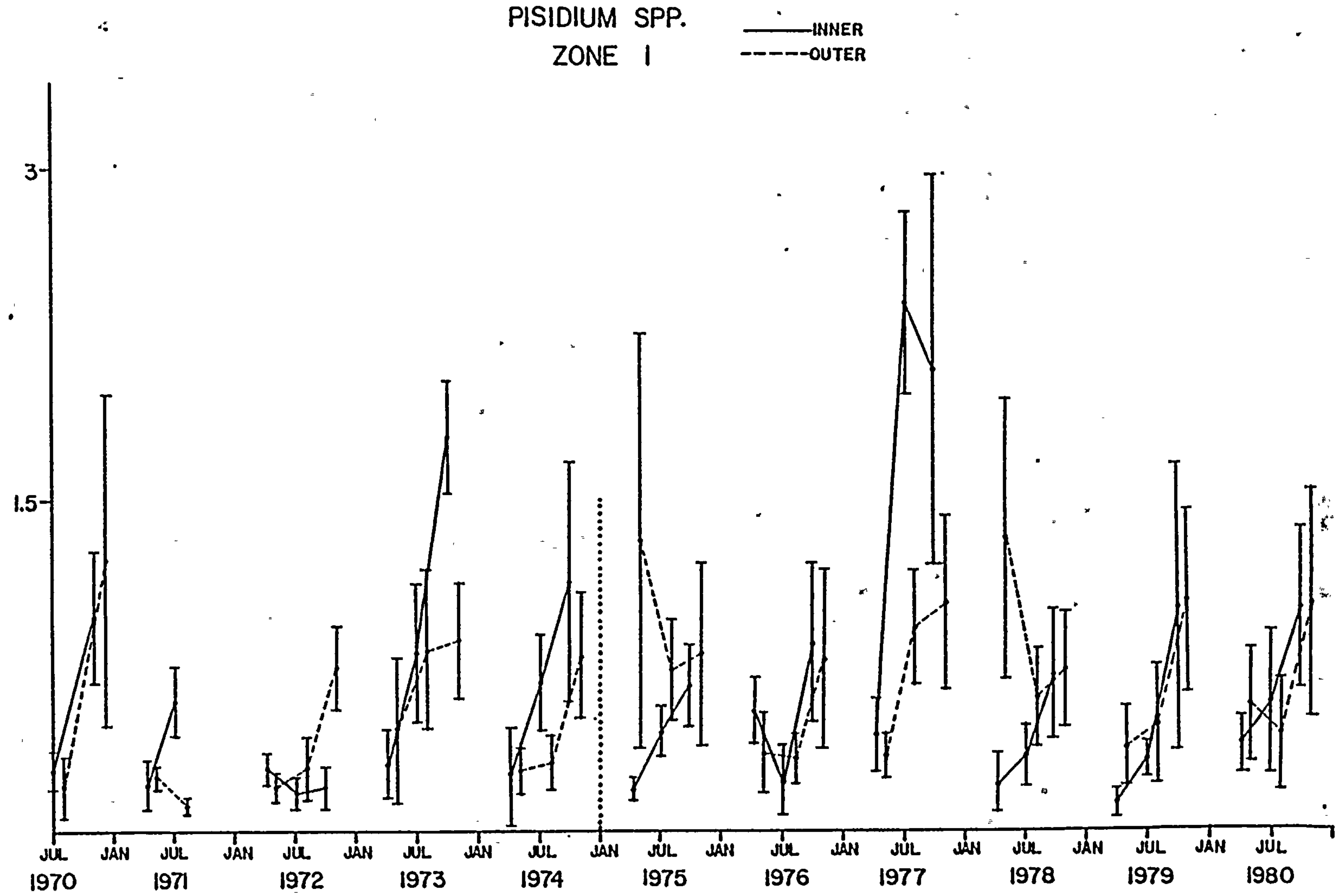

FIGURE 8. Density (animals m^{-2}) of Pisidium spp. in the Inner and Outer regions of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

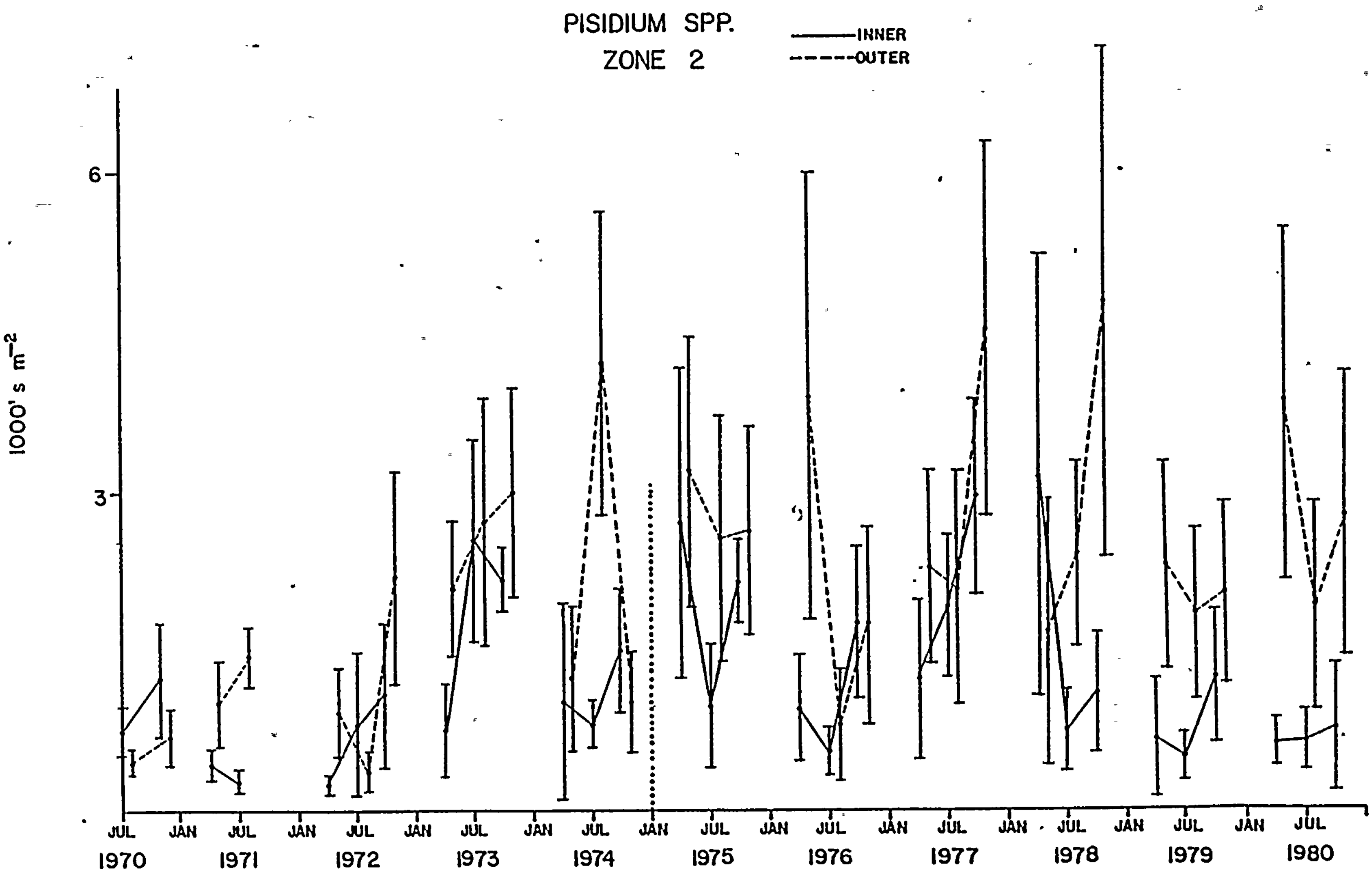

FIGURE 9. Density (animals m^{-2}) of Pisidium spp. in the Inner and Outer regions of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

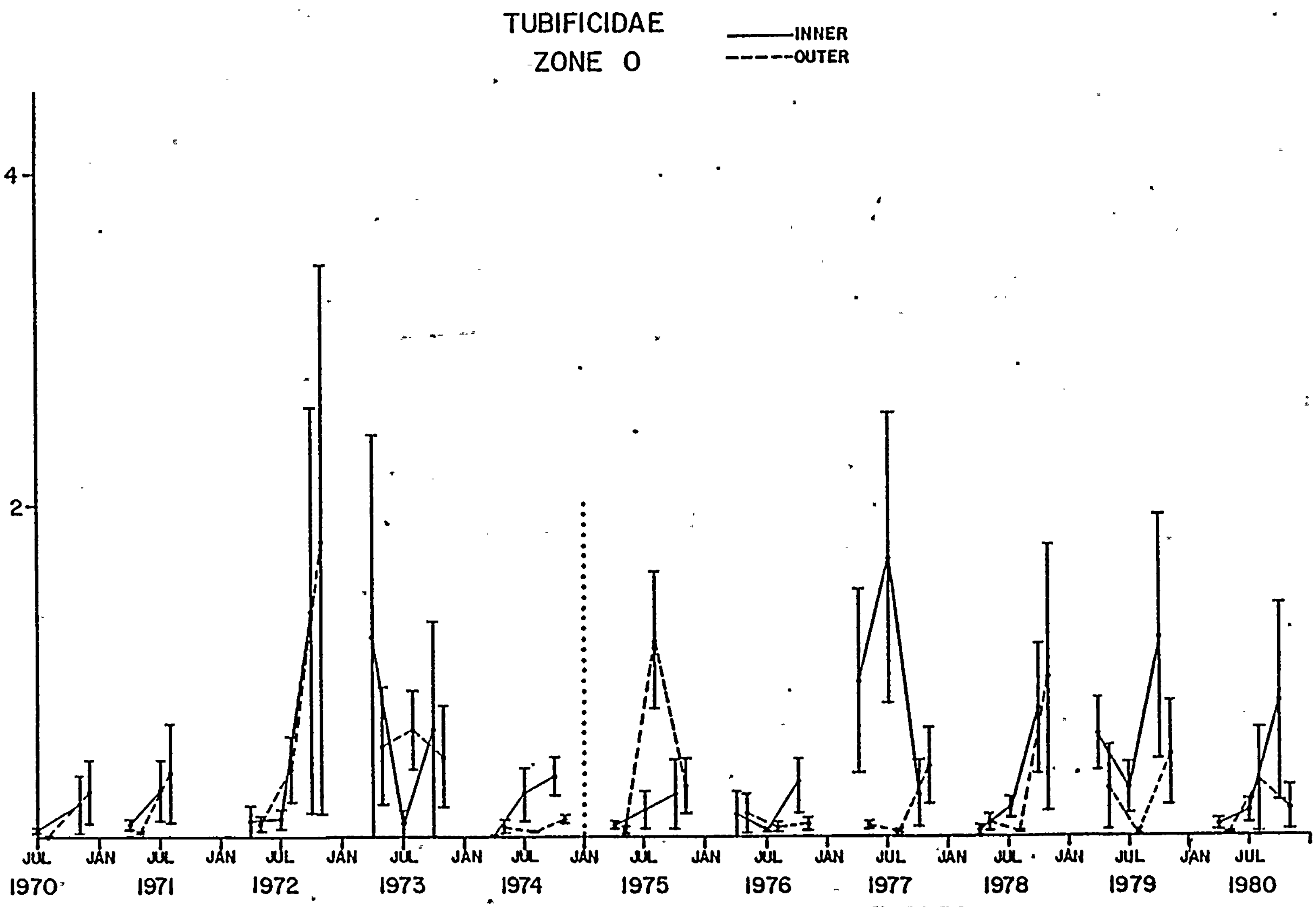

FIGURE 10. Density (animals m^{-2}) of Tubificidae in the Inner and Outer regions of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

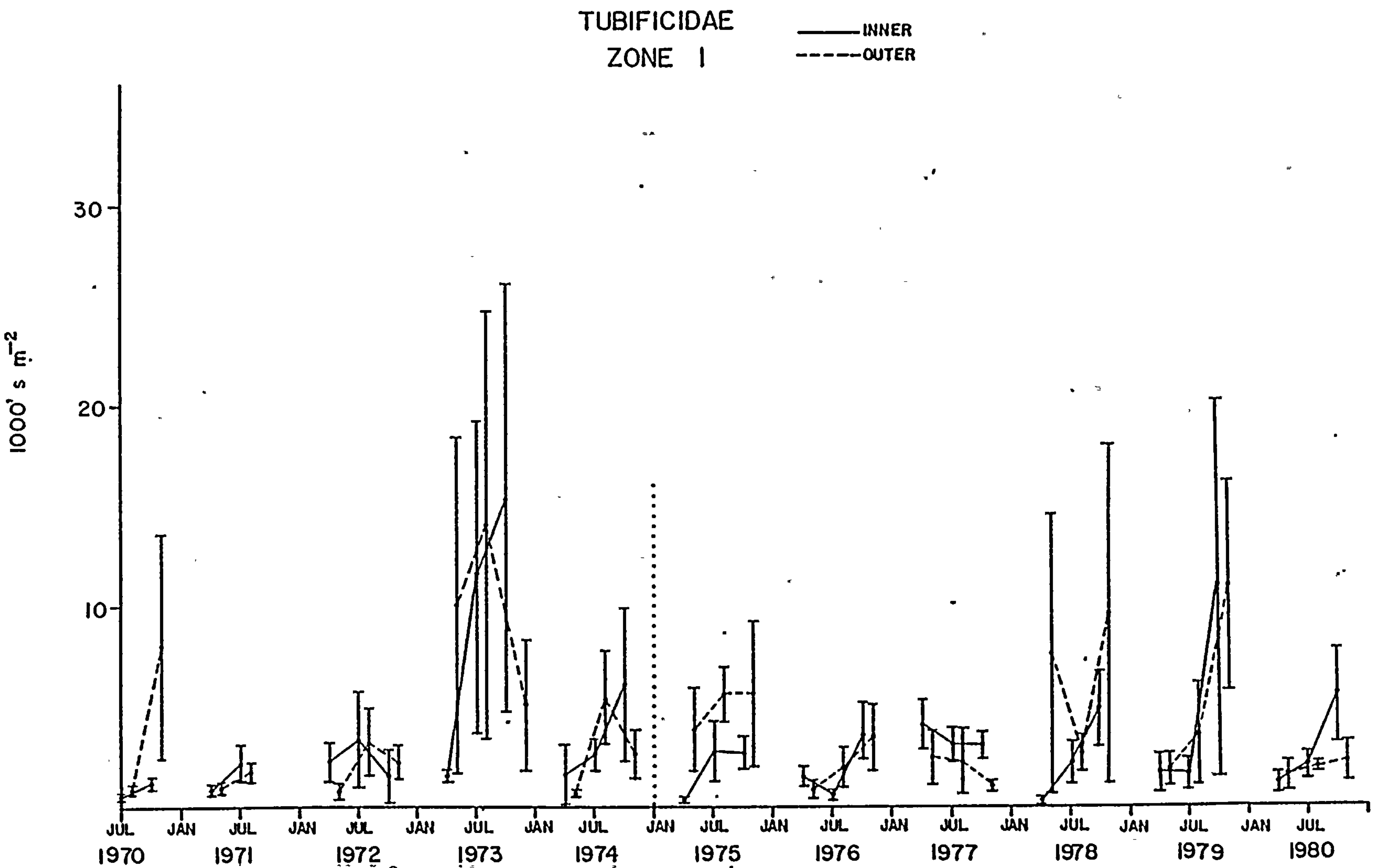

FIGURE 11. Density (animals m^{-2}) of Tubificidae in the Inner and Outer regions of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

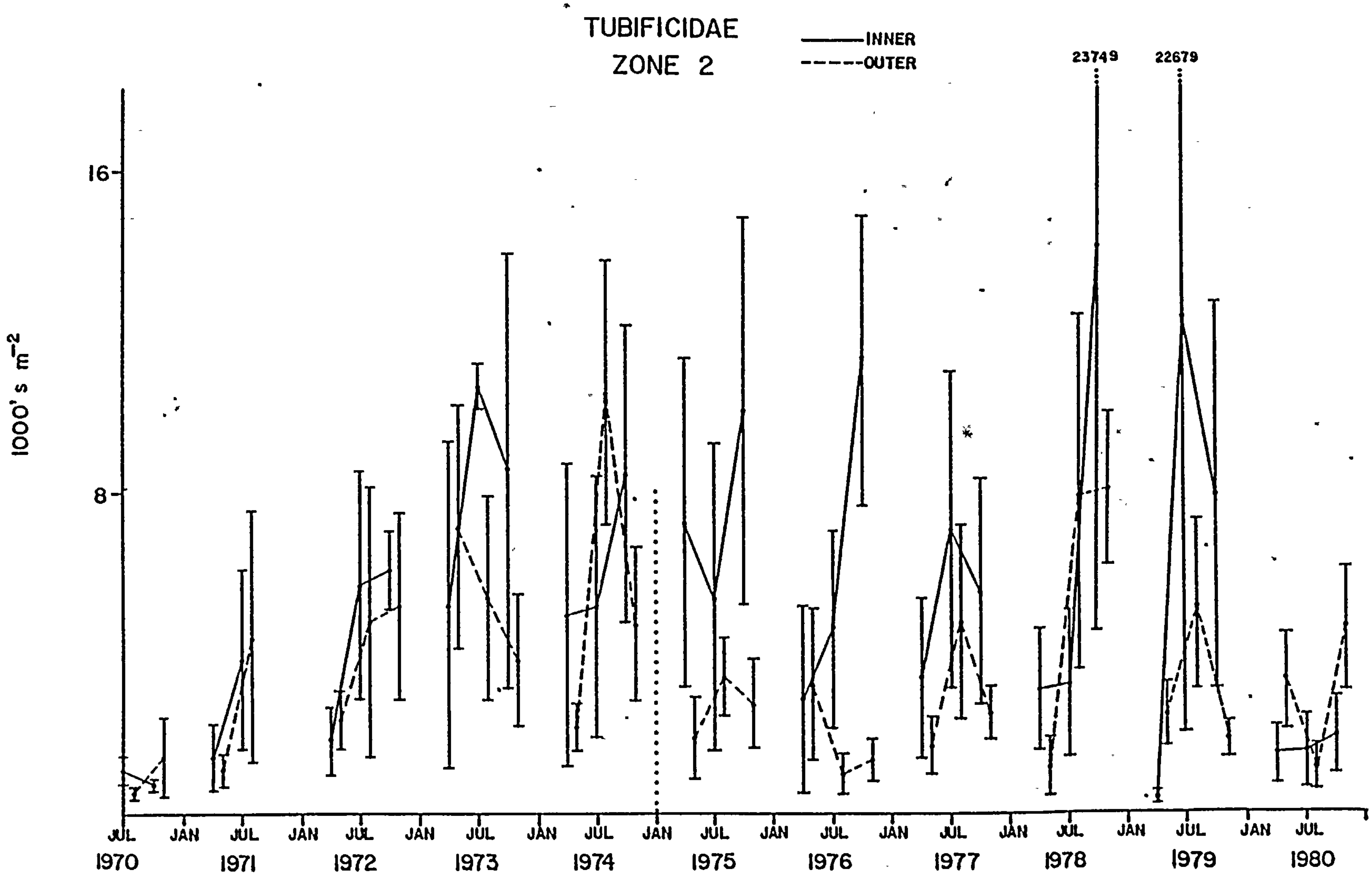

FIGURE 12. Density (animals m^{-2}) of Tubificidae in the Inner and Outer regions of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

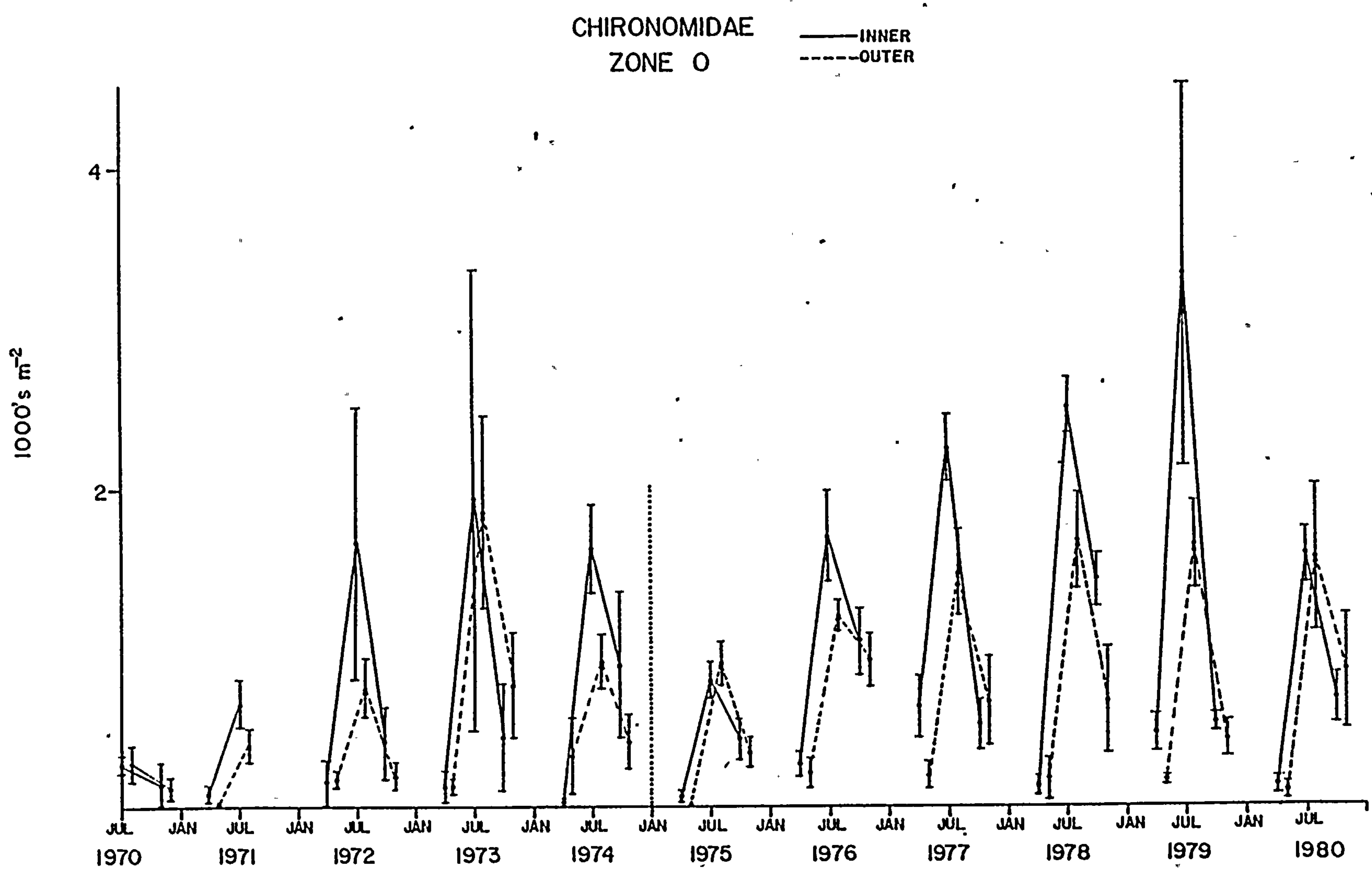

FIGURE 13. Density (animals m^{-2}) of Chironomidae in the Inner and Outer regions of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

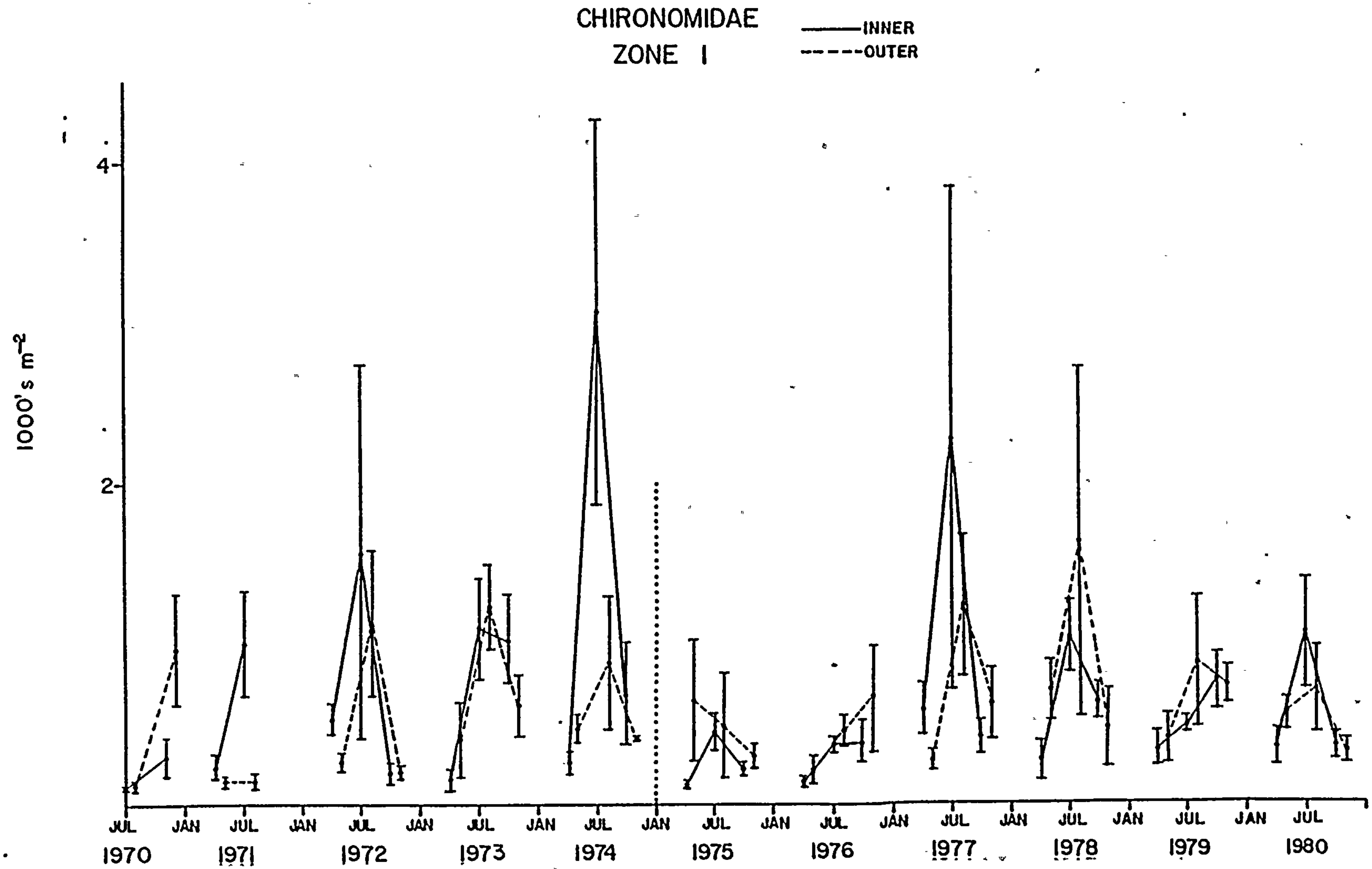

FIGURE 14. Density (animals m^{-2}) of Chironomidae in the Inner and Outer regions of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

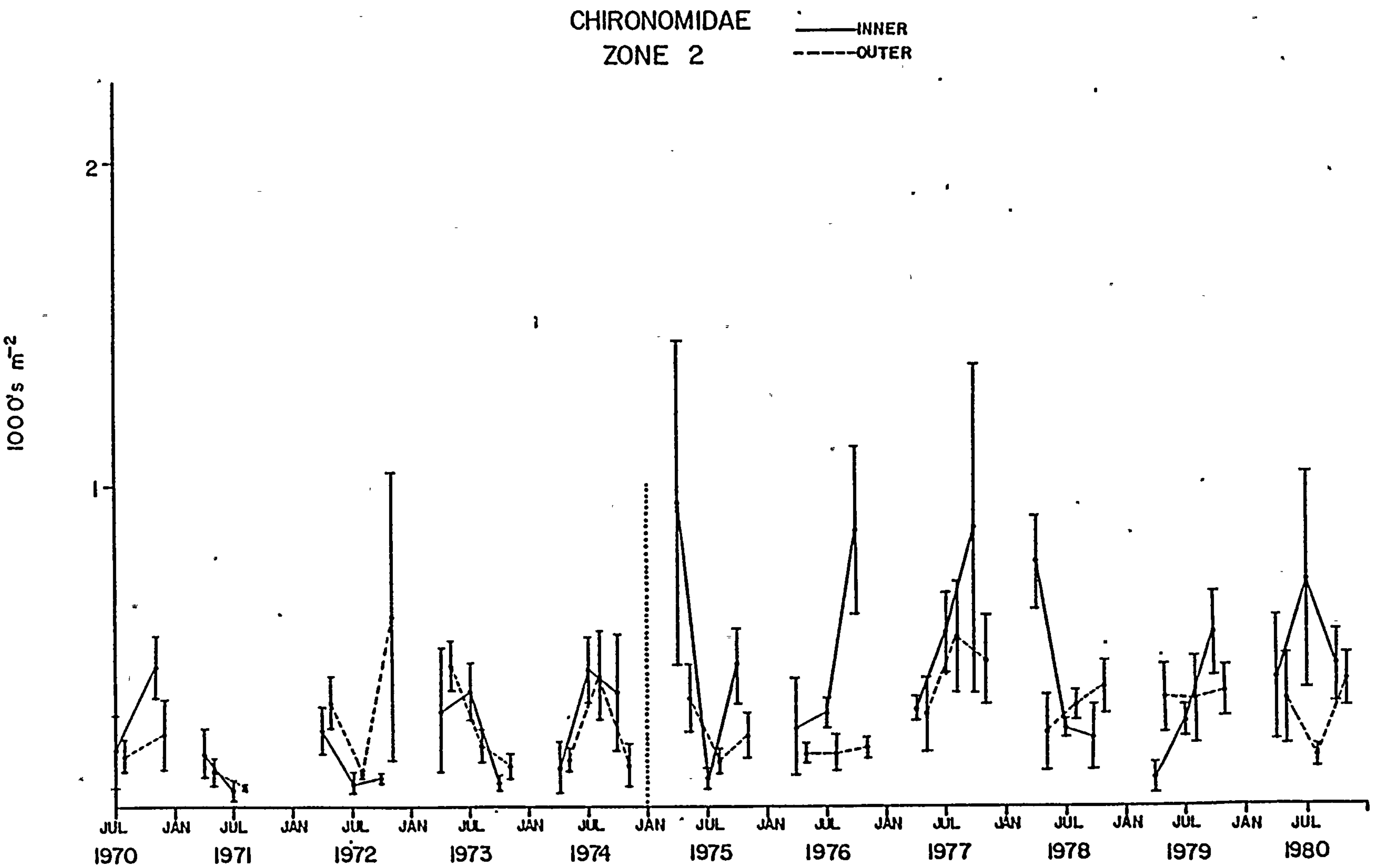

FIGURE 15. Density (animals m^{-2}) of Chironomidae in the Inner and Outer regions of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

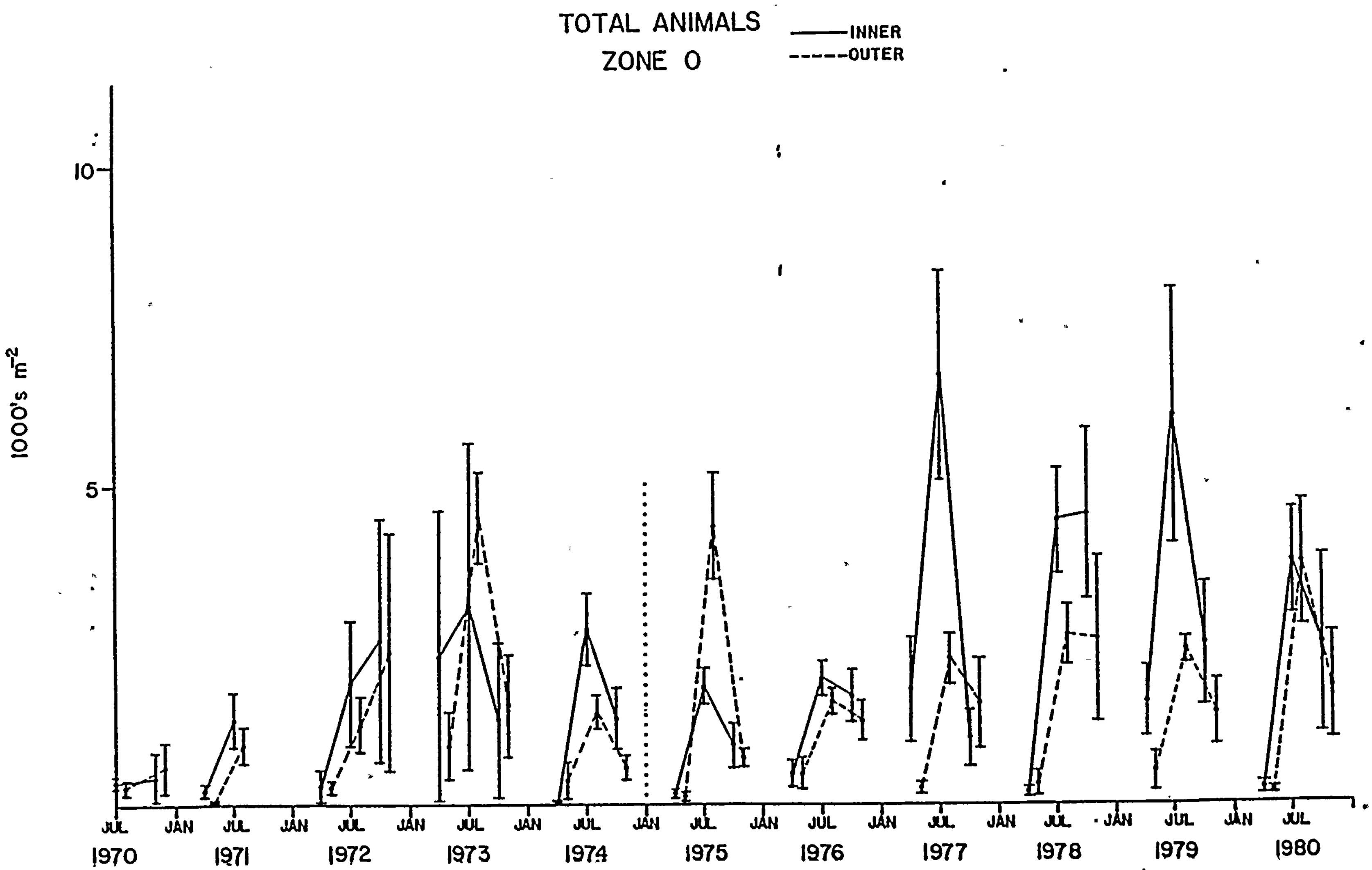

FIGURE 16. Density (animals m^{-2}) of Total Animals in the Inner and Outer regions of Zone 0 (0-8 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

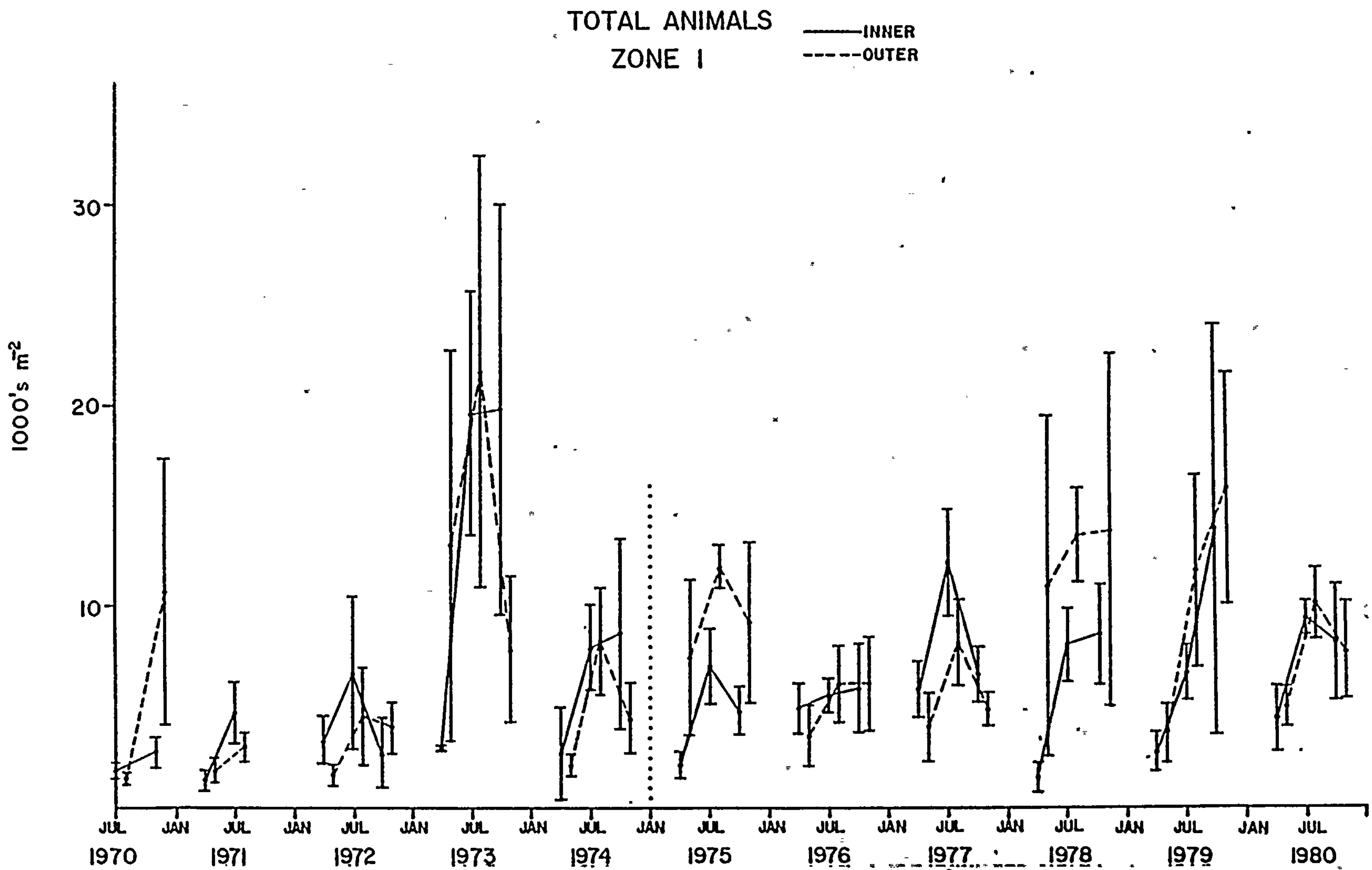

FIGURE 17. Density (animals m^{-2}) of Total Animals in the Inner and Outer regions of Zone 1 (8-16 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

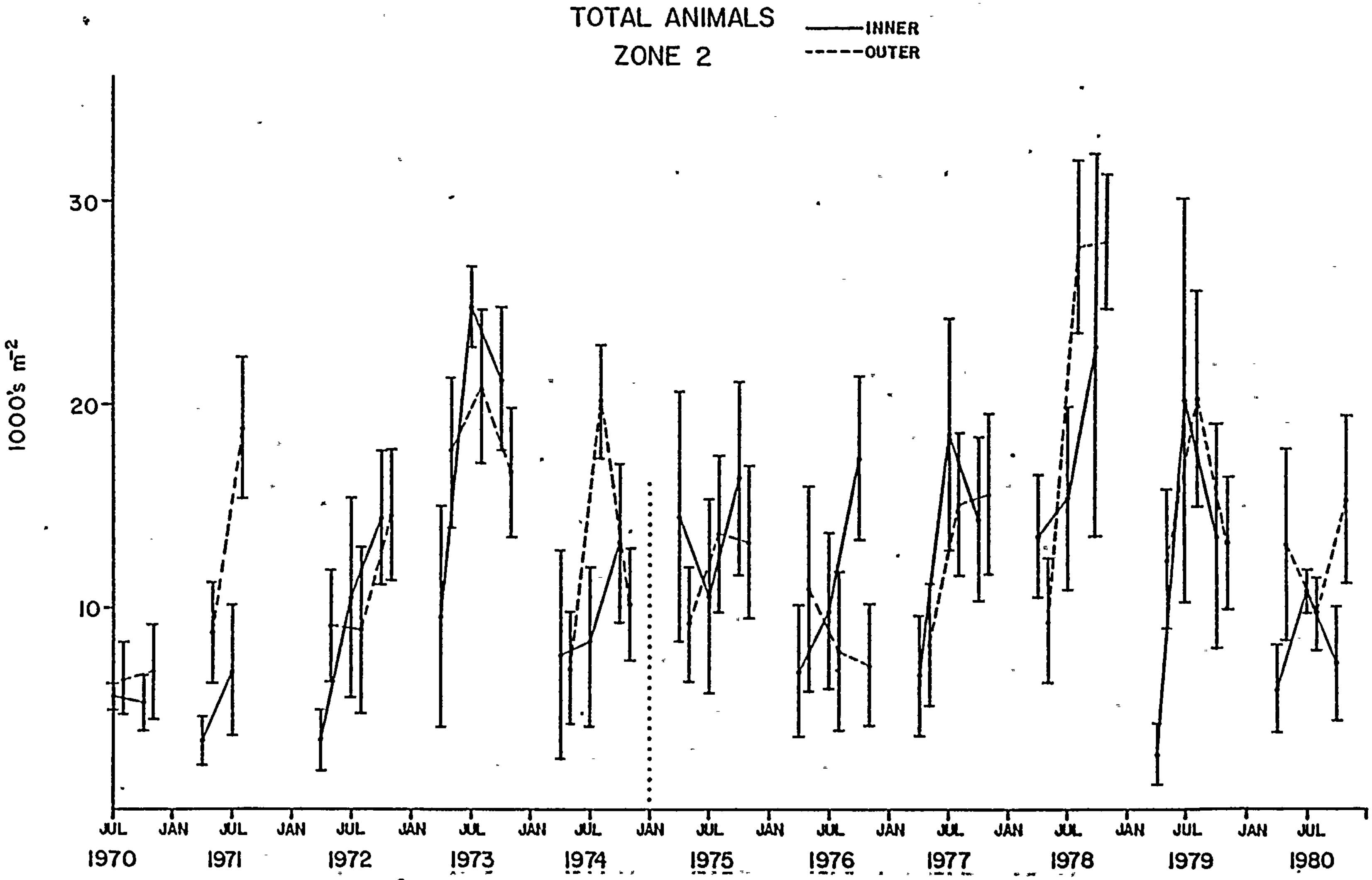

FIGURE 18. Density (animals m^{-2}) of Total Animals in the Inner and Outer regions of Zone 2 (16-24 m depth), vertical bars are standard errors, vertical dotted line indicates the start of plant operation.

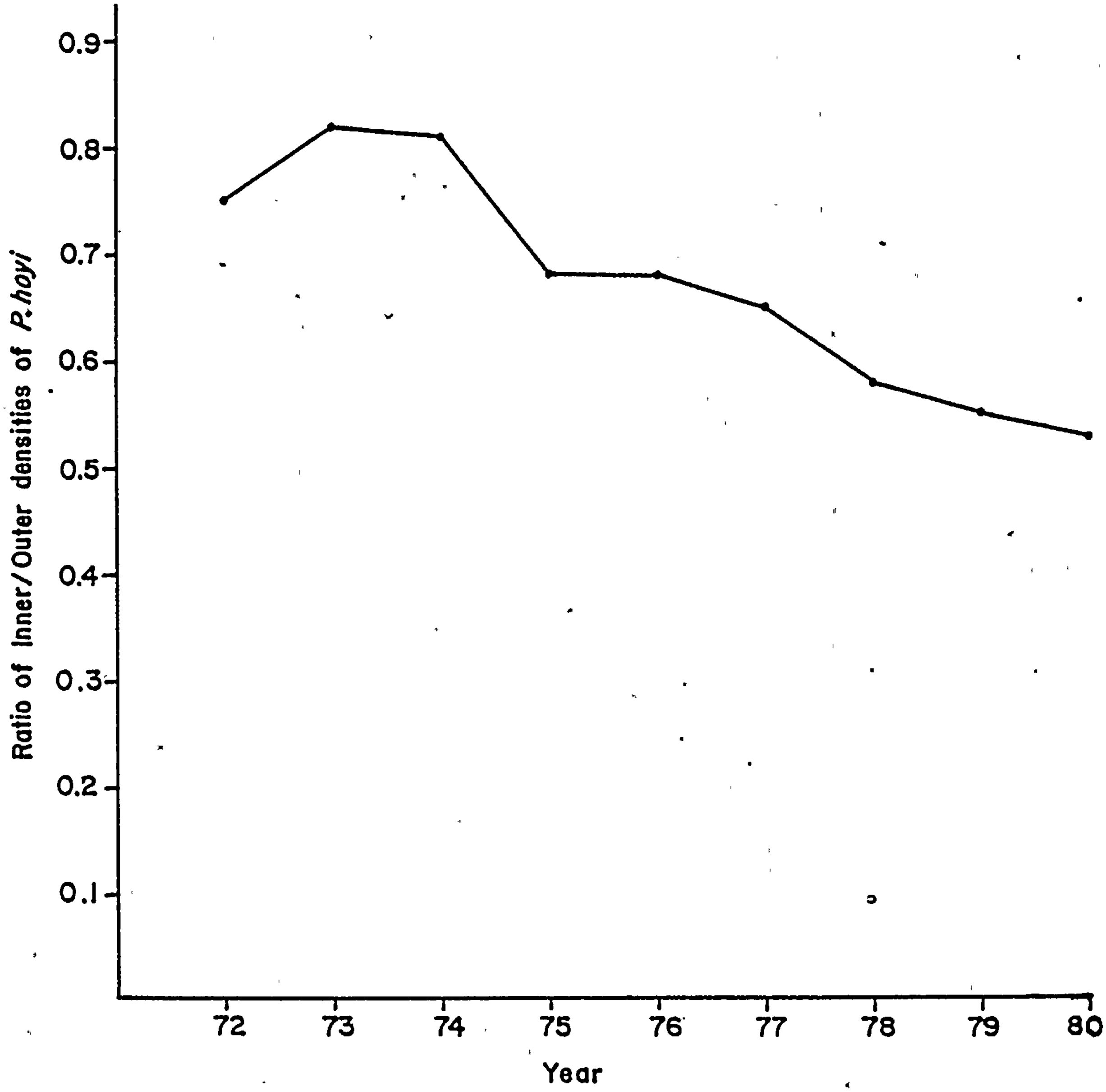

FIGURE 19. October Zone 2 Inner/Outer ratios of mean number m^{-2} for Pontoporeia hoyi for each year summed consecutively within the before and after construction time periods.

Table 1. Mean density (number m^{-2}) of major benthic taxa in April, 1980. The standard error (SE) is given in each case. The number (n) of Inner and Outer stations in each zone for which data were available is given in parentheses following the Total Animals entry.

Taxon	Region	Zone 0 (0-8 m) Mean	S E	Zone 1 (8-16 m) Mean	S E	Zone 2 (16-24 m) Mean	S E
Pontoporeia	INNER	15.2	8.3	2181.6	847.6	1127.2	577.3
	OUTER	30.3	23.5	1539.2	628.4	1842.2	1255.3
Tubificidae	INNER	66.7	38.8	1145.3	496.6	1472.6	737.1
	OUTER	12.1	5.7	1563.5	747.0	3272.4	1202.2
Naididae	INNER	12.1	5.7	212.1	58.3	60.6	27.1
	OUTER	12.1	7.4	175.7	116.3	72.7	34.0
Stylodrilus heringianus	INNER	3.0	3.0	127.3	72.0	2133.1	1165.1
	OUTER	24.2	10.3	418.1	227.6	2981.5	1337.1
Sphaerium nitidum	INNER	0.0	0.0	6.1	6.1	6.1	6.1
	OUTER	0.0	0.0	6.1	6.1	278.8	164.7
Sphaerium striatinum	INNER	0.0	0.0	0.0	0.0	3.0	0.0
	OUTER	0.0	0.0	12.1	7.4	12.1	7.4
Pisidium	INNER	3.0	3.0	307.8	123.2	630.2	222.3
	OUTER	12.1	5.7	563.6	255.8	3799.6	1648.3
Chironomidae	INNER	130.3	54.1	363.6	116.6	393.9	190.7
	OUTER	93.9	52.1	563.6	104.3	327.2	141.0
Hirudinea	INNER	0.0	0.0	0.0	0.0	6.1	6.1
	OUTER	0.0	0.0	0.0	0.0	12.1	12.1
Operculata	INNER	0.0	0.0	6.1	6.1	24.2	14.8
	OUTER	0.0	0.0	66.7	27.8	230.3	104.3
Pulmonata	INNER	0.0	0.0	6.1	6.1	0.0	0.0
	OUTER	0.0	0.0	6.1	6.1	30.3	30.3
Other	INNER	3.0	3.0	12.1	12.1	84.8	50.2
	OUTER	9.1	6.1	97.0	55.4	103.0	31.2
Total Animals	INNER	233.3	97.9(5)	4440.0	1587.9(5)	5939.8	2129.1(5)
	OUTER	193.9	48.5(5)	5311.6	1004.5(5)	12962.3	4701.2(5)

Table. 2 Mean density (number m^{-2}) of major benthic taxa in July, 1980. The standard error (SE) is given in each case. The number (n) of Inner and Outer stations in each zone for which data were available is given in parentheses following the Total Animals entry.

Taxon	Region	Zone 0 (0-8 m) Mean	S E	Zone 1 (8-16 m) Mean	S E	Zone 2 (16-24 m) Mean	S E
Pontoporeia	INNER	103.0	53.2	2230.1	156.4	4654.1	478.4
	OUTER	60.6	23.0	4054.1	1569.6	4417.7	1030.4
Tubificidae	INNER	148.5	66.1	2042.2	666.5	1527.1	904.4
	OUTER	333.3	314.5	1969.5	295.8	1133.2	567.6
Naididae	INNER	1663.5	623.5	3036.1	563.2	2078.6	568.0
	OUTER	1612.0	525.8	2042.2	485.8	793.9	247.0
Stylodrilus heringianus	INNER	12.1	8.8	54.5	33.7	587.8	126.6
	OUTER	0.0	0.0	509.0	233.2	715.1	478.3
Sphaerium nitidum	INNER	0.0	0.0	0.0	0.0	97.0	59.4
	OUTER	0.0	0.0	6.1	6.1	175.7	108.6
Sphaerium striatinum	INNER	3.0	3.0	0.0	0.0	0.0	0.0
	OUTER	0.0	0.0	0.0	0.0	0.0	0.0
Pisidium	INNER	18.2	18.2	575.7	326.2	648.4	279.8
	OUTER	36.4	22.8	430.3	254.3	1902.8	974.5
Chironomidae	INNER	1563.5	174.7	1066.6	338.1	696.9	334.5
	OUTER	1551.3	455.7	715.1	273.6	151.5	33.2
Hirudinea	INNER	0.0	0.0	0.0	0.0	36.4	36.4
	OUTER	0.0	0.0	18.2	7.4	0.0	0.0
Operculata	INNER	0.0	0.0	12.1	12.1	30.3	13.6
	OUTER	9.1	6.1	24.2	14.8	90.9	49.8
Pulmonata	INNER	3.0	3.0	12.1	12.1	18.2	7.4
	OUTER	0.0	0.0	0.0	0.0	6.1	6.1
Other	INNER	254.5	93.2	418.1	45.3	315.1	58.0
	OUTER	151.5	78.0	369.7	102.9	200.0	61.1
Total Animals	INNER	3769.3	837.0 (5)	9447.5	892.0 (5)	10689.8	1951.7 (5)
	OUTER	3754.1	972.6 (5)	10138.4	1801.4 (5)	9586.9	1777.8 (5)

Table 3. Mean density (number m^{-2}) of major benthic taxa in October, 1980. The standard error (SE) is given in each case. The number of Inner and Outer stations in each zone for which data were 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	INNER	42.4	20.0	387.8	92.6	1824.1	793.7
	OUTER	41.4	25.1	1860.4	692.2	4417.7	1754.4
Tubificidae	INNER	806.0	593.3	5526.7	2388.2	1933.1	954.7
	OUTER	173.7	139.1	2224.0	1012.6	4557.1	1541.5
Naididae	INNER	839.3	609.1	466.6	140.4	290.9	70.1
	OUTER	333.3	187.0	618.1	406.1	206.0	120.2
Stylodrilus heringianus	INNER	9.1	6.1	127.3	71.3	1436.2	998.4
	OUTER	6.1	6.1	1381.7	750.1	2248.3	722.1
Sphaerium nitidum	INNER	0.0	0.0	0.0	0.0	175.7	160.7
	OUTER	0.0	0.0	0.0	0.0	224.2	114.8
Sphaerium striatinum	INNER	3.0	3.0	6.1	6.1	6.1	6.1
	OUTER	0.0	0.0	18.2	7.4	6.1	6.1
Pisidium	INNER	57.6	43.2	1006.0	362.3	763.6	591.1
	OUTER	168.7	133.5	1024.1	515.4	2763.4	1338.7
Chironomidae	INNER	675.7	154.0	357.5	82.6	433.3	112.7
	OUTER	840.3	357.9	327.2	75.1	387.8	82.6
Hirudinea	INNER	0.0	0.0	127.3	68.7	18.2	12.1
	OUTER	6.1	6.1	12.1	12.1	24.2	11.3
Operculata	INNER	3.0	3.0	24.2	14.8	54.5	54.5
	OUTER	39.4	39.4	48.5	26.4	127.3	66.7
Pulmonata	INNER	0.0	0.0	0.0	0.0	30.3	19.2
	OUTER	6.1	6.1	36.4	24.2	18.2	7.4
Other	INNER	45.5	17.3	206.0	70.0	224.2	59.5
	OUTER	216.1	117.2	266.6	85.4	236.3	73.2
Total Animals	INNER	2481.6	1392.4 (5)	8235.5	2874.6 (5)	7187.2	2770.1 (5)
	OUTER	1831.1	820.2 (5)	7817.4	2358.4 (5)	15216.7	4151.3 (5)

TABLE 4. Logarithms of ratios of Inner to Outer mean population densities for _Pontoporeia hoyi_ 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 ($p < .05$), NS = no significance.

Month	Depth Zone	Year											
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Student's _t_	Significance
April	0	0.38	-0.26	0.48	-0.30	-0.04	0.00	1.49	0.95	1.03	-0.29	1.11	NS
	1	-0.67	-0.06	-0.27	-0.15	-0.20	0.11	-0.19	0.00	-0.05	0.15	1.98	NS
	2	-0.74	-0.77	-0.39	-0.17	0.33	0.01	-0.03	-0.05	-0.57	-0.21	2.28	NS
July	0	-0.82	-0.41	-1.56	0.32	-0.39	0.18	-0.10	0.58	1.07	0.23	2.16	NS
	1	0.09	0.36	0.03	-0.08	-0.19	0.17	-0.10	-0.52	-0.22	-0.26	2.10	NS
	2	-0.65	-0.09	-0.10	-0.21	-0.17	-0.07	-0.16	-0.13	-0.28	0.02	1.12	NS
October	0	--	0.28	-0.11	1.11	0.39	0.27	-1.20	0.29	0.25	0.01	0.99	NS
	1	--	-0.61	-0.18	-0.28	-0.31	-0.37	-0.57	-0.73	-0.67	-0.68	1.47	NS
	2	--	-0.13	-0.06	-0.13	-0.17	-0.16	-0.22	-0.29	-0.35	-0.38	2.69	*

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 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 ($p < .05$), NS = no significance.

Month	Depth Zone	Year											
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Student's *t*	Significance
April	0	0.70	-0.26	0.18	0.00	0.00	-0.89	0.60	0.60	0.09	-0.80	0.60	NS
	1	-1.24	-0.21	0.82	0.16	-1.50	-0.28	0.18	-1.03	-0.89	-0.52	1.22	NS
	2	-0.88	-0.64	-0.51	-0.57	-0.39	-0.24	-0.74	0.09	-0.88	-0.15	1.40	NS
July	0	1.00	-0.30	-0.70	-0.60	-0.68	1.00	-0.24	0.00	0.64	1.11	0.94	NS
	1	0.11	-0.80	-0.16	-0.70	-1.00	-1.28	-0.52	-0.24	-0.62	-0.97	2.18	NS
	2	-0.74	0.61	-0.02	-0.58	-0.60	-0.20	-0.01	-0.74	-0.40	-0.08	0.55	NS
October	0	—	-0.95	0.22	-0.27	0.00	-0.85	-0.24	-0.40	-0.50	0.15	0.09	NS
	1	—	-1.36	0.12	-0.57	-0.71	-1.18	-0.64	-0.58	-0.36	-1.04	0.44	NS
	2	—	0.28	0.18	-0.49	-0.51	-0.03	-0.45	-0.42	-0.52	-0.19	1.74	NS

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 ($p < .05$), NS = no significance.

Month	Depth Zone	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Student's *t*	Significance
April	0	0.38	0.30	0.83	-0.60	-0.36	-0.74	1.69	-0.70	1.02	-0.51	0.28	NS
	1	-0.05	0.17	-0.18	-0.02	-0.83	0.19	0.10	-0.78	-0.51	-0.16	1.34	NS
	2	-0.36	-0.57	-0.44	-0.09	-0.07	-0.61	-0.27	0.27	-0.53	-0.78	0.16	NS
July	0	-1.53	-0.42	-1.82	0.20	-0.87	-0.27	0.09	1.28	0.10	-0.29	1.72	NS
	1	0.72	-0.23	-0.01	0.34	-0.21	-0.15	0.41	-0.25	-0.18	0.13	1.17	NS
	2	-0.71	0.34	-0.03	-0.71	-0.41	-0.16	-0.04	-0.50	-0.58	-0.47	0.35	NS
October	0	—	0.29	-0.10	0.11	-0.12	0.26	-0.68	0.69	-0.05	-0.46	0.53	NS
	1	—	-0.58	0.31	0.15	-0.08	0.04	0.30	-0.01	-0.01	-0.01	0.40	NS
	2	—	-0.30	-0.14	0.17	-0.09	0.01	-0.19	-0.64	-0.21	-0.56	1.05	NS

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 ($p < .05$), NS = no significance.

Month	Depth Zone	Year											
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Student's t	Significance
April	0	0.58	0.08	0.35	-0.90	0.25	0.00	1.16	-0.36	0.33	0.75	0.87	NS
	1	-0.04	0.45	-0.80	0.36	-1.02	0.24	0.22	-1.41	-0.04	-0.14	0.84	NS
	2	0.12	-0.10	-0.14	0.37	0.59	-0.05	0.30	0.43	-0.80	-0.35	0.15	NS
July	0	-0.13	-0.58	-0.89	0.98	-0.88	-0.24	1.79	0.90	1.19	-0.35	0.90	NS
	1	0.11	0.02	0.09	-0.32	-0.30	-0.52	0.14	-0.08	-0.35	0.02	0.76	NS
	2	-0.06	0.08	0.30	-0.31	0.20	0.67	0.28	-0.39	0.38	0.13	1.02	NS
October	0	--	-0.12	0.12	0.56	-0.08	0.67	-0.22	-0.10	0.38	0.67	0.12	NS
	1	--	-0.16	0.48	0.36	-0.32	0.01	0.45	-0.29	0.00	0.40	0.79	NS
	2	--	0.07	0.35	0.26	0.57	0.93	0.34	0.24	0.64	-0.37	0.61	NS

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 ($p < .05$), NS = no significance.

Month	Depth Zone	Year											
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Student's t	Significance
April	0	0.56	-0.04	-0.02	-1.07	1.31	0.11	0.52	-0.12	0.45	0.14	1.47	NS
	1	0.21	0.30	-0.40	-0.25	-0.67	-0.17	0.34	-0.42	-0.07	0.19	0.73	NS
	2	0.17	-0.14	-0.17	-0.09	0.45	0.18	0.03	0.52	-0.59	0.08	0.80	NS
July	0	0.23	0.35	0.02	0.25	-0.05	0.15	0.19	0.18	0.31	0.00	0.95	NS
	1	0.81	0.14	-0.05	0.54	-0.03	-0.09	0.26	-0.20	-0.25	0.17	2.07	NS
	2	-0.08	-0.14	0.28	0.02	-0.21	0.25	0.01	-0.11	-0.10	0.66	0.35	NS
October	0	—	0.32	-0.24	0.34	0.09	0.05	-0.11	0.33	0.09	-0.09	0.51	NS
	1	—	-0.01	0.22	0.22	-0.14	-0.22	-0.18	0.13	0.01	0.04	2.09	NS
	2	—	-0.83	-0.23	0.44	0.31	-0.67	0.28	0.24	0.18	0.04	1.37	NS

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 ($p < .05$), NS = no significance.

Month	Depth Zone	Year											
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Student's t	Significance
April	0	0.61	0.00	0.39	-1.04	0.13	0.00	0.83	-0.22	0.50	0.08	0.66	NS
	1	-0.11	0.33	-0.64	0.11	-0.55	0.15	0.17	-0.86	-0.12	-0.05	0.50	NS
	2	-0.42	-0.41	-0.27	0.04	0.20	-0.20	-0.09	0.16	-0.65	-0.34	0.71	NS
July	0	0.14	0.18	-0.16	0.27	-0.37	0.08	0.47	0.22	0.40	0.00	0.15	NS
	1	0.19	0.08	-0.04	-0.01	-0.23	-0.04	0.17	-0.22	-0.24	-0.03	1.66	NS
	2	-0.44	0.07	0.08	-0.39	-0.11	0.10	0.09	-0.26	0.00	0.05	1.12	NS
October	0	—	0.04	-0.06	0.37	0.09	0.12	-0.19	0.26	0.24	0.13	0.06	NS
	1	—	-0.26	0.40	0.24	-0.28	-0.02	0.13	-0.20	-0.06	0.02	1.24	NS
	2	—	0.00	0.11	0.11	0.09	0.39	-0.04	-0.09	0.01	0.33	0.34	NS

TABLE 10. Benthos entrainment data, November-December 1979 and January-October 1980: *Pontoporeia hoyi*, 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. 12-13	0	0	0	0	0	0	0.009	0
Nov. 28-29	0.002	0	0	0.019	0.015	0	0.069	0.041
Dec. 10-11	0.106	0.035	0	0	0.021	0	0.245	0.259
Dec. 19-20	0.375	0.055	0.229	0.101	0.065	0.056	0.498	0.086
Jan. 20-21	0.282	—	0.104	0.241	0.193	0.038	0.275	0.168
Jan. 28-29	1.068	1.154	0.182	0.454	0.070	0.334	0.720	0.517
Feb. 4- 5	0.237	0.099	0.039	0.092	0.024	0	0.117	0.211
Feb. 19-20	0.026	0	0	0.019	0*	0	0.030	0.016
Mar. 10-11	0.010	0.016	0	0	0	0	0.022	0
Mar. 27-28	0	0	0*	0	0	0.012	0	0
Apr. 7- 8	0.009	0	0	0	0	0	0	0
Apr. 22-23	0.494	0.675	0	0	0	0	0*	0
May 12-13	0.010	0	0	0	0	0	0*	0
May 29-30	0	0.019	0	0	0	0	0*	—
June 6- 7	0	0	0	0	0.009	0	0.175	0.159
June 9-10	0.593	0.521	0	0.048	0.016	0	0.835	0.280
June 20-21	0.537	0.495	0.050	0	0.007	0	5.895	4.660
June 25-26	0.098	0.110	0.007	0.016	0	0	0.007	0.134
July 7- 8	Plant not fully operational							
July 14-15	0.132	0.071	0.024	0	0	0.012	0.132	0.050
July 24-25	0.013	0	0.011	0	0	0	0.022	0.064
July 30	0.042	0.019	0	0	0	0	1.711	1.371
Aug. 6- 7	0.024	0.021	0	0	0.031	0.132	0.276	0.070
Aug. 11-12	0.107	0.016	0.027	0	0.012	0	0.094	0
Aug. 21-22	0.027	0.014	0	0.034	0.008	0.012	0.057	0.045
Aug. 28-29	0.018	0	0	0	0	0	0.024*	0.076
Sep. 8- 9	0	0	0	0	0.013	0	0	0
Sep. 23-24	0.017	0.020	0	0.026	0	0	0.030	0.021
Oct. 13-14	0.007	0	0	0	0	0	0	0
Oct. 28-29	0.017	0.026	0	0	0.113	0.021	0	0

TABLE 11. Benthos entrainment data, November-December 1979 and January-October 1980: *Mysis relicta*, 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. 12-13	0.007	0.026	0	0	0	0	0.020	0
Nov. 28-29	0.039	0.079	0	0	0	0	0.010	0.014
Dec. 10-11	0.007	0	0	0	0	0	0	0
Dec. 19-20	0.015	0	0	0	0	0	0.019	0
Jan. 20-21	0.022	—	0.018	0	0	0	0.020	0
Jan. 28-29	0.013	0.026	0	0	0	0	0	0
Feb. 4- 5	0.015	0.012	0.045	0	0.014	0	0.021	0
Feb. 19-20	0.012	0.025	0	0.019	0*	0	0	0
Mar. 10-11	0.043	0.016	0.017	0	0	0.077	0.143	0.048
Mar. 27-28	0.013	0	0*	0	0	0	0	0
Apr. 7- 8	0	0	0	0	0	0	0.015	0
Apr. 22-23	0	0	0	0	0	0	0*	0
May 12-13	0.021	0	0	0	0	0	0*	0
May 29-30	0.010	0	0	0	0	0	0*	—
June 6- 7	0	0.055	0	0	0	0	0	0
June 9-10	0	0	0	0	0	0	0	0
June 20-21	0	0	0	0	0	0	0	0.027
June 25-26	0.027	0.022	0	0	0	0	0	0.033
July 7- 8	Plant not fully operational							
July 14-15	0	0.036	0	0	0	0	0	0
July 24-25	0	0	0.	0	0	0	0	0
July 30	0	0	0	0	0	0	0	0
Aug. 6- 7	0	0	0	0	0	0	0	0
Aug. 11-12	0.032	0	0	0	0	0	0	0
Aug. 21-22	0.160	0.135	0.011	0	0	0	0.111	0.121
Aug. 28-29	0	0	0	0	0.008	0	0.024*	0
Sep. 8- 9	0.026	0	0.015	0	0.007	0	0.036	0
Sep. 23-24	0.010	0.020	0.012	0	0	0	0	0
Oct. 13-14	0.036	0.032	0	0	0	0	0.024	0
Oct. 28-29	0.414	0.259	0	0.031	0.113	0.064	0	0.029

TABLE 12. Benthos entrainment data, November-December 1979 and January-October 1980: Gammarus, number m^{-3}. I = intake, D = discharge, * = based on one intake sample, — = missing data.

Sampling Date	SAMPLE PERIOD MIDN---->SUNR I	D	SUNR---->NOON I	D	NOON---->SUNS I	D	SUNS---->MIDN I	D
Nov. 12-13	0.014	0.013	0.037	0	0.031	0	0.018	0.053
Nov. 28-29	0.017	0	0.010	0	0.040	0	0.028	0.027
Dec. 10-11	0.033	0	0	0	0	0	0.015	0.015
Dec. 19-20	0.016	0	0	0.025	0.049	0	0.010	0
Jan. 20-21	0.013	—	0	0	0	0	0.020	0
Jan. 28-29	0.071	0	0	0	0	0	0.039	0
Feb. 4- 5	0	0.012	0	0	0	0	0	0
Feb. 19-20	0.056	0	0	0	0*	0.016	0.030	0
Mar. 10-11	0.008	0.016	0	0	0	0	0.011	0
Mar. 27-28	0	0	0*	0	0	0	0.035	0
Apr. 7- 8	0	0	0	0	0	0	0	0
Apr. 22-23	0	0	0.013	0.018	0	0	0*	0
May 12-13	0	0	0	0.020	0.015	0	0*	0
May 29-30	0	0	0	0	0	0	0*	—
June 6- 7	0	0	0	0	0	0	0	0
June 9-10	0	0	0	0	0.011	0	0	0
June 20-21	0	0	0	0	0.007	0	0.039	0
June 25-26	0.011	0	0.007	0	0	0	0	0
July 7- 8	Plant not fully operational							
July 14-15	0.088	0.053	0.078	0	0.016	0	0.071	0
July 24-25	0.057	0.047	0.050	0.017	0.039	0.014	0.083	0
July 30	0.026	0.019	0.022	0	0.015	0.014	0.056	0
Aug. 6- 7	0.034	0.021	0.155	0	0.016	0	0.037	0
Aug. 11-12	0.050	0	0	0	0	0	0	0
Aug. 21-22	0.071	0.027	0.033	0.017	0	0	0.061	0.015
Aug. 28-29	0.055	0	0	0.023	0	0	0*	0.019
Sep. 8- 9	0	0	0	0	0.027	0.050	<0.001	0
Sep. 23-24	0.053	0.079	0.033	0	0.020	0	0.012	0
Oct. 13-14	0	0	0	0	0	0	0	0
Oct. 28-29	0	0.013	0.011	0	0.058	0.021	0	0.015

TABLE 13. Benthos entrainment data, November-December 1979 and January-October 1980: Asellus, 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. 12-13	0	0.013	0	0	0	0	0	0
Nov. 28-29	0	0	0	0	0	0	0	0
Dec. 10-11	0	0	0	0	0	0	0	0
Dec. 19-20	0	0	0	0	0.016	0	0	0
Jan. 20-21	0	—	0	0	0	0	0	0
Jan. 28-29	0.071	0	0.029	0	0	0	0	0
Feb. 4- 5	0	0	0	0	0	0	0	0
Feb. 19-20	0	0	0	0	0*	0	0	0
Mar. 10-11	0	0	0	0	0	0	0	0
Mar. 27-28	0	0	0*	0	0	0	0	0
Apr. 7- 8	0	0	0	0	0	0	0	0
Apr. 22-23	0	0	0	0	0	0	0*	0
May 12-13	0.010	0	0	0	0	0	0*	0
May 29-30	0	0	0	0	0	0.010	0*	—
June 6- 7	0	0	0	0	0.009	0	0	0
June 9-10	0	0	0	0	0	0	0	0
June 20-21	0	0	0	0	0	0	0	0
June 25-26	0	0	0	0	0	0	0	0
July 7- 8	Plant not fully operational							
July 14-15	0	0	0	0.025	0	0	0	0
July 24-25	0	0	0	0	0	0	0	0
July 30	0	0	0	0	0	0	0	0
Aug. 6- 7	0	0	0	0	0.008	0	0	0
Aug. 11-12	0	0	0	0	0.006	0.013	0	0
Aug. 21-22	0	0	0	0	0	0	0	0
Aug. 28-29	0	0	0	0	0	0	0*	0
Sep. 8- 9	0	0	0	0	0	0.013	0	0
Sep. 23-24	0	0	0	0	0	0	0	0
Oct. 13-14	0	0	0	0	0	0	0	0
Oct. 28-29	0	0.026	0	0.015	0	0.064	0	0

TABLE 14. Numbers and weights of crayfish (<u>Orconectes propinquus</u>) 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.

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 (0)	0	0	0	0
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 (0)	0	0	0	0
June	1-15 (0)	0	0	0	0
	16-30 (0)	0	0	0	0
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
October	1-16 (1)	2	0.01	16	0.12
	17-31 (1)	1	0.01	15	0.08
November	1-15 (0)	0	0	0	0
	16-30 (0)	0	0	0	0
December	1-16 (0)	0	0	0	0
	17-31 (0)	0	0	0	0
TOTAL				2487	16.71

* 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 1980. 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 (0)	0	0	0	0
	17-31 (0)	0	0	0	0
February	1-14 (2)	7	0.04	49	0.27
	15-28 (3)	17	0.12	79	0.55
March	1-16 (1)	9	0.06	144	1.04
	17-31 (5)	86	0.58	258	1.74
April	1-15 (5)	236	1.70	708	5.11
	16-30 (2)	286	1.76	2145	13.22
May	1-16 (3)	48	0.33	256	1.78
	17-31 (3)	195	1.34	585	4.03
June	1-15 (1)	12	0.08	180	1.27
	16-30 (2)	9	0.06	56	0.43
July	1-16 (2)	2	0.01	16	0.09
	17-31 (5)	18	0.11	54	0.33
August	1-16 (2)	127	0.87	1016	7.00
	17-31 (3)	100	0.72	500	3.62
September	1-15 (1)	50	0.35	750	5.30
	16-30 (5)	25	0.17	75	0.52
October	1-16 (6)	24	0.17	64	0.44
	17-31 (3)	9	0.09	45	0.44
TOTAL, January - October (83% of the year)				6980	47.18
Projected Total for January - December 1980				8376	56.62

APPENDIX B-4

PERIPHYTON COLLECTED AT

THE DONALD C. COOK NUCLEAR PLANT

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, and 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 1980 have resulted in the entrainment samples being worked up only through September 1979.

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 composition 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 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 1979.

Ninety-seven periphyte taxa were diver-collected in each of 1975 and 1977, 67 were taken in 1976, 117 in 1978, and 131 in 1979. 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.

Visual observations by our divers indicate that the animal community on the underwater structures is apparently stabilizing at a lower population density and that the peak of colonization has passed. On the basis of the numbers of taxa taken from the structures in 1979, this appears to be not yet the case in the periphyte community.

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
48 taxa which were present in 1979 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.

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 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 intallations, 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; 1978, 117, and 1979, 131. Of the taxa taken in 1978, 40 (29 diatoms, 10 green algae, and 1 blue-green) have been taken in every year of the study. Another 16 (10 diatoms, 3 greens, 1 chrysophyte, and

2 blue-greens) were taken in four of the five years. It appears safe to consider that these 56 taxa, with the addition of Cladophora which is almost never entrained, probably constitute the basic periphyte community that is embroidered with about 60 rarer taxa that are taken much less frequently.

On the basis of samples through September 1979, the dominant periphytes were: diatoms of the genera Asterionella, Cyclotella, Cymbella, Diatoma, Fragilaria, Melosira, Navicula, Nitzschia, Stephanodiscus, Synedra, and Tabellaria, all of which occurred in more than 50% of the samples; the green alga, Scenedesmus quadricauda, which occurred in 47% of the samples; and blue-green algae of the genus Schizothrix occurred in 42%. There were 48 rare taxa that were present in 1979 only.

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.

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 elia	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	2.3	0.3	0.3
Amphipleura pellucida	11.6	0	0.1	0	1.4	0.3
Amphora calumatica	0	0	0	0.6	0	0.3
A. ovalis	0	0.3	0	0.6	0.3	0
A. sp.	2.8	0	1.9	4.7	2.2	1.9
Asterionella formosa	139.9	68.3	2.1	81.3	102.0	62.7
Cocconeis pediculus	1.1	0	0	0	0.3	0
C. sp.	0	0	0	0	0	0
Cyclotella comta	1.1	1.1	0	4.7	3.3	1.7
C. meneghiniana	6.7	5.3	3.0	14.1	4.2	0.3
C. stelligera	32.6	5.2	5.2	6.1	2.0	1.1
C. spp.	16.0	9.1	5.9	9.7	1.9	10.2
Cymatopleura elliptica	0	0	0	0	0	0
C. solea	0.6	0	0.1	1.1	0	0
Cymbella prostrata	0	0	0	0	0	0
C. prostrata v. auerswaldii	0	0	0	0.3	0	0
C. tumida	0	0	0	0	0	0
C. spp.	1.1	0	0	0	0	0
Diatoma tenue v. elongatum	33.7	0.6	0.3	0	0.3	0.3
D. vulgare	0	0	0	0.8	0	0
Diploneis sp.	0	0	0	0.3	0	0.3
Fragilaria capucina	0	0	0.6	14.4	40.9	136.2
F. construens	8.9	0	4.6	4.4	17.0	0.3
F. crotonensis	459.3	363.9	29.3	213.3	460.7	127.7
F. intermedia	4.4	0	0.3	3.3	2.8	1.4
F. intermedia v. fallax	14.9	0	2.0	18.0	14.9	3.9
F. pinnata	0	0.6	1.8	11.9	50.8	10.0
F. sp.	5.5	0	4.4	5.3	5.5	3.3
Gomphonema olivaceum	0.6	0	0	0	0	0
G. spp.	0.6	0	0	1.7	0	0
Gyrosigma sp.	0	0	0	0	0	0
Melosira distans	0	0	0	0	0	0
M. granulata	274.7	54.4	111.4	686.2	56.1	1.1
M. granulata v. angustissima	0	0	8.9	0	2.5	0
M. islandica	63.6	0	0	1.4	0	0
M. italica	50.9	0.6	0.6	7.2	3.6	0.3
M. varians	0	0	0	0	0.3	0
M. spp.	0	0	3.1	0	0	0
Meridion circulare	0	0	0	0	0	0
Navicula anglica	0	0	0	0	0	0
N. aurora	0	0	0	0	0	0
N. capitata	0.6	0	0.6	1.1	0.3	0
N. cryptocephala	1.1	0	0.2	1.1	0.6	0.3
N. cuspidata	0	0	0	0	0	0
N. gastrum	0	0	0	0	0	0
N. menisculus	0	0	0	0	0	0
N. placentula v. rostrata	0	0	0	0.6	0	0
N. radiosa	0	0	0	0.3	0	0
N. radiosa v. tenella	0	0	0	0	0	0
N. tripunctata	1.1	0	0.3	0.3	0	0
N. viridula v. linearis	0	0	0	0	0	0
N. sp. #78	0	0	0.2	0	0	0
N. spp.	0.6	0.6	1.2	2.2	3.1	0.3
Neidium dubium	0	0	0.1	0	0	0
Nitzschia acicularis	26.5	0	1.1	9.9	1.7	0.6
N. dissipata	14.4	0.3	0.2	1.7	1.7	0
N. sp. #2	5.5	0.3	0	1.4	0.8	0.3
N. spp.	85.6	1.9	11.7	46.7	43.4	12.2
Pinnularia major	0	0	0	0	0	0
Rhizosolenia gracilis	87.9	4.0	0.1	0.5	0.3	0
Rhoicosphenia curvata	0	0	0	0	0	0
Stephanodiscus alpinus	24.9	1.4	1.8	28.7	20.7	8.3
S. tenuis	0.6	1.1	0.6	3.0	0	0
S. transilvanicus	2.2	0.3	0	2.2	0	0
S. spp.	159.2	11.1	8.4	67.2	8.8	22.1

Table 1. continued.

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Surirella angusta	3.9	0	0.4	1.1	2.5	0
S. ovata	0	0	0	0.5	0.3	0
Synedra delicatissima v. angustissima	6.6	0	2.4	5.0	0	0
S. filiformis	62.5	13.0	5.1	8.6	18.0	3.1
S. ostenfeldii	117.2	3.1	1.0	7.2	0.3	0.3
S. parasitica	2.2	0	0	0	0.3	0
S. ulna	3.9	0	0	0	0.6	0
S. ulna v. chaseana	23.8	1.1	0	0.8	0.3	0
S. spp.	14.4	0.6	1.1	15.2	18.5	3.9
Tabellaria fenestrata v. intermedia	214.5	80.4	5.5	83.5	73.5	89.8
CHLOROPHYTA						
Ankistrodesmus falcatus	0	0	0	0	0	0
Binuclearia sp.	0	0	0	0	0	0
Cladophora sp.	0	0	0	0	0	0
Closterium sp.	0	0	0	0	0.3	0
Coelastrum sp.	0	0	2.5	2.2	0	0
Cosmarium sp.	3.3	0.9	0	0	1.1	0.6
Crucigenia quadrata	0	0	2.8	40.4	6.6	15.5
Gloeocystis planctonica	118.3	75.7	34.9	84.3	76.0	19.6
Golenkinia radiata	0	2.2	1.7	0	0	0
Kirchneriella ella	0	0	0	0	0	0
K. sp.	0	1.4	0.8	5.3	0.3	0
Mougeotia sp.	19.3	8.0	0.6	8.8	16.0	44.0
Oocystis sp.	7.7	5.5	2.2	22.7	35.4	64.9
Pediastrum boryanum	0	0	0	8.9	0	0
P. duplex	0	0	5.2	0	0	0
P. simplex	0	0	1.1	4.4	0	0
Scenedesmus acuminatus	5.5	2.2	0.8	12.4	2.8	0
S. acutus	6.6	0	0.3	0	0	0
S. armatus	2.2	0	0.1	0	0	0
S. bicellularis	239.9	27.6	14.8	20.7	12.4	11.6
S. quadricauda	15.5	6.6	9.1	19.6	10.2	6.1
S. quadricauda v. longispina	16.6	7.2	7.7	23.2	3.3	1.7
S. spinosus	14.4	5.0	5.2	6.6	0.6	0
S. spp.	65.8	13.6	13.6	34.8	25.7	21.0
Spirogyra sp.	0	0	0	0	0	0
Staurastrum paradoxum	0	0	0	0	0	0
Tetraedron caudatum	0	0	0.3	1.7	0.3	0
T. pentaedricum	0	0	0	0	0	0
Ulothrix sp.	0	0	0	0	0	0
CHRYSOPHYTA						
Dinobryon divergens	3.3	22.4	0.3	4.7	0	0
CYANOPHYTA						
Agmenellum quadruplicatum	0	0	8.9	0	0	0
Anabaena flos-aquae	5.5	170.8	4.8	48.9	63.6	63.5
A. sp.	0	0	0	5.0	0	0
Anacystis incerta	181.3	54.2	697.8	2046.6	1117.8	1155.1
A. thermalis	0	0	46.2	144.8	63.3	155.9
Gomphosphaeria lacustris	248.7	116.1	2.4	726.8	544.4	1238.0
Oscillatoria sp.	12.7	0.6	0.6	0.9	2.0	0.6
Phormidium sp.	0	0	0	0	0	0
Schizothrix calcicola	21.6	3.6	1.2	3.0	0.3	0
S. sp.	0	0	0	0	0	0
EUGLENOPHYTA						
Trachelomonas sp.	0	0	0	0	0	0
PYRROPHYTA						
Peridinium sp.	0.6	3.3	0.7	0	0	0

TOTAL TAXA 117

APPENDIX B-5

FISHERIES STUDIES AT THE DONALD C. COOK NUCLEAR PLANT

INTRODUCTION

This section of the Annual Report covers fisheries data collected from 1973 through August 1980. Due to varying degrees of analysis, the actual time period covered varies by area of research. Most effort in the 1980 report was devoted to compiling and analyzing data not presented in past Environmental Operating Reports. The extensive data analysis done for past reports was not repeated here, but will be referenced with 1980 data integrated with these findings.

Larval fish field data were analyzed via ANOVA for three species in an attempt to document any potential effects of the plant. Preoperational data (1973-1974) were compared with operational data (1975-1979). The 1979 year was the first year of full operation of both units.

Entrainment data are presented for 1973-1979. Numbers were extrapolated based on densities observed in entrainment samples and two-unit flows.

Visual inspections of the intake forebay continued through 1980. Fish were seldom observed, except during summer when either one or both units were not operating.

Field catches of juvenile and adult fish were evaluated for 1973-1979 via ANOVA in past reports. Here, we reference results from previous ANOVAs and discuss field catch data for April-August 1980. Effects of the thermal plume on fish distributions are discussed.

During 1980, the Cook Plant impinged the largest number of fish since the plant began operation. Numbers and biomass are presented; apparently, a combination of inshore limnological conditions and two-unit operation were responsible for the large impingement events observed in 1980.

FISH LARVAE - FIELD

Introduction

Spatial and temporal distributions of larval fish were examined to determine if plant-related differences between the Cook Plant study area and the Warren Dunes reference area were evident. Analyses in this section of the report are restricted to 1973-1974 preoperational and 1975-1979 operational data. The addition of 1979 data to the data base not only increased sample size and the power of ANOVA, but also incorporated data from one full season of two-unit operation.

The following discussion will focus primarily on new information generated by the addition of 1979 data to the data base. Further discussion of 1973-1978 results can be found in the 1979 Environmental Operating Report. Sampling methods are described in detail in earlier reports (Jude et al. 1975, 1979).

Statistical Analysis

ANOVA was applied to larval data of three species: alewife, yellow perch and spottail shiner. All ANOVA designs were Model I, full factorial, balanced analysis of variance calculated with the statistical package BMD8V (Statistical Research Laboratory 1975). To more closely meet the assumptions of the model, larval densities were transformed using log(density + 1). Two zones, beach and open water, were analyzed separately. Because preliminary tests indicated no significant trend in larval densities among depth strata (surface to near-bottom) for a particular sampling site and time, samples from different depths from the same spatial and temporal periods were treated as replicates in the ANOVAs of the open water stations. Since larval samples are taken at 2-m intervals in open water, stations at 6 m (C, south Cook and G, Warren Dunes) had one less replicate than 9-m stations (D, south Cook and H, Warren Dunes). To balance the design, the cell mean from the four strata at 6-m stations replaced the "missing" value. The unweighted means method for balancing designs (Fox 1973) was then applied to the open water results. Treatment sum of squares were multiplied by the ratio of harmonic mean cell size to maximum cell size to adjust for substitutions; the number of missing values was substracted from degrees of freedom of the error term to adjust mean square error.

Preliminary residual analyses indicated the assumption of normality may have been violated. Results of Lilliefors test for normality showed that ANOVA residuals were not from a normally distributed population (Table 1). Residual distributions were more severely kurtotic than skewed. In a balanced design, as was used in this study, the F distribution is robust with respect to departures from the assumption of normality and is less sensitive to kurtotic distributions than skewed distributions. Homoscedasticity was evaluated by examining plots of residuals against cell means. Examination of plots revealed that cell means were not correlated with variance.

Alewife

Introduction--The most abundant larval fish found in Cook Plant study areas is the alewife which is most abundant from June through August, in both beach zone and open water areas. Both zones were analyzed for plant impact by applying ANOVA to transformed data.

Beach zone--Analysis of variance of transformed alewife data included 7 yr (1973-1979), 3 mo (June-August), three stations (A, north Cook; B, south Cook and F, Warren Dunes) and two diel periods (day and night) (Table 2). ANOVA results (Table 3) indicate that differences in the abundance of larval alewives have occurred during 1973-1979 in the beach zone ($P = 0.0000$). Geometric means of density + 1 showed 1973 to be a year of especially high abundance (3342.61 larvae/1000 m^3) while 1979 was a year of particularly low abundance (39.30 larvae/1000 m^3). Geometric means of density + 1 from 1973 to 1979 (respectively) were 3342.61, 181.83, 497.99, 326.87, 190.16, 273.19 and 39.303. Examination of both open water and beach yearly geometric means seems to reveal a trend toward decreasing larval population of alewives in the Cook Plant study areas. However, in 1979 an exceptionally large catch

of young-of-the-year alewives was made in the fall, suggesting our larval sampling may not have coincided with peak larval abundance.

Over all years, highest densities of larval alewives were usually sampled in July, although the significant Year x Month interaction (P = 0.0000) indicated that monthly fluctuations occur from year to year. During 1973, 1977 and 1979, July was the month of peak abundance, whereas in 1974, 1975 and 1976 more larvae were caught in June. During 1978, larvae were abundant in both July and August, but lower densities were observed in June. These differences are not surprising since peak spawning periods vary from year to year with seasonal water temperatures and weather conditions.

Although there was no significant Station effect, the Year x Station interaction was probably related to high densities at station B (south Cook) and F (Warren Dunes) during 1975, while densities at station A (north Cook) remained low. During 1976 just the opposite occurred, high densities were found at station A (north Cook), while low densities were found at stations B (south Cook) and F (Warren Dunes). No plant impact was apparent from examination of the significant factors of the beach ANOVA.

Open Water Zone--Analysis of open water alewife data included 7 yr (1973-1979), 3 mo (June through August), two areas (Cook and Warren Dunes), two depths (6- and 9-m contours) and two diel periods (day and night) (Table 2). Abundance of alewives differed from year to year (P = 0.0000) (Table 4). In the open water more larval alewives were caught during 1974 than any other year. Geometric means of density + 1 were 117.30, 524.76, 212.52, 125.17, 32.26, 5.46, 39.58, respectively for 1973 to 1979 sampling. Even though there was not a high correlation of beach zone alewife larval abundance with open water densities, the larval alewife population does seem to be declining in the Cook Plant study areas. However, this apparent population decline may be the result of sampling schedule rather than true population change.

July was the month of particularly large catches as indicated by the geometric means of the significant Month factor. Examination of the Year x Month interaction revealed yearly deviations from this trend. For example, during 1975, 1976 and 1979, highest densities occurred during July, but during 1974, June and July catches were virtually equal. During 1973, highest catches occurred in June while during 1977 and 1978, August geometric means were highest. Future analyses such as multiple comparison tests should confirm or refute these evaluations.

More larval alewives were generally caught at night than during the day, although in June and July 1977 and August 1978 this was not true; more were caught during the day. In June 1979, no larvae were caught at stations C (6 m, south Cook), D (9 m, north Cook), G (6 m, Warren Dunes) or H (9 m, Warren Dunes). Onset of spawning appears to have occurred in late June during 1979, whereas sampling occurred during mid-June. These variations were undoubtedly the cause of the significant interactions of Year x Time and Year x Month x Time.

Two of the most important factors in evaluating plant impact, Area and Year x Area, were not significant. A third-order interaction involving Area

(Year x Month x Area) was significant, but appeared to be caused by different peak monthly abundances during various years rather than differences between areas during any year.

In summary, the Cook Plant did not seem to have an effect on the distribution of larval alewives in either the beach zone (stations A, north Cook and B, south Cook) or the open water zone [station C (6 m, south Cook) and D (9 m, south Cook)]. Future analysis of variance including station R (6 m, north Cook) might be valuable to confirm these conclusions. Multiple comparison tests should also clarify where significant differences occurred among levels of each significant factor.

Spottail Shiner

Beach Zone--The data set used in the analysis of spottail shiner larvae in the beach zone included 7 yr (1973-1979), 3 mo (June, July, August) and three stations (A, north Cook; B, south Cook and F, Warren Dunes), with duplicate tows taken at each station (Table 2). Only nighttime sampling data were used because daytime samples too often contained no spottail shiner larvae. Nevertheless, zero catches comprised 25% of the night data set.

Densities of spottail shiner larvae in Cook Plant study areas differed significantly among years (Table 5). Geometric mean densities (no./1000 m^3) for 1973-1979 were, respectively, 41, 1142, 518, 177, 41, 36 and 487. These results suggest a highly variable yearly reproductive output in this species. However, it is also possible that our once-a-month sampling efforts sometimes caught and sometimes missed the period of peak abundance of spottail shiner larvae.

The Month factor also was significant. This effect stems from the brief spawning peak in this species, which produces a peak month of larval abundance. Furthermore, the Year x Month interaction term was significant, because the 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, 1977 and 1979.

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

Yellow Perch

Open Water Zone--Because low numbers of perch larvae were caught at most times and places, an ANOVA was performed for only part of the open water yellow perch larval data. For the years considered in this report, 1973 through 1979, only in the last three were larval yellow perch caught in sufficient numbers to analyze with ANOVA. Thus, the data set consisted of 3 yr (1977, 1978, 1979), 1 mo (June), two areas (Cook, Warren Dunes), two depth-stations (6 m, 9 m) and two times (day, night) (Table 2).

Results of the analysis showed one statistically significant factor, Year (Table 6). Geometric mean densities (no./1000 m^3) of yellow perch larvae in June for 1977, 1978 and 1979 were 16, 4 and 2, respectively.

Lack of significance for the factor Area (Cook Plant vs. Warren Dunes) means that for 1977 through 1979 the open water densities of yellow perch larvae did not differ significantly between the treatment and reference area. Thus, we concluded there was no difference in density of perch between Warren Dunes and the Cook Plant, establishing the plant as having no demonstrable effect on perch larval populations.

Rainbow Smelt

Although rainbow smelt larvae often were found in May samples in 1979, they were too scarce to be included in the ANOVAs. The species has been rare every year since 1975 at both beach and open water stations. In 1979 rainbow smelt larvae were not collected in April, peaked in abundance in May, declined steadily through August and were absent thereafter. The highest May densities were at Cook open water stations D (2-m stratum), C (4-m stratum) and beach station B (surface), with 320, 243 and 189, respectively, per 1000 m^3. At Warren Dunes, numbers peaked in June, with 89/1000 m^3 at station H (6-m stratum).

Minor Species

Other species of larvae were captured in small numbers during 1979. These included burbot, johnny darter, fourhorn sculpin and trout-perch. In previous years these species, as well as carp, slimy sculpin, ninespine stickleback, and unidentified members of the sucker, minnow, sculpin and herring families, have been taken during field larvae sampling. Four of the species, trout-perch, carp, burbot and johnny darter, have been taken often enough to show regularities in distribution. The most consistent records are for trout-perch larvae, which were taken at beach station A (north Cook) in each of the 5 yr, 1974-1978. Carp larvae occurred at Cook stations A (0.5 m, north Cook), B (0.5 m, south Cook) and R (6 m, north Cook) in each of the 3 yr starting in 1975, and they were never taken at Warren Dunes. Burbot larvae were found during 2 yr at Cook stations E (21 m), C (6 m) and Warren Dunes station W (21 m). The presence of burbot larvae is surprising, since so few adults are caught in the study area. However, we do not field sample during winter months when burbot would be inshore spawning. Burbot is the only minor species whose larvae have been taken at stations E and W, which are the farthest offshore.

Johnny darter larvae occurred at Warren Dunes station H (9 m) and south Cook station D (9 m) in 1976 and 1977. Fourhorn sculpin larvae were collected in 1978 at Cook station D and in 1979 at Warren Dunes station H. Each of the six other species occurred in 1 yr only during the period 1973-1979.

Distributional records of larvae of minor species showed two differences between Cook Plant and Warren Dunes. First, trout-perch larvae occurred consistently at Cook beach station A, but seldom at Warren Dunes. Whether this is a plant effect is unknown. Second, carp spawned at Cook, but not at Warren Dunes, and we attribute this to the warm-water plume and currents

produced by the discharge structure of the Cook Plant.

FISH LARVAE - ENTRAINMENT

Introduction

Mortality caused by entrainment of fish eggs and larvae in the once-through cooling system at the Cook Plant represents an important biological impact upon Lake Michigan fish populations. Because of this potentially significant influence, we have sought to document species and estimate numbers of fish larvae and eggs entrained at the plant from 1974 to 1979. In this section, we will review estimates for entrained fish larvae and eggs during 1979 and relate these data to those of previous years.

Methods

Species and numbers of larvae and eggs entrained at the Cook Plant have been monitored by standardized sampling since 1974. Samples were collected twice per month, except for June, July and August, when sampling was done once per week to coincide with peak larvae abundance. Samples were collected over a 24-h period. Each period was divided into four divisions (noon-dusk, dusk-midnight, midnight-dawn, dawn-noon) which varied from 4 to 8 h depending on division and hours of sunlight. Sixteen samples (three intake, one discharge) (four samples per division), were collected for each 24-h period. Larvae identifications were to species, if possible, otherwise to the lowest taxonomic group. Fish eggs including fertilized, unfertilized and unviable were counted. When large numbers of eggs were found, estimates were made via a volumetric subsampling technique (see Jude et al. 1979).

Estimates of entrained fish eggs and larvae were determined by pooling data from each 24-h entrainment period and then calculating average density per volume sampled. Next, non-overlapping time intervals (usually 1-2 wk) were established such that the sampling series date was the approximate midpoint of the interval. Entrainment rates were assumed to be similar over the time interval under consideration. Mean densities of larvae and eggs were then multiplied by the maximum condenser service water flow rates for both units (104 m^3/s) over that time interval. Finally, these estimates were totaled for each month and then yearly estimates computed. These estimates represent an expanded mean entrainment rate assuming continuous pumping at maximum rated capacity.

General Trends

Larvae, representing 22 ichthyoplankton categories, have been observed in Cook Plant entrainment samples collected from 1974 to 1979 (Table 7). During that period, 542 million larvae and 11.3 billion eggs were estimated to have been entrained. In 1979, an estimated 204 million fish larvae comprising 12 taxonomic categories and 1.8 billion fish eggs were entrained (Table 8). Alewives comprised 54.9% of all entrained larvae. Remaining species, listed in decreasing order of abundance were: rainbow smelt (4.0%), spottail shiner (3.0%), johnny darter (2.0%), yellow perch (1.2%), trout-perch (0.7%), mottled

sculpin (0.5%), carp (0.4%) and fourhorn sculpin (< 0.1%). Two other groups could not be identified to species: cottids (0.7%) and cyprinids (0.6%). Approximately 32% of all larvae collected could not be identified as a result of their poor condition. Total 1979 entrainment (204 million) was three times greater than the 1974-1978 average (68 million). Total 1979 egg entrainment (1.8 billion) approximated the 1974-1978 average (1.9 billion).

Alewife

Alewife was the most common species entrained during 1979, accounting for 55% (112 million larvae) of the total estimated annual entrainment loss. Alewives appeared in entrainment samples from June to early December 1979. Most (66%) of the estimated larval alewife entrainment occurred during July. Elevated July entrainment estimates were concomitant with peak 1979 alewife abundance in beach and open water larvae collections which also occurred in July. Alewife densities in entrainment and field larvae samples were maximum in July of most years, although some annual fluctuation did occur. Larval alewife entrainment has decreased overall during operational years 1975-1978. The production of a substantial 1979 year class (verified by seining data, but not larval fish data) in combination with full two-unit operation resulted in a substantial increase in alewife entrainment during 1979. A more detailed review of two-unit operation and alewife biology and abundance in the study areas will be necessary to further determine causes and impacts of continued increased alewife entrainment rates.

Rainbow Smelt

The second-most abundant species of larval fish entrained during 1979 was rainbow smelt. Estimated entrainment losses for this species were 8.2 million larvae, representing 4% of the total estimated larval entrainment during 1979 (Table 8). Rainbow smelt entrainment gradually declined from a maximum (9 million) in 1974. However, the 1979 entrainment estimate was second only to the 1974 value. Smelt larvae were present in entrainment samples from May through August 1979 (Table 8). Peak 1979 rainbow smelt abundance in entrainment and field collections occurred in May. Decreases in entrainment rates of smelt larvae from 1974 to 1978 coincided with an overall reduction in adult smelt catches in our study areas. A large 1979 year class (see Adult and Juvenile Fish - Rainbow Smelt) may have contributed substantially to the increased rate of smelt entrainment in that year. Total smelt entrainment for 1979 (8.2 million) was substantially greater than the mean (0.6 million) for operational years 1975-1978.

Spottail Shiner

Spottail shiner, the third-most commonly entrained species, represented 3% (6 million) of the total estimated larval entrainment loss during 1979 (Table 8). Over 19 million spottails have been entrained since 1974. Estimated 1979 spottail shiner entrainment was higher than any other year and was more than twice the 1975-1978 average (2.9 million). Maximum spottail entrainment occurred in May 1979 (Table 8). Increased 1979 abundance of spottail shiners in entrainment samples coincided with increases in field larvae abundance. Elevated entrainment rates were probably associated with the production of a strong 1979 spottail

year class. The spottail population increase appears to be continuing as indicated by large 1980 catches of yearlings. Spottail shiners will probably continue to be entrained at increasing rates.

Johnny Darter

We estimate that almost 6 million johnny darters have been entrained at the Cook Plant since monitoring began in 1974. They were the fourth-most abundant larvae entrained during 1977-1978, but were relatively insignificant from 1975 to 1976 and absent from 1974 samples (Table 7). Johnny darters were entrained from May through August 1979 with June and July months of greatest entrainment (Table 8). An estimated 4 million johnny darter larvae were entrained during 1979 accounting for 2% of annual total estimated entrainment losses. The estimated entrainment rate of johnny darters in 1979 was significantly greater than the 1975-1978 annual mean (0.44 million). As a consequence of two-unit operation, entrainment of johnny darters is expected to continue at these elevated levels in 1980.

Yellow Perch

Yellow perch was the fifth-most abundant species entrained during 1979 by the Cook Plant (Table 8). This species was found in entrainment samples primarily during June, but was also noted in May and July 1979 samples. Just over 1% (2.5 million) of the total estimated 1979 entrainment loss, representing a significant increase over mean annual rates (1.28 million) during operational years 1975-1978, was yellow perch larvae (Table 7).

Trout-perch

The sixth-most common species entrained during 1979 was trout-perch (Table 8). Approximately 1.4 million trout-perch larvae, representing 0.7% of the total 1979 estimated larval entrainment loss were removed by the Cook Plant. Trout-perch larvae persisted in entrainment samples every month from June through October (Table 8).

Trout-perch entrainment was high in 1974, followed by a slow decline through 1978 and a dramatic increase in 1979 to a level near 1974 estimates (Table 7).

Sculpins

Mottled sculpin larvae accounted for 0.5% (0.96 million) of the total estimated fish larvae entrainment during 1979 (Table 8). Mottled sculpin larvae were present only in June 1979 samples. In previous years (1975-1978) all Cottus species were identified as slimy sculpins. Recent improvements in identification and taxonomic procedures have allowed a more definitive treatment of this genus. A review and verification of specimens from previous years will be necessary to correct any misidentification. Undetermined Cottus specimens may be either slimy or mottled sculpins. The poor condition of these larvae did not permit identification to species.

Fourhorn sculpin entrainment rates were estimated from one specimen collected in 1979 and another in 1978 (Table 7). Estimates based upon one specimen per year are questionable at best. This species was apparently entrained in small numbers during 1978 and 1979.

Carp

Carp were present in entrainment samples from June to August during 1979 (Table 8). Carp larvae comprised less than 1% (0.85 million) of the total estimated 1979 fish larvae entrainment loss. Adult carp apparently concentrate around the discharge area in the thermal plume. Entrainment of carp larvae began in 1976 and has fluctuated since then (Table 7). Carp are expected to continue to inhabit the discharge area; thus, carp entrainment will continue at current levels.

Poor condition larvae

Undoubtedly, many of the larvae reported as being in poor condition were alewives. Peak abundance of larvae in poor condition coincided with larval alewife peak abundance. The remaining larvae in poor condition probably represent damaged specimens of other species presented in this report.

Fish eggs

An estimated 1.8 billion fish eggs passed through the Cook Plant during 1979. Fish eggs were entrained from January to October. Peak fish egg entrainment coincided with peak larval entrainment months indicating a short incubation period for most eggs. Eggs found during January and February were probably burbot eggs, however, no burbot larvae were noted in entrainment samples. Reduced sampling effort during these months probably accounts for the absence of this species.

Summary

In 1979, the estimated rate of fish larvae entrainment reached the highest level since monitoring began in 1974. Almost all ichthyoplankton categories experienced dramatic increases. A combination of factors may have contributed to these recent trends. Our 1979 data set was the first in which two-unit maximum pump rates were used. Two-unit operation doubles circulating water volume and hence entrainment rates. Additionally, substantial 1979 year classes of alewives, spottail shiners and smelt probably resulted in their increased abundance in our entrainment samples.

FOREBAY VISUAL INSPECTION

Inspections to monitor presence and behavior of fish in the intake forebay were conducted monthly from January to August 1980 in accordance with technical specifications. No fish were observed during two-unit operation from January to May and during August. The associated increases in water velocities probably reduced fish residence time in the forebay and increased turbulence and surface reflections, limiting our ability to detect fish. However, fish

were observed in June and July when either one or both units were not operating. On 21-22 June and 25-26 June, when only Unit 2 was operating, fish were seen on the Unit 1 side. During both periods, spottail shiners (many infected with fungus) were very abundant on the Unit 1 side. On 21-22 June a few (approximately 10) yellow perch were also seen. One salmonid (species unknown), weighing approximately 2-3 kg, was noted on 25 June. Additionally, during these periods large numbers of unidentified smaller fish were observed. In most instances, all fish appeared to easily maintain their position on the Unit 1 side of the forebay and occasionally moved freely in and out of the trash rack grates. During an inspection on 17 July, when neither unit was operating, we noted approximately 35 dead alewives, 10 dead yellow perch and 2 dead white suckers floating in the forebay. On 15-16 July Cook Plant divers reported a substantial number of dead alewives in the forebay. Also, many live alewives were swimming in the forebay.

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. As a result of time constraints and delay in data processing, only April through August data were treated. These catch data were examined and compared with 1973 to 1979 results. For abundant species, 1980 data were subjectively analyzed to determine if the Year, Area and Year x Area factors in the 1973-1979 ANOVA may change in significance when the 1980 data are added to the ANOVA model. ANOVA was not applied to the 1980 data because September and October data were not available. Statistical analyses were also not performed for common species, but 1980 data were examined for differences and similarities with previous year's results. Comparisons were also made of catches (1975-1980) at stations R and Q (6 and 9 m, north Cook) with catches at standard series stations C and D (6 and 9 m, south Cook) and reference stations 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 and statistical analysis of not only the catch data, but also limnological and meteorological data. These analyses will be treated in future special reports.

Statistical Procedures

Statistical procedures have been previously documented in detail in the 1978 and 1979 Environmental Operating Reports and by Jude et al. (1975, 1979). No changes in these procedures have occurred.

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) (Fig. 1). For details of materials and methods, see

the 1978 Environmental Operating Report and Jude et al. (1975, 1979). No changes in sampling methodology occurred in 1980. Scientific names for common fish names used in this report and abbreviations used in previous reports are given in Table 9.

Abundant Species

Alewife--Alewife has been the most abundant species collected by standard series gear in every year since 1973 (Tables 10-17). Annual catch has varied from 148,451 (1973) to a low of 38,492 (1978). Standard series seines, gill nets and trawls contributed 84%, 6% and 10% to total 1973-1979 alewife catches (Tables 18-41). Data indicate that, except for 1976 and 1979, alewife populations in southeastern Lake Michigan have declined. In both years (1976 and 1979) large fall catches of young-of-the-year alewives contributed substantially to total annual collections. From April to August 1980, 14,499 alewives have been taken in standard series gear with seines, trawls and gill nets accounting for 64.8%, 20.4% and 14.8% respectively of the total catch. The 1980 alewife catch was the third lowest recorded during that period for all years (1973-1980). Unless a large year class is produced, the 1980 catch will follow the long-term decline pattern established for this species. We estimate that the 1980 alewife catch, based on the results of previous year's fall netting, may be as low as 35,000 fish, but will most likely approach 50,000 fish. Occurrence of a large 1980 year class may boost this total to 100,000 fish, but we believe this possibility is unlikely. We have seldom noted record year classes in two consecutive years.

The reduced period (April to August) covered by this report (April to October in previous years) did not allow us to prepare ANOVA comparisons of 1980 catch with previous years. Here, we review 1973-1979 ANOVA results and comment upon the influence that 1980 data may have. A detailed ANOVA comparison will be made after the 1980 data set is complete. The 1973-1979 trawl ANOVA indicated that Year, Month, Depth and Time main effects were highly significant, but Area was not. The significance of the Year main effect was attributed to the characteristic oscillations of alewife year classes. Large catches in 1973, 1976 and 1979 were significant contributors to this main effect. A low 1980 catch will also add to Year effect variability. Month main effect and all two-way Month interactions, except Month x Area, were significant in 1973-1979 ANOVA comparisons. Substantial monthly variations in catch were caused by changes in alewife abundance in nearshore areas as a result of shoreward spawning migrations (March-June), post-spawning departure of adults (July-August) and recruitment of young-of-the-year alewives to our gear (August-October). Trawl Area main effect was not significant in previous ANOVA comparisons, but some differences surfaced in 1980. The mean April to August 1980 trawl catch totals for Cook and Warren Dunes stations were 895 and 747, indicating slightly higher catches at Cook Plant stations. However, an entire annual data set will be necessary to properly evaluate this trend. To date, total 1980 alewife standard series trawl catches (1015 fish) have substantially lagged behind the average annual catch (2148) of operational years (April-August, 1975-1979).

Alewife gill net ANOVA (1973-1979) showed significant main effects for

Year, Month and Time. Significant Year interactions were caused by annual population variations and an overall alewife decline. A reduced 1980 alewife catch will strengthen gill net ANOVA Year effect and Year interactions. Month main effects can be linked to spawning migrations and responses to environmental conditions (e.g., upwellings). Time main effects were probably the result of diel activity differences between young and adult alewives, differential susceptibility to survey gear and fluctuations in population densities. Lack of significant Area and Year x Area interaction suggests that Cook Plant operation has had little effect on alewives sampled by gill net. Preliminary review of 1980 data indicates little significant deviation from these patterns. However, a slightly higher total catch was noted at Warren Dunes (1312) than Cook (1127). The April-August 1980 gill net catch (2836 fish) was below the annual mean for the same period during operational years (3106 fish).

ANOVA for 1973-1979 seine collections indicated significant main effects for all factors except Station and two of its interactions (Station x Time and Month x Station x Time). Contributors to significant Year, Month, Time and their interactions have been previously noted and are discussed in detail in previous reports. The lack of a significant Station main effect suggests that Cook Plant operation does not dramatically affect the alewife population surveyed by beach seines. Again, April-August 1980 seine data do not indicate significant departure from previously established catch patterns. To date, total seine catch has been relatively equal at all beach stations: A (3331), B (2940) and F (2925).

Analyses indicate that the Cook Plant has had no long-term detectable effects on southeastern Lake Michigan alewife populations. Most significant statistical interactions can be associated with the characteristic large annual oscillations in alewife population densities. Additionally, localized responses to the physical environment and biological factors complicate our analyses. Our data indicate that the long-term alewife decline is continuing (across all stations) in 1980. A strong 1979 year class did not significantly elevate total 1980 catch indicating a continuation of population instability for this species.

Bloater--All coregonids (except lake whitefish) under approximately 300 mm could not be accurately identified to species because of recent morphometric changes in Lake Michigan populations and possible hybridization of some species (for further discussion, see Smith 1964; 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*). In past Environmental Operating Reports and Special Reports (Jude et al. 1975, 1979) we titled sections on small coregonids as "Unidentified Coregonids", but in keeping with present practices of other Great Lakes fishery biologists, we will refer to these fish as bloaters.

The bloater population increase in southeastern Lake Michigan, which we first observed in 1978 field catches, was again found in 1980. This recent population increase has resulted in our classifying bloaters as an abundant species in the study area. Total standard series catch for April to August

1980 was 1,981 fish, the second largest bloater catch from 1973 to 1980 (Tables 11-17). The 2054 fish collected in 1979 (April to August only) was the largest catch; lowest catch (47 fish) occurred in 1975. Apparently, the bloater population has stabilized because no increase occurred in 1980, however September to November 1980 data have not been examined yet.

Most bloaters caught from April to August 1980 were yearlings, as they were in 1978 and 1979. However, young-of-the-year are usually collected only from September to November. Lack of a full year's data in 1980 prevents us from speculating on the size of the 1980 year class. The strong year classes of 1977, 1978, 1979 and possibly 1980 probably resulted from decreased fishing mortality because the Lake Michigan commercial chub (coregonids) fishery was closed in 1976. Increased salmonid predation on alewives, a competing species, may have also been a contributing factor in the bloater population increase.

Examination of standard series bloater catches revealed some variation between stations and gear type. Gill net data from 1973 to 1980 showed similar catches among north Cook, south Cook and Warren Dunes stations. Gill net catches also remained similar between all study years (Tables 26-33), even though trawl catches increased dramatically in 1978, 1979 and 1980. Gill nets sampled only larger yearlings and adults, which apparently remain in deeper water. Our data, therefore, are indicative only of yearling and young-of-the-year abundance. Since most bloater spawning occurs in deep water (Wells 1966; Scott and Crossman 1973), our data on young-of-the-year abundance might not be an accurate representation of lake-wide abundance. While gill net data were similar among years and areas, seine and trawl data were not. Bloaters were seined in very low numbers from 1973 to 1978, but a very large young-of-the-year catch occurred in September 1979 at north Cook station A. Cause for this large catch, which did not occur in 1978 when total abundance was high, was undetermined. It may be just a random catch of a school of young bloaters, which is atypical for the study area. September 1980 data were not available for comparison. Trawl data showed considerable variation among years (as previously discussed) and, unlike gill net data, also among areas. Trawl catches were similar at all stations within each year from 1973 to 1977 . However, during 1978 and 1979, when bloaters were abundant, catches were much larger at Warren Dunes compared with Cook stations. In 1980 this area difference was not present at 6-m stations, but the 9-m Warren Dunes catch was almost twice as large as the Cook catch (1099 fish vs. 626). A full year's data may show more differences at 6-m stations. Causes for the lower abundance at Cook are unknown, but it is possible that impingement (large numbers of bloaters were impinged in 1978, 1979 and 1980) at the power plant is depressing the yearling bloater population in the Cook area. Further examination with statistical analyses may help establish causes.

In summary, the bloater population in the study areas increased dramatically in 1978 and 1979, while in 1980 the population appears to have stabilized at 1979 levels. This population change probably reflects a lake-wide increase and is not related to plant operation. However, lower trawl catches in 1978, 1979 and 1980 at the Cook Plant compared with Warren Dunes may be related to operation of the Cook Plant.

Rainbow smelt--Standard series catches from April to August 1980 indicated relatively large populations of rainbow smelt were present in the study areas. Catches (all gear) totalled 9016 smelt, comprising 17.1% of the catch of all species (Table 17). Although smelt remained the third-most abundant species, its percentage of total catch increased significantly from the 4.6% average over the 1973-1979 period (Tables 10-16). Most smelt were taken in trawls (7469 fish, 83% of all smelt caught) with seines contributing a sizeable 16% (1473 fish) (Tables 25 and 41). Only 74 smelt (less than 1%) were taken in gill nets (Table 33).

Standard series trawl catch of smelt for April through August 1980 (7469) was 79% higher than the catch of smelt for the same months in 1979, and approached the peak catches of 1973 (11,599 smelt) and 1978 (8389 smelt). More than half of the 1980 trawl catch was taken in May (4256 smelt), a monthly total exceeded only by the large catches of August 1973 (8273 smelt) and August 1978 (5338 smelt). In fact, the May 1980 standard series trawl catch of smelt exceeded the April-August smelt trawl catches of 1975, 1976 and 1977 combined (4045 smelt).

The smelt trawl catches in August 1973 and August 1978 were dominated by young-of-the-year; 78% of the 1973 catch and 63% of the 1978 catch were 35-44-mm smelt, spawned just months earlier in April or May. The catch in May 1980 was also composed of young fish; 81% were 55-84 mm, spawned in April or May 1979. This year class was evident in the August 1979 trawls, when 97% of the smelt catch were fish ranging from 25 to 44 mm. Even though August 1979 standard series trawl catches totalled only 915 smelt, not nearly as large as August 1973 and August 1978 catches, it is apparent from the abundance of young smelt in May 1980 trawl catches that the 1979 spawning was quite successful. Trawl catches in August 1980 were slightly smaller (748 smelt) than in August 1979, but were also composed primarily of young-of-the-year smelt (74% were between 25 and 54 mm) indicating that the 1980 spawning was successful as well.

The 1973-1979 trawl ANOVA revealed the same significant main effects and interactions as were found in the 1973-1978 ANOVA, and it is most likely that addition of 1980 data will not change those results. Year was a significant main effect, with geometric mean catch declining from a peak of 21.69 in 1973 to a low of 2.68 in 1976. Geometric mean catch of smelt increased from 1976 to 1979 (12.23), and it appears that 1980 mean catch will be as large or larger than 1979. Significant Area main effect was attributed to consistently larger mean catches at Warren Dunes than at Cook Plant stations. Through August 1980, trawl catches at Warren Dunes totalled 3719 smelt, almost equal to the total for comparable Cook Plant stations (3750 smelt). This absence of strong Area effect in 1980 will not be enough to alter the highly significant 1973-1979 Area main effect, but will contribute to the significant Year x Area interaction, because it contrasts with the strong Area difference exhibited by 1973 trawl data. In 1973, geometric mean catches were over twice as large at Warren Dunes (33.01) as at Cook Plant stations (14.25). Overall, the Year x Area and Area effects show a natural preference by smelt for the Warren Dunes area over the Cook Plant area, especially in preoperational years. The strong Year effect, characterized by a preoperational peak abundance with a decline through 1976 and increasing abundance through 1980, is indicative of natural population changes, rather than plant operation.

Seine catches of rainbow smelt through August 1980 were the largest catches since 1973. Monthly totals for May (381 smelt), June (513 smelt) and August (570 smelt) were each larger than the seine catch of smelt in any other month except April 1973 (2388 smelt). However, while the April 1973 catch was dominated by spawning adults (76% of the smelt were 125-164 mm, and only 1% were less than 95 mm), the large catches in 1980 were comprised almost entirely of yearling and young-of-the-year smelt (only 2% of the smelt were greater than 94 mm). Seine catches in May and June 1980 featured smelt spawned the previous year (85% were between 55 and 84 mm), while 570 smelt taken in August 1980 were representatives of the 1980 year class (all were between 25 and 54 mm). The large numbers of young-of-the-year and yearling smelt indicated excellent spawning success in both 1979 and 1980, corroborating trawl data.

ANOVA applied to April and May smelt seine data for 1973-1979 revealed significant Year and Year x Station effects, but no significant main effect due to Stations. Addition of 1980 seine data to ANOVA will produce the same results. Significant Year main effect in seine ANOVA paralleled the result in trawl ANOVA; preoperational peak abundance in 1973 (2482 smelt) with a decline to only 5 smelt taken in 1977 and increasing abundance through 1980. Lack of significant Station main effect indicated that between 1973 and 1979 smelt utilized the beach zone evenly at stations A and B (north and south Cook) and F (Warren Dunes). However, significant Year x Station interaction revealed differential abundance between stations from year to year. April and May seine catches at Warren Dunes station F exceeded catches at Cook Plant stations A and B in 1973, 1974 and 1979; catches at station B exceeded catches at the other two stations in 1976, 1977 and 1978. Station A catches were the largest observed at the three stations in 1975 and 1980. These fluctuations in abundance between stations over the years appear to be unrelated to plant operations, and are most likely the result of natural shifts of abundance and patchy distribution of smelt in the beach zone at any one time.

In contrast to the increase in smelt abundance revealed by seine and trawl data, gill net smelt catches for April through August 1980 indicated fewer smelt in study areas. However, trawl and seine catches were dominated by young smelt in a size range (less than 95 mm) which is not very susceptible to capture in gill nets. Thus, gill net catches pertain to the abundance of larger smelt and do not reflect the abundance of young smelt in the study areas.

From April through August 1980, only 74 rainbow smelt were taken in standard series gill nets. This was a decline to 48% of the catch for comparable months of 1979 (153 smelt). Only in 1975 and 1977 were less smelt gilled (36 and 42 smelt, respectively). However, the low numbers of smelt taken in standard series gill nets in 1980 are balanced by larger catches of smelt at stations Q (9 m, north Cook) and R (6 m, north Cook). From April through August, 95 smelt were gilled at station Q and 23 smelt at station R. The largest catch of smelt at a standard series gill net station was 27 smelt at station H (9 m, Warren Dunes). Thus, the apparent decline in abundance of large smelt from 1979 to 1980 may actually be a shift in spatial distribution instead. If we combine the gill net catches at Q and R with the standard series catches (stations C, D, G and H) for April through August, the 1980 catch (192 smelt) is nearly as large

as the 1979 catch (222 smelt) at stations C, D, G, H, Q and R, indicating no substantial change in abundance of adult smelt from 1979 to 1980. The shift in spatial distribution between 1979 (when smelt gill net catch was evenly apportioned to north Cook, south Cook and Warren Dunes stations) and 1980 (when catches at north Cook stations exceeded catches at south Cook and Warren Dunes stations) is probably the result of natural changes in smelt distribution similar to those observed for seined smelt over the years.

In summary, 1980 trawl and seine catches revealed increased abundance of young-of-the-year and yearling smelt, indicating that 1979 and 1980 spawnings were quite successful, which continued a trend of increasing smelt abundance since 1976-1977. Numbers of adult smelt taken in standard series gill nets and at stations R and Q in 1980 were comparable to numbers of smelt gilled in 1979. Some differences in spatial distribution of smelt in the study areas were noted. More smelt were gillnetted at north Cook Plant stations than at south Cook or Warren Dunes stations, in contrast to a more homogeneous distribution in 1979. Trawl catches at standard series Cook Plant stations were slightly larger, but comparable to catches at Warren Dunes stations, in contrast to the marked preference by smelt for Warren Dunes stations in preoperational years. Seine catches in 1980 were largest at north Cook Plant station A and smallest at Warren Dunes station F, a reversal of the pattern exhibited by 1979 seine catches. These changes in spatial distribution of smelt over the years appear to be unrelated to plant operation, and are most likely due to natural shifts in smelt abundance and patchy distribution of smelt in the study areas.

Spottail Shiners—Spottail shiner has been the second-most abundant species collected in every survey year from 1973 to 1979 (Tables 10-16). During that period, standard series seines, trawls and gill nets accounted for 70%, 21%, and 9% of annual spottail catches (Tables 18-40). Annual standard series catches have ranged from 14,115 (1976) to 30,399 (1977). Spottails were taken in standard series nets and impinged in almost every month. Larvae were collected in both field and entrainment samples from June to October in most years. Jude et al. (1975, 1979) reviewed spottail biology in our study areas.

From April to August 1980, 20,754 spottails were collected in our standard series gear; 69.7% in seines, 20.8% in trawls and 9.5% in gill nets (Tables 17, 25, 33 and 41). Catches during the same months in operational years (1975-1979) ranged from 11,871 (1976) to 23,323 (1977) and comprised from 61% to 84.7% of total annual spottail catches. The April-August 1980 catch was the third largest for that period since monitoring began in 1973. If fall 1980 spottail catches mirror those of other operational years, 1980 spottail collections may be the second or third largest since monitoring began in 1973, approaching a total 1980 standard series catch of 25,000-30,000 fish. To date, spottails have been the most abundant species taken in 1980, but we expect that large catches of young-of-the-year alewives in September and October will allow that species to reclaim its most abundant status. A number of factors contributed to this year's substantial projected spottail catch. A strong 1977 year class is now appearing as adults. A large 1979 year class entered our catch in early summer. If a strong 1980 year class is produced, it should be recruited to our gear in September and October and contribute significantly to the 1980 spottail catch.

Statistical comparisons of spottail catches from 1973 to 1979 were presented in the 1978 and 1979 Environmental Operating Reports. We will briefly review those results and comment on the effect of 1980 catches. Gill net and trawl ANOVA yielded similar results for spottail catch comparisons from 1973 to 1979. Significant main effects were found for Year, Month, Depth and Time. Significant Year effects were the result of large or small catches caused by the highly variable year class strength of this species. The April-August 1980 trawl (5178 fish) and gill net (3767 fish) catches were the largest on record since monitoring began in 1973. The large 1980 total catch will strengthen the significance of the Year main effect. Catch distributions producing significant Month, Depth and Time main effects with significant first- and second-order interactions, upon preliminary analysis, appear to be continuing in 1980. Month and depth interactions are probably caused by the seasonal behavioral patterns of spottail shiners, including large-scale inshore spawning migrations of adults and their subsequent exodus from our study areas in late summer and recuitment of young-of-the-year to our gear in the fall. Significant main effects for Time, or differences in diel catch patterns, are associated with the relative frequency of either adults or immature fish in our catch. For example, in June 1977, when 93% of our standard series catch was comprised of sexually mature spottails, 61% were caught at night. In August, however, when most (85%) spottails were immature, 83% of our total standard series spottail catch was taken during day sampling. Thus, the ratio of adult to immature fish can strongly influence Time main effects and interactions.

Month was the only significant main effect in our 1973-1979 seine ANOVA. Again, spottail biology is the primary source of this variation. Lack of significant interaction in Year (preoperational vs. operational) or Station in seine ANOVA from 1973 to 1979 indicates that spottail shiners in the beach zone were not dramatically influenced by plant operation during those years. To date, the 1980 spottail seine catch differs somewhat from that of previous operational years. Cook Plant stations A (4464 fish) and B (4420 fish) have contributed substantially more to the total seine catch than Warren Dunes station F (2925 fish). If this trend persists, it may add variability and increase the significance of seine Station main effect. However, an entire annual data set is needed to more closely define any population shift.

The 1980 spottail standard series catch, projected to be substantial, followed overall trends established during previous years. A more definitive statistical treatment of 1980 data will be done. In summary, spottail shiner populations in our southeastern Lake Michigan study areas appear robust. They periodically produce large year classes (1977, 1979 and possibly 1980) which will maintain spottail catches at high levels for the next several years. Rather than any effect of plant operation, year class variability and the behavioral characteristics of this species appear to be the main reasons for spottail distributional patterns.

Trout-perch—Trout-perch were taken in every month of standard series sampling in 1980 through August. Although twice as many trout-perch were taken from April to August 1980 (1892 fish) as from the corresponding period in 1979 (922 fish), trout-perch remained the sixth-most abundant species in standard series samples (Tables 10-17). Trawl catches comprised most (89%) of the trout-perch

trout-perch). Gill net ANOVA for 1973-1979 data indicated no significant differences among mean catches of the 6 yr, and it is apparent that 1980 will not cause a significant Year effect.

Both the main effect Month and the Year x Month interaction were highly significant in the 1973-1978 and 1973-1979 ANOVAs. Addition of 1980 data to the analysis will maintain these results. Monthly catches in 1980 resemble the patterns of 1975 and 1978, with moderate catches in May, June and August and very low catches in July. This is in contrast to the pattern observed in other years, when peak catches occurred in July. Differences in seasonal catches between years typically result from varying temperature patterns and occasional upwellings.

The Year x Area interaction was significant for the first time when 1979 gill net data were incorporated into ANOVA. This occurred because Cook Plant catches (84 trout-perch) exceeded Warren Dunes catches (52 trout-perch) for the first time in 1979. The same trend continued through August 1980, with 35 trout-perch taken at stations C (6 m, Cook) and D (9 m, Cook), and only 25 trout-perch gilled at Warren Dunes stations G (6 m) and H (9 m). Since Year and Area main effects were not significant in 1973-1979 ANOVA, the Year x Area interaction appears to represent a true shift in preference by trout-perch for the Cook Plant area over Warren Dunes in 1979 and 1980.

Peak seine catches of trout-perch in 1980 occurred during May sampling at beach stations. Average catches occurred in other months. May seine samples yielded 116 trout-perch, which was larger than the yield of any other month since the start of seine sampling in 1973, and even larger than the entire annual seine catch for any year except 1977. About 48% of the catch was taken at station B (south Cook), the rest split almost evenly between stations A (north Cook) and F (Warren Dunes). Most fish were between 75 mm and 134 mm in length, which was comparable to the length frequencies exhibited by fish from the two next-highest monthly catches (99 trout-perch in June 1977, 91 trout-perch in September 1977).

Data for 1980 seine catches of trout-perch will reinforce the highly significant Year, Month and Year x Month effects appearing in 1973-1979 ANOVA. These effects are a result of natural population fluctuations and varying use of the shoreline zone by trout-perch as seasonal weather patterns change from year to year. Seine catches peaked in 1973, 1977 and in 1980, a pattern which was very similar to trawl catch fluctuations. Year and Year x Station effects were not significant in the 1973-1979 ANOVA, and 1980 data revealed a relatively homogenous distribution of trout-perch across the three beach stations. This is a clear indication that plant operation is not affecting trout-perch use of the shoreline zone.

Overall, trout-perch catch data for 1980 were consistent with patterns established from the 1973-1979 ANOVA. Trawls and seines contained relatively large catches, portending a peak year for trout-perch populations in 1980. Previous peaks occurred in 1973 and 1977-1978, with trout-perch exhibiting a cycle of population abundance unrelated to plant operation. Mean annual gill net catches (1973-1979) were not significantly different. Seine data (all

total catch, with seines and gill nets contributing 8% and 3%, respectively (Tables 18-41). Nocturnal behavior preference of trout-perch was evident in catches from all field gear; 92% of the standard series catch was taken at night.

Standard series trawl catches revealed the presence of relatively large populations of trout-perch in the study areas. Compared to corresponding periods of previous years (1973-1979), trout-perch catches in May and August 1980 were the largest ever, exceeding the next highest catches by 106% and 32%, respectively. June catches were also exceptionally large (317 trout-perch), exceeding by over 50% the June catches of all other years except 1973. July catches were somewhat below average, but the total trawl catch from April to August was third largest (following 1973 and 1977) of all years.

The total trawl catch of trout-perch from June to October of each year fell from a peak of 3034 fish in 1973 to a low of 542 fish in 1975, rising again to a peak in 1978 (2843 fish). Catch declined in 1979, (1456 trout-perch). These fluctuations in annual catch resulted in a highly significant Year main effect in the 1973-1979 ANOVA. Data through August suggest that 1980 will produce an above-average trawl catch of trout-perch, and that Year will remain a significant main effect when 1980 data are incorporated into ANOVA.

Cook Plant trawl catches yielded slightly more trout-perch than Warren Dunes catches in 1980. For all previous years except 1975, Warren Dunes catches exceeded Cook Plant catches, resulting in a highly significant Area main effect in the 1973-1979 ANOVA. Area should remain a significant main effect in 1973-1980 ANOVA; the difference between Cook Plant and Warren Dunes trout-perch trawl catches in 1980 is too small to counteract the 1973-1979 Area effect. However, 1980 data may contribute to a significant Year x Area interaction. This interaction was close to significance ($P = 0.0206$) in the 1973-1979 ANOVA. If significant, the Year x Area interaction would indicate a true shift in relative abundance of trout-perch in two Areas over the 1973-1980 study period. Note that the overall pattern appears to be a larger population of trout-perch in the Warren Dunes sampling area, with a slight shift of abundance to the Cook Plant area in 1975 and again in 1980. This pattern, coupled with significant Year effect, is probably indicative of natural population fluctuations, rather than any consistent effect of plant operation.

Incorporation of 1980 data in ANOVA with 1973-1979 data should not reduce the highly significant main effects Month, Depth and Time. These main effects and interactions involving them are due to natural trout-perch behavior patterns, seasonal fluctuations in abundance and responses of fish to such phenomena as upwellings and storms. Specific examples were discussed in the 1978 Environmental Operation Report. These effects appear to be unrelated to plant operation.

Standard series gill net catches of trout-perch through August 1980 were similar to, but slightly smaller than catches in recent years. From 1976 through 1979, trout-perch gill net catches during May through August ranged from 64 to 85 fish; whereas, 60 trout-perch were gilled May through August 1980. Larger catches occurred in preoperational years 1973 and 1974 (202 and 180 trout-perch, respectively) and the lowest May-August catch occurred in 1975 (36

years) indicated trout-perch use of the beach zone did not vary between Cook Plant and Warren Dunes stations. However, for both trawls and gill nets, Cook Plant catches exceeded Warren Dunes catches in 1980. While this represents a change from the pattern of previous years for both gear, there are inconsistencies. Trawl ANOVA for 1973-1979 exhibited a highly significant Area effect, as Warren Dunes catches exceeded Cook Plant catches most of those years. But 1973-1979 gill net ANOVA revealed no significant difference between Warren Dunes and Cook Plant catches. Further, the Year x Area interaction was significant in 1973-1979 gill net ANOVA, but not significant in the trawl ANOVA. It is unclear whether 1980 trawl data will produce a significant Year x Area interaction in the 1973-1980 ANOVA, although it is likely that the interaction will at least be close to significance. Considering the differences between trawl and gill net Area effects and the pattern of annual fluctuations in trout-perch abundance since 1973, the subtle differences between Cook Plant and Warren Dunes trawl and gill net catches in 1980 probably reflect natural changes in trout-perch populations in southeastern Lake Michigan, rather than effects of plant operation.

Yellow Perch—The total standard series catch of yellow perch (3917 fish) from April to August 1980 was considerably above the 8-yr average catch (2702 fish) for April to August 1973-1980 (Tables 10-17). Only the 1974 catch (3968 fish) was greater than the 1980 catch. The 1980 trawl catch (1358 fish) was more than twice as large as the 8-yr average of 675 fish and the 1980 seine catch (1887 fish) was also greater than the 8-yr average of 1307 fish (Tables 18-41). In contrast, the gill net catch of 675 fish was near the 8-yr average of 732 fish (Tables 26-33). Many yearlings and young-of-the-year trawled in August and numerous yearlings seined in July accounted for the increased 1980 catch. As in all previous study years, strong and weak year classes explained most of the variation in yearly catch. The 1979 year class was exceptionally large and contributed to large catches in 1979 and, as yearlings, in 1980. Large seine catches of young-of-the-year indicate that the 1980 year class may also be strong.

ANOVA applied to 1973-1979 trawl data revealed Year, Month and Time to be highly significant sources of variation; however, Area and Depth main effects and the Year x Area interaction were not significant. Due to time constraints and delay in data processing, the 1980 data could not be added to the ANOVA model for this report. However, the April to August 1980 data were examined and will be discussed as they relate to the 1973-1979 ANOVA.

It appears that 1980 trawl data will not change the significance of any main effect in the 1973-1979 trawl ANOVA. The large catch in 1980 shows there still is considerable year-to-year variation in abundance of the perch population. As we explained in the 1978 and 1979 Environmental Operating Reports, the yearly variation is the result of natural population changes in year class strength and not a result of plant operation. Lack of significance between Area mean catches adds to this conclusion. However, the Year x Area interaction (attained significance level = 0.0234) was close to being significant at α = 0.01. (In the 1979 Environmental Operating Report - Table 29 showed the Year x Area interaction to be at the 0.0075 significance level, but this was an error. Corrected data changed the level to 0.0234, which was not significant; other factors in the corrected ANOVA did not change significance at α = 0.01.) Trawl

data for April to August 1980 showed more fish caught at Warren Dunes than at Cook. If this trend continues through the rest of 1980 the Year x Area interaction in the 1973-1980 ANOVA may become significant. Since a larger catch at Warren Dunes also occurred in preoperational year 1973, this area difference does not appear to be a plant effect. But we can not as yet definitively say whether this is a plant effect due to two-unit operation or the result of natural population changes.

ANOVA applied to 1973-1979 seine data showed the main effects of Year, Month and Time to be highly significant, but Station was not. Addition of 1980 data will probably not change these findings. Our conclusion in the 1979 Environmental Operating Report, that examination of terms involving Year in the 1973-1979 ANOVA did not show any preoperational/operational trends that could be ascribed to plant operation, will probably be valid for 1973-1980 data. The large catch in 1980 will continue to cause Year to be a highly significant main effect. This significant variation was caused by strong and weak year classes resulting from natural population changes. Examination of the Year x Station interaction, which was significant in the 1973-1979 ANOVA, showed abundance to be greatest at either Cook station A or B in any given year (especially B in preoperational years), but never greatest at Warren Dunes station F. Contrary to these findings, April to August 1980 catches were largest at station F. This reversal in the distributional trends will probably cause the Year x Station interaction in the 1973-1980 ANOVA to continue to be significant at $\alpha = 0.01$ (significance level was 0.0048 in the 1973-1979 ANOVA). Whether this change is a result of two-unit operation or a result of natural causes remains unknown.

It is difficult to determine whether addition of 1980 gill net data will change the significance of main factors in the gill net ANOVA model. Year, Month and Depth factors will probably not change, but Area and Time factors could change. Regarding plant operation effects, the 1980 data may change some of the conclusions made in the 1979 Environmental Operating Report. In that report, we believed that the plant's plume and riprap were attracting larger perch to the plant area. Although not significant, the Year x Area interaction did show a possible trend of greater abundance at the Cook area in operational years. While 1980 catches were larger at the 9-m Cook station than at the 9-m Warren Dunes station, 6-m station catches were greater at Warren Dunes. This confounds our earlier conclusion and may indicate the assumed trend observed in 1973-1979 data was not a result of plant operation. However, the possibility exists that larger perch are still attracted to the Cook area, but impingement losses are beginning to depress the population at Cook. More thorough examination of a full year's data coupled with the 1973-1980 ANOVA may help define the causes.

Total gill net catches of yellow 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 1980. This finding was similar to 1975-1979 data conclusions. As in most previous operational years, total catch at 9-m Warren Dunes station H was lower than at 9-m Cook stations D and Q. However, unlike all other operational years, the gill net catch at 6-m Warren Dunes station G was higher than at 6-m Cook stations R and C. The trawl catch of yellow perch at station R was similar to the catch at station C and both were less than the 6-m Warren Dunes station in 1980.

In conclusion, 1980 catch data on yellow perch showed the study area population to be high compared to most previous study years. Many yearlings and young-of-the-year were caught in 1980 demonstrating that the 1979 and probably 1980 year classes were strong in numbers. Trawl and seine data when added to the ANOVA model will probably not change any of our previous conclusions about lack of acute plant effects on the younger individuals of the perch population. Gill net data, which in previous years showed a plume and riprap attraction of larger perch to the Cook area compared with Warren Dunes, were confounded in 1980. At 6-m stations more fish were gillnetted at Warren Dunes, while at 9-m stations more were gillnetted at Cook.

Common Species

Brown Trout—Brown trout were collected in our Lake Michigan study areas in every year since 1973. Annual standard series catches ranged from 26 (1975) to 162 fish (1978) (Tables 10-17). The large 1978 catch was caused by a substantial seine catch (mostly juveniles) at station B (south Cook) in April. From 1973 to 1979 most brown trout were caught in seines (61%) and gill nets (38%). Catches were divided evenly between day (54.2%) and night (45.8%) sampling periods. During operational years (1975-1979), mean annual catches at all 6-m stations (C, G and R) were greater (35.8 fish) than at 9-m stations (D, H and Q; 20.2 fish). There were no obvious differences among Cook and Warren Dunes stations. Annual catch fluctuations have occurred simultaneously at both Cook and Warren Dunes. The April-August 1980 standard series catch (35 fish) was similar to the mean annual catch (36 fish) of similar periods during other operational years (1975-1979). In summary, there have been no detectable Cook Plant influences on the brown trout population surveyed by our gear. Most catch variation can be attributed to natural population variability, seasonal behavior patterns and differential annual stocking efforts.

Carp—Numbers of carp netted at Cook Plant stations increased during operational years, while numbers netted at Warren Dunes stations were static. Mean annual catches at Cook Plant stations during operational years 1975-1979 were more than double those of preoperational years (Tables 10-16). Preoperational and operational standard series data through 1979 showed similar numbers of carp were seined, but a large increase in the number gillnetted occurred, from a mean of 10 per year to a mean of 42.4 (Tables 18-32). This change presumably shows that the additional carp present during operational years occupied open water, not the beach zone. Carp caught in gill nets in operational years were similar in body length (400-750 mm) to those caught in preoperational years. Numbers of carp caught in trawls remained constant and low through both preoperational and operational years (Tables 34-41).

Comparison of 6- and 9-m stations at the Cook Plant through August 1980 showed that 6-m station gill nets consistently collected more carp (166 carp at station C and 110 carp at station R) than did 9-m stations (70 carp at station D and 44 carp at station Q). We feel these differences were the result of carp being attracted to the warm water and currents of the discharge plume. Numbers of carp gillnetted in the same period at stations G (6 m) and H (9 m) at Warren Dunes were similar, but small (9 at G and 7 at H).

Carp larvae were not observed in the Cook Plant area during preoperational

years, but they have been common in field and entrainment samples during operational years. Carp larvae were undetected in the Warren Dunes area through 1979. We suspect the warm-water plume and possible currents produced by the intake and discharge of water at the Cook Plant promoted spawning in that area. Evidence that carp are attracted to the intake and discharge structures and the surrounding riprap was supplied by SCUBA divers, who saw carp schooling in those areas (Dorr and Miller 1975). Rarity of juvenile fish (under 400 mm) and abundance of adults in field samples suggest that the Cook Plant vicinity is not a carp nursery, but that carp frequent the area as adults.

Chinook Salmon—Chinook salmon, while not an abundant species, was regularly netted in Cook Plant study areas (Tables 10-41). During this study chinook salmon have comprised an average of only 0.09% of the number of fish netted, but occasionally have represented considerable biomass in the catches. Chinook salmon were taken throughout the year, with the largest catch occurring in spring (April-June) or fall (September-October). They were taken almost exclusively in seines and gill nets.

Numbers of chinook salmon netted at standard series stations have been greater in each of the years 1978 through 1980 than in 1973-1977. The increases have been similar at all stations and therefore do not suggest a plant effect. It may be related to increased plantings of chinook salmon in the St. Joseph River by the Michigan Department of Natural Resources. Nearly all of the increase has been in beach seine catches at stations A (north Cook), B (south Cook) and F (warren Dunes), and involves fish less than 200 mm. Paralleling this beach seine catch increase is a greater variation in catches among years and stations in 1978-1980. For example, in June 1980 station A yielded 140 chinook salmon, the largest catch ever in 1 mo at a single station. Yet in all of 1978 station A yielded no chinook salmon. The reasons for this variation are unknown, but it may reflect a patchy distribution of chinook salmon at beach stations. Stations in deeper water have had more consistent catches.

Comparison of gill net catches of chinook salmon at north Cook stations Q and R with those at south Cook stations C and D and Warren Dunes stations G and H showed a general similarity in both numbers and seasonal distribution. The comparisons are for 1978-1980 only, as catches for individual stations and months in previous years were too small to show trends clearly. The overall similarity in gill net catch data among stations suggests that the thermal plume from the Cook Plant had no effect on chinook salmon abundance.

Coho Salmon—Coho salmon represented an average of 0.11% of the number of fish sampled from 1973 to 1980 (Tables 10-17). Coho salmon were collected mainly in spring and fall, with largest catches in spring. Coho rarely were taken in summer except during upwellings, when fish moved inshore with cold hypolimnetic water. Coho salmon were collected almost exclusively in seines (62%) and gill nets (38%), with trawl catches accounting for less than 1% (two fish) (Tables 18-41).

The number of coho salmon taken in standard series nets was similar in preoperational and operational years and at Cook Plant and Warren Dunes

stations. Catches varied among years by a factor of 10, with the largest annual catches typically including exceptionally large beach seine catches in a single month. For example, the 1977 catch of 96 fish included 83 fish in May from the three beach seining stations and the 1978 catch of 301 fish included 220 fish in June from those same stations. Almost all fish in large seine catches were juveniles. Thus, they were probably stocked locally by the Indiana or Michigan Department of Natural Resources.

Comparison of coho salmon catches at standard series gillnetting stations demonstrated no differences between stations within or among years, though the samples were too small to show trends clearly. Catches at gillnetting stations Q (9 m, north Cook) and R (6 m, north Cook) were like those at standard series gillnetting stations of equal depth within and among years. Thus, we found no changes in coho salmon abundance or distribution attributable to plant operation.

Emerald Shiner--Emerald shiners are collected infrequently in our southeastern Lake Michigan study areas. Only 112 have been taken since monitoring began in 1973 (Tables 10-17). Average annual catch has been 12; none were caught in 1976 and none have yet been taken in 1980. Emerald shiners were collected only by seining and were most abundant at Cook Plant stations A (24%) and B (68%) in all survey years. Only 8% of the total catch since 1973 has been collected at Warren Dunes. Most (76%) emerald shiners were found in day seine catches.

Localized emerald shiner populations are characterized by instability, often producing substantial annual fluctuations. This species usually remains offshore during most of the year, moving inshore during late summer and fall where they congregate around nearshore structures (Fuchs 1967; Scott and Crossman 1973). Since 1973, over 70% of our emerald shiner catch has been taken from July to November. The relatively large catch in 1973 (49) may have been related to the presence of a safe harbor built during the early stages of plant construction. Reduced emerald shiner population levels have been noted lakewide since the early 1960s (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.

Gizzard Shad--Gizzard shad catches for 1973 through 1979 were discussed in detail in the 1979 Environmental Operating Report and will be briefly summarized here. Gizzard shad have been netted consistently, though not abundantly, in Cook Plant study areas (Table 10-17). Except for 1976, shad have been more common in the Cook Plant area than the reference area since the plant began operation. Number of shad caught each year ranged from a low of 23 fish in 1973 to a high of 193 fish in 1975. From 1973 through 1975, most of the annual catch of gizzard shad were seined young-of-the-year or yearlings; since 1976, most shad have been gillnetted adults. We feel this population change is due to the attraction of adult gizzard shad to the thermal plume, discharge currents and possibly to *Cladophora* growth on the intake and discharge structures and riprap. This assumption is based on consistently larger gill net catches of gizzard shad at Cook Plant 9-m stations than at Warren Dunes 9-m stations. At 6-m stations, more shad were also netted at

Cook between 1976 and 1978, though Cook and Warren Dunes catches were similar in 1975 and 1979 at this depth. Number of gizzard shad impinged by the plant fluctuated from year to year, but more shad were always impinged each year than were caught in the field, further suggesting a population closely associated with the riprap and structures. Because most gizzard shad are caught September-November and these months have not yet been analyzed for 1980, conclusions about 1980 abundance of gizzard shad in the study areas must be deferred.

Johnny Darter--The January to August 1980 standard series catch of 143 johnny darters (Table 17) was somewhat below the average 1973-1980 catch (194 fish). The 1980 trawl catch of 142 fish (Table 41) was also smaller than the 8-yr average of 183 fish. These smaller catches do not appear to be related to plant operation. However, because the January to August 1979 catch (164 fish) was also small, the 2-yr decline may be the result of two-unit operation in 1979 and 1980. A thorough analysis of a full year's data and possibly another year's data will be needed to substantiate this conclusion. A very small catch (64 fish) occurred in one-unit operational year 1975 (January to August) and another small catch (166 fish) occurred in preoperational year 1973. Largest catch (321 fish) occurred in 1977. We concluded that 1980 field catch data compared with previous years' data did not reveal any substantial changes or trends which could be directly attributed to power plant operation.

Examination of 1980 trawl catch data from each station showed more johnny darters at the Cook area than at Warren Dunes which was also found in all previous study years. The 1980 trawl catches at station R (6 m, north Cook) were similar to those at station C (6 m, south Cook), but greater than at station G (6 m, Warren Dunes). As we stated in the 1979 Environmental Operating Report, greater abundance at the Cook area may be the result of darter attraction to the riprap around the discharge and intake structures.

Trawl catches from January to August 1980 showed greater abundance of darters at night than during the day (129 fish caught at night, 13 during the day). This finding is consistent with trawl results from all previous study years. Also similar to previous years' data was the small seine catch (one fish) in 1980 and the zero catch in gill nets. These data demonstrate darter avoidance of beach waters and the inefficiency of gill nets in capturing darters.

In summary, catch data for January to August 1980 revealed no substantial changes from previous operational and preoperational year's data. This leads us to a tentative conclusion of no plant effects on the johnny darter population sampled by field gear in 1980. Thorough analysis of a full year's data will help substantiate this conclusion.

Lake Sturgeon--Lake sturgeon was not a commonly caught species during our studies, but because it is a threatened species in Lake Michigan, we will discuss it here. Five sturgeons were gillnetted during standard series fishing from 1973 to 1978; none were collected in 1979 or in 1980 (April through August). Most caught were released alive. No effect of plant operation on lake sturgeon numbers was discernible.

Lake Trout--Lake trout represented an average of 0.13% of the total catch over the course of the study. They were caught almost exclusively in gill nets (94%), and only rarely in seines (3%) and trawls (3%). While lake trout were taken throughout the year, they were collected in greatest numbers from September through November (Tables 10-17), the period in which they come inshore to spawn. Therefore, very little can be said about 1980 catch results because only April through August data were available for analysis.

Numbers of lake trout collected annually varied over the study period, with lowest abundance in 1975 and 1976. However, because these variations were observed at both Cook and Warren Dunes stations, the fluctuations were not attributed to plant operation.

Lake trout gill net catches generally were 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, south of the plant. Thus, the thermal plume apparently had no effect on numbers of lake trout collected in the area.

Longnose Dace--Data collected from April to August 1980 indicate that longnose dace population levels in our study areas remained low, accounting for only 0.02% of our standard series catch (Tables 10-17). Eight fish were collected in 1980, six from Cook stations and two from Warren Dunes stations. All fish collected during standard series netting from 1973 to 1980 were taken by seine, except for one fish collected by trawl (station H, 9 m - Warren Dunes) in 1977. Most (85.2%) of our longnose dace collections were made at night. During our preoperational survey (1973-1974) mean annual catches at Cook (two stations) and Warren Dunes (one station) were 19 and 3 fish, respectively. From 1975 to 1978 these catches averaged 14 fish per year at Cook stations and 5 at Warren Dunes. In 1979 mean catches at Cook and Warren Dunes stations were 2 and 2, respectively. Catch declines, especially at Cook, appear to be continuing in 1980.

The proclivity of longnose dace for Cook Plant stations may be related to the occurrence of some gravel bottom sediments in this area (Seibel et al. 1974). Gravel is the preferred substrate of this species (Brazo et al. 1978; Scott and Crossman 1973). Few longnose dace were impinged during plant operation from 1975 to August 1980 and larvae have not yet been identified in entrainment samples. Thus, plant operation has apparently had minimal direct impact upon this species. Recent catch declines probably indicate localized population instability or signal a reduction of preferred habitat in this area of Lake Michigan.

Longnose Sucker--Field catches of longnose suckers from 1973 to 1979 showed a relatively stable population inhabits the study area (Tables 10-16). The addition of 1980 data did not indicate any substantial changes in the sucker population (Table 17). Total catch from April to August 1980 was 31 fish which was somewhat below the 8-yr average (April to August catches only) of 48 fish. No trends (e.g., a continual decline in abundance) were evident in catches from preoperational years compared with operational years or in

catches from one-unit operational years compared with two-unit operational years.

The longnose sucker gill net catch at Warren Dunes was greater than the gill net catch at either north or south Cook areas in 1980. Greater abundance at Warren Dunes was also found during all preoperational years and during operational years 1977-1979 (abundance was less at Warren Dunes in 1975 and 1976). White suckers were also found to be more abundant at Warren Dunes during all study years reflecting a preference of both sucker species for the Warren Dunes area. In summary, plant operation did not appear to influence longnose sucker abundance or distribution as evidenced from January to August 1980 field catches.

Ninespine Stickleback--Standard series catches of ninespine sticklebacks were higher during preoperational years and the first year of plant operation, 1975, but lower from 1976 through 1980 (Tables 10-17). Mean annual catches were about three times as large in the early period as in the later period. Because the decline was similar at Cook Plant and Warren Dunes stations, we attributed it to natural causes, not to plant operation. The amount of decline differed among stations, but since no station has produced more than four ninespine sticklebacks in any year after 1975, the samples seem too small to allow further analysis.

Northern Pike--No northern pike were collected by standard series netting from April to August 1980. Only 58 have been caught in standard series gear since 1973 (Tables 10-16). When all survey years are combined (1973-August 1980), approximately 30% of the total northern pike catch was taken from January to August. Since 1973, northern pike catches have declined substantially. In preoperational years (1973-1974) 46 fish were collected by standard series netting; 35 by gill nets, 8 by seines and 3 by trawls. Only 12 were taken from 1975 to August 1980, 6 each in gill nets and seines. These catch reductions occurred at Cook and Warren Dunes stations simultaneously and suggest that the decline has occurred at both study areas and is not a result of Cook Plant operation.

Rainbow Trout--Rainbow trout have been collected in every survey year since 1973 (Tables 10-17). The annual standard series catch (1974-1979, mean = 14) has been remarkably consistent with the exception of a large 1973 catch (86). Most rainbow trout were collected in seines (90.0%) and a few in gill nets (9.4%). Only one trout (juvenile) was collected in a trawl. No consistent differences in rainbow trout catches by station or gear type have occurred in either preoperational (1973-1974) or operational years (1975-1980). Only three rainbow trout were collected from January to August 1980. In most previous years a majority of the annual standard series trout catch has been collected by August.

Comparison of preoperational and operational years indicates that the rainbow trout population in the vicinity of the Cook Plant has remained relatively constant with infrequent catch increases (1973) and declines (1980). We suggest that these occasional fluctuations are not directly attributable to plant operation, but are probably the result of the infrequent occurrence of salmonids in our study areas. Additionally, significant annual fluctuations

in abundance may be the result of differential stocking efforts and the associated variation of individual year classes.

Slimy Sculpin--The April to August 1980 standard series catch of 50 slimy sculpins was somewhat below the 8-yr (1973-1980) average of 81 fish (Tables 10-17). Highest April to August catch (231 fish) occurred in 1974, lowest in 1978 (13 fish). The lack of trends between preoperational and operational years' abundance demonstrates no obvious plant effect on the study area sculpin population. Instead it appears that this species exhibits considerable natural population fluctuations.

Examination of trawl and seine catches at Cook and Warren Dunes stations revealed a slight tendency for greater abundance at Cook. Also, catches at 6-m stations were usually greater at north Cook than south Cook or Warren Dunes. Seine catches, although small, also showed a tendency for greater abundance at Cook than Warren Dunes and slightly more were caught at the north Cook than the south Cook station. These differences were apparent in all study years, including 1980. We believe the localized slimy sculpin population on the intake and discharge riprap is causing the slightly greater catches at Cook stations.

White Sucker--The April to August 1980 standard series catch of 84 white suckers was near the 8-yr average (April to August catches only) of 86 fish (Tables 10-17). Largest catch (139 fish) occurred in 1979 while the smallest (40 fish) occurred in 1978. These abundance fluctuations appeared to be the result of natural population changes rather than plant operational effects.

White sucker catches at Warren Dunes were higher than at the Cook Plant area in 1980. Greater abundance at Warren Dunes was also found during all preoperational and operational years. While 1979 data showed more white suckers at south Cook stations than at north Cook stations, 1980 data showed the reverse. Data for 1975 to 1978 showed similar catches between north and south Cook areas. Causes for the differences in 1979 and 1980 were not determined. In summary, the addition of 1980 field catch data did not show any substantial abundance or distribution changes in the study areas' white sucker population which might be attributed to plant operation.

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 March 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:

$$\text{TMI} = \text{Number or weight of fish in samples} \times \frac{\text{Number of days in month}}{\text{Number of sampling days}}$$

Total weight of fish impinged on non-sampling days was recorded before fish were

discarded. Impingement data for 1975 through September 1979 were presented and discussed in detail in the 1979 Environmental Operating Report and will be briefly summarized here. Data from October 1979 through August 1980 will be presented in this report and discussed in relation to Unit 2 operation. These data are summarized in Tables 42-53.

In April 1980, excessively large impingement catches necessitated development of additional subsampling procedures. When depth of fish in the trash baskets equals or exceeds 20.3 cm (8 in), plant personnel record the depth of fish in the basket on log sheets, then remove and bag a subsample of fish. A box, which plant personnel fill with fish, has been provided to assure an adequate subsample. In addition, all fish longer than 25.4 cm (10 in) are removed from the basket and saved. Total weight of the sample is calculated based on a conversion factor of 821.4 kg/m^3 (50.6 lb/ft^3), derived by weighing fish samples of known volume. After fish are processed in the lab, species composition is extrapolated to the total weight.

1975-September 1979

From 1975 through 1979, number of fish impinged per year ranged from 50,080 in 1977 to 735,334 in 1979 (Tables 42-46). Percent species composition varied from year to year, but alewives were always most abundant by number, accounting for 40% of the total number of fish impinged in 1978 to 78% in 1975. Other numerically abundant species included trout-perch, yellow perch, spottail shiner and rainbow smelt. If fish biomass rather than number is considered, then alewives and yellow perch were the primary contributors (Tables 48-52). Lake trout also contributed significantly to total biomass, especially from 1977 through 1979. Number of lake trout impinged increased during this time as did the proportion of adult to juvenile lake trout. More lake trout per year were also caught in standard series fishing during these 3 yr (1977-1979) than during 1975 and 1976.

In September 1979 an unusually large number of fish (mostly young-of-the-year alewives and yearling perch) were impinged. This large impingement of fish occurred while both plant units were operating at full capacity and was associated with a storm and a strong upwelling which may have been instrumental in causing such large numbers of fish to be impinged.

1979-1980

Total number of fish impinged in 1979 was 735,334. Total number impinged to date in 1980 (Jan-Aug) was 3,522,989 (Tables 46 and 47). Adult alewives were impinged in extremely large numbers during April 1980. Alewives continued to be abundant through June, as were smelt.

Impingement rates remained high for an extended period of time in April and May. Number of fish impinged during these 2 mo were plotted against environmental variables of water temperature, wind speed, wind direction, wave height and barometric pressure. There was no clear relationship between impingement rates and any of the variables. This differed from the large numbers of yellow perch and alewives impinged during September 1979, which we felt

resulted from fish concentrating around the intake structures during a storm. However, there is evidence that concentration of fish in the inshore area was also a factor in spring of 1980. Inshore water temperatures began to rise above 4.0 C about 10 days prior to the first unusually large impingement collections in April. As inshore water tends to warm faster than offshore water, alewives attracted to the warm water tend to concentrate in the inshore area in the spring while this temperature differential exists (Jude et al. 1979). Though total number of alewives in field catches was not exceptionally large in 1980, number of alewives caught in standard series fishing from April to May was 16 times higher than the number caught during the previous 2 yr, suggesting that alewives were indeed concentrating inshore.

Both plant units were operating at full capacity during April through June. The record of two-unit operation so far indicated that the result of operating two units compared to one unit is negligible during periods of low fish density, but greatly more than additive when fish are concentrated in the area of the intakes. During times of stress or disorientation, fish may be unable to avoid the intake current when the plant is fully operational. There was further evidence of this in the slight suggestion of diel differences in impingement rates, with night catches being slightly higher than day catches. This could be due to fish avoiding the structure during the day, or to their relative inactivity at night.

It is unknown at this time why so many smelt were impinged in June. Over 90% of these fish (mostly yearlings) were impinged on 1 day, which again suggests thay were concentrated at the intakes. Weather data were not obtained to date for June, so storm conditions may or may not have been a factor. Prior to 1977, smelt were not very abundant in impingement collections, being the sixth-most abundant species by number. In 1977 and 1978 they were the fourth-most abundant species, and in 1980 they were second-most abundant and third-most important in biomass (Table 53). Field catches of smelt were considerably higher between 1978 and 1980 than during previous years. Apparently, there is a direct relationship between population density of smelt and their vulnerability to impingement.

The number of salmonids impinged has increased with two-unit operation. Most significant has been the increased number of chinook salmon, from 9 fish in 1976, to 1733 (mostly yearlings) in 1980 (Tables 42-47).

Several other common species have been impinged in greater numbers since Unit 2 began operating, though their rate of impingement relative to other species has remained constant. These species include bloater, white sucker, longnose sucker and burbot. So far, no decline in abundance in field catches of any species, except possibly bloater (see Bloater Section), has been observed which could be attributed to impingement.

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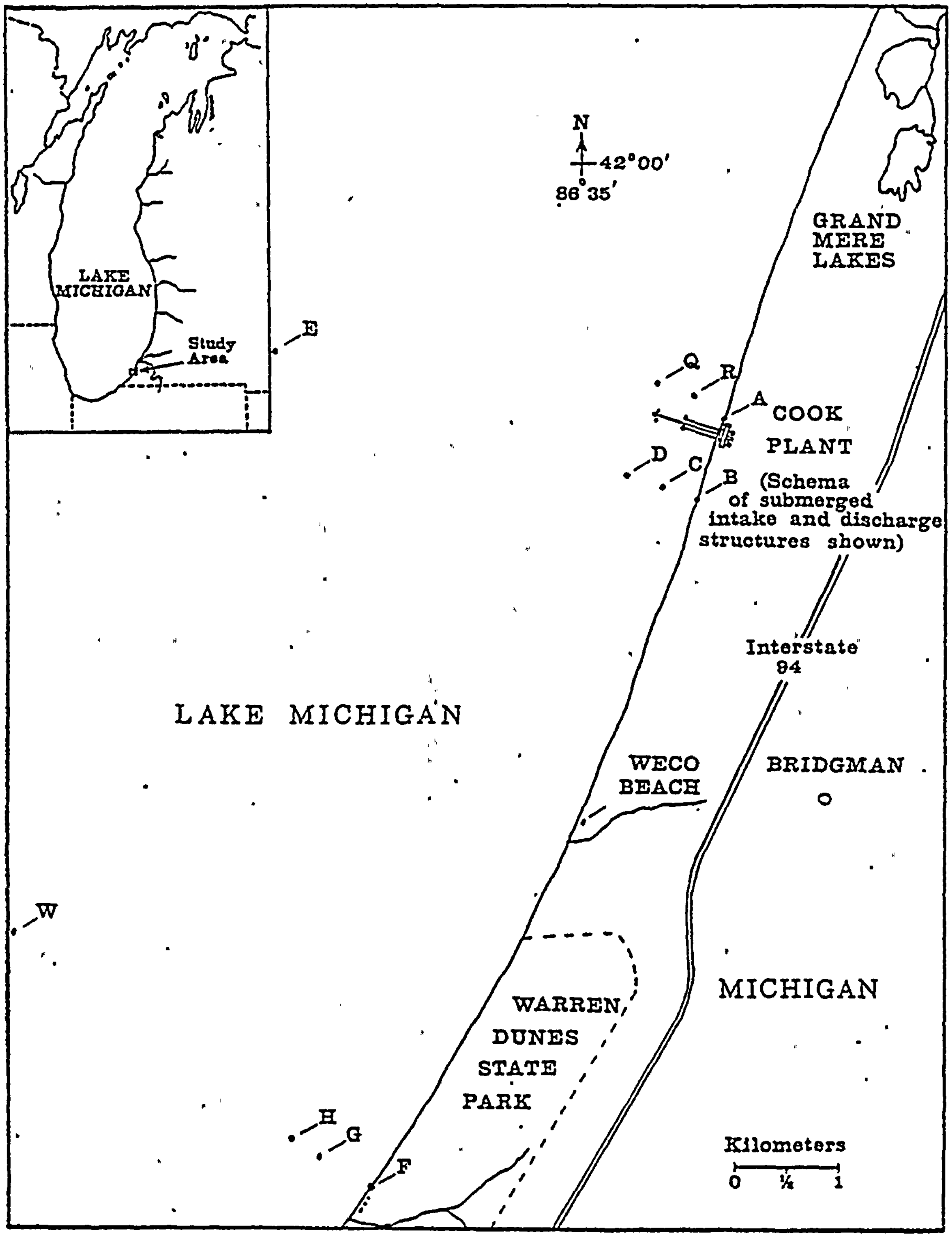

Fig. 1. Location of sampling stations at the Cook Plant and Warren Dunes study areas, southeastern Lake Michigan. Standard series stations are A, B, C, D, F, G and H. Stations R, Q and W are at 6-, 9- and 21-m depths, respectively.

Table 1. Values of the Lilliefors test statistic for normality of log-transformed larval data for alewives, spottail shiners, and yellow perch. The data were normally distributed if the test statistic (D) was less than the Lilliefors critical difference (Dc). Lilliefors critical difference values were chosen at $\alpha = 0.01$.

Species	Area	Sample size	Critical value Dc	Test statistic D
Alewife	beach	252	0.06495	0.16972
Spottail shiner	beach	126	0.09184	0.17769
Alewife	open water	840	0.03557	0.13878
Yellow perch	open water	120	0.09412	0.11667

Table 2. Summary of factors used in analysis of variance applied to larval fish density data [log(density + 1)] from Cook Plant study areas, southeastern Lake Michigan.

Species	Beach: Year	Beach: Month	Beach: Station	Beach: Time
Alewife	1973-1979	Jun-Aug	A, B, F	day, night
Spottail shiner	1973-1979	Jun-Aug	A, B, F	night

Species	Open Water: Year	Open Water: Month	Open Water: Area	Open Water: Depth	Open Water: Time
Alewife	1973-1979	Jun-Aug	Warren Dunes, Cook	6 m, 9 m	day, night
Yellow perch	1977-1979	Jun	Warren Dunes, Cook	6 m, 9 m	day, night

Table 3. Analysis of variance summary for log (density + 1) of larval alewives. Larvae were netted in the beach zone from June to August, 1973-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df	Mean square	F-statistic	Attained significance level
Year	6	12.0785	24.3211	0.0000**
Month	2	20.4778	41.2337	0.0000**
Station	2	0.8262	1.6637	0.1936
Time	1	3.2659	6.5763	0.0115
Y x M	12	11.9491	24.0605	0.0000**
Y x S	12	1.6039	3.2295	0.0005**
M x S	4	0.3893	0.7839	0.5377
Y x T	6	1.7365	3.4965	0.0031*
M x T	2	4.1779	8.4125	0.0004**
S x T	2	0.5974	1.2030	0.3037
Y x M x S	24	1.2748	2.5670	0.0004**
Y x M x T	12	2.6715	5.3793	0.0000**
Y x S x T	12	1.5083	3.0372	0.0009**
M x S x T	4	0.4106	0.8268	0.5105
Y x M x S x T	24	0.8271	1.6655	0.0378
Within cell error	126	0.4966		

**Highly significant (P < 0.001)
* Significant (P < 0.01)

Table 4. Analysis of variance summary for log (density + 1) of larval alewives. Larvae were netted in the open water zone from June to August, 1973-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df#	Adjusted mean square†	F-statistic	Attained significance level
Year	6	43.1664	71.4185	0.0000**
Month	2	33.8231	55.9600	0.0000**
Area	1	1.2589	2.0829	0.1495
Depth	1	16.2792	26.9337	0.0000**
Time	1	21.6127	35.7580	0.0000**
Y x M	12	28.7671	47.5949	0.0000**
Y x A	6	0.3085	0.5105	0.8006
M x A	2	0.6081	1.0060	0.3663
Y x D	6	0.6897	1.1411	0.3369
M x D	2	0.1469	0.2431	0.7843
A x D	1	0.0600	0.0992	0.7529
Y x T	6	3.4443	5.6986	0.0001**
M x T	2	0.1285	0.2127	0.8085
A x T	1	1.4464	2.3931	0.1224
D x T	1	1.5394	2.5470	0.1111
Y x M x A	12	1.7585	2.9094	0.0006**
Y x M x D	12	0.5082	0.8408	0.6082
Y x A x D	6	0.1853	0.3066	0.9335
M x A x D	2	0.6969	1.1530	0.3164
Y x M x T	12	3.6870	6.1002	0.0000**
Y x A x T	6	0.7275	1.2037	0.3026
M x A x T	2	0.0148	0.0245	0.9758
Y x D x T	6	0.8378	1.3861	0.2179
M x D x T	2	0.9226	1.5264	0.2182
A x D x T	1	0.1488	0.2461	0.6200
Y x M x A x D	12	0.6713	1.1106	0.3484
Y x M x A x T	12	0.9978	1.6509	0.0741
Y x M x D x T	12	0.7961	1.3171	0.2041
Y x A x D x T	6	0.6734	1.1141	0.3525
M x A x D x T	2	0.9398	1.5550	0.2121
Y x M x A x D x T	12	0.6032	0.9980	0.4493
Within cell error	569	0.6044		

One-hundred-three degrees of freedom were subtracted from the error term to correct for 103 missing observations where the cell means were substituted.

† Mean squares were multiplied by harmonic mean cell size/maximum cell size (nh/n = .8708) to correct for missing observations where cell means were substituted.

**Highly significant (P < 0.001).

Table 5. Analysis of variance summary for log (density + 1) of larval spottail shiners. Larvae were netted in the beach zone from June to August, 1973-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df	Mean square	F-statistic	Attained significance level
Year	6	7.0050	9.1904	0.0000**
Month	2	14.4169	18.9147	0.0000**
Station	2	0.1790	0.2348	0.7914
Y x M	12	6.1416	8.0577	0.0000**
Y x S	12	1.1172	1.4657	0.1614
M x S	4	1.2609	1.6542	0.1718
Y x M x S	24	1.3461	1.7660	0.0375
Within cell error	63	0.7622		

**Highly significant (P < 0.001).

Table 6. Analysis of variance summary for log (density + 1) of larval yellow perch. Larvae were netted in the open water during June, 1977-1979 at Cook Plant study areas, southeastern Lake Michigan.

Source of variation	df#	Adjusted mean square†	F-statistic	Attained significance level
Year	2	7.5310	9.3722	0.0002**
Area	1	0.1043	0.1298	0.7195
Depth	1	0.3572	0.4445	0.5068
Time	1	0.8241	1.0256	0.3141
Y x A	2	1.2090	1.5045	0.2280
Y x D	2	0.0119	0.0148	0.9853
A x D	1	0.0805	0.1002	0.7524
Y x T	2	1.3356	1.6621	0.1959
A x T	1	0.1092	0.1359	0.7134
D x T	1	0.1371	0.1706	0.6807
Y x A x D	2	0.8449	1.0514	0.3540
Y x A x T	2	1.4540	1.8095	0.1701
Y x D x T	2	0.6676	0.8308	0.4392
A x D x T	1	0.7471	0.9297	0.3377
Y x A x D x T	2	0.6485	0.8070	0.4496
Within cell error	84	0.8035		

Twelve degrees of freedom were subtracted from the error term to correct for 12 missing observations where cell means were substituted.

† Mean squares were multiplied by harmonic mean cell size/maximum cell size (nh/n = .8888) to correct for 12 missing observations where cell means were substituted.

**Highly significant ($P < 0.001$).

Table 7. Estimates of mean annual entrainment losses for 22 categories of ichthyoplankton at the D. C. Cook Nuclear Plant, southeastern Lake Michigan, 1974-1979. Maximum flow rates were assumed for all calculations. Estimates represent millions of larvae.

Taxon	Year of Estimate					
	1974*,#	1975*	1976	1977	1978	1979†
Alewife	64.6	105.0	61.2	42.9	20.1	112.0
Spottail shiner	1.28	4.96	1.04	4.80	0.921	6.07
Yellow perch		0.0763	0.0333	2.50	2.50	2.51
Trout-perch	4.17	0.748	0.235	0.143	0.0508	1.42
Rainbow smelt	8.97	1.22	0.788	0.256	0.219	8.20
Slimy sculpin		0.808	0.300	0.0675	0.118	
Mottled sculpin						0.963
Fourhorn sculpin					0.0871	0.109
Carp			0.143	0.0339	0.0618	0.854
Johnny darter		0.0129	0.208	1.12	0.409	3.99
Burbot			0.0522		0.0522	
Ninespine stickleback					0.0464	
White sucker				0.0740		
Log perch				0.0322		
Unidentified *Cottus*				0.132	0.179	1.37
Unidentified *Coregonus*				0.100		
Unidentified *Etheostoma*				0.0651		
Unidentified Cyprinidae				0.0880	0.170	1.23
Unidentified *Lepomis*				0.115		
Poor condition				0.508	1.71	65.3
Unidentified pisces	0.956	0.959	0.197	0.158	0.132	
Total no. of larvae	80	114	64.2	53.4	26.8	204
Total no. of fish eggs	649	942	2740	1460	3700	1810

* Larvae in poor condition were assumed to be alewives.

\# Only intermittent plant pumping and therefore sampling were performed.

† Assumes maximum flow rate for Unit 1 and Unit 2; 1974-1978 assumes maximum flow rate for Unit 1.

Table 8. Estimates of entrainment losses for various taxons of larval fish and fish eggs in 1979 at the D. C. Cook Nuclear Plant, southeastern Lake Michigan. Unit 1 and Unit 2 maximal flow rates were assumed over the year for all calculations. No fish were observed in entrainment samples collected between 5 December and 31 December 1979. Estimates represent millions of larvae.

Taxon	1 Jan-3 Feb	4 Feb-28 Feb	29 Feb-31 Mar	1 Apr-3 May	4 May-31 May	1 Jun-1 Jul	2 Jul-29 Jul	30 Jul-26 Aug	27 Aug-2 Oct	3 Oct-30 Oct	1 Nov-4 Dec	Total	Percent
Alewife						9.67	74.4	21.9	4.21	1.44	0.200	112	54.9
Spottail shiner					3.50	0.229	0.462	1.88				6.07	3.0
Yellow perch					0.327	1.67	0.511					2.51	1.2
Trout-perch						0.692	0.208	0.0799	0.0512	0.393		1.42	0.7
Rainbow smelt				0.192	7.62	0.117	0.177	0.0915				8.20	4.0
Mottled sculpin						0.963						0.963	0.5
Carp						0.483	0.327	0.0437				0.854	0.4
Johnny darter					0.452	1.80	1.68	0.0593				3.99	2.0
Fourhorn sculpin						0.109						0.109	<0.1
Unidentified *Cottus*					0.259	1.11						1.37	0.7
Unidentified *Cyprinidae*					0.144	0.0631	0.740	0.281				1.23	0.6
Poor condition				0.151	0.682	0.955	55.5	7.98				65.3	32.0
Fish eggs	13.6	0.282	0.813	0.999	10.7	71.5	1,040	672	0.303	0.137		1,810	

Table 9. Scientific name, common name and abbreviations for all species of fish captured 1972-1980 from the Cook Plant study areas, southeastern Lake Michigan. Names are according to Bailey et al. 1970.

Scientific and common name	Abbreviation
Petromyzontidae	
Ichthyomyzon castaneus Girard Chestnut lamprey	CL
Petromyzon marinus Linnaeus Sea lamprey	SL
Acipenseridae	
Acipenser fulvescens Rafinesque Lake sturgeon	LG
Amiidae	
Amia calva Linnaeus Bowfin	BF
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
Coregonus spp. Unidentified coregonid	XC
Oncorhynchus kisutch (Walbaum) Coho salmon	CM
Oncorhynchus tshawytscha (Walbaum) Chinook salmon	CH
Prosopium cylindraceum (Pallas) Round whitefish	RW
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

Table 9. Continued.

Scientific and common name	Abbreviation
Umbridae	
Umbra limi (Kirtland) Central mudminnow	MM
Esocidae	
Esox americanus vermiculatus Lesueur Grass pickerel	GP
Esox lucius Linnaeus Northern pike	NP
Cyprinidae	
Carassius auratus (Linnaeus) Goldfish	GF
Couesius plumbeus (Agassiz) Lake chub	LC
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 spilopterus (Cope) Spotfin shiner	SF
Notropis stramineus (Cope) Sand shiner	SH
Pimephales notatus (Rafinesque) Bluntnose minnow	BM
Pimephales promelas Rafinesque Fathead minnow	PP
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
Minytrema melanops (Rafinesque) Spotted sucker	ME

Table 9. Continued.

Scientific and common name	Abbreviation
Catostomidae	
Moxostoma anisurum (Rafinesque)	MA
Silver redhorse	
Moxostoma erythrurum (Rafinesque)	GR
Golden redhorse	
Moxostoma macrolepidotum (Lesueur)	SR
Shorthead redhorse	
Ictaluridae	
Ictalurus melas (Rafinesque)	BB
Black bullhead	
Ictalurus natalis (Lesueur)	YB
Yellow bullhead	
Ictalurus nebulosus (Lesueur)	BN
Brown bullhead.	
Ictalurus punctatus (Rafinesque)	CC
Channel catfish	
Noturus gyrinus (Mitchill)	MT
Tadpole madtom	
Aphredoderidae	
Aphredoderus sayanus (Gilliams)	PR
Pirate perch	
Percopsidae	
Percopsis omiscomaycus (Walbaum)	TP
Trout-perch	
Gadidae	
Lota lota (Linnaeus)	BR
Burbot	
Atherinidae	
Labidesthes sicculus (Cope)	SV
Brook silverside	
Gasterosteidae	
Pungitius pungitius (Linnaeus)	NS
Ninespine stickleback	
Centrarchidae	
Ambloplites rupestris (Rafinesque)	RB
Rock bass	
Lepomis cyanellus Rafinesque	GN
Green sunfish	
Lepomis gibbosus (Linnaeus)	PS
Pumpkinseed	

Table 9. Continued.

Scientific and common name	Abbreviation
Centrarchidae	
Lepomis macrochirus Rafinesque Bluegill	BG
Micropterus dolomieui Lacepede Smallmouth bass	SB
Micropterus salmoides (Lacepede) Largemouth bass	LB
Pomoxis annularis White crappie	WC
Pomoxis nigromaculatus Black crappie	BC
Percidae	
Etheostoma nigrum Rafinesque Johnny darter	JD
Percina caprodes (Rafinesque) Logperch	LP
Perca flavescens (Mitchill) Yellow perch	YP
Stizostedion vitreum vitreum (Mitchill) Walleye	WL
Sciaenidae	
Aplodinotus grunniens (Rafinesque) Freshwater drum	FD
Cottidae	
Cottus bairdi Girard Mottled sculpin	MS
Cottus cognatus Richardson Slimy sculpin	SS
Myoxocephalus quadricornis (Linnaeus) Fourhorn sculpin	FS

Table 10. Number of fish caught in standard series nets (trawls, gill nets, and seines) during 1973 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	0	1869	10286	3207	6792	13204	79934	765	32389	5	0	148451	76.58
Spottail shiner	ND	17	439	2687	3374	7416	1819	2514	768	1435	121	1	20591	10.62
Rainbow smelt	ND	4	119	3926	823	957	294	8394	1425	338	14	0	16294	8.41
Yellow perch	ND	6	35	15	41	1458	611	909	243	395	22	0	3735	1.93
Trout-perch	ND	0	2	47	156	1567	703	515	160	339	21	0	3510	1.81
Johnny darter	ND	0	0	13	47	58	17	31	11	30	0	0	207	0.11
White sucker	ND	1	7	7	14	26	22	30	41	26	0	0	174	0.09
Lake trout	ND	0	2	1	2	2	6	19	49	27	54	0	162	0.08
Bloater	ND	0	0	0	2	26	42	35	1	20	0	0	126	0.07
Rainbow trout	ND	1	1	15	30	13	6	11	1	3	5	0	86	0.04
Slimy sculpin	ND	0	0	44	14	3	0	6	4	7	1	0	79	0.04
Brown trout	ND	1	4	2	6	33	18	4	3	7	0	0	78	0.04
Longnose sucker	ND	1	4	9	15	14	27	1	1	1	0	0	73	0.04
Emerald shiner	ND	1	2	1	6	1	2	11	15	8	2	0	49	0.03
Longnose dace	ND	2	0	2	4	3	3	4	22	0	1	0	41	0.02
Northern pike	ND	0	0	0	0	2	0	1	8	10	9	0	30	0.01
Coho salmon	ND	0	5	3	9	7	0	0	3	2	0	0	29	0.02
Carp	ND	0	0	2	2	14	1	2	0	6	0	0	27	0.01
Chinook salmon	ND	0	1	2	5	6	2	2	3	2	0	0	23	0.01
Gizzard shad	ND	0	0	0	0	0	0	0	0	1	22	0	23	0.01
Ninespine stickleback	ND	0	1	1	12	5	0	0	0	0	0	0	19	0.01
Mottled sculpin	ND	0	0	9	3	2	0	0	0	2	0	0	16	0.01
Channel catfish	ND	1	0	0	0	1	0	2	0	2	4	0	10	0.01
Bluegill	ND	0	0	0	1	3	0	1	0	0	5	0	10	0.01
Burbot	ND	0	0	4	0	2	0	0	0	0	0	0	6	<0.01
Lake whitefish	ND	0	0	0	1	1	0	0	0	0	0	0	2	<0.01
Black bullhead	ND	0	0	1	0	0	1	0	0	0	0	0	2	<0.01
Fathead minnow	ND	0	0	0	1	0	1	0	0	0	0	0	2	<0.01
Rock bass	ND	0	0	0	0	1	0	0	0	0	1	0	2	<0.01
Golden shiner	ND	0	0	2	0	0	0	0	0	0	0	0	2	<0.01
Largemouth bass	ND	0	0	1	0	0	0	0	0	0	0	0	1	<0.01
Totals	ND	35	2491	17080	7775	18413	16779	92426	3523	35050	287	1	193860	

Table 11. Number of fish caught in standard series nets (trawls, gill nets, and seines) during 1974 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	0	ND	282	4832	13920	3788	4662	36669	8179	2977	724	0	76033	66.69
Spottail shiner	1	ND	167	313	4111	6942	5884	6047	414	476	36	22	24413	21.41
Rainbow smelt	0	ND	55	701	794	59	385	3304	93	345	13	5	5754	5.05
Yellow perch	1	ND	14	35	14	156	2581	1182	453	9	75	16	4536	3.98
Trout-perch	0	ND	0	10	145	55	928	128	106	187	17	2	1578	1.38
Johnny darter	0	ND	0	5	93	86	60	6	7	22	14	0	293	0.26
Slimy sculpin	0	ND	2	155	19	15	14	28	2	18	19	0	272	0.24
Bloater	0	ND	0	0	0	3	199	7	1	15	0	0	225	0.20
Coho salmon	0	ND	8	8	71	13	2	26	0	0	25	0	153	0.13
White sucker	2	ND	2	3	16	19	29	13	16	13	5	8	126	0.11
Lake trout	0	ND	1	1	17	9	0	0	0	12	85	0	125	0.11
Longnose sucker	1	ND	2	4	26	11	39	2	3	3	6	2	99	0.09
Gizzard shad	0	ND	5	4	44	1	0	1	20	9	0	0	84	0.07
Brown trout	0	ND	3	5	14	13	6	5	2	1	2	0	51	0.05
Bluegill	0	ND	1	0	40	5	0	0	0	0	0	0	46	0.04
Longnose dace	0	ND	2	1	3	8	2	1	0	20	6	0	43	0.04
Chinook salmon	0	ND	0	3	6	3	6	6	13	0	3	1	41	0.04
Carp	0	ND	0	2	7	0	1	9	5	3	0	0	27	0.02
Ninespine stickleback	0	ND	0	1	15	4	3	1	0	0	0	0	24	0.02
Channel catfish	0	ND	0	1	0	1	8	0	5	1	1	0	17	0.02
Northern pike	1	ND	3	3	1	2	0	1	0	5	0	0	16	0.01
Burbot	0	ND	1	1	2	1	0	0	0	0	0	10	15	0.01
Emerald shiner	0	ND	2	1	1	3	0	0	0	6	0	0	13	0.01
Rainbow trout	0	ND	5	2	0	0	0	0	0	0	1	0	8	0.01
Green sunfish	0	ND	0	0	5	0	0	0	0	1	0	0	6	0.01
Sand shiner	0	ND	0	0	0	0	0	0	0	3	1	0	4	<0.01
Black bullhead	0	ND	0	1	1	0	0	0	0	0	0	0	2	<0.01
Lake herring	0	ND	0	0	0	0	0	0	0	0	0	1	1	<0.01
Lake whitefish	0	ND	0	0	0	0	0	1	0	0	0	0	1	<0.01
Largemouth bass	0	ND	0	0	0	1	0	0	0	0	0	0	1	<0.01
Golden shiner	0	ND	0	0	0	0	0	1	0	0	0	0	1	<0.01
Bluntnose minnow	0	ND	0	0	0	0	0	0	0	1	0	0	1	<0.01
Totals	6	ND	555	6092	19365	11198	14809	47438	9319	4127	1033	67	114009	

Table 12. Number of fish caught in standard series nets (trawls, gill nets, and seines) during 1975 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	0	ND	797	176	6974	2718	1096	757	7740	21188	168	42	41656	58.74
Spottail shiner	1	ND	12	103	1740	8483	3076	1583	2022	1535	428	831	19814	27.94
Yellow perch	7	ND	29	12	4	968	2143	560	280	151	103	80	4337	6.12
Rainbow smelt	3	ND	21	255	1233	1032	0	173	94	179	105	14	3109	4.38
Trout-perch	0	ND	0	14	151	221	68	114	150	108	51	28	905	1.28
Gizzard shad	0	ND	0	2	0	0	0	28	18	13	106	26	193	0.27
Johnny darter	0	ND	0	2	35	19	3	5	31	19	19	9	142	0.20
Slimy sculpin	0	ND	0	38	48	12	0	1	1	2	5	4	111	0.16
Longnose sucker	1	ND	50	3	9	22	1	2	1	2	3	0	94	0.13
White sucker	1	ND	7	3	6	37	9	0	17	2	2	5	89	0.13
Lake trout	0	ND	1	3	8	21	0	0	0	4	47	1	85	0.12
Coho salmon	0	ND	6	40	1	12	0	2	0	0	2	0	63	0.09
Chinook salmon	0	ND	0	3	0	11	3	3	2	20	7	1	50	0.07
Carp	0	ND	0	0	1	0	14	14	17	2	2	0	50	0.07
Bloater	0	ND	0	0	2	34	0	11	1	1	0	0	49	0.07
Sand shiner	0	ND	0	0	0	0	0	0	1	1	32	0	34	0.05
Brown trout	0	ND	7	2	1	1	1	1	1	1	10	1	26	0.04
Ninespine stickleback	0	ND	0	2	10	14	0	0	0	0	0	0	26	0.04
Longnose dace	0	ND	0	0	0	1	0	2	2	7	6	0	18	0.03
Rainbow trout	0	ND	1	2	0	0	1	0	1	6	3	1	15	0.02
Burbot	1	ND	0	0	0	0	0	0	0	1	0	13	15	0.02
Channel catfish	0	ND	0	0	0	0	1	1	5	1	1	0	9	0.01
Northern pike	1	ND	0	1	0	1	0	0	0	0	3	0	6	0.01
Shorthead redhorse	0	ND	0	0	0	0	0	0	4	0	0	0	4	0.01
Lake whitefish	0	ND	0	1	0	1	0	0	0	0	0	0	2	<0.01
Bluegill	0	ND	0	0	0	1	0	0	1	0	0	0	2	<0.01
Logperch	0	ND	0	0	1	1	0	0	0	0	0	0	2	<0.01
Emerald shiner	0	ND	0	1	0	0	0	0	0	0	0	0	1	<0.01
Lake herring	0	ND	0	1	0	0	0	0	0	0	0	0	1	<0.01
Quillback	0	ND	0	0	0	1	0	0	0	0	0	0	1	<0.01
Lake sturgeon	0	ND	0	0	1	0	0	0	0	0	0	0	1	<0.01
Pumpkinseed	0	ND	0	0	0	0	1	0	0	0	0	0	1	<0.01
Largemouth bass	0	ND	0	0	0	1	0	0	0	0	0	0	1	<0.01
Silver redhorse	0	ND	0	0	0	0	0	0	0	1	0	0	1	<0.01
Totals	15	ND	931	664	10225	13612	6417	3257	10389	23244	1103	1056	70913	

Table 13. Number of fish caught in standard series nets (trawls, gill nets, and seines) during 1976 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	0	204	2020	7446	3862	2852	43406	74708	2225	20	ND	136743	86.77
Spottail shiner	ND	47	49	967	1708	3307	5309	580	823	1178	147	ND	14115	8.96
Yellow perch	ND	13	5	54	24	318	1242	386	422	30	4	ND	2498	1.59
Trout-perch	ND	2	1	25	118	115	1146	134	261	145	8	ND	1955	1.24
Rainbow smelt	ND	1	21	452	67	143	416	19	11	13	122	ND	1265	0.80
Johnny darter	ND	0	0	2	139	12	25	30	31	59	6	ND	304	0.19
Bloater	ND	0	0	3	2	26	76	0	0	0	0	ND	107	0.07
Brown trout	ND	6	0	2	32	18	10	1	17	4	0	ND	90	0.06
White sucker	ND	4	0	6	24	5	18	5	18	8	1	ND	89	0.06
Slimy sculpin	ND	0	0	55	12	1	0	6	2	5	3	ND	84	0.05
Gizzard shad	ND	1	0	0	0	1	1	20	20	7	1	ND	51	0.03
Coho salmon	ND	0	0	0	27	16	1	0	1	1	0	ND	46	0.03
Longnose sucker	ND	20	3	8	4	3	2	0	0	0	0	ND	40	0.03
Sand shiner	ND	0	0	1	0	0	0	7	0	31	0	ND	39	0.03
Lake trout	ND	0	3	6	8	7	2	0	0	11	0	ND	37	0.02
Carp	ND	0	0	0	10	2	1	14	4	1	0	ND	32	0.02
Longnose dace	ND	0	0	1	3	2	1	5	10	1	4	ND	27	0.02
Chinook salmon	ND	1	0	0	0	9	1	0	3	0	0	ND	14	0.01
Rainbow trout	ND	2	0	2	2	1	1	0	4	2	0	ND	14	0.01
Channel catfish	ND	0	0	0	2	0	1	2	8	0	0	ND	13	0.01
Ninespine stickleback	ND	0	0	0	8	1	0	0	0	0	0	ND	9	0.01
Lake whitefish	ND	0	1	2	1	1	1	0	0	0	0	ND	6	<0.01
Burbot	ND	1	0	2	0	0	1	0	0	2	0	ND	6	<0.01
Bluegill	ND	0	0	0	1	0	1	0	0	0	1	ND	3	<0.01
Silver redhorse	ND	0	0	0	0	0	3	0	0	0	0	ND	3	<0.01
Quillback	ND	0	0	0	0	1	1	0	0	0	0	ND	2	<0.01
Golden shiner	ND	1	0	0	0	0	0	0	0	1	0	ND	2	<0.01
Lake sturgeon	ND	0	0	0	1	0	0	0	0	0	0	ND	1	<0.01
Smallmouth bass	ND	0	0	0	0	0	0	1	0	0	0	ND	1	<0.01
Largemouth bass	ND	0	0	0	0	0	0	1	0	0	0	ND	1	<0.01
Brook silverside	ND	0	0	1	0	0	0	0	0	0	0	ND	1	<0.01
Totals	ND	99	287	3609	9639	7851	11112	44617	76343	3724	317	ND	157598	

Table 14. Number of fish caught in standard series nets (trawls, gill nets, and seines) during 1977 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	66	34	1270	1607	3507	20151	12731	3017	13596	0	55979	63.36
Spottail shiner	ND	ND	54	20	2333	2190	2363	10098	3535	1564	398	0	22555	25.53
Yellow perch	ND	ND	11	28	19	189	1300	897	470	47	416	1	3378	3.82
Trout-perch	ND	ND	1	4	193	317	1919	130	172	501	2	0	3239	3.67
Rainbow smelt	ND	ND	0	113	170	2	669	88	99	148	166	0	1455	1.65
Johnny darter	ND	ND	0	34	171	44	31	41	82	4	16	0	423	0.48
Bloater	ND	ND	0	0	0	24	40	0	7	141	15	0	227	0.28
Lake trout	ND	ND	4	10	6	6	6	0	9	27	119	0	187	0.21
White sucker	ND	ND	0	8	29	18	68	13	23	8	5	1	173	0.20
Gizzard shad	ND	ND	0	0	0	0	1	15	39	41	8	0	104	0.12
Longnose sucker	ND	ND	4	5	3	0	34	9	14	6	24	0	99	0.11
Coho salmon	ND	ND	3	1	83	2	0	0	1	2	4	0	96	0.11
Carp	ND	ND	0	5	30	0	5	22	20	3	7	0	92	0.10
Chinook salmon	ND	ND	11	21	0	43	0	0	0	1	0	0	76	0.09
Brown trout	ND	ND	5	9	8	13	5	0	5	1	9	6	61	0.07
Longnose dace	ND	ND	0	1	0	3	1	0	9	38	8	0	60	0.07
Slimy sculpin	ND	ND	0	15	0	0	7	1	2	0	5	0	30	0.03
Emerald shiner	ND	ND	0	0	0	2	23	0	0	3	0	0	28	0.03
Sand shiner	ND	ND	0	1	0	2	13	5	1	0	1	0	23	0.03
Rainbow trout	ND	ND	0	2	1	0	1	0	6	0	2	0	12	0.01
Channel catfish	ND	ND	0	0	0	0	0	5	2	2	0	0	9	0.01
Golden redhorse	ND	ND	0	0	0	0	0	6	3	0	0	0	9	0.01
Burbot	ND	ND	1	0	0	0	0	1	0	0	0	6	8	0.01
Ninespine stickleback	ND	ND	0	0	5	0	2	0	0	0	0	0	7	0.01
Mottled sculpin	ND	ND	0	0	0	0	0	0	0	3	0	0	3	<0.01
Quillback	ND	ND	0	0	0	0	0	1	2	0	0	0	3	<0.01
Lake sturgeon	ND	ND	0	0	0	0	1	1	0	0	0	0	2	<0.01
Bluegill	ND	ND	0	0	0	1	0	0	1	0	0	0	2	<0.01
Rock bass	ND	ND	0	0	0	0	0	0	0	1	0	0	1	<0.01
Golden shiner	ND	ND	0	0	0	0	0	0	1	0	0	0	1	<0.01
Shorthead redhorse	ND	ND	0	0	0	0	0	0	0	0	0	1	1	<0.01
Freshwater drum	ND	ND	0	0	0	0	0	0	0	1	0	0	1	<0.01
Silver redhorse	ND	ND	0	0	0	0	0	0	1	0	0	0	1	<0.01
Bluntnose minnow	ND	ND	0	0	0	0	0	1	0	0	0	0	1	<0.01
Totals	ND	ND	160	311	4321	4463	9996	31485	17235	5559	14801	15	88346	

Table 15. Number of fish caught in standard series nets (trawls, gill nets, and seines) during 1978 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	4	294	5498	641	1786	2686	26882	701	ND	38492	41.79
Spottail shiner	ND	ND	ND	108	414	6824	15913	6064	2288	4788	202	ND	36601	39.73
Rainbow smelt	ND	ND	ND	66	1580	59	1844	5446	89	109	68	ND	9261	10.05
Trout-perch	ND	ND	ND	5	80	194	610	310	254	1631	20	ND	3104	3.37
Yellow perch	ND	ND	ND	50	4	181	379	206	609	57	90	ND	1576	1.71
Bloater	ND	ND	ND	0	1	117	269	868	29	52	56	ND	1392	1.51
Johnny darter	ND	ND	ND	1	77	57	82	17	5	112	34	ND	385	0.42
Coho salmon	ND	ND	ND	11	23	224	22	17	4	0	0	ND	301	0.33
Lake trout	ND	ND	ND	9	34	31	18	11	89	53	41	ND	286	0.31
Brown trout	ND	ND	ND	63	12	9	10	11	30	17	10	ND	162	0.18
White sucker	ND	ND	ND	1	6	9	15	9	36	31	11	ND	118	0.13
Gizzard shad	ND	ND	ND	0	0	0	0	0	12	88	8	ND	108	0.12
Chinook salmon	ND	ND	ND	7	6	55	4	2	7	22	4	ND	107	0.12
Longnose sucker	ND	ND	ND	14	2	2	1	7	12	8	25	ND	71	0.08
Carp	ND	ND	ND	0	4	0	1	2	6	16	5	ND	34	0.04
Longnose dace	ND	ND	ND	3	3	2	0	0	5	8	5	ND	26	0.03
Rainbow trout	ND	ND	ND	4	1	2	2	5	1	5	1	ND	21	0.02
Slimy sculpin	ND	ND	ND	5	6	1	1	0	0	1	0	ND	14	0.02
Sand shiner	ND	ND	ND	0	0	0	0	0	12	0	0	ND	12	0.01
Emerald shiner	ND	ND	ND	0	0	0	0	3	0	7	0	ND	10	0.01
Lake whitefish	ND	ND	ND	0	1	3	0	2	2	0	1	ND	9	0.01
Ninespine stickleback	ND	ND	ND	1	2	1	0	0	1	0	0	ND	5	0.01
Channel catfish	ND	ND	ND	0	0	0	1	0	1	2	1	ND	5	0.01
Burbot	ND	ND	ND	2	1	0	0	0	0	1	1	ND	5	0.01
Quillback	ND	ND	ND	0	0	0	0	0	0	2	0	ND	2	<0.01
Northern pike	ND	ND	ND	0	0	0	0	0	0	2	0	ND	2	<0.01
Golden shiner	ND	ND	ND	0	0	0	2	0	0	0	0	ND	2	<0.01
Spotfin shiner	ND	ND	ND	0	0	0	0	0	2	0	0	ND	2	<0.01
Lake herring	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Lake sturgeon	ND	ND	ND	0	0	0	0	0	0	0	1	ND	1	<0.01
Fathead minnow	ND	ND	ND	0	0	0	0	0	1	0	0	ND	1	<0.01
Silver redhorse	ND	ND	ND	0	0	0	0	0	0	1	0	ND	1	<0.01
Brook silverside	ND	ND	ND	0	0	0	0	0	1	0	0	ND	1	<0.01
Totals	ND	ND	ND	355	2551	13270	19815	14766	6182	33895	1285	ND	92119	

Table 16. Number of fish caught in standard series nets (trawls, gill nets, and seines) during 1979 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	267	71	2248	1178	16700	66560	54607	140	ND	141771	76.28
Spottail shiner	ND	ND	ND	711	834	3475	9796	2147	8582	2080	200	ND	27825	14.97
Rainbow smelt	ND	ND	ND	788	2152	579	146	923	54	150	467	ND	5259	2.83
Yellow perch	ND	ND	ND	41	25	104	511	1031	2733	63	151	ND	4659	2.51
Bloater	ND	ND	ND	0	4	68	1979	3	518	90	347	ND	3009	1.62
Trout-perch	ND	ND	ND	41	27	152	326	376	324	461	23	ND	1730	0.93
Chinook salmon	ND	ND	ND	168	83	61	1	1	7	0	1	ND	322	0.17
Johnny darter	ND	ND	ND	20	52	53	38	1	42	20	7	ND	233	0.13
White sucker	ND	ND	ND	40	19	31	8	41	30	18	1	ND	188	0.10
Lake trout	ND	ND	ND	15	3	4	0	2	0	55	85	ND	164	0.09
Gizzard shad	ND	ND	ND	3	0	1	0	6	124	17	8	ND	159	0.09
Slimy sculpin	ND	ND	ND	89	28	7	1	0	0	1	2	ND	128	0.07
Longnose sucker	ND	ND	ND	2	35	20	5	9	20	7	0	ND	98	0.05
Carp	ND	ND	ND	11	29	7	2	12	3	7	0	ND	71	0.04
Coho salmon	ND	ND	ND	39	26	0	0	0	0	0	0	ND	65	0.03
Brown trout	ND	ND	ND	20	10	9	11	0	1	4	5	ND	60	0.03
Rainbow trout	ND	ND	ND	3	1	1	1	1	2	2	3	ND	14	0.01
Emerald shiner	ND	ND	ND	7	1	3	0	0	0	0	1	ND	12	0.01
Silver redhorse	ND	ND	ND	0	0	0	0	1	6	3	0	ND	10	0.01
Channel catfish	ND	ND	ND	1	0	0	0	3	3	1	0	ND	8	<0.01
Ninespine stickleback	ND	ND	ND	0	1	7	0	0	0	0	0	ND	8	<0.01
Sand shiner	ND	ND	ND	0	0	0	0	0	0	7	0	ND	7	<0.01
Lake whitefish	ND	ND	ND	3	3	1	0	0	0	0	0	ND	7	<0.01
Longnose dace	ND	ND	ND	3	0	0	0	0	1	2	0	ND	6	<0.01
Mottled sculpin	ND	ND	ND	2	0	0	0	0	0	0	4	ND	6	<0.01
Burbot	ND	ND	ND	1	0	2	0	2	0	0	0	ND	5	<0.01
Northern pike	ND	ND	ND	0	0	0	0	1	3	0	0	ND	4	<0.01
Shorthead redhorse	ND	ND	ND	1	0	0	1	0	0	2	0	ND	4	<0.01
Golden redhorse	ND	ND	ND	0	0	0	0	0	3	0	0	ND	3	<0.01
Spotfin shiner	ND	ND	ND	0	0	0	0	2	0	1	0	ND	3	<0.01
Fathead minnow	ND	ND	ND	0	0	1	0	1	0	0	0	ND	2	<0.01
Round whitefish	ND	ND	ND	1	0	0	0	0	0	1	0	ND	2	<0.01
Central mudminnow	ND	ND	DN	1	0	0	0	0	0	0	0	ND	1	<0.01
Bluntnose minnow	ND	ND	ND	0	1	0	0	0	0	0	0	ND	1	<0.01
Green sunfish	ND	ND	ND	0	0	1	0	0	0	0	0	ND	1	<0.01
Bluegill	ND	ND	ND	0	0	1	0	0	0	0	0	ND	1	<0.01
Black crappie	ND	ND	ND	0	1	0	0	0	0	0	0	ND	1	<0.01
Lake chub	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Totals	ND	ND	ND	2279	3406	6836	14004	21263	79016	57599	1445	ND	185848	

Table 17. Number of fish caught in standard series nets (trawls, gill nets, and seines) during 1980 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Spottail shiner	ND	ND	ND	150	6347	3625	7925	2699	ND	ND	ND	ND	20754	39.36
Alewife	ND	ND	ND	810	4777	4230	2349	2325	ND	ND	ND	ND	14499	27.50
Rainbow smelt	ND	ND	ND	517	4676	2307	89	1345	ND	ND	ND	ND	9016	17.10
Yellow perch	ND	ND	ND	6	49	329	2020	1533	ND	ND	ND	ND	3937	7.47
Bloater	ND	ND	ND	0	143	1064	754	20	ND	ND	ND	ND	1981	3.76
Trout-perch	ND	ND	ND	19	483	350	363	674	ND	ND	ND	ND	1892	3.59
Chinook salmon	ND	ND	ND	2	12	141	11	3	ND	ND	ND	ND	169	0.32
Johnny darter	ND	ND	ND	3	64	67	4	5	ND	ND	ND	ND	143	0.27
White sucker	ND	ND	ND	2	31	23	25	3	ND	ND	ND	ND	84	0.16
Slimy sculpin	ND	ND	ND	23	19	7	1	0	ND	ND	ND	ND	50	0.09
Lake trout	ND	ND	ND	2	17	9	0	11	ND	ND	ND	ND	39	0.07
Brown trout	ND	ND	ND	15	6	9	0	5	ND	ND	ND	ND	35	0.07
Longnose sucker	ND	ND	ND	2	14	9	3	3	ND	ND	ND	ND	31	0.06
Carp	ND	ND	ND	2	3	2	3	4	ND	ND	ND	ND	14	0.03
Lake whitefish	ND	ND	ND	0	12	0	0	1	ND	ND	ND	ND	13	0.02
Gizzard shad	ND	ND	ND	0	1	9	1	2	ND	ND	ND	ND	13	0.02
Coho salmon	ND	ND	ND	2	6	2	0	0	ND	ND	ND	ND	10	0.02
Ninespine stickleback	ND	ND	ND	1	5	3	0	0	ND	ND	ND	ND	9	0.02
Mottled sculpin	ND	ND	ND	1	4	3	0	1	ND	ND	ND	ND	9	0.02
Longnose dace	ND	ND	ND	0	1	2	0	5	ND	ND	ND	ND	8	0.02
Sand shiner	ND	ND	ND	0	0	0	1	5	ND	ND	ND	ND	6	0.01
Rainbow trout	ND	ND	ND	3	0	0	0	0	ND	ND	ND	ND	3	0.01
Black bullhead	ND	ND	ND	0	0	2	1	0	ND	ND	ND	ND	3	0.01
Burbot	ND	ND	ND	1	0	1	0	0	ND	ND	ND	ND	2	<0.01
Silver redhorse	ND	ND	ND	0	0	0	0	1	ND	ND	ND	ND	1	<0.01
Fathead minnow	ND	ND	ND	1	0	0	0	0	ND	ND	ND	ND	1	<0.01
White crappie	ND	ND	ND	0	0	1	0	0	ND	ND	ND	ND	1	<0.01
Totals	ND	ND	ND	1573	16670	12205	13550	8695	ND	ND	ND	ND	52723	

Table 18.

Number of fish caught in standard series seines during 1973 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	0	0	4658	489	1015	10387	77060	3	31813	5	ND	125430	87.81
Spottail shiner	ND	5	37	1044	2012	6401	1528	1710	32	1025	25	ND	13819	9.67
Rainbow smelt	ND	3	1	2388	94	0	1	0	5	4	2	ND	2498	1.75
Yellow perch	ND	0	0	0	1	571	9	1	0	47	0	ND	629	0.44
Rainbow trout	ND	1	1	14	28	13	6	11	1	3	5	ND	83	0.06
Trout-perch	ND	0	0	1	59	0	1	4	0	14	1	ND	80	0.06
Brown trout	ND	1	0	1	4	32	18	2	3	6	0	ND	67	0.05
Emerald shiner	ND	1	2	1	6	1	2	11	15	8	2	ND	49	0.03
Longnose dace	ND	2	0	2	4	3	3	4	22	0	1	ND	41	0.03
White sucker	ND	0	5	1	4	12	8	0	0	0	0	ND	30	0.02
Gizzard shad	ND	0	0	0	0	0	0	0	0	1	22	ND	23	0.02
Carp	ND	0	0	2	2	14	1	1	0	0	0	ND	20	0.01
Chinook salmon	ND	0	1	0	3	5	1	0	0	0	0	ND	10	0.01
Bluegill	ND	0	0	0	0	3	0	1	0	0	5	ND	9	0.01
Coho salmon	ND	0	0	3	0	6	0	0	0	0	0	ND	9	0.01
Ninespine stickleback	ND	0	1	1	6	0	0	0	0	0	0	ND	8	0.01
Slimy sculpin	ND	0	0	7	0	0	0	0	0	0	1	ND	8	0.01
Johnny darter	ND	0	0	0	0	1	2	0	0	3	0	ND	6	<0.01
Northern pike	ND	0	0	0	0	2	0	0	0	1	1	ND	4	<0.01
Longnose sucker	ND	0	0	0	2	0	1	0	0	0	0	ND	3	<0.01
Mottled sculpin	ND	0	0	2	1	0	0	0	0	0	0	ND	3	<0.01
Channel catfish	ND	1	0	0	0	0	0	2	0	0	0	ND	3	<0.01
Fathead minnow	ND	0	0	0	1	0	1	0	0	0	0	ND	2	<0.01
Black bullhead	ND	0	0	1	0	0	1	0	0	0	0	ND	2	<0.01
Golden shiner	ND	0	0	2	0	0	0	0	0	0	0	ND	2	<0.01
Bloater	ND	0	0	0	1	0	0	0	0	0	0	ND	1	<0.01
Largemouth bass	ND	0	0	1	0	0	0	0	0	0	0	ND	1	<0.01
Rock bass	ND	0	0	0	0	0	0	0	0	0	1	ND	1	<0.01
Totals	ND	14	48	8129	2717	8079	11970	78807	81	32925	71	ND	142841	

Table 19. Number of fish caught in standard series seines during 1974 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	0	ND	3	13	4312	251	526	36187	7839	2052	0	ND	51183	69.17
Spottail shiner	0	ND	69	39	1656	5274	5542	5875	252	61	9	ND	18777	25.38
Yellow perch	0	ND	0	1	0	39	2508	802	10	0	0	ND	3360	4.54
Rainbow smelt	0	ND	37	224	39	0	2	10	1	2	0	ND	315	0.43
Gizzard shad	0	ND	5	4	43	1	0	0	0	1	0	ND	54	0.07
Coho salmon	0	ND	0	4	31	13	2	0	0	0	0	ND	50	0.07
Longnose dace	0	ND	2	1	3	8	2	1	0	20	6	ND	43	0.06
Bluegill	0	ND	1	0	39	3	0	0	0	0	0	ND	43	0.06
Brown trout	0	ND	2	3	9	12	0	0	0	1	0	ND	27	0.04
Slimy sculpin	0	ND	2	17	0	1	0	0	0	1	2	ND	23	0.03
Trout-perch	0	ND	0	1	1	0	2	3	12	0	2	ND	21	0.03
Chinook salmon	0	ND	0	2	5	2	5	0	0	0	0	ND	14	0.02
Emerald shiner	0	ND	2	1	1	3	0	0	0	6	0	ND	13	0.02
Carp	0	ND	0	2	7	0	1	2	0	0	0	ND	12	0.02
Channel catfish	0	ND	0	0	0	1	8	0	1	0	0	ND	10	0.01
White sucker	0	ND	1	0	1	0	3	1	1	0	0	ND	7	0.01
Rainbow trout	0	ND	4	2	0	0	0	0	0	0	1	ND	7	0.01
Green sunfish	0	ND	0	0	5	0	0	0	0	1	0	ND	6	0.01
Johnny darter	0	ND	0	0	0	4	0	0	0	0	0	ND	4	0.01
Ninespine stickleback	0	ND	0	1	2	0	1	0	0	0	0	ND	4	0.01
Northern pike	0	ND	1	0	0	2	0	1	0	0	0	ND	4	0.01
Sand shiner	0	ND	0	0	0	0	0	0	0	3	1	ND	4	0.01
Longnose sucker	0	ND	1	0	0	0	0	1	0	1	0	ND	3	<0.01
Bloater	0	ND	0	0	0	0	0	2	0	0	0	ND	2	<0.01
Black bullhead	0	ND	0	1	1	0	0	0	0	0	0	ND	2	<0.01
Lake trout	0	ND	1	0	0	0	0	0	0	0	0	ND	1	<0.01
Largemouth bass	0	ND	0	0	0	1	0	0	0	0	0	ND	1	<0.01
Golden shiner	0	ND	0	0	0	0	0	1	0	0	0	ND	1	<0.01
Bluntnose minnow	0	ND	0	0	0	0	0	0	0	1	0	ND	1	<0.01
Totals	0	ND	131	316	6155	5615	8602	42886	8116	2150	21	ND	73992	

Table 20.

Number of fish caught in standard series seines during 1975 at the Cook Plant study areas, southeastern Lake Michigan.
ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	NC	ND	ND	0	4775	1708	424	540	5569	20740	18	ND	33774	65.90
Spottail shiner	NC	ND	ND	52	976	7596	2679	927	1119	1311	251	ND	14911	29.09
Yellow perch	NC	ND	ND	0	0	722	1209	62	1	0	12	ND	2006	3.91
Rainbow smelt	NC	ND	ND	84	127	0	0	0	2	1	0	ND	214	0.42
Gizzard shad	NC	ND	ND	2	0	0	0	0	2	12	104	ND	120	0.23
Trout-perch	ND	ND	ND	1	5	0	0	4	41	15	0	ND	66	0.13
Sand shiner	NC	ND	ND	0	0	0	0	0	1	1	32	ND	34	0.07
Longnose dace	NC	ND	ND	0	0	1	0	2	2	7	6	ND	10	0.04
Slimy sculpin	NC	ND	ND	1	17	0	0	0	0	0	0	ND	18	0.04
Chinook salmon	NC	ND	ND	3	0	11	2	0	0	1	0	ND	17	0.03
Johnny darter	NC	ND	ND	0	0	3	0	2	0	0	9	ND	14	0.03
Brown trout	NC	ND	ND	0	1	0	1	0	0	0	10	ND	12	0.02
Rainbow trout	NC	ND	ND	2	0	0	1	0	0	6	3	ND	12	0.02
Coho salmon	ND	ND	ND	0	0	7	0	0	0	0	1	ND	8	0.02
Ninespine stickleback	ND	ND	ND	2	5	0	0	0	0	0	0	ND	7	0.01
White sucker	NC	ND	ND	2	2	0	1	0	0	0	0	ND	5	0.01
Northern pike	NC	ND	ND	1	0	0	0	0	0	0	3	ND	4	0.01
Carp	NC	ND	ND	0	1	0	3	0	0	0	0	ND	4	0.01
Bluegill	NC	ND	ND	0	0	1	0	0	1	0	0	ND	2	<0.01
Emerald shiner	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Channel catfish	NC	ND	ND	0	0	0	0	0	1	0	0	ND	1	<0.01
Bloater	NC	ND	ND	0	0	0	0	1	0	0	0	ND	1	<0.01
Quillback	NC	ND	ND	0	0	1	0	0	0	0	0	ND	1	<0.01
Largemouth bass	NC	ND	ND	0	0	1	0	0	0	0	0	ND	1	<0.01
Pumpkinseed	NC	ND	ND	0	0	0	1	0	0	0	0	ND	1	<0.01
Totals	NC	ND	ND	151	5909	10051	4321	1538	6739	22094	449	ND	51252	

Table 21.

Number of fish caught in standard series seines during 1976 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	0	ND	5	1905	1654	824	42919	74554	49	0	ND	121910	91.82
Spottail shiner	ND	7	ND	122	873	2801	4857	343	250	3	1	ND	9337	7.03
Yellow perch	ND	0	ND	0	0	16	750	16	13	0	0	ND	795	0.60
Rainbow smelt	ND	0	ND	300	13	0	0	5	7	0	1	ND	326	0.25
Trout-perch	ND	2	ND	9	9	1	32	38	25	0	1	ND	117	0.09
Brown trout	ND	4	ND	1	31	17	8	0	16	3	0	ND	80	0.06
Sand shiner	ND	0	ND	1	0	0	0	7	0	31	0	ND	39	0.03
Longnose dace	ND	0	ND	1	3	2	1	5	10	1	4	ND	27	0.02
White sucker	ND	1	ND	1	13	2	3	0	0	1	1	ND	22	0.02
Slimy sculpin	ND	0	ND	17	0	1	0	2	1	0	0	ND	21	0.02
Coho salmon	ND	0	ND	0	8	10	1	0	1	1	0	ND	21	0.02
Rainbow trout	ND	1	ND	2	2	1	1	0	4	2	0	ND	13	0.01
Carp	ND	0	ND	0	10	2	0	0	0	0	0	ND	12	0.01
Lake trout	ND	0	ND	1	0	0	0	0	0	9	0	ND	10	0.01
Chinook salmon	ND	1	ND	0	0	9	0	0	0	0	0	ND	10	0.01
Johnny darter	ND	0	ND	0	0	3	0	4	1	0	0	ND	8	0.01
Gizzard shad	ND	1	ND	0	0	1	0	0	2	1	0	ND	5	<0.01
Silver redhorse	ND	0	ND	0	0	0	3	0	0	0	0	ND	3	<0.01
Bloater	ND	0	ND	0	1	0	2	0	0	0	0	ND	3	<0.01
Quillback	ND	0	ND	0	0	1	1	0	0	0	0	ND	2	<0.01
Golden shiner	ND	1	ND	0	0	0	0	0	0	1	0	ND	2	<0.01
Ninespine stickleback	ND	0	ND	0	1	1	0	0	0	0	0	ND	2	<0.01
Bluegill	ND	0	ND	0	0	0	1	0	0	0	1	ND	2	<0.01
Channel catfish	ND	0	ND	0	1	0	1	0	0	0	0	ND	2	<0.01
Longnose sucker	ND	0	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Brook silverside	ND	0	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Smallmouth bass	ND	0	ND	0	0	0	0	1	0	0	0	ND	1	<0.01
Largemouth bass	ND	0	ND	0	0	0	0	1	0	0	0	ND	1	<0.01
Totals	ND	18	ND	462	2870	4602	6485	43341	74884	102	9	ND	132773	

Table 22. Number of fish caught in standard series seines during 1977 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	6	298	573	2590	20022	11451	51	11812	ND	46803	74.57
Spottail shiner	ND	ND	ND	11	1310	960	2235	8453	239	274	356	ND	13838	22.05
Yellow perch	ND	ND	ND	0	1	1	1004	25	3	0	285	ND	1319	2.10
Trout-perch	ND	ND	ND	0	7	99	4	9	91	3	1	ND	214	0.34
Rainbow smelt	ND	ND	ND	3	2	1	0	0	15	20	62	ND	103	0.16
Coho salmon	ND	ND	ND	1	83	2	0	0	0	0	3	ND	89	0.14
Longnose dace	ND	ND	ND	1	0	3	1	0	9	37	8	ND	59	0.09
Gizzard shad	ND	ND	ND	0	0	0	1	0	0	40	8	ND	49	0.08
Johnny darter	ND	ND	ND	0	4	0	5	35	1	0	1	ND	46	0.07
White sucker	ND	ND	ND	3	5	14	16	0	2	2	2	ND	44	0.07
Chinook salmon	ND	ND	ND	0	0	42	0	0	0	0	0	ND	42	0.07
Carp	ND	ND	ND	3	27	0	4	4	0	1	2	ND	41	0.07
Brown trout	ND	ND	ND	9	3	8	3	0	1	0	6	ND	30	0.05
Emerald shiner	ND	ND	ND	0	0	2	23	0	0	3	0	ND	28	0.04
Sand shiner	ND	ND	ND	1	0	2	13	5	1	0	1	ND	23	0.04
Rainbow trout	ND	ND	ND	2	1	0	0	0	6	0	0	ND	9	0.01
Bloater	ND	ND	ND	0	0	1	0	0	5	0	3	ND	9	0.01
Slimy sculpin	ND	ND	ND	1	0	0	0	0	0	0	3	ND	4	0.01
Quillback	ND	ND	ND	0	0	0	0	1	1	0	0	ND	2	<0.01
Bluegill	ND	ND	ND	0	0	1	0	0	1	0	0	ND	2	<0.01
Longnose sucker	ND	ND	ND	0	0	0	0	1	0	0	0	ND	1	<0.01
Lake trout	ND	ND	ND	0	0	0	0	0	0	0	1	ND	1	<0.01
Channel catfish	ND	ND	ND	0	0	0	0	1	0	0	0	ND	1	<0.01
Rock bass	ND	ND	ND	0	0	0	0	0	0	1	0	ND	1	<0.01
Golden shiner	ND	ND	ND	0	0	0	0	0	1	0	0	ND	1	<0.01
Freshwater drum	ND	ND	ND	0	0	0	0	0	0	1	0	ND	1	<0.01
Bluntnose minnow	ND	ND	ND	0	0	0	0	1	0	0	0	ND	1	<0.01
Totals	ND	ND	ND	41	1741	1709	5899	28557	11827	433	12554	ND	62761	

Table 23.

Number of fish caught in standard series seines during 1978 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Spottail shiner	NE	ND	ND	33	24	5438	15905	5830	1246	2	12	ND	28490	50.36
Alewife	NE	ND	ND	0	0	3717	90	1630	2553	18839	6	ND	26835	47.43
Rainbow smelt	NE	ND	ND	0	81	12	283	0	0	2	1	ND	379	0.67
Yellow perch	NE	ND	NE	1	0	0	263	7	20	0	1	ND	292	0.52
Coho salmon	NE	ND	NE	2	15	220	11	0	0	0	0	ND	248	0.44
Brown trout	NE	ND	ND	58	7	9	7	0	0	1	0	ND	82	0.14
Trout-perch	NE	ND	ND	1	3	39	32	0	5	0	0	ND	80	0.14
Chinook salmon	NE	ND	ND	0	0	55	0	0	0	0	0	ND	55	0.10
Longnose dace	NE	ND	ND	3	3	2	0	0	5	8	5	ND	26	0.05
White sucker	NE	ND	NE	1	2	1	14	1	0	0	2	ND	21	0.04
Rainbow trout	NE	ND	ND	3	1	2	2	4	1	4	1	ND	18	0.03
Sand shiner	NE	ND	ND	0	0	0	0	0	12	0	0	ND	12	0.02
Emerald shiner	NE	ND	ND	0	0	0	0	3	0	7	0	ND	10	0.02
Bloater	NE	ND	ND	0	0	3	3	0	0	0	0	ND	6	0.01
Johnny darter	ND	ND	ND	0	2	1	0	1	1	0	0	ND	5	0.01
Carp	NE	ND	NE	0	2	0	1	0	2	0	0	ND	5	0.01
Lake trout	NE	ND	ND	1	0	0	0	0	0	1	0	ND	2	<0.01
Spotfin shiner	NE	ND	ND	0	0	0	0	0	2	0	0	ND	2	<0.01
Golden shiner	NE	ND	ND	0	0	0	2	0	0	0	0	ND	2	<0.01
Blackchin shiner	NE	ND	ND	0	0	1	0	0	0	0	0	ND	1	<0.01
Channel catfish	NE	ND	ND	0	0	0	1	0	0	0	0	ND	1	<0.01
Longnose sucker	NE	ND	ND	0	0	0	0	1	0	0	0	ND	1	<0.01
Brook silverside	NE	ND	ND	0	0	0	0	0	1	0	0	ND	1	<0.01
Ninespine stickleback	NE	ND	ND	0	1	0	0	0	0	0	0	ND	1	<0.01
Burbot	NE	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Gizzard shad	NE	ND	ND	0	0	0	0	0	0	0	1	ND	1	<0.01
Fathead minnow	NE	ND	ND	0	0	0	0	0	1	0	0	ND	1	<0.01
TOTALS	NE	ND	NE	104	141	9500	16614	7477	3849	18864	29	ND	56578	

Table 24. Number of fish caught in standard series seines during 1979 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	2	1	121	108	16381	65914	52792	2	ND	135321	86.68
Spottail shiner	ND	ND	ND	108	410	885	8271	163	7074	422	2	ND	18135	11.62
Yellow perch	ND	ND	ND	1	0	0	428	29	687	0	0	ND	1145	0.73
Bloater	ND	ND	ND	0	0	0	0	0	402	25	0	ND	507	0.32
Rainbow smelt	ND	ND	ND	26	236	1	0	3	3	67	5	ND	341	0.22
Chinook salmon	ND	ND	ND	140	77	58	1	0	0	0	0	ND	276	0.18
Trout-perch	ND	ND	ND	22	4	21	26	4	2	1	0	ND	80	0.05
White sucker	ND	ND	ND	38	6	1	7	5	0	1	0	ND	58	0.04
Johnny darter	ND	ND	ND	0	0	0	21	0	37	0	0	ND	58	0.04
Coho salmon	ND	ND	ND	10	26	0	0	0	0	0	0	ND	36	0.02
Slimy sculpin	ND	ND	ND	27	0	0	0	0	0	0	0	ND	27	0.02
Brown trout	ND	ND	ND	5	14	3	0	0	0	3	1	ND	24	0.02
Gizzard shad	ND	ND	ND	3	0	1	0	0	0	10	8	ND	22	0.01
Carp	ND	ND	ND	10	2	3	2	0	0	0	0	ND	17	0.01
Emerald shiner	ND	ND	ND	7	1	3	0	0	0	0	1	ND	12	0.01
Rainbow trout	ND	ND	ND	2	1	1	0	1	1	2	3	ND	11	0.01
Lake trout	ND	ND	ND	0	0	0	0	0	0	10	0	ND	10	0.01
Sand shiner	ND	ND	ND	0	0	0	0	0	0	7	0	ND	7	<0.01
Longnose dace	ND	ND	ND	3	0	0	0	0	1	2	0	ND	6	<0.01
Longnose sucker	ND	ND	ND	0	1	1	2	0	1	0	0	ND	5	<0.01
Spotfin shiner	ND	ND	ND	0	0	0	0	2	0	1	0	ND	3	<0.01
Burbot	ND	ND	ND	0	0	1	0	2	0	0	0	ND	3	<0.01
Northern pike	ND	ND	ND	0	0	0	0	0	2	0	0	ND	2	<0.01
Fathead minnow	ND	ND	ND	0	0	0	0	1	0	0	0	ND	2	<0.01
Bluntnose minnow	ND	ND	ND	0	1	0	0	0	0	0	0	ND	1	<0.01
Ninespine stickleback	ND	ND	ND	0	0	1	0	0	0	0	0	ND	1	<0.01
Black crappie	ND	ND	ND	0	1	0	0	0	0	0	0	ND	1	<0.01
Lake chub	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Bluegill	ND	ND	ND	0	0	1	0	0	0	0	0	ND	1	<0.01
Green sunfish	ND	ND	ND	0	0	1	0	0	0	0	0	ND	1	<0.01
Shorthead redhorse	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Totals	ND	ND	ND	406	771	1104	8074	16591	75004	53343	22	ND	156115	

B5-60

Table 25. Number of fish caught in standard series seines during 1980 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Spottail shiner	ND	ND	ND	11	4071	993	6026	708	ND	ND	ND	ND	11809	47.19
Alewife	ND	ND	ND	0	3399	1971	1820	2212	ND	ND	ND	ND	9402	37.57
Yellow perch	ND	ND	ND	1	2	0	1646	238	ND	ND	ND	ND	1887	7.54
Rainbow smelt	ND	ND	ND	9	381	513	0	570	ND	ND	ND	ND	1473	5.89
Trout-perch	ND	ND	ND	5	116	19	3	7	ND	ND	ND	ND	150	0.60
Chinook salmon	ND	ND	ND	0	2	139	9	0	ND	ND	ND	ND	150	0.60
Bloater	ND	ND	ND	0	0	50	0	0	ND	ND	ND	ND	50	0.20
White sucker	ND	ND	ND	2	7	0	23	0	ND	ND	ND	ND	32	0.13
Brown trout	ND	ND	ND	11	4	2	0	0	ND	ND	ND	ND	17	0.07
Gizzard shad	ND	ND	ND	0	1	9	1	1	ND	ND	ND	ND	12	0.05
Longnose dace	ND	ND	ND	0	1	2	0	5	ND	ND	ND	ND	8	0.03
Sand shiner	ND	ND	ND	0	0	0	1	5	ND	ND	ND	ND	6	0.02
Carp	ND	ND	ND	1	3	0	2	0	ND	ND	ND	ND	6	0.02
Slimy sculpin	ND	ND	ND	1	4	0	0	0	ND	ND	ND	ND	5	0.02
Rainbow trout	ND	ND	ND	3	0	0	0	0	ND	ND	ND	ND	3	0.01
Black bullhead	ND	ND	ND	0	0	2	1	0	ND	ND	ND	ND	3	0.01
Coho salmon	ND	ND	ND	1	2	0	0	0	ND	ND	ND	ND	3	0.01
Ninespine stickleback	ND	ND	ND	0	2	1	0	0	ND	ND	ND	ND	3	0.01
Longnose sucker	ND	ND	ND	0	2	0	0	0	ND	ND	ND	ND	2	0.01
Johnny darter	ND	ND	ND	0	1	0	0	0	ND	ND	ND	ND	1	<0.01
Totals	ND	ND	ND	45	7998	3701	9532	3746	ND	ND	ND	ND	25022	

Table 26.

Number of fish caught in standard series gill nets during 1973 at the Cook Plant study areas, southeastern Lake Michigan.
NC=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	NC	0	1869	2682	1091	4190	854	263	79	68	0	0	11104	63.59
Spottail shiner	NC	12	402	914	799	848	25	300	104	137	96	1	3638	20.83
Yellow perch	NC	6	35	10	15	527	338	422	34	33	22	0	1442	8.26
Rainbow smelt	NC	1	118	180	7	4	1	121	60	8	12	0	512	2.93
Trout-perch	NC	0	2	0	7	62	114	19	5	31	20	0	260	1.49
Lake trout	NC	0	2	1	1	0	6	18	49	27	54	0	158	0.90
White sucker	NC	1	2	6	10	11	13	26	38	26	0	0	133	0.76
Longnose sucker	NC	1	4	9	13	11	24	1	1	1	0	0	65	0.37
Bloater	NC	0	0	0	1	12	33	14	1	1	0	0	62	0.36
Northern pike	NC	0	0	0	0	0	0	0	8	7	8	0	23	0.13
Coho salmon	NC	0	5	0	9	1	0	0	3	2	0	0	20	0.11
Chinook salmon	NC	0	0	2	2	0	1	2	3	2	0	0	12	0.07
Brown trout	NC	0	4	1	2	0	0	2	0	1	0	0	10	0.06
Carp	NC	0	0	0	0	0	0	1	0	6	0	0	7	0.04
Channel catfish	NC	0	0	0	0	0	0	0	0	2	4	0	6	0.03
Burbot	NC	0	0	4	0	1	0	0	0	0	0	0	5	0.03
Rainbow trout	NC	0	0	1	2	0	0	0	0	0	0	0	3	0.02
Rock bass	NC	0	0	0	0	1	0	0	0	0	0	0	1	0.01
Mottled sculpin	NC	0	0	1	0	0	0	0	0	0	0	0	1	0.01
Totals	NC	21	2443	3011	1959	5676	1409	1189	385	352	216	1	17462	

Table 27.

Number of fish caught in standard series gill nets during 1979 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	0	ND	279	891	1800	2782	2987	351	174	160	1	0	9425	66.70
Spottail shiner	1	ND	78	162	700	1335	161	39	76	77	17	22	2668	19.02
Yellow perch	1	ND	14	15	7	28	50	315	359	2	56	16	863	6.11
Rainbow smelt	0	ND	18	169	17	0	10	20	3	59	0	5	301	2.13
Trout-perch	0	ND	0	1	21	2	140	17	6	50	3	2	242	1.71
Lake trout	0	ND	0	0	16	9	0	0	0	12	83	0	120	0.85
White sucker	2	ND	1	3	15	19	25	10	13	13	5	8	113	0.80
Coho salmon	0	ND	8	4	40	0	0	26	0	0	25	0	103	0.73
Longnose sucker	1	ND	1	4	26	11	38	1	3	1	6	2	94	0.67
Bloater	0	ND	0	0	0	0	59	0	1	0	0	0	60	0.42
Gizzard shad	0	ND	0	0	1	0	0	1	20	8	0	0	30	0.21
Chinook salmon	0	ND	0	1	1	1	0	3	13	0	3	1	23	0.16
Brown trout	0	ND	1	2	5	1	4	5	2	0	2	0	22	0.16
Burbot	0	ND	1	1	1	1	0	0	0	0	0	10	14	0.10
Carp	0	ND	0	0	0	0	0	7	4	2	0	0	13	0.09
Northern pike	1	ND	2	3	1	0	0	0	0	5	0	0	12	0.08
Channel catfish	0	ND	0	0	0	0	0	0	4	0	0	0	4	0.03
Rainbow trout	0	ND	1	0	0	0	0	0	0	0	0	0	1	0.01
Lake whitefish	0	ND	0	0	0	0	0	1	0	0	0	0	1	0.01
Lake herring	0	ND	0	0	0	0	0	0	0	0	0	1	1	0.01
Slimy sculpin	0	ND	0	1	0	0	0	0	0	0	0	0	1	0.01
Totals	6	ND	424	1257	2651	4180	3874	796	678	389	201	67	14131	

Table 28.

Number of fish caught in standard series gill nets during 1975 at the Cook Plant study areas, southeastern Lake Michigan.
ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	0	ND	797	157	319	867	511	201	52	44	50	10	3009	46.67
Spottail shiner	1	ND	12	12	133	545	212	205	159	108	21	39	1437	22.29
Yellow perch	7	ND	29	8	2	130	361	366	255	132	87	3	1388	21.53
Longnose sucker	1	ND	50	1	8	20	0	0	1	2	3	0	88	1.36
White sucker	1	ND	7	1	4	17	8	0	17	1	1	4	81	1.26
Lake trout	0	ND	1	2	5	18	0	0	0	4	47	1	78	1.21
Trout-perch	0	ND	0	1	12	17	0	7	20	15	2	0	74	1.15
Rainbow smelt	3	ND	21	12	11	6	0	2	0	7	0	1	65	1.01
Coho salmon	0	ND	6	40	1	5	0	2	0	0	1	0	55	0.85
Gizzard shad	0	ND	0	0	0	0	0	28	15	1	2	0	46	0.71
Carp	0	ND	0	0	0	0	9	13	17	2	2	0	43	0.67
Chinook salmon	0	ND	0	0	0	0	0	3	2	19	7	1	32	0.50
Burbot	1	ND	0	0	0	0	0	0	0	0	0	13	14	0.22
Brown trout	0	ND	7	2	0	1	0	1	1	1	0	1	14	0.22
Channel catfish	0	ND	0	0	0	0	1	1	4	1	1	0	8	0.12
Shorthead redhorse	0	ND	0	0	0	0	0	0	4	0	0	0	4	0.06
Rainbow trout	0	ND	1	0	0	0	0	0	1	0	0	1	3	0.05
Bloater	0	ND	0	0	0	1	0	1	0	0	0	0	2	0.03
Northern pike	1	ND	0	0	0	1	0	0	0	0	0	0	2	0.03
Lake whitefish	0	ND	0	1	0	1	0	0	0	0	0	0	2	0.03
Lake herring	0	ND	0	1	0	0	0	0	0	0	0	0	1	0.02
Silver redhorse	0	ND	0	0	0	0	0	0	0	1	0	0	1	0.02
Lake sturgeon	0	ND	0	0	1	0	0	0	0	0	0	0	1	0.02
Totals	15	ND	931	250	499	1657	1102	830	593	338	224	69	6448	

Table 29.

Number of fish caught in standard series gill nets during 1976 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct.	Nov	Dec	Total	Percent
Alewife	ND	0	204	1267	1136	2078	1647	89	76	12	ND	ND	6509	67.19
Spottail shiner	ND	40	49	142	259	102	384	103	139	31	ND	ND	1449	14.96
Yellow perch	ND	11	5	21	21	244	406	216	167	4	ND	ND	1097	11.32
Rainbow smelt	ND	1	21	16	17	143	1	0	1	1	ND	ND	201	2.07
Trout-perch	ND	0	1	1	3	52	26	4	57	2	ND	ND	146	1.51
White sucker	ND	3	0	5	11	3	14	5	17	7	ND	ND	65	0.67
Gizzard shad	ND	0	0	0	0	0	1	20	18	6	ND	ND	45	0.46
Bloater	ND	0	0	0	0	25	14	0	0	0	ND	ND	39	0.40
Longnose sucker	ND	20	3	5	4	3	2	0	0	0	ND	ND	37	0.38
Coho salmon	ND	0	0	0	17	6	0	0	0	0	ND	ND	25	0.26
Lake trout	ND	0	3	4	7	7	0	0	0	2	ND	ND	23	0.24
Carp	ND	0	0	0	0	0	1	14	3	0	ND	ND	18	0.19
Brown trout	ND	2	0	1	1	1	2	1	1	1	ND	ND	10	0.10
Channel catfish	ND	0	0	0	0	0	0	2	8	0	ND	ND	10	0.10
Lake whitefish	ND	0	1	2	1	1	0	0	0	0	ND	ND	5	0.05
Chinook salmon	ND	0	0	0	0	0	1	0	3	0	ND	ND	4	0.04
Burbot	ND	1	0	1	0	0	1	0	0	0	ND	ND	3	0.03
Rainbow trout	ND	1	0	0	0	0	0	0	0	0	ND	ND	1	0.01
Lake sturgeon	ND	0	0	0	1	0	0	0	0	0	ND	ND	1	0.01
Totals	ND	81	287	1665	1480	2665	2500	454	490	66	ND	ND	9688	

Table 30.
Number of fish caught in standard series gill nets during 1977 at the Cook Plant study areas, southeastern Lake Michigan.
ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	66	26	608	785	783	92	38	172	4	0	2574	40.05
Spottail shiner	ND	ND	54	2	684	813	60	208	119	133	17	0	2090	32.52
Yellow perch	ND	ND	11	14	11	66	283	408	134	18	11	1	957	14.89
Lake trout	ND	ND	4	10	6	6	6	0	9	27	118	0	186	2.89
White sucker	ND	ND	0	5	21	4	50	10	21	5	3	1	120	1.87
Trout-perch	ND	ND	1	0	15	13	54	3	6	5	0	0	97	1.51
Longnose sucker	ND	ND	4	5	3	0	34	0	5	6	23	0	80	1.24
Rainbow smelt	ND	ND	0	35	0	0	6	1	6	17	0	0	65	1.01
Gizzard shad	ND	ND	0	0	0	0	0	15	39	1	0	0	55	0.86
Carp	ND	ND	0	2	3	0	1	18	20	2	5	0	51	0.79
Bloater	ND	ND	0	0	0	20	29	0	0	0	0	0	49	0.76
Chinook salmon	ND	ND	11	21	0	0	0	0	0	1	0	0	33	0.51
Brown trout	ND	ND	5	0	5	5	2	0	4	1	3	6	31	0.48
Golden redhorse	ND	ND	0	0	0	0	0	6	3	0	0	0	9	0.14
Channel catfish	ND	ND	0	0	0	0	0	4	2	2	0	0	8	0.12
Coho salmon	ND	ND	3	0	0	0	0	0	1	2	1	0	7	0.11
Burbot	ND	ND	1	0	0	0	0	0	0	0	0	6	7	0.11
Rainbow trout	ND	ND	0	0	0	0	1	0	0	0	2	0	3	0.05
Lake sturgeon	ND	ND	0	0	0	0	1	1	0	0	0	0	2	0.03
Shorthead redhorse	ND	ND	0	0	0	0	0	0	0	0	0	1	1	0.02
Quillback	ND	ND	0	0	0	0	0	0	1	0	0	0	1	0.02
Silver redhorse	ND	ND	0	0	0	0	0	0	1	0	0	0	1	0.02
Totals	ND	ND	160	120	1356	1712	1310	766	409	392	187	15	6427	

Table 31.

Number of fish caught in standard series gill nets during 1978 at the Cook Plant study areas, southeastern Lake Michigan

ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	4	294	1152	537	138	78	25	1	ND	2229	44.37
Spottail shiner	ND	ND	ND	61	244	25	5	204	126	148	24	ND	837	16.66
Yellow perch	ND	ND	ND	28	9	126	31	197	318	0	36	ND	740	14.73
Rainbow smelt	ND	ND	ND	19	47	27	29	108	48	5	1	ND	284	5.65
Lake trout	ND	ND	ND	8	34	31	17	10	89	51	39	ND	279	5.55
Gizzard shad	ND	ND	ND	0	0	0	0	0	12	88	7	ND	107	2.13
Trout-perch	ND	ND	ND	1	23	26	5	10	19	20	2	ND	106	2.11
White sucker	ND	ND	ND	0	9	5	1	8	36	21	9	ND	84	1.67
Brown trout	ND	ND	ND	4	5	0	3	11	30	16	10	ND	79	1.57
Bloater	ND	ND	ND	0	1	8	9	42	2	0	0	ND	62	1.23
Longnose sucker	ND	ND	ND	14	2	0	1	6	6	7	24	ND	60	1.19
Chinook salmon	ND	ND	ND	7	6	0	4	2	7	22	4	ND	52	1.04
Coho salmon	ND	ND	ND	7	8	4	11	17	4	0	0	ND	51	1.02
Carp	ND	ND	ND	0	2	0	0	2	3	16	5	ND	28	0.56
Lake whitefish	ND	ND	ND	0	1	3	0	2	2	0	1	ND	9	0.18
Channel catfish	ND	ND	ND	0	0	0	0	0	1	2	1	ND	4	0.08
Rainbow trout	ND	ND	ND	1	0	0	0	1	0	1	0	ND	3	0.06
Burbot	ND	ND	ND	0	1	0	0	0	0	1	1	ND	3	0.06
Northern pike	ND	ND	ND	0	0	0	0	0	0	2	0	ND	2	0.04
Quillback	ND	ND	ND	0	0	0	0	0	0	2	0	ND	2	0.04
Lake herring	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	0.02
Silver redhorse	ND	ND	ND	0	0	0	0	0	0	1	0	ND	1	0.02
Lake sturgeon	ND	ND	ND	0	0	0	0	0	0	0	1	ND	1	0.02
TOTALS	ND	ND	ND	155	676	1407	653	758	781	428	166	ND	5024	

Table 32. Number of fish caught in standard series gill nets during 1979 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Spottail shiner	ND	ND	ND	74	210	852	1182	181	251	195	70	ND	3015	38.04
Alewife	ND	ND	ND	243	50	1509	844	190	17	0	6	ND	2859	36.08
Yellow perch	ND	ND	ND	11	18	28	42	389	500	7	11	ND	1006	12.69
Rainbow smelt	ND	ND	ND	90	48	2	0	5	3	18	18	ND	192	2.42
Lake trout	ND	ND	ND	15	3	2	0	2	0	45	85	ND	152	1.92
Gizzard shad	ND	ND	ND	0	0	0	0	6	124	6	0	ND	136	1.72
Trout-perch	ND	ND	ND	0	4	21	25	34	12	37	3	ND	136	1.72
White sucker	ND	ND	ND	2	12	26	0	34	29	16	1	ND	120	1.51
Longnose sucker	ND	ND	ND	2	33	16	3	4	3	7	0	ND	68	0.86
Carp	ND	ND	ND	1	27	4	0	11	3	7	0	ND	53	0.67
Bloater	ND	ND	ND	0	1	0	46	1	0	0	1	ND	49	0.62
Chinook salmon	ND	ND	ND	20	2	1	0	1	7	0	1	ND	40	0.50
Brown trout	ND	ND	ND	14	6	6	3	0	1	1	4	ND	35	0.44
Coho salmon	ND	ND	ND	29	0	0	0	0	0	0	0	ND	29	0.37
Silver redhorse	ND	ND	ND	0	0	0	0	1	6	3	0	ND	10	0.13
Channel catfish	ND	ND	ND	1	0	0	0	3	3	1	0	ND	8	0.10
Lake whitefish	ND	ND	ND	3	1	1	0	0	0	0	0	ND	5	0.06
Shorthead redhorse	ND	ND	ND	0	0	0	1	0	0	2	0	ND	3	0.04
Golden redhorse	ND	ND	ND	0	0	0	0	0	3	0	0	ND	3	0.04
Rainbow trout	ND	ND	ND	1	0	0	1	0	0	0	0	ND	2	0.03
Northern pike	ND	ND	ND	0	0	0	0	1	1	0	0	ND	2	0.03
Round whitefish	ND	ND	ND	1	0	0	0	0	0	1	0	ND	2	0.03
Totals	ND	ND	ND	523	415	2468	2147	863	963	346	200	ND	7925	

Table 33. Number of fish caught in standard series gill nets during 1980 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Spottail shiner	ND	ND	ND	137	522	2227	820	61	ND	ND	ND	ND	3767	54.39
Alewife	ND	ND	ND	817	478	421	345	80	ND	ND	ND	ND	2141	30.91
Yellow perch	ND	ND	ND	4	2	81	213	392	ND	ND	ND	ND	692	9.99
Rainbow smelt	ND	ND	ND	2	39	6	0	27	ND	ND	ND	ND	74	1.07
Trout-perch	ND	ND	ND	0	14	22	6	18	ND	ND	ND	ND	60	0.87
White sucker	ND	ND	ND	0	22	23	2	2	ND	ND	ND	ND	49	0.71
Lake trout	ND	ND	ND	2	15	7	0	11	ND	ND	ND	ND	35	0.51
Bloater	ND	ND	ND	0	3	5	7	8	ND	ND	ND	ND	23	0.33
Longnose sucker	ND	ND	ND	2	10	8	3	0	ND	ND	ND	ND	23	0.33
Brown trout	ND	ND	ND	4	2	7	0	5	ND	ND	ND	ND	18	0.26
Chinook salmon	ND	ND	ND	2	9	2	1	3	ND	ND	ND	ND	17	0.25
Lake whitefish	ND	ND	ND	0	10	0	0	0	ND	ND	ND	ND	10	0.14
Coho salmon	ND	ND	ND	1	4	2	0	0	ND	ND	ND	ND	7	0.10
Carp	ND	ND	ND	1	0	1	1	3	ND	ND	ND	ND	6	0.09
Burbot	ND	ND	ND	1	0	0	0	0	ND	ND	ND	ND	1	0.01
Slimy sculpin	ND	ND	ND	0	0	0	1	0	ND	ND	ND	ND	1	0.01
Silver redhorse	ND	ND	ND	0	0	0	0	1	ND	ND	ND	ND	1	0.01
Gizzard shad	ND	ND	ND	0	0	0	0	1	ND	ND	ND	ND	1	0.01
Totals	ND	ND	ND	973	1130	2812	1399	612	ND	ND	ND	ND	6926	

Table 34.

Number of fish caught in standard series trawls during 1973 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Rainbow smelt	ND	ND	ND	1358	722	953	292	8273	1360	326	ND	ND	13284	39.59
Alewife	ND	ND	ND	2946	1627	1579	1963	2611	683	508	ND	ND	11917	35.51
Trout-perch	ND	ND	ND	46	90	1505	588	492	155	294	ND	ND	3170	9.45
Spottail shiner	ND	ND	ND	729	563	167	266	504	632	273	ND	ND	3134	9.34
Yellow perch	ND	ND	ND	5	25	360	264	486	209	315	ND	ND	1664	4.96
Johnny darter	ND	ND	ND	13	47	57	15	31	11	27	ND	ND	201	0.60
Slimy sculpin	ND	ND	ND	37	14	3	0	6	4	7	ND	ND	71	0.21
Bloater	ND	ND	ND	0	0	14	9	21	0	19	ND	ND	63	0.19
Mottled sculpin	ND	ND	ND	6	2	2	0	0	0	2	ND	ND	12	0.04
Ninespine stickleback	ND	ND	ND	0	6	5	0	0	0	0	ND	ND	11	0.03
White sucker	ND	ND	ND	0	0	3	1	4	3	0	ND	ND	11	0.03
Longnose sucker	ND	ND	ND	0	0	3	2	0	0	0	ND	ND	5	0.01
Lake trout	ND	ND	ND	0	1	2	0	1	0	0	ND	ND	4	0.01
Northern pike	ND	ND	ND	0	0	0	0	1	0	2	ND	ND	3	0.01
Lake whitefish	ND	ND	ND	0	1	1	0	0	0	0	ND	ND	2	0.01
Brown trout	ND	ND	ND	0	0	1	0	0	0	0	ND	ND	1	<0.01
Channel catfish	ND	ND	ND	0	0	1	0	0	0	0	ND	ND	1	<0.01
Chinook salmon	ND	ND	ND	0	0	1	0	0	0	0	ND	ND	1	<0.01
Bluegill	ND	ND	ND	0	1	0	0	0	0	0	ND	ND	1	<0.01
Burbot	ND	ND	ND	0	0	1	0	0	0	0	ND	ND	1	<0.01
Totals	ND	ND	ND	5140	3099	4658	3400	12430	3057	1773	ND	ND	33557	

Table 35.

Number of fish caught in standard series trawls during 1974 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	3928	7808	755	1149	131	166	765	723	ND	15425	59.59
Rainbow smelt	ND	ND	ND	308	738	59	373	3274	89	284	13	ND	5130	19.85
Spottail shiner	ND	ND	ND	112	1755	333	101	133	86	338	10	ND	2940	11.37
Trout-perch	ND	ND	ND	8	123	53	786	108	88	137	12	ND	1315	5.08
Yellow perch	ND	ND	ND	19	7	89	23	65	84	7	19	ND	313	1.21
Johnny darter	ND	ND	ND	5	73	82	60	6	7	22	14	ND	289	1.12
Slimy sculpin	ND	ND	ND	137	19	14	14	28	2	17	17	ND	248	0.96
Bloater	ND	ND	ND	0	0	3	140	5	0	15	0	ND	163	0.63
Ninespine stickleback	ND	ND	ND	0	13	4	2	1	0	0	0	ND	20	0.08
White sucker	ND	ND	ND	0	0	1	1	2	2	0	0	ND	6	0.02
Lake trout	ND	ND	ND	1	1	0	0	0	0	0	2	ND	4	0.02
Chinook salmon	ND	ND	ND	0	0	0	1	3	0	0	0	ND	4	0.02
Bluegill	ND	ND	ND	0	1	2	0	0	0	0	0	ND	3	0.01
Channel catfish	ND	ND	ND	1	0	0	0	0	0	1	1	ND	3	0.01
Longnose sucker	ND	ND	ND	0	0	0	1	0	0	1	0	ND	2	0.01
Carp	ND	ND	ND	0	0	0	0	0	1	1	0	ND	2	0.01
Brown trout	ND	ND	ND	0	0	0	2	0	0	0	0	ND	2	0.01
Burbot	ND	ND	ND	0	1	0	0	0	0	0	0	ND	1	<0.01
Totals	ND	ND	ND	4519	10559	1395	2733	3756	525	1588	811	ND	25886	

Table 36.

Number of fish caught in standard series trawls during 1975 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	9	1089	143	161	16	2119	404	100	32	4873	36.88
Spottail shiner	ND	ND	ND	39	631	342	185	451	749	116	156	797	3466	26.23
Rainbow smelt	ND	ND	ND	159	1093	1026	0	171	92	171	105	11	2830	21.42
Yellow perch	ND	ND	ND	4	2	108	573	132	24	19	4	77	943	7.14
Trout-perch	ND	ND	ND	12	134	204	68	103	89	78	49	28	765	5.79
Johnny darter	ND	ND	ND	2	35	16	3	3	31	19	10	9	128	0.97
Slimy sculpin	ND	ND	ND	37	31	12	0	1	1	2	5	4	93	0.70
Bloater	ND	ND	ND	0	2	33	0	9	1	1	0	0	46	0.35
Gizzard shad	ND	ND	ND	0	0	0	0	0	1	0	0	26	27	0.20
Ninespine stickleback	ND	ND	ND	0	5	14	0	0	0	0	0	0	19	0.14
Lake trout	ND	ND	ND	1	3	3	0	0	0	0	0	0	7	0.05
Longnose sucker	ND	ND	ND	0	1	2	1	2	0	0	0	0	6	0.05
Carp	ND	ND	ND	0	0	0	2	1	0	0	0	0	3	0.02
White sucker	ND	ND	ND	0	0	0	0	0	0	1	1	1	3	0.02
Logperch	ND	ND	ND	0	1	1	0	0	0	0	0	0	2	0.02
Chinook salmon	ND	ND	ND	0	0	0	1	0	0	0	0	0	1	0.01
Burbot	ND	ND	ND	0	0	0	0	0	0	1	0	0	1	0.01
Totals	ND	ND	ND	263	3027	1904	994	889	3107	812	410	987	13213	

Table 37.

Number of fish caught in standard series trawls during 1976 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	748	4405	130	301	398	78	2164	20	ND	8324	54.99
Spottail shiner	ND	ND	ND	503	576	324	68	134	434	1144	146	ND	3329	21.99
Trout-perch	ND	ND	ND	15	106	62	1088	92	179	143	7	ND	1692	11.18
Rainbow smelt	ND	ND	ND	136	37	0	415	14	3	12	121	ND	738	4.88
Yellow perch	ND	ND	ND	33	3	58	86	154	242	26	4	ND	606	4.00
Johnny darter	ND	ND	ND	2	139	9	25	26	30	59	6	ND	296	1.96
Bloater	ND	ND	ND	3	1	1	60	0	0	0	0	ND	65	0.43
Slimy sculpin	ND	ND	ND	38	12	0	0	4	1	5	3	ND	63	0.42
Ninespine stickleback	ND	ND	ND	0	7	0	0	0	0	0	0	ND	7	0.05
Lake trout	ND	ND	ND	1	1	0	2	0	0	0	0	ND	4	0.03
Burbot	ND	ND	ND	1	0	0	0	0	0	2	0	ND	3	0.02
White sucker	ND	ND	ND	0	0	0	1	0	1	0	0	ND	2	0.01
Carp	ND	ND	ND	0	0	0	0	0	1	1	0	ND	2	0.01
Longnose sucker	ND	ND	ND	2	0	0	0	0	0	0	0	ND	2	0.01
Channel catfish	ND	ND	ND	0	1	0	0	0	0	0	0	ND	1	0.01
Bluegill	ND	ND	ND	0	1	0	0	0	0	0	0	ND	1	0.01
Lake whitefish	ND	ND	ND	0	0	0	1	0	0	0	0	ND	1	0.01
Gizzard shad	ND	ND	ND	0	0	0	0	0	0	0	1	ND	1	0.01
Totals	ND	ND	ND	1482	5289	504	2127	822	969	3556	308	ND	15137	

B4=75

Table 38.

Number of fish caught in standard series trawls during 1977 at the Cook Plant study areas, southeastern Lake Michigan. ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Spottail shiner	ND	ND	ND	7	337	417	68	1437	3177	1157	25	ND	6627	34.59
Alewife	ND	ND	ND	2	364	249	134	37	1242	2794	1780	ND	6602	34.46
Trout-perch	ND	ND	ND	4	171	205	1861	118	75	493	1	ND	2929	15.20
Rainbow smelt	ND	ND	ND	75	168	1	663	87	78	111	104	ND	1287	6.72
Yellow perch	ND	ND	ND	14	7	122	13	464	333	29	120	ND	1102	5.75
Johnny darter	ND	ND	ND	34	167	49	26	6	81	4	15	ND	377	1.97
Bloater	ND	ND	ND	0	0	3	11	0	2	141	12	ND	169	0.88
Slimy sculpin	ND	ND	ND	14	0	0	7	1	2	0	2	ND	26	0.14
Longnose sucker	ND	ND	ND	0	0	0	0	8	9	0	1	ND	18	0.09
White sucker	ND	ND	ND	0	3	0	2	3	0	1	0	ND	9	0.05
Ninespine stickleback	ND	ND	ND	0	5	0	2	0	0	0	0	ND	7	0.04
Mottled sculpin	ND	ND	ND	0	0	0	0	0	0	3	0	ND	3	0.02
Burbot	ND	ND	ND	0	0	0	0	1	0	0	0	ND	1	0.01
Chinook salmon	ND	ND	ND	0	0	1	0	0	0	0	0	ND	1	0.01
Longnose dace	ND	ND	ND	0	0	0	0	0	0	1	0	ND	1	0.01
Totals	ND	ND	ND	150	1224	1042	2787	2162	4999	4734	2060	ND	19158	

Table 39.
Number of fish caught in standard series trawls during 1978 at the Cook Plant study areas, southeastern Lake Michigan.
ND=no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	ND	ND	ND	0	0	629	14	18	55	8018	694	ND	9428	30.89
Rainbow smelt	ND	ND	ND	47	1452	20	1532	5338	41	102	66	ND	8598	28.17
Spottail shiner	ND	ND	ND	14	146	1361	3	30	916	4638	166	ND	7274	23.84
Trout-perch	ND	ND	ND	3	54	129	573	300	230	1611	18	ND	2918	9.56
Bloater	ND	ND	ND	0	0	106	257	826	27	52	56	ND	1324	4.34
Yellow perch	ND	ND	ND	21	0	55	85	2	271	57	53	ND	544	1.78
Johnny darter	ND	ND	ND	1	75	56	82	16	4	112	34	ND	380	1.25
Slimy sculpin	ND	ND	ND	5	6	1	1	0	0	1	0	ND	14	0.05
White sucker	ND	ND	ND	0	0	3	0	0	0	10	0	ND	13	0.04
Longnose sucker	ND	ND	ND	0	0	2	0	0	6	1	1	ND	10	0.03
Lake trout	ND	ND	ND	0	0	0	1	1	0	1	2	ND	5	0.02
Ninespine stickleback	ND	ND	ND	1	1	1	0	0	1	0	0	ND	4	0.01
Coho salmon	ND	ND	ND	2	0	0	0	0	0	0	0	ND	2	0.01
Burbot	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Carp	ND	ND	ND	0	0	0	0	0	1	0	0	ND	1	<0.01
Brown trout	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
TOTALS	ND	ND	ND	96	1734	2363	2548	6531	1552	14603	1090	ND	30517	

Table 40. Number of fish caught in standard series trawls during 1979 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Spottail shiner	ND	ND	ND	529	214	1738	343	1803	457	1463	120	ND	6675	30.61
Rainbow smelt	ND	ND	ND	664	1868	576	146	915	48	65	444	ND	4726	21.67
Alewife	ND	ND	ND	22	20	618	226	129	629	1815	132	ND	3591	16.47
Yellow perch	ND	ND	ND	29	7	76	41	613	1546	56	140	ND	2508	11.50
Bloater	ND	ND	ND	0	3	68	1933	2	36	65	346	ND	2453	11.25
Trout-perch	ND	ND	ND	19	19	110	275	338	310	423	20	ND	1514	6.94
Johnny darter	ND	ND	ND	20	52	53	17	1	5	20	7	ND	175	0.80
Slimy sculpin	ND	ND	ND	62	28	7	1	0	0	1	2	ND	101	0.46
Longnose sucker	ND	ND	ND	0	1	3	0	5	16	0	0	ND	25	0.11
White sucker	ND	ND	ND	0	1	4	1	2	1	1	0	ND	10	0.05
Ninespine stickleback	ND	ND	ND	0	1	6	0	0	0	0	0	ND	7	0.03
Chinook salmon	ND	ND	ND	0	4	2	0	0	0	0	0	ND	6	0.03
Mottled sculpin	ND	ND	ND	2	0	0	0	0	0	0	4	ND	6	0.03
Lake trout	ND	ND	ND	0	0	2	0	0	0	0	0	ND	2	0.01
Burbot	ND	ND	ND	1	0	1	0	0	0	0	0	ND	2	0.01
Lake whitefish	ND	ND	ND	0	2	0	0	0	0	0	0	ND	2	0.01
Rainbow trout	ND	ND	ND	0	0	0	0	0	1	0	0	ND	1	<0.01
Brown trout	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Carp	ND	ND	ND	0	0	0	0	1	0	0	0	ND	1	<0.01
Gizzard shad	ND	ND	ND	0	0	0	0	0	0	1	0	ND	1	<0.01
Central mudminnow	ND	ND	ND	1	0	0	0	0	0	0	0	ND	1	<0.01
Totals	ND	ND	ND	1350	2220	3264	2983	3809	3049	3910	1223	ND	21808	

Table 41. Number of fish caught in standard series trawls during 1980 at the Cook Plant study areas, southeastern Lake Michigan. ND = no data.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Rainbow smelt	ND	ND	ND	506	4256	1870	89	748	ND	ND	ND	ND	7469	35.95
Spottail shiner	ND	ND	ND	10	1754	405	1079	1930	ND	ND	ND	ND	5178	24.92
Alewife	ND	ND	ND	1	900	1838	184	33	ND	ND	ND	ND	2956	14.23
Bloater	ND	ND	ND	0	140	1009	747	12	ND	ND	ND	ND	1908	9.18
Trout-perch	ND	ND	ND	9	353	317	354	649	ND	ND	ND	ND	1682	8.10
Yellow perch	ND	ND	ND	1	45	248	161	903	ND	ND	ND	ND	1358	6.54
Johnny darter	ND	ND	ND	3	63	67	4	5	ND	ND	ND	ND	142	0.68
Slimy sculpin	ND	ND	ND	22	15	7	0	0	ND	ND	ND	ND	44	0.21
Mottled sculpin	ND	ND	ND	1	4	3	0	1	ND	ND	ND	ND	9	0.04
Ninespine stickleback	ND	ND	ND	1	3	2	0	0	ND	ND	ND	ND	6	0.03
Longnose sucker	ND	ND	ND	0	2	1	0	3	ND	ND	ND	ND	6	0.03
Lake trout	ND	ND	ND	0	2	2	0	0	ND	ND	ND	ND	4	0.02
Lake whitefish	ND	ND	ND	0	2	0	0	1	ND	ND	ND	ND	3	0.01
White sucker	ND	ND	ND	0	2	0	0	1	ND	ND	ND	ND	3	0.01
Carp	ND	ND	ND	0	0	1	0	1	ND	ND	ND	ND	2	0.01
Chinook salmon	ND	ND	ND	0	1	0	1	0	ND	ND	ND	ND	2	0.01
Burbot	ND	ND	ND	0	0	1	0	0	ND	ND	ND	ND	1	<0.01
White crappie	ND	ND	ND	0	0	1	0	0	ND	ND	ND	ND	1	<0.01
Fathead minnow	ND	ND	ND	1	0	0	0	0	ND	ND	ND	ND	1	<0.01
Totals	ND	ND	ND	555	7592	5772	2619	4287	ND	ND	ND	ND	20775	

Table 42. Estimated number of fish impinged on Cook Plant traveling screens during 1975.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	193	1	1620	48984	22811	82838	11230	1910	458	2533	1016	1732	175326	77.67
Trout-perch	7	10	22	120	261	376	129	107	517	7327	5620	877	15373	6.81
Yellow perch	228	154	245	1195	45	313	399	492	414	4539	1816	2164	12004	5.32
Spottail shiner	86	261	345	972	749	701	117	44	318	1880	1980	2544	9997	4.43
Slimy sculpin	116	120	340	2963	1494	1171	437	321	357	261	294	268	8142	3.61
Rainbow smelt	8	11	75	873	1041	158	49	229	39	842	198	222	3745	1.66
Gizzard shad	1	13	10	33	0	0	0	0	0	4	64	153	278	0.12
Ninespine stickleback	1	0	9	69	86	20	2	0	1	3	0	3	194	0.09
Johnny darter	1	0	0	1	30	90	17	16	11	2	10	2	180	0.08
Lake trout	4	0	1	39	4	7	5	0	1	0	17	23	101	0.04
Channel catfish	16	4	10	12	0	3	1	1	1	0	0	2	50	0.02
Bloater	0	0	2	5	2	4	9	5	6	9	5	2	49	0.02
Bluegill	0	0	0	6	6	5	1	1	2	0	9	18	48	0.02
Burbot	2	1	3	5	4	6	1	4	2	4	2	3	37	0.02
Black bullhead	6	1	4	12	9	0	0	1	0	1	0	1	35	0.02
Longnose sucker	0	1	0	2	2	6	1	4	1	2	4	0	23	0.01
Pumpkinseed	0	0	0	0	0	1	0	0	0	2	4	16	23	0.01
White sucker	0	0	1	2	3	7	1	0	1	0	0	1	16	0.01
Largemouth bass	0	0	0	0	0	0	0	2	2	1	1	7	13	0.01
Green sunfish	0	0	0	0	0	0	0	0	0	1	1	11	13	0.01
Black crappie	0	0	0	0	0	0	0	0	0	1	2	8	11	<0.01
Central mudminnow	1	2	2	2	0	0	0	0	0	0	1	1	9	<0.01
Coho salmon	0	0	0	3	4	0	0	0	0	0	0	1	8	<0.01
Chinook salmon	0	0	0	3	0	0	3	1	0	0	0	0	7	<0.01
White crappie	1	0	0	0	0	0	0	0	0	1	0	4	6	<0.01
Longnose dace	0	0	0	1	0	0	0	0	0	1	4	0	6	<0.01
Golden shiner	0	0	1	3	0	0	0	0	0	0	1	0	5	<0.01
Smallmouth bass	1	0	0	0	0	0	0	0	2	0	1	1	5	<0.01
Yellow bullhead	0	1	0	0	0	0	0	0	0	0	3	1	5	<0.01
Rainbow trout	0	1	0	0	0	1	0	1	0	0	0	1	4	<0.01
Chestnut lamprey	0	0	0	2	1	0	0	1	0	0	0	0	4	<0.01
Northern pike	0	0	0	1	1	0	0	1	0	0	0	0	3	<0.01
Rock bass	0	0	0	2	0	0	0	0	0	0	1	0	3	<0.01
Carp	0	0	0	0	0	0	0	2	0	0	0	0	2	<0.01
Goldfish	0	0	0	1	1	0	0	0	0	0	0	0	2	<0.01
Quillback	0	1	0	0	0	0	0	0	0	0	1	0	2	<0.01
Unidentified pisces	0	0	0	0	1	0	0	0	0	0	0	0	1	<0.01
Emerald shiner	0	0	1	0	0	0	0	0	0	0	0	0	1	<0.01
Pirate perch	0	0	0	1	0	0	0	0	0	0	0	0	1	<0.01
Lake whitefish	0	0	0	1	0	0	0	0	0	0	0	0	1	<0.01
Fourhorn sculpin	0	0	0	1	0	0	0	0	0	0	0	0	1	<0.01
Logperch	0	0	0	0	1	0	0	0	0	0	0	0	1	<0.01
Spotted sucker	0	0	0	0	0	0	0	0	0	0	0	1	1	<0.01
Hybrid sunfish	0	0	1	0	0	0	0	0	0	0	0	0	1	<0.01
Totals	672	582	2692	55314	26556	85707	12402	3143	2133	17414	11035	8067	225737	

Table 43. Estimated number of fish impinged on Cook Plant traveling screens during 1976.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	186	3	16159	1946	7140	31489	28028	3844	3694	2360	4303	171	99323	60.86
Spottail shiner	2330	1872	11683	889	708	188	426	275	1864	2953	1071	1833	26092	15.99
Yellow perch	1663	111	461	146	300	330	2019	1541	6077	4127	99	1194	18068	11.07
Trout-perch	145	34	171	8	852	281	2073	536	4209	682	77	81	9149	5.61
Slimy sculpin	252	106	1031	1001	1803	289	271	182	403	151	56	93	5638	3.46
Rainbow smelt	240	75	411	270	615	45	194	84	9	116	43	101	2203	1.35
Gizzard shad	1161	72	132	0	0	0	0	0	9	27	154	93	1648	1.01
Johnny darter	0	1	0	8	139	15	23	4	103	19	9	4	325	0.20
Lake trout	8	10	62	0	26	11	0	0	0	0	4	16	137	0.08
Ninespine stickleback	5	3	12	0	77	0	0	0	0	4	9	0	110	0.07
Channel catfish	22	12	23	0	0	4	0	0	0	4	0	12	77	0.05
Burbot	5	7	16	4	5	4	4	0	9	0	9	4	67	0.04
Bloater	7	0	4	0	10	0	19	0	0	8	4	0	52	0.03
Black bullhead	2	1	16	4	5	0	0	0	0	4	4	4	40	0.03
Pumpkinseed	2	2	8	0	0	0	0	0	0	16	4	0	32	0.02
Coho salmon	1	2	8	0	5	4	0	0	0	0	4	4	28	0.02
White sucker	4	2	0	0	0	8	4	0	9	0	0	0	27	0.02
Longnose sucker	2	4	8	4	0	0	0	9	0	0	0	0	27	0.02
Brown trout	0	0	0	4	5	0	0	0	0	0	4	8	21	0.01
Central mudminnow	0	0	19	0	0	0	0	0	0	0	0	0	19	0.01
Bluegill	2	0	0	0	0	4	0	0	0	8	4	0	18	0.01
Rainbow trout	0	1	0	0	5	0	4	0	0	0	0	4	14	0.01
Smallmouth bass	0	0	0	0	0	0	0	0	0	0	4	8	12	0.01
Northern pike	2	0	0	0	0	4	0	4	0	0	0	0	10	0.01
Chinook salmon	0	0	4	0	5	0	0	0	0	0	0	0	9	0.01
Longnose dace	3	1	0	0	0	0	0	0	0	4	0	0	8	0.01
Carp	4	0	4	0	0	0	0	0	0	0	0	0	8	0.01
Hybrid sunfish	0	0	8	0	0	0	0	0	0	0	0	0	8	0.01
Green sunfish	2	0	0	0	0	4	0	0	0	0	0	0	6	<0.01
Black crappie	2	0	4	0	0	0	0	0	0	0	0	0	6	<0.01
Lake chub	0	1	0	0	0	0	0	0	4	0	0	0	5	<0.01
Fourhorn sculpin	0	0	0	0	5	0	0	0	0	0	0	0	5	<0.01
Largemouth bass	0	0	0	0	0	0	0	0	4	0	0	0	4	<0.01
Unidentified pisces	0	0	0	0	0	0	4	0	0	0	0	0	4	<0.01
Tadpole madtom	0	0	0	0	0	0	4	0	0	0	0	0	4	<0.01
Rock bass	0	1	0	0	0	0	0	0	0	0	0	0	1	<0.01
Grass pickerel	0	1	0	0	0	0	0	0	0	0	0	0	1	<0.01
Yellow bullhead	0	1	0	0	0	0	0	0	0	0	0	0	1	<0.01
Totals	6050	2323	30244	4284	11705	32680	33073	6479	16394	10483	5862	3630	163207	

Table 44. Estimated number of fish impinged on Cook Plant traveling screens during 1977.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	7	0	567	1946	2949	9583	2499	124	578	6421	345	448	25467	50.79
Yellow perch	10	126	1156	469	39	77	5510	186	94	558	484	403	9112	18.17
Trout-perch	1	21	27	109	35	137	1845	67	135	3166	210	96	5849	11.67
Spottail shiner	4	109	2201	1166	167	77	465	21	45	492	263	210	5220	10.41
Slimy sculpin	6	7	204	1024	275	124	70	5	19	35	23	21	1813	3.62
Rainbow smelt	8	109	124	225	85	73	469	5	11	465	64	45	1683	3.36
Bloater	0	4	0	0	0	9	19	0	0	288	15	24	359	0.72
Lake trout	5	4	9	8	12	0	0	0	0	9	49	38	134	0.27
Johnny darter	0	0	0	11	39	17	8	0	0	4	0	0	79	0.16
Ninespine stickleback	1	0	9	30	27	4	0	0	0	4	0	0	75	0.15
Burbot	0	4	0	0	8	9	8	5	4	0	11	0	49	0.10
Gizzard shad	5	0	0	0	0	0	0	0	0	13	19	7	44	0.09
Channel catfish	7	11	13	0	0	0	0	0	0	4	0	0	35	0.07
Longnose sucker	0	0	0	0	0	0	31	0	0	0	0	0	31	0.06
Brown trout	9	7	0	8	0	0	0	0	0	0	4	0	28	0.06
Coho salmon	2	4	4	4	0	0	0	0	0	0	4	7	25	0.05
Longnose dace	0	0	0	0	0	0	0	0	0	4	0	14	18	0.04
Black bullhead	0	0	18	0	0	0	0	0	0	0	0	0	18	0.04
White sucker	0	0	0	0	0	0	0	0	4	0	8	3	15	0.03
Mottled sculpin	0	0	0	0	0	0	0	0	0	0	4	10	14	0.03
Smallmouth bass	0	0	4	0	0	0	0	0	0	0	4	3	11	0.02
Bluegill	0	0	0	0	0	0	0	0	0	0	4	7	11	0.02
Black crappie	0	0	0	0	0	0	0	0	0	9	0	0	9	0.02
Largemouth bass	1	0	0	0	0	0	4	0	0	4	0	0	9	0.02
Lake chub	0	0	0	0	0	0	0	0	0	0	4	3	7	0.01
Shorthead redhorse	0	4	0	0	0	0	0	0	0	0	0	3	7	0.01
Green sunfish	0	0	4	0	0	0	0	0	0	0	0	0	4	0.01
Pumpkinseed	0	0	0	0	0	0	0	0	0	0	4	0	4	0.01
Rock bass	0	0	0	0	0	0	0	0	0	4	0	0	4	0.01
Lake chubsucker	0	0	4	0	0	0	0	0	0	0	0	0	4	0.01
Yellow bullhead	2	0	0	0	0	0	0	0	0	0	0	0	2	<0.01
Totals	68	410	4344	5000	3636	10110	10928	413	890	11480	1519	1342	50140	

Table 45. Estimated number of fish impinged on Cook Plant traveling screens during 1978.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	0	0	0	13	4810	49746	109669	8653	2240	4673	3698	1391	184893	39.97
Spottail shiner	2573	316	1166	3549	661	1080	104935	5499	2900	3821	683	1842	129025	27.89
Trout-perch	105	12	43	30	517	1242	55711	2348	1170	1697	45	142	63062	13.63
Rainbow smelt	105	32	1360	86	3720	1032	19588	13640	365	39	0	66	40033	8.66
Yellow perch	488	56	442	540	62	222	14433	4352	1055	461	3308	239	25658	5.55
Bloater	4	0	0	0	0	36	15451	636	10	105	45	102	16389	3.54
Slimy sculpin	31	24	27	206	449	54	93	35	10	16	0	133	1078	0.23
Gizzard shad	12	0	4	0	0	0	4	0	0	171	113	350	654	0.14
Mottled sculpin	54	12	4	0	36	18	4	19	50	39	0	71	307	0.07
Ninespine stickleback	8	0	58	9	150	48	13	4	0	0	0	9	299	0.07
Lake trout	0	16	12	4	10	6	0	4	5	27	98	84	266	0.06
Longnose sucker	12	8	16	21	5	30	18	4	10	8	15	9	156	0.03
White sucker	4	0	4	0	5	0	22	16	0	81	0	13	145	0.03
Burbot	4	16	16	13	5	0	4	12	5	23	0	9	107	0.02
Coho salmon	4	12	23	21	10	6	13	0	0	4	0	0	93	0.02
Johnny darter	0	0	4	0	10	18	40	16	0	0	0	0	88	0.02
Brown trout	4	4	4	0	0	0	0	0	5	0	0	40	57	0.01
Chinook salmon	0	0	0	4	0	6	4	0	0	0	8	31	53	0.01
Longnose dace	16	0	0	0	0	0	0	0	0	0	0	18	34	0.01
Shorthead redhorse	0	0	4	0	0	0	0	0	0	0	0	27	31	0.01
Channel catfish	8	0	0	4	0	0	0	0	0	8	0	0	20	<0.01
Black bullhead	0	0	0	4	0	0	0	0	0	0	0	9	13	<0.01
Freshwater drum	0	0	0	0	0	0	0	0	10	0	0	0	10	<0.01
Brown bullhead	0	0	0	0	0	6	0	0	0	0	0	4	10	<0.01
Pumpkinseed	0	0	0	0	0	0	4	0	5	0	0	0	9	<0.01
Rainbow trout	0	0	8	0	0	0	0	0	0	0	0	0	8	<0.01
Bluegill	0	0	0	0	0	0	4	0	0	4	0	0	8	<0.01
Rock bass	4	4	0	0	0	0	0	0	0	0	0	0	8	<0.01
White crappie	0	0	0	0	0	0	4	0	0	4	0	0	8	<0.01
Emerald shiner	0	0	0	0	0	0	0	0	0	0	0	4	4	<0.01
Carp	0	0	0	0	0	0	0	0	0	0	0	4	4	<0.01
Lake chub	4	0	0	0	0	0	0	0	0	0	0	0	4	<0.01
Smallmouth bass	0	0	0	4	0	0	0	0	0	0	0	0	4	<0.01
Northern pike	0	0	0	0	0	0	0	0	0	0	0	4	4	<0.01
Green sunfish	0	0	0	0	0	0	4	0	0	0	0	0	4	<0.01
Black crappie	0	4	0	0	0	0	0	0	0	0	0	0	4	<0.01
Chestnut lamprey	0	0	0	0	0	0	0	0	0	0	0	4	4	<0.01
Siver redhorse	0	0	0	0	0	0	0	0	0	4	0	0	4	<0.01
Totals	3440	516	3195	4508	10450	53550	320018	35238	7840	11185	8013	4605	462558	

Table 46. Estimated number of fish impinged on Cook Plant traveling screens during 1979.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	9	0	4	896	22	60	133008	18303	367397	1329	98	1643	522769	71.09
Yellow perch	1112	159	446	317	18	0	713	1205	71104	531	45	115	75765	10.30
Spottail shiner	4375	299	515	9210	31	0	4464	2896	33377	4114	165	159	59605	8.11
Rainbow smelt	323	28	353	3411	13	0	7825	2347	38494	275	11	27	53107	7.22
Trout-perch	266	37	27	279	4	0	4402	1120	8194	1435	64	40	15868	2.16
Bloater	27	0	4	0	0	0	2759	13	141	27	8	4	2983	0.41
Slimy sculpin	128	42	190	1839	22	0	186	31	39	18	0	44	2539	0.35
Chinook salmon	9	9	481	17	0	0	9	13	9	0	0	0	547	0.07
Burbot	195	56	97	39	27	0	22	4	34	18	8	0	500	0.07
Mottled sculpin	155	19	8	0	0	0	35	58	47	22	8	13	365	0.05
Lake trout	31	14	0	0	4	0	0	13	34	44	41	35	216	0.03
White sucker	44	33	39	34	9	15	4	13	0	9	0	0	200	0.03
Longnose sucker	13	9	39	30	13	0	22	9	13	13	15	0	176	0.02
Gizzard shad	40	5	4	0	0	0	0	4	9	58	4	31	155	0.02
Coho salmon	13	0	62	60	18	0	0	0	0	0	0	0	153	0.02
Brown trout	22	14	27	17	0	0	0	0	0	0	0	0	80	0.01
Ninespine stickleback	9	0	4	47	0	0	4	0	0	0	0	0	64	0.01
Shorthead redhorse	31	14	12	0	0	0	0	0	0	0	0	0	57	0.01
Channel catfish	18	9	4	9	0	0	0	0	13	0	0	0	53	0.01
Johnny darter	0	0	0	0	0	0	9	13	17	0	0	0	39	0.01
Carp	0	0	12	0	4	0	0	4	0	0	0	0	20	<0.01
Rainbow trout	0	0	8	4	0	0	0	0	0	0	0	0	12	<0.01
Lake whitefish	4	0	4	0	0	0	0	0	0	0	0	0	8	<0.01
Goldfish	0	5	0	0	0	0	0	0	0	0	0	0	5	<0.01
Smallmouth bass	0	0	4	0	0	0	0	0	0	0	0	0	4	<0.01
White crappie	0	0	0	0	0	0	0	0	4	0	0	0	4	<0.01
Largemouth bass	0	0	0	0	0	0	0	0	0	4	0	0	4	<0.01
Sea lamprey	0	0	4	0	0	0	0	0	0	0	0	0	4	<0.01
Central mudminnow	0	0	4	0	0	0	0	0	0	0	0	0	4	<0.01
Lake chubsucker	0	0	0	4	0	0	0	0	0	0	0	0	4	<0.01
Black crappie	4	0	0	0	0	0	0	0	0	0	0	0	4	<0.01
Freshwater drum	0	0	0	0	0	0	0	0	4	0	0	0	4	<0.01
Black bullhead	0	0	0	4	0	0	0	0	0	0	0	0	4	<0.01
Silver redhorse	0	0	0	0	0	0	0	0	0	4	0	0	4	<0.01
Rock bass	0	0	4	0	0	0	0	0	0	0	0	0	4	<0.01
Brown bullhead	0	0	0	4	0	0	0	0	0	0	0	0	4	<0.01
Totals	6828	752	2356	16221	185	75	153462	26046	518930	7901	467	2111	735334	

Table 47. Estimated number of fish impinged on Cook Plant traveling screens during 1980.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	98	4	44	1935048	480318	503070	43701	89802	ND	ND	ND	ND	3052085	86.63
Rainbow smelt	93	182	766	16313	7768	248096	323	9104	ND	ND	ND	ND	282645	8.02
Spottail shiner	36	551	1745	20715	1541	30146	523	1581	ND	ND	ND	ND	56838	1.61
Yellow perch	713	1417	837	1639	80	30026	2825	12829	ND	ND	ND	ND	50366	1.43
Bloater	0	0	0	0	0	37643	4	5	ND	ND	ND	ND	37652	1.07
Trout-perch	10	54	71	2996	1054	18086	168	2666	ND	ND	ND	ND	25105	0.71
Slimy sculpin	108	116	669	6904	2834	840	4	124	ND	ND	ND	ND	11599	0.33
Burbot	21	46	27	60	35	1294	221	150	ND	ND	ND	ND	1854	0.05
Chinook salmon	5	0	13	11	0	1699	0	5	ND	ND	ND	ND	1733	0.05
Mottled sculpin	26	4	35	394	421	71	0	46	ND	ND	ND	ND	997	0.03
Longnose sucker	5	25	22	23	40	671	0	10	ND	ND	ND	ND	796	0.02
Ninespine stickleback	0	0	9	4	226	349	0	0	ND	ND	ND	ND	588	0.02
Lake trout	21	25	0	4	31	90	0	10	ND	ND	ND	ND	181	0.01
White sucker	5	8	18	98	0	23	0	0	ND	ND	ND	ND	152	<0.01
Channel catfish	5	0	9	79	0	0	0	10	ND	ND	ND	ND	103	<0.01
Coho salmon	0	25	27	8	4	0	0	0	ND	ND	ND	ND	64	<0.01
Johnny darter	5	0	0	0	9	19	0	21	ND	ND	ND	ND	54	<0.01
Gizzard shad	0	4	40	0	0	0	0	0	ND	ND	ND	ND	44	<0.01
Fourhorn sculpin	0	0	9	0	4	0	0	10	ND	ND	ND	ND	23	<0.01
Brown trout	0	0	4	0	0	0	0	10	ND	ND	ND	ND	14	<0.01
Rainbow trout	0	4	9	0	0	0	0	0	ND	ND	ND	ND	13	<0.01
Black bullhead	0	0	0	8	4	0	0	0	ND	ND	ND	ND	12	<0.01
Sea lamprey	0	0	9	0	0	0	0	0	ND	ND	ND	ND	9	<0.01
Carp	0	0	9	0	0	0	0	0	ND	ND	ND	ND	9	<0.01
Green sunfish	0	0	0	0	0	4	0	5	ND	ND	ND	ND	9	<0.01
Black crappie	0	0	0	4	0	0	0	5	ND	ND	ND	ND	9	<0.01
Freshwater drum	0	0	0	0	0	0	0	5	ND	ND	ND	ND	5	<0.01
Lake sturgeon	5	0	0	0	0	0	0	0	ND	ND	ND	ND	5	<0.01
Goldfish	0	0	0	0	0	0	0	5	ND	ND	ND	ND	5	<0.01
Central mudminnow	0	0	4	0	0	0	0	0	ND	ND	ND	ND	4	<0.01
Warmouth	0	0	0	0	0	4	0	0	ND	ND	ND	ND	4	<0.01
Lake chub	0	0	0	4	0	0	0	0	ND	ND	ND	ND	4	<0.01
Rock bass	0	4	0	0	0	0	0	0	ND	ND	ND	ND	4	<0.01
Bluegill	0	0	0	0	0	4	0	0	ND	ND	ND	ND	4	<0.01
Totals	1156	2469	4376	1984312	494369	872135	47769	116403					3522989	

Table 48. Estimated weight (kg) of fish impinged on Cook Plant traveling screens during 1975.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	7.67	0.01	64.06	1842.57	797.80	2062.24	278.75	46.64	6.91	12.80	23.43	71.32	5214.20	84.90
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
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
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
Slimy sculpin	0.78	1.13	2.55	19.92	8.26	6.48	2.62	1.71	1.94	1.46	2.34	2.00	51.19	0.83
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
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
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
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
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
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
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
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
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
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
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
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
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
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
Bloater	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
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
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	0.08	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
Goldfish	0.0	0.0	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01	<0.01
Totals	27.29	15.95	90.03	1983.83	853.55	2143.73	346.91	105.40	34.33	170.24	198.12	172.38	6141.77	

Table 49. Estimated weight (kg) of fish impinged on Cook Plant traveling screens during 1976.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
Bloater	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
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
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
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
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
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
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
Pumpkinseed	0.00	0.00	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.18	0.0	0.25	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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
Lake chub	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	<0.01
Unidentified pieces	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	<0.01
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	<0.01
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	<0.01
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	<0.01
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 50. Estimated weight (kg) of fish impinged on Cook Plant traveling screens during 1977.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
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	542.07	35.04
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
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
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
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
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
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
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
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
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
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
Bloater	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
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
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
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
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
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
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
Ninespine stickleback	0.0	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
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
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
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
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
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
Bluegill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.01	<0.01
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	<0.01
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 51. Estimated weight (kg) of fish impinged on Cook Plant traveling screens during 1978.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
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
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
Lake trout	0.0	56.84	31.93	13.71	34.10	19.80	0.0	20.54	16.63	105.15	341.44	296.36	936.49	10.91
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
Spottail shiner	31.18	3.19	15.45	52.92	6.75	7.68	327.95	38.18	20.28	32.55	5.54	19.44	561.10	6.54
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
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
Bloater	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
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
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
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
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
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
Brown trout	0.35	0.39	0.48	0.0	0.0	0.0	0.0	0.0	27.50	0.0	0.0	3.18	31.90	0.37
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
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
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
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
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
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
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
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
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
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	0.88	0.01
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
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
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
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
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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	<0.01
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 52. Estimated weight (kg) of fish impinged on Cook Plant traveling screens during 1979.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	0.06	0.0	0.16	42.72	0.95	2.37	3080.99	398.29	931.53	18.29	3.40	82.40	4561.15	41.95
Yellow perch	36.63	13.22	47.52	28.19	3.94	0.0	65.89	70.90	3066.38	31.39	0.47	6.17	3370.72	31.00
Lake trout	75.02	58.52	0.0	0.0	13.15	0.0	0.0	31.44	106.69	138.41	146.72	126.57	696.53	6.41
Spottail shiner	49.51	3.77	7.51	99.24	0.42	0.0	28.27	20.28	265.85	38.36	1.53	1.13	515.86	4.68
Rainbow smelt	3.40	0.52	7.48	20.66	0.17	0.0	27.43	16.23	247.36	5.61	0.34	0.14	329.35	3.03
White sucker	68.86	54.63	64.39	37.43	8.68	13.14	3.76	7.76	0.0	0.13	0.0	0.0	258.78	2.38
Longnose sucker	21.28	15.98	65.29	39.50	19.62	0.0	23.84	4.55	12.57	19.60	11.65	0.0	233.88	2.15
Burbot	84.11	28.84	52.70	23.17	20.59	0.0	6.89	0.15	2.65	1.36	4.42	0.0	224.88	2.07
Chinook salmon	0.94	2.10	149.66	3.03	0.0	0.0	0.10	0.18	0.97	0.0	0.0	0.0	156.98	1.44
Trout-perch	3.39	0.58	0.40	2.89	0.04	0.0	21.74	9.96	59.19	18.78	1.26	0.56	118.77	1.09
Coho salmon	4.81	0.0	42.11	40.77	9.86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	97.54	0.90
Carp	0.0	0.0	26.30	0.0	43.62	0.0	0.0	0.04	0.0	0.0	0.0	0.0	69.96	0.64
Gizzard shad	16.79	2.13	1.42	0.0	0.0	0.0	0.0	3.04	8.14	23.69	0.04	4.63	59.88	0.55
Channel catfish	5.20	6.33	19.57	2.27	0.0	0.0	0.0	0.0	10.27	0.0	0.0	0.0	43.65	0.40
Brown trout	4.88	1.64	11.49	13.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.18	0.29
Bloater	0.14	0.0	0.01	0.0	0.0	0.0	22.18	0.12	1.16	0.42	0.04	0.02	24.09	0.22
Rainbow trout	0.0	0.0	9.71	9.86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.57	0.18
Slimy sculpin	1.31	0.38	1.56	14.29	0.24	0.0	0.86	0.19	0.25	0.12	0.0	0.45	19.64	0.18
Shorthead redhorse	7.94	3.60	3.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.55	0.13
Silver redhorse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.63	0.0	0.0	10.63	0.10
Lake whitefish	2.03	0.0	1.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.73	0.03
Mottled sculpin	1.54	0.21	0.12	0.0	0.0	0.0	0.33	0.56	0.30	0.20	0.06	0.18	3.50	0.03
Freshwater drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.20	0.0	0.0	0.0	3.20	0.03
Smallmouth bass	0.0	0.0	1.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.28	0.01
Goldfish	0.0	0.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.78	0.01
Sea lamprey	0.0	0.0	0.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.62	0.01
White crappie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.62	0.0	0.0	0.0	0.62	0.01
Rock bass	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	<0.01
Black crappie	0.21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.21	<0.01
Ninespine stickleback	0.02	0.0	0.01	0.14	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.19	<0.01
Brown bullhead	0.0	0.0	0.0	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.14	<0.01
Johnny darter	0.0	0.0	0.0	0.0	0.0	0.0	0.03	0.03	0.04	0.0	0.0	0.0	0.09	<0.01
Lake chubsucker	0.0	0.0	0.0	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.09	<0.01
Central mudminnow	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	<0.01
Largemouth bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	0.0	0.0	0.04	<0.01
Black bullhead	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	<0.01
TOTALS	388.05	193.24	514.48	377.56	121.27	15.51	3282.33	563.71	4717.15	307.03	169.92	222.25	10872.52	

Table 53. Estimated weight (kg) of fish impinged on Cook Plant traveling screens during 1980.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Alewife	4.74	0.17	2.00	81585.25	17131.77	2616.04	1234.00	1933.65	ND	ND	ND	ND	104507.50	92.83
Yellow perch	4.50	34.02	81.85	121.84	5.29	1895.37	823.06	441.76	ND	ND	ND	ND	3407.70	3.03
Rainbow smelt	0.69	4.38	18.71	172.69	45.41	913.63	3.45	23.55	ND	ND	ND	ND	1182.50	1.05
Longnose sucker	8.01	32.55	37.35	40.41	69.42	866.48	0.0	0.08	ND	ND	ND	ND	1054.29	0.94
Burbot	1.36	10.22	1.94	6.86	20.24	510.00	214.66	41.27	ND	ND	ND	ND	806.55	0.72
Spottail shiner	0.27	6.87	22.94	238.87	17.48	218.26	4.10	10.02	ND	ND	ND	ND	518.82	0.46
Lake trout	68.07	86.17	0.0	14.77	81.10	26.78	0.0	40.87	ND	ND	ND	ND	317.77	0.28
Bloater	0.0	0.0	0.0	0.0	0.0	217.03	0.19	0.08	ND	ND	ND	ND	217.30	0.19
Trout-perch	0.08	0.62	0.80	17.03	14.57	144.43	2.20	10.96	ND	ND	ND	ND	190.69	0.17
White sucker	5.16	8.38	28.13	12.20	0.0	15.42	0.0	0.0	ND	ND	ND	ND	69.27	0.06
Slimy sculpin	1.20	1.28	5.88	36.91	13.82	4.22	0.07	0.67	ND	ND	ND	ND	64.06	0.06
Coho salmon	0.0	24.33	25.95	6.04	2.73	0.0	0.0	0.0	ND	ND	ND	ND	59.05	0.05
Brown trout	0.0	0.0	0.24	0.0	0.0	0.0	0.0	42.37	ND	ND	ND	ND	42.61	0.04
Carp	0.0	0.0	38.31	0.0	0.0	0.0	0.0	0.0	ND	ND	ND	ND	38.31	0.03
Chinook salmon	5.94	0.0	1.62	21.99	0.0	7.62	0.0	0.04	ND	ND	ND	ND	37.21	0.03
Lake sturgeon	24.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	ND	ND	ND	24.02	0.02
Channel catfish	0.02	0.0	0.29	9.60	0.0	0.0	0.0	2.24	ND	ND	ND	ND	12.14	0.01
Mottled sculpin	0.28	0.08	0.37	4.09	6.32	0.65	0.0	0.27	ND	ND	ND	ND	12.07	0.01
Gizzard shad	0.0	0.06	6.59	0.0	0.0	0.0	0.0	0.0	ND	ND	ND	ND	6.65	0.01
Freshwater drum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.85	ND	ND	ND	ND	4.85	<0.01
Sea lamprey	0.0	0.0	2.37	0.0	0.0	0.0	0.0	0.0	ND	ND	ND	ND	2.37	<0.01
Rainbow trout	0.0	0.27	1.60	0.0	0.0	0.0	0.0	0.0	ND	ND	ND	ND	1.88	<0.01
Ninespine stickleback	0.0	0.0	0.03	0.01	0.89	0.95	0.0	0.0	ND	ND	ND	ND	1.88	<0.01
Black bullhead	0.0	0.0	0.0	0.67	0.25	0.0	0.0	0.0	ND	ND	ND	ND	0.92	<0.01
Black crappie	0.0	0.0	0.0	0.40	0.0	0.0	0.0	0.15	ND	ND	ND	ND	0.55	<0.01
Rock bass	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	ND	ND	ND	ND	0.38	<0.01
Fourhorn sculpin	0.0	0.0	0.07	0.0	0.13	0.0	0.0	0.13	ND	ND	ND	ND	0.33	<0.01
Lake chub	0.0	0.0	0.0	0.16	0.0	0.0	0.0	0.0	ND	ND	ND	ND	0.16	<0.01
Warmouth	0.0	0.0	0.0	0.0	0.0	0.14	0.0	0.0	ND	ND	ND	ND	0.14	<0.01
Johnny darter	0.02	0.0	0.0	0.0	0.03	0.04	0.0	0.04	ND	ND	ND	ND	0.13	<0.01
Central mudminnow	0.0	0.0	0.08	0.0	0.0	0.0	0.0	0.0	ND	ND	ND	ND	0.08	<0.01
Bluegill	0.0	0.0	0.0	0.0	0.0	0.07	0.0	0.0	ND	ND	ND	ND	0.07	<0.01
Green sunfish	0.0	0.0	0.0	0.0	0.0	0.03	0.0	0.01	ND	ND	ND	ND	0.04	<0.01
Goldfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	ND	ND	ND	ND	0.03	<0.01
Totals	124.38	209.79	277.10	82289.25	17409.41	7437.12	2281.75	2553.04	ND	ND	ND	ND	112581.63	

APPENDIX C

ENVIRONMENTAL OPERATING REPORT 1980

GROUNDWATER MONITORING

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

GROUND WATER WELL 1A

Chemical Analysis Parameters

Date	3/4/80	9/3/80
Sodium (Na), mg/L	22.6	21.7
Sulfate (SO_4), mg/L	0	0
Phosphate (PO_4), mg/L	3.1	1.2
pH, standard units	6.6	6.7
Conductivity, μmho	355	425
Nitrate (NO_3), mg/L	0.19	0.33
Iron (Fe), mg/L	10.0	8.2
Copper (Cu), mg/L	0	0
Groundwater elevation (ft.)	604.66	602.24

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

GROUND WATER WELL 8

Chemical Analysis Parameters

Date	3/4/80	9/3/80
Sodium (Na), mg/L	80.4	40.0
Sulfate (SO_4), mg/L	0	0
Phosphate (PO_4), mg/L	1.2	3.5
pH, standard units	7.0	6.9
Conductivity, µmho	890	640
Nitrate (NO_3), mg/L	0.08	0
Iron (Fe), mg/L	5.0	0.8
Copper (Cu), mg/L	0	0
Groundwater elevation (ft.)	608.20	608.70

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

GROUND WATER WELL 11

Chemical Analysis Parameters

Date	3/4/80	9/3/80
Sodium (Na), mg/L	165.8	131.9
Sulfate (SO_4), mg/L	248.0	279.0
Phosphate (PO_4), mg/L	0.6	1.2
pH, standard units	7.0	7.7
Conductivity, µmho	1115	1055
Nitrate (NO_3), mg/L	0.38	0
Iron (Fe), mg/L	1.8	0.7
Copper (Cu), mg/L	0	0
Groundwater Elevation (ft.)	602.64	602.85

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

GROUND WATER WELL 12

Chemical Analysis Parameters

Date	3/4/80	9/3/80
Sodium (Na), mg/L	189.7	179.2
Sulfate (SO_4), mg/L	301.0	312.0
Phosphate (PO_4), mg/L	0.4	2.0
pH, standard units	7.2	7.3
Conductivity, μmho	1080	1115
Nitrate (NO_3), mg/L	0.02	0.18
Iron (Fe), mg/L	1.7	0.7
Copper (Cu), mg/L	0	0
Groundwater Elevation (ft.)	592.15	593.95

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

CIRC. WATER I

Chemical Analysis Parameters

Date	3/4/80	9/3/80
Sodium (Na), mg/L	7.0	3.6
Sulfate (SO_4), mg/L	0	0
Phosphate (PO_4), mg/L	0	0
pH, standard units	6.9	7.8
Conductivity, µmho	325	260
Nitrate (NO_3), mg/L	0.08	0.20
Iron (Fe), mg/L	0.1	0
Copper (Cu), mg/L	0	0

DONALD C. COOK NUCLEAR PLANT

BRIDGMAN, MICHIGAN

CIRC. WATER II

Chemical Analysis Parameters

Date	3/4/80	9/3/80
Sodium (Na), mg/L	7.7	3.6
Sulfate (SO_4), mg/L	4.0	0
Phosphate (PO_4), mg/L	0	0
pH, standard units	7.0	8.1
Conductivity, µmho	315	260
Nitrate (NO_3), mg/L	0.09	0.23
Iron (Fe), mg/L	0.1	0
Copper (Cu), mg/L	0	0

APPENDIX D

ICE CONDITIONS AT THE DONALD C. COOK NUCLEAR PLANT

The winter of 1979-1980 was slow in developing a shore ice complex. Small amounts of spray ice were present on the beach on 4, 6, and 7 January; first shore ice formation was observed on 8 January when an icefoot, first lagoon, and first ridge were formed. These gradually were broken up by surf and melted, leaving only the icefoot on the beach. After 24 January ice formation became persistent and snowfalls were much more frequent during the rest of January and during February. During March snowfalls became more sporadic and endured on the ground for shorter times.

In this winter our program of stereo time lapse photography of ice conditions was almost completely negated because one of the cameras suffered a series of mostly non-recurrent mechanical and electrical failures which resulted in very few usable pictures in its output. Judging from the output of the second camera, this series of failures is not considered disastrous because the positions of breaking wave zones and ice ridges appear to be the same as found in previous years.

Extensive ice fields in the lake were characteristic of this winter, as they have been in previous years. The fields were composed of patches of blue sheet-ice, white floe blocks, pancake ice (some with sand color in the elevated pancake rims), iceballs (some with sand color), and slush ice between cakes. On the days when overflights were made the components of the fields were consolidated by being frozen together; at other times (particularly in March) they appeared to be comprised of loose components. Whether consolidated or loose, the fields were mobile under the influence of wind, appearing and disappearing offshore of the shore-ice complex. When present, they prevented

wave action against the face of the shore ice and accretion stopped; when absent, the face of the shore-ice complex could receive augmentation by iceballs, spray ice, and small brash-ice blocks brought by waves.

The shore-ice complex was best developed during February. During March it melted and re-formed with the re-forming processes becoming less strong as the month progressed. On 30 March the ice complex was reduced by surf to wreckage ice pushed against the beach. By 4 April the last of the wreckage ice was melted, ending the ice season.

The shore ice of this winter was unusually sandy, particularly in the case of the icefoot on the beach which was formed on 8 January and augmented on 12 January by a push of wreckage ice onto shore before a heavy surf from the northwest. Sand incorporated during this push of wreckage ice was the cause of the high sand content of the icefoot. The icefoot was protected from accretion by ice offshore, and gradually melted until it disappeared on 7 March leaving a distinct, narrow, and temporary ridge of sand on the beach.

OVERFLIGHTS

Aerial overflights of shore ice conditions in southeastern Lake Michigan from Bailly Station to Grand Haven were carried out on 18 February and 12 March. Conditions at and near the Cook Plant are shown in Figures 1-7. On 18 February the lake icefield was extensive and very continuous; a few small cracks (Fig. 1) with parallel edges showed that the field was well frozen together. Within the frozen icefield the Cook Plant melthole (Fig. 2) appeared to be somewhat wider, north-to-south, than the 712-foot length of the turbine building. The melthole lay opposite the south end of the turbine building and lakeward of a shore-ice

complex in front of the plant; it extended first westward for a distance of several lengths of the turbine building then turned northwestward for some additional turbine building lengths. The shore-ice complex in front of the plant (Fig. 3) consisted of an icefoot, an ice-covered first lagoon, and a first ice ridge with a band of floe ice in the second lagoon lakeward of the first ice ridge.

On 12 March the Cook Plant melthole lay in a lake icefield which had been separated by wind into three large sub-fields (Fig. 4). That the sub-fields were still largely frozen together is shown by the crack with parallel sides in the upper right of the figure. The shape of the melthole retained by the icefield near the shore suggests that the hole (like the one on 18 February) first extended westward outside the shore-ice then turned northwestward. As in February, the north-south width of the melthole appeared to be somewhat wider than the 712-foot length of the turbine building.

Figure 5 shows that the shore-ice complex in front of the plant consisted of an icefoot, a first lagoon, a first ice ridge, a second lagoon, and a breached second ice ridge. As in February, heat of the discharge water was disrupting the ice beside it as is shown in Figure 6, except that in February the disruption was on the north side of the melthole while in March it was on the south.

In March the nearshore end of the melthole was located off the north end of the turbine building (Fig. 7), instead of opposite the south end where it usually has been. This position has been seen before but is not usual. There was melting in the first lagoon along the front of the plant property; this is attributed to the nearshore leakage from the south discharge pipe and to runoff from the parking lots which enters the lake just north of the turbine building.

WEST-LOOKING MONITOR CAMERA, GENERAL

The west-looking monitor camera was established to monitor conditions in front of the plant, at the shore, and in the melthole resulting from the plant's waste heat. Well-defined meltholes were somewhat less common than in other years because the icefield offshore, while extensive, was more mobile under the wind than previously. Although the component cakes of the field were frozen together much of January, February, and March, the field frequently fractured along north-south lines and the subfields moved downwind. When the field was fractured the potential lakeward edge of the melthole was usually absent. When the subfields returned, the melthole position was filled until plant heat could re-melt a hole.

Between the first significant formation of shore ice on 8 January and its final disappearance on 4 April there was shore-ice present in varying quantity along the beach in front of the plant on all days except 19 through 22 January when a general meltoff occurred along all the beach in the plant vicinity.

Both the solid shore-ice adjacent to the plant and the offshore icefield inhibited wave action and the plant property was free of wave action when either or both were present.

The daily ice conditions in front of the plant, as recorded by the west-looking monitor camera, are given in Table 1.

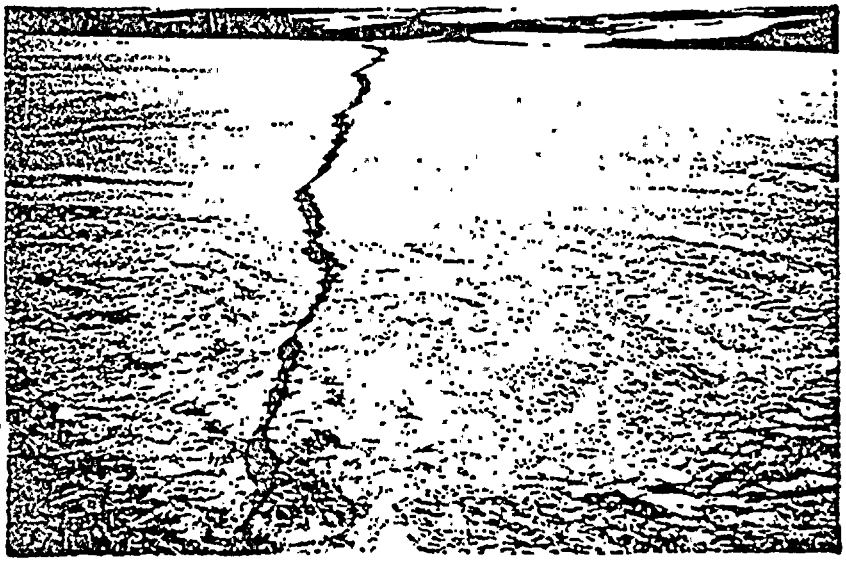

Figure 1. Crack in icefield off New Buffalo, 18 February 1980, showing that the components of the icefield were consolidated by freezing. Slide: Roll 1, #33, 18 February 1980.

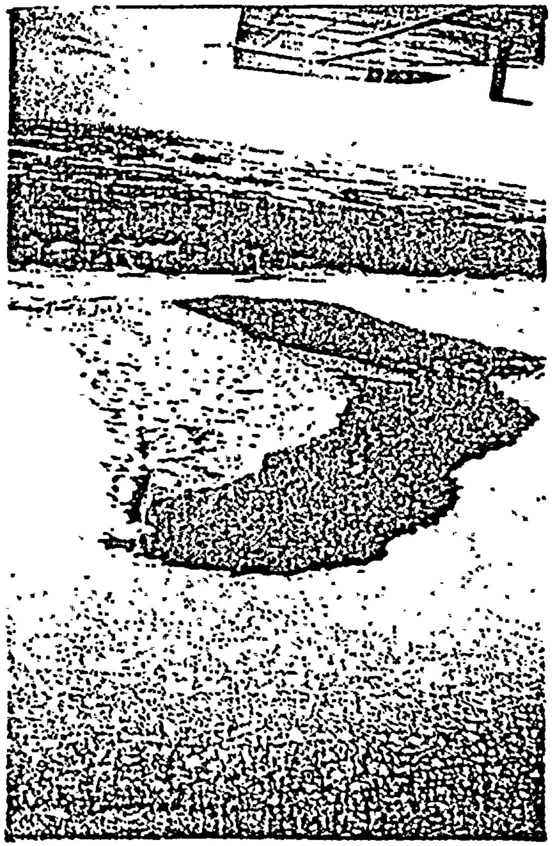

Figure 2. The Cook Plant melthole on 18 February 1980, viewed from west to east. Heat from the plant has loosened the icefield floes along the left (north) side of the melthole. Slide: Roll 1, #18, 18 February 1980.

Figure 3. The shore ice complex between the melthole and the beach on 18 February 1980, viewed from the south. Slide: Roll 1, #23, 18 February 1980.

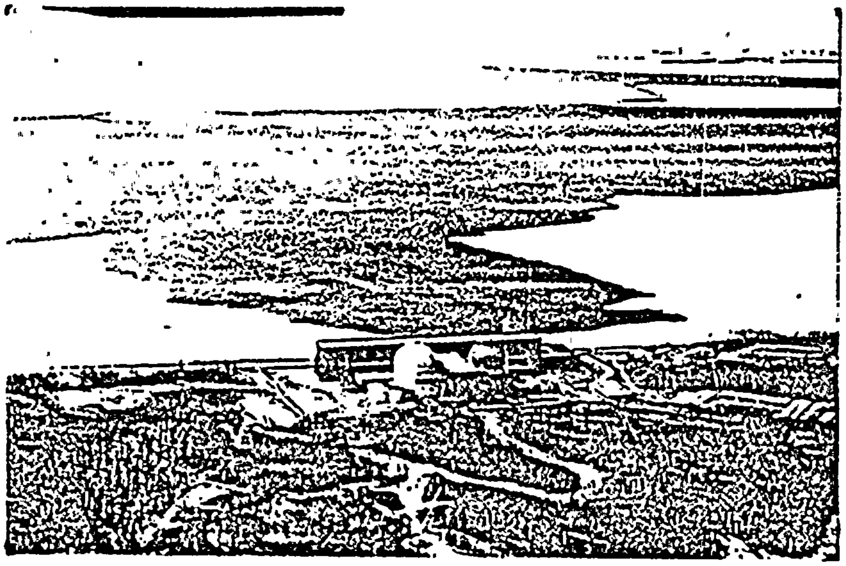

Figure 4. The Cook Plant melthole in the wind-separated icefield on 12 March 1980. The parallel-edged crack in the upper right shows that the components of the broken field are still frozen together. Before separation of the icefield the melthole is considered to have extended, as in February, first westward then northwestward. Slide: Roll 1, #5, 12 March 1980.

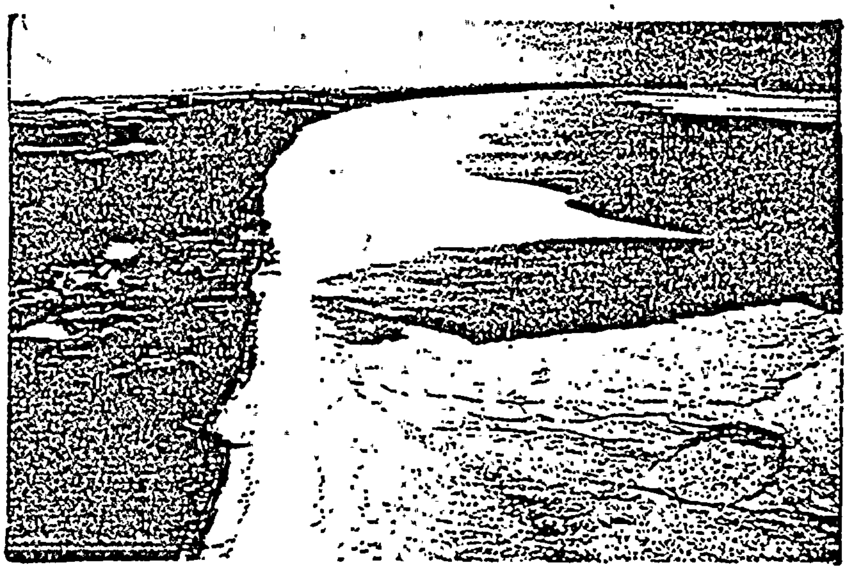

Figure 5. The shore ice complex in front of the plant on 12 March 1980. The complex consisted of an icefoot (dark on the beach), a mostly melted first lagoon, a first ice ridge, a second lagoon, and a breached second ice ridge. Slide: Roll 3, #34, 12 March 1980.

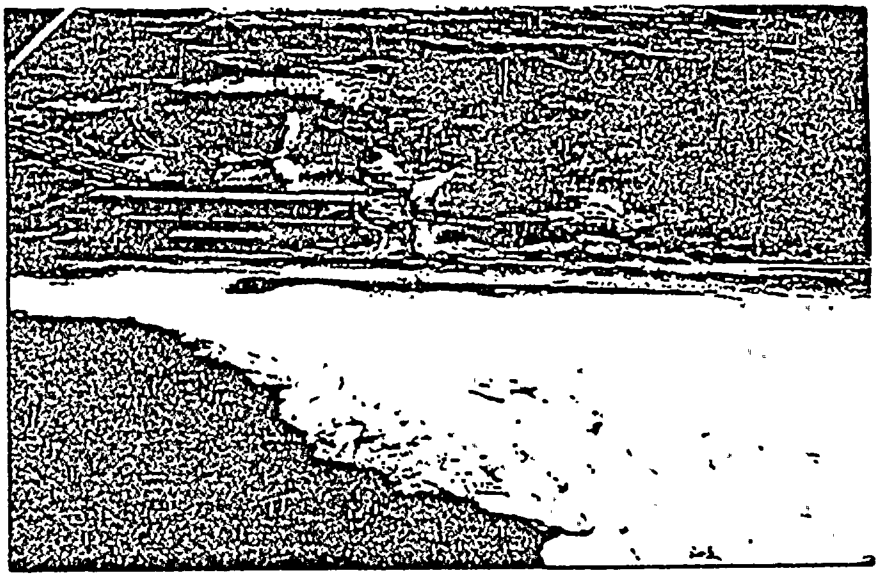

Figure 6. The disrupted lake icefield along the south side of the melthole on 12 March 1980. Slide: Roll 4, #3, 12 March 1980.

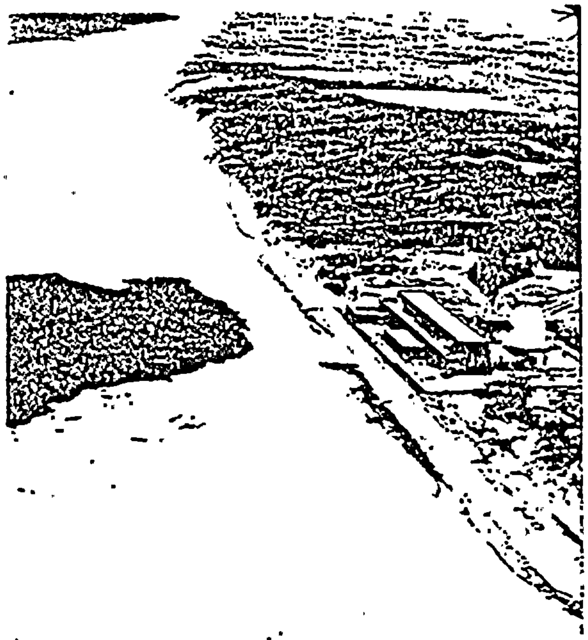

Figure 7. In the shore ice complex, the melted first lagoon extends discontinuously from well north of the plant to well south of the plant. View from the south. Slide: Roll 1, #9, 12 March 1980.

TABLE 1. WEST-LOOKING CAMERA, DAILY ICE CONDITIONS.

20 Dec. through 3 Jan.	No ice.
4 Jan.	Small amount of spray ice on beach just back of water's edge.
5 Jan.	No ice.
6 Jan.	No ice.
7 Jan.	No ice.
8 Jan.	Significant arrival of slush and ice balls, construction of ice-filled first lagoon and building of first ice ridge, slush and ice balls in water.
9 Jan.	Slush and ice balls in water, continued building of first ridge. Snowfall; ridge, lagoon, and beach were covered.
10 Jan.	Development of breaches thru first ridge (by discharge water?). First lagoon beginning to melt. Beach snowcovered.
11 Jan.	Heavy surf, first ridge reduced to wreckage and dumped at edge of beach. First lagoon now open. Beach bare.
12 Jan.	Wreckage of first ridge pushed across first lagoon, ending on lakeward edge of icefoot. This ice very dark and sandy. New brash ice in water's edge.
13 Jan.	Static.
14 Jan.	Some accretion at lakeward edge of wreckage ice in first lagoon. No outer icefield.
15 Jan.	Static. No outer icefield.
16 Jan.	Nearly static; very slow melting. No outer icefield. No melting in first lagoon.
17 Jan.	Surf, some accretion of lakeward edge of wreckage ice but accretion overmatched by melting in first lagoon. No outer icefield.
18 Jan.	Surf, progressive melting of wreckage ice, wreckage ice pushed into first lagoon. No outer ice field.
19 Jan.	Waves. No ice visible, except dark sandy icefoot on beach.
20 Jan.	Waves. No ice visible, except dark sandy icefoot on beach.
21 Jan.	Small waves. No ice visible, except dark sandy icefoot on beach.

22 Jan. As on 21st. No outer ice.

23 Jan. Brash ice at water's edge.

24 Jan. Influx during the night of slush ice, brash ice, and iceballs, filling first lagoon and beginning to establish a first ridge. No outer ice. Water calm during the day. Snow during night, icefoot snowcovered.

25 Jan. Surf. Continued accretion of first ridge; first lagoon filled. No outer ice. Icefoot snowcovered.

26 Jan. As on 25th but with increasing abundance of slush ice and iceballs lakeward of first ridge. No outer ice. Icefoot snowcovered.

27 Jan. Extensive field of slush ice and iceballs lakeward of first ridge. No outer icefield. First lagoon icefilled. Icefoot snowcovered.

28 Jan. As on 27th.

29 Jan. As on 27th, but in afternoon sun came out showing that the first ridge was substantially developed, second lagoon was filled with iceballs, and second ridge was moderately developed across part of mid-distance. Extensive area of iceballs in third lagoon. Icefoot snowcovered.

30 Jan. Melthole appeared and developed extensively in second and third lagoons with reduction of second ridge. Melting begun in first lagoon. Icefoot snowcovered.

31 Jan. Progressive melting in second lagoon and reduction of second ridge. Icefoot snowcovered.

1 Feb. Second ridge melted. Some ice in far distance. Small floes coming in toward first ridge in afternoon. Icefoot snowcovered.

2 Feb. Many small floes lakeward of first ridge, otherwise no change. Melting in first lagoon. Icefoot snowcovered.

3 Feb. Outer icefield visible, giving a melthole with floes in it lakeward of first ridge. No change in first ridge, first lagoon, or icefoot on beach. Icefoot snowcovered.

4 Feb. No change from 3rd, except that floes in melthole were gone in late afternoon. Icefoot snowcovered.

5 Feb. Large melthole in morning; no outer ice visible rest of day. First lagoon melted. Icefoot snowcovered.

6 Feb. Large melthole with floes in it, melting in first lagoon. No change in first ridge or icefoot.

7 Feb. Numerous floes lakeward of first ridge and in first lagoon. No outer ice visible. Icefoot snowcovered.

8 Feb. As on 7th, but first ridge somewhat reduced and with progressive melting in first lagoon. Few floes in lake.

9 Feb. As on 8th.

10 Feb. Influx of slush ice lakeward of first ridge. Melting of first ridge with a few floes entering first lagoon.

11 Feb. Influx of a large field of floes and slush ice lakeward of first ridge. Melting of first ridge nearly breached it. Several floes in first lagoon. No visible change of icefoot, still snowcovered.

12 Feb. As on 11th, except icefield outside first ridge has been compacted.

13 Feb. An outer icefield has come into view; an open water area present between the inner and outer floe fields. Otherwise as on 12th.

14 Feb. As on 13th except open water between inner and outer icefields narrowed and closed in afternoon. Icefoot snowcovered, but showing some sand color.

15 Feb. Large melthole visible. Some brash ice lakeward of first ridge. No changes in first ridge, first lagoon, or icefoot.

16 Feb. Continuous icefield to horizon. Somewhat more ice in first lagoon. No changes in first ridge or icefoot.

17 Feb. Medium size melthole visible. No other changes. Some sand color showing in icefoot. Beach snowcovered.

18 Feb. As on 17th. OVERFLIGHT ON THIS DAY.

19 Feb. A little melting in first lagoon, otherwise as on 18th. Pronounced sand color in icefoot.

20 Feb. Moderate melthole visible. Some brash ice in water lakeward of first ridge. Melting has breached first ridge, reduced ice in first lagoon, and reduced icefoot. First ridge showing color of included sand.

21 Feb. No change from 20th, except more melting in first lagoon.

22 Feb. No melthole. Substantial influx of ice floes to outside of first ridge and into first lagoon. No icefoot on beach. Melting outside first ridge, of first ridge, and in first lagoon.

23 Feb. Melting of ice floes outside first ridge and in first lagoon. No icefoot on beach.

24 Feb. Extensive influx of ice floes reaching to far distance of photo. No icefoot.

25 Feb. Varying influx of floes, during the afternoon these pushed through the breach of the first ridge and filled the first lagoon. No icefoot.

26 Feb. Heavy influx of floes extending almost to the horizon. Snow during night of 25-26 covered beach but melted during the day.

27 Feb. No change from afternoon of 26th.

28 Feb. Large melthole with afternoon influx of floes nearly filling it. No change in first ridge or first lagoon.

29 Feb. Large melthole, during day floes in it blew up against first ridge and melted, first lagoon almost full of consolidated floes. No icefoot.

1 Mar. No outer ice visible. Floes have pushed in and accreted to first ridge. First lagoon full of solid ice with melting just begun. No ice on beach.

2 Mar. Slush ice in lake as far as visible. During the day it pushed shoreward and accreted onto first ridge. No change in first lagoon. No icefoot on beach.

3 Mar. Influx of slush ice and floes establishing ice sheet in second lagoon. Small amount of melting in first lagoon. No icefoot.

4 Mar. Continued influx of slush ice and floes with beginning of reestablishment of second ridge. No icefoot on beach. Ice sheet in second lagoon.

5 Mar. Melthole present in morning became filled with brash ice and remained filled rest of day. Continued melting in first lagoon. Second ridge built somewhat. Ice sheet in second lagoon.

6 Mar. Rather large melthole in icefield with floes in it. Snow in afternoon left sparse covering on beach. Second ridge accreted somewhat, solid ice sheet in second lagoon.

7 Mar. Open water outside second ridge; second ridge melted some during day; second lagoon covered solidly. No change in first lagoon. Snow on beach from 6th melted during the day.

8 Mar. Ice and beach covered with new snow. First lagoon melted except for snow slush. Otherwise as on 7th.

9 Mar. As on 8th.

10 Mar. Steady influx of an icefield from offshore progressively wiped out open water outside the ice ridges. Otherwise as on 9th. First ridge becoming cracked and breached. Beach snowcovered.

11 Mar. As on 10th, except that there was a melthole outside the second ridge. Snow on beach melted.

12 Mar. Melthole present and large. Size due mostly to offshore movement of icefield. Part of second ridge present. Second lagoon icecovered. First ridge present but cracked and breached. Slush ice in first lagoon. No snow on beach. OVERFLIGHT THIS DAY.

13 Mar. No outer ice visible. First ridge more cracked, breached, and reduced in size. Slush ice in first lagoon.

14 Mar. In morning second ridge melted and second lagoon ice was in cakes. During the day an influx of floe ice wiped out melthole which started to re-form during afternoon. Slush ice in first lagoon. Snow on beach.

15 Mar. Distant icefield visible. Ice of second ridge and second lagoon has melted. First ridge greatly reduced and more breached. No ice or snow on beach.

16 Mar. A few floes in far distance; first ridge reduced to a few blocks. No ice or snow on beach.

17 Mar. Substantial influx of ice floes which in afternoon had begun to re-establish second ridge, second lagoon and first ridge. Beach bare. Loose floes in first lagoon.

18 Mar. Large icefield outside the ridges. Second ridge more pronounced than on 17th. Otherwise as on 17th.

19 Mar. Very large melthole with floes in it: second ridge, first ridge, and second lagoon melting during the day. Loose floes in first lagoon. Beach bare.

20 Mar. Numerous floes lakeward of the second ridge, in second lagoon, and in first lagoon. Both ridges breached, first ridge showing sand color. Beach bare.

21 Mar. Surf, ice floe field compressed with very substantial building of second ridge. Second lagoon full of floes and many in first lagoon. Beach bare.

22 Mar. As on 21st, except larger outer icefield.

23 Mar. Outer icefield gone, some melting in second lagoon, otherwise unchanged.

24 Mar. Small outer icefield arrived during day. Second ridge breached and reduced during the day. Increased melting in second lagoon. Floes in first lagoon melting during day. Beach bare.

25 Mar. As on 24th.

26 Mar. Large outer icefield with partial formation of melthole. Progressive reduction in second and first ridges. Few floes melting in first lagoon. Beach bare.

27 Mar. Progressive, but slow, melting of first and second ridges and in both lagoons. Beach bare.

28 Mar. Both ice ridges reduced to a few chunks. A few floes in second lagoon, none in first lagoon. Beach bare.

29 Mar. Second ridge and second lagoon floes piled as wreckage onto first ridge. Small amount of slush ice and iceballs outside of first ridge. Small floes in first lagoon. Beach bare.

30 Mar. First ridge and floes in first lagoon moved as wreckage to water's edge. Beach bare.

31 Mar. Accretion to wreckage ice by slush ice and iceballs from the lake. Beach bare.

1 Apr. As on 31st except that wreckage ice has been reduced in volume. Beach bare.

2 Apr. As on 1st, with further melting of the wreckage ice.

3 Apr. Further melting of the wreckage ice. Beach bare.

4 Apr. No ice.

5 Apr. No ice.

6 Apr. No ice.

7 Apr. No ice.

APPENDIX E

ENVIRONMENTAL RADIATION DATA

TABLE OF CONTENTS

SECTION 1

PREFACE

ABSTRACT

This report presents the data obtained from the analyses of environmental samples collected for the American Electric Power Service Corporation Donald C. Cook Nuclear Station Environmental Radiological Surveillance Program for the period 01 January 1980 through 31 December 1980.

The activity present above the detection limits in the routinely collected sample media was observed to be of natural and atmospheric origin. The results show that the radiation dose to a member of the general population did not exceed the technical specifications of 1% of the 10 CFR 20 limit during 1980.

INTRODUCTION

The Donald C. Cook Nuclear Station of American Electric Power Service Corporation consists of two Westinghouse PWR units (Unit 1 and Unit 2). Each unit consists of a pressurized water reactor (PWR) which generates about 3250 megawatts (MW) of heat to generate about 1100 MW of electricity. The station is located in Benton Harbor, Michigan.

The D.C. Cook Plant utilizes a pressurized water reactor with a radwaste hold-up and treatment system that has been designed to keep radioactive releases to as low as is practible 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 1980 through December 1980.

SUMMARY
1980

Environmental monitoring results showed that the radiation dose to a member of the general population did not exceed Tehcnical Specifications of 1% of the 10CFR20 limit during during 1980. The activity present above the detection limits in the routinely collected sample media was observed to be of natural and atmospheric fallout origin.

Table 1 summarizes the range and average concentrations for measurements at the indicator and control locations, and the location with the highest annual mean. Complete information is given in the Sample Data Tables (Section 5).

SECTION 2

SAMPLING PROGRAM

All samples are collected by Eberline personnel and shipped to the Eberline laboratory in West Chicago, Illinois. The sample collection procedures remained the same as those detailed in the semi-annual report for the period 01 January through 30 June 1973.

Upon receipt of the samples, the laboratory staff enters the samples in a log book identifying them as to sample type, collection date, and sample code number of location, then verifies the specific analyses to be performed on each sample. The samples are then stored, awaiting analysis, on shelves expressly for this purpose to assure accountability through the laboratory processes.

Table 1 lists the sampling locations and frequencies. Figures I and II show the locations of the various sampling environs.

Table 1 lists the sample analysis program - sample type, frequency, and the type of analysis required.

Table 2 lists the LLD's (Lower Limits of Detection) for the analytical program. These LLD's are based on the Regulatory Guide 4.8. For analyses not listed in Regulatory Guide 4.8, Federal EPA, former requirements for similar programs or other appropriate guides are used. The LLD's are calculated at the 3σ (99% confidence) level.

The Guide specifically states that the LLD's are a priori, not a posteriori (after the fact) limit for a particular measurement. When however, RG 4.8 or other LLD's have not been achieved, a footnote giving a brief explanation has been inserted.

TABLE 1

ENVIRONMENTAL MONITORING PROGRAM

DONALD C. COOK NUCLEAR PLANT

Sample Type	No. Station Ind.	- 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	4	3	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 1 (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	3	2	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	

Table 2

LOWER LIMITS OF DETECTION
(LLD's)

Sample Class	Analysis	LLD	Units
Air Particulates	Gross Beta	0.01	pCi/m^3
	Gamma Isotopic	0.01	pCi/m^3
	Sr-89	0.002	pCi/m^3
	Sr-90	0.001	pCi/m^3
Airborne Iodine	I-131	0.01	pCi/m^3
Milk	I-131	0.05	pCi/l
	Gamma Isotopic	10	pCi/l
	Sr-89	5	pCi/l
	Sr-90	1	pCi/l
Well Water	LS Tritium	1000	pCi/l
	Gamma Isotopic	10	pCi/l
Precipitation	Gamma Isotopic	10	pCi/l
	Sr-89	2	pCi/l
	Sr-90	1	pCi/l
Lake Water	Gamma Isotopic	10	pCi/l
	Enriched Tritium	0.2	pCi/ml
Aquatic Organisms	Gamma Isotopic	1	pCi/g wet
	Sr-89	0.05	pCi/g wet
	Sr-90	0.005	pCi/g wet
Sediment	Gamma Isotopic	1	pCi/g dry
	Sr-89	0.05	pCi/g dry
	Sr-90	0.005	pCi/g dry
Fish	Gamma Isotopic	1	pCi/g wet
	Sr-89	0.05	pCi/g wet
	Sr-90	0.005	pCi/g wet
Food Crops	Gamma Isotopic	1	pCi/g wet
Background Radiation (TLD)	Gamma Dose	-	mR/week

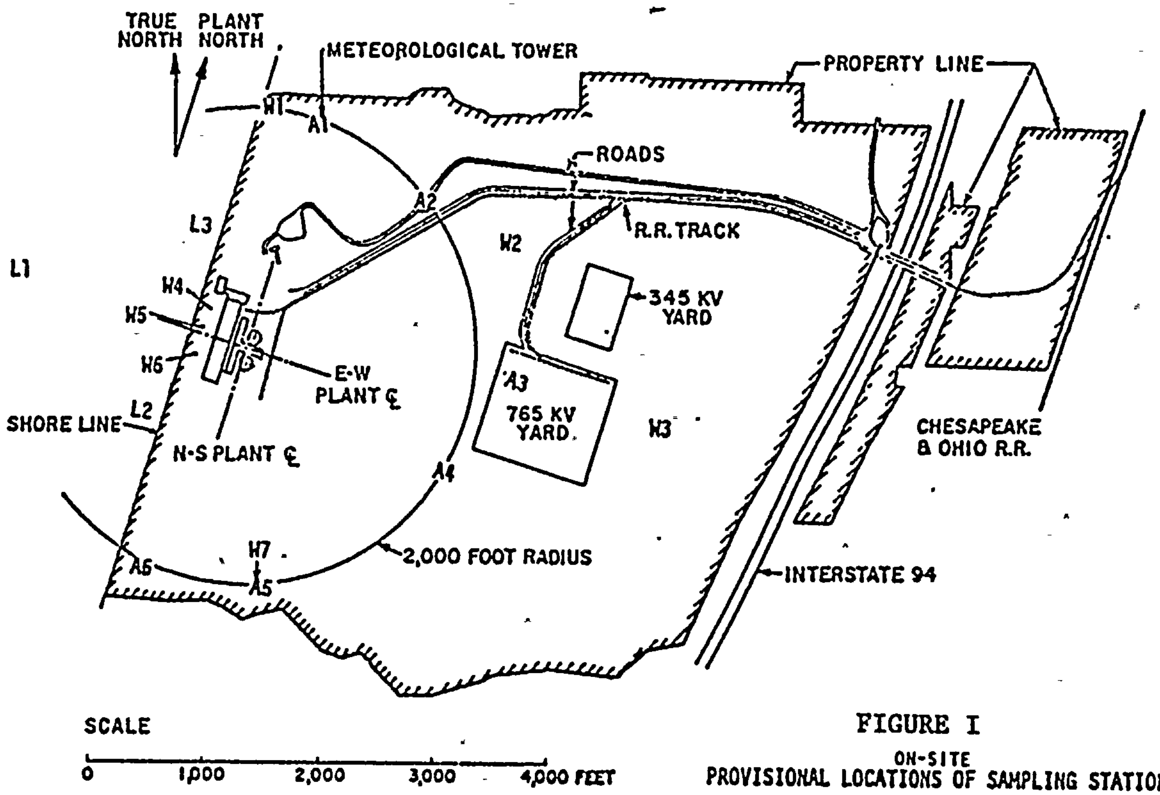

FIGURE I

ON-SITE
PROVISIONAL LOCATIONS OF SAMPLING STATIONS

A - Air, Precipitation, TLD Stations
W - Well Water Sample Stations
L - Lake Water Sample Stations

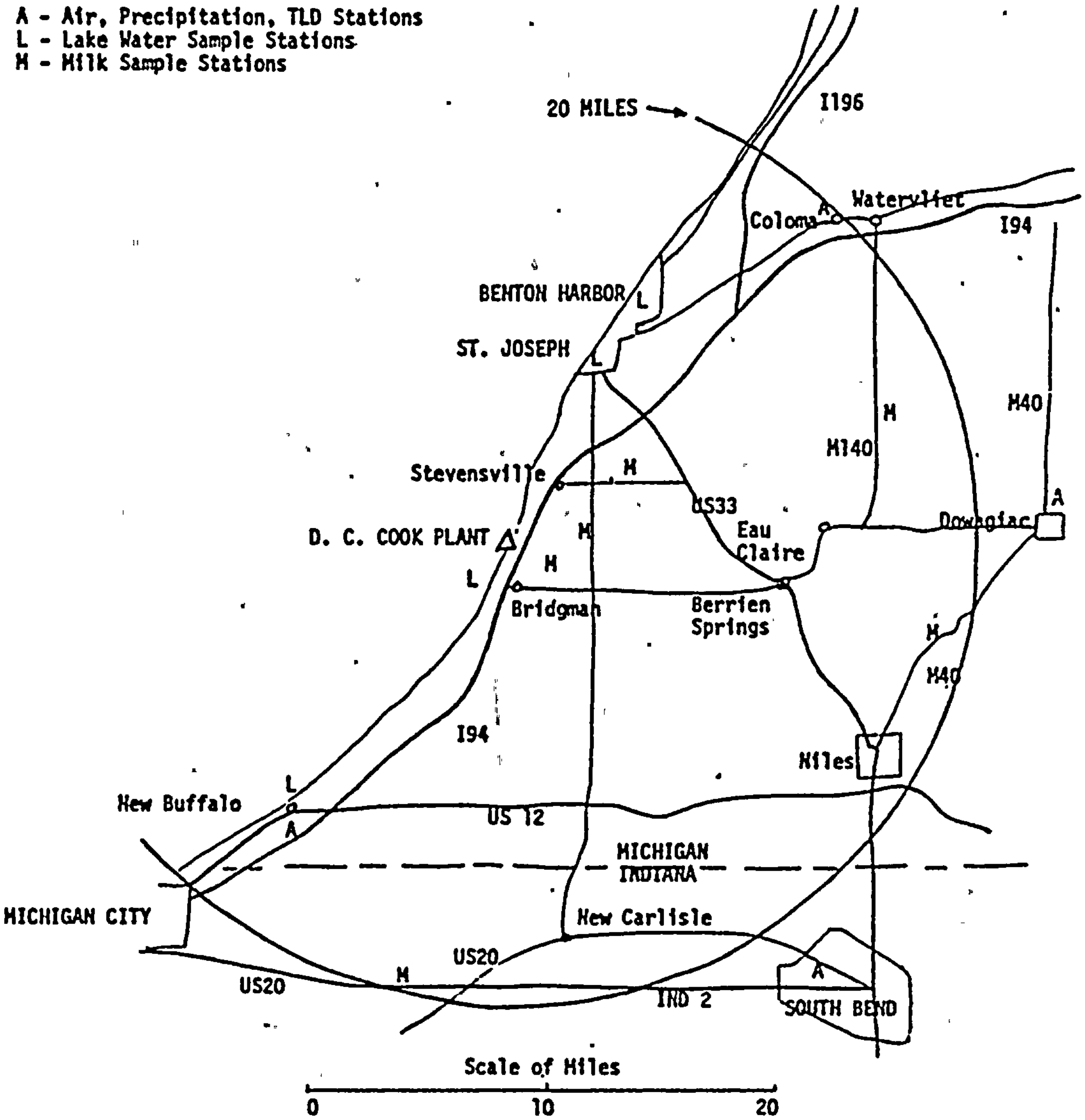

FIGURE II
OFF-SITE
PROVISIONAL LOCATIONS OF SAMPLING STATIONS

SECTION 3

ANALYSIS PROGRAM

ANALYTICAL PROCEDURES

Samples received at the laboratory are analyzed for the various radioactive components by standard radiochemical methods. These methods are equal to, and in most cases, identical with, those of the U.S.D.O.E.(1) or those of the Federal E.P.A.(2).

Brief descriptions of analytical procedures are available in the Laboratory Procedures Manual available at Surry Station and the radioanalytical contractor's laboratory.

Air Particulate Filters

Gross Beta - Exposed air particulate filters are counted in low background Geiger or proportional flow beta counters using anti-coincidence background suppression after the short-lived naturally-occuring radon and thoron daughters have decayed. Filters are counted long enough to ensure that the required sensitivity (LLD) will be met

Gamma Isotopic - Quarterly composites of air particulate filters are counted in high resolution (GeLi) gamma spectrometers for periods of time long enough to ensure that the required program sensitivity (LLD) is met. (See also introduction to data tables, Section 5.)

Water Samples (Includes Surface, Well, Precipitation, James River)

Gross Beta - A measured aliquot of sample is digested, "wet-ashed", evaporated, transferred to a tared 47mm stainless steel planchet, dried, and weighed. The planchetted sample is counted long enough in a low background beta counter to ensure that the LLD of the program will be met.

(1) HASL Procedures Manual, edited by John H. Harley, Health and Safety Laboratory, US 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.

Gamma Isotopic - a measured aliquot of the sample is evaporated to a small controlled volume and counted in a standard geometry in a high resolution (Geli) gamma spectrometer long enough to ensure meeting the sensitivity requirements of the program. See also the Introduction to Data Tables.

Strontium-89 and Strontium-90 - carrier strontium is added to a measured aliquot of sample. The strontium is then separated and purified by either ion exchange chromatography (EPA method) or straight wet chemistry (HASL method). The chemical yield for strontium is determined by atomic adsorption spectrometry or gravimetric methods. After a suitable period (usually 14 days) to allow for ingrowth of Y-90 the sample is counted in a low background beta counter (equilibrim or total Sr count). The strontium is next put into solution, carrier yttrium added, and the strontium and yttrium fractions separated. The yttrium is counted and from the Y-90 (Sr-90 daughter) count, the Sr-90 concentration can be determined. The difference between the total strontium concentration as determined by the equilibrium count and the Sr-90 concentration as determined from the Y-90 count is the Sr-89 concentration. Equations are available to permit calculation of Sr-89 and Sr-90 by counting the purified Sr fraction at two points during ingrowth of the Sr-90 daughter Y-90. While either method is acceptable, we find the former method to provide more consistent results.

Tritium - tritium as tritiated water is analyzed by liquid scintillation counting after distillation. If high sensitivity is not required (ie. LLD ~500 pCi/l) the sample is distilled, mixed with the appropriate counting phosphors and counted with no further treatment. If higher sensitivity is required (ie. <~300 pCi/l) the sample is isotopically enriched in tritium concentration prior to liquid scintillation counting.

Isotopic enrichment is done by the classical method of Ostlund which involves alkaline electrolysis of a purified aliquot of sample under controlled conditions of temperature and electrode current density.

Milk Samples

I-131 - measured amounts of carrier iodide are added to a known volume of milk and the iodine extracted on anion exchange resin. The iodine is recovered and purified by classical iodine chemistry methods which are similar to those given in former Regulatory Guide 4.3. The yield or recovery of iodine is measured gravimetrically and the precipitated sample is mounted and counted in a low level beta detector for a long enough period to ensure that the required LLD is met.

Gamma Isotopic - a measured aliquot of sample is evaporated and oven dried to a standard volume and counted in a fixed geometry in a high resolution (GeLi) gamma spectrometer for a long enough period to ensure that the required LLD's are reached (see also Introduction to data Tables).

Sr-89 and Sr-90 - Stable strontium carrier is added to an aliquot of the sample which is then dried and ashed at high temperature (>700°c). The ash is dissolved and the solution treated from this point on in the same manner as are water samples (Q.V.).

Organic Samples (including Clams, Oysters, Fish, Crabs, Food Crops and Fowl).

Gamma Isotopic Analysis - a measured aliquot of sample is oven dried or ashed as appropriate, placed in a controlled geometry and counted in a high resolution (GeLi) gamma spectrometer for a period long enough to ensure that the LLD's of the program will be met (see also intro. to Data Tables).

In the case of samples such as fish and fowl, the edible flesh is separated from bones and entrails prior to drying.

Sr-89 and Sr-90 - stable strontium carrier is added to a weighed aliquot of the sample and the sample is ashed at high temperature (>700°c). The ashed sample is then dissolved and processed in the same manner as are water or milk samples.

Soil and Silt Samples

Gamma Isotopic Analysis - the sample is oven dried to facilitate handling and then sieved to remove pieces of stone and/or other large pieces of material. An appropriate sized, weighed aliquot of the sample is then transferred into a standard geometry container and counted for a period long enough to ensure that the LLD of the program will be met. (See also Introduction to Data Tables).

Thermoluminescent Dosimeters (TLD)

Environmental radiation doses are measured using badges comprizing five chips sealed in plastic protective holders having a density of 50 mg/cm². The TLD chips are 1/8" x 1/8" x 1/32 LiF (thallium activated) known commercially as Harshaw-100. The chips are all selected to provide uniform response to within 5% of the mean for the batch.

Prior to installation, the chips are annealed by a standard cycle of 60 minutes at 400°c and immediate cooling to ambient temperature by placing the tray containing the annealed chips on an aluminum block 12" x 12" x 1".

After exposure the chips are read on an Eberline Instrument Corporation Model TLR-6 reader. The system employs a preheat cycle which removes low temperature peaks and integrates and digitizes only the light output in a selected temperature range.

The dose is calculated from the average light output for the five chips and the statistical uncertainty is the standard deviation of the five readings. Control badges are used to detect any unusual exposure to the badge which might occur during shipment.

QUALITY ASSURANCE PROGRAM

A. Design of Plan

Quality of product or service has always been a primary key to increase is sales, customer satisfaction, and profit. The management of Eberline Instrument Corporation recognizes the ever increasing demand for higher quality and reliability for services related to protection of workers and the environment. It is our firm belief that in order to judge the worth of a support service, one must know the philosophy behind it. Eberline will provide only those services for which it is qualified and these will be provided in a manner that is reliable, with a quality assurance program that maintains a high degree of client confidence. This quality assurance program has been prepared consistent with the following specifications, per the Technical and Quality Assurance Requirements for Special Purposes.

ANSI-N45.2, American National Standards Institute

NRC Branch Technical Position of November 1979

NRC Regulatory Guide 4.15, Revision 1 of February 1979.

B. Intercomparison Program

Results of Eberline's Midwestern Facility participation in the USEPA's Crosscheck Program will be included in the monthly reports provided to the client. Other intercomparisons in which we routinely participate include:

Environmental Protection Agency
Environmental Measurement Lab DOE Quality Assessment Program
Battelle Northwest Laboratories
IAEA Analytical Quality Control Service
US National Bureau of Standards
Eberline's Albuquerque Laboratory.

Each of the laboratory managers is responsible for preparing spikes and blanks to be run routinely. Every tenth sample is a spike, a blank, or a split sample.

Regular QC reports are prepared by the laborary manager on a monthly

schedule and forwarded to each client. Each report routinely includes:

results from EIC interlaboratory comparison,
results from EPA Crosscheck program, and
results from other intercomparison programs.

Results are reviewed by the laboratory manager. If a problem is indicated by the data, the nature of the problem is investigated and corrective steps taken immediately. A copy of each report is also provided to the Quality Assurance Manager of the Nuclear Services Division.

C. Quality Assurance Plan

The Quality Assurance Program follows the requirments of Company and Division Manuals. The discussion below outlines Quality Assurance Programs as conducted in the laboratory and as required in our QA Manual.

Procedure Approval

Each procedure goes through a vigorous evaluation and review process before it is incorporated into the EIC Procedures Manual. Established procedures of the Environmental Protection Agency (EPA) or the Environmental Measurements Laboratory of the US Department of Energy (EML) are used unless thorough testing has demonstrated that an alternate procedure is equal to or better than the EPA or EML procedure. Uniform procedures are used at both laboratories to the fullest extent possible, except when deviations are necessary to meet the specific requirements of the client. The manager of each laboratory and the quality assurance manager review and approve significant procedural changes before they are implemented.

Equipment Calibration and Maintenance

Equipment used for qualitative or quantitative measurements is carefully calibrated and maintained with records of each calibration or maintenance action kept in appropriate logbooks. To the extent possible, certified standards are used for all primary calibrations. The following standards are used for the application indicated:

Measurement	Calibration Standard
Gross Beta	Solution of Standard ^{137}Cs certified by NBS or Amersham Searle
Tritium	Solution standard of ^{3}H certified by NBS
Gamma Spectrometry	Solution standards of various gamma emitters certified by NBS or Amersham Searle. Standards are used to calibrate each counting geometry used.
Strontium-89 and 90	Solution standards of ^{90}Sr certified by Amersham Searle or NBS
Gross Alpha	Solution standards of ^{239}Pu certified by NBS or Amersham Searle.
Radiation Dose	^{137}Cs gamma source cross-referenced with NBS using R-meters. ^{226}Ra is used for some special application.

When suitable standards are not available for a specific gamma emitter, quantitative gamma isotopic analysis is based on an energy calibration of the gamma spectrometer and the gamma energy and abundance information provided in Table of Isotopes, Sixth Edition by Ledrer, Hollander, and Perlman.

The results of the Quality Control Programs are summarized in Section 6.

SECTION 4

RESULTS AND DISCUSSION

Table 3

Environmental Radiological Monitoring Program

Name of Facility: Donald C. Cook Nuclear Station   Docket Numbers: 50-315 and 50-316

Location of Facility: Berrien (County) Michigan (State)   Reporting Period: January - December 1980

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean[1] (Range)	Location with Highest Mean		Control Locations Mean[1] (Range)	Number of Non-routine Reported Measurements
				Name	Mean (Range)		
Air Particulates (pCi/m^3)	Gross β 312	0.01	0.04 (301/312) 0.01-0.17	On-site 5	0.04 (51/52) 0.01-0.17	0.04 (204/208) 0.01-0.16	0
	Ce-144 24	0.01	0.02 (1/12) 0.02	Not Applicable		0.02 (1/12) 0.02	0
	Other γ 24	0.01	All LLD	Not Applicable		All LLD	0
	Sr-89 8	0.002	All LLD	Not Applicable		All LLD	0
	Sr-90 8	0.001	All LLD	Not Applicable		All LLD	0
Airborne Iodine (pCi/m^3)	I-131 312	0.01	All LLD	Not Applicable		All LLD	0
Milk (pCi/l)	I-131 57	0.05	All LLD	Not Applicable		All LLD	0
	Sr-89 53	5	All LLD	Not Applicable		All LLD	0
	Sr-90 53	1	4.7 (29/31) 1-15	Bridgman	5.1 (10/11) 1-10	6.1 (20/22) 2-13	0
	γ Spec. 53	10	All LLD	Not Applicable		All LLD	0
Well Water (pCi/l)	Tritium 14	1000	1467 (3/14) 700-2300	On-site 4	1850 (2/2) 1400-2300	All LLD	0
	γ Spec. 14	10	All LLD	Not Applicable		All LLD	0

[1] Mean and range based on detectable measurements only. Fractions indicated in parentheses.

Table 3 (continued)

Facility: Donald C. Cook Nuclear Plant

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean[1] (Range)	Location with Highest Mean: Name	Location with Highest Mean: Mean (Range)	Control Locations Mean[1] (Range)	Number of Non-routine Reported Measurements
Special Well Water (pCi/ml)	Tritium 39	1	1.8 (22/39) 0.4-5.4	On-site 4	2.8 (9/10) 1.2-5.4	Not Measured	0
Precipitation (pCi/l)	γ Spec. 24	10	All LLD	Not Applicable		All LLD	0
	Sr-89 4	2	All LLD	Not Applicable		All LLD	0
	Sr-90 4	1	2 (1/2) 2	Not Applicable		All LLD	0
Lake Water (pCi/l - γ) (pCi/ml - HTO)	γ Spec. 22	10	All LLD	Not Applicable		All LLD	0
	Tritium 8	0.2	0.35 (4/4) 0.24-0.53	Not Applicable		0.30 (4/4) 0.20-0.49	0
Aquatic Organisms (pCi/g wet)	γ Spec. 8	1	All LLD	Not Applicable		All LLD	0
	Sr-89 8	0.05	All LLD	Not Applicable		All LLD	0
	Sr-90 8	0.005	0.03 (1/4) 0.03	South On-site	0.03 (1/2)	All LLD	0
Sediment (pCi/g dry)	γ Spec. 8	1	All LLD	Not Applicable		All LLD	0
	Sr-89 8	0.05	All LLD	Not Applicable		All LLD	0
	Sr-90 8	0.005	All LLD	Not Applicable		All LLD	0
Food Crops (pCi/g wet)	γ Spec. 4	1	All LLD	Not Applicable		All LLD	0

[1] Mean and range based on detectable measurements only. Fractions indicated in parentheses.

Table 3 (continued)

Facility: Donald C. Cook Nuclear Plant

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean[1] (Range)	Location with Highest Mean Name	Location with Highest Mean Mean (Range)	Control Locations Mean[1] (Range)	Number of Non-routine Reported Measurements
Fish (pCi/g Wet)	γ Spec. 8	1	All LLD	Not Applicable		All LLD	0
	Sr-89 8	0.05	All LLD	Not Applicable		All LLD	0
	Sr-90 8	0.005	0.015 (2/4) 0.006-0.023	South On-site	0.023 (1/2) 0.023	0.017 (3/4) 0.006-0.023	0
Background Radiation (TLD) (mR/week)	γ Dose 68	-	0.9 (36/36) 0.6-1.0	On-site 3	0.92 (5/5) 0.7-1.1	0.9 (32/32) 0.6-1.2	0

[1] Mean and range based on detectable measurements only. Fractions indicated in parentheses.

Results of all the analyses for January through December 1980 are presented in full in Section 5, Data Tables pages 35 through 48.

Table 3 summarizes the range and average concentrations for measurements at the indicator and control locations with the highest annual mean. Environmental monitoring results showed that the radiation dose to a memeber of the general population did not exceed Technical Specifications of 1% of the 10CFR20 limit during 1980.

Specific findings for the various environmental media are discussed below:

AIR PARTICULATE SAMPLES

Atmospheric particulate matter at a field location is accumulated for a one-week period on a glass fiber filter using a low-volume air sampler at a collection rate of one cubic foot per minute. This particulate matter comtained on the filter is counted for beta activity in a low background counting system after the short-lived naturally-occurring radon and thoron daughters have decayed.

The average gross beta concentration for the year for all indicator stations was 0.04 pCi/m^3, and was 0.04 pCi/m^3 for the background stations as well. Data for analyses of individual filters are given on pages 36 through 39 in Section 5.

The following table summarizes the average gross beta concentrations for both indicator and background stations for each year from 1973 through 1980. The preoperational data were collected in 1973 and 1974; operational data were collected from 1975 through 1980.

	Indicator	Background
	pCi/m³(±2σ)	
Preoperational		
1973	0.04±0.04	0.04±0.04
1974	0.16±0.24	0.16±0.29
Operational		
1975	0.08±0.18	0.09±0.17
1976	0.09±0.22	0.08±0.19
1977	0.22±0.63	0.22±0.53
1978	0.12±0.40	0.11±0.30
1979	0.04±0.16	0.04±0.16
1980	0.04±0.16	0.04±0.16

The elevated levels of gross beta activity at both indicator and background locations during preoperational and operational phases from 1974 through 1978 were mainly the result of nuclear test explosions in the atmosphere by the People's Republic of China. Such tests took place on or about 30 June 1973, 26 September 1976, 17 October 1976, 17 September 1977, and during March and December 1978.(1)

The data indicate that there is significantly no difference between the levels of gross beta activity measured at the indicator and background locations for the operational and preoperational phases of the program. The activity detected are not attributable to the operation of the Cook plant.

Airborne Iodine-131 concentration was less than 0.1 pCi/m³ for all samples received.

Gamma spectrometry of monthly composites of air particulate filters indicated that the concentrations of gamma emitters were less than 0.01

(1) See Annual Environmental Monitoring Reports for D.C.Cook Plant from years 1973 through 1978 for details.

pCi/m^3 for both indicator and background locations in all except the November composite. Traces of Cerium-141 above the detection limit were measured in both November composites. This is attributable to atmospheric fallout. Beryllium-7, a naturally-occurring nuclide formed by the cosmic ray interaction with nuclei in the upper atmosphere, was detected in the gamma isotopic analyses of the air filter composites. These were generally in the range to be expected from measurements of this nuclide in this medium.

Quarterly composites of air particulate filters were analyzed for Strontium-89 and Strontium-90. Strontium-89 concentrations were less than the detection limit of 0.002 pCi/m^3, and Strontium-90 was at or below the detection limit of 0.001 pCi/m^3 for both indicator and background locations. These were generally in the range to be expected from measurements of these nuclides in this medium.

MILK

Milk samples were collected monthly and were analyzed for Iodine-131, Strontium-89 and 90, and gamma emitters.

Strontium-89 concentrations measured below the detection limit of 5 pCi/l in all samples collected during the year. Strontium-90 concentrations continued to display considerable variation, which is typical for this type of sample. This nuclide is atributable to worldwide fallout from both recent and older nuclear test programs. Data are given on page 41.

Iodine-131 concentrations were below the detection limits of the program. Data are presented on page 41.

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 42.

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/m²). Strontium-89 concentrations were less than the detection limit of 2 pCi/l and Strontium-90 levels were at or below the detection limit of 1 pCi/l. Traces of Strontium-90 attributable to long term fallout were detected during the second half of the year. Data are presented on page 45.

WELL WATER

Well water is collected from seven locations during the year 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 intake from Lake Michigan. Tritium in varying degrees was found in many of the well water samples throughout 1980, but gamma emitters were below the detection limits in all samples analyzed.

The tritium concentrations in the Lake Township intake ranged from less than 1.0 to 5.4 pCi/ml. Modified sample collection techniques by station personnel appear to have eliminated most of the hydrocarbons in the water samples collected during 1980. It is possible that the tritium found in these special samples is a result of plant operations. Data for well water samples are given on pages 43 and 44.

LAKE WATER

Samples of water from Lake Michigan are composited by indicator and background locations and analyzed for gamma emitters on a monthly basis.

Quarterly composites of the monthly composites were analyzed for tritium.

The gamma emitters in the monthly composites were measured to be less than the detection limit of 10 pCi/l per nuclide for all samples.

The tritium concentrations in the quarterly composites were in the range of 240 to 530 pCi/l for the indicator locations and 200 to 460 pCi/l for the background locations. These concentrations were in the range to be expected from measurements of this nuclide in this medium.

AQUATIC ORGANISMS

Aquatic organisms were collected twice during the year from areas north and south of the plant, at on-site and off-site locations. The samples were analyzed for gamma emitters, Strontium-89 and 90.

No gamma emitters were detected at a sensitivity of 1 pCi/g (wet) in any of the samples collected.

Strontium-89 was not detected in any of the samples, and for most samples the detection limit of 0.05 pCi/g (wet) was achieved. However, for some samples, due to an insufficient sample amount being available, the detection limit was not achieved.

Strontium-90 was detected at trace level (0.03 pCi/g wet) in one sample and was attributable to worldwide fallout. For most samples the detection limit of 0.005 pCi/g(wet) was not achieved due to the insufficient sample amounts available for analysis. Data are presented on page 46.

SEDIMENT

Sediment samples were collected twice during the year from areas north and south of the plant, at on-site and off-site locations. The samples were analyzed for gamma emitters, and Strontium-89 and 90.

The gamma emitters were below the detection limit of 1 pCi/g (dry) in all the samples. Strontium-89 and Strontium-90 were also below the detection limits of 0.05 and 0.005 pCi/g (dry) respectively in all samples. Data are presented on page 47.

FISH

Fish samples collected from areas noth and south of the plant, both. on-site and off-site locations, were analyzed for gamma emitters and Strontium-89 and 90.

For all samples, gamma emitters were below and detection limit of 1 pCi/g (wet), and Sr-89 was below the detection limit of 0.05 pCi/g (wet). Strontium-90 in most samples ranged in concentration from 0.006 to 0.023 pCi/g (wet), but was below the detection limit of 0.005 pCi/g (wet) for the rest of the samples. The concentrations observed were attributable to worldwide fallout and were generally in the range to be expected from measurements of this nuclide in this medium. Data are given on page 47.

FOOD CROPS

Grapes and grape leaves were collected during the fall harvest period from on-site and off-site locations and were analyzed for gamma emitters. They were found to be below the detection limit of 1 pCi/g (wet) at both on- and off-site locations. Data are given on page 47.

GAMMA DOSE

Gamma radiation dose was measured with Thermoluminiscent Dosimeters (TLDs) on a quarterly schedule. A total of ten field locations (six indicator and four background) were monitored during the first, second, and third quarters of the year. Three indicator and seven background

locations were added in the fourth quarter.

Throughout the year, 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. Data are presented on page 48.

SECTION 5

DATA TABLES

INTRODUCTION TO THE DATA TABLES

The following information will be helpful in understanding the presentation of the data in the tables in this section.

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^{o} 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 peak of any nuclides present in concentrations exceeding the sensitivity limits set for that particular experiment.
NA, NS, NR	used in place of a concentration 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.
Exponents	Exponents necessary to prevent data tables from being cumbersome are handled in the conventional manner of including them in the column headings.
Sensitivity	In general, all analyses meet the sensitivity requirements of the program as given in Table 3. 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

AIRBORNE IODINE-131* and GROSS BETA in AIR PARTICULATE FILTERS
(Weekly Collections)

	Gross Beta 10^{-2} pCi/m^3									
	ON-SITE 1		ON-SITE 2		ON-SITE 3		ON-SITE 4		ON-SITE 5	
Collection Date	Volume (m^3)	Gross β	Volume (m^3)	Gross β	Volume (m^3)	Gross β	Volume (m^3)	Gross β	Volume (m^3)	Gross β
01/07/80	390	2±1	420	3±1	400	3±1	380	3±1	340	3±1
01/14/80	460	5±1	430	5±1	360	5±1	400	6±1	455	7±1
01/21/80	480	4±1	495	4±1	395	4±1	460	4±1	455	5±1
01/29/80	415	2±1	405	4±1	385	3±1	455	3±1	415	3±1
02/05/80	435	3±1	430	3±1	365	3±1	440	3±1	400(a)	4±1
02/12/80	430	2±1	410	3±1	390	3±1	450	3±1	405(a)	3±1
02/19/80	470	6±1	415	5±1	415	7±1	460	5±1	290	10±1
02/26/80	450	2±1	415	4±1	415	4±1	455	4±1	345	5±1
03/04/80	480	3±1	430	4±1	415	3±1	450	3±1	475	3±1
03/11/80	480	3±1	390	5±1	415	4±1	455	5±1	475	4±1
03/18/80	415	3±1	355	4±1	380	3±1	450	4±1	460	4±1
03/25/80	410	3±1	360	4±1	400	4±1	405	3±1	415	4±1
04/01/80	370	2±1	350	2±1	380	3±1	410	2±1	360	3±1
04/08/80	320	3±1	350	3±1	400	4±1	420	1±1	365	2±1
04/15/80	320	2±1	340	2±1	375	2±1	390	2±1	350	1±1
04/22/80	350	4±1	360	4±1	395	3±1	385	4±1	360	5±1
04/29/80	230	1±1	350	2±1	395	1±1	395	1±1	350	1±1
05/03/80	200	2±1	340	2±1	380	2±1	390	2±1	325	3±1
05/13/80	600	1±1	350	2±1	390	1±1	390	2±1	320	2±1
05/20/80	570	2±1	365	1±1	395	1±1	285	1±1	315	1±1
05/27/80	270	4±1	300	5±1	300	4±1	420	4±1	320	5±1
06/03/80	285	1±1	340	3±1	330	3±1	385	3±1	325	3±1
06/10/80	280	1±1	355	2±1	365(b)	<1	405	2±1	320	3±1
06/17/80	290	3±1	385	3±1	190	4±1	435	3±1	275	6±1
06/24/80	295	4±1	325	4±1	265	4±1	415	3±1	380	5±1
07/01/80	290	3±1	325	3±1	265	3±1	425	2±1	395	4±1

(b) Calculation based on average volume; pump off.
(a) Calculation based on average volume; meter broken.
* Iodine cartidges are sampled weekly. Concentrations are <0.10 pCi/m^3 unless otherwise noted.

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		ON-SITE 2		ON-SITE 3		ON-SITE 4		ON-SITE 5	
	Volume (m³)	Gross β	Volume (m³)	Gross β	Volume (m³)	Gross β	Volume (m³)	Gross β	Volume (m³)	Gross β
07/08/80	290	3±1	345	2±1	265	3±1	310	3±1	400	3±1
07/15/80	305	3±1	350	4±1	260	3±1	275	3±1	300	5±1
07/22/80	285	3±1	415	3±1	270	3±1	310	3±1	330	4±1
07/29/80	315	<1	390	2±1	300	2±1	295	2±1	435	1±1
08/05/80	315	6±1	390	5±1	315	1±1	285	4±1	500	6±1
08/11/80	300	3±1	350	2±1	310	3±1	270	3±1	415	3±1
08/18/80	325	4±1	400	<1	330	3±1	280	2±1	420	3±1
08/25/80	345	3±1	380	2±1	340	3±1	300	3±1	425	4±1
09/01/80	355	2±1	395	3±1	340	5±1	300	5±1	390	7±1
09/08/80	370	1±1	390	1±1	360	3±1	310	3±1	405	4±1
09/15/80	360	2±1	385	3±1	375	4±1	320	4±1	400	4±1
09/22/80	355	1±1	370	2±1	380	3±1	325	2±1	400	4±1
09/29/80	350	1±1	365	2±1	385	3±1	200	4±1	390	4±1
10/06/80	300	<1	315	2±1	300	4±1	195	2±1	335	4±1
10/13/80	365	<1	345	1±1	315	2±1	240	2±1	300	3±1
10/20/80	365	1±1	350	2±1	330	4±1	255	3±1	310	4±1
10/27/80	360	<1	355	<1	370	2±1	275	3±1	330(a)	<1
11/03/80	360	<1	325	2±1	380	3±1	385	4±1	210	4±1
11/10/80	345	3±1	320	4±1	365	6±1	370	7±1	400	6±1
11/17/80	350	2±1	380	2±1	375	4±1	305	4±1	405	5±1
11/24/80	355	4±1	375	4±1	385	8±1	285	5±1	405	5±1
12/01/80	355	3±1	385	3±1	395	6±1	315	6±1	405	5±1
12/08/80	365	4±1	385	5±1	395	7±1	325	9±1	340	10±1
12/15/80	365	4±1	385	<1	400	12±1	320	13±1	430	4±1
12/22/80	355	5±1	390	3±1	410	7±1	325	9±1	180	17±1
12/29/80	355	5±1	385	5±1	425	12±1	335	11±2	345	11±1

(a) Calculations based on average volume (no power).

* 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)

	ON-SITE 6			Gross Beta 10^{-2} pCi/m^3 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
01/07/80	360	2±1	01/05/80	315	3±1	325	3±1	340	3±1	390	3±1
01/14/80	405	6±1	01/12/80	340	4±1	320	5±1	365	5±1	415	6±1
01/21/80	430	5±1	01/19/80	385	5±1	330	5±1	365	5±1	425	4±1
01/29/80	385	3±1	01/26/80	390	3±1	350	3±1	360	3±1	400	3±1
02/05/80	385	3±1	02/02/80	405	3±1	340	3±1	380	3±1	410	3±1
02/12/80	395	2±1	02/09/80	415	2±1	340	3±1	395	2±1	415	2±1
02/19/80	455	4±1	02/16/80	390	5±1	360	5±1	375	5±1	345	5±1
02/26/80	420	4±1	02/23/80	425	3±1	385	4±1	410	4±1	425	6±1
03/04/80	415	3±1	03/01/80	400	4±1	405	5±1	415	5±1	485	5±1
03/11/80	330	5±1	03/08/80	430	3±1	315	3±1	380	3±1	425	3±1
03/18/80	395	3±1	03/15/80	370	4±1	390	4±1	410	4±1	450	5±1
03/25/80	395	4±1	03/22/80	380	3±1	355	3±1	390	3±1	405	3±1
04/01/80	390	3±1	03/29/80	425	3±1	400	2±1	425	2±1	460	2±1
04/08/80	405	1±1	04/05/80	370	1±1	370	2±1	340	3±1	405	2±1
04/15/80	385	2±1	04/12/80	390	3±1	355	3±1	325	3±1	415	4±1
04/22/80	385	4±1	04/19/80	400	3±1	350	3±1	335	3±1	425	3±1
04/29/80	375	1±1	04/26/80	385	1±1	330	2±1	345	2±1	420	3±1
05/03/80	375	3±1	05/06/80	380	<1	335	1±1	345	<1	420	1±1
05/13/80	380	2±1	05/10/80	400	2±1	385	3±1	345	2±1	415	3±1
05/20/80	385	1±1	05/17/80	380	1±1	325	1±1	355	2±1	405	1±1
05/27/80	405	4±1	05/24/80	370	3±1	360	3±1	325	2±1	430	3±1
06/03/80	390	3±1	05/31/80	390	4±1	390	4±1	310	5±1	450	<1
06/10/80	405	2±1	06/07/80	350	2±1	380	3±1	340	3±1	430	2±1
06/17/80	435	3±1	06/14/80	370	2±1	415	3±1	355	3±1	415	3±1
06/24/80	415	4±1	06/21/80	360	3±1	420	3±1	365	2±1	340	2±1
07/01/80	425	3±1	06/28/80	305	4±1	380	4±1	360	3±1	300	4±1

* Iodine cartridges are sampled weekly. Concentrations are <0.10 pCi/m^3 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										
	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
07/08/80	420	3±1	07/05/80	330	3±1	430	2±1	365	3±1	315	3±1
07/15/80	400	2±1	07/12/80	355	2±1	435	2±1	360	2±1	315	2±1
07/22/80	360	3±1	07/19/80	420	3±1	455	4±1	355	4±1	335	3±1
07/29/80	415	3±1	07/26/80	435	3±1	490	3±1	395	3±1	315	<1
08/05/80	430	5±1	08/02/80	420	4±1	360	4±1	360	3±1	355	4±1
08/11/80	400	2±1	08/09/80	460	2±1	320	4±1	410	2±1	370	3±1
08/18/80	410	3±1	08/16/80	360	3±1	340	3±1	375	2±1	340	3±1
08/25/80	420	3±1	08/23/80	355	3±1	385	3±1	385	3±1	355	3±1
09/01/80	395	6±1	08/30/80	365	5±1	355	5±1	390	4±1	390	4±1
09/08/80	420	3±1	09/06/80	350	3±1	350	3±1	410	3±1	380	3±1
09/15/80	400	3±1	09/13/80	340	3±1	340	3±1	390	4±1	345	5±1
09/22/80	410	3±1	09/20/80	350	3±1	350	3±1	380	2±1	335	2±1
09/29/80	570	3±1	09/27/80	335	3±1	345	3±1	395	4±1	345	5±1
10/06/80	340	4±1	10/04/80	340	4±1	345	3±1	350	4±1	300	2±1
10/13/80	285	5±1	10/11/80	270	3±1	265	5±1	210	3±1	295	2±1
10/20/80	295	3±1	10/18/80	295	3±1	275	3±1	285(a)	3±1	300	2±1
10/27/80	330(a)	<1	10/25/80	335	2±1	360	2±1	320	2±1	270	3±1
11/03/80	170	5±1	11/01/80	305	2±1	355	2±1	330	2±1	290	3±1
11/10/80	285	8±1	11/08/80	370	5±1	370	10±1	360	6±1	320	7±1
11/17/80	235	5±1	11/15/80	365	4±1	360	4±1	345	6±1	345	5±1
11/24/80	250	8±1	11/22/80	360	6±1	360	5±1	265	4±1	365	6±1
12/01/80	255	8±1	11/29/80	365	4±1	380	4±1	155	8±1	355	5±1
12/08/80	345	9±1	12/06/80	365	8±1	390	8±1	380	8±1	360	6±1
12/15/80	355	5±1	12/13/80	370	11±1	380	12±1	415	14±1	390	16±1
12/22/80	135	16±1	12/20/80	370	9±1	380	9±1	390	9±1	385	7±1
12/29/80	315	16±2	12/27/80	440	12±1	410	7±1	380	9±1	375	8±1

(a) Calculations based on average sample volume.
* 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 pCi/m³		Background Stations pCi/m³	
	Be-7	Other γ	Be-7	Other γ
January	0.08±0.01	<0.01	0.05±0.01	<0.01
February	0.05±0.01	<0.01	0.04±0.02	<0.01
March	0.07±0.01	<0.01	0.06±0.02	<0.01
April	0.04±0.01	<0.01	0.05±0.01	<0.01
May	0.06±0.02	<0.01	0.12±0.02	<0.01
June	0.05±0.01	<0.01	0.09±0.01	<0.01
July	0.05±0.01	<0.01	0.11±0.03	<0.01
August	0.10±0.01	<0.01	0.06±0.01	<0.01
September	<0.01	<0.01	<0.01	<0.01
October	<0.01	<0.01	0.05±0.01	<0.01
November	0.05±0.01	<0.01(a)	0.03±0.01	<0.01(b)
December	0.03±0.01	<0.01	0.07±0.01	<0.01

(a) Ce-141 = 0.02±0.01
(b) Ce-141 = 0.02±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 Quarter	<0.002	<0.001	<0.002	<0.001
2nd Quarter	<0.002	<0.001	<0.002	<0.001
3rd Quarter	<0.002	<0.001	<0.002	<0.001
4th Quarter	<0.002	<0.001	<0.002	<0.001

DONALD C. COOK

Sr 89*/90 and I-131 CONCENTRATIONS in MILK SAMPLES
(Monthly Collection)

Collection Site:	Indicator Stations			Background Stations	
	Bridgman K2	Stevensville K1	Galien	Dowagiac K1	South Bend K1
Collection Date	I-131 pCi/l				
01/05/80	<0.5	<0.5	<0.5	<1 (a)	<0.5
02/02/80	<0.5	<0.5	<0.5	<0.5	<0.5
03/08/80	<0.5	<0.5	(b)	<0.5	<0.5
04/12/80	<0.5	<0.5	(b)	<0.5	<0.5
05/03/80	<1 (a)	<2 (a)	<1 (a)	<1 (a)	<1 (a)
06/07/80	<0.5	<0.5	(b)	<0.5	<0.5
07/05/80	<0.5	<0.5	<0.5	<0.5	<0.5
08/09/80	<0.5	<0.5	<0.5	<0.5	<0.5
09/06/80	<0.5	<0.5	<0.5	<0.5	<0.5
10/11/80	<0.5	<0.5	<0.5	<0.5	<0.5
11/08/80	<0.5	<0.5	<0.5	<0.5	<0.5
12/06/80	<0.5	<0.5	<0.5	<0.5	<0.5
	Sr-90 pCi/l				
01/05/80	5±2	2±1	4±4	6±2	5±2
02/02/80	9±3	8±3	2±1	13±3	5±2
03/08/80	1±1	15±5	(b)	11±4	6±4
04/12/80	6±3	11±3	7±3	2±1	2±2
05/03/80	2±2	4±4	4±1	8±2	9±3
06/07/80	10±5	2±2	(b)	7±5	<2
07/05/80	<1	<1	7±3	8±3	<4(a)
08/09/80	5±2	3±2	5±2	9±2	5±2
09/06/80	(b)	(b)	(b)	(b)	(b)
10/11/80	6±2	1±1	1±1	6±1	3±1
11/08/80	4±1	1±1	4±1	7±1	3±2
12/06/80	3±1	2±1	3±1	3±1	4±1

* Sr-89 was determined on each sample and was <5 pCi/l unless otherwise noted.
(a) Lower sensitivity due to low chemical yield.
(b) See Listing of Missed Samples page.

DONALD C. COOK

RADIONUCLIDES in MILK SAMPLES
(Monthly Collections)

	Indicator Stations			Background Stations	
Collection Site:	Bridgman K2	Stevensville K1	Galien	Dowagiac K1	South Bend K1
Collection Date	Cs-137 pCi/1				
01/05/80	<10	<10	<10	<10	<10
02/02/80	<10	<10	<10	<10	<10
03/08/80	<10	<10	(a)	<10	<10
04/12/80	<10	<10	<10	<10	<10
05/03/80	<10	<10	<10	<10	<10
06/07/80	<10	<10	(a)	<10	<10
07/05/80	<10	<10	<10	<10	<10
08/09/80	<10	<10	<10	<10	<10
09/06/80	(a)	(a)	(a)	(a)	(a)
10/11/80	<10	<10	<10	<10	<10
11/08/80	<10	<10	<10	<10	<10
12/06/80	<10	<10	<10	<10	<10
	Other Gamma Emitters pCi/1				
01/05/80	<10	<10	<10	<10	<10
02/02/80	<10	<10	<10	<10	<10
03/08/80	<10	<10	(a)	<10	<10
04/12/80	<10	<10	<10	<10	<10
05/03/80	<10	<10	<10	<10	<10
06/07/80	<10	<10	(a)	<10	<10
07/05/80	<10	<10	<10	<10	<10
08/09/80	<10	<10	<10	<10	<10
09/06/80	(a)	(a)	(a)	(a)	(a)
10/11/80	<10	<10	<10	<10	<10
11/08/80	<10	<10	<10	<10	<10
12/06/80	<10	<10	<10	<10	<10

(a) See Listing of Missed Samples page.

DONALD C. COOK

RADIONUCLIDES IN WELL WATER SAMPLES
(18-week Interval Collections)

Collection Site:	Background Stations			Indicator Stations			
	ONS 1	ONS 2	ONS 3	ONS 4	ONS 5	ONS 6	ONS 7
Collection Date	Tritium pCi/ml						
04/30/80	<1	<1	<1	2.3±0.4	<1	<1	<1
09/05, 10/03/80	<1	<1	<1	1.4±0.4	0.7±0.4	<1	<1
	Gamma Emitters pCi/l						
	<10	<10	<10	<10	<10	<10	<10
	<10	<10	<10	<10	<10	<10	<10

DONALD C. COOK

TRITIUM CONCENTRATION in WELL WATER SAMPLES
Special Collection Program
(All Indicator locations)

Collection Date	pCi/ml (±2σ)					
	LTI (a)	No. 4	No. 5	No. 6	No. 11	No. 12
01/22-23/80	<1	5.4±0.5(b)	1.1±0.3(b)	<1	<1	<1
02/12/80	<1	4.1±0.4(b)	1.0±0.3(b)	<1	<1	<1
03/13/80	<1	3.5±0.4	<1	<1	1.0±0.1	<1
05/23/80	-	3.2±0.4(b)	1.1±0.4(b)	1.4±0.4(b)	-	-
06/12/80	-	3.3±0.4(b)	1.2±0.4(b)	1.1±0.4(b)	-	-
07/18/80	-	1.6±0.4(b)	1.7±0.4(b)	0.8±0.3(b)	-	-
08/18/80	-	1.2±0.4(b)	0.4±0.3(b)	1.1±0.4(b)	-	-
10/14/80	-	1.4±0.1(b)	<1(b)	<1(b)	-	-
11/10/80	-	1.6±0.4(b)	0.9±0.4(b)	1.3±0.4(b)	-	-
12/02/80	-	<1	<1	<1	-	-

(a) Lake Township Intake - lake water sample.
(b) Direct Scintillation counting due to oil in samples.

DONALD C. COOK

GAMMA ISOTOPIC ANALYSIS OF PRECIPITATION SAMPLES
(Monthly Collections)

Collection Site:	Indicator	Background
Collection Period	Gamma Emitters nCi/m²	
January	<0.1	<0.1
February	<0.1	<0.1
March	<0.2	<0.2
April	<0.2	<0.1
May	<0.2	<0.2
June	<0.6	<0.5
July	<0.3	<0.5
August	<0.2	<0.2
September	<0.1	<0.1
October	<0.1	<0.1
November	<0.2	<0.2
December	<0.2	<0.2

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
1st half 1980	<2	<1	<2	<1
2nd half 1980	<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	<10	<10
February	(a)	(a)
March	<10	<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/ml	
	Indicator Stations	Background Stations
1st Quarter	0.31±0.10	0.20±0.09
2nd Quarter	0.53±0.16	0.46±0.16
3rd Quarter	0.28±0.11	0.29±0.10
4th Quarter	0.24±0.11	0.25±0.15

RADIONUCLIDES IN AQUATIC ORGANISMS
(Semiannual Collections when Available)

Location	Collection Date	pCi/g (wet)		
		Sr-89	Sr-90	Gamma Emitters
N OFS	06/04/80	<0.2(b)	<0.2(b)	<1
S OFS	06/04/80	<1.0(b)	<1.0(b)	<1
S ONS	06/04/80	<0.4(b)	<0.4(b)	<1
N ONS	06/04/80	<0.8(b)	<0.8(b)	<1
N OFS	09/19/80	<0.05	<0.005	<1
S OFS	09/19/80	<0.05	<0.06(b)	<1
S ONS	09/19/80	<0.05	0.03±0.03	<1
N ONS	09/19/80	<0.05	<0.02(b)	<1

(a) See Listing of Missed Samples page.
(b) Insufficient sample for more sensitive analysis.

RADIONUCLIDES IN SEDIMENT SAMPLES
(Semiannual Collections)

Collection Site	Collection Date	pCi/g (dry) Gamma Emitters	Sr-89	Sr-90
ONS N	05/06/80	<1	<0.05	<0.005
ONS S	"	<1	<0.05	<0.005
OFS N	"	<1	<0.05	<0.005
OFS S	"	<1	<0.05	<0.005
ONS N	09/22/80	<1	<0.05	<0.005
ONS S	"	<1	<0.05	<0.005
OFS N	"	<1	<0.05	<0.005
OFS S	"	<1	<0.05	<0.005

RADIONUCLIDES IN FISH SAMPLES
(Semiannual Collections)

Collection Site	Collection Date	pCi/g (wet) Gamma Emitters	Sr-89	Sr-90
OFS N	05/27/80	<1	<0.05	<0.005
OFS S	05/27/80	<1	<0.05	0.021±0.003
ONS N	05/27/80	<1	<0.05	<0.005
ONS S	05/27/80	<1	<0.05	<0.005
OFS N	09/08/80	<1	<0.05	0.006±0.004
OFS S	09/08/80	<1	<0.05	0.023±0.006
ONS N	09/08/80	<1	<0.05	0.006±0.004
ONS S	09/08/80	<1	<0.05	0.023±0.006

RADIONUCLIDES IN FOOD CROPS
(Annual Fall Harvest Collection)

Collection Date	Collection Site: Sample Type	ON Site pCi/g (wet) Gamma Emitters	OFF Site pCi/g (wet) Gamma Emitters
09/24/80	Grapes	<1	<1
09/24/80	Grape leaves	<1	<1

DONALD C. COOK

GAMMA RADIATION
(Quarterly)

(Measured using Thermoluminescent Dosimeters)

Date Annealed:	12/17/79	03/20/80	06/18/80	09/17/80*	
Date Read:	04/15/80	08/03/80	10/14/80	01/06/81	
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	4th Qtr. "A" set
Location	Measured mR/Week				
Indicator Stations					
On-Site 1	0.9±0.1	0.9±0.1	0.7±0.1	1.0±0.2	1.0±0.1
On-Site 2	1.0±0.2	0.9±0.2	0.7±0.2	0.9±0.1	1.0±0.2
On-Site 3	1.0±0.2	0.9±0.1	0.7±0.2	0.9±0.2	1.1±0.1
On-Site 4	1.0±0.2	0.9±0.1	0.6±0.1	0.9±0.1	1.0±0.1
On-Site 5	1.0±0.2	0.9±0.1	0.7±0.1	0.8±0.2	1.0±0.2
On-Site 6	1.0±0.1	0.9±0.1	0.6±0.1	0.9±0.1	1.0±0.2
On-Site 7				1.0±0.1	1.0±0.1
On-Site 8				1.0±0.2	0.9±0.1
On-Site 9				1.0±0.1	1.0±0.1
Background Stations					
Coloma	1.1±0.2	0.9±0.1	0.6±0.1	0.8±0.3	1.0±0.2
Dowagiac	1.0±0.2	0.8±0.1	0.6±0.1	0.8±0.1	1.0±0.1
New Buffalo	1.0±0.1	0.9±0.1	0.6±0.1	0.9±0.1	1.0±0.2
South Bend	1.2±0.1	1.0±0.1	0.6±0.1	0.9±0.2	1.2±0.1
Off-Site-1				0.7±0.1	1.0±0.1
Off-Site-2				1.1±0.1(a)	1.1±0.1(a)
Off-Site-3				missing	missing
Off-Site-4				1.1±0.1	1.1±0.1
Off-Site-5				1.1±0.1	1.0±0.1
Off-Site-6				1.1±0.1	1.1±0.2
Off-Site-7				0.9±0.1	1.0±0.1

*new badges effective 4th quarter 1980; all new badges annealed 10/08/80

(a) Read 01/20/81.

COOK

LISTING OF MISSED SAMPLES

Sample Type	Location	Expected Collection Date	Reason
Milk	Galien	02/80	No milk left.
Lake water	Indicator Background	February	All points frozen all month.
Milk	Galien	04/12	Sample lost in processing.
Milk	Galien	06/07	No milk left.
Milk	all stations	09/06	Samples lost in processing for GeLi and Strontium analyses.

SECTION 6

QUALITY ASSURANCE DATA

TLD Intercomparison Badges
Irradiated by Battelle Northwest Labs

1980

	Total mR less transportation control							
	1st Qtr		2nd Qtr		3rd Qtr		4th Qtr	
Badge	Known	Measured	Known	Measured	Known	Measured	Known	Measured
A	8	5±1	10	10.1±3.4	100	102.0±15.0	100	94±9
B	16	13±2	20	21.0±4.1	10	10.2±2.6	50	47±6
C	24	22±7	30	29.0±5.5	15	15.5±3.8	25	24±5
D	100	103±10	60	63.4±8.6	30	29.3±9.0	25	23±2
E	80	77±6	70	62.8±5.9	35	32.5±8.8	50	47±6
F	64	59±6	100	91.8±14.4	45	41.4±7.2	75	66±7
G	28	27±3	30	26.6±5.3	60	56.9±7.1	100	97±11
H	32	29±3	40	37.5±3.8	80	74.3±10.6	75	67±7
J	40	36±4	60	52.2±6.5	10	8.4±1.3	25	26±5
K	37	38±4	80	70.4±10.5	100	82.4±12.4	50	48±7

QUALITY CONTROL ANALYSES SUMMARY

1980

The tables below summarize results of samples run for process quality control purposes during the subject month. 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	68	0
Gross alpha	43	0
Strontium-89	49	0
Strontium-90	178	0
Iodine-131	152	0
Tritium	87	0
Gamma emitters	46	0

SPLIT SAMPLES

Nuclide Analyzed	Number of Det'ns	No. agreeing within 2σ	No. agreeing within 3σ	No. differing by > 3σ
Gross beta	99	94	5	0
Gross alpha	25	23	1	0
Strontium-89	48	48	0	0
Strontium-90	48	48	0	0
Tritium	134	134	0	0
Iodine-131	77	77	0	0
Gamma emitters	121	120	0	0
Calcium-45	2	2	1	0

SPIKED SAMPLES

Nuclide Analyzed	No. of Det'ns	Within 2σ of known	Within 3σ of known	differing from known by > 3σ
Gross beta	44	43	1	0
Strontium-89	23	23	2	0
Strontium-90	73	73	4	0
Tritium	52	51	1	0
Gamma emitters	29	29	0	0
Iodine-131	29	27	2	0

USDOE QUALITY ASSESSMENT PROGRAM

1980

Sample Type	Nuclide	Known	Measured ±2σ error	Units
Air (80-4)	Be-7	0.272 E+03	0.260±0.044 E+03	pCi/filter
Air (80-4)	Mn-54	0.720 E+02	0.645±0.095 E+02	pCi/filter
Air (80-4)	Sr-90	0.199 E+02	0.143±0.094 E+02	pCi/filter
Air (80-4)	Zr-95	0.720 E+02	0.605±0.094 E+02	pCi/filter
Air (80-4)	Sb-125	0.258 E+04	0.180±0.026 E+04	pCi/filter
Air (80-4)	Cs-137	0.257 E+03	0.230±0.034 E+03	pCi/filter
Air (80-4)	Ce-144	0.376 E+04	0.339±0.048 E+04	pCi/filter
Air (80-10)	Be-7	0.230 E+04	0.270±0.038 E+04	pCi/filter
Air (80-10)	Co-60	0.200 E+03	0.225±0.032 E+03	pCi/filter
Air (80-10)	Sr-90	0.107 E+02	0.105±0.016 E+02	pCi/filter
Air (80-10)	Cs-134	0.247 E+04	0.215±0.031 E+04	pCi/filter
Air (80-10)	Ce-141	0.404 E+03	0.475±0.068 E+03	pCi/filter
Air (80-10)	Ce-144	0.346 E+04	0.280±0.040 E+04	pCi/filter
Water (80-4)	H-3	0.103 E+02	0.097±0.017 E+02	pCi/ml
Water (80-4)	Na-22	0.107 E+01	0.095±0.014 E+01	pCi/ml
Water (80-4)	Cr-51	0.137 E+01	0.170±0.029 E+01	pCi/ml
Water (80-4)	Co-57	0.337 E 00	0.600±0.140 E 00	pCi/ml
Water (80-4)	Co-60	0.922 E 00	0.900±0.127 E 00	pCi/ml
Water (80-4)	Sr-89	0.240 E-01	0.267±0.172 E-01	pCi/ml
Water (80-4)	Cs-137	0.978 E 00	0.850±0.127 E 00	pCi/ml
Water (80-4)	U	0.283 E-01	0.200±0.173 E-01	μg/ml
Water (80-10)	H-3	0.149 E+02	0.133±0.017 E+02	pCi/ml
Water (80-10)	Co-60	0.197 E+01	0.207±0.036 E+01	pCi/ml
Water (80-10)	Sr-89	0.218 E 00	0.803±0.263 E-01	pCi/ml
Water (80-10)	Sr-90	0.216 E-01	0.230±0.069 E-01	pCi/ml
Water (80-10)	Cs-134	0.244 E+01	0.283±0.052 E+01	pCi/ml
Water (80-10)	Cs-137	0.226 E+01	0.263±0.045 E+01	pCi/ml
Soil (80-4)	K-40	0.770 E+01	1.100±0.341 E+01	pCi/g
Soil (80-4)	Sr-90	0.374 E 00	0.300±0.172 E 00	pCi/g
Soil (80-4)	Cs-137	0.680 E+01	0.507±0.087 E+01	pCi/g
Soil (80-10)	K-40	0.207 E+02	0.273±0.053 E+02	pCi/g
Soil (80-10)	Co-60	0.100 E 00	0.100±0.100 E 00	pCi/g
Soil (80-10)	Sr-90	0.460 E 00	0.333±0.172 E 00	pCi/g
Soil (80-10)	Cs-137	0.110 E+02	0.110±0.017 E+02	pCi/g
Tissue (80-4)	K-40	0.143 E+02	0.207±0.036 E+02	pCi/g
Tissue (80-4)	Co-60	0.386 E+01	0.373±0.056 E+01	pCi/g
Tissue (80-4)	Sr-90	0.182 E+02	0.180±0.034 E+02	pCi/g
Tissue (80-4)	Cs-137	0.122 E+02	0.103±0.018 E+02	pCi/g
Tissue (80-10)	K-40	0.170 E+01	0.550±0.143 E+01	pCi/g
Tissue (80-10)	Co-60	0.874 E+01	0.950±0.141 E+01	pCi/g
Tissue (80-10)	Sr-90	0.387 E+02	0.250±0.042 E+02	pCi/g
Tissue (80-10)	Cs-137	0.275 E+02	0.270±0.044 E+02	pCi/g

Sample Type	Nuclide	Known	Measured ±2σ error	Units
Vegetation (80-4)	K-40	0.317 E+02	0.457±0.083 E+02	pCi/g
Vegetation (80-4)	Sr-90	0.246 E+02	0.243±0.039 E+02	pCi/g
Vegetation (80-4)	Cs-137	0.171 E+02	0.147±0.025 E+02	pCi/g
Vegetation (80-10)	K-40	0.225 E+02	0.303±0.053 E+02	pCi/g
Vegetation (80-10)	Co-60	0.272 E+01	0.297±0.052 E+01	pCi/g
Vegetation (80-10)	Sr-90	0.138 E+02	0.133±0.030 E+02	pCi/g
Vegetation (80-10)	Cs-137	0.961 E+01	0.967±0.167 E+01	pCi/g

EPA INTERCOMPARISON RESULTS
1980

Sample Type	Analysis	Agency Value	Control Limits (3σ,n=1)	MWF Measured ±2σ error	Units
Water	I-131	53	15	49±5	pCi/l
Air Filter	Gross α	10	15	11±1	pCi/filter
Air Filter	Gross β	31	15	34±3	pCi/filter
Air Filter	Sr-90	10	5	6±1	pCi/filter
Air Filter	Cs-137	12	15	16±4	pCi/filter
Water	Gross α	21	15	26±3	pCi/l
Water	Gross β	49	15	50±5	pCi/l
Water	Sr-90	7	5	8±1	pCi/l
Water	Co-60	33	15	37±4	pCi/l
Water	Cs-134	56	15	58±6	pCi/l
Water	Cs-137	0	0	<5	pCi/l
Water	Gross α	12	15	13±1	pCi/l
Water	Gross β	27	15	29±3	pCi/l
Air Filter	Gross α	24	6	29±3	pCi/filter
Air Filter	Gross β	28	5	41±4	pCi/filter
Air Filter	Sr-90	8	2	9±1	pCi/filter
Air Filter	Cs-137	12	5	14±2	pCi/filter
Water	H-3	2040	1040	2260±230	pCi/l
Air Filter	Gross α	10	5	11±1	pCi/filter
Air Filter	Gross β	29	5	33±3	pCi/filter
Air Filter	Sr-90	9	1.5	10±1	pCi/filter
Air Filter	Cs-137	10	5	12±1	pCi/filter
Water	Gross α	30	8	30±3	pCi/l
Water	Gross β	45	5	45±5	pCi/l
Water	Sr-89	10	5	LT 5	pCi/l
Water	Sr-90	20	1.5	20±2	pCi/l
Water	H-3	1750	341	1600±160	pCi/l
Milk	Sr-89	10	5	LT 5	pCi/l
Milk	Sr-90	25	1.5	18±3	pCi/l
Milk	I-131	0.01	0.1	LT 5	pCi/l
Milk	Cs-137	40	5	43±4	pCi/l
Milk	Ba-140	0.01	0.1	LT 10	pCi/l
Milk	K	1600	80	2000±200	pCi/l
Water	Gross α	13	5	14±1	pCi/l
Water	Gross β	22	5	23±2	pCi/l
Air Filter	Gross α	15	5	18±2	pCi/filter
Air Filter	Gross β	41	5	50±5	pCi/filter
Air Filter	Sr-90	10	1.5	10±1	pCi/filter
Air Filter	Cs-137	20	5	23±2	pCi/filter
Water	I-131	44	5	35±4	pCi/l
Water	H-3	3400	360	3030±300	pCi/l
Water	Sr-89	5	5	LT 2	pCi/l
Water	Sr-90	12	1.5	12±1	pCi/l
Water	H-3	2000	345	2300±200	pCi/l
Water	Gross α	36	9	34±3	pCi/l
Water	Gross β	38	5	42±4	pCi/l
Water	H-3	1210	329	1100±100	pCi/l

EPA INTERCOMPARISON RESULTS

1980

(continued)

Sample Type	Analysis	Agency Value	Control Limits (3σ,n=1)	MWF Measured ±2σ error	Units
Water	Sr-89	24	8.6	27±3	pCi/1
Water	Sr-90	15	2.6	14±1	pCi/1
Water	H-3	3200	625	3400±300	pCi/1
Water	Cr-51	86	8.6	<100	pCi/1
Water	Co-60	16	8.6	19±5	pCi/1
Water	Zn-65	25	8.6	40±10	pCi/1
Water	Ru-106	46	8.6	<50	pCi/1
Water	Cs-134	20	8.6	24±5	pCi/1
Water	Cs-137	12	8.6	15±3	pCi/1
Water	Gross α	32	8.0	31±3	pCi/1
Water	Gross β	21	5.0	22±2	pCi/1
Water	Gross α	16	8.6	21±2	pCi/1
Water	Gross β	13	8.6	19±3	pCi/1
Air filter	Gross α	24	10.0	25±3	pCi/filter
Air filter	Gross β	10	8.6	17±2	pCi/filter
Air filter	Sr-90	0	0.0	<1	pCi/filter
Air filter	Cs-137	10	8.6	10±1	pCi/filter

SECTION 7

LAKE WATER SAMPLES

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 1980 for the five indicator stations and two background stations were analyzed for gamma emitters on a monthly basis. The October composite lake water sample taken at the South Lake Station was found to contain 1.071 E-7 µCi/cc of Co-58. This may have been due to possible inadvertent contamination during laboratory analysis. All other samples throughout the year 1980 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 analysis are listed in Table II.

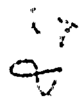

Table I

Donald C. Cook Nuclear Plant

1980 Lake Water Monthly Composite Gamma Isotopic Analysis

Isotope	Concentration (μCi/cc)
I-131	< 9.705 E-8
Cs-137	< 3.600 E-8
Cs-134	< 2.708 E-8
Co-60	< 4.973 E-8
Co-58	< 3.695 E-8
Mn-54	< 3.038 E-8
Zn-65	< 6.513 E-8
Nb-95	< 3.618 E-8
Zr-95	< 6.608 E-8
Cr-51	< 2.948 E-7

Table II

Donald C. Cook Nuclear Plant

Quarterly Lake Water Composite Sr-89, Sr-90, H-3 Analysis 1980

Location	Quarter	Concentration (μCi/cc) Sr-89	Sr-90	H-3
North Lake	1	<3.0 E-9	<3.0 E-9	<8.17 E-7
South Lake	1	<3.0 E-9	<3.0 E-9	<8.17 E-7
Benton Harbor	1	<1.0 E-9	<1.0 E-9	<8.17 E-7
Bridgman	1	<1.0 E-9	<1.0 E-9	<8.17 E-7
Lake Township	1	<1.0 E-9	<1.0 E-9	<8.17 E-7
New Buffalo	1	<1.0 E-9	<1.0 E-9	<8.17 E-7
St. Joseph	1	<1.0 E-9	<1.0 E-9	<8.17 E-7
North Lake	2	<2.0 E-9	<1.0 E-9	<7.68 E-7
South Lake	2	<2.0 E-9	<1.0 E-9	<7.68 E-7
Benton Harbor	2	<2.0 E-9	<1.0 E-9	<7.68 E-7
Bridgman	2	<2.0 E-9	<1.0 E-9	<7.68 E-7
Lake Township	2	<2.0 E-9	<1.0 E-9	<7.68 E-7
New Buffalo	2	<2.0 E-9	<1.0 E-9	<7.68 E-7
St. Joseph	2	<2.0 E-9	<1.0 E-9	<7.68 E-7
North Lake	3	<2.0 E-9	<1.0 E-9	<7.83 E-7
South Lake	3	<2.0 E-9	<2.0 E-9	<7.83 E-7
Benton Harbor	3	<2.0 E-9	<1.0 E-9	<7.83 E-7
Bridgman	3	<2.0 E-9	<1.0 E-9	<7.83 E-7
Lake Township	3	<2.0 E-9	<1.0 E-9	<7.83 E-7
New Buffalo	3	<2.0 E-9	<2.0 E-9	<7.83 E-7
St. Joseph	3	<2.0 E-9	<2.0 E-9	<7.83 E-7

Table II
Donald C. Cook Nuclear Plant
Quarterly Lake Water Composite
Sr-89, Sr-90, H-3 Analysis (Continued)

Location	Quarter	Sr-89	Sr-90	H-3
North Lake	4	<2.0 E-9	(1.0 ± 1.0) E-9	<8.13 E-7
South Lake	4	<2.0 E-9	(2.0 ± 1.0) E-9	<8.13 E-7
Benton Harbor	4	<2.0 E-9	(1.0 ± 1.0) E-9	<8.13 E-7
Bridgman	4	<2.0 E-9	(1.0 ± 1.0) E-9	<8.13 E-7
Lake Township	4	<2.0 E-9	<1.0 E-9	<8.13 E-7
New Buffalo	4	<2.0 E-9	(2.0 ± 1.0) E-9	<8.13 E-7
St. Joseph	4	<2.0 E-9	<1.0 E-9	<8.13 E-7

(2)