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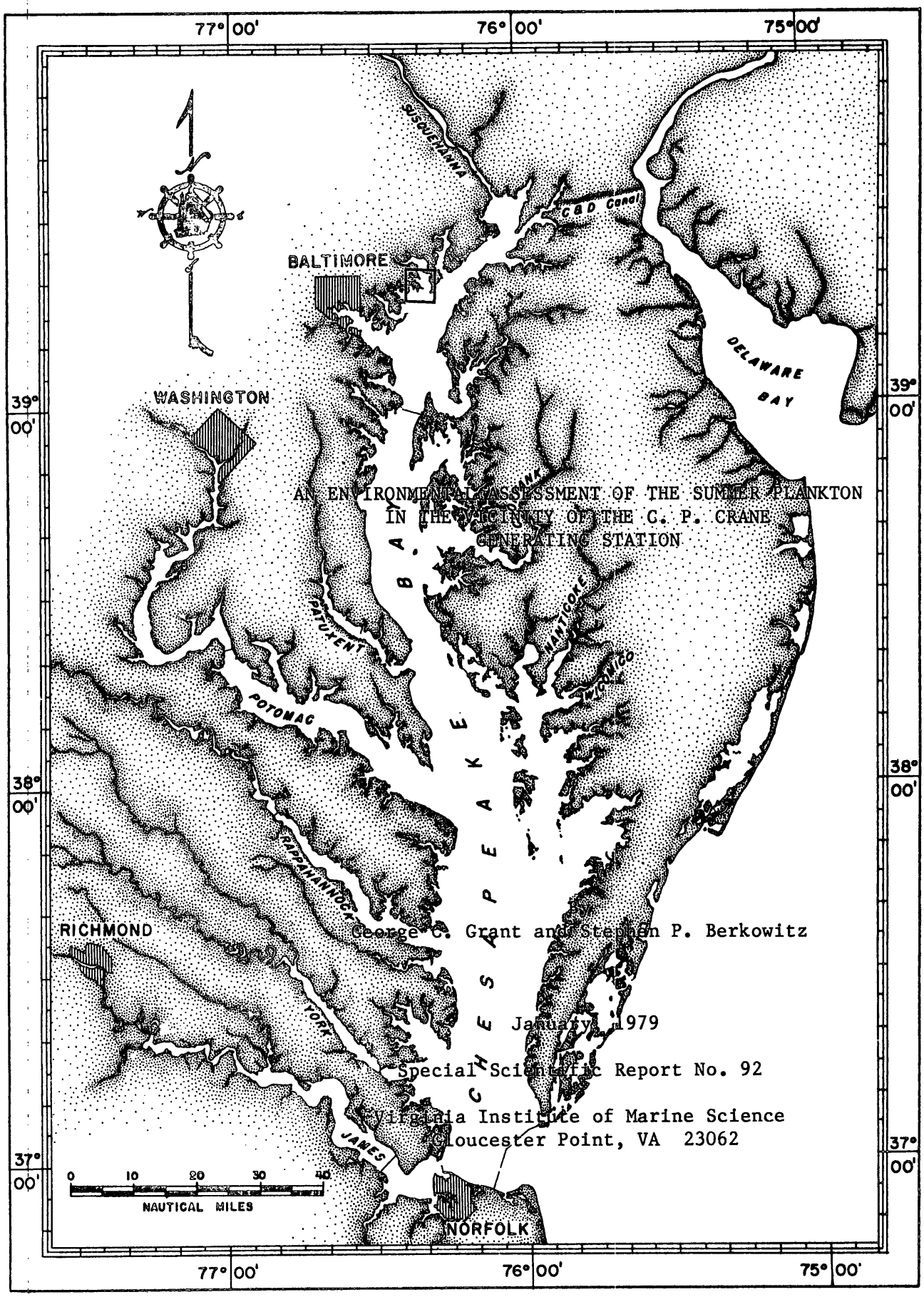

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ABSTRACT

A preliminary survey of summer plankton in waters surrounding the C. P. Crane generating station in Bengies, Maryland, revealed several possible effects of plant operation. These perturbations were separated into apparent small-scale and large-scale effects:

Small-scale effects were limited to the immediate discharge region of Saltpeter Creek and included (1) occasional elevation of temperatures at the surface (in August) to above the lethal limit for most zooplankton and sufficiently high to inhibit photosynthesis, (2) a decrease in chlorophyll-a, seen in July and August, (3) a sharp decrease in productivity, also in July and August, and (4) absence of a common cladoceran in July.

Possible large-scale effects covered most of the sampled area and included (1) a reduction in diversity due to displacement of a natural freshwater community with an oligohaline one that has been altered somewhat by the addition of heat, (2) increased temperature and productivity throughout Saltpeter Creek and the lower Gunpowder River when higher ambient temperatures coincide with peak demand for electric power and (3) an increase in the barnacle population by the provision of submerged power plant structures for settlement of larvae and the distribution of larvae throughout the system via cooling water discharged into Saltpeter Creek.

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1. INTRODUCTION

1.1 Introductory Remarks and a Brief Description of the Study Area

The operation of electric power generating stations produces changes in environmental parameters in the immediate and surrounding regions. The two most obvious and probably most critical influences on aquatic life are the entrainment of organisms and the elevation of water temperatures, both due to the use of adjacent water bodies for cooling purposes. When estuarine waters are utilized, particular attention must be directed toward assessing effects on the biota, as these waters are often important spawning and nursery grounds for ecologically and economically valuable crustaceans and fishes.

Regulations governing the operation of generating stations in Maryland specify that studies be conducted to "determine whether plant cooling water entrainment affects a spawning or nursery area of consequence for Representative Important Species (RIS)", which are specified (State of Maryland, 1978). Since lower trophic levels provide food for the RIS, the primary producers and zooplankton must also be studied for possible plant effects. The regulations also specify that impact be assessed during "critical periods", defined as "that time of the year during which sensitive life stages or densities of RIS are present in the plant intake or receiving waters." If significant adverse impact is demonstrated,

plant modifications may be required to bring harmful effects within acceptable limits, as defined by the regulations.

The C. P. Crane Generating Station is located on an isthmus between Seneca Creek, from which cooling water is drawn, and Saltpeter Creek, which receives the heated discharge. Both creeks empty into the lower Gunpowder River, a tributary of upper Chesapeake Bay. The area is oligohaline in a portion of Chesapeake Bay strongly affected by runoff from the Susquehanna River, the principal source of fresh water for Chesapeake Bay. The study area is generally shallow, with depths of 1-2 meters MLW, except for deeper channels in Seneca Creek and lower Gunpowder River. The C. P. Crane station is an oil-fired plant that circulates about 650 cubic feet of water per second through the cooling system when operating at its peak load of 400 megawatts.

1.2 Other Studies in the Vicinity

No previous studies of the plankton have been conducted at Seneca, Saltpeter and Dundee creeks. In a study of the Bush River, the next embayment up the Chesapeake Bay from the present site, two stations were periodically sampled within the lower Gunpowder River (Johns Hopkins Univ., 1973). The latter study, an investigation of the Perryman site, is most pertinent to our findings, because of ecological similarities between these neighboring subestuaries. A concurrent study of waters around the

C. P. Crane station is also being conducted by Ecological Analysts, Inc. for Baltimore Gas and Electric Company, but results were not available at the time of this report. Physical effects of thermal discharges were examined in July 1978 by Binkerd et al. (1978).

Studies in other areas of the upper Chesapeake Bay include those of the Bay proper (Dovel, 1971a; Whaley and Taylor, 1968), Baltimore Harbor (Dovel, 1971b; Johns Hopkins Univ., 1972), and the Rhode River (Seliger and Loftus, 1974; Allan et al., 1976). The more distant Patuxent River has been well studied (Heinle, 1966, 1969; Herman et al., 1968). Results of these studies are helpful in predicting the approximate qualitative composition of the plankton in the present study site, but lack of pre-operational data at the site renders an assessment of biological impact more difficult.

1.3 Objectives and Limitations of the Present Study

The present study was designed to:

(1) Characterize the summer and early fall mero- and holoplankton of Seneca Creek, Saltpeter Creek and the lower Gunpowder River

(2) Determine whether the C. P. Crane Generating Station demonstrably alters <u>in situ</u> productivity, phytoplankton and zooplankton standing crops, species composition, and reproduction of the dominant copepods.

The sampling was limited to single 2-3 day periods in each of the months July - September; sampling during other months, particularly the critical spring and early summer spawning period is necessary for a more complete assessment. Sampling was conducted on an already altered environment and without benefit of comparable data from years prior to operation of the C. P. Crane generating station; the system's natural state is therefore obscure. Finally, zooplankton sampling was concentrated on collections from pumps and from 18.5 cm bongo nets of 202 µm mesh, all of which were obtained in daylight hours. The more agile forms of zooplankton were, therefore, undersampled.

2. METHODS AND MATERIALS

2.1 The Sampling Scheme

Sampling, in this preliminary survey, was limited to the summer months of July, August and September. Assumptions concerning the distribution of plant effluent were incorporated in a grid of possible sampling sites and division of these into four subareas: A, intake waters of Seneca Creek; B, immediate discharge waters of upper Saltpeter Creek and Dundee Creek; C, far-field discharge waters of lower Saltpeter Creek; and D, the receiving waters of lower Gunpowder River (Fig. 1). The grids of stations (0.1 naut. mi. in subareas A-C and 0.2 naut. mi. in subarea D) were utilized in a random selection of sampling sites each month in the case of phytoplankton measurements. Twelve

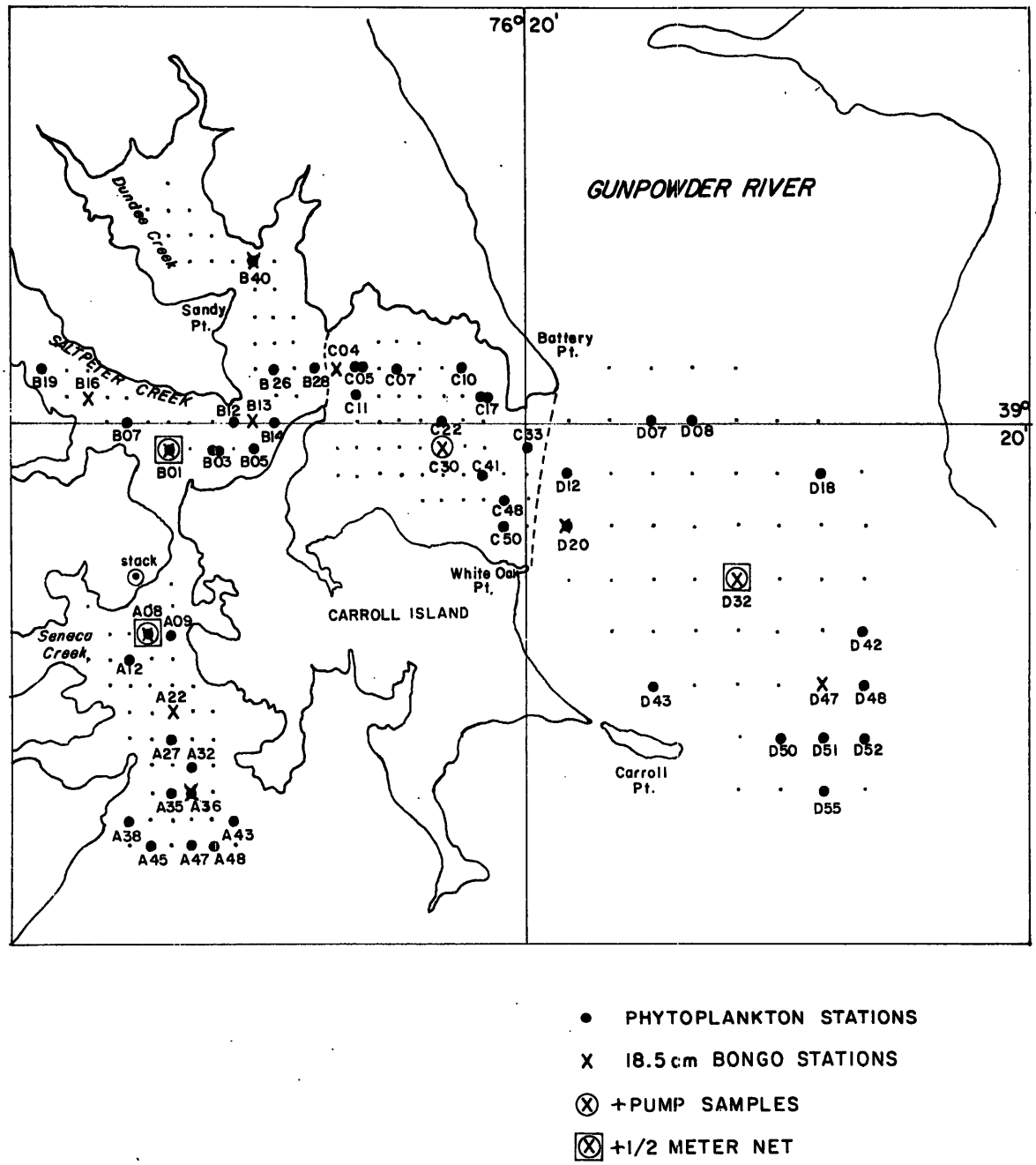

Fig. 1 Location and identity of stations sampled in the vicinity of the C. P. Crane generating station, July - September 1978, for phytoplankton, micro-, meso- and macrozooplankton.

111 filter fluorometer equipped with a red-sensitive photomultiplier (Strickland and Parsons, 1972); 50 ml of water was filtered through a glass fibre filter (Whatman GF/A), which was then frozen on dry ice. After extraction with 90% acetone, and centrifugation to remove the filter and particulate debris, the sample was diluted to 10 ml and the fluorescence read before and after acidification with 2 drops of 2N HCl using the appropriate excitation window. The excitation filter was 430 nm (Filter 5-60) and the emission was > 625 nm (Filter 2-64); calibration was previously made against known dilutions of chlorophyll a extracts using the EPA Method Study 9, Chlorophyll Analyses.

Primary productivity was measured in situ using the light-dark bottle technique (Biological Methods Panel Committee on Oceanography, 1969) after 1.0 μCi of $NaHCO_3$ was added to each of six sub-samples of surface (0.5 m) water in glass tubes; three sub-samples were incubated in the dark and three were incubated in the light at ambient temperature and light intensity at 0.5 m for 2-3 hours, usually between 10:00 A.M. and 3:00 P.M. EDT. The uptake was terminated by the addition of 0.2 ml of borate-buffered formalin. ^{14}C-labeled particulate matter was trapped on Millipore® HA 0.45 μ filters and counted using a 2-5-diphenyloxazole toluene counting solution in a Beckman LS-150 liquid scintillation counter (Pugh, 1973). When necessary, an internal standard was added to determine efficiency and quenching. Computation of productivity (mgC $m^{-3}h^{-1}$) was then completed using

the stock of isotope added and the light, dark and alkalinity values.

Seston was determined gravimetrically using previously washed and tared Millipore® HAWP 04700, 0.45 µ filters (when available).

Phytoplankton were preserved with Lugol's iodine solution and identified and enumerated with an inverted microscope according to the method of Utermöhl (1958).

2.2.2 Microzooplankton

Zooplankton smaller than those forms normally retained in 202 µm mesh nets were sampled by pump (Flotec's Tempest submersible pump Model S1400). Pumping was conducted while in motion in a small outboard motor boat. Samples were integrated over the water column by raising and lowering the pump from near-bottom to near-surface during the operation, and quantified by pumping into carboys of known volume, which were then poured into a partially submerged #20 (76 µm) net to concentrate collected organisms. At each sampling site, three replicate samples of 0.1 m^3 each were obtained and preserved in 5% formalin.

Preserved samples were stained with rose bengal to aid in sorting and identification of collected organisms in the laboratory. Most counts were performed at 45-60X and identifications at 100-1000X under a dissecting microscope. Separate counts were made of the naupliar, copepodid and adult

stages of the dominant copepods. The identification of collected cyclopoid copepods as Eucyclops agilis was confirmed from scanning electron microscope (SEM) photographs of the 5th legs.

2.2.3 Mesozooplankton

This size range of zooplankton has been defined (BMPCO, 1969) as those organisms retained in netting constructed of 202 µm mesh. This mesh size retains the adults and later copepodid stages of most dominant estuarine copepods (e.g. Acartia tonsa). It is too coarse for quantitative sampling of nauplii and the early copepodids of dominants, as well as certain small species such as Paracalanus crassirostris and Oithona spp., yet may frequently become clogged with phytoplankton when towed through blooms. Any choice of mesh size is a compromise of net efficiency (a function of open mesh area and mouth opening) and the size range and agility of targeted organisms (Jacobs and Grant, 1978). The present choice of 202 µm mesh nets was based on BMPCO (1969) recommendations and past experience in Chesapeake Bay. Nets were mounted on bongo sampler frames with mouth openings of 18.5 cm and towed obliquely through the water column at each of 12 fixed stations each month. The volume of water sampled during each tow was calculated from the number of revolutions registered on a General Oceanics, Inc. flowmeter mounted in the mouth of the collection net.

Collections, preserved in 5% formalin, were initially

measured for displacement volume (Kramer, 1972), then sorted under dark-field microscopes (Olympus JM-100) into major categories such as copepods, barnacle larvae and decapod larvae, with the size of aliquot examined dependent upon the abundance and relative size of the sorted category. Larger and rarer organisms were sorted from whole samples; successively smaller aliquots were sorted for the smaller, more abundant taxa. Identification of sorted organisms was carried out to species wherever possible and resulting counts (total sample counts) were entered on data cards, one for each species occurrence.

2.2.4 Macrozooplankton

The small-mouthed 18.5 cm bongo sampler is inefficient in the capture of larger or more agile zooplankton. A limited amount of sampling (3 replicated tows) was conducted each month, using a 1/2-meter net of 505 µm mesh, to assess the presence and abundance of the larger (macro-) zooplankton. Ring nets were used despite the higher efficiency of bongo samplers because of our inability to tow 60 cm bongos from a small outboard motor boat. Most estuarine copepods and other mesozooplankton, typically smaller than marine forms, easily pass through a net of 505 µm mesh. Resulting collections were, therefore, of low displacement volume and largely limited to certain taxa.

2.3 Data Processing

2.3.1 Phytoplankton and Ancillary Data

Phytoplankton productivity, biomass and certain of the

ancillary data (temperature, salinity, dissolved oxygen, phaeopigments) were examined with a canonical discriminant function analysis (Nie et al., 1975) to quantify and identify differences between subareas in these parameters.

2.3.2 Microzooplankton

Pumped microzooplankton collections were compared by month and subarea, again with a discriminant function analysis. The stepwise addition of variables provided a list of species (or life stages of a given species in the case of dominant copepods) contributing most to the separation of respective blocks of data (grouped by months and subarea).

2.3.3 The Larger Zooplankton

Collections taken with the 18.5 cm bongo (202 μm mesh nets) were compared with cluster analyses, both normal and inverse, without regard to pre-selected sampling strata. The analyses, based on matrices of the quantitative Bray-Curtis coefficient, employed transformed [log (x+1)] counts of identified taxa per 100 m^3 of water sampled. The normal analysis clustered samples (stations) according to similarity in species composition and abundance; the inverse analysis clustered species according to similarity in distribution among the stations (see Boesch, 1977; Grant, 1977, 1978). A flexible ($\beta = -0.25$) clustering strategy was used to avoid excessive "chaining" (Williams, 1971).

The 18.5 cm bongo collections were also used as the data set for calculations of diversity. Standard equations for calculations of H', the Shannon-Wiener index of diversity, and J', evenness, were used in computer programs (Pielou, 1975). Margalef's index of species richness was also calculated for each collection:

$$d = S-1/\log_e N$$

where S is the number of species in a collection and $\log_e N$ is the natural log of the total number of individuals in a collection (Margalef, 1961).

3. PHYTOPLANKTON BIOMASS, PRODUCTIVITY AND ANCILLARY MEASUREMENTS

Data from the 16 phytoplankton stations sampled each month, including surface light and secchi disc readings, temperature, salinity, dissolved oxygen, seston, chlorophyll-a, phaeopigments, alkalinity and productivity, are included in the Appendix to this report in Table A-1.

3.1 Physical Measurements

Salinity at the study site increased slightly during the three months of investigation, with ranges of 0.63-1.66 °/oo in July, 1.85-2.40 °/oo in August, and 1.99-3.51 °/oo in September. The entire study area was oligohaline during summer 1978, but northern portions (Dundee Creek and Gunpowder River) quite likely

are fresh during winter and spring periods of higher runoff. Lowest salinities occurred in upper "D" stations of the Gunpowder River in both July and August, with salt content of the discharge creeks Saltpeter and Dundee apparently governed largely by plant transfer of cooling waters from Seneca Creek (Binkerd et al., 1978). However, this apparent pattern was altered in September, when Dundee Creek appeared to be the primary source of fresh water for lower Saltpeter Creek. This could also have been a tidal effect, as early morning tides during both July and August sampling periods were at the late ebb stage but at slack low or early flood in September.

Highest temperatures occurred at the surface at stations closest to the plant discharge, although equally high temperatures were recorded at upper "D" stations in September. Ranges were 25.0-32.4°C in July, 28.6-33.4°C in August and 21.6-26.0°C in September. Although determination of the Δt due to passage of water through the plant is difficult because of leakage of discharge back into Seneca Creek via the "hole in the wall", differences between average Seneca Creek temperatures and maximum recorded temperatures on the discharge side were approximately 5°C in July, 3.5°C in August and 2.5°C in September.

Whereas all phytoplankton stations were occupied within a few hours of mid-day, oxygen levels were consistently high, with no evidence of reduction to a point where stress in estuarine animals

might be expected. Diurnal, or at least dawn and dusk, measurements of oxygen content are still needed to determine whether temperature elevation and oxygen reduction interact in impacting the natural system.

Light penetration was low throughout the July-September study period, with Secchi disc readings averaging close to 0.6 meter in all three months. The disc disappeared in only 0.2 meter at one July station; greatest depths of visibility were 1.0 and 1.25 meters at two stations, all others falling below 1 meter. A rough inverse relationship between turbidity, measured as seston in mg/l and Secchi disc depth is shown in Fig. 2 for the months of July and September. August measurements of seston were invalid due to a change in filter type and an excessive reduction in sample size. A large reduction in turbidity from July to September did not result in a corresponding sharp increase in water transparency, although data points from July sampling do indicate an inverse relationship between the parameters. Lower than expected Secchi readings in September may have been related to the generally lower incident radiation occurring over the study area in that time period (Table A-1).

3.2 Phytoplankton Biomass

Phytoplankton standing crop was estimated by measurement of chlorophyll-a and its decomposition products, the phaeopigments (B.M.P.C.O., 1969). Resulting measurements are shown in the

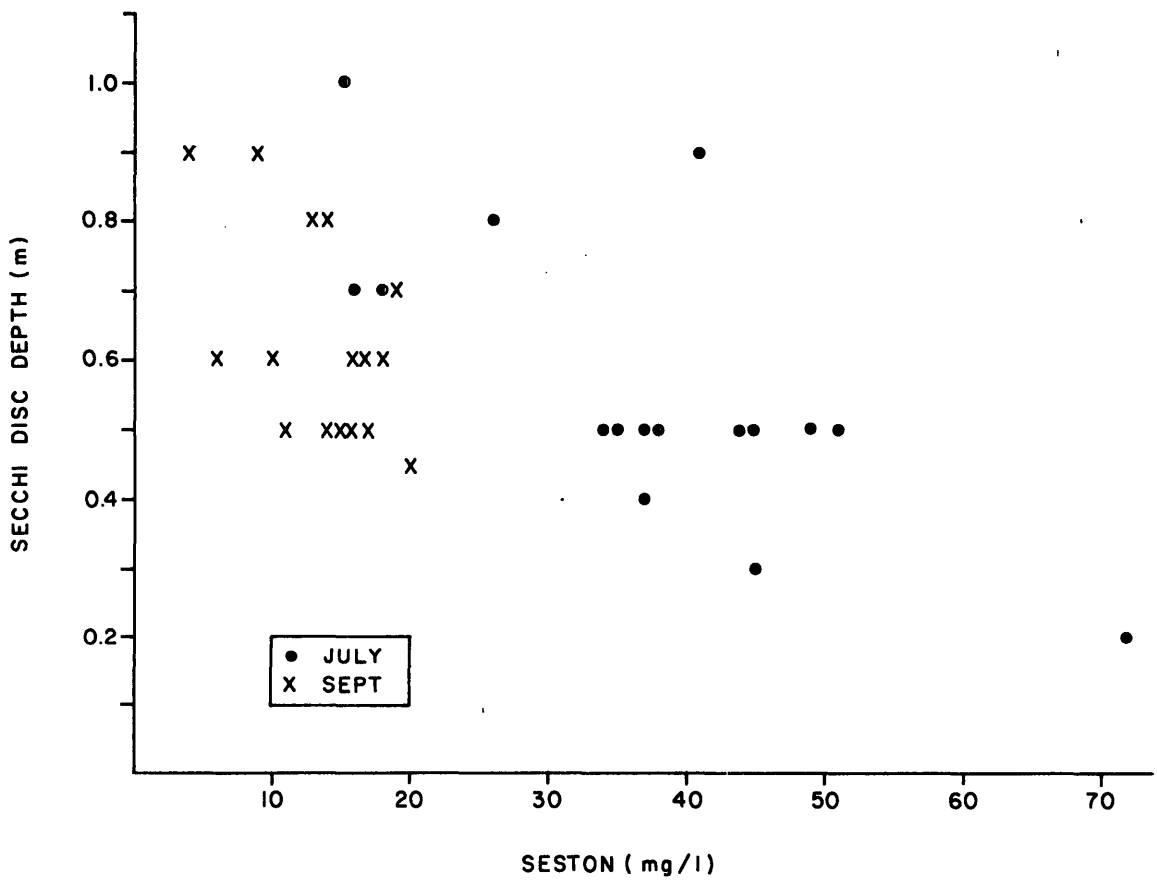

Fig. 2 Relationship of water transparency (Secchi disc depths) and turbidity near the C. P. Crane generating station in July and September 1978.

bottom halves of Figs. 3-5, where stations have been aligned according to their position relative to the plant location.

The amount of phaeopigment was fairly constant (4-8 µg/l) at all July stations, while chlorophyll-a decreased from over 18 µg/l at the mouth of Seneca Creek to a minimum of 7 µg/l in the immediate discharge (station B01), fluctuated around an intermediate concentration in near- and far-field discharge waters of Saltpeter and Dundee creeks, then rose to a maximum of over 23 µg/l in the lower Gunpowder River. Because phaeopigments remained at relatively constant levels, changes in the chlorophyll-a/ phaeopigment ratio closely mirrored measurements of chlorophyll-a.

Phaeopigments in August increased slightly to concentrations of about 6-9 µg/l. Concentrations were similar at all stations except C17 where they increased to nearly 11 µg/l. The lowest value was recorded at station C33 and this station and station C17 represented the only two deviations in similarity of trends in measurements of chlorophyll-a and chlorophyll-a/phaeopigment ratios. Chlorophyll-a reached a peak of over 32 µg/l at the head of Seneca Creek, near the plant intake, then decreased to the low of < 10 µg/l in the immediate discharge. Chlorophyll-a then increased to nearly 20 µg/l in nearby stations in upper Saltpeter Creek, decreasing to nearly constant levels of 11 µg/l in lower Saltpeter Creek and Gunpowder River.

Phytoplankton biomass was considerably reduced in September

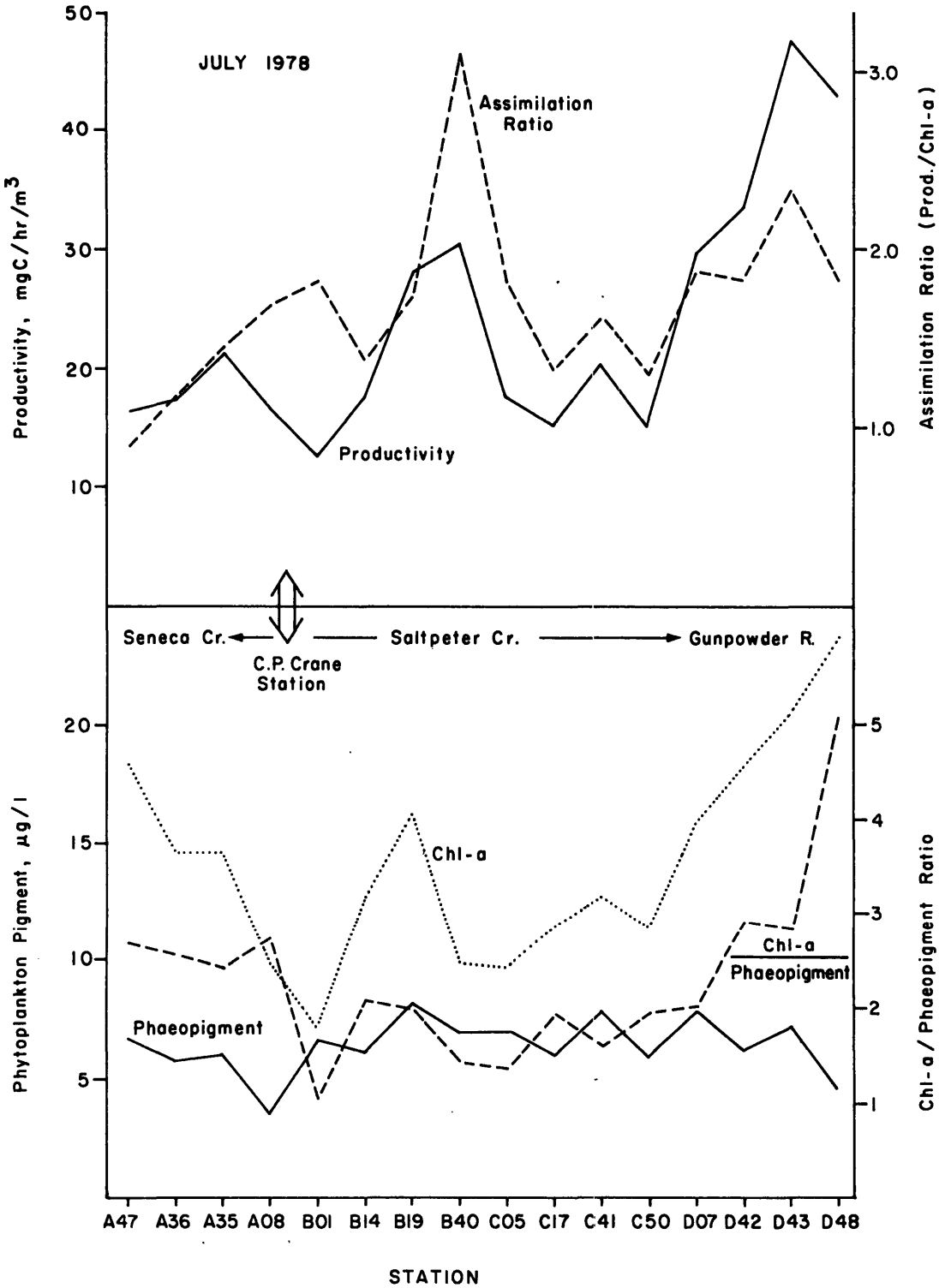

Fig. 3 Distribution of chlorophyll, phaeopigments, productivity and their associated ratios, July 1978. Stations aligned according to position relative to plant location.

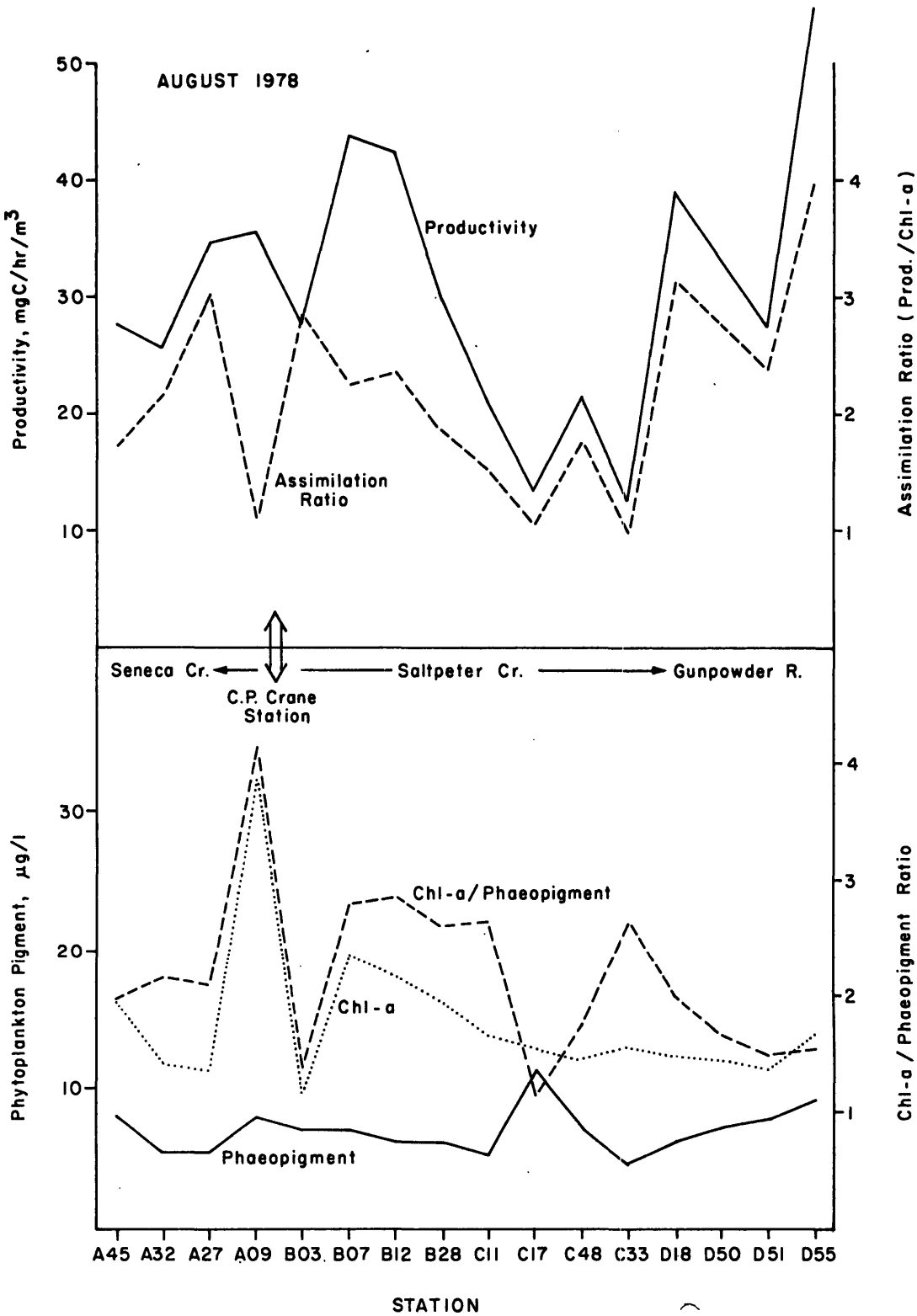

Fig. 4 Distribution of chlorophyll, phaeopigments, productivity and their associated ratios, August 1978. Stations aligned according to position relative to plant location.

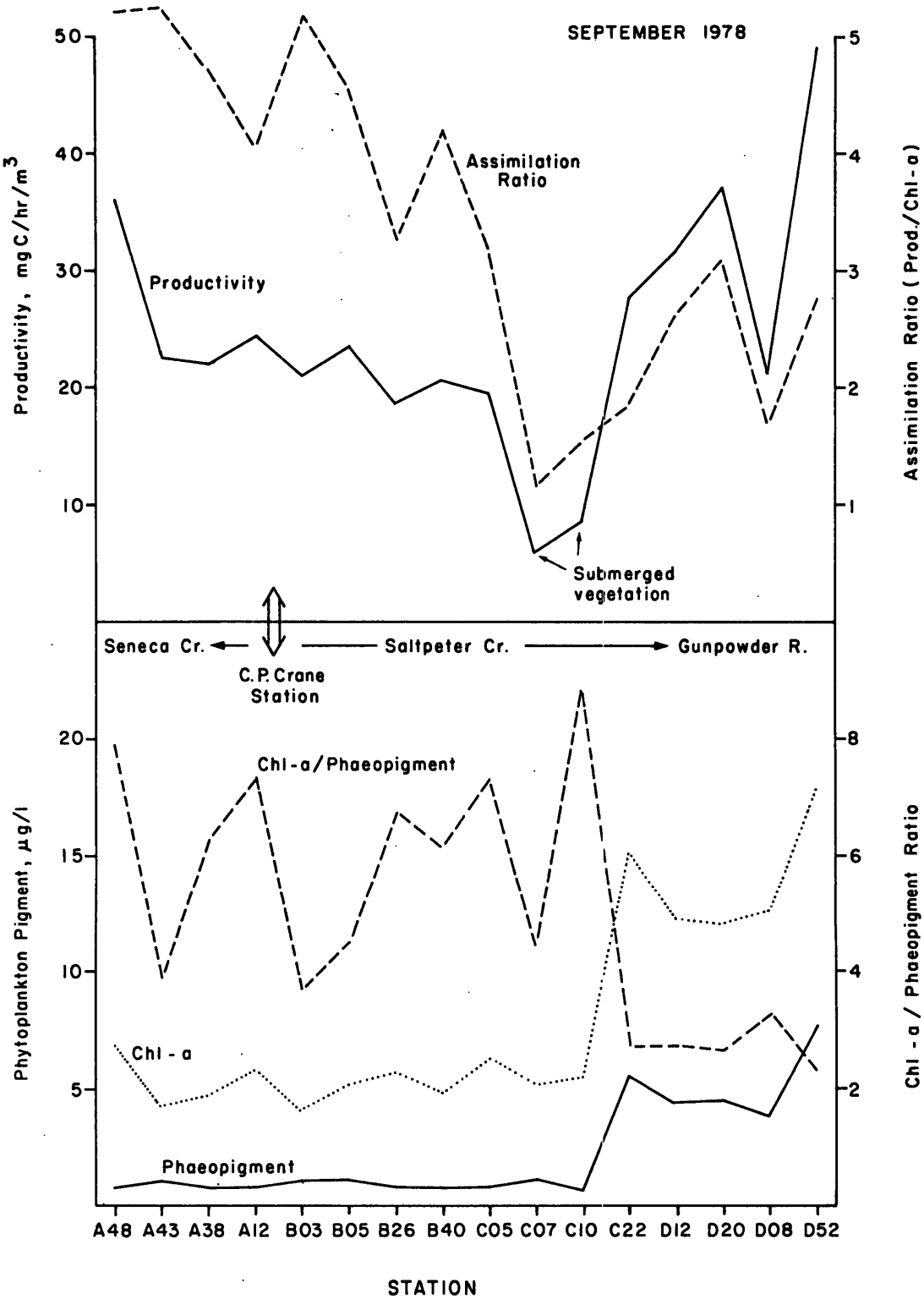

Fig. 5 Distribution of chlorophyll, phaeopigments, productivity and their associated ratios, September 1978. Stations aligned according to position relative to plant location.

compared with July and August, except at the mouth of Saltpeter Creek and in the lower Gunpowder River. Both phaeopigment and chlorophyll-a were fairly constant (0.6-1.2 µg/l and 4-7 µg/l, respectively) throughout Seneca and Saltpeter creeks. Wide fluctuations in the generally high chlorophyll-a/phaeopigment ratio in this portion of the system resulted from small fluctuations in its components. A sharp increase in chlorophyll-a occurred at the mouth of Saltpeter Creek (station C22), with measurements from there to the mouth of Gunpowder River ranging from 12-18 µg/l chlorophyll-a and 4-8 µg/l phaeopigments. The ratio of these two measurements decreased to about 3 at the latter stations.

3.3 Phytoplankton Productivity

Productivity (upper portions of Figs. 3-5) roughly corresponded to levels of chlorophyll in July, i.e. with a minimum in the immediate discharge (station B01), a secondary maximum in upper Saltpeter Creek and highest levels in Gunpowder River. Trends in the assimilation ratio were similar to those of productivity except at the immediate intake and discharge stations. Productivity was similar at Seneca and lower Saltpeter Creek stations (15-21 mgC/hr/m^3), increased from a low of 13 at station B01 to over 30 mgC/hr/m^3 at the mouth of Dundee Creek in subarea B, and attained a maximum rate of 47.7 mgC/hr/m^3 in the lower Gunpowder River.

Trends in productivity also followed those of chlorophyll-a in August through the intake and near-discharge subareas, but productivity increased sharply in the Gunpowder River while chlorophyll remained uniformly low. The assimilation ratio again followed productivity except in the immediate vicinity of the plant (stations A09 and B03). Productivity estimates ranged from 11 in lower Saltpeter Creek to over 55 mgC/hr/m^3 at the mouth of Gunpowder River.

In September, productivity patterns were similar to those of chlorophyll except at stations C07 and C10 where submerged vegetation apparently shaded the suspended incubation vials. Assimilation ratios were much higher in intake and near-discharge areas than in previous months, so that the reversal in trends between this ratio and productivity near the plant is less evident in Fig. 5, but occurred at stations A12, B03 and B05. Productivity declined from 36 at the mouth of Seneca Creek to about 20 mgC/hr/m^3 at the juncture of Saltpeter and Dundee creeks. There was no sharp decrease in productivity at the immediate discharge. A maximum rate of nearly 49 mgC/hr/m^3 was measured at the mouth of the Gunpowder River.

In the presence of elevated temperatures, the productivity of a phytoplankton population may be expected to increase, providing temperatures are not so high as to inhibit photosynthesis (Nugent, 1970; McKellar, 1977). Depression of productivity at the

immediate discharge of the C. P. Crane plant, followed by increased productivity in receiving waters fits this pattern of inhibition and stimulation.

3.4 Phytoplankton Taxonomy

A limited number (12) of surface water samples were preserved for a taxonomic characterization of the surface phytoplankton community. The results (Table 1) show the oligohaline nature of the environment by an abundance of chlorophytes, presence of many blue-greens and a general shift in dominance through the summer from diatoms to blue-greens or microflagellates.

Attempts to relate species composition and abundance to observations on phytoplankton biomass and productivity are limited by the lack of replication in sampling, but include the following:

July - an abundance of green algae and Skeletonema costatum appears to have contributed most to the relatively high measures of chlorophyll and productivity at station D48,

August - a peak of chlorophyll at station A09 coincides with an abundance of green algae and high productivity at stations A09 and D51 with green algae and Cryptomonas,

September - maximum productivity and chlorophyll found at station D52 is not reflected in cell counts at that location.

Table 1. Species and cell counts per ml of phytoplankton (filaments or colonies counted where indicated) from waters in the vicinity of the C. P. Crane generating station, July - September 1978.

Taxa / Stations:	July				August				September			
	A08	B01	C41	D48	A09	B03	C48	D51	A12	B03	C22	D52
Cyanophyta												
*Anabaena sp.					207							
†Chroococcus sp.					2482	3930	1758					
*Cylindrospermum minimum									155	26	824	206
†Gomphosphaeria sp.		104						414				309
†Merismopedia elegans				26							26	
†M. tenuissima	827		414	103	26	103	310	26			26	309
*Oscillatoria angustissima							517			1034	20687	1655
*Spirulina sp.					26	52	103				612	106
Chlorophyta												
Ankistrodesmus falcatus				103	517	78	414	129	207		206	103
Crucigenia sp.						414						
Crucigenia tetrapedia					1448		414	414				
C. truncata					26							
Oocystis sp.								414				52
Scenedesmus acuminatus				414								
S. arcuata				207								
S. bijuga				207								
S. quadricauda				828								
Selenastrum sp.								207				206
Tetraedron minimum						52						
Tetrastrum sp.				414				517				103
Euglenophyta												
Phacus					207		129					
Bacillariophyta												
Centric												
Cyclotella sp.	103	26		26	103	26		26			103	106
Leptocylindrus danicus		104										
Melosira sulcata		52		103								
Rhizosolenia sp.										1138	325	721
Skeletonema costatum	1861	721	515	4136				2482		234		
Thalassiosira pseudonana	827	1551	1344	931				620	1034		1344	309
Pennate												
Navicula sp.	26							26				
Nitzschia sp.	52					103		103	78			
N. kutzinguiana	103								129	310		
N. longissima									26		26	26
Pleurosigma sp.										26	130	26
Cocconeis sp.									26			
Cryptophyceae												
Cryptomonas erosa	517	103			514			724	1034	1551	1344	
Dinophyceae												
Diplopsalis lenticula								26				
Peridinium sp.	414		310							103	78	
Prorocentrum minimum									310			26
Katodinium rotundatum									620			
Microflagellates	1655				931	310	517	3102	3102	3412	3090	515

†Colonies *Filaments

3.5 Subarea Differences in Phytoplankton and Ancillary Measurements

Data obtained from the 16 phytoplankton stations each month were entered into a canonical discriminant function analysis to determine the relative contribution of six variables (temperature, salinity, dissolved oxygen, chlorophyll-a, phaeopigments and productivity) to differences among subareas A-D. Results are presented in the form of summary statistics (Tables 2, 3 and 4) and as territorial maps of the first two discriminant functions with group centroids and discriminant scores for each station (Fig. 6).

Statistics in Tables 2-4 include those needed to show the number of functions required to clearly separate the groups (subareas). These are the eigenvalues and their associated canonical correlations found in the upper left side of the tables. The upper right side of the tables contain values for Wilks' lambda and X^2 significance as information is successively removed in discriminant functions. The larger the lambda, the less the discriminating power left, so Wilks' lambda is seen to increase as functions are added.

The left center of Tables 2-4 contains standardized discriminant function coefficients. These have been derived, in the SPSS program (Nie et al., 1975), in such a way that discriminant scores produced by multiplying these coefficients

with each discriminating variable and summing results over all stations will produce a score for each function with a mean of zero and a standard deviation of one. Therefore, absolute values of the coefficients are a measure of the relative importance of the variables within a function. Group centroids at the right center of these tables are simply averages of scores for all stations within subareas, and classification results at the bottom of the tables show the success of the calculated functions in correct placing of stations within subareas.

3.5.1 July 1978 Subarea Differences

Two functions based on all six of the entered variables were sufficient to account for over 96% of the variance. The third function did not contribute further to separation of the subareas (Table 2). Variables with the largest weights (absolute values of coefficients) in the first two functions were salinity and dissolved oxygen, respectively. Differences between subareas (indicated in Fig. 6 by solid lines for $p < 0.01$ and dashed lines for $p < 0.05$) were highly significant for all pairs of subareas that included subarea D (lower Gunpowder River), significant for the pairs A-B and A-C, but not significant for B and C subareas, where station scores showed considerable overlap and group centroids were closely spaced. Despite this overlap, all of the stations were correctly classified in this analysis (bottom of Table 2).

Table 2. Summary statistics from canonical discriminant function analysis of July 1978 phytoplankton and ancillary data.

Discriminant Function	Eigenvalue	Cumulative % of Variance	Canonical Correlation
1	17.83350	79.77	0.9731
2	3.77645	96.66	0.8892
3	0.74640	100.00	0.6538

After Function	Wilk's Lambda	Chi-Square	d.f.	Significance
0	0.0064	50.57	18	0.0001**
1	0.1199	21.21	10	0.0197*
2	0.5726	5.58	4	0.2332 ns

Standardized Discriminant Function Coefficients

	1	2
Temperature	0.84862	0.00207
Salinity	-1.39838	-0.18616
DO_2	-0.25232	-0.86950
Chlorophyll	0.92170	-0.12880
Phaeopigments	-1.02666	0.22188
Productivity	0.42428	-0.13908

Group Centroids

Subarea	Function 1	Function 2
A	-4.19517	-2.18288
B	-0.63057	1.47196
C	-1.04109	1.79508
D	5.86682	-1.08416

Classification Results

Actual Group	Number of Stations	Predicted Group Membership (%) A	B	C	D
Subarea A	4	100.0	0.0	0.0	0.0
Subarea B	4	0.0	100.0	0.0	0.0
Subarea C	4	0.0	0.0	100.0	0.0
Subarea D	4	0.0	0.0	0.0	100.0

* - $p \leq 0.05$
** - $p \leq 0.01$
ns - not significant, $p > 0.05$

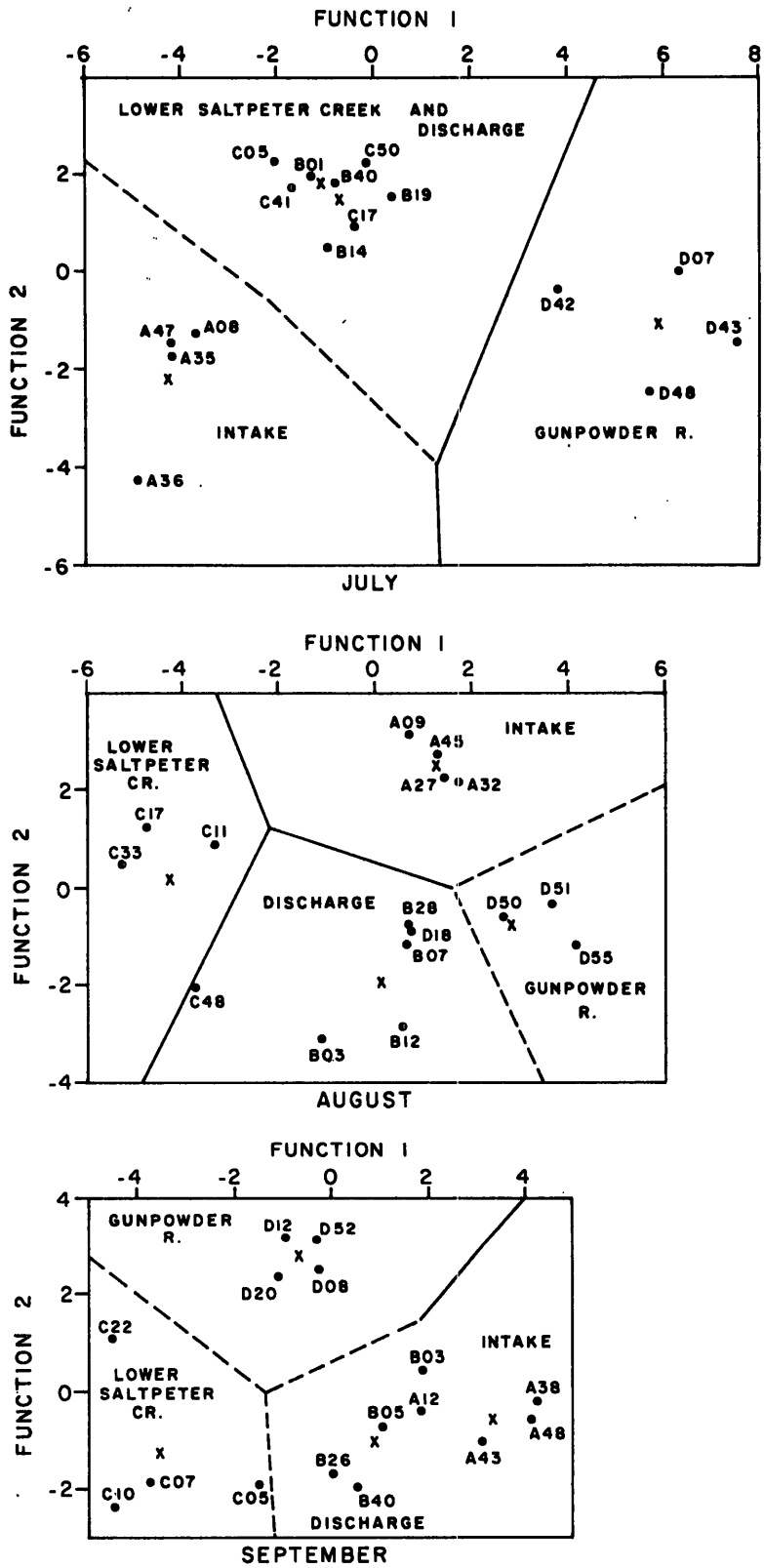

Fig. 6 Territorial map, subarea centroids (x) and discriminant scores (·) for each phytoplankton station, based on the first two discriminant functions of July, August and September data.

The highest correlations evident in July 1978 data were:

(1) -0.583 between phaeopigments and salinity ($p < 0.05$)

(2) -0.582 between productivity and temperature ($p < 0.05$)

(3) 0.506 between productivity and chlorophyll ($p < 0.05$)

Phaeopigment concentrations > 7.0 µg/l all occurred in salinities lower than 1.3 °/oo in subareas B, C and D. Concentrations < 7.0 µg/l were found in salinities higher than 1.0 °/oo and including half the stations in subareas B, C and D, and all of the subarea A (intake) stations. The negative correlation of productivity and temperature resulted primarily from the maximum temperature and minimum productivity measured at the immediate discharge and high productivity found in the lower temperatures of Gunpowder River.

A positive correlation between chlorophyll and productivity again showed extremes of relationships between low values at station B01 and highs in the lower Gunpowder River.

3.5.2 August 1978 Subarea Differences

The phytopigment variables, chlorophyll and phaeopigment, were dropped in the analysis of August data, as they were found not to increase separation of subarea centroids. In this analysis, the first two functions accounted for nearly 92% of the total variance (Table 3). Although contribution of the third function was still significant ($p = 0.0149$), it has been excluded from Fig. 6 for the sake of keeping a two-dimensional presentation

Table 3. Summary statistics from canonical discriminant function analysis of August 1978 phytoplankton and ancillary data.

Discriminant Function	Eigenvalue	Cumulative % of Variance	Canonical Correlation	After Function	Wilk's Lambda	Chi-Square	d.f.	Significance
				0	0.0096	51.06	12	0.0000**
1	9.24151	65.52	0.9499	1	0.0987	25.47	6	0.0003**
2	3.71498	91.86	0.8876	2	0.4654	8.41	2	0.0149*
3	1.14864	100.00	0.7312					

Standardized Discriminant Function Coefficients

	1	2
Temperature	-1.46207	-0.70358
Salinity	1.60469	0.55960
DO_2	-0.68203	0.80828
Productivity	0.39622	-0.44014

Group Centroids

Subarea	Function 1	Function 2
A	1.29817	2.56563
B	0.16880	-1.97996
C	-4.26440	0.19231
D	2.79744	-0.77798

Classification Results

Actual Group	Number of Stations	Predicted Group Membership (%) A	B	C	D
Subarea A	4	100.0	0.0	0.0	0.0
Subarea B	4	0.0	75.0	0.0	25.0
Subarea C	4	0.0	0.0	100.0	0.0
Subarea D	4	0.0	0.0	0.0	100.0

* - $p \leq 0.05$
** - $p \leq 0.01$

of results. As in July, the variables with largest weights in the first two functions were, respectively, salinity and dissolved oxygen. Differences between pairs of subareas were either highly significant ($p < 0.01$) or, in the case of pairs A-D and B-D, significant at the level of $p < 0.05$. All but one of the 16 stations were correctly classified by the analysis: Station B28 was placed in subarea D in this classification. This station had the lowest salinity and temperature in its group, more nearly matching those of subarea D. Since both of these parameters had high weights in the first function, the result was predicted membership of that station in the D subarea.

Correlated variables in the August set of data included:

(1) 0.801 between temperature and salinity, a result of relatively sharp gradients in both these measurements from the plant discharge through subareas B and C to the lower Gunpowder River

(2) 0.534 between chlorophyll and dissolved oxygen ($p < 0.05$), and

(3) 0.407 between chlorophyll and productivity ($p > 0.05$, not significant).

Lowest measurements of dissolved oxygen and chlorophyll were recorded at the immediate discharge (station B03), highest measurements at the intake station A09. The relationship of productivity and chlorophyll was less evident, as reflected in

their lower correlation.

3.5.3 September 1978 Subarea Differences

The first two functions from September data accounted for 98% of the total variance, with phaeopigment deleted as not contributing to further discrimination among subareas. The third function was not significant ($p = 0.5135$, Table 4). Variables with largest weights in the first two functions were productivity and chlorophyll, respectively. Differences between subareas A (intake) and B (discharge), were insignificant. Differences between all other pairs of subareas were significant ($p \leq .05$; B-C, B-D, C-D) or highly significant ($p \leq .01$; A-C, A-D).

All but one of the stations were correctly classified by the analysis (station A12, nearest the plant intake was placed among discharge stations). The slightly higher temperature and lower salinity at this station, compared with other stations in Seneca Creek, may have resulted from recycling of discharge waters through the plant's "hole in the wall" and contributed to the station's predicted membership in the discharge group of stations, and to the lack of discrimination between subareas A and B.

Highest correlations between variables in September included:

(1) 0.937 between chlorophyll and phaeopigment ($p < 0.01$)

(2) 0.762 between chlorophyll and productivity ($p < 0.01$)

(3) 0.752 between phaeopigment and productivity ($p < 0.01$)

The latter can only be considered a result of the high correlation

Table 4. Summary statistics from canonical discriminant function analysis of September 1978 phytoplankton and ancillary data.

Discriminant Function	Eigenvalue	Cumulative % of Variance	Canonical Correlation	After Function	Wilk's Lambda	Chi-Square	d.f.	Significance
				0	0.0190	41.64	15	0.0003**
1	8.35036	68.85	0.9450	1	0.1772	18.17	8	0.0200*
2	3.53421	97.99	0.8829	2	0.8037	2.29	3	0.5135 ns
3	0.24429	100.00	0.4431					

Standardized Discriminant Function Coefficients

	1	2
Temperature	0.89393	0.54181
Salinity	0.70288	0.31267
DO_2	-0.74269	-0.23534
Chlorophyll	-1.29443	1.22548
Productivity	1.68816	-0.47741

Group Centroids

Subarea	Function 1	Function 2
A	3.34478	-0.54085
B	0.87581	-0.97578
C	-3.55766	-1.26750
D	-0.66293	2.78413

Classification Results

Actual Group	Number of Stations	Predicted Group Membership (%) A	B	C	D
Subarea A	4	75.0	25.0	0.0	0.0
Subarea B	4	0.0	100.0	0.0	0.0
Subarea C	4	0.0	0.0	100.0	0.0
Subarea D	4	0.0	0.0	0.0	100.0

* - $p \leq 0.05$
** - $p \leq 0.01$
ns - not significant, $p > 0.05$

between chlorophyll and phaeopigment. Phytopigments (an estimate of biomass) varied from lower values in subareas A and B to highest values in the lower Saltpeter Creek and Gunpowder River. Productivity was similarly distributed except for two abnormally low rates in lower Saltpeter Creek in the presence of interfering submerged vegetation.

4. MICROZOOPLANKTON

Four stations (A08, B01, C30 and D32) were sampled each month by pump for microzooplankton. Resulting identifications and counts may be found in Table A2 of the Appendix. Dominants included developmental stages of Acartia tonsa and Eurytemora affinis in all July collections except those from the near-discharge (station B01) where the cladoceran Moina micrura was the dominant. A. tonsa and E. affinis predominated in all August collections, although barnacle larvae had increased in importance. Barnacle nauplii were dominant in September at the plant discharge, while collections at the remaining three locations were again dominated by A. tonsa and E. affinis. The number of species found in any individual collection varied from 6-13 in July, 3-8 in August and 3-10 in September.

Molluscs, the rotifer Brachionus calyciflorus, and unidentified insects occurred only sporadically, while the Cladocera, the identified copepods and barnacle larvae were frequent and generally abundant. The cladocerans, all of which are only slightly tolerant of salinity, were distributed in greatest diversity and abundance in

stations of lowest salinity. Possible plant effects in this group were limited, in this set of data, to the absence of Diaphanosoma sp. at the discharge in July. Nauplii of Acartia tonsa were proportionally reduced at the discharge in July, but not in other months. The many hard surfaces added to an ecosystem by the addition of structures in power plants provide a favorable environment for barnacles. The Crane plant, as a result of such an increase in adult barnacles, increases the natural density of barnacle larvae, evident in the relatively large catches at station B01 in August and September.

Data from pumped samples of microzooplankton were submitted to a computer program for discriminant function analysis (SPSS), grouped initially by month of collection and station. Input data included transformed counts per 0.1 m^3 for stages of development in the case of Acartia tonsa, Eurytemora affinis (nauplii, copepodids, adults) and barnacle larvae (nauplii and cyprids), and for species or higher taxa for all other elements in the collections.

The number of taxa (variables) in these collections exceeded the number that could be included in a stepwise analysis, so the significance of variables was first determined for each month by running a direct analysis. The seven taxa having the lowest Wilk's lambda were then analyzed in a stepwise manner (7 was the maximum number that could be treated in a stepwise analysis with the number of groups and replicates existing in our microzooplankton data).

4.1 July 1978 Subarea Differences

The first two functions, based on the six variables retained in the analysis (Acartia tonsa nauplii, Eurytemora affinis copepodids and adults, Diaphanosoma sp., Moina micrura amd Scottolana canadensis) accounted for nearly all of the variance. The first function alone accounted for over 99% of the variance (Table 5). Highest coefficients were for Diaphanosoma sp. in the first function: these were absent in the discharge station B01 and increased in the order shown in Fig. 7 at stations A08, C30, and D32. Separation of the latter two stations was aided by the second function in which Moina micrura held the largest coefficient. All of the replicates were correctly classified by station, and differences among stations were all highly significant ($p < 0.01$).

4.2 August 1978 Subarea Differences

The first two functions, based on the six variables retained in the analysis (Table 6), accounted for over 97% of the variance. The third function was still significant ($p = 0.0210$). Highest coefficients in the first two functions were those for chydorids and Acartia tonsa nauplii, respectively. Chydorids were actually absent at the A, B and D stations as were Eucyclops agilis, another species with a high coefficient in the first function. The distribution of stations along the axis of the first function (Fig. 7, August) is closer to the observed abundance of Eurytemora

Table 5. Summary statistics from canonical discriminant function analysis of July 1978 microzooplankton collections.

Discriminant Function	Eigenvalue	Cumulative % of Variance	Canonical Correlation
1	20,782.96134	99.28	0.99998
2	149.13113	99.99	0.9967
3	2.24447	100.00	0.8317

After Function	Wilk's Lambda	Chi-Square	d.f.	Significance
0	0.0000	96.78	18	0.0000**
1	0.0021	37.13	10	0.0001**
2	0.3082	7.06	4	0.1327 ns

Standardized Discriminant Function Coefficients

	1	2
A. tonsa nauplii	3.82598	1.09093
E. affinis adults	-9.28736	-0.05302
Diaphanosoma sp.	11.86043	-1.01322
E. affinis copepodids	4.28717	-1.80721
Moina micrura	8.99292	-1.91302
Scottolana canadensis	4.70737	0.03073

Group Centroids

Station	Function 1	Function 2
A08	3.42315	6.92118
B01	-193.25760	-2.61004
C30	90.31010	10.76118
D32	99.52435	-15.07192

Classification Results

Actual Station	Number of Replicates	Predicted Station Membership (%) A08	B01	C30	D32
A08	3	100.0	0.0	0.0	0.0
B01	3	0.0	100.0	0.0	0.0
C30	3	0.0	0.0	100.0	0.0
D32	3	0.0	0.0	0.0	100.0

** - $p \leq 0.01$
ns - not significant, $p > 0.05$

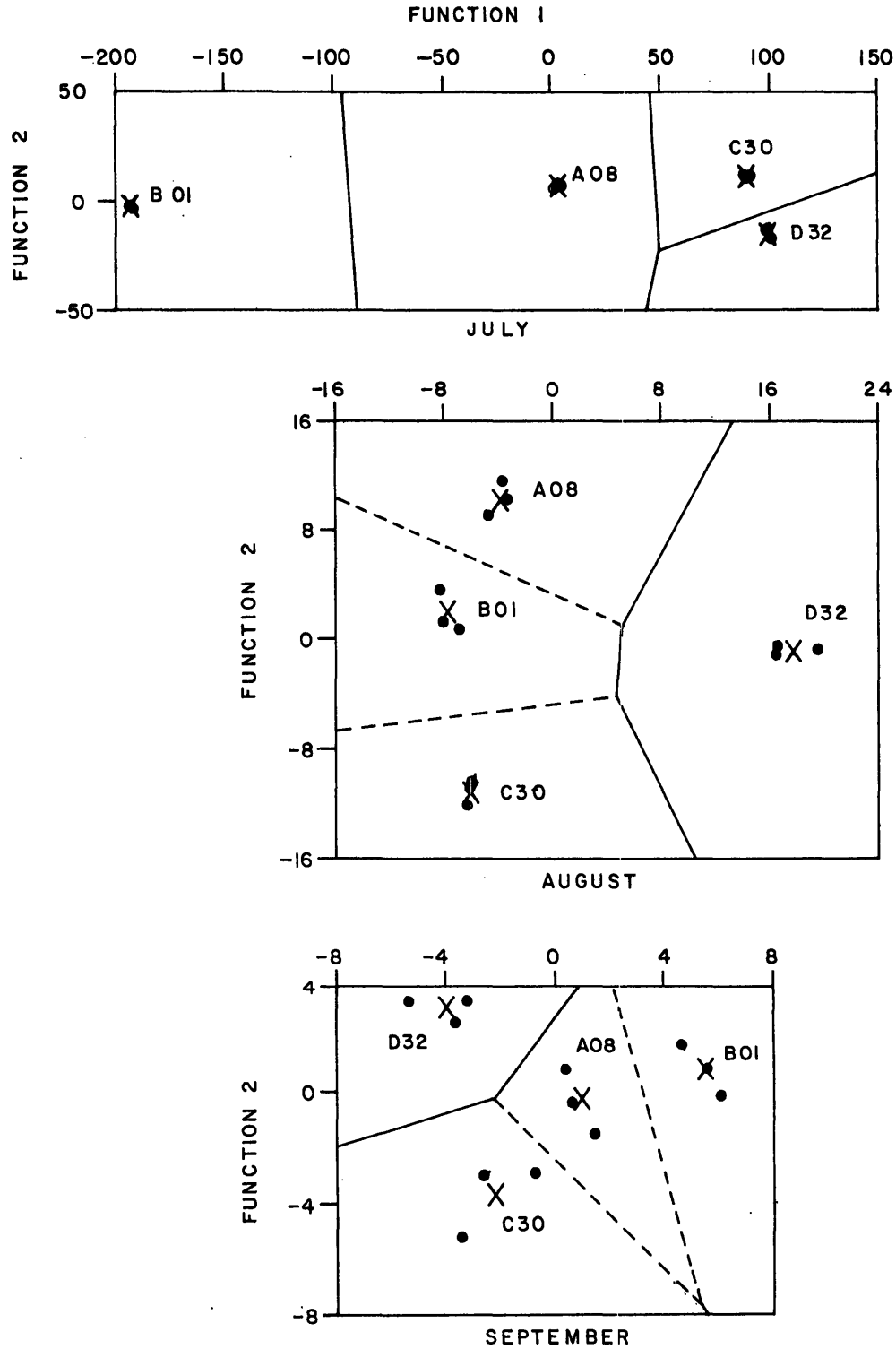

Fig. 7 Territorial map, station centroids (x) and discriminant scores (·) for each replicate sample of microzooplankton, based on the first two discriminant functions of July, August and September data.

Table 6. Summary statistics from canonical discriminant function analysis of August 1978 microzooplankton collections.

Discriminant Function	Eigenvalue	Cumulative % of Variance	Canonical Correlation
1	157.02534	62.54	0.9968
2	88.19676	97.67	0.9944
3	5.85998	100.00	0.9242

After Function	Wilk's Lambda	Chi-Square	d.f.	Significance
0	0.0000	68.88	18	0.0000**
1	0.0016	38.50	10	0.0000**
2	0.1458	11.55	4	0.0210 *

Standardized Discriminant Function Coefficients

	1	2
E. affinis nauplii	-2.59165	2.04714
chydorids	-7.44069	-0.14248
Eucyclops agilis	7.10178	-1.09099
A. tonsa nauplii	0.24740	-3.18765
A. tonsa copepodids	1.02255	1.12072
E. affinis copepodids	2.03296	-1.58789

Group Centroids

Station	Function 1	Function 2
A08	-3.80009	10.26739
B01	-7.69178	1.80790
C30	-6.06716	-11.21439
D32	17.55903	-0.86090

Classification Results

Actual Station	Number of Replicates	Predicted Station Membership (%) A08	B01	C30	D32
A08	3	100.0	0.0	0.0	0.0
B01	3	0.0	100.0	0.0	0.0
C30	3	0.0	0.0	100.0	0.0
D32	3	0.0	0.0	0.0	100.0

* - $p \leq 0.05$
** - $p \leq 0.01$

affinis nauplii with its lower and negative coefficient. Differences between station D32 and all others were highly significant. Differences between A08 and B01, and B01 and C30, were significant at a $p = < 0.05$ level.

Classification of replicates into actual station location was 100% correct.

4.3 September 1978 Differences

As with August microzooplankton data, the first two functions from September data accounted for over 97% of the variance and the third function was still significant ($p = 0.0474$). However, in September only three taxa were retained in the analysis (Table 7). Highest coefficients in the first two functions were those for barnacle nauplii and Acartia tonsa copepodids, respectively. Distribution of stations along the first function (Fig. 7, September) coincides with an increase in barnacle larvae toward the discharge station B01 and an increase in A. tonsa copepodids are reflected in positioning of stations along the second function.

As in August, differences between stations A08 and B01 and between B01 and C30 are less than those evident between station D32 and other stations. All replicates, however, were correctly classified into stations.

Table 7. Summary statistics from canonical discriminant function analysis of September 1978 microzooplankton collections.

Discriminant Function	Eigenvalue	Cumulative % of Variance	Canonical Correlation
1	19.74997	66.76	0.9756
2	9.14197	97.67	0.9494
3	0.68939	100.00	0.6388

After Function	Wilk's Lambda	Chi-Square	d.f.	Significance
0	0.0028	44.05	9	0.0000**
1	0.0584	21.31	4	0.0003**
2	0.5919	3.93	1	0.0474 *

Standardized Discriminant Function Coefficients

	1	2
barnacle nauplii	0.90366	0.46326
A. tonsa copepodids	-0.56705	0.74690
E. affinis nauplii	-0.16385	0.21671

Group Centroids

Station	Function 1	Function 2
A08	0.84790	-0.34221
B01	5.49107	0.88682
C30	-2.24631	-3.68747
D32	-4.09266	3.14286

Classification Results

Actual Station	Number of Replicates	Predicted Station Membership (%) A08	B01	C30	D32
A08	3	100.0	0.0	0.0	0.0
B01	3	0.0	100.0	0.0	0.0
C30	3	0.0	0.0	100.0	0.0
D32	3	0.0	0.0	0.0	100.0

* - $p \leq 0.05$
** - $p \leq 0.01$

5. MESO- AND MACROZOOPLANKTON

Collections made with 18.5 cm bongo nets of 202 μm mesh, the mesh size recommended for division between micro- and mesozooplankton (BMPCO, 1969), provided the principal source of information on composition, abundance and structure of the zooplankton community in this study. These collections were utilized for measures of biomass, sample and species similarity, and diversity.

5.1 Biomass

A relatively rough, but non-destructive, method for estimating zooplankton biomass was used in this preliminary study: displacement volume of total preserved collections. Volume is a poor measurement of biomass (1) in the presence of large numbers of coelenterates or ctenophores, and (2) where net meshes become clogged in heavy blooms of phytoplankton or heavy loads of detritus. Jellyfishes and ctenophores were absent in the low salinities of the study area in the summer of 1978, so the first disadvantage of the method can be discounted. The second problem with the method probably contributed to some of the wide differences in results listed in Table 8. One consistency in tabulated results from month to month is the low biomass at intake stations compared with stations downstream from the plant's discharge. A 2.5 - 4-fold increase occurred from the intake (station A08) to the immediate discharge (B01). Even larger

Table 8. Displacement volume (ml/m^3) of 18.5 cm bongo, 202 µm mesh net, collections at the C. P. Crane generating station, July - September 1978.

Station	July	August	September
A08	0.08	0.04	0.09
A22	0.04	0.06	0.07
A36	0.08	0.06	0.07
B01	0.20	0.16	0.36
B13	0.33	0.14	0.10
B16	0.37	0.89	0.27
B40	0.08	0.55	0.14
C04	0.45	0.23	0.15
C30	0.29	0.13	0.09
D20	0.12	0.08	0.04
D32	0.61	0.19	0.18
D47	0.16	0.05	0.08

estimates were evident at stations farther downstream in July and August.

Increases in detritus can be expected in power plant discharges as a result of thermal and mechanical damage to entrained organisms and from an increase in turbulence and sediment stirring. Similarly, downstream production of phytoplankton increases in direct response to temperature elevation. Thus, the above-mentioned second problem with displacement volume as a measure of biomass could be expected to apply in the study area, and in the manner shown by our data. It should be noted that use of the more tedious, destructive method of lyophilizing for dry weight does not overcome this problem of phytoplankton and detritus addition, which is a function of the net mesh size employed and local abundance of suspended organic matter.

Macrozooplankton net collections were always sparse and unrepresentative of zooplankton populations due to the large mesh size (505 μm) through which, in estuaries, most of the dominant species escape.

5.2 Species Occurrence, Dominance and Relative Abundance

A checklist of the zooplankton identified from 18.5 cm bongo and 1/2 meter nets is in the Appendix to this report (Table A-3). Acartia tonsa, Argulus alosae, barnacle larvae and the larvae of

the mud crab Rhithropanopeus harrisii occurred at all sampled stations (36). The cyclopoid parasite of catfishes, Ergasilus cerastes, was found at 35 stations. Other frequent species included the cladocerans Moina micrura, at all July and August stations but decreasing in frequency in September, and Leptodora kindtii, at every station in July but rare after that. Eurytemora affinis occurred at 80% of sampled stations. Also common were water mites (Acarina), cladocerans Diaphanosoma sp. and species of the family Chydoridae, and Palaemonetes sp. larvae in July and August.

Three of the common species were particularly abundant over the study area, as listed in Table 9, where calculated densities are averaged over the 12 stations sampled each month: Moina micrura, 1644/m^3 in July, declining rapidly to near-absence in September; Acartia tonsa declining through the summer from 855 to 395/m^3; and barnacle larvae with an August maximum of 242/m^3.

A quick assessment of environmental differences in habitat among stations in a study area can often be gained by identifying the species that numerically dominate the collections. Dominants from C. P. Crane waters are listed in Table 10. In each month a pair of taxa shared dominance of all 12 stations, a display of high similarity of the area's fauna. Seasonally, Moina micrura relinquished its dominant role to the increased numbers of barnacle larvae in August. Changes from station to station

Table 9. Frequency of occurrence (%) and average abundance (total numbers per total sampled volume in m^3) of the more common zooplankton species occurring near the C. P. Crane generating station, summer 1978. Based on collections made with 18.5 cm bongo samplers (202 μm mesh nets).

Species	July		August		September	
	%	no./m^3	%	no./m^3	%	no./m^3
Moina micrura	100	1644.2	100	36.8	42	0.1
Acartia tonsa	100	855.4	100	701.3	100	394.9
barnacle larvae	100	23.2	100	271.7	100	141.0
Eurytemora affinis	75	73.6	92	17.6	42	0.7
Rhithropanopeus harrisii	100	16.8	100	10.0	100	3.5
Leptodora kindtii	100	30.9	8	<0.1	0	--
Ergasilus cerastes	92	8.7	100	5.6	100	3.0
Argulus alosae	100	0.7	100	1.2	100	0.5
Diaphanosoma sp.	83	27.0	42	0.9	42	0.5
Palaemonetes sp.	67	0.2	58	0.1	0	--

Table 10. Rank of numerical dominance of zooplankton species in 18.5 cm bongo, 202 µm mesh nets. Stations listed in order of approach to, and distance from, the C. P. Crane power plant. Designations 1, 2, 3 represent first, second and third most abundant species in individual collections.

Month	Dominant Taxa	Station A36	A22	A08	B01	B13	B16	B40	C04	C30	D20	D32	D47
JULY	Acartia tonsa	1	1	1	1	2	1	2	2	1	2	2	2
	Moina micrura	2	2	2	2	1	2	1	1	2	1	1	1
	Eurytemora affinis					3			3	3		3	
	Rhithropanopeus harrisii		3		3		3						
	Leptodora kindtii			3							3		3
	Ergasilus cerastes	3											
	Diaphanosoma sp.							3					
AUG	Acartia tonsa	1	1	1	2	2	1	1	1	1	1	1	1
	barnacle larvae	2	2	2	1	1	2	2	2	2	2	2	2
	Moina micrura	3	3		3		3		3	3		3	3
	Eurytemora affinis					3		3			3		
	Rhithropanopeus harrisii			3									
SEPT	Acartia tonsa	1	2	1	1	2	2	1	2	2	1	1	1
	barnacle larvae	2	1	2	2	1	1	2	1	1	2	2	2
	Rhithropanopeus harrsii	3			3	3	3		3		3		
	Ergasilus cerastes		3	3								3	3
	Chydorids							3					
	Sida crystallina									3			

appeared coincident to plant location in July with a shift in primary dominance from Acartia tonsa to Moina micrura and in August and September with the emergence of barnacle larvae as the most abundant taxon. Eurytemora affinis ranked as a tertiary dominant only at stations on the discharge side of the plant.

5.3 Community Analysis

5.3.1 Cluster and Nodal Analyses

The normal cluster analysis of July 1978 small bongo collections reflected the close similarity of fauna evident in the above examination of species dominance. All twelve collections were linked at a relatively high level of similarity (Fig. 8). Clustering of species (inverse analysis) was mostly according to relative abundance, with the two primary dominants, Acartia tonsa and Moina micrura, occurring as species group B. Fidelity indices were all at or close to unity, showing a general lack of "preference" or "avoidance" by any particular species group for any of the station clusters. All four station clusters had a fidelity index of 1.0 in the case of species group B. Only the least abundant group of species (D) exhibited a moderate range of fidelity for station groups (0.4 - 1.2).

The station clusters designated I - IV have little informational content in that groups I and III include mixtures of geographically distant stations, an upper Saltpeter Creek station

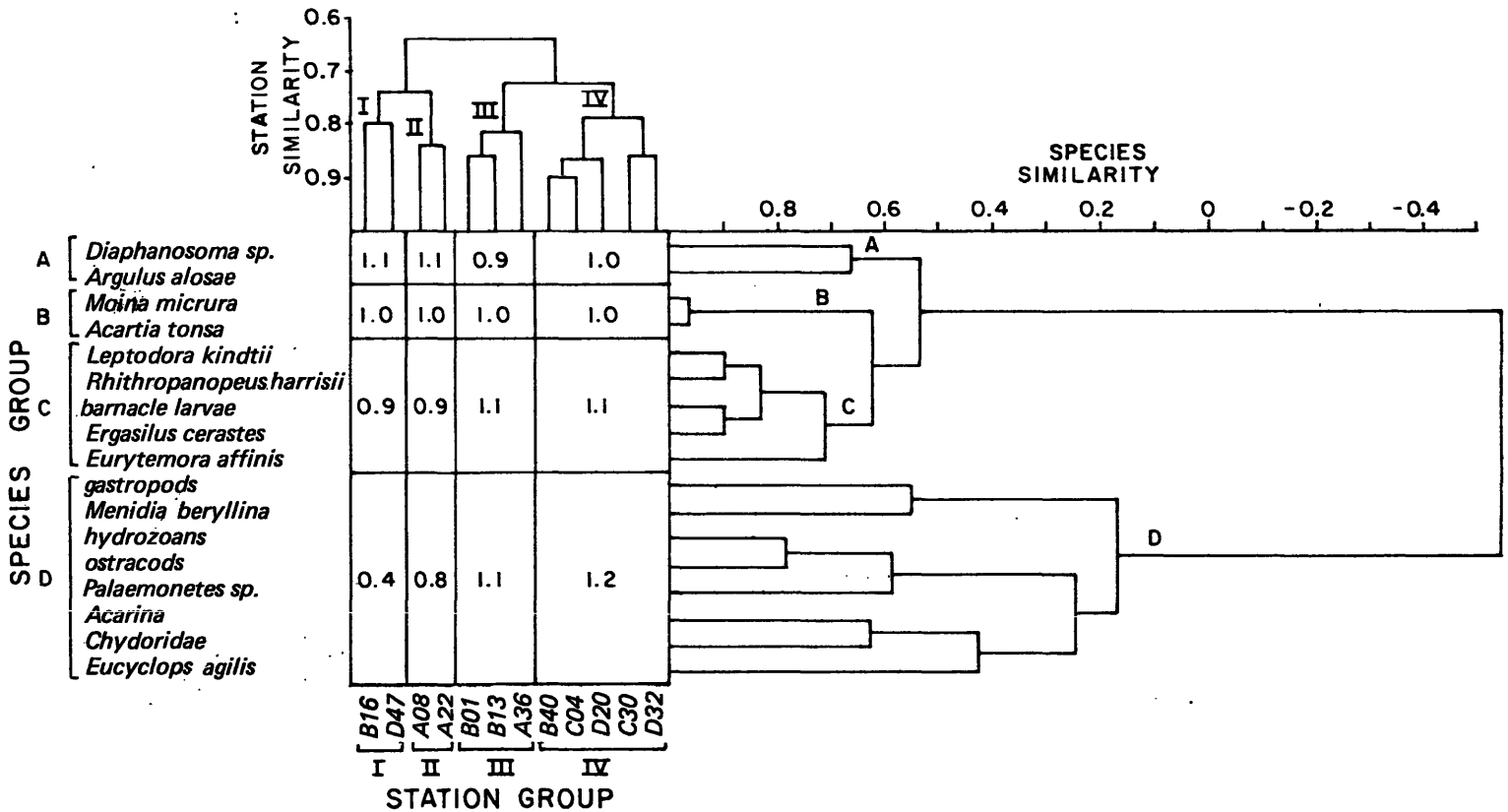

Fig. 8 Station and species clusters from July 1978 18.5 cm bongo collections, with the relationship of species clusters to station clusters shown by indices of fidelity.

with one from the lower Gunpowder River, and two near-discharge stations with one at the mouth of the intake creek. This is further indication of the overall, close similarity of the 12 stations.

In summary, except for an upper tier of slightly lower salinity stations (Group IV, stations B40, C04, C30, D20 and D32) for which some preference was shown by the less abundant, freshwater species group D, the cluster and nodal analyses in July showed a general close similarity among all localities in the study area.

August 1978 collections were again closely similar (all 12 stations linked at a similarity of > 0.6, Fig. 9). The inverse analysis of species again linked the two primary dominants, in this case Acartia tonsa and barnacle larvae, as a single species group (C). As in July, fidelity indices for the dominant species equaled 1.0 throughout the station groups. The subdominants (species group B) also showed a general lack of preference for any particular cluster of stations.

Species characteristic of fresher waters were, in August, divided into two groups (A and D) which, in terms of fidelity, differed primarily in their occurrence in station groups I, II and IV. Species group A, including Eucyclops agilis and Diaphanosoma sp., was absent in the immediate discharge while showing a slight preference (fidelity = 1.1) for lower stations in Seneca Creek and

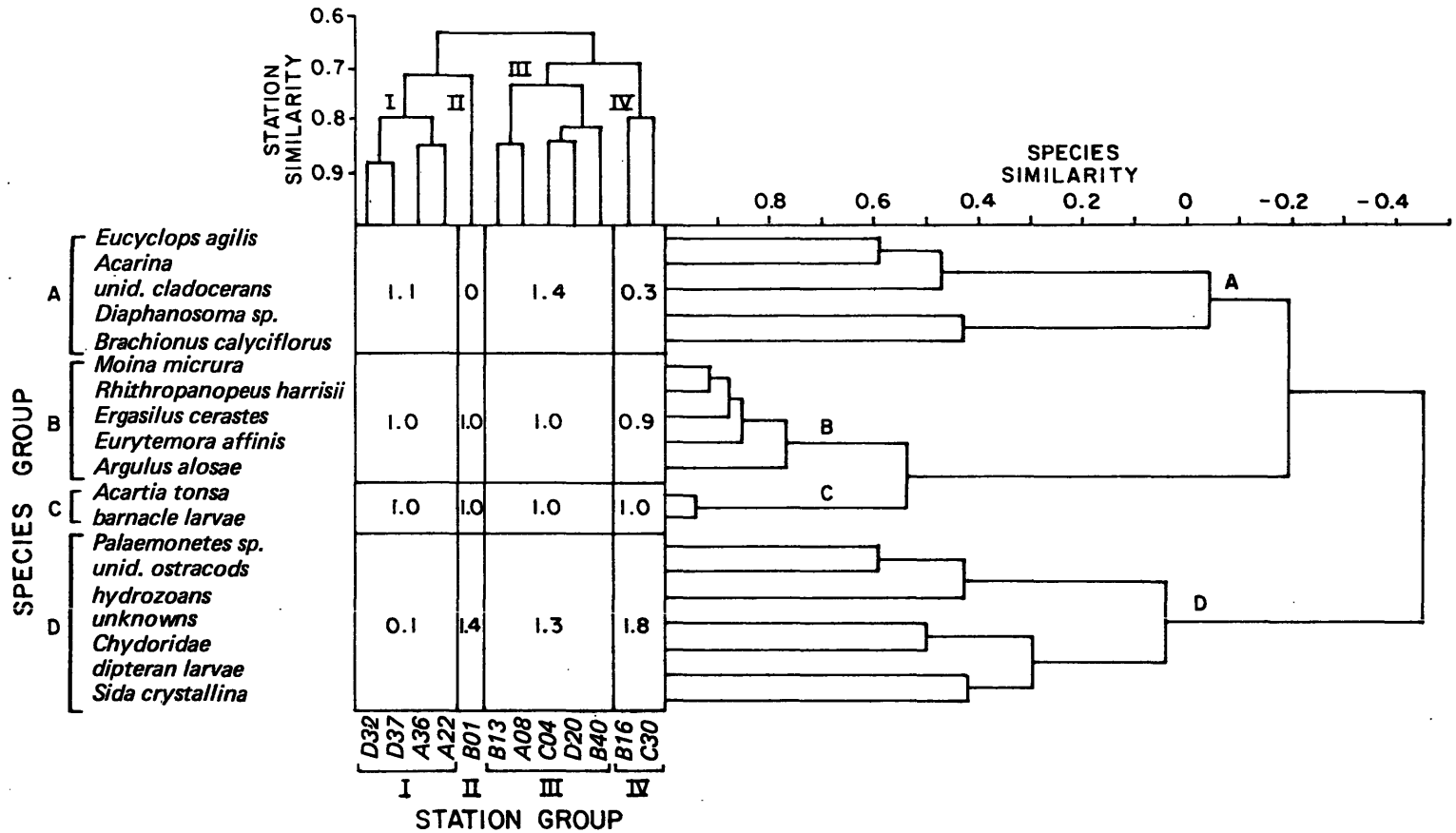

Fig. 9 Station and species clusters from August 1978 18.5 cm bongo collections, with the relationship of species clusters to station clusters shown by indices of fidelity.

Gunpowder River (station group I). Species group D, including Palaemonetes sp. larvae and chydorid cladocerans, showed greater preference for the immediate discharge and station group IV (stations B16, C30).

However, as in July, differences among stations in August were too slight to produce distinctive and meaningful clusters.

One station group in September (group IV, consisting of stations B40, C04, C30 and D20), the upper tier of lower salinity locations, remained distinct from other stations to a similarity level below 0.5. Its distinctiveness was due primarily to the moderately high fidelity shown for those stations by species groups B and E (Fig. 10). Both the dominants, Acartia tonsa and barnacle larvae, and the subdominants (species group D), were as likely to occur in one station cluster as another (all indices of fidelity equal to unity).

September data provided the first evidence of a distinctive cluster of stations among the set of 12 regularly sampled locations, with the final linking of all collections occurring at a similarity level just below 0.5. The distinctive cluster (station group IV) was similar to the cluster of July 1978 data that also showed some preference by freshwater species. It would appear that this is the primary ecological division that can be expected among collections taken at the C. P. Crane site, i.e. low salinity vs. fresh water communities of zooplankton. It follows

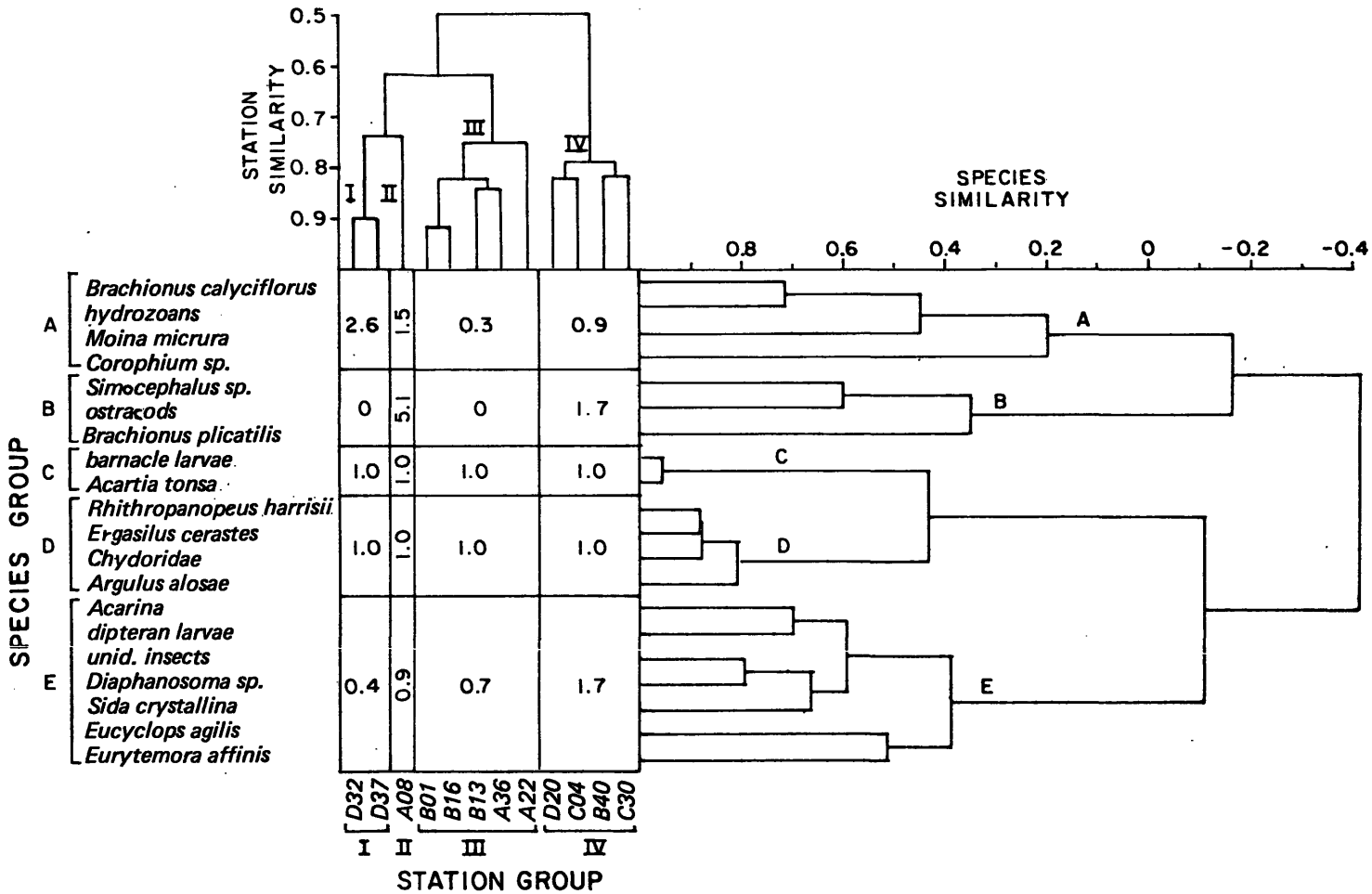

Fig. 10 Station and species clusters from September 1978 18.5 cm bongo collections, with the relationship of species clusters to station clusters shown by indices of fidelity.

that plant effect consists of displacement of the freshwater community, which during our abbreviated study, was maximal during August, intermediate in July when some preference of freshwater species for the upper tier of stations could be seen, and minimal in September when the cluster of lower salinity stations became distinct.

5.3.2 Diversity

The Shannon-Wiener index of diversity (H'), evenness (J') and Margalef's index of species richness (d) were calculated for each collection and are listed in Table 11. In general, diversity was low, with the highest H' = 2.2801 recorded at station A36 (mouth of Seneca Creek) in July. Diversity indices below 1.65 accounted for 90% of the observations. Evenness (J') estimates were below 0.5 in all collections but one, showing that numerical dominance of one or a few taxa contributed to low diversity. Species richness was also low, with none of the indices reaching 2.0.

In previous studies of continental shelf waters Grant (1978) found a useful correspondence between the relationship of Shannon-Wiener and species richness indices to ecological groups of stations derived from cluster analysis. In Fig. 11, it is evident that this correspondence occurred at the C. P. Crane site only in September when the upper tier of stations D40, C04, C30 and D20 were set off from other stations of generally lower

Table 11. Diversity (H') evenness (J') and species richness (d) of 18.5 cm bongo collections (202 μm mesh nets) at the C. P. Crane generating station, July - September 1978. Stations designated A: Seneca Creek, intake; B: Saltpeter Creek, near discharge; C: lower Saltpeter Creek, far-field discharge; D: lower Gunpowder River.

	July			August			September		
Station	H'	J'	d	H'	J'	d	H'	J'	d
A08	1.1651	0.3250	1.2061	1.5851	0.4284	1.5283	1.0962	0.2741	1.6380
A22	1.3161	0.3962	1.1580	0.8022	0.2674	0.7367	1.2509	0.3765	1.1655
A36	2.2801	0.6360	1.5789	1.0337	0.3261	1.0105	0.9205	0.2904	0.9058
B01	1.5798	0.4269	1.3907	1.4770	0.4120	1.3865	1.2240	0.4080	0.8239
B13	1.0651	0.2726	1.2780	0.8519	0.2238	1.4662	0.6473	0.1871	1.1681
B16	1.3000	0.3913	0.8801	1.4057	0.3921	1.1767	1.2076	0.4025	0.8543
B40	1.7094	0.4490	1.3171	1.6350	0.4418	1.2338	1.4632	0.3843	1.6060
C04	1.7250	0.4137	1.5972	1.3364	0.3270	1.7140	1.3972	0.3576	1.7756
C30	1.3928	0.4026	0.9325	1.0850	0.3136	1.0339	1.8586	0.4647	1.8408
D20	1.1866	0.2903	1.5750	1.2418	0.3262	1.3585	1.3488	0.3300	1.9362
D32	0.9755	0.2937	0.7767	1.1612	0.3239	1.0483	0.7183	0.2162	0.9517
D47	1.2922	0.4307	0.6619	1.0313	0.3105	0.9922	1.0088	0.2814	1.3044

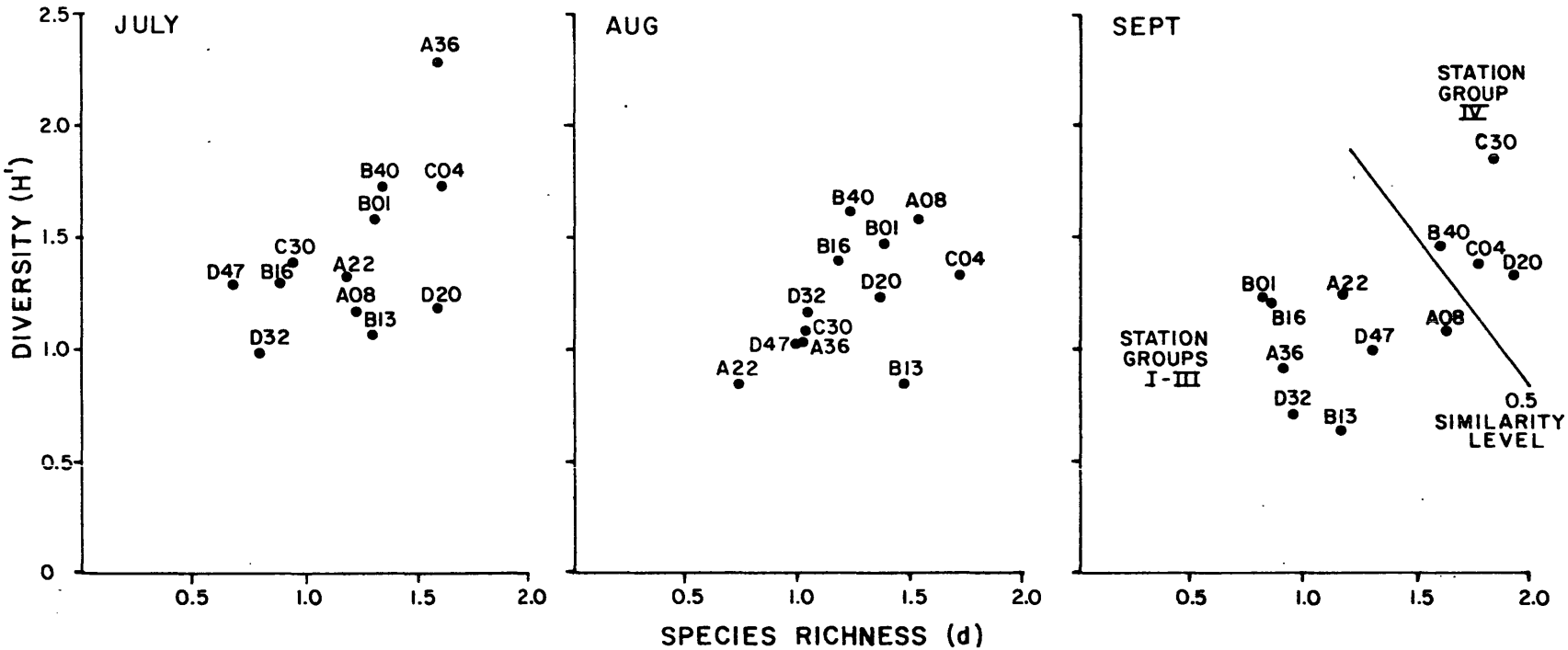

Fig. 11 Relationship of diversity (H') to species richness (d) as calculated from 18.5 cm bongo collections, July - September 1978. Distinctiveness of station group IV from other stations in September is indicated by a line representing the 0.5 similarity level obtained in the cluster analysis (cf. Fig. 10).

diversity and species richness. In July and August, stations of the most distinct clusters (at higher levels of similarity) were intermingled with other stations on these bivariate plots.

6. SUMMARY OF RESULTS

The principal physical effects of the C. P. Crane generating station include the transfer of relatively large volumes of oligohaline water into a shallow system of even fresher water and the elevation of temperatures in the receiving body of water. The horizontal extent of these changes depends on whether the plant is operating at partial or full capacity, on fresh water runoff from watersheds of Saltpeter Creek, Dundee Creek and Gunpowder River, and on tidal exchange.

Our limited data on temperature and salinity, observed only ancillary to biological sampling, show that a small range of salinity occurs in the area even in summer, when salinity is typically at a maximum. However, the range includes the juncture of fresh and brackish water where small changes are often critical to animals of both fresh and estuarine systems. Temperature effects could favor certain species in winter, accelerate reproductive and developmental rates in spring, and increase mortality in summer when ambient temperatures are already close to upper lethal limits for many species.

Apparent effects on plankton populations observed during the

summer of 1978 are divided below into small- and large-scale effects.

6.1 Apparent Small-scale Effects of Thermal Discharge

(1) Elevation of temperatures in immediate discharge area to above lethal limits for most zooplankton (> 38°C). Occurred in our August sampling, but only at station B01.

(2) Decrease in phytoplankton biomass. Minimum measures of chlorophyll were obtained at the discharge in July and August. In September biomass was low throughout the intake and discharge creeks.

(3) Sharp decrease in productivity at the immediate discharge. Occurred in both July and August.

(4) Absence of Diaphanosoma sp., a cladoceran, in discharge waters in July.

6.2 Possible Large-scale Effects

(1) Natural, pre-operational state of the environment in Saltpeter Creek was likely more nearly fresh than at present, with a more diverse fauna consisting of numerous cladocerans, aquatic insects and cyclopoid copepods similar to those evident in upper stations in September 1978.

(2) Present summer fauna is atypically structured, with 2 of the 5 common copepods parasitic on fishes. Decapod larvae were limited to two species, only those of Rhithropanopeus harrisii occurring in abundance. The altered environment may have selected

for these species. R. harrisii larvae can be expected to have highest survival in relatively low salinity and high temperature (Costlow, Bookhout and Monroe, 1966). Elevation of temperatures near the plant could therefore favor this species, especially when combined with a maintenance of salinity above 1.0 °/oo where Costlow et al. (1966) found high mortality of larvae at all temperatures. Eucyclops agilis has been reported as a eurythermal species (Rylov, 1948) and as the commonest littoral cyclopoid copepod in North America (Yeatman, 1959), so is probably limited mostly by the distribution of fresh water in the present site. There is no available information on temperature and salinity requirements of the copepod parasites of fishes, Argulus alosae and Ergasilus cerastes, the latter described from specimens collected from catfish at a Washington, D. C. fish market (Roberts, 1969).

(3) Increase in temperature from the plant's operation becomes large-scale in periods of higher ambient temperature (coinciding with higher demand for electric power), at which time temperature elevation is evident throughout Saltpeter Creek and the lower Gunpowder River (see also Binkerd et al., 1978).

(4) When discharge waters at the immediate discharge in summer cool below temperatures that may be inhibitory to photosynthesis (> 38°C in August), the warmed waters may increase productivity through wide areas of the lower Saltpeter Creek and

lower Gunpowder River. Maximum productivity was recorded in all three months in lower Gunpowder River stations.

(5) The plant augments natural populations of barnacle larvae, which are then distributed throughout the system. These larvae, mostly nauplii, assumed dominance of zooplankton populations on the discharge side of the plant in both August and September.

6.3 Recommendations for Further Studies by the Power Plant Siting Program

(1) Extension of studies on phytoplankton and zooplankton through all seasons of the year.

(2) Addition of measurements of at least one primary nutrient, e.g. phosphorus, to phytoplankton studies, and of continuous measurements for temperature, salinity and incident light.

(3) Addition of close-spaced stations extending from the plant discharge to help delineate small-scale effects of the plant.

(4) Substitution of additional microzooplankton stations for replicate samples taken in summer 1978.

(5) Relocation and extension of zooplankton 18.5 cm bongo sample stations along transects through Seneca Creek, Saltpeter and Dundee creeks, Gunpowder River and out into the Chesapeake Bay proper, to aid in defining large-scale effects of the plant.

(6) Investigate temperature and salinity requirements for species such as Ergasilus cerastes and Argulus alosae, for which such information is lacking.

(7) Investigate food habits and parasitology of local juvenile and adult fishes.

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Table A-1. Phytoplankton biomass, productivity and ancillary measurements, C. P. Crane generating station, July - September 1978.

Station	Date 1978	Time EDT	Surface Light (ly/hr)	Secchi Disc (meters)	Depth (m)	Temp. (°C)	Salinity (ppt)	Dissolved Oxygen (mg/l)	Seston (mg/l)	Chloro-phyll a (µg/l)	Phaeo-pigments (µg/l)	Alkalinity (mg CO_2/l)	Productivity (mg C/hr/m^3)
A08	19 July	1115	40	0.7	0.5	27.4	1.63	8.2	18	9.92	3.62	12.68	16.67
					1.0	27.4	1.48						
					2.0	27.3	1.44						
					3.0	27.1	1.52						
					4.0	26.9	1.52	7.4					
A35	19 July	1150	60	0.5	0.5	27.2	1.60	8.8	34	14.57	6.02	13.95	21.25
					1.0	27.1	1.59						
					2.0	26.9	1.58						
					3.0	26.9	1.59	8.6					
A36	19 July	1210	65	0.7	0.5	27.6	1.62	11.0	16	14.57	5.74	14.37	17.30
					1.0	27.5	1.55						
					2.0	27.0	1.66	8.0					
A47	19 July	1227	65	0.8	0.5	27.4	1.65	8.5	26	18.41	6.58	14.37	16.32
					1.0	27.3	1.59						
					2.0	27.0	1.58	8.5					
B01	17 July	1303	67	0.5	0.5	32.4	1.38	6.4	51	7.13	6.69	15.22	12.94
					1.0	28.0	1.29	6.5					
B14	17 July	1340	65	0.5	0.5	28.9	1.35	7.3	38	12.71	6.19	14.80	17.63
					1.0	28.2	1.33						
					2.0	28.1	1.33	5.3					
B19	17 July	1226	70	0.4	0.5	27.7	1.18	6.6	37	16.12	8.14	15.22	28.03
B40	17 July	1050	60	0.5	0.5	26.1	1.15	---	49	9.92	7.01	14.37	30.63
					1.0	26.3	1.17	6.1					
C05	18 July	0948	65	0.5	0.5	27.2	1.24	6.2	35	9.61	7.03	14.37	17.71
					1.0	26.5	1.16						
					2.0	25.7	1.08	5.8					
C17	18 July	1010	62	1.0	0.5	26.9	1.16	7.2	15	11.47	6.02	13.53	15.21
					1.0	26.8	1.14						
					2.0	26.5	1.12	5.8					
C41	18 July	1022	58	0.5	0.5	27.5	1.24	6.6	45	12.71	7.88	13.53	20.49
					1.0	27.1	1.22						
					2.0	25.9	1.11	5.9					
C50	18 July	1043	60	0.5	0.5	27.3	1.19	6.1	37	11.47	6.02	13.53	15.04
					1.0	26.9	1.19						
					2.0	26.8	1.22	6.5					
D07	18 July	1314	70	0.2	0.5	28.5	0.63	8.6	72	15.81	7.89	15.64	29.57
					1.0	26.3	0.69						
					2.0	26.3	0.81	6.4					
D42	18 July	1410	72	0.5	0.5	26.8	1.02	8.0	44	18.29	6.25	16.07	33.50
					1.0	25.3	0.75						
					2.0	25.1	1.14						
					3.0	25.0	1.25	6.1					

Table A-1. (continued)

Station	Date 1978	Time EDT	Surface Light (ly/hr)	Secchi Disc (meters)	Depth (m)	Temp. (°C)	Salinity (ppt)	Dissolved Oxygen (mg/l)	Seston (mg/l)	Chloro-phyll a (µg/l)	Phaeo-pigments (µg/l)	Alkalinity (mg CO_2/l)	Productivity (mg C/hr/m^3)
D43	18 July	1337	70	0.3	0.5	28.5	0.81	9.0	45	20.46	7.19	16.07	47.72
					1.0	26.7	1.17						
					2.0	25.3	1.31	5.9					
D48	18 July	1352	70	0.9	0.5	26.8	1.15	9.0	41	23.56	4.65	21.99	43.00
					1.0	26.3	1.05						
					2.0	25.1	1.13						
					3.0	25.0	1.23	6.1					
A09	16 Aug	1422	52	0.5	0.5	30.5	2.40	8.9	--	32.24	7.82	12.26	35.52
					1.0	30.5	2.34	9.2					
A27	16 Aug	1403	55	0.8	0.5	30.1	2.35	8.4	--	11.47	5.46	13.11	34.54
					1.0	30.0	2.35						
					2.0	29.7	2.35	7.5					
A32	16 Aug	1350	55	0.75	0.5	30.0	2.35	8.1	--	11.78	5.43	12.47	25.67
					1.0	29.8	2.35						
					2.0	29.6	2.35						
					3.0	29.2	2.35	6.6					
A45	16 Aug	1336	65	0.8	0.5	29.9	2.34	8.4	--	16.12	8.14	13.53	27.53
					1.0	29.9	2.35						
					2.0	29.8	2.38	8.7					
B03	15 Aug	1025	55	0.7	0.5	33.4	2.38	6.8	--	9.61	7.03	12.68	27.54
					1.0	31.5	2.37	6.8					
B07	15 Aug	1045	40	0.6	0.5	31.8	2.36	7.6	--	19.53	6.99	13.32	43.95
					1.0	31.5	2.24	6.8					
B12	15 Aug	0946	18	0.6	0.5	31.1	2.19	6.9	--	17.98	6.28	12.90	42.65
					1.0	30.7	2.17	6.3					
B28	15 Aug	1007	52	0.7	0.5	29.6	2.10	7.2	--	16.12	6.17	12.68	29.88
					1.0	29.5	2.11	7.2					
C11	15 Aug	1253	68	0.75	0.5	31.7	2.23	8.3	--	13.95	5.23	13.32	21.01
					1.0	31.1	2.19						
					2.0	30.3	2.12	7.6					
C17	15 Aug	1310	68	1.25	0.5	30.4	2.00	8.3	--	12.71	11.27	13.53	13.35
					1.0	29.2	2.02	8.1					
C33	15 Aug	1324	70	0.6	0.5	31.1	2.04	8.2	--	12.71	4.78	13.53	12.62
					1.0	30.4	1.90	8.2					
C48	15 Aug	1340	75	0.5	0.5	30.0	1.85	7.1	--	12.09	6.81	13.95	21.60
					1.0	29.9	1.88						
					2.0	29.7	2.05	6.5					
D18	16 Aug	0946	40	0.4	0.5	28.6	1.97	7.3	--	12.40	6.22	15.22	38.99
					1.0	28.6	1.95						
					2.0	28.6	1.95	6.9					
D50	16 Aug	1005	40	0.4	0.5	28.6	2.09	7.0	--	12.09	7.38	15.22	33.21
					1.0	28.6	2.10						
					1.5	28.6	2.10	6.9					

Table A-1. (continued)

Station	Date 1978	Time EDT	Surface Light (ly/hr)	Secchi Disc (meters)	Depth (m)	Temp. (°C)	Salinity (ppt)	Dissolved Oxygen (mg/l)	Seston (mg/l)	Chloro-phyll a (µg/l)	Phaeo-pigments (µg/l)	Alkalinity (mg CO_2/l)	Productivity (mg C/hr/m^3)
D51	16 Aug	1022	43	0.4	0.5	28.7	2.17	6.8	--	11.47	7.71	15.43	27.09
					1.0	28.6	2.18						
					2.0	28.6	2.14	6.5					
D55	16 Aug	1045	46	0.5	0.5	28.9	2.18	7.2	--	13.95	9.18	18.18	55.45
					1.0	28.9	2.20						
					2.0	28.7	2.19						
					3.0	28.6	2.18	6.8					
A12	13 Sept	1238	75	0.5	0.5	23.3	3.05	7.1	15	5.94	0.81	13.19	24.19
					1.0	23.3	3.09						
					2.0	23.3	3.08	7.1					
A38	13 Sept	1225	40	0.6	0.5	23.1	3.18	6.3	16	4.68	0.74	12.75	22.00
					1.0	23.1	3.17						
					2.0	23.1	3.17	7.4					
A43	13 Sept	1134	32	0.6	0.5	22.9	2.09	6.9	18	4.31	1.11	12.75	22.69
					1.0	22.9	3.13	7.1					
A48	13 Sept	1210	36	0.7	0.5	23.1	3.49	7.5	19	6.90	0.87	15.83	35.99
					1.0	23.1	3.51	7.8					
B03	14 Sept	0930	25	0.6	0.5	25.4	3.24	6.7	10	4.05	1.10	12.75	20.97
					1.0	25.3	3.24	6.6					
B05	14 Sept	1115	42	0.6	0.5	23.7	3.05	7.4	6	5.17	1.15	12.09	23.39
					1.0	24.2	3.12						
					2.0	24.1	3.17	6.9					
B26	14 Sept	0940	21	0.5	0.5	21.9	2.38	7.2	15	5.73	0.85	12.09	18.82
					1.0	22.0	2.38	7.1					
B40	14 Sept	0950	19	0.5	0.5	22.2	2.31	7.1	11	4.93	0.80	11.43	20.66
					1.0	22.2	2.31						
					2.0	22.2	2.32	7.2					
C05	14 Sept	1136	33	0.5	0.5	22.0	2.19	7.6	14	6.26	0.86	11.65	19.58
					1.0	22.0	2.23						
					2.0	22.2	2.38	7.1					
C07	14 Sept	1209	32	0.9	0.5	21.6	2.25	7.8	8	5.16	1.17	10.99	5.96
					1.0	21.7	2.28						
					2.0	21.7	2.32	7.7					
C10	14 Sept	1310	34	0.9	0.5	21.4	2.05	8.1	4	5.51	0.62	9.89	8.45
					1.0	21.5	2.04	8.0					
C22	14 Sept	1334	22	0.5	0.5	21.9	2.00	7.7	17	15.10	5.51	12.09	27.69
					1.0	21.9	2.00						
					2.0	21.9	1.99	7.5					
D08	14 Sept	1030	18	0.45	0.5	22.4	3.12	6.8	20	12.57	3.86	15.83	21.13
					1.0	22.4	3.20						
					2.0	22.2	3.16	7.0					

Table A-1. (concluded)

Station	Date 1978	Time EDT	Surface Light (ly/hr)	Secchi Disc (meters)	Depth (m)	Temp. (°C)	Salinity (ppt)	Dissolved Oxygen (mg/1)	Seston (mg/1)	Chloro-phyll a (µg/1)	Phaeo-pigments (µg/1)	Alkalinity (mg CO_2/1)	Productivity (mg C/hr/m^3)
D12	12 Sept	1040	38	0.8	0.5	25.9	2.97	6.8	13	12.23	4.46	12.31	31.80
					1.0	25.6	2.84						
					2.0	25.4	2.75	6.6					
D20	12 Sept	1055	40	0.8	0.5	25.9	2.82	7.2	14	12.04	4.54	12.75	37.13
					1.0	26.0	2.91						
					2.0	25.4	2.81	6.6					
D52	12 Sept	1000	26	0.5	0.5	23.9	2.64	7.2	16	17.91	7.61	15.17	48.86
					1.0	23.8	2.64						
					2.0	23.7	3.11	6.6					

Table A-2. Identity and counts (per 0.1 m^3) of microzooplankton sampled by pump at the C. P. Crane generating station, July - September 1978.

Taxa / Replicate		Station A08 1	A08 2	A08 3	B01 1	B01 2	B01 3	C30 1	C30 2	C30 3	D32 1	D32 2	D32 3
JULY													
MOLLUSCA													
unid.				8				4	4		4		
ROTIFERA													
Brachionus calyciflorus			2	4									
CLADOCERA													
Diaphanosoma sp.		26	32	24				72	120	180	292	212	132
Leptodora kindtii		1		1		1		8					
Moina micrura		21	51	66	261	613	459	48	28	24	232	688	472
COPEPODA													
Acartia tonsa	nauplii	240	212	207	13	21	12	1052	1252	688	476	548	380
	copepodites	56	62	71	52	42	41	96	88	68	120	32	20
	adults	5	3	26	20	32	17	4	20	4	6	40	12
Eurytemora affinis	nauplii	141	160	59	25	24	9	424	444	444	84	172	188
	copepodites	105	33	49	72	32	29	60	64	32	740	612	468
	adults				4	7	5				8	12	4
Argulus alosae		1		2		2	1						
Ergasilus cerastes		4			1		1	8				8	
Eucyclops agilis		9	2		3	3	1	36			28	8	
Scottolana canadensis		5					1	120	8	20	20	72	72
unid. harpacticoid		10	2	4	1				44	16			
unid. copepod		2	1	3	8	8	4		4				
DECAPODA													
Rhithropanopeus harrisii		2										4	
CIRRIPEDIA													
nauplii		37	90	91	14	30	23	92	56	36		24	12
cyprid larvae			2				3						
INSECTA													
unid.									4				
AUGUST													
MOLLUSCA													
unid.													4
CLADOCERA													
Chydoridae								736	512	32			
Diaphanosoma sp.						4			8		4	32	28
Moina micrura		4								8	12	20	12
Sida crystallina								108	124				
COPEPODA													
Acartia tonsa	nauplii	508	564	256	1316	1688	1368	1140	1688	2376	536	632	576
	copepodites	92	64	16	44	80	72	156	212	280	396	544	872
	adults	8	4	4	4	4	4	4	16	4	16		24
Eurytemora affinis	nauplii	352	216	172	788	80	72	184	624	476	16	36	8
	copepodites	4		4	8			76	64	56	12	64	4
	adults							36	8				
Argulus alosae		4				4							
Ergasilus cerastes											4	8	
Eucyclops agilis								212	292	12			
Scottolana canadensis		8	4		24	40	20	28	44	64	16	12	12
DECAPODA													
Rhithropanopeus harrisii		4									12		
CIRRIPEDIA													
nauplii		88	64	80	240	208	232	4	52	84	96	88	124
cyprid larvae									8				12
INSECTA													
unid.								4					
SEPTEMBER													
MOLLUSCA													
unid.			4										
ROTIFERA													
Brachionus calyciflorus		4	8	8		4		4		1	56	16	48
CLADOCERA													
Chydoridae								92	8	1			
Sida crystallina								128	4	1			
COPEPODA													
Arcartia tonsa	nauplii	824	340	428	328	314	110	348	210	206	1224	864	1204
	copepodites	76	40	64	32	60	52	56	38	45	336	224	260
	adults	4		4	8	4					20		16
Eurytemora affinis	nauplii	564	240	100	168	264	30	36	16	35	368	312	308
	copepodites		4					44	24	3			
	adults							12					
Argulus alosae							2						
Ergasilus cerastes						2		4			4		
Eucyclops agilis								52					
Scottolana canadensis		36	12				2	24	8	16	48	36	28
unid. copepod									4				
CIRRIPEDIA													
nauplii		100	84	84	392	386	402	20	10	35	36	48	64
cyprid larvae			4								4		
INSECTA													
unid.								132	10				

Table A-3. Checklist of zooplankton identified from meso- and macrozooplankton collections, vicinity of C. P. Crane generating station, July - September 1978

Taxa	July										August										September									
	A36	A22	A08	B01	B13	B16	B40	C04	C30	D20	D32	D47	A36	A22	A08	B01	B13	B16	B40	C04	C30	D20	D32	D47	A36	A22	A08	B01	B13	B16	B40	C04	C30	D20	D32	D47
COELENTERATA																																				
unid. polyps & medusae				X	X		X	X	X	X						X				X					X	X	X					X			X	X
TURBELLARIA																							X													
ROTIFERA																																				
Brachionus calyciflorus													X										X	X			X								X	X
Brachionus plicatilis																											X							X		
ANNELIDA															X		X															X				
MOLLUSCA																																				
unid. gastropods					X																						X								
Littorina irrorata				X		X		X																												
Pyramidella sp.											X																									
Hydrobia sp.																	X																			
Rangia cuneata															X																					
Acarina		X	X			X	X	X		X				X	X		X		X	X		X	X	X	X		X	X	X	X	X	X	X	X		
Cladocera																																				
unid. cladocerans																	X		X									X								
Leptodora kindtii	X	X	X	X	X	X	X	X	X	X	X	X								X																
Sida crystallina				X						X			X		X						X					X	X		X		X	X	X	X	X	X
Simocephalus sp.											X																X				X					
Diaphanosoma sp.	X	X	X	X	X	X	X	X		X	X	X					X	X				X	X	X					X		X	X	X	X		
daphnids																		X																		
Moina micrura	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X			X	X		X	X	X
chydorids			X		X		X	X		X					X	X	X	X		X	X				X	X	X	X	X	X	X	X	X	X	X	X
Chydorus sp.																																X				
Ostracoda (unid.)	X		X	X	X		X	X	X	X					X	X				X		X					X			X		X			
Copepoda																																				
unid. copepods																			X																	
Eurytemora affinis	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X		X	X	X		X	X		X	X	X	
Acartia tonsa	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Scottolana canadensis								X														X														
Eucyclops agilis								X		X						X	X		X	X		X										X	X			
Ergasilus cerastes	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Argulus alosae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cirripedia (unid.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mysidacea																																				
Neomysis americana										X																										
Isopoda																																				
Aegathoa oculata																																		X		
Edotea triloba								X																												
Amphipoda																																				
Gammarus sp.											X																									
Gamarus palustris															X																					
Corophium sp.															X	X											X					X			X	X
Leptocheirus plumulosus			X	X											X	X																				
Decapoda																																				
Palaemonetes sp.	X		X	X		X	X	X	X		X				X	X		X	X	X	X	X														
Rhithropanopeus harrisii	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Insecta											X					X				X	X	X			X	X	X	X	X		X	X	X	X	X	X
PISCES																																				
unid. fish larvae											X																									
Anchoa mitchilli				X												X																				
Menidia beryllina	X	X			X			X			X				X																					
Pomoxis sp.			X	X	X																															
Gobiosoma bosci			X	X							X				X	X							X					X						X		
Unknown organism																		X	X		X						X									