INTERIM TECHNICAL REPORT TO THE CALIFORNIA COASTAL COMMISSION

4. Plankton

MARINE REVIEW COMMITTEE, INC.

William W. Murdoch, Chairman
University of California

Byron J. Mechalas
Southern California Edison Company

Rimmon C. Fay
Pacific Bio-Marine Labs, Inc.

Prepared by:
Jon Kastendiek, Technical Coordinator
and
Keith Parker, Statistical Supervisor

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SUMMARY

The study of plankton in the vicinity of SONGS addressed three basic questions: Are standing stocks of zooplankton and phytoplankton changed in the vicinity of the Plant? Are nearshore zooplankton moved offshore by the discharge waters? What is the average annual loss of zooplankton to intake withdrawal? The results of the study can be summarized as follows:

Abundance Changes

There is no evidence that a severe reduction in total numbers of zooplankton has occurred in the vicinity of the plant. The once-predicted decline of 50% did not occur. In fact, while there was evidence of a decrease in one relatively uncommon species of cladoceran, a number of taxa, mostly larvae of benthic invertebrates, increased in the vicinity of the Plant.

While the occurrence of these changes at the Impact site in the After periods suggests that SONGS is responsible, the mechanism by which the operation of the Plant results in these changes is not known. It is possible that adult populations of the benthic invertebrates associated with the diffuser system may be the source of the increased numbers of larvae near the Plant.

There was no increase in phytoplankton (as measured by the chlorophyll-a content of seawater) near the Plant in the After period.

Distributional Changes

One potential effect of concern was the offshore displacement of nearshore larvae. There is little evidence that such movement, which occurs as discharge water is moved offshore, is sufficient to cause a significant change in the cross-shelf distribution of most species. Evidence of significant offshore shifts was seen in two taxa, both larvae of benthic invertebrates. In both of these cases, the movement offshore probably did not extend further than several hundred meters beyond the end of the diffuser lines and did not displace the plankters into an area where they do not normally occur.

Intake Loss

Incorporating 10 years of density estimates, we estimate that the Plant withdraws an average of approximately 12 trillion zooplankters (of the sizes we sampled) per year. This is equivalent to approximately 1,000 US tons of zooplankton per year. We estimate that an additional 350 US tons of smaller microzooplankton are also withdrawn. These estimates are based on the average pumping rate that has occurred during the operational period.

I. INTRODUCTION

Speculation on the potential depletion of plankton in the vicinity of the power plant was given at the Permit hearings of 1973, and concern for the plankton was expressly stated in the Permit establishing the MRC. In response to the mandate of the Permit, the MRC began its study of zooplankton and phytoplankton in 1976. Marine Ecological Consultants, Inc. (MEC) was awarded the contract to conduct the study, which was completed in 1987.

The first phase of the program was designed to determine the effects of the operation of Unit 1. The intent was to use this information to predict the effects of the two new units. This phase of the study ran from 1976 to 1979.

During this period, the cross-shelf distributions and abundances of various zooplankton taxa were determined. Both holoplanktonic and meroplanktonic taxa were enumerated. This information was necessary to estimate the amount of the zooplankton withdrawn into the Plant and to determine if specific taxa were distributed as to be at greater risk of either withdrawal into the Plant or movement offshore in water entrained by the Plant's discharge. In addition, the chlorophyll content of seawater (a measure of phytoplankton abundance) was determined at all sampling locations.

The results of this early study which pertain to Unit 1 alone are presented elsewhere (Barnett and Sertic, 1979). However, information gained during the Unit 1 study has also been used in the second major phase of the Plankton program, assessing the impact of the operation of Units 2 and 3. This phase of the program began in 1979.

Although the studies of Unit 1 did not indicate a significant adverse effect on zooplankton (Barnett and Sertic, 1979), the much greater volume of water both withdrawn and entrained by Units 2 and 3 led MRC contractors to predict that the zooplankton community might indeed be adversely affected. They also predicted that entrainment of bottom water by the diffusers would result in an increase in phytoplankton productivity. The subsequent study of Units 2 and 3, the subject of this report, addressed the questions:

(1) During the period of operation, did standing stocks of zooplankton and phytoplankton change at a site near the Plant (the Impact site) relative to those at a Control site located beyond the influence of the Plant?

(2) Are nearshore zooplankton, particularly those which are found predominantly in the area corresponding to the location of the Unit 2 and 3 diffuser lines, moved offshore by the discharged water from the diffuser?

(3) What amount of zooplankton is killed annually by intake withdrawal?

2 II. METHODS

2.1 A. Sampling Locations

The basic sampling design consisted of sampling along two transects extending offshore (Fig. 1). One transect, the Impact site, was located 500 m north of the Unit 2 and 3 diffuser lines. This location was chosen because (1) it was close to the diffuser lines and therefore in the area of the greatest potential impact, (2) it was away from the area immediately south of the diffuser lines where construction activity in the early portion of the Before period made sampling difficult, and (3) because it had been the Impact site of the Unit 1 studies, it allowed a continuity of the data collected and allowed the use of the early samples in the analysis of effects of Units 2 and 3. The Control transect was located 12 km south of the diffuser lines. Early plume modelling studies indicated that this was beyond any expected influence of the discharge plume.

It should be noted that the longshore current flow past SONGS can move in either an upcoast or downcoast direction. Therefore, since the discharge plume is moved by the longshore current, fixing the location of the Impact site on one side of the diffusers means that the discharge plume may not be present on all sampling dates. However, as will be discussed, the samples are representative of average conditions at the chosen distance from the diffusers. And, the presence of the plume can be factored . . .

On each transect three stations, located on the 8 m, 13 m, and 30 m isobaths, were sampled. These depth contours correspond to (1) the depth of the intake structures, (2) the midpoint of the diffuser lines, and (3) the point at which the faunal break between inshore and more oceanic plankton occurs. On some surveys a fourth location was sampled, the 18 m contour. This location corresponded to approximately 500 m offshore of the seaward end of the Unit 2 diffuser. Because this station was not sampled frequently during the Before period, data from this location were not used in the final analysis of SONGS' effects. Likewise, some samples were taken at the 100 m isobath. However, these data were not used in the analysis because the sampling location was at a distance beyond any potential influence of the Plant's discharge.

At each station three depth strata were sampled: the bottom 1 m of water column (epibenthos), the top 2-3 m of the water column (surface), and the midwater between. The midwater was sampled at two depths (except for the 8 m station where the sample was taken at a depth of 4 m) on each survey. At the 13 m isobath samples were taken at 4 m and 8 m depths. At the 30 m station samples were taken at 8 m and 20 m depths. See Barnett, 1987 for further details.

A single estimate of the mean density of zooplankton in a meter-wide strip of the water column extending from the shoreline to the 30 meter depth contour was obtained in the following manner: The cross-shelf wedge was divided into three blocks (A, B and C), whose dimensions and offshore locations are given in Appendices A and B. The estimated density of a species within a stratum in each block was multiplied by the volume of water in the stratum. The resulting abundances were added across all block/stratum combinations. The mean cross-density was obtained by dividing the combined block/stratum abundances by the total volume of the cross-shelf wedge.

Sampling these various depths and distances offshore allowed us to sample all areas likely to be influenced by the operation of SONGS. Furthermore, the three blocks spanned all or nearly all of the offshore distribution of those species most likely to be at risk from SONGS, those species largely restricted to nearshore areas.

Water samples from each sampling location were analyzed for chlorophyll-a concentration. This measure was used as an index of the abundance of phytoplankton. A cross-shelf average was obtained as above.

B. Sampling Techniques

All zooplankton samples were collected with a plankton pump. At each depth at each sampling location replicate samples of 1 cubic meter were drawn though 0.202 mm mesh netting. The same pumping rate (1 m^3/min) was used at all locations. The material from the replicate samples was pooled and subsampled for analysis. Water samples analyzed for chlorophyll-a concentration were collected by either plankton pump or Van Dorn bottles. Further details concerning the field sampling and laboratory preparation of the samples are described in Barnett, 1987.

C. Sampling Schedule

The dates on which zooplankton samples were collected are presented in Appendix C. The 32 preoperational (Before) samples were collected over a five year period from August 25, 1976 to November 5, 1981. The operating conditions of the three units at SONGS during this period are presented in Appendices C and D. Neither Units 2 nor 3 generated power during the Before period although some water was circulated through Unit 2 during a period of low level testing of the circulating pumps. Table 3 presents the operating conditions of Units 2 and 3 combined on the sampling dates. Note that no power was generated on any of the dates, and that the average number of pumps running on the preoperational sampling dates was 0.17 (the maximum number possible is 8). The average daily number of pumps running in Units 2 and 3 throughout the Before period was 0.28.

Unit 1 was operating during the Before period and the average daily number of pumps and percent power generated throughout this period were 1.4 (2 is the maximum possible) and 48.8%. The average number of pumps and power generated on the Before sampling dates were 1.46 and 51.0% (Appendix D).

The 23 operational (After) samples were taken over a three year period from August 18, 1983 to September 11, 1986 (Appendix C). Throughout this period Units 2 and 3 circulated water. Unit 2 was generating power by July, 1983 and Unit 3 began generating power in September of that year. Throughout the period over which samples were taken, the average number of pumps and average power generated by the combined units were 6.1 and 56.4%, respectively. The number of pumps and power averaged over the specific dates the samples were taken are 6.6 and 70.4%. Unit 1 was also operating during this period. The average daily number of pumps and power generated during the period was 1.1 and 25.6%, and on the sampling dates they were 1.27 and 31.3%.

The projected number of operational samples was determined by a power analysis using the sample variance found in the preoperational samples. We set as our goal having an 80% chance of detecting a 50% reduction in abundance of several of the most abundant zooplankters. After collecting three-quarters of the projected operational samples, analysis indicated that our ability to detect adverse effects would not be significantly aided by further sampling and sampling ceased.

From February, 1977 on, the direction and velocity of the longshore current were measured at SONGS. On 13 of the 32 Before sampling dates, the current flowed downcoast (and the Impact site was "upstream" of the diffusers). On 10 of the 32 dates the current direction was upcoast and the Impact site was "downstream" of the diffusers (current records are not available for the other nine dates). In the After period, there was a downcoast current on 10 of 23 sampling dates and an upcoast current on 11 dates (no records are available for two dates). Throughout the entire study period the longshore current moved downcoast approximately 61% of the time (ECOSystems Management, 1988).

2.4 D. Intake Loss Sampling

There were no special sampling techniques used to estimate intake loss of zooplankton. Sampling within the intake structure was too difficult and had some attendant risk to both sampler and SONGS. Therefore, the samples taken at the 8 m station (the depth of the intake structures) during the monitoring surveys were used for intake loss estimation. Samples from both the Impact and the Control transects were used. Data from both sites were used because use of only Impact samples would bias the estimate because of the incorporation of whatever Plant effects may be present. For example, if plankton were reduced downstream of the intake, samples taken at that location would underestimate the abundances withdrawn. By like token, use of only Control samples would overestimate plankton loss because the impact (reduction in this example) averaged over all current conditions would not be incorporated into the estimate. Furthermore, since the objective was to determine an average yearly loss, using samples from both locations allowed a better estimate of the average abundance within a particular year by increasing the sample size. Details of the estimation procedure are described in the Results section below.

In addition to the surveys listed in Appendix C, data from six other cross-shelf surveys taken between January, 1982 and July, 1983 were incorporated into this estimate. Other additional data used in this estimation come from six surveys from 1985 to 1986 on which intake samples only were collected.

III. RESULTS

A. The Zooplankton Community

The average cross-shelf density (per m^3) of the 21 zooplankton taxa enumerated during the study at both the Control and Impact areas during each of the Before and After periods are presented in Appendix E. Standard errors of the means and the percentage of the total zooplankton each taxon represents at each location/period combination are also presented. Table 1 ranks the taxa by this percentage for both areas during both sampling periods.

The cross-shelf distribution patterns of the zooplankton taxa are presented in Appendix F. The mean density (per m^3) found in each block/stratum combination is presented.

A general description of the community and the natural history of the component taxa is presented elsewhere (Barnett, 1987).

1. BACIP tests on abundance

a. Notes on the presentation of the test results

The BACIP test procedure was used to detect abundance changes in zooplankton (see Interim Technical Report Vol 2, for a discussion of the rationale and design of the Before-After-Control-Impact-Paired test procedure). Note that the BACIP test results presented in this report are those based on the log transformation (of a number of equally appropriate log transformations) which gave the lowest alpha, or most significant result. We recognize that selecting in this manner may overestimate the occurrence of significant test results. However, by following this procedure we feel that all potentially affected species will receive further consideration.

It is also important to note that the reported estimate of percent relative change is based on the geometric means associated with the log transformation used in the BACIP test procedure, and not on the arithmetic means of the abundances observed at the various locations and periods. We therefore present the geometric means in the discussion of the results for each taxon (below). The arithmetic means are presented in Appendix E.

We calculate the percent relative change in the following manner:

The difference between preoperational and operational deltas, symbolically $\Delta\Delta$, based on log transformations, is equal to

$$(\log(t*s*U) - \log(t*k*U)) - (\log(U) - \log(k*U)).$$

U is abundance at SONGS in the Before period. k is the multiplier relating Control abundance to Impact abundance (location effect). If Impact and Control were of equal abundance in the preoperational period, k would have been 1. t is the multiplier due to changes in time, from preoperational to operational periods. t is the same for both Impact and Control. s is the multiplier due to SONGS operation and only affects Impact. If there was a 50% decline s would equal 0.5. In the preceding equation, U and factors k and t cancel out.

Thus,

$\Delta\Delta = \log(s)$.

Back-calculating s from the $\Delta\Delta$, the relative percent change is given by

$(\text{antilog}(\Delta\Delta)-1) \times 100$.

In many cases, the estimate of percent relative change is not precise. Because zero abundances occur at times, a small constant is added to the log transformation. Estimates of percent relative change can be sensitive to the constant chosen, particularly in those species whose survey-by-survey data have a high proportion of zeros at either Impact or Control location. We will present the range of percent changes associated with the transformations which pass the assumption tests of the BACIP procedure. Also note the asymmetry in the reported percent increases and decreases. While a doubling is a 100% increase, a halving is a 50% decrease. Increases can exceed 100%, but decreases cannot. (Percent changes are translated into "factors" or "folds" in Appendix G).

Note that for the species discussed below, detailed BACIP test results, a figure of the survey-by-survey deltas, and either a figure or a listing of the survey-by-survey sampling data are presented in Appendix H.

3.2.2 <u>b. Taxa tested for changes in abundance</u>

3.2.2.1 *Holoplankton*

The BACIP test on abundance was conducted on all taxa enumerated except for two, the copepods *Eucalanus californicus* and *Rhincalanus nasutus*, which were collected on only three Before surveys. Table 2 lists the 14 taxa of holoplankton tested. The combined taxon Total holoplankton was also tested. The significant ($p<0.1$) test results are summarized in Table 3. We also present an estimate of the size of the relative abundance change for these same taxa. Under these criteria of reporting, one species obtained an alpha level of less than .05 (the cladoceran *Evadne spinifera*) and one obtained an alpha level between .05 and .10 (*Evadne nordmanni*).

Evadne spinifera

The BACIP results indicate that the abundance of this cladoceran decreased in the Impact area since the onset of Plant operation. This relatively uncommon species was the only taxon in which a significant decrease was detected. It accounted for 0.86% (at Control) and 0.34% (at Impact) of the zooplankton during the Before period and 0.30% (at Control) and 0.14% (at Impact) during the After period. The geometric mean abundances, percent relative change, and alpha level of the test were:

	Impact	Control	% change	P
Before	5.12	7.12		
After	0.98	4.10	-45 to -66	0.02

This species was the only taxon whose deltas exhibited a significant trend with time in the After period. The trend indicates that the relative decrease observed at Impact became larger with time in the After period (see Appendix H for a figure of the survey-by-survey deltas).

Evadne nordmanni

This cladoceran increased in abundance in the Impact area. It accounted for 1.12% (at Impact) and 1.87% (at Control) of the zooplankton during the Before period and 1.90% (at Impact) and 3.86% (at Control) during the After period. The geometric mean abundances, percent relative change and alpha level of the test (Mann-Whitney U) were:

	Impact	Control	% change	P
Before	12.82	16.45		
After	20.24	15.39	68	0.058

Meroplankton

All taxa enumerated were tested with the BACIP procedure (Table 2). The combined taxon, Total meroplankton, was also tested. A significant ($p<0.05$) result was obtained for Total meroplankton (see Table 3 for summary of results). Other results ($0.05<P<0.10$) were obtained for Cirriped nauplii (a larval stage of barnacles), Cyphonautes larvae (bryozoan larvae), Unidentified meroplankton, ~~and Total meroplankton.~~ All demonstrated relative increases at the Impact site during the After period. The taxa are discussed below in order of their abundance.

Total meroplankton

When all meroplankters are combined, the test result indicates an increase in the Impact area. Meroplankton accounted for 6.3% of the zooplankton when averaged over both sites and periods.

The geometric mean abundances, percent relative change, and alpha level of the test were:

	Impact	Control	% change	P
Before	150.9	195.7		
After	313.2	241.8	64	0.029

Unidentified meroplankton

This taxon is composed of the larval stages of unidentified benthic invertebrates of many taxa. The test result indicates an increase at the Impact site in the After period. During the Before period this taxon accounted for 1.75% (at Impact) and 2.45% (at Control) of the zooplankton, and during the After period it accounted for 6.19% (at Impact) and 3.47% (at Control). The geometric mean abundances, percent relative change, and alpha level of the test were:

	Impact	Control	% change	P
Before	52.54	71.98		
After	164.30	134.10	+ 68	0.07

Cyphonautes larvae

The BACIP results for this combined taxon (the larvae of unidentified bryozoans) indicate an increase in the Impact area. This taxon accounted for 1.89% (at Impact) and 2.85% (at Control) of the zooplankton in the Before period and 2.83% and 2.19% in the After period. The geometric mean abundances, percent relative change, and alpha level of the test (Mann-Whitney U) were:

	Impact	Control	% change	P
Before	60.64	70.19		
After	83.68	70.26	+ 38	0.093

Cirriped nauplii

This taxon, composed of the naupliar stage of unidentified barnacle larvae, increased in abundance in the Impact area. It accounted for 0.69% (at Impact) and 0.46% (at Control) of the zooplankton during the Before period and 0.24% (at Impact) and 0.16% (at Control) during the After period. The geometric mean abundances, percent relative change, and alpha level of the test were:

	Impact	Control	% change	P
Before	10.05	9.86		
After	5.57	2.34	69 to 134	0.054

2. BACIP test using current direction

The preceding BACIP analyses test whether, averaged over all current conditions, the abundance of zooplankton has changed at the Impact site relative to Control. To test whether these results were biased against detecting Plant effects compared to samples taken only when the prevailing longshore current direction places the Impact site "downstream" of the diffusers, we sorted the surveys in both Before and After periods by current direction and performed BACIP tests on the two sets of surveys.

The results are summarized in Appendix I. Because sample sizes are decreased when sorted by current direction, the power of the test is lessened and changes in the alpha levels of the test are not particularly informative. More telling, if consideration of current direction was critical to the detection of Plant effects, are differences in the indicated direction (increase or decrease) of the abundance change. As can be seen, the direction of the indicated abundance change obtained on dates when the longshore current flowed upcoast ("plume" dates), are the same as obtained when data from all samplinng dates are used. These results corroborate the results of the BACIP analyses using all survey dates.

3.2.4 3. Test of hypothesis of 50% decline

One of the goals of the MRC's zooplankton program was to be able to detect 50% reductions in the abundance of plankton in the vicinity of SONGS. When we do not detect a significant effect on a taxon, we can ask: Can we confidently say (at an alpha level of 0.10) that a 50% reduction did not occur? To answer this question we test the null hypothesis of the specified percent reduction (eg. 50% or greater) against the alternative hypothesis of a smaller reduction (or increase). We do so by reducing the Before abundance values found at SONGS by the specified percentage and testing against the After abundance values. (This is akin to the standard statistical procedure of testing a null hypothesis $u = c$ when c does not equal zero, by subtracting c from each sample value.) Had a 50% (or more) decline occurred in the After period, we would fail to reject the null hypothesis. On the other hand, rejection of the null hypothesis demonstrates that the change observed in the BACIP comparison was indeed not a 50% (or greater) reduction (at an alpha level of $P=0.1$). The results of these tests are presented in Appendix J.

3.3 B. Phytoplankton

A significant ($p<0.1$) relative change between Impact and Control in the average cross-shelf concentration of the chlorophyll was not observed. See Appendix H for detailed results of the BACIP test.

3.4

C. Distributional Changes

One of the predicted effects of the operation of SONGS on the zooplankton community was an offshore movement of nearshore individuals by the seaward flow of water entrained by the Plant's discharge. Examination of the distributional patterns of the zooplankton taxa (Appendix B) indicates that most of the taxa enumerated are found across the cross-shelf transect. However, several taxa appear to be somewhat restricted to the areas corresponding to the offshore location of the diffusers (A and B blocks), and these taxa are the ones expected to be at greatest risk to offshore movement. Specifically, the copepods *Acartia clausi* and *Oithonna occulata*, Cypris larvae, and the cladocerans *Evadne nordmanni* and *Podon polyphemoides*, appeared to be found predominantly in the A and B blocks in the Before period. *Oithonna occulata* was the taxon which had the most restrictive nearshore distribution in the Before period with most individuals found in A block. The expected action of the discharge was to move plankton from A to B Block and from AB Block to C block.

We tested for distributional shifts by comparing the proportions of the cross-shelf abundances found in the offshore blocks at both Control and Impact in both the Before and After periods.

The test procedure is as follows: On each survey the abundances in A and B block are combined. These data and the abundance in C block are then transformed (log transformations). The C abundance value is then subtracted from the AB abundance value. The resulting difference from the Control line is then subtracted from the corresponding difference from the Impact line. These final differences (or deltas) from the Before surveys are compared to those from the

After surveys using the BACIP procedure.

The same taxa tested for changes in abundance were tested for changes in cross-shelf distribution. Two taxa demonstrated a change: Total Zooplankton (p=0.036) and Cypris larvae (p=0.05). Both of these taxa displayed a greater relative proportion in the nearshore AB block at the Impact site than at the Control site during the After period.

The percentages of Total Zooplankton in the AB blocks were:

	Control	Impact
Before	59.1	51.1
After	50.5	56.6

The percentages of Cypris larvae in the AB block were:

	Control	Impact
Before	62.0	78.0
After	78.5	84.6

Please note that the percentages shown here (and below) are those of the abundances summed over all surveys. The test, however, was performed on survey-by-survey distribution data as described above.

A second analysis, using the same procedure, was performed testing for shifts between A and B block. Again, the same taxa were tested and two displayed significant changes in the relative proportions found in A and B block, Cypris larvae ($p = 0.008$) and Unid. meroplankton ($p = 0.041$). Both of these taxa demonstrated an increase in the relative proportion found in B block on the Impact transect in the After period.

The percentage of Cypris larvae found in B block was:

	Control	Impact
Before	68.7	48.8
After	38.0	72.3

The percentage of unidentified meroplankton found in B block was:

	Control	Impact
Before	85.4	74.6
After	76.8	77.0

2.5 D. Estimation of Intake Loss

The average annual loss to intake withdrawal was calculated by averaging the density of plankton in the water column at or near the intake depth over several years and then multiplying this number by the volume of water withdrawn under specific operating conditions and periods.

In general, plankton abundances have strong seasonal patterns. In the face of such seasonality, the estimate of the yearly average would be influenced by the relative number of samples taken during periods of low and high abundance. To avoid this potential bias, the year was divided into two seasons, fall-winter (September-February) and spring-summer (March-August), and two seasonal averages determined for each year. These seasonal averages were then averaged to give the average "intake density" for that year. Table 4 presents the seasonal average intake densities of Total Zooplankton for the years 1976 through 1986 (except 1981 when too few samples were taken).

The average annual density was obtained by averaging over all years. This density was then multiplied by the volume of water withdrawn to arrive at the average annual intake loss. In making this estimate we have assumed that there will be no large seasonal difference in the long-term pumping rates of the new units. During the After period the average daily pumping rates for the two seasons were 70% (fall-winter) and 83% (spring-summer). If these seasonal differences in pumping rates continue, and if spring-summer plankton abundances continue to be, on average, greater than fall-winter, the procedure followed underestimates the loss by approximately 5%.

While the majority of the water withdrawn by the Plant is from the mid-water stratum of the water column, other strata must also be at risk during periods when the column is mixed (during storm periods, for example). To bracket the true proportion of the water column at risk we have made two different estimates of intake density (Table 4). One is based on the densities of plankton found in the mid-water stratum only. The second estimate incorporates densities from all strata of the water column.

Table 5 presents the average annual intake loss estimates of zooplankton. (For a complete list of estimates for each taxon and the equations used in the calculation, see Barnett, 1987.) One estimate is based on the average volume of water circulated during the After period (mid-1983 through 1986). This corresponds to six of the eight pumps in operation. The second estimate is based on the maximum volume of water potentially circulated through the plant. The estimated average annual loss of zooplankton (when six pumps are operating) is approximately 1.2×10^{13} plankters per year. This number can be converted to biomass by multiplying by the dry weight of the average individual plankter withdrawn by SONGS (calculated as 0.084 mg/individual; see Barnett and Jahn, 1987). The average annual loss is approximately 900 metric tons of biomass.

We should note that these estimates are for the macrozooplankton (zooplankton caught on 0.202 mm mesh) and do not include an estimate of the amount of microzooplankton withdrawn. The MRC did not address the question of microzooplankton loss directly. However, a rough estimate can be made using published values of microzooplankton abundances in the nearshore waters of Southern California. Strickland (1967) measured an average of 5.9 mg carbon of microzooplankton/m^3 near La Jolla, California (approximately 65 km south of

SONGS). Using this value, the estimate of microzooplankton lost to SONGS pumping at 75% of maximum would be approximately 325 metric tons/year (see Appendix J for calculations).

4

IV. DISCUSSION

4.1

A. SONGS' Effects on Abundance

The central question asked by the MRC's zooplankton program was: does the operation of SONGS result in a large, on the order of 50% or more, decrease in the standing stock of zooplankton in the vicinity of the plant? The effect for which we tested did not occur. Large decreases in the zooplankton community were not observed.

However, when considered on a taxon-by-taxon basis, changes in abundance were observed. Three of the taxa which exhibited abundance changes are composed of the larvae of benthic invertebrates. The taxa are: the naupliar stage of barnacle larvae; the larvae of bryozoans (cyphonautes larvae); and Unidentified Meroplankton, a collection of the larvae of other benthic groups (tunicates, molluscs, etc.). All of these taxa exhibited relative increases in abundance in the Impact area ranging in size from 35 to 135%.

The other taxa which showed significant results in the analysis of relative abundances were two species of cladocerans, *Evadne nordmanni* and *Evadne spinifera*. While similar taxonomically, their abundances changed differently. *E. nordmanni* increased in the Impact area and *E spinifera* decreased.

The increases in relative abundance at the Impact site are somewhat unexpected (although some increases were observed in samples taken very near Unit 1 in the study of its effects; see Barnett and Sertic, 1979). One possible mechanism which could account for the increases in the meroplanktonic taxa at the Impact site is a localized increase in the source of the larvae. The insides of the diffuser lines are colonized by large numbers of benthic invertebrates whose reproductive products and larvae are released into the discharge stream. Additional surfaces for these animals are afforded by the rip-rap and diffuser lines themselves. Perhaps these populations of adult barnacles, bryozoans and other benthic animals have subsequently increased the number of their larvae in the immediate area.

The abundance changes of the two cladocerans are more difficult to relate to SONGS activity. The increased relative abundance of *Evadne nordmanni* is difficult to explain. If the Plant is making the Impact area "better" in some way for this cladoceran it is difficult to imagine what process is involved. Because of the relatively short time that any plankter resides in the area near SONGS, it is hard to imagine that any biological process (eg. growth, reproduction, competition with or predation by another species) would occur fast enough to result in a locally detected increase in abundance of this planktonic species.

Assigning a mechanism that results in the observed decrease in *Evadne spinifera* is equally difficult. Particularly intriguing is the occurrence of the trend with time in the After deltas. This implies that the Impact area is somehow worsening in time with respect to this animal. But it is difficult to hypothesize what factors accumulate and how they do so to make an area progressively unattractive to a planktonic organism.

4.2 B. Distributional Changes

There is evidence that relative shifts in the cross-shelf distributions of some taxa have occurred at the Impact site since the onset of Plant operation. However, these shifts do not indicate movement of large numbers of individuals out of areas of restricted nearshore abundance. The two instances where significant offshore movements, as expressed by the proportion of the cross-shelf number present in a block, were detected involve the movement of Unidentified meroplankton and Cypris larvae from the nearshore block (A) to the adjacent offshore block (B).

This seaward shift in the distribution of these two taxa is consistent with the expectation that the water entrained by the discharge of SONGS would move nearshore plankton offshore. An alternative mechanism, however, can be posed. The increase in the B block proportion of these larvae of benthic invertebrates may result from an increase in the adult local population. A portion of the B block corresponds to the diffuser depths. Perhaps the increased amount of hard substrate made available by the diffuser lines and associated rip-rap has increased the source of these larvae in the area.

This alternative mechanism is more tenable for the meroplankton than the cypris larvae, however. The cypris larva is the last stage in the planktonic portion of the barnacle's life cycle. The young of most barnacle species are released as younger naupliar stages, and the residence time of water near the Impact site is much less than the time necessary for a locally released larvae to mature through several naupliar stages to the cypris stage. It is more likely, therefore, that the shift in the cypris distribution is indeed the result of the offshore movement of nearshore waters by the action of the diffusers.

Does this shift in distribution adversely affect the larvae? While this question has not been experimentally addressed, it seems unlikely. Cypris larvae normally occur in the region where they have increased in the Impact area and it is unlikely that the area represents a particularly inhospitable environment. Again, however, there is no direct evidence either for or against any increased mortality associated with being displaced offshore to the distance we have detected.

Comparisons of the proportions of abundance in the two combined nearshore blocks (A and B) to those found in the block further offshore (C) indicate that the distributions of two taxa, Total zooplankton and Cypris larvae, have shifted shoreward at the Impact site. While this may indicate that the larvae are being moved shoreward by some as yet undocumented water movement, it more likely reflects not a movement but a general increase in abundance of the zooplankton in these blocks at the Impact site.

While Cypris larvae and Unidentified meroplankton appear to shift from A to B block, movement from AB to C block is not detected. This accords with the observed behavior of the discharge plume. Most of the water in AB block that encounters the plume is not displaced much beyond the offshore end of the Unit 2 diffuser. (The nearshore boundary of C block is approximately 500 m seaward of this point.)

In summary, although the Plant kills approximately 900 metric tons of zooplankton a year, this loss is insufficient to cause large reductions in the local standing stocks. In fact, there is some evidence that some select zooplankton taxa have increased near the Plant. The offshore movement of the nearshore zooplankton that occurs from entrainment of the discharge waters does not appear to be great enough to result in either large scale shifts in the cross-shelf distribution or in local population reductions.

V. REFERENCES

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TABLES

TABLE 1: Zooplankton taxa in order of % abundance

DBMACZP.CRØØ3 - DBMACZP.CR213	MRC Databases
ZOSTRATA SAS	SAS Program
ZOBACI.STRAT	temporary Database
ZOXshelf SAS	SAS Program
ZOBACI.XSHELF1	temporary Database
ISParse EXEC	SAS Program
ZOBACI.XShelf1Ø	temporary Database
Rank_IZ SAS	SAS Program

255.90

~~256.90~~

i ~~188.00~~

i+d ~~262.12~~

TABLE 1. THE ZOOPLANKTON COMMUNITY, IN ORDER OF % ABUNDANCE.

PREOPERATIONAL

RANK	SONGS	% ABUN-DANCE	RANK	CONTROL	% ABUN-DANCE
1	*Acartia tonsa*	36.76	1	*Acartia tonsa*	30.12
2	*Paracalanus parvus*	19.20	2	*Paracalanus parvus*	16.12
3	Unid. holoplankton	11.45	3	Unid. holoplankton	13.97
4	*Podon polyphemoides*	6.36	4	*Penilia avirostris*	10.25
5	*Penilia avirostris*	5.91	5	*Podon polyphemoides*	7.20
6	*Corycaeus anglicus*	5.52	6	*Corycaeus anglicus*	5.22
7	*Sagitta euneritica*	3.90	7	*Sagitta euneritica*	4.02
8	Cyphonautes larvae	1.89	8	Cyphonautes larvae	2.85
9	Unid. meroplankton	1.75	9	Unid. meroplankton	2.45
10	*Oithona plumifera*	1.47	10	*Oithona plumifera*	2.23
11	*Labidocera trispinosa*	1.19	11	*Evadne nordmanni*	1.87
12	*Evadne nordmanni*	1.12	12	*Evadne spinifera*	0.87
13	*Calanus pacificus*	0.92	13	*Calanus pacificus*	0.79
14	*Acartia clausi*	0.74	14	*Labidocera trispinosa*	0.75
15	Cirriped nauplii	0.69	15	Cirriped nauplii	0.46
16	*Evadne spinifera*	0.34	16	*Acartia clausi*	0.28
17	Unid. others	0.22	17	Cypris larvae	0.24
18	Cypris larvae	0.22	18	*Oithona oculata*	0.11
19	*Rhincalanus nasutus*	0.19	19	Unid. others	0.11
20	*Oithona oculata*	0.17	20	*Rhincalanus nasutus*	0.07
21	*Eucalanus californicus*	< 0.01	21	*Eucalanus californicus*	0.01
~~22~~	~~Unid. meroplankton~~	~~<0.01~~	~~22~~	~~Unid. meroplankton~~	~~<0.01~~

TABLE 1. (Continued)

OPERATIONAL

RANK	SONGS	% ABUNDANCE	RANK	CONTROL	% ABUNDANCE
1	*Acartia tonsa*	33.38	1	*Acartia tonsa*	31.40
2	*Paracalanus parvus*	20.23	2	*Paracalanus parvus*	21.88
3	Unid. holoplankton	14.24	3	Unid. holoplankton	15.14
4	*Corycaeus anglicus*	7.76	4	*Corycaeus anglicus*	10.07
5	Unid. meroplankton	6.19	5	*Evadne nordmanni*	3.86
6	*Sagitta euneritica*	3.19	6	*Sagitta euneritica*	3.54
7	*Podon polyphemoides*	3.10	7	Unid. meroplankton	3.47
8	Cyphonautes larvae	2.83	8	*Podon polyphemoides*	3.36
9	*Oithona plumifera*	2.80	9	*Oithona plumifera*	2.30
10	*Calanus pacificus*	2.63	10	Cyphonautes larvae	2.20
11	*Evadne nordmanni*	1.90	11	*Calanus pacificus*	1.65
12	*Labidocera trispinosa*	0.89	12	*Labidocera trispinosa*	0.43
13	Cirriped nauplii	0.24	13	*Evadne spinifera*	0.30
14	Cypris larvae	0.18	14	Cirriped nauplii	0.16
15	Unid. others	0.14	15	Cypris larvae	0.13
16	*Evadne spinifera*	0.14	16	Unid. others	0.10
17	*Oithona oculata*	0.12	17	*Oithona oculata*	0.01
18	*Acartia clausi*	0.05	18	*Acartia clausi*	0.01
19	*Rhincalanus nasutus*	0.01	19	*Rhincalanus nasutus*	<0.01
20	*Eucalanus californicus*	0.01	20	*Eucalanus californicus*	<0.01
21	*Penilia avirostris*	<0.01	21	*Penilia avirostris*	<0.01

TABLE 2 Zooplankton taxa in order of % abundance

DBMACZP.CRØØ3 - DBMACZP.CR213	MRC Databases
ZOSTRATA SAS	SAS Program
ZOBACI.STRAT	temporary Database
ZOXshelf SAS	SAS Program
ZOBACI.XSHELF1	temporary Database
ISparse FXFC	SAS Program
ZOBACI.Xshelf1Ø	temporary Database
Rank_IZ SAS	SAS Program

TABLE 2. ZOOPLANKTON TAXA TESTED FOR CHANGES IN ABUNDANCE. The direction of change for all species, regardless of alpha level of the test, is indicated (d = decrease, i = increase). Question marks indicate that the direction of could not be determined. N is the frequency of occurrence.

TAXON	DIRECTION OF CHANGE	N
Holoplankton		
Acartia clausi	i	54
A. tonsa	d	54
Calanus pacificus	i	54
Corycaeus anglicus	d	54
Evadne nordmanni	i*	54
E. spinifera	d**	54
Labidocera trispinosa	i	54
Oithona oculata	?	54
O. plumifera	i	54
Paracalanus parvus	d	54
Penilia avirostris	i	54
Podon polyphemoides	i	54
Sagitta euneritica	i	54
Unid. holoplankton	i	42
Total holoplankton	i	41
Meroplanton		
Cirriped nauplii	i*	42
Cyphonautes larvae	i*	54
Cypris larvae	i	54
Unid. meroplankton	i*	42
Total meroplankton	i**	41

** $p<0.05$
* 0.05> p 0.10<

Table 3: BACIP test results

DBMACZP.CRØØ3 – DBMACZP.CR213	MRC Databases
ZOSTRATA SAS	SAS program
ZOBACI.STRAT	temporary database
ZOXshelf SAS	SAS program
ZOBACI.XShelf1	temporary database
BACIP1 SAS	SAS program

TABLE 3. BACIP TEST RESULTS ($p < 0.10$) FOR ZOOPLANKTON. Often more than one transformation passed assumption tests and was appropriate for BACIP testing (see Appendix H). Shown here are the test results and estimate of percent relative change for the transformation with the lowest alpha.

TAXON	df	TRANSFORMATION	P>t	% CHANGE
Holoplankton				
Evadne spinifera	39	log(x+0.01)	0.023	-51
Evadne nordmanni	50	log(X+0.1)	0.058	+68
Meroplankton				
Cyphonautes larvae	52	log(X+1)	0.093	+38
Cirriped nauplii	40	log(X)	0.054	+134
Unidentified meroplankton	40	log(X)	0.070	+67
Total meroplankton	40	log(XX+100)	0.029	+45

TABLE 4. SEASONAL AVERAGE INTAKE DENSITIES OF ZOOPLANKTON, 1976-1986. Mean and standard error of total number of plankters/ m^3 at intake depth for two seasons (fall-winter, and spring-summer). N = number of samples on which the estimate is based. Two estimates are given, one based on densities in the midwater stratum only the other on densities througout the entire water column. Insufficient samples were taken to make midwater only estimates in 1978 and spring-summer of 1979.

YEAR	SEASON	MEAN DENSITY Midwater Only	N	Entire Column	N
1976	f-w	2952 (1952)	4	2133 (1196)	4
	s-s	5284 (1856)	4	5445 (1815)	4
1977	f-w	1184 (235)	4	2218 (336)	4
	s-s	16493 (8047)	6	15557 (7786)	5
1978	f-w	-		3021 (450)	9
	s-s	-		3852 (1304)	6
1979	f-w	2421 (354)	3	5078 (1110)	10
	s-s	-		5192 (1142)	13
1980	f-w	5364 (2324)	4	7867 (1291)	4
	s-s	5603 (1407)	6	8366 (1084)	6
1982	f-w	3755 (614)	2	3201 (93)	2
	s-s	6163 (4174)	2	7658 (217)	2
1983	f-w	2951 (335)	2	4455 (1818)	2
	s-s	1692 (527)	2	2034 (602)	2
1984	f-w	2749 (471)	4	2786 (548)	4
	s-s	1546 (701)	3	3120 (553)	3
1985	f-w	1272 (401)	5	1766 (507)	5
	s-s	6655 (1944)	7	7790 (882)	7
1986	f-w	2627 (927)	4	2250 (694)	4
	s-s	17248 (12760)	4	14957 (6970)	4

TABLE 5. AVERAGE ANNUAL INTAKE LOSS OF ZOOPLANKTON. The mean (and standard error) of intake loss based on two circulating water volumes and on two sources of intake water. The numbers are 10^{12}, or trillions, of plankton. N for the midwater only estimate is 9, for the entire water column, 10.

TAXON	INTAKE SOURCE	CIRCULATING WATER 75%	CIRCULATING WATER 100%
Total zooplankton	midwater	11.02 (2.49)	14.70 (3.31)
	entire column	13.06 (1.23)	17.42 (1.64)
Total holoplankton	midwater	9.95 (2.45)	13.26 (3.26)
	entire column	12.05 (1.23)	16.06 (1.64)
Total meroplankton	midwater	1.07 (0.20)	1.43 (0.27)
	entire column	1.01 (0.13)	1.36 (0.17)

FIGURES

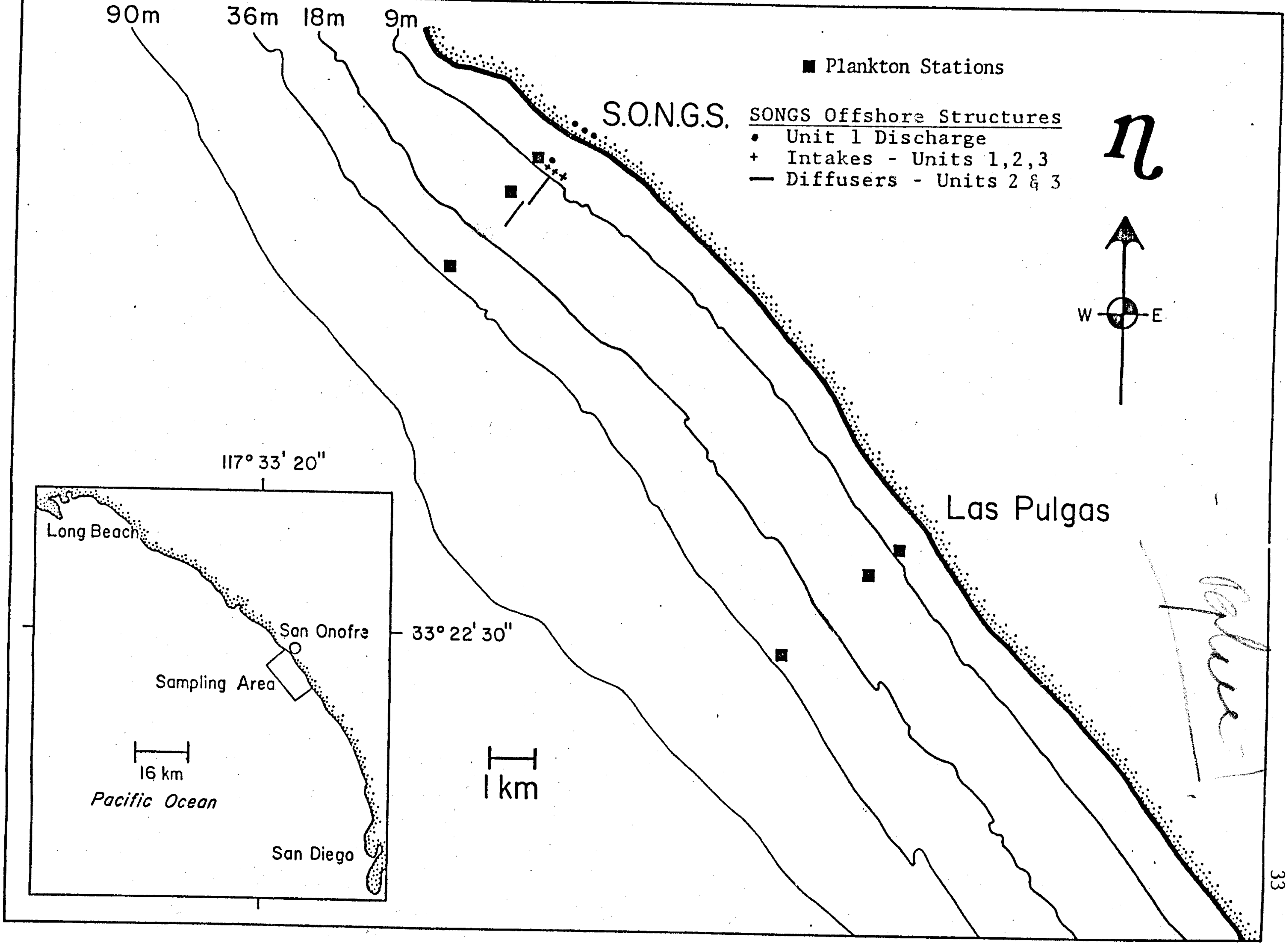


Figure 1. Locations of stations sampled for plankton.

APPENDICES

APPENDIX A. BOUNDARIES OF THE BLOCKS OF THE CROSS-SHELF TRANSECTS.

Block	Distance offshore (m)	Depth contours (m)
A	shoreline - 1370	0 - 10.5
B	1370 - 3070	10.5 - 18
C	3070 - 4140	18 - 30

APPENDIX B. VOLUME OF WATER (IN M^3) IN THE BLOCKS AND STRATA OF A METER-WIDE STRIP OF CROSS-SHELF TRANSECT.

STRATUM	BLOCK		
	A	B	C
Surface	2500	4250	3745
High Midwater	5188	7100	8025
Low Midwater	-	11238	12840
Epibenthos	1000	1700	1070
Total	8688	24288	25680

GRAND TOTAL 58656

APPENDIX C. OPERATION OF UNITS 2 AND 3 ON ZOOPLANKTON SAMPLING DATES.

Date	Pumps*	% Power
Preoperational		
25 AUG 76	0.0	0
26 AUG 76	0.0	0
15 SEP 76	0.0	0
17 SEP 76	0.0	0
4 NOV 76	0.0	0
11 JAN 77	0.0	0
13 JAN 77	0.0	0
23 MAR 77	0.0	0
7 JUN 77	0.0	0
9 JUN 77	0.0	0
2 NOV 77	0.0	0
20 JAN 78	0.0	0
31 MAY 78	0.0	0
27 JUL 78	0.0	0
24 AUG 78	0.0	0
15 SEP 78	0.0	0
10 JAN 79	0.0	0
27 NOV 79	0.0	0
20 DEC 79	0.0	0
24 JAN 80	0.0	0
25 FEB 80	0.0	0
23 MAR 80	0.0	0
29 APR 80	0.8	0
29 MAY 80	1.0	0
29 JUN 80	1.0	0
31 JUL 80	0.7	0
31 AUG 80	1.0	0
25 SEP 80	1.0	0
29 OCT 80	0.0	0
24 JUN 81	0.0	0
5 AUG 81	0.0	0
5 NOV 81	0.0	0
MEAN	0.17	0

Date		Pumps*	% Power
Operational			
18 AUG 83		6	50
5 DEC 83		4	50
7 FEB 84	-2.6	1	0
11 MAY 84	12.6 *	5	50
8 JUN 84	-3.6 *	8	100
31 AUG 84	-5.5 *	8	100
28 SEP 84	-22.3	8	100
18 OCT 84	1.0	8	92
14 DEC 84	-8.9	4	50
18 JAN 85	-2.1 *	4	50
26 MAR 85	4.8	6	50
19 APR 85	-5.6	8	62
16 MAY 85	-10.8	8	100
7 JUN 85	-10.5	8	100
2 JUL 85	10.1	8	78
30 JUL 85	1.9	8	78
30 AUG 85	0.6	8	78
11 FEB 86	3.3	8	98
9 MAR 86	-3.8 *	6	35
9 MAY 86	-9.1	4	50
3 JUN 86	-8.3	7	50
3 JUL 86	15.5	8	100
11 SEP 86	-2.8	8	97
MEAN		6.6	70.4

* upcoast during afternoon

* Maximum number of pumps is 8; flow rate for each pump is about 207,000 gallons per minute.

APPENDIX D. OPERATION OF UNIT 1 ON ZOOPLANKTON SAMPLING DATES.

Date	Pumps*	% Power	Date	Pumps*	% Power
Preoperational			Operational		
25 AUG 76	2.0	78	18 AUG 83	2.0	0
26 AUG 76	2.0	78	5 DEC 83	1.7	0
15 SEP 76	2.0	68	7 FEB 84	2.0	0
17 SEP 76	2.0	68	11 MAY 84	2.0	0
4 NOV 76	1.0	0	8 JUN 84	0.0	0
11 JAN 77	0.0	0	31 AUG 84	0.0	0
13 JAN 77	0.0	0	28 SEP 84	0.0	0
23 MAY 77	2.0	0	18 OCT 84	2.0	0
7 JUN 77	2.0	99	14 DEC 84	1.0	87
9 JUN 77	2.0	77	18 JAN 85	2.0	93
2 NOV 77	1.0	45	26 MAR 85	2.0	87
20 JAN 78	2.0	97	19 APR 85	2.0	89
31 MAY 78	2.0	54	16 MAY 85	2.0	84
27 JUL 78	2.0	97	7 JUN 85	2.0	93
24 AUG 78	2.0	88	2 JUL 85	2.0	93
15 SEP 78	2.0	65	30 JUL 85	2.0	93
10 JAN 79	2.0	95	30 AUG 85	1.0	0
27 NOV 79	2.0	95	11 FEB 86	0.0	0
20 DEC 79	2.0	92	9 MAR 86	0.0	0
24 JAN 80	2.0	92	9 MAY 86	0.0	0
25 FEB 80	2.0	95	3 JUN 86	0.6	0
23 MAR 80	2.0	88	3 JUL 86	2.0	0
29 APR 80	0.0	0	11 SEP 86	1.0	0
29 MAY 80	0.2	0			
29 JUN 80	1.5	0			
31 JUL 80	0.2	0			
31 AUG 80	2.0	0			
25 SEP 80	0.7	0			
29 OCT 80	0.0	0			
24 JUN 81	2.0	81			
5 AUG 81	0.0	0			
5 NOV 81	2.0	82			
MEAN	1.46	51	MEAN	1.27	31.26

* Maximum number of pumps is 2; flow rate for each pump is 160,000 gallons per minute.

APPENDIX E. Zooplankton abundances. Mean cross-shelf density (per m^3) during preoperational and operational periods.

DBMACZP.CRØØ3 - DBMACZP.CR213	MRC Databases
ZO-STRATA SAS	SAS program
ZOBACI.STRAT	temporary database
ZOXshelf SAS	SAS program
ZOBACI.XSHElf1	temporary Database
ISParse EXEC	SAS program
ZOBACI.XShelf1Ø	temporary Database
I-ZMNTPL SAS	SAS Program

APPENDIX E. ZOOPLANKTON ABUNDANCES. Mean cross-shelf density (per m^3) during preoperational and operational periods. Standard errors of the mean and the percentage of the total zooplankton accounted for by the taxon is given. The number of surveys on which the taxon was found at either Contol or Impact site is presented in the right hand column.

A note concerning the taxa listed. The taxa are mutually exclusive. Plankters were indentified to species where possible. If species could not be determined, larvae were assigned to more inclusive taxa.

Appendix E. (Continued)

SPECIES	PERIOD	MEAN AT SONGS	STANDARD ERROR	PERCENT AT SONGS	MEAN AT CONTROL	STANDARD ERROR	PERCENT CONTROL	SURVEYS W/OCCURRENCES AT SONGS OR CONTROL
Acartia clausi	op	2.64	1.43	0.05	0.32	0.28	0.01	23
	pre-op	32.42	13.07	0.74	11.24	3.38	0.28	31
	diff	-29.78			-10.92			
Acartia tonsa	op	1779.34	404.73	33.38	1544.56	366.76	31.40	23
	pre-op	1605.45	281.73	36.76	1188.82	183.40	30.12	31
	diff	173.89			355.74			
Calanus pacificus	op	140.13	55.27	2.63	81.06	25.39	1.65	23
	pre-op	40.21	12.46	0.92	31.32	9.74	0.79	24
	diff	99.91			49.74			
Cirriped nauplii	op	12.76	3.08	0.24	7.63	2.46	0.16	23
	pre-op	30.18	14.63	0.69	17.99	5.04	0.46	19
	diff	-17.42			-10.36			
Corycaeus anglicus	op	413.43	54.17	7.76	495.33	85.52	10.07	23
	pre-op	241.06	45.72	5.52	206.16	31.18	5.22	31
	diff	172.37			289.17			
Cyphonautes larvae	op	150.60	33.74	2.83	108.13	21.92	2.20	23
	pre-op	82.46	10.98	1.89	112.50	18.22	2.85	31
	diff	68.14			-4.37			
Cypris larvae	op	9.33	3.20	0.18	6.17	2.02	0.13	23
	pre-op	9.42	2.13	0.22	9.42	2.06	0.24	31
	diff	-0.08			-3.25			
Eucalanus californicus	op	0.40	0.22	0.01	0.19	0.15	0.00	23
	pre-op	0.00	0.00	0.00	0.42	0.42	0.01	3
	diff	0.40			-0.22			

Appendix E. (Continued)

SPECIES	PERIOD	MEAN AT SONGS	STANDARD ERROR	PERCENT AT SONGS	MEAN AT CONTROL	STANDARD ERROR	PERCENT CONTROL	SURVEYS W/OCCURRENCES AT SONGS OR CONTROL
Evadne nordmanni	op	101.21	34.33	1.90	190.05	94.59	3.86	23
	pre-op	48.75	19.85	1.12	73.93	27.59	1.87	31
	diff	52.46			116.12			
Evadne spinifera	op	7.22	4.22	0.14	14.81	7.58	0.30	23
	pre-op	14.72	3.78	0.34	34.19	11.33	0.87	31
	diff	-7.50			-19.38			
Labidocera trispinosa	op	47.40	20.31	0.89	20.95	4.81	0.43	23
	pre-op	51.96	18.21	1.19	29.48	5.50	0.75	31
	diff	-4.56			-8.53			
Oithona oculata	op	6.17	5.10	0.12	0.60	0.21	0.01	23
	pre-op	7.39	2.71	0.17	4.47	2.66	0.11	31
	diff	-1.22			-3.87			
Oithona plumifera	op	149.23	51.93	2.80	112.95	21.04	2.30	23
	pre-op	64.18	9.29	1.47	88.20	21.47	2.23	31
	diff	85.05			24.75			
Paracalanus parvus	op	1078.12	174.40	20.23	1076.40	161.20	21.88	23
	pre-op	838.53	188.52	19.20	636.11	91.24	16.12	31
	diff	239.59			440.29			
Penilia avirostris	op	0.07	0.05	0.00	0.07	0.05	0.00	23
	pre-op	258.30	108.97	5.91	404.42	175.62	10.25	31
	diff	-258.23			-404.36			
Podon polyphemoides	op	165.28	158.00	3.10	165.13	160.95	3.36	23
	pre-op	277.66	175.57	6.36	284.25	205.50	7.20	31
	diff	-112.38			-119.12			

Appendix E. (Continued)

SPECIES	PERIOD	MEAN AT SONGS	STANDARD ERROR	PERCENT AT SONGS	MEAN AT CONTROL	STANDARD ERROR	PERCENT CONTROL	SURVEYS W/OCCURRENCES AT SONGS OR CONTROL
Rhincalanus nasutus	op	0.77	0.37	0.01	0.19	0.08	0.00	23
	pre-op	8.32	4.82	0.19	2.69	2.63	0.07	3
	diff	-7.56			-2.50			
Sagitta euneritica	op	169.85	51.24	3.19	174.24	54.73	3.54	23
	pre-op	170.36	40.48	3.90	158.76	33.96	4.02	31
	diff	-0.51			15.48			
Unid. holoplankton	op	759.00	122.28	14.24	745.02	149.09	15.14	23
	pre-op	500.09	64.27	11.45	551.29	117.01	13.97	19
	diff	258.92			193.73			
Unid. meroplankton	op	329.96	125.26	6.19	170.59	27.66	3.47	23
	pre-op	76.65	16.20	1.75	96.71	16.89	2.45	19
	diff	253.31			73.88			
Unid. others	op	7.34	2.22	0.14	5.15	1.47	0.10	23
	pre-op	9.47	2.99	0.22	4.16	0.80	0.11	19
	diff	-2.13			0.99			
Total holoplankton	op	4835.30	639.01	90.58	4633.60	747.97	94.06	23
	pre-op	4421.99	788.30	95.45	3968.61	593.74	93.87	18
	diff	413.31			664.99			
Total meroplankton	op	502.66	141.40	9.42	292.51	37.32	5.94	23
	pre-op	210.55	40.95	4.55	259.36	37.66	6.13	18
	diff	292.10			33.15			

APPENDIX F: Zooplankton Distribution.
mean density (per m³) in individual
strata at Impact and Control

DBMACZP.CRØØ3 - DBMACZP.CR213	MRC Databases
ZOSTRATA SAS	SAS program
ZOBACI.STRAT	temporary database
ISPAPSC EXEC	SAS program
ZOBACI.STRATØ	temporary database
ZMNSTB3 SAS	SAS program

APPENDIX F. ZOOPLANKTON DISTRIBUTION. Mean density (per m^3) in individual strata at Impact and Control. Subsurface (S) is the top 1 m of the water column of all blocks. Epibenthos (E) is bottom 1 m in all blocks. Water column in between is divided into two layers, high (HM) and low (LM) midwater. A block midwater was not divided into two layers.

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Acartia clausi

CONTROL

		A	B	C
S	op	2.55	0.00	0.00
S	pre-op	23.60	6.28	0.26
	diff	-21.05	-6.28	-0.26
HM	op	0.00	0.00	0.00
HM	pre-op	30.54	9.49	0.12
	diff	-30.54	-9.49	-0.12
LM	op	0.00	0.00	0.00
LM	pre-op	0.00	5.53	4.66
	diff	0.00	-5.53	-4.66
E	op	11.30	0.64	0.04
E	pre-op	116.00	62.48	1.58
	diff	-104.70	-61.84	-1.55

Acartia clausi

SONGS

		A	B	C
S	op	1.57	0.00	0.00
S	pre-op	140.28	0.99	0.17
	diff	-138.70	-0.99	-0.17
HM	op	4.72	0.00	0.00
HM	pre-op	79.65	0.42	0.74
	diff	-74.93	-0.42	-0.74
LM	op	0.00	0.04	0.00
LM	pre-op	0.00	7.41	0.55
	diff	0.00	-7.37	-0.55
E	op	125.04	0.44	0.00
E	pre-op	368.76	365.76	40.35
	diff	-243.72	-365.32	-40.35

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Acartia tonsa

CONTROL

		A	B	C
S	op	288.71	1157.02	282.86
S	pre-op	571.58	433.25	249.48
	diff	-282.86	723.76	33.38
HM	op	697.59	1252.61	1646.37
HM	pre-op	1327.33	1513.02	1326.25
	diff	-629.73	-260.42	320.12
LM	op	0.00	2234.18	1981.22
LM	pre-op	0.00	1174.39	950.94
	diff	0.00	1059.79	1030.28
E	op	3411.61	2347.30	211.13
E	pre-op	4452.82	4151.30	314.93
	diff	-1041.21	-1804.00	-103.80

Acartia tonsa

SONGS

		A	B	C
S	op	896.87	651.02	212.07
S	pre-op	799.41	455.16	491.05
	diff	97.46	195.86	-278.99
HM	op	2509.84	2312.84	808.22
HM	pre-op	978.58	1731.16	2370.41
	diff	1531.26	581.69	-1562.19
LM	op	0.00	2423.85	2210.45
LM	pre-op	0.00	2115.51	1578.64
	diff	0.00	308.34	631.82
E	op	3642.87	1864.89	190.15
E	pre-op	3834.22	2231.70	313.05
	diff	-191.35	-366.81	-122.89

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Calanus pacificus

CONTROL

		A	B	C
S	op	1.17	5.67	14.35
S	pre-op	0.39	1.74	8.74
	diff	0.78	3.94	5.61
HM	op	0.90	12.82	88.87
HM	pre-op	0.51	4.01	52.62
	diff	0.39	8.82	36.25
LM	op	0.00	22.97	277.31
LM	pre-op	0.00	7.37	94.35
	diff	0.00	15.61	182.95
E	op	1.17	12.10	22.56
E	pre-op	0.87	11.38	26.10
	diff	0.30	0.72	-3.54

Calanus pacificus

SONGS

		A	B	C
S	op	1.67	4.43	8.27
S	pre-op	1.37	2.75	19.33
	diff	0.30	1.68	-11.07
HM	op	3.69	13.66	149.60
HM	pre-op	1.06	8.88	47.91
	diff	2.63	4.78	101.69
LM	op	0.00	11.87	516.58
LM	pre-op	0.00	6.15	133.09
	diff	0.00	5.72	383.50
E	op	1.12	10.87	58.62
E	pre-op	1.21	3.84	30.36
	diff	-0.09	7.03	28.25

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Cirriped nauplii

CONTROL

		A	B	C
S	op	1.32	2.41	1.99
S	pre-op	2.17	7.61	2.24
	diff	-0.85	-5.19	-0.25
HM	op	1.54	10.36	10.86
HM	pre-op	16.81	18.58	28.18
	diff	-15.27	-8.22	-17.31
LM	op	0.00	11.46	9.31
LM	pre-op	0.00	20.49	17.06
	diff	0.00	-9.03	-7.74
E	op	1.77	4.05	0.58
E	pre-op	11.46	60.00	0.85
	diff	-9.69	-55.95	-0.27

Cirriped nauplii

SONGS

		A	B	C
S	op	2.96	1.94	6.24
S	pre-op	32.19	27.62	56.52
	diff	-29.23	-25.68	-50.27
HM	op	11.07	21.17	15.11
HM	pre-op	32.20	38.88	45.56
	diff	-21.13	-17.70	-30.45
LM	op	0.00	25.64	6.13
LM	pre-op	0.00	27.39	15.08
	diff	0.00	-1.75	-8.95
E	op	1.35	6.93	0.62
E	pre-op	3.89	26.93	0.84
	diff	-2.54	-20.00	-0.22

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Corycaeus anglicus

CONTROL

		A	B	C
S	op	55.79	268.33	448.48
S	pre-op	27.98	133.44	238.87
	diff	27.81	134.89	209.61
HM	op	56.14	571.36	589.92
HM	pre-op	39.69	221.53	361.99
	diff	16.45	349.84	227.94
LM	op	0.00	563.30	749.33
LM	pre-op	0.00	187.90	260.91
	diff	0.00	375.40	488.43
E	op	106.63	464.89	152.71
E	pre-op	71.34	109.70	147.38
	diff	35.29	355.19	5.33

Corycaeus anglicus

SONGS

		A	B	C
S	op	122.10	194.37	354.60
S	pre-op	41.64	166.59	309.22
	diff	80.46	27.79	45.38
HM	op	140.74	397.87	504.34
HM	pre-op	33.70	223.61	428.24
	diff	107.04	174.26	76.11
LM	op	0.00	595.58	521.25
LM	pre-op	0.00	207.33	318.75
	diff	0.00	388.24	202.50
E	op	107.46	318.77	142.86
E	pre-op	33.96	252.32	79.09
	diff	73.50	66.45	63.78

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Cyphonautes larvae

CONTROL

		A	B	C
S	op	44.59	34.34	29.42
S	pre-op	47.98	81.65	69.14
	diff	-3.39	-47.31	-39.72
HM	op	68.77	63.60	260.30
HM	pre-op	79.25	189.19	128.44
	diff	-10.48	-125.58	131.87
LM	op	0.00	113.05	111.82
LM	pre-op	0.00	102.82	134.95
	diff	0.00	10.23	-23.13
E	op	167.13	109.54	16.64
E	pre-op	55.54	76.05	13.74
	diff	111.58	33.49	2.90

Cyphonautes larvae

SONGS

		A	B	C
S	op	102.02	107.20	36.71
S	pre-op	80.86	28.04	36.75
	diff	21.16	79.16	-0.03
HM	op	212.31	243.20	147.36
HM	pre-op	90.88	71.99	103.70
	diff	121.43	171.21	43.67
LM	op	0.00	241.89	75.41
LM	pre-op	0.00	111.05	82.49
	diff	0.00	130.83	-7.08
E	op	80.97	116.95	7.63
E	pre-op	192.86	35.06	3.23
	diff	-111.89	81.89	4.39

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Cypris larvae

CONTROL

		A	B	C
S	op	6.60	4.84	1.51
S	pre-op	4.89	3.53	3.97
	diff	1.71	1.31	-2.46
HM	op	12.50	2.46	3.60
HM	pre-op	12.03	8.16	8.82
	diff	0.48	-5.70	-5.22
LM	op	0.00	4.69	3.17
LM	pre-op	0.00	9.26	8.04
	diff	0.00	-4.57	-4.88
E	op	94.01	10.96	1.56
E	pre-op	34.25	36.43	14.57
	diff	59.76	-25.47	-13.01

Cypris larvae

SONGS

		A	B	C
S	op	8.46	2.43	2.09
S	pre-op	9.00	2.50	1.58
	diff	-0.55	-0.07	0.51
HM	op	13.59	9.71	2.76
HM	pre-op	30.43	5.40	4.52
	diff	-16.84	4.31	-1.76
LM	op	0.00	18.39	3.71
LM	pre-op	0.00	8.86	5.66
	diff	0.00	9.53	-1.94
E	op	33.75	30.41	6.45
E	pre-op	39.84	36.39	6.37
	diff	-6.09	-5.97	0.07

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Eucalanus californicus

CONTROL

		A	B	C
S	op	0.00	0.00	0.08
S	pre-op	0.00	0.00	0.00
	diff	0.00	0.00	0.08
HM	op	0.00	0.00	0.18
HM	pre-op	0.00	0.26	0.26
	diff	0.00	-0.26	-0.08
LM	op	0.00	0.00	0.73
LM	pre-op	0.00	0.00	1.59
	diff	0.00	0.00	-0.86
E	op	0.00	0.00	0.07
E	pre-op	0.00	0.00	0.00
	diff	0.00	0.00	0.07

Eucalanus californicus

SONGS

		A	B	C
S	op	0.07	0.33	0.00
S	pre-op	0.00	0.00	0.00
	diff	0.07	0.33	0.00
HM	op	0.00	0.33	0.65
HM	pre-op	0.00	0.00	0.00
	diff	0.00	0.33	0.65
LM	op	0.00	0.29	0.86
LM	pre-op	0.00	0.00	0.00
	diff	0.00	0.29	0.86
E	op	0.00	0.00	0.14
E	pre-op	0.00	0.00	0.25
	diff	0.00	0.00	-0.10

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Evadne nordmanni

CONTROL

		A	B	C
S	op	83.39	215.08	115.12
S	pre-op	36.02	113.41	119.91
	diff	47.37	101.67	-4.78
HM	op	111.61	603.05	123.77
HM	pre-op	45.79	113.26	116.96
	diff	65.82	489.78	6.81
LM	op	0.00	312.22	8.96
LM	pre-op	0.00	99.24	12.82
	diff	0.00	212.99	-3.86
E	op	20.10	54.64	2.79
E	pre-op	31.99	12.14	2.41
	diff	-11.88	42.50	0.37

Evadne nordmanni

SONGS

		A	B	C
S	op	68.86	178.93	63.10
S	pre-op	28.68	79.59	48.87
	diff	40.18	99.34	14.22
HM	op	135.47	182.92	32.36
HM	pre-op	33.87	147.03	37.34
	diff	101.59	35.89	-4.98
LM	op	0.00	129.23	78.31
LM	pre-op	0.00	53.70	8.18
	diff	0.00	75.52	70.12
E	op	10.02	20.60	3.37
E	pre-op	14.99	11.69	3.27
	diff	-4.96	8.91	0.10

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Evadne spinifera

CONTROL

		A	B	C
S	op	11.04	58.97	56.33
S	pre-op	54.02	69.15	132.41
	diff	-42.98	-10.18	-76.07
HM	op	12.76	6.23	24.87
HM	pre-op	48.66	64.95	25.68
	diff	-35.90	-58.72	-0.81
LM	op	0.00	2.72	2.66
LM	pre-op	0.00	9.16	2.75
	diff	0.00	-6.43	-0.09
E	op	2.96	0.66	0.75
E	pre-op	11.16	6.09	1.44
	diff	-8.20	-5.43	-0.69

Evadne spinifera

SONGS

		A	B	C
S	op	4.31	15.07	29.13
S	pre-op	7.64	23.46	58.79
	diff	-3.33	-8.39	-29.66
HM	op	6.46	17.33	3.91
HM	pre-op	7.04	18.47	31.05
	diff	-0.58	-1.14	-27.14
LM	op	0.00	3.01	1.03
LM	pre-op	0.00	4.84	3.31
	diff	0.00	-1.83	-2.28
E	op	0.46	1.29	1.62
E	pre-op	2.12	4.07	1.43
	diff	-1.66	-2.78	0.19

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Labidocera trispinosa

CONTROL

		A	B	C
S	op	7.94	15.67	11.74
S	pre-op	12.91	79.40	41.73
	diff	-4.97	-63.73	-29.99
HM	op	11.80	17.13	16.65
HM	pre-op	32.55	52.92	34.22
	diff	-20.76	-35.79	-17.57
LM	op	0.00	25.64	30.82
LM	pre-op	0.00	24.25	10.62
	diff	0.00	1.39	20.20
E	op	35.07	33.16	6.13
E	pre-op	89.69	30.64	10.74
	diff	-54.62	2.52	-4.61

Labidocera trispinosa

SONGS

		A	B	C
S	op	18.84	33.30	16.84
S	pre-op	29.47	58.83	180.91
	diff	-10.62	-25.54	-164.06
HM	op	32.55	42.69	12.39
HM	pre-op	31.50	151.61	27.53
	diff	1.05	-108.91	-15.13
LM	op	0.00	137.04	16.60
LM	pre-op	0.00	77.51	14.31
	diff	0.00	59.53	2.30
E	op	58.93	49.86	56.06
E	pre-op	105.40	61.06	6.41
	diff	-46.46	-11.20	49.65

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Oithona oculata

CONTROL

		A	B	C
S	op	1.45	0.52	0.14
S	pre-op	7.47	1.45	0.16
	diff	-6.02	-0.93	-0.01
HM	op	1.47	0.22	0.00
HM	pre-op	32.81	0.71	0.24
	diff	-31.34	-0.49	-0.24
LM	op	0.00	0.19	0.49
LM	pre-op	0.00	0.35	0.31
	diff	0.00	-0.16	0.17
E	op	9.46	0.79	0.52
E	pre-op	46.19	3.19	0.05
	diff	-36.73	-2.40	0.48

Oithona oculata

SONGS

		A	B	C
S	op	2.21	0.51	0.38
S	pre-op	16.39	1.06	0.27
	diff	-14.18	-0.55	0.10
HM	op	4.45	0.64	0.10
HM	pre-op	18.26	5.08	0.18
	diff	-13.81	-4.43	-0.07
LM	op	0.00	1.07	0.04
LM	pre-op	0.00	1.71	0.17
	diff	0.00	-0.64	-0.13
E	op	295.09	9.53	0.45
E	pre-op	209.63	13.51	0.56
	diff	85.46	-3.99	-0.11

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Oithona plumifera

CONTROL

		A	B	C
S	op	16.70	12.59	22.03
S	pre-op	13.10	37.91	30.33
	diff	3.60	-25.32	-8.29
HM	op	22.30	24.58	120.09
HM	pre-op	21.75	87.53	146.09
	diff	0.55	-62.95	-26.00
LM	op	0.00	78.89	322.82
LM	pre-op	0.00	49.76	171.83
	diff	0.00	29.12	150.99
E	op	46.26	24.74	68.61
E	pre-op	31.49	41.46	85.79
	diff	14.77	-16.72	-17.18

Oithona plumifera

SONGS

		A	B	C
S	op	40.93	27.09	10.33
S	pre-op	20.63	20.10	20.46
	diff	20.30	7.00	-10.13
HM	op	80.30	68.54	125.27
HM	pre-op	42.05	37.68	85.72
	diff	38.25	30.86	39.55
LM	op	0.00	88.26	410.92
LM	pre-op	0.00	61.14	117.02
	diff	0.00	27.12	293.90
E	op	41.50	26.64	218.25
E	pre-op	39.68	52.79	54.26
	diff	1.82	-26.15	164.00

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Paracalanus parvus

CONTROL

		A	B	C
S	op	301.59	761.61	1800.78
S	pre-op	294.53	677.04	1067.86
	diff	7.06	84.57	732.92
HM	op	272.28	994.83	1492.49
HM	pre-op	329.83	726.70	410.55
	diff	-57.55	268.13	1081.94
LM	op	0.00	1290.40	970.16
LM	pre-op	0.00	708.94	633.35
	diff	0.00	581.47	336.81
E	op	1090.72	2021.45	433.41
E	pre-op	862.60	1073.63	697.35
	diff	228.12	947.82	-263.94

Paracalanus parvus

SONGS

		A	B	C
S	op	307.63	625.98	931.98
S	pre-op	288.65	844.59	1767.39
	diff	18.98	-218.61	-835.40
HM	op	421.41	1533.27	780.74
HM	pre-op	382.48	994.22	1037.90
	diff	38.92	539.05	-257.15
LM	op	0.00	1425.18	1360.52
LM	pre-op	0.00	776.89	698.67
	diff	0.00	648.29	661.86
E	op	1246.59	993.15	523.30
E	pre-op	776.54	1005.38	649.45
	diff	470.06	-12.23	-126.15

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Penilia avirostris

CONTROL

		A	B	C
S	op	0.04	0.04	0.04
S	pre-op	97.27	307.85	96.60
	diff	-97.23	-307.81	-96.57
HM	op	0.03	0.00	0.23
HM	pre-op	143.33	835.23	381.02
	diff	-143.30	-835.23	-380.79
LM	op	0.00	0.04	0.08
LM	pre-op	0.00	654.20	345.79
	diff	0.00	-654.17	-345.72
E	op	0.00	0.03	0.00
E	pre-op	43.16	63.40	125.47
	diff	-43.16	-63.37	-125.47

Penilia avirostris

SONGS

		A	B	C
S	op	0.00	0.00	0.00
S	pre-op	37.22	214.42	167.13
	diff	-37.22	-214.42	-167.13
HM	op	0.00	0.32	0.00
HM	pre-op	30.91	467.05	699.44
	diff	-30.91	-466.73	-699.44
LM	op	0.00	0.07	0.07
LM	pre-op	0.00	212.72	147.77
	diff	0.00	-212.65	-147.70
E	op	0.00	0.00	0.00
E	pre-op	26.46	64.20	6.86
	diff	-26.46	-64.20	-6.86

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Podon polyphemoides

CONTROL

		A	B	C
S	op	39.91	88.92	192.77
S	pre-op	398.00	133.43	13.94
	diff	-358.09	-44.51	178.84
HM	op	27.33	429.59	335.03
HM	pre-op	704.66	1005.25	52.45
	diff	-677.33	-575.66	282.58
LM	op	0.00	194.52	27.10
LM	pre-op	0.00	250.40	5.45
	diff	0.00	-55.88	21.65
E	op	44.93	13.23	3.72
E	pre-op	484.37	279.67	0.82
	diff	-439.44	-266.44	2.90

Podon polyphemoides

SONGS

		A	B	C
S	op	49.32	337.44	58.51
S	pre-op	534.33	561.86	25.93
	diff	-485.01	-224.42	32.58
HM	op	1031.78	285.83	7.53
HM	pre-op	533.83	729.05	34.62
	diff	497.95	-443.22	-27.09
LM	op	0.00	32.13	1.76
LM	pre-op	0.00	312.25	11.94
	diff	0.00	-280.12	-10.18
E	op	75.63	9.19	0.97
E	pre-op	143.34	255.92	1.51
	diff	-67.72	-246.72	-0.54

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Rhincalanus nasutus

CONTROL

		A	B	C
S	op	0.00	0.00	0.07
S	pre-op	0.00	0.26	0.26
	diff	0.00	-0.26	-0.19
HM	op	0.00	0.00	0.15
HM	pre-op	0.00	1.32	6.35
	diff	0.00	-1.32	-6.21
LM	op	0.00	0.04	0.72
LM	pre-op	0.00	0.00	7.41
	diff	0.00	0.04	-6.68
E	op	0.00	0.00	0.07
E	pre-op	0.00	0.00	0.00
	diff	0.00	0.00	0.07

Rhincalanus nasutus

SONGS

		A	B	C
S	op	0.00	0.07	0.11
S	pre-op	0.00	0.00	1.12
	diff	0.00	0.07	-1.01
HM	op	0.04	0.08	0.97
HM	pre-op	0.00	0.00	6.61
	diff	0.04	0.08	-5.64
LM	op	0.00	0.04	2.74
LM	pre-op	0.00	0.00	33.51
	diff	0.00	0.04	-30.77
E	op	0.00	0.00	0.15
E	pre-op	0.00	0.00	0.75
	diff	0.00	0.00	-0.60

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Sagitta euneritica

CONTROL

		A	B	C
S	op	10.30	71.38	74.80
S	pre-op	12.97	58.63	66.46
	diff	-2.67	12.75	8.34
HM	op	24.99	215.93	183.13
HM	pre-op	55.55	231.26	183.06
	diff	-30.56	-15.34	0.07
LM	op	0.00	331.17	147.81
LM	pre-op	0.00	224.28	178.82
	diff	0.00	106.89	-31.01
E	op	101.71	229.55	343.07
E	pre-op	89.73	142.56	218.56
	diff	11.97	86.99	124.51

Sagitta euneritica

SONGS

		A	B	C
S	op	32.08	174.25	23.31
S	pre-op	88.45	84.43	46.05
	diff	-56.37	89.83	-22.74
HM	op	111.34	277.28	145.51
HM	pre-op	57.74	222.45	211.63
	diff	53.60	54.83	-66.11
LM	op	0.00	209.89	165.83
LM	pre-op	0.00	241.84	192.08
	diff	0.00	-31.95	-26.24
E	op	112.50	235.16	318.01
E	pre-op	47.23	135.53	188.23
	diff	65.27	99.62	129.78

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Unid. holoplankton

CONTROL

		A	B	C
S	op	169.60	522.30	835.52
S	pre-op	80.40	284.21	487.91
	diff	89.20	238.10	347.61
HM	op	123.67	854.20	925.69
HM	pre-op	270.22	784.74	791.77
	diff	-146.55	69.46	133.92
LM	op	0.00	743.76	1071.13
LM	pre-op	0.00	300.32	850.58
	diff	0.00	443.44	220.55
E	op	250.92	644.32	312.13
E	pre-op	306.94	351.49	534.22
	diff	-56.02	292.83	-222.08

Unid. holoplankton

SONGS

		A	B	C
S	op	248.52	551.16	746.28
S	pre-op	92.31	297.07	510.64
	diff	156.21	254.09	235.63
HM	op	216.66	806.35	615.77
HM	pre-op	109.88	440.63	786.16
	diff	106.78	365.72	-170.39
LM	op	0.00	940.49	1159.08
LM	pre-op	0.00	396.65	805.43
	diff	0.00	543.84	353.65
E	op	262.52	434.31	484.15
E	pre-op	219.63	298.13	368.18
	diff	42.89	136.19	115.97

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Unid. meroplankton

CONTROL

		A	B	C
S	op	47.50	46.46	141.40
S	pre-op	13.70	23.81	27.19
	diff	33.80	22.66	114.21
HM	op	67.90	79.01	284.46
HM	pre-op	29.36	71.66	86.04
	diff	38.53	7.35	198.42
LM	op	0.00	148.81	265.39
LM	pre-op	0.00	58.36	188.71
	diff	0.00	90.45	76.67
E	op	383.34	226.78	108.00
E	pre-op	126.79	456.10	96.08
	diff	256.56	-229.32	11.92

Unid. meroplankton

SONGS

		A	B	C
S	op	57.44	50.21	148.89
S	pre-op	26.96	29.43	38.64
	diff	30.48	20.78	110.26
HM	op	83.34	167.92	449.08
HM	pre-op	83.29	76.17	78.94
	diff	0.05	91.75	370.14
LM	op	0.00	260.52	698.81
LM	pre-op	0.00	85.23	91.92
	diff	0.00	175.29	606.89
E	op	280.57	377.82	362.39
E	pre-op	118.99	119.32	86.47
	diff	161.58	258.50	275.91

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Unid. others

CONTROL

		A	B	C
S	op	5.90	2.45	1.00
S	pre-op	0.50	0.72	0.52
	diff	5.40	1.73	0.48
HM	op	0.93	0.68	1.62
HM	pre-op	1.33	1.57	2.94
	diff	-0.40	-0.89	-1.32
LM	op	0.00	1.48	2.74
LM	pre-op	0.00	2.72	6.49
	diff	0.00	-1.24	-3.74
E	op	108.18	18.30	55.44
E	pre-op	23.01	16.26	29.49
	diff	85.17	2.04	25.95

Unid. others

SONGS

		A	B	C
S	op	4.22	2.11	0.58
S	pre-op	1.54	0.41	0.92
	diff	2.68	1.70	-0.34
HM	op	3.40	1.40	2.47
HM	pre-op	7.44	1.89	1.99
	diff	-4.04	-0.49	0.48
LM	op	0.00	5.71	4.15
LM	pre-op	0.00	2.42	4.49
	diff	0.00	3.29	-0.34
E	op	152.08	47.58	10.31
E	pre-op	314.57	35.72	17.06
	diff	-162.49	11.86	-6.75

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Total zooplankton

CONTROL

		A	B	D
S	op	1104.36	3286.53	4040.85
S	pre-op	1217.68	2698.60	2494.84
	diff	-113.32	587.92	1546.02
HM	op	1519.93	5148.39	6113.71
HM	pre-op	1998.97	6791.57	4998.04
	diff	-479.04	-1643.17	1115.67
LM	op	0.00	6086.74	5985.34
LM	pre-op	0.00	4203.53	3874.10
	diff	0.00	1883.20	2111.24
E	op	5890.37	6219.60	1741.49
E	pre-op	9385.16	9907.95	2081.12
	diff	-3494.79	-3688.35	-339.63

Total zooplankton

SONGS

		A	B	D
S	op	1978.77	2974.87	2658.39
S	pre-op	1672.93	3155.62	4140.52
	diff	305.84	-180.75	-1482.13
HM	op	5028.86	6395.31	3811.57
HM	pre-op	2364.57	6012.73	6785.95
	diff	2664.29	382.58	-2974.38
LM	op	0.00	6558.89	7237.32
LM	pre-op	0.00	4556.11	4762.99
	diff	0.00	2002.79	2474.33
E	op	6532.20	4558.56	2388.34
E	pre-op	7417.89	4271.39	2030.43
	diff	-885.69	287.17	357.91

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Total holoplankton

CONTROL

		A	B	D
S	op	42.81	231.75	246.87
S	pre-op	48.93	187.11	150.62
	diff	-6.12	44.64	96.25
HM	op	121.10	604.38	759.95
HM	pre-op	163.45	782.03	640.60
	diff	-42.35	-177.65	119.35
LM	op	0.00	1112.87	1224.93
LM	pre-op	0.00	769.21	765.77
	diff	0.00	343.66	459.16
E	op	89.41	170.08	29.46
E	pre-op	156.30	268.85	35.75
	diff	-66.89	-98.77	-6.29

Total holoplankton

SONGS

		A	B	D
S	op	77.06	203.83	157.35
S	pre-op	65.79	221.73	256.81
	diff	11.27	-17.90	-99.46
HM	op	416.43	720.63	437.44
HM	pre-op	187.57	703.31	897.18
	diff	228.86	17.32	-459.74
LM	op	0.00	1151.91	1412.67
LM	pre-op	0.00	820.16	994.05
	diff	0.00	331.75	418.61
E	op	104.60	116.70	36.69
E	pre-op	122.50	117.63	35.25
	diff	-17.89	-0.93	1.44

Appendix F. Continued

DENSITIES AT SONGS AND CONTROL BY BLOCK AND DEPTH

Total meroplankton

CONTROL

		A	B	D
S	op	4.26	6.38	11.13
S	pre-op	2.97	8.42	8.67
	diff	1.29	-2.04	2.46
HM	op	13.33	18.81	76.51
HM	pre-op	13.34	40.07	43.22
	diff	-0.02	-21.25	33.29
LM	op	0.00	53.26	85.31
LM	pre-op	0.00	36.13	82.30
	diff	0.00	17.13	3.00
E	op	11.02	10.18	2.31
E	pre-op	3.71	18.31	2.22
	diff	7.31	-8.13	0.09

Total meroplankton

SONGS

		A	B	D
S	op	7.28	11.72	12.38
S	pre-op	5.51	6.92	7.55
	diff	1.77	4.80	4.83
HM	op	28.33	53.50	84.05
HM	pre-op	21.55	24.51	31.25
	diff	6.78	28.99	52.80
LM	op	0.00	104.69	171.64
LM	pre-op	0.00	52.73	48.60
	diff	0.00	51.96	123.03
E	op	6.76	15.42	6.88
E	pre-op	3.97	6.17	1.79
	diff	2.79	9.25	5.09

APPENDIX G. CONVERSION OF PERCENT RELATIVE CHANGE INTO FACTORS OF CHANGE.

% DECREASE	% INCREASE	FACTOR OF CHANGE
-10%	11%	1.1
-20%	25%	1.3
-30%	43%	1.4
-40%	67%	1.7
-50%	100%	2.0
-60%	150%	2.5
-70%	233%	3.3
-80%	400%	5.0
-90%	900%	10.0

APPENDIX H
1) BACIP test results
2) Graph of The survey by survey deltas with mean line for preop and op
3) Impact vs control Density

DBMACZP.CR003 - DBMACZP.CR213	MRC databases
ZOSTRATA SAS	SAS program
ZOBACI.STRAT	temporary database
ZOXSHELF SAS	SAS program
ZOBACI.XSHELF1	temporary database

1) BACIP1 SAS	SAS program
2) GRAF_XS SAS	SAS program
3) ICTPLOT SAS	SAS program

APPENDIX H.

For each taxon listed below (which are discussed in the text of the report), we present the following: the detailed results of the BACIP test, a figure of the survey-by-survey deltas, and a figure of the survey-by-survey data.

Page No.

Evadne nordmanni H-2

Evadne spinifera H-6

Total meroplankton H-10

Cirriped nauplii H-14

Cyphonautes larvae H-18

Unid. meroplankton larvae H-22

Total holoplankton H-26

Chlorophyll H-27

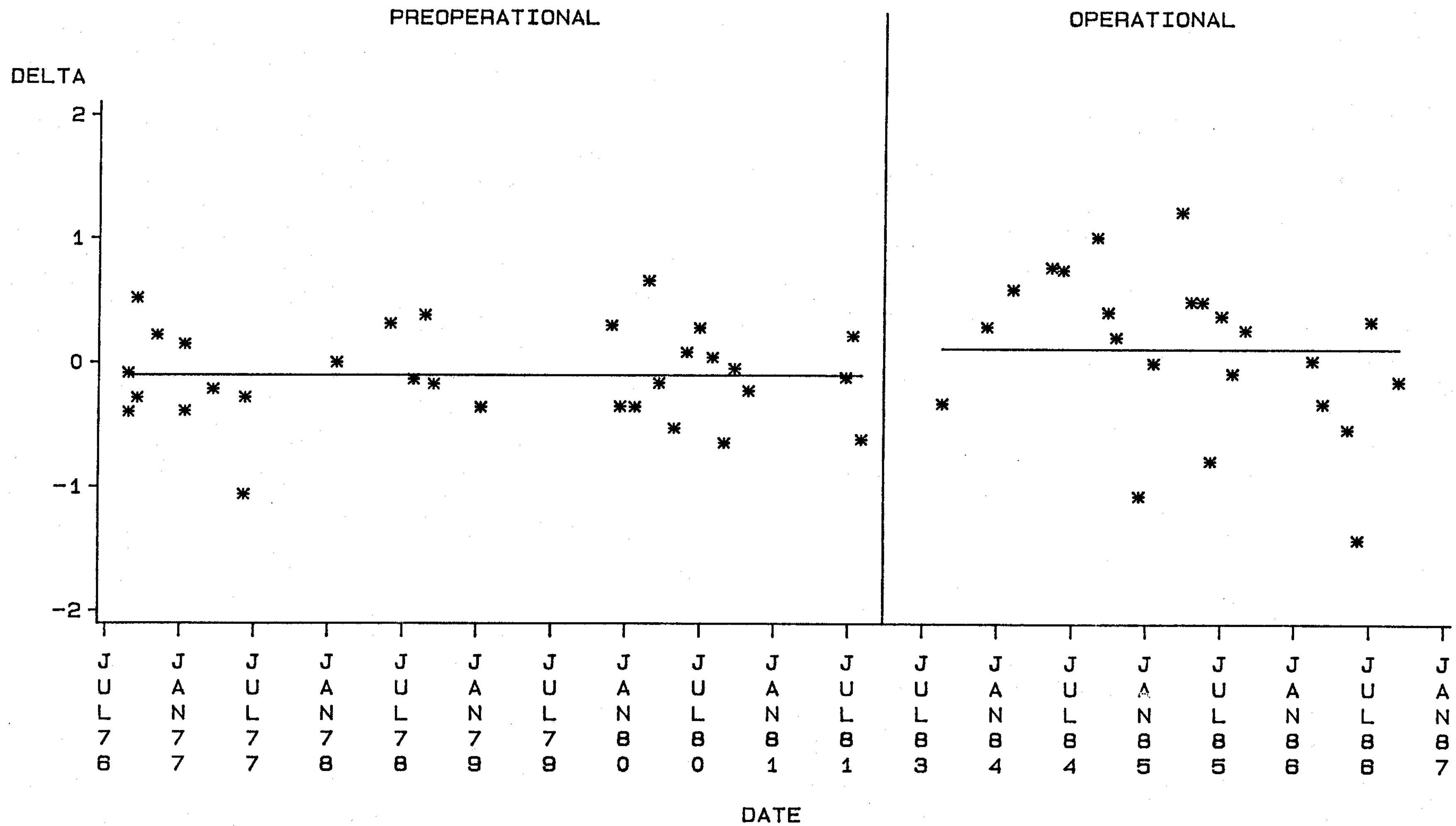
SUMMARY OF BACI TEST

Evadne nordmanni

TRANSFORMATION	NUMBER OF OBSERVATIONS		TEST FOR ADDITIVITY	TEST FOR SERIAL	TRENDS TEST P-LEVEL	
	BEFORE	AFTER	P-LEVEL	CORRELATION	BEFORE	AFTER
LOG(X+0.01)	30	22	0.020	p > 0.05	0.811	0.082
LOG(X+0.1)	30	22	0.148	p > 0.05	0.981	0.078
LOG(X+0)	29	22	0.580	p > 0.05	0.827	0.083
LOG(X+1)	30	22	0.260	p > 0.05	0.901	0.069
LOG(X+10)	30	22	0.130	p > 0.05	0.953	0.129
LOG(X+100)	30	22	0.026	p > 0.05	0.922	0.204

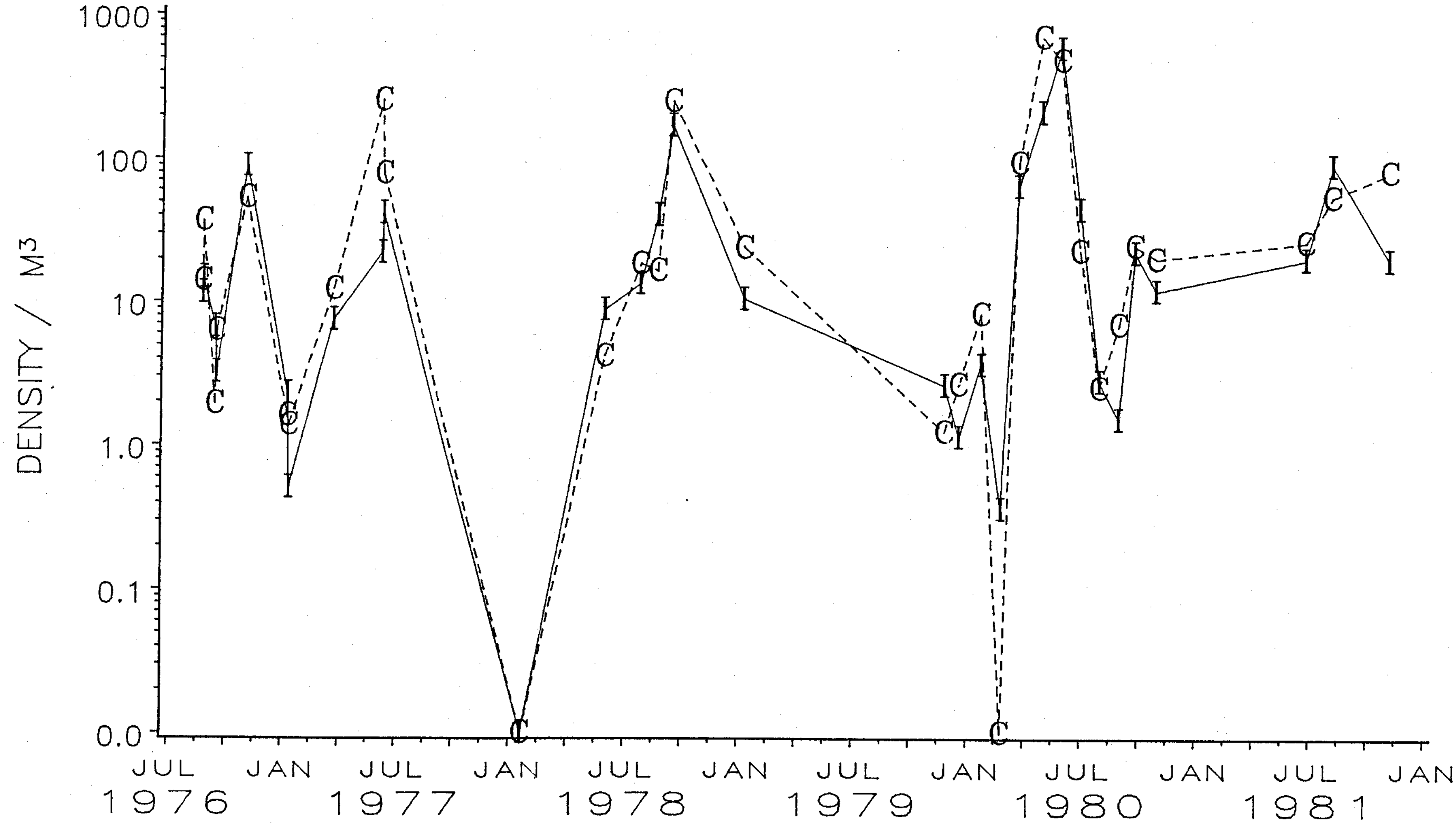
TRANSFORMATION	GEOMETRIC MEANS BEFORE		GEOMETRIC MEANS AFTER		PERCENT	SIGNIFICANCE TESTS	
	SONGS	CONTROL	SONGS	CONTROL	CHANGE	T	Z
LOG(X+0.01)	12.59	15.11	19.42	14.76	57.9	0.220	0.071
LOG(X+0.1)	12.82	16.45	20.24	15.39	68.1	0.160	0.058
LOG(X+0)	14.19	19.43	19.31	14.68	80.1	0.122	0.037
LOG(X+1)	14.42	19.04	24.55	18.96	66.3	0.108	0.060
LOG(X+10)	20.38	27.07	37.85	31.13	42.0	0.131	0.101
LOG(X+100)	33.07	45.83	66.30	67.15	9.0	0.515	0.127

Evadne nordmanni
PLOT OF DELTAS (SONGS - CONTROL)
TRANSFORMATION LOG (X+0.1)



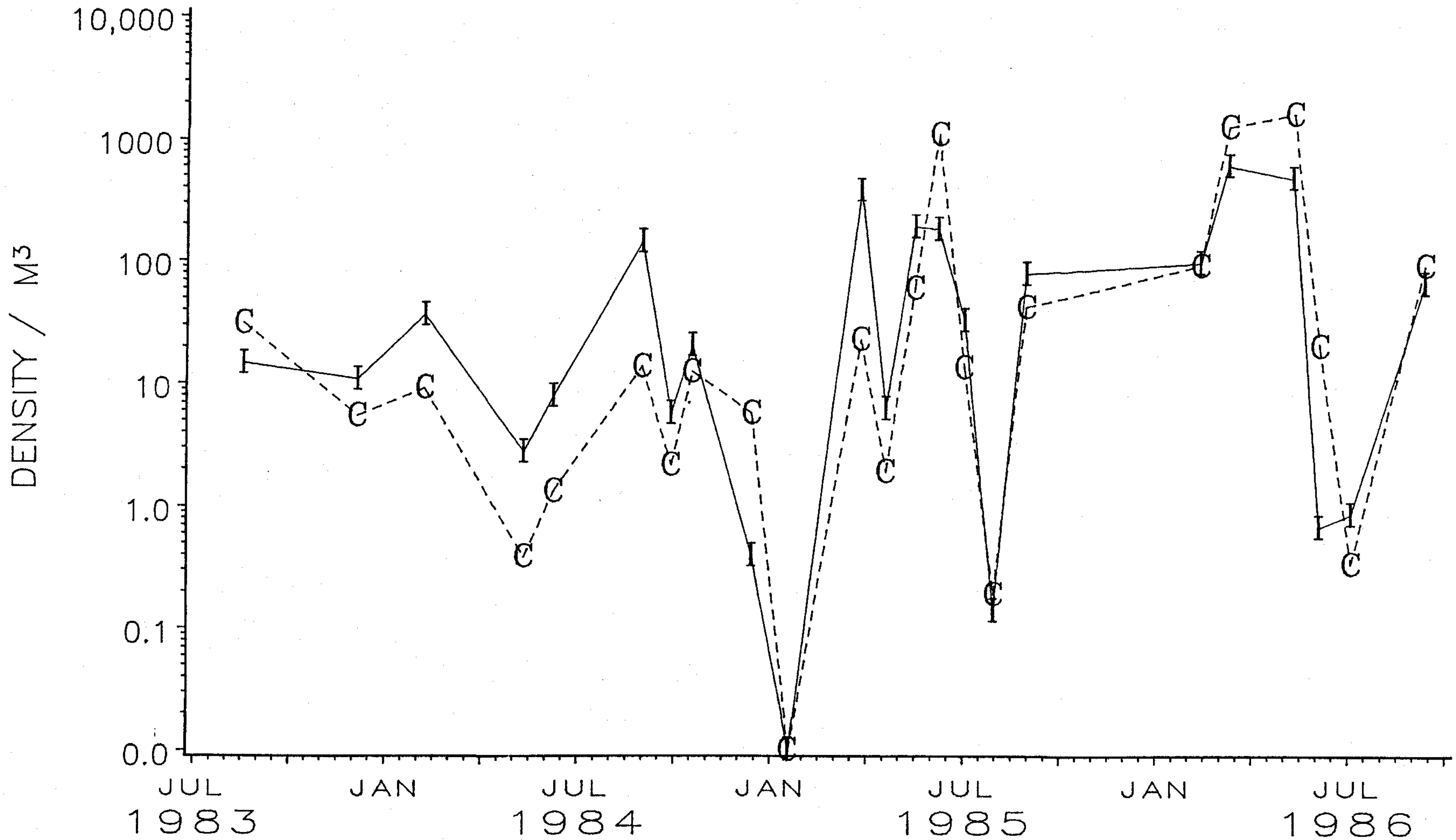
Evadne nordmanni

IMPACT (I) VS. CONTROL (C) LOCATIONS
BEFORE PERIOD



Evadne nordmanni

IMPACT (I) VS. CONTROL (C) LOCATIONS
AFTER PERIOD



SUMMARY OF BACI TEST

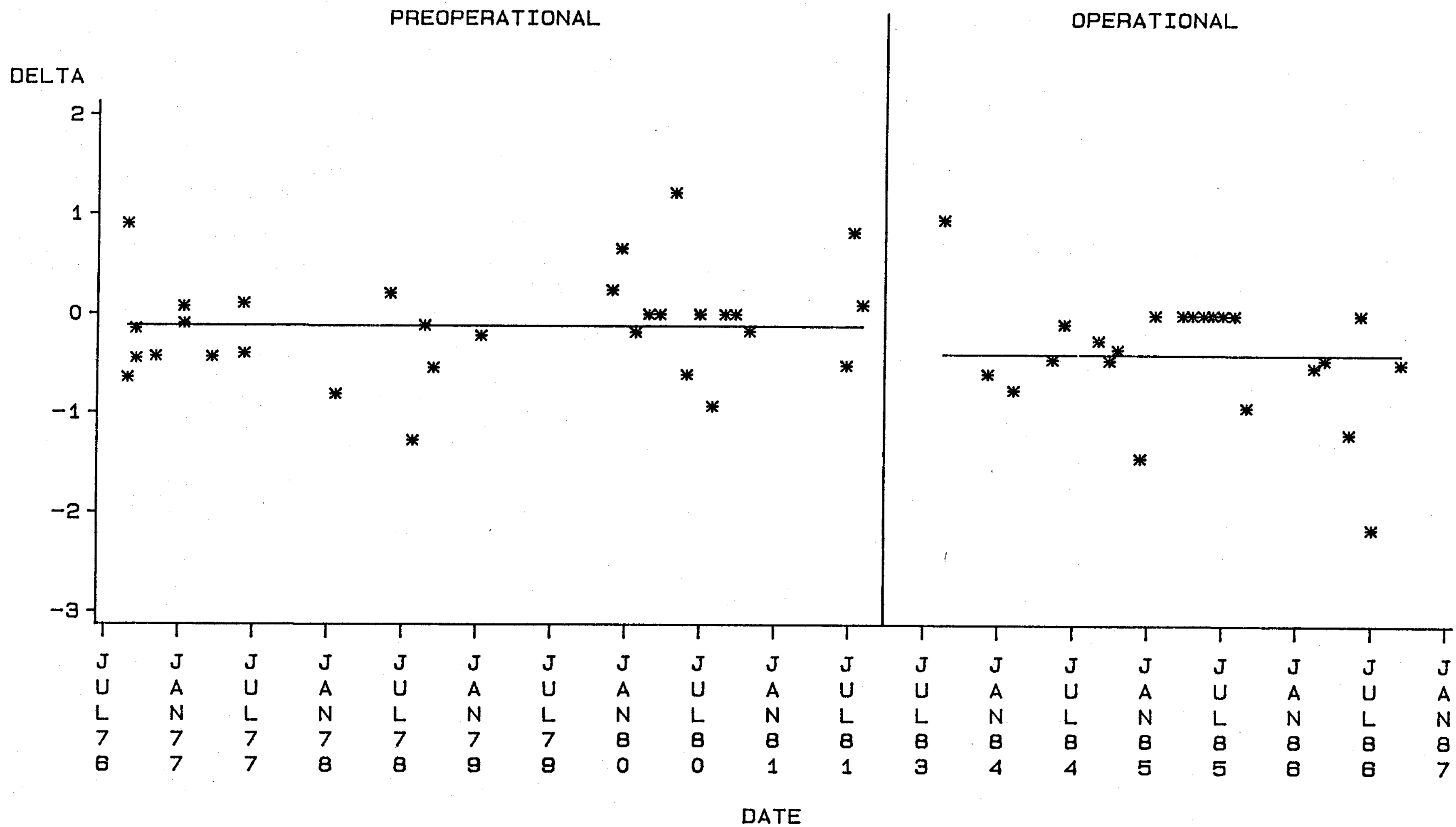
Evadne spinifera

TRANSFORMATION	NUMBER OF OBSERVATIONS BEFORE	AFTER	TEST FOR ADDITIVITY P-LEVEL	TEST FOR SERIAL CORRELATION	TRENDS TEST P-LEVEL BEFORE	AFTER
LOG(X+0.01)	26	15	0.732	p > 0.05	0.406	0.032
LOG(X+0.1)	26	15	0.231	p > 0.05	0.253	0.051
LOG(X+0)	25	12	0.226	p > 0.05	0.242	0.167
LOG(X+1)	26	15	0.043	p > 0.05	0.184	0.114
LOG(X+10)	26	15	0.000	p > 0.05	0.076	0.070
LOG(X+100)	26	15	0.000	p > 0.05	0.024	0.071

TRANSFORMATION	GEOMETRIC MEANS BEFORE SONGS	BEFORE CONTROL	AFTER SONGS	AFTER CONTROL	PERCENT CHANGE	SIGNIFICANCE TESTS T	Z
LOG(X+0.01)	5.12	7.12	0.98	4.10	-66.4	0.023	0.021
LOG(X+0.1)	5.85	7.62	1.60	4.43	-51.3	0.069	0.034
LOG(X+0)	6.52	8.45	3.10	7.32	-45.2	0.178	0.072
LOG(X+1)	7.71	10.01	2.89	6.05	-30.4	0.267	0.148
LOG(X+10)	11.67	17.30	5.63	10.49	-3.9	0.849	0.525
LOG(X+100)	15.87	30.19	9.23	17.74	4.2	0.608	0.598

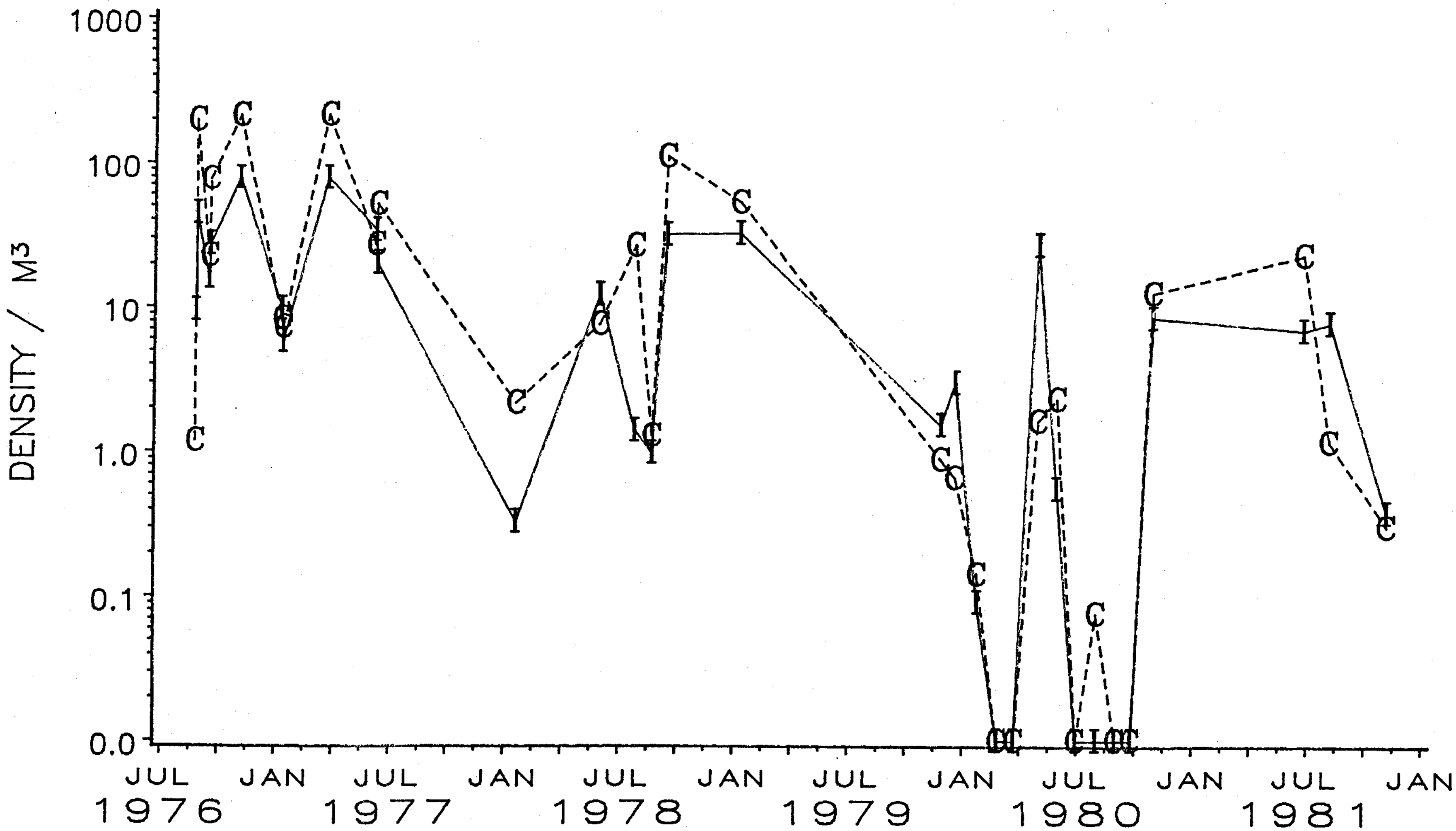
Evadne spinifera

PLOT OF DELTAS (SONGS - CONTROL)
TRANSFORMATION LOG (X+0.01)



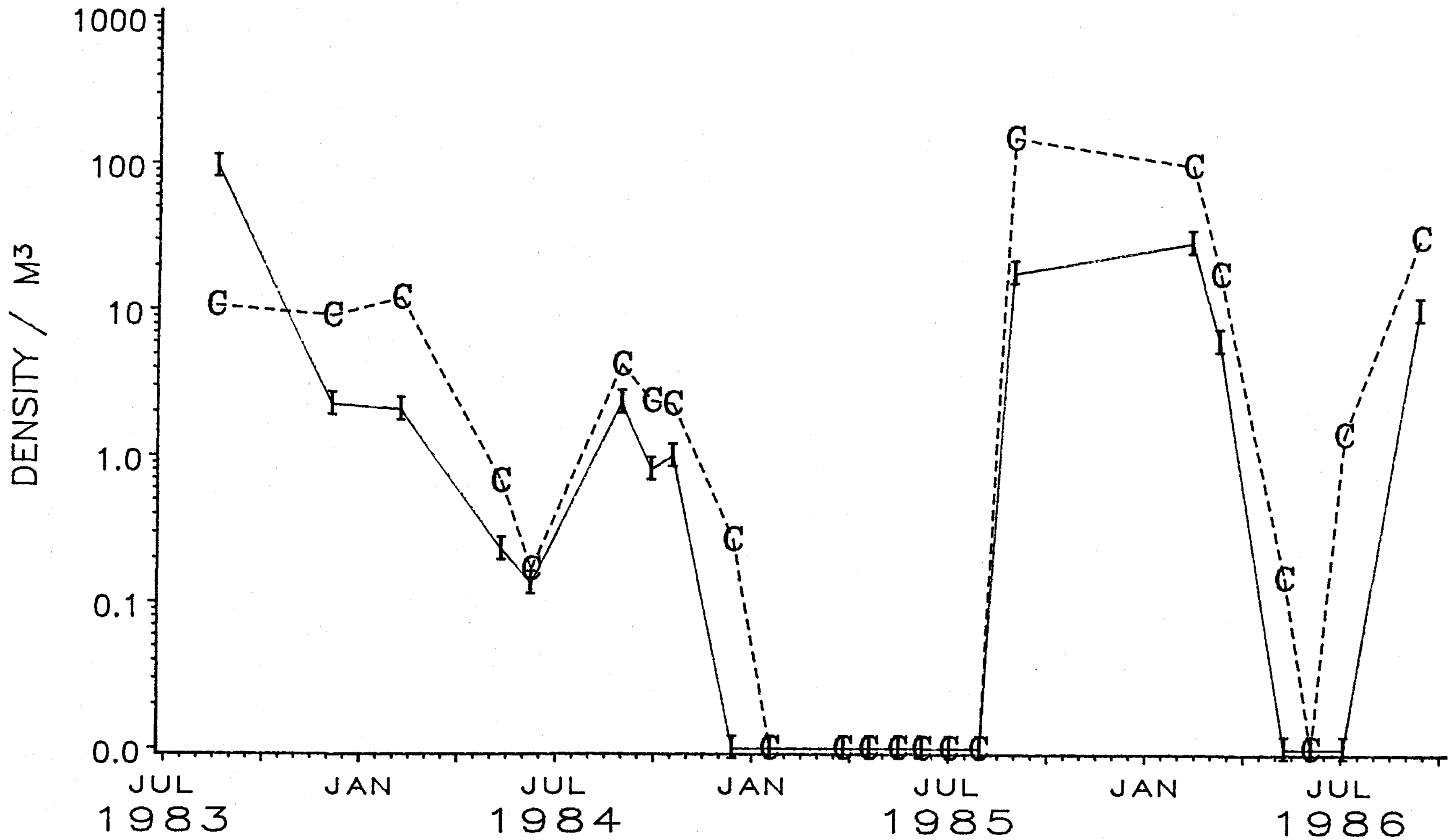
Evadne spinifera

IMPACT (I) VS. CONTROL (C) LOCATIONS
BEFORE PERIOD



Evadne spinifera

IMPACT (I) VS. CONTROL (C) LOCATIONS
AFTER PERIOD



SUMMARY OF BACI TEST

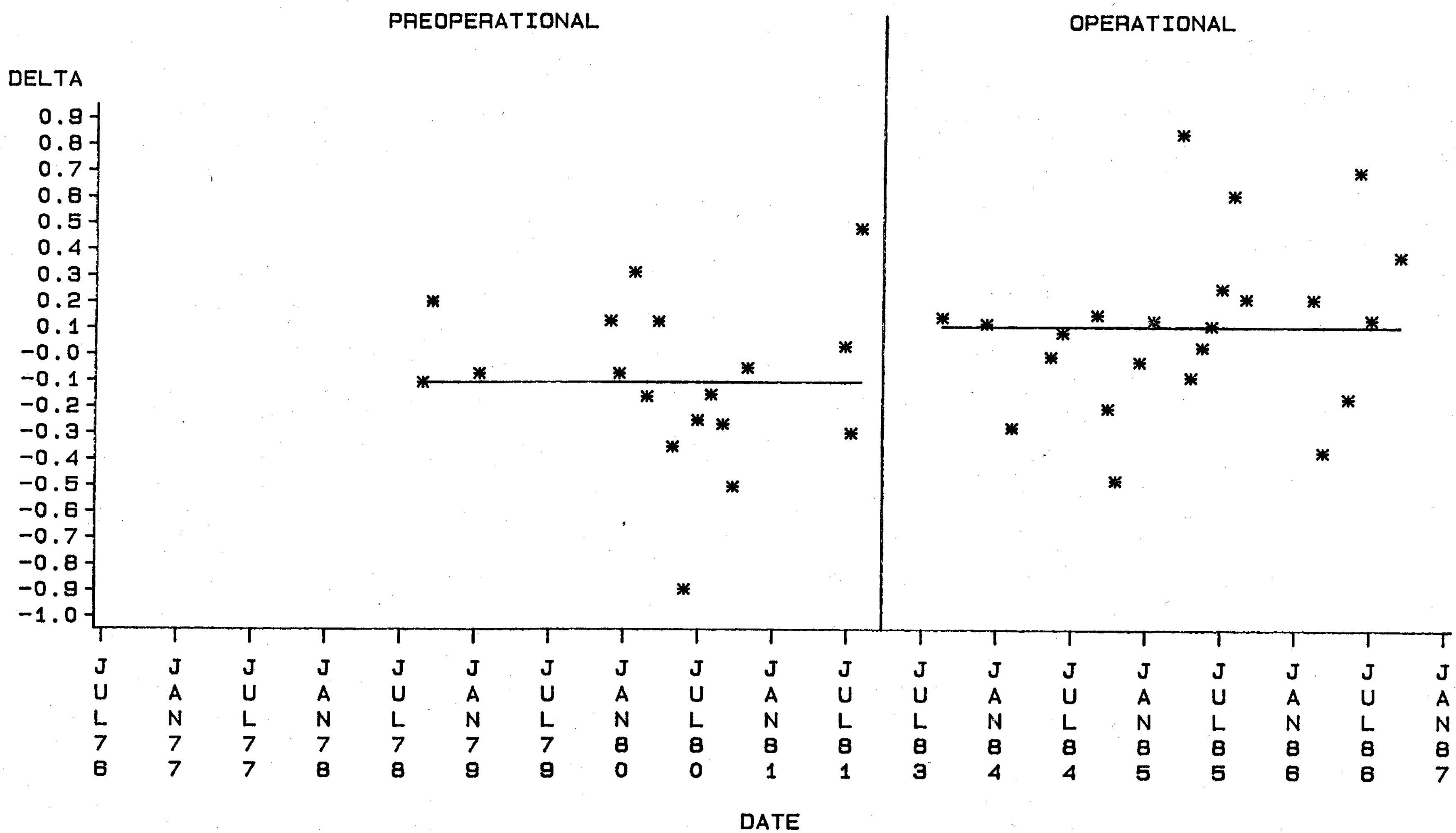
Total meroplankton

TRANSFORMATION	NUMBER OF OBSERVATIONS BEFORE	AFTER	TEST FOR ADDITIVITY P-LEVEL	TEST FOR SERIAL CORRELATION	TRENDS TEST P-LEVEL BEFORE	AFTER
LOG(X+0.01)	18	23	0.927	p > 0.05	0.826	0.221
LOG(X+0.1)	18	23	0.927	p > 0.05	0.826	0.221
LOG(X+0)	18	23	0.927	p > 0.05	0.826	0.221
LOG(X+1)	18	23	0.926	p > 0.05	0.826	0.221
LOG(X+10)	18	23	0.918	p > 0.05	0.828	0.224
LOG(X+100)	18	23	0.932	p > 0.05	0.849	0.245

TRANSFORMATION	GEOMETRIC MEANS BEFORE SONGS	CONTROL	AFTER SONGS	CONTROL	PERCENT CHANGE	SIGNIFICANCE TESTS T	Z
LOG(X+0.01)	158.94	202.86	314.90	245.30	63.8	0.037	0.042
LOG(X+0.1)	158.96	202.89	314.94	245.32	63.8	0.037	0.042
LOG(X+0)	158.93	202.85	314.90	245.30	63.8	0.037	0.042
LOG(X+1)	159.24	203.23	315.30	245.50	63.5	0.037	0.042
LOG(X+10)	161.81	206.33	318.79	247.24	60.9	0.036	0.044
LOG(X+100)	176.31	223.73	343.38	258.50	44.9	0.029	0.028

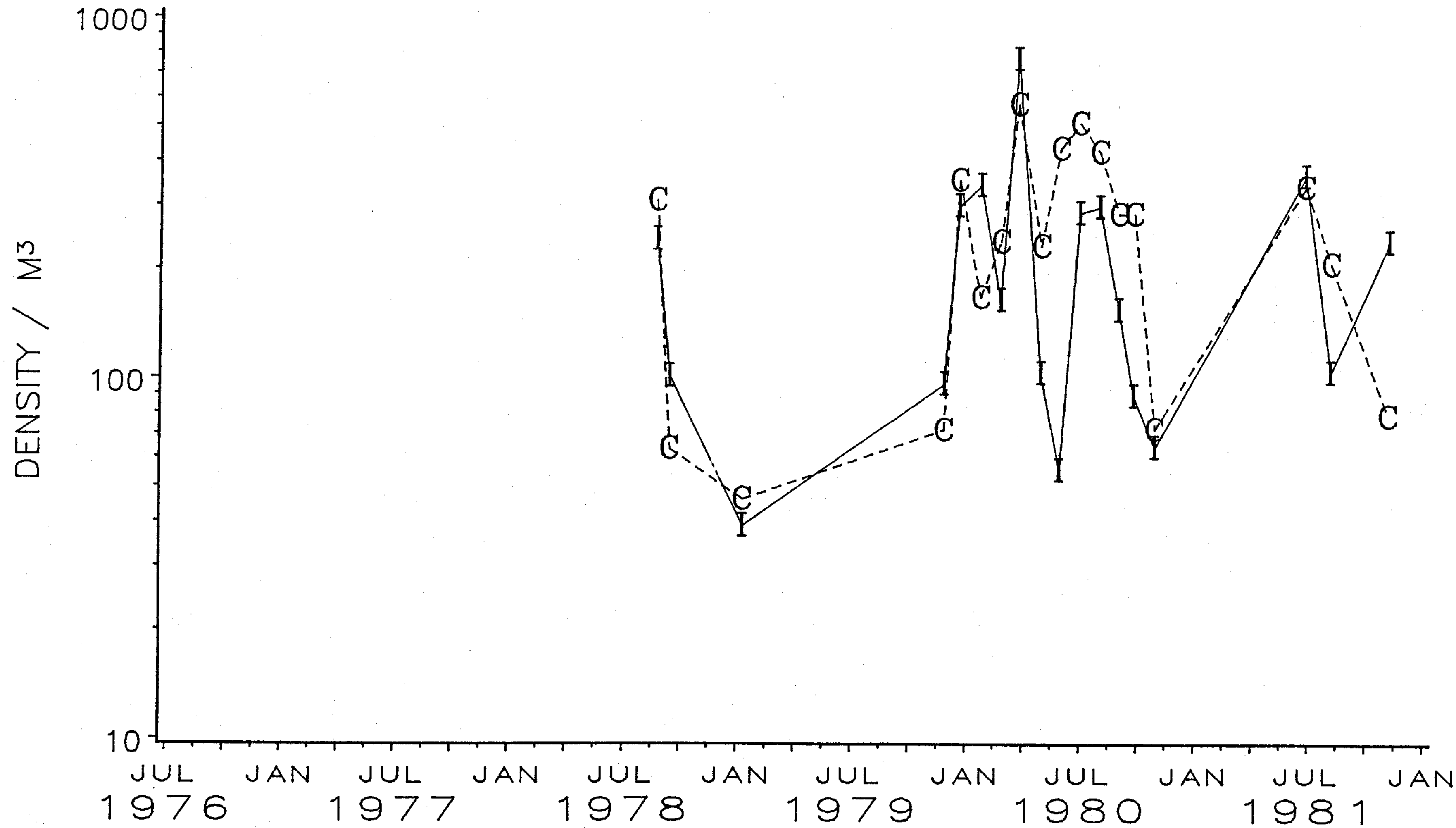
Total meroplankton

PLOT OF DELTAS (SONGS - CONTROL)
TRANSFORMATION LOG (X)



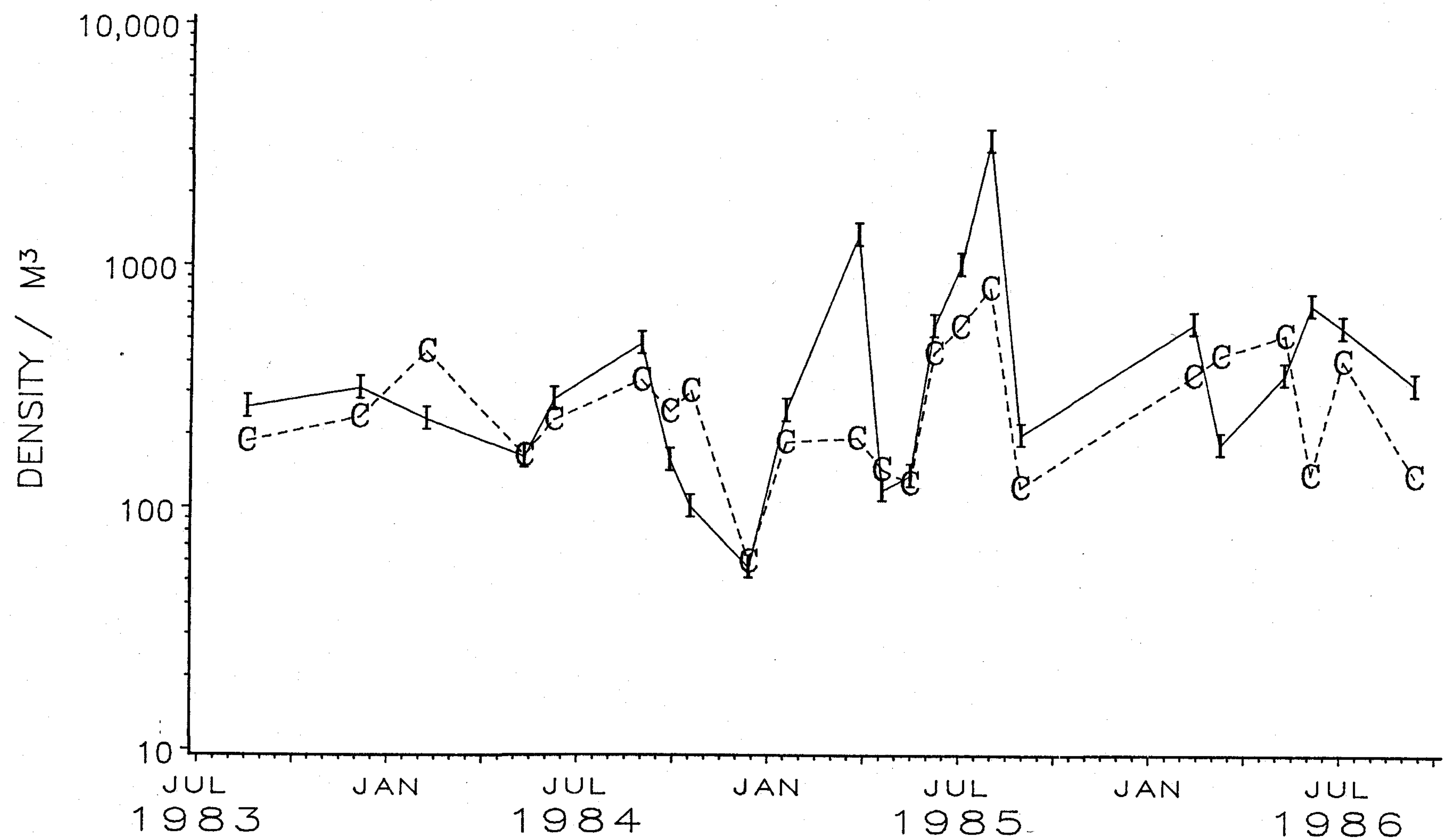
Total meroplankton

IMPACT (I) VS. CONTROL (C) LOCATIONS
BEFORE PERIOD



Total meroplankton

IMPACT (I) VS. CONTROL (C) LOCATIONS
AFTER PERIOD



SUMMARY OF BACI TEST

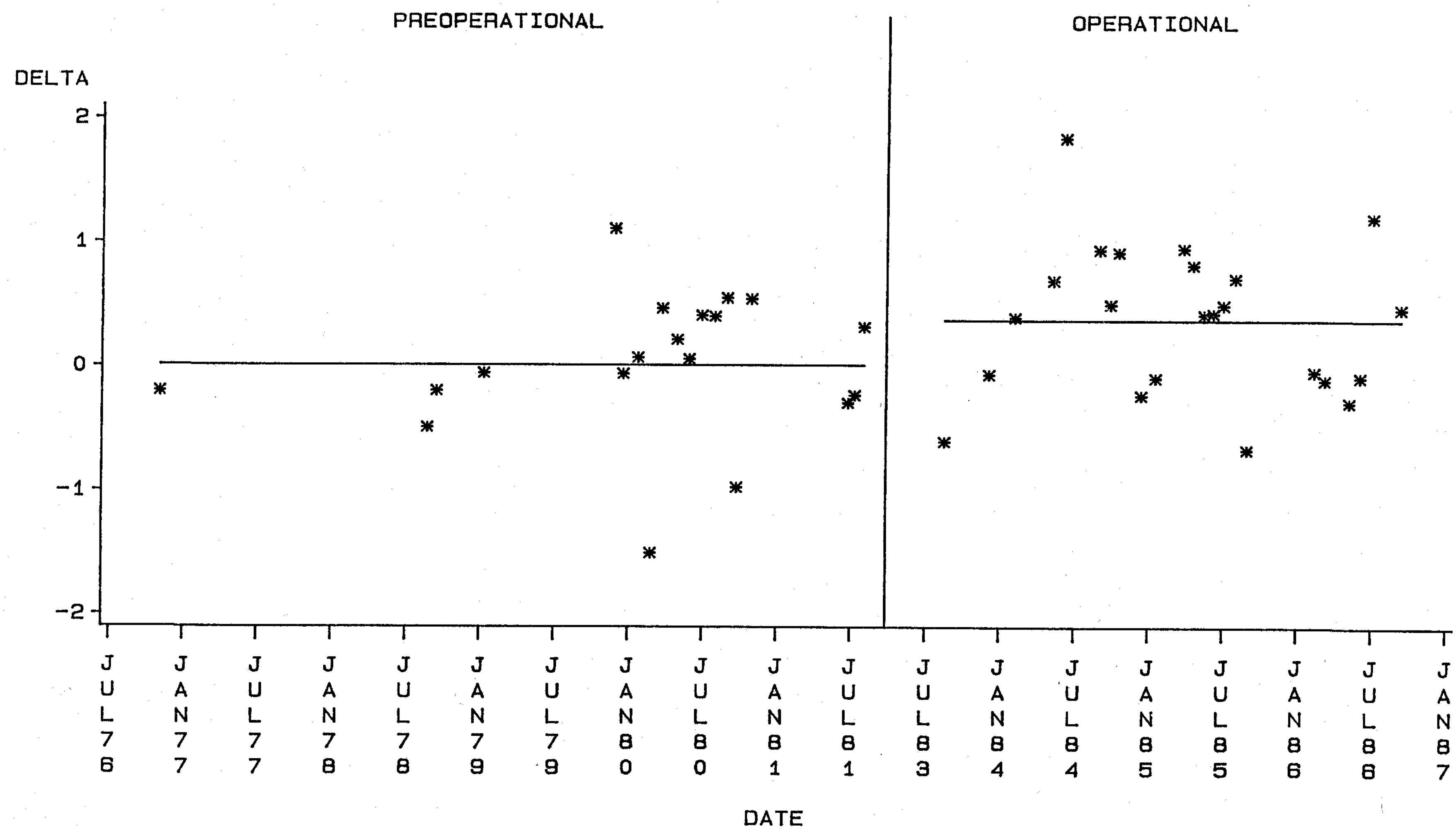
Cirriped nauplii

TRANSFORMATION	NUMBER OF OBSERVATIONS BEFORE	AFTER	TEST FOR ADDITIVITY P-LEVEL	TEST FOR SERIAL CORRELATION	TRENDS TEST P-LEVEL BEFORE	AFTER
LOG(X+0.01)	19	23	0.328	p > 0.05	0.551	0.756
LOG(X+0.1)	19	23	0.335	p > 0.05	0.534	0.872
LOG(X+0)	19	23	0.326	p > 0.05	0.554	0.738
LOG(X+1)	19	23	0.255	p > 0.05	0.472	0.811
LOG(X+10)	19	23	0.018	p > 0.05	0.527	0.549
LOG(X+100)	19	23	0.000	p > 0.05	0.738	0.414

TRANSFORMATION	GEOMETRIC MEANS BEFORE SONGS	CONTROL	AFTER SONGS	CONTROL	PERCENT CHANGE	SIGNIFICANCE TESTS T	Z
LOG(X+0.01)	10.08	9.87	5.59	2.36	131.2	0.054	0.081
LOG(X+0.1)	10.29	10.00	5.78	2.55	115.4	0.055	0.111
LOG(X+0)	10.05	9.86	5.57	2.34	133.8	0.054	0.081
LOG(X+1)	11.40	10.81	6.77	3.36	69.7	0.067	0.086
LOG(X+10)	14.99	13.26	9.36	5.31	17.7	0.237	0.324
LOG(X+100)	22.42	16.45	11.93	7.09	-0.6	0.900	0.613

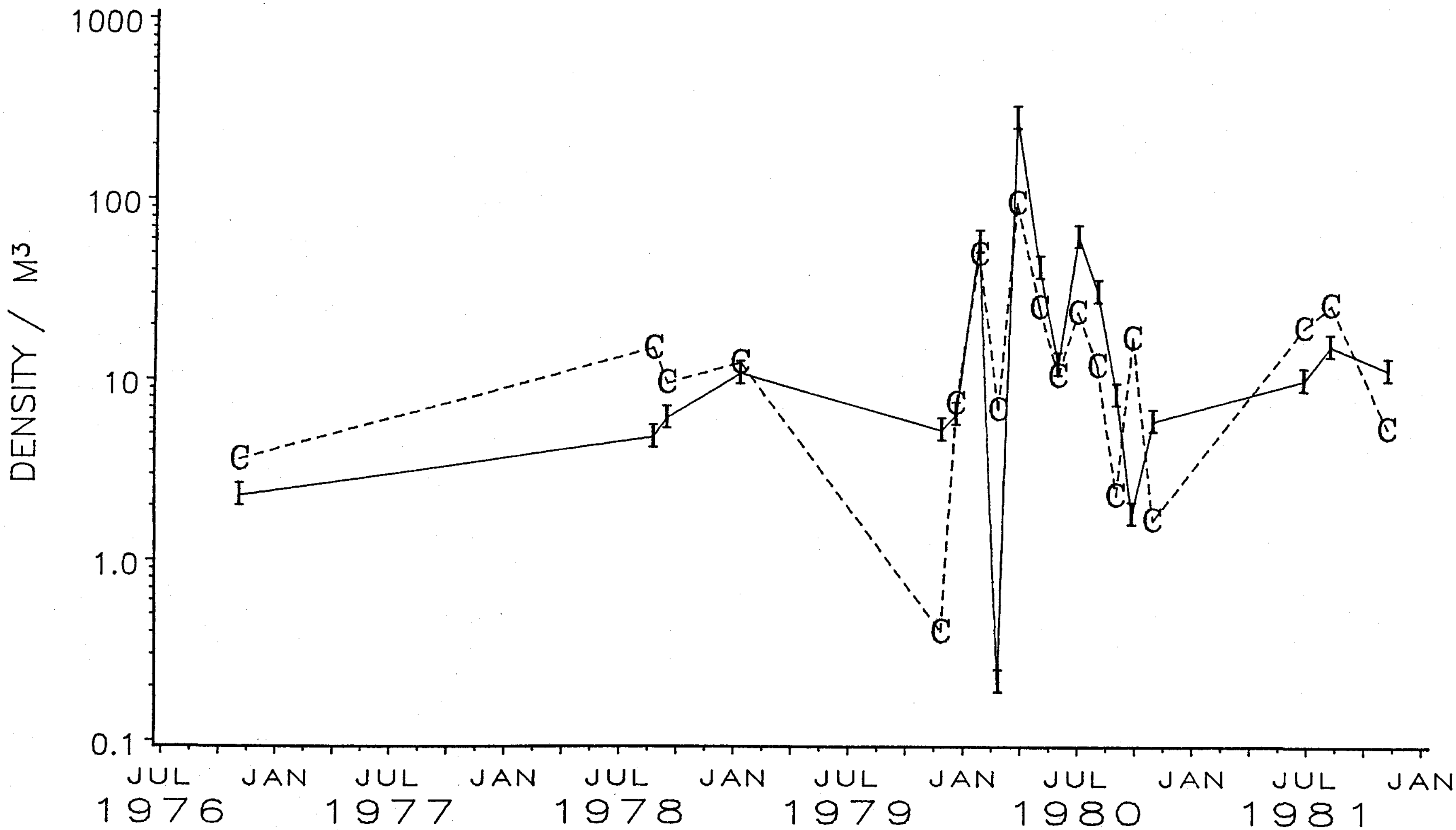
Cirriped nauplii

PLOT OF DELTAS (SONGS - CONTROL)
TRANSFORMATION LOG (X)



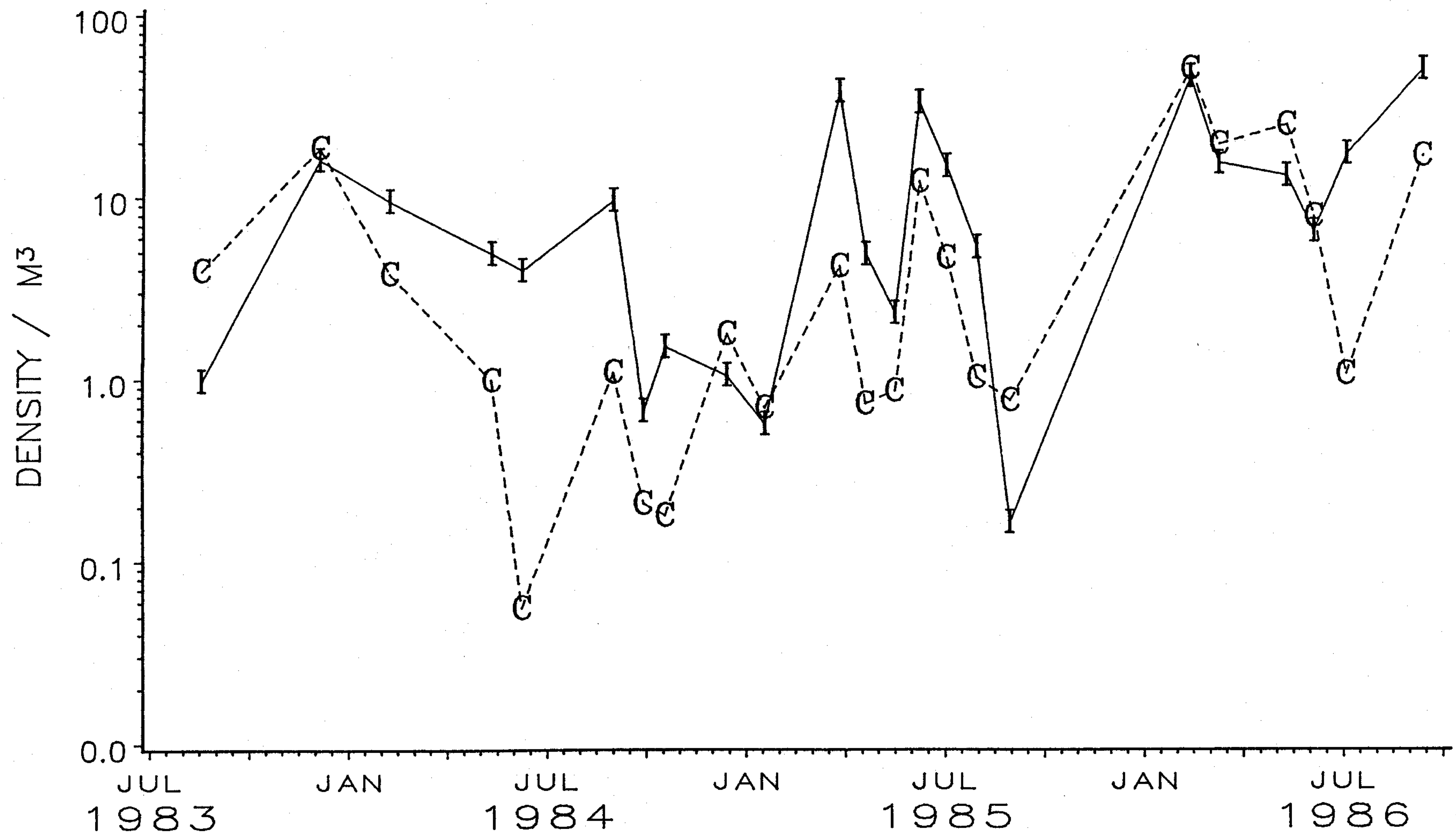
Cirriped nauplii

IMPACT (I) VS. CONTROL (C) LOCATIONS
BEFORE PERIOD



Cirriped nauplii

IMPACT (I) VS. CONTROL (C) LOCATIONS
AFTER PERIOD



SUMMARY OF BACI TEST

Cyphonautes larvae

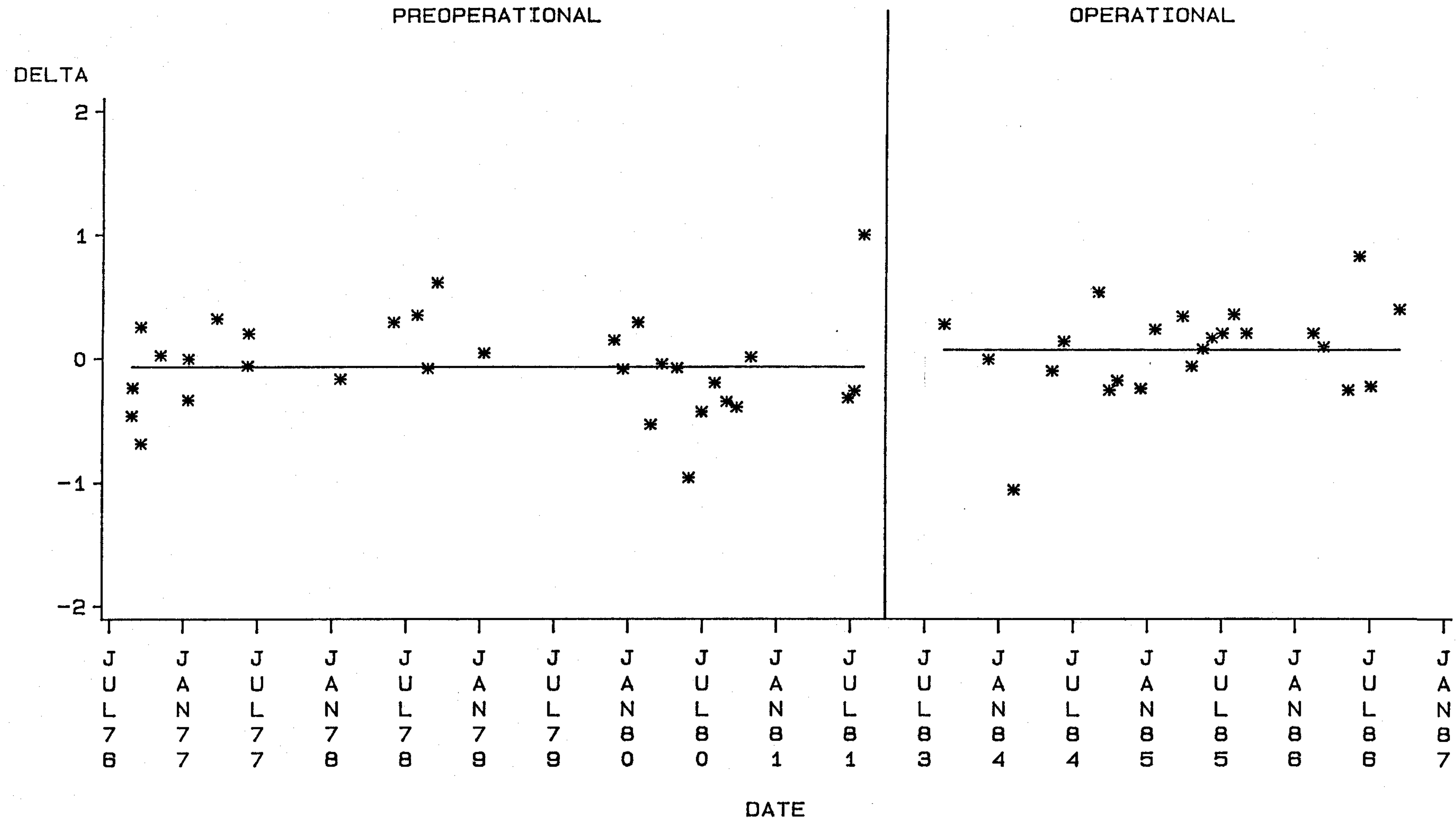
TRANSFORMATION	NUMBER OF OBSERVATIONS BEFORE	AFTER	TEST FOR ADDITIVITY P-LEVEL	TEST FOR SERIAL CORRELATION	TRENDS TEST P-LEVEL BEFORE	AFTER
LOG(X+0.01)	31	23	0.159	p > 0.05	0.942	0.147
LOG(X+0.1)	31	23	0.159	p > 0.05	0.940	0.147
LOG(X+0)	31	23	0.159	p > 0.05	0.942	0.147
LOG(X+1)	31	23	0.157	p > 0.05	0.925	0.148
LOG(X+10)	31	23	0.118	p > 0.05	0.833	0.161
LOG(X+100)	31	23	0.012	p > 0.05	0.613	0.229

TRANSFORMATION	GEOMETRIC MEANS BEFORE SONGS	CONTROL	AFTER SONGS	CONTROL	PERCENT CHANGE	SIGNIFICANCE TESTS T	Z
LOG(X+0.01)	60.59	70.12	83.60	70.21	37.8	0.202	0.097
LOG(X+0.1)	60.64	70.19	83.68	70.26	37.8	0.201	0.097
LOG(X+0)	60.59	70.12	83.59	70.21	37.8	0.202	0.097
LOG(X+1)	61.04	70.88	84.43	70.72	38.0	0.188	0.093
LOG(X+10)	64.14	75.88	90.50	74.44	37.9	0.119	0.059
LOG(X+100)	73.70	92.46	113.97	88.79	25.6	0.028	0.012

Cyphonautes larvae

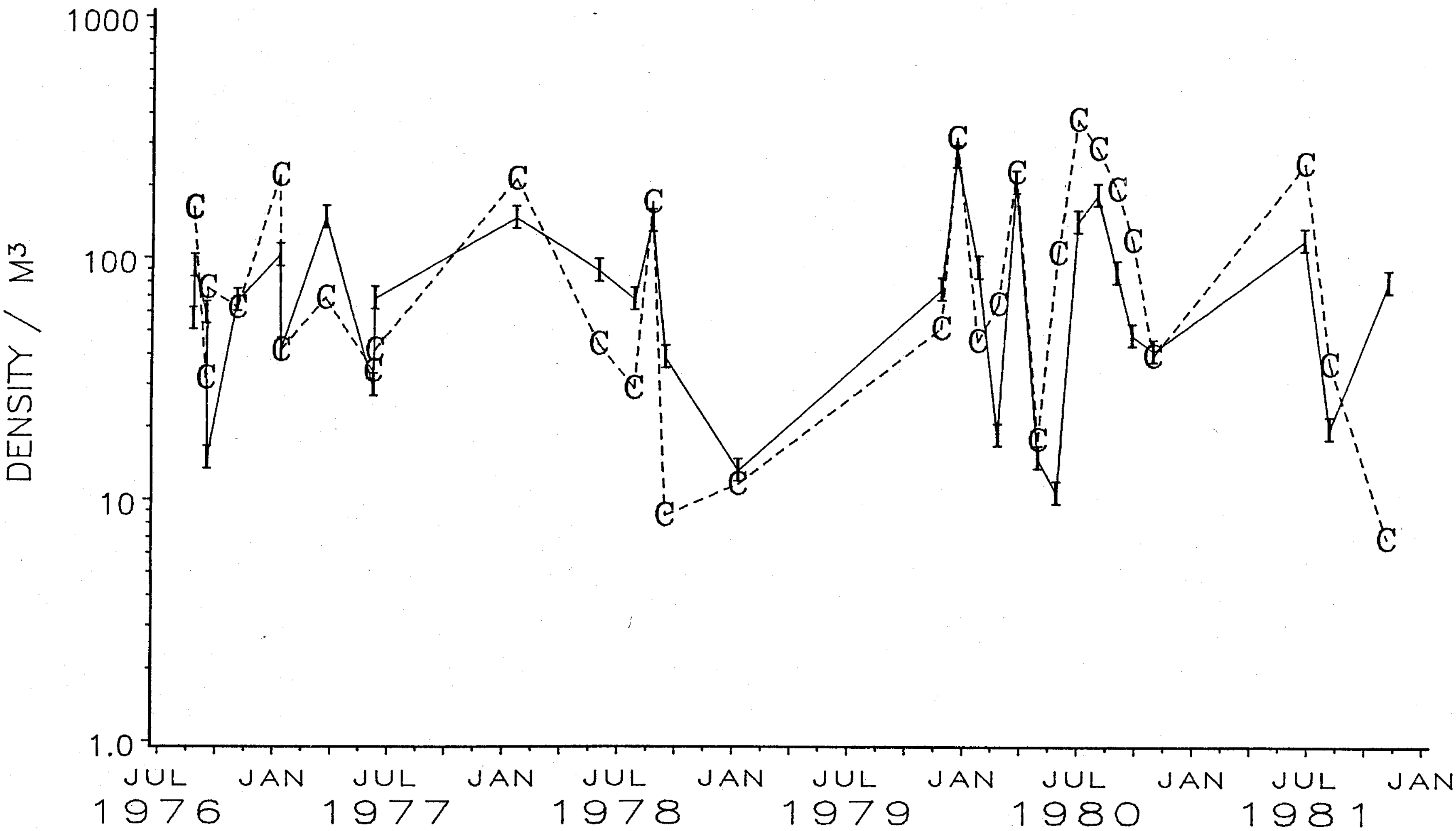
PLOT OF DELTAS (SONGS - CONTROL)

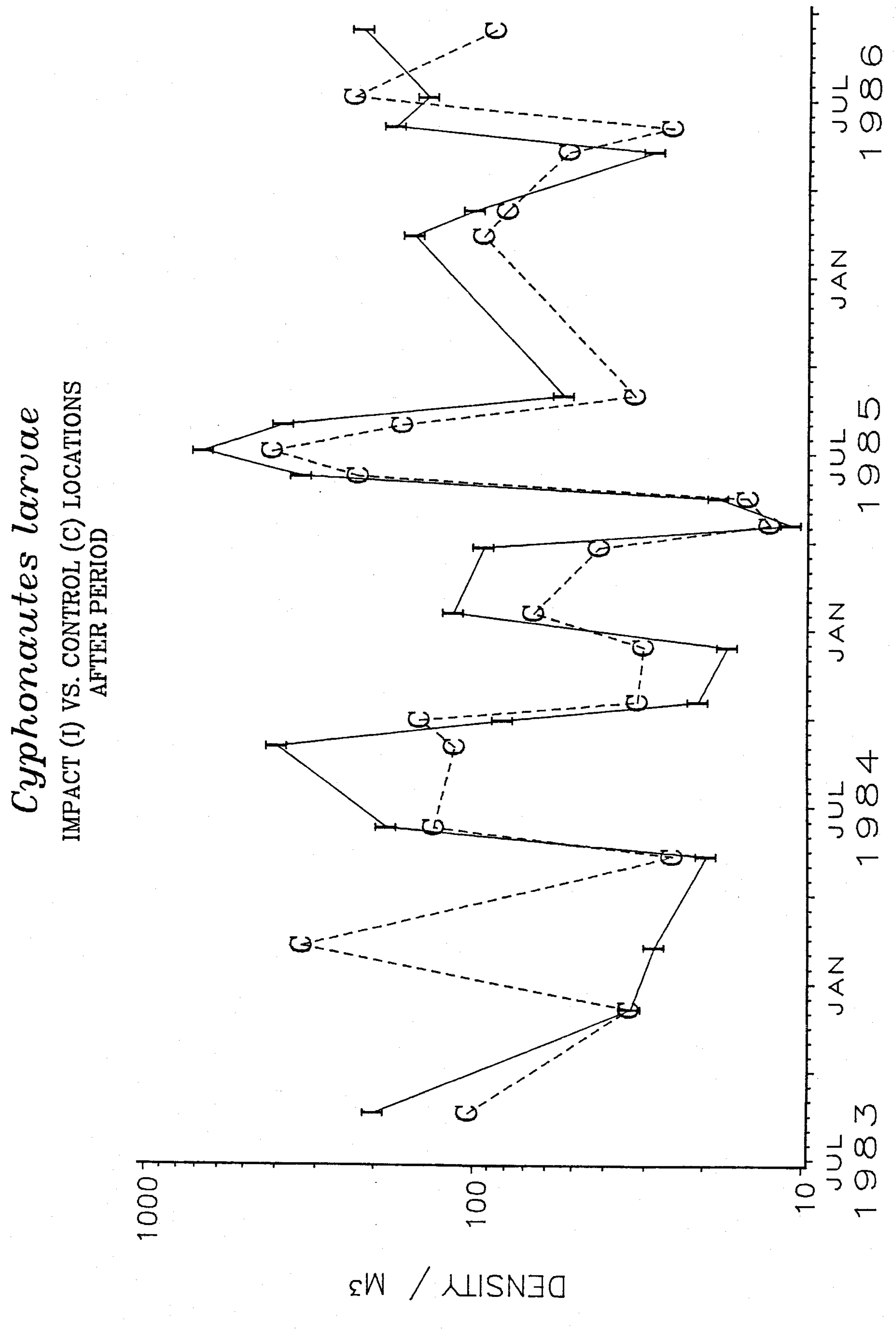
TRANSFORMATION LOG (X+1.0)



Cyphonautes larvae

IMPACT (I) VS. CONTROL (C) LOCATIONS
BEFORE PERIOD




Cyphonautes larvae
IMPACT (I) VS. CONTROL (C) LOCATIONS
AFTER PERIOD
DENSITY / M3
1000
100
10
JUL
1983
JAN
JUL
1984
JAN
JUL
1985
JAN
JUL
1986

SUMMARY OF BACI TEST

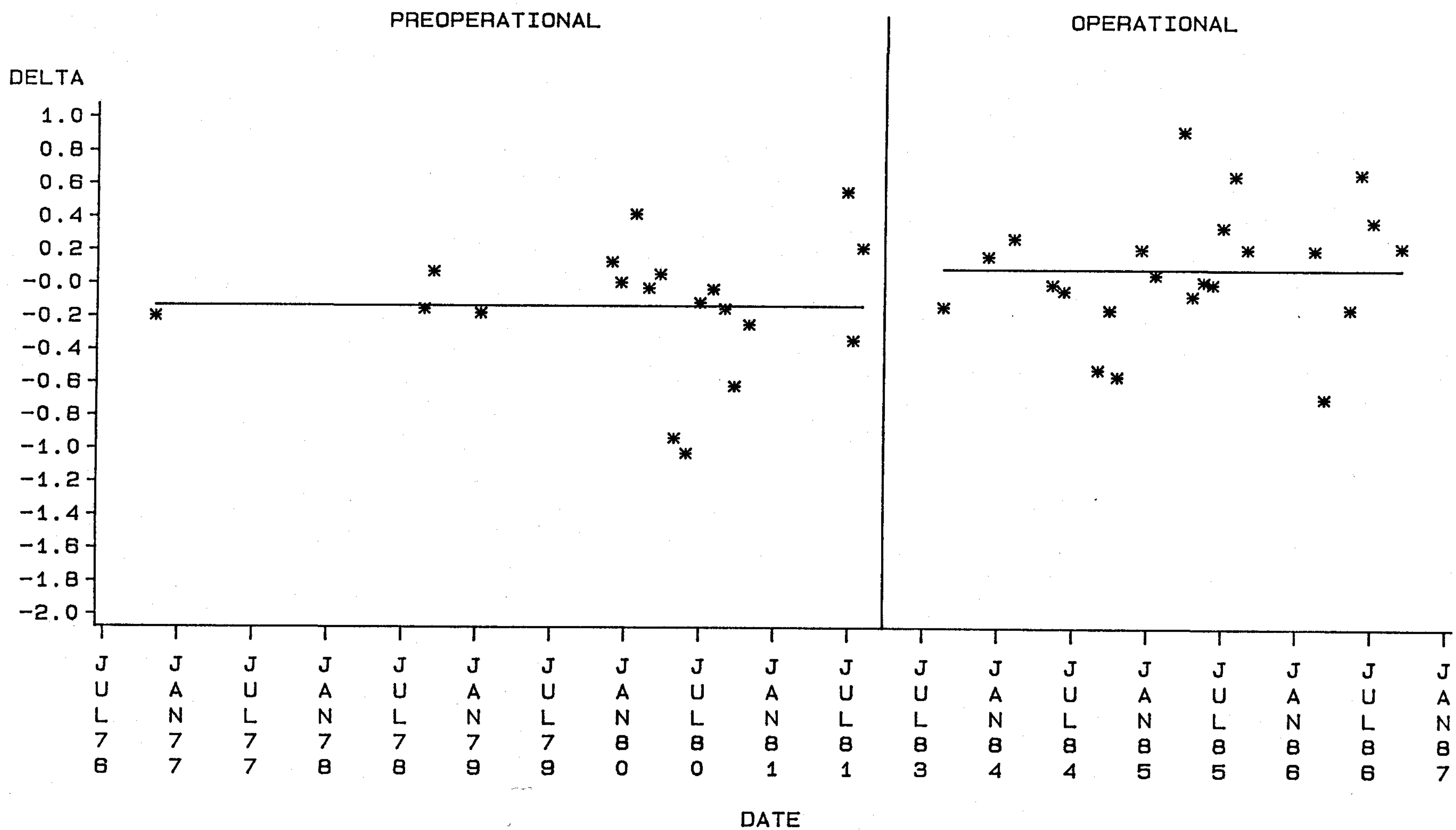
Unid. meroplankton larvae

TRANSFORMATION	NUMBER OF OBSERVATIONS BEFORE	NUMBER OF OBSERVATIONS AFTER	TEST FOR ADDITIVITY P-LEVEL	TEST FOR SERIAL CORRELATION	TRENDS TEST P-LEVEL BEFORE	TRENDS TEST P-LEVEL AFTER
LOG(X+0.01)	19	23	0.759	p > 0.05	0.847	0.313
LOG(X+0.1)	19	23	0.759	p > 0.05	0.847	0.313
LOG(X+0)	19	23	0.759	p > 0.05	0.847	0.313
LOG(X+1)	19	23	0.763	p > 0.05	0.848	0.314
LOG(X+10)	19	23	0.798	p > 0.05	0.853	0.326
LOG(X+100)	19	23	0.952	p > 0.05	0.861	0.372

TRANSFORMATION	GEOMETRIC MEANS BEFORE SONGS	GEOMETRIC MEANS BEFORE CONTROL	GEOMETRIC MEANS AFTER SONGS	GEOMETRIC MEANS AFTER CONTROL	PERCENT CHANGE	SIGNIFICANCE TESTS T	SIGNIFICANCE TESTS Z
LOG(X+0.01)	52.51	71.94	164.27	134.10	67.8	0.070	0.058
LOG(X+0.1)	52.54	71.98	164.32	134.13	67.7	0.070	0.058
LOG(X+0)	52.50	71.94	164.27	134.10	67.8	0.070	0.058
LOG(X+1)	52.90	72.35	164.75	134.43	66.6	0.071	0.058
LOG(X+10)	55.73	75.25	168.74	136.96	57.8	0.080	0.073
LOG(X+100)	65.85	85.46	193.92	148.35	32.3	0.096	0.095

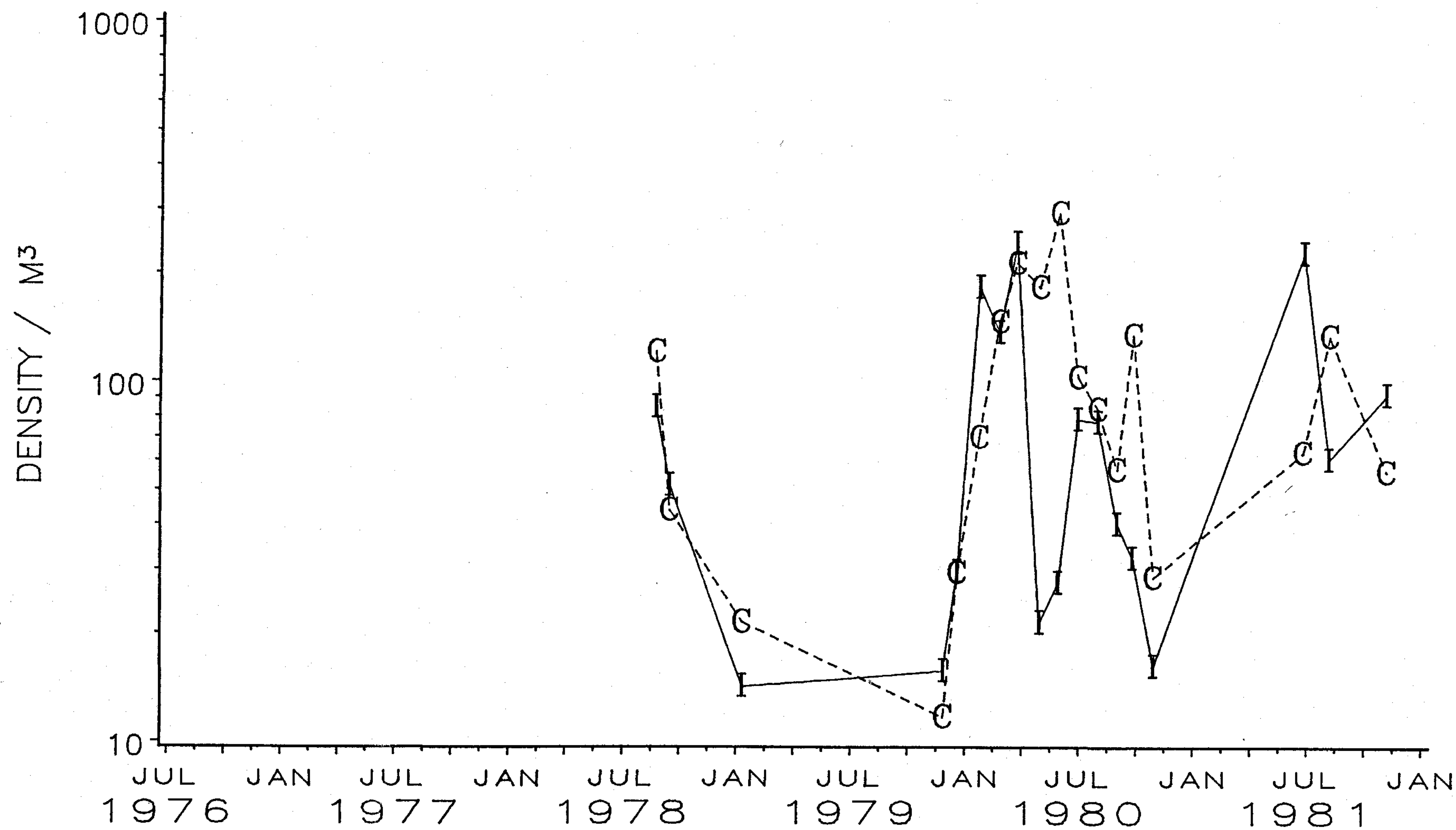
Unid. meroplankton

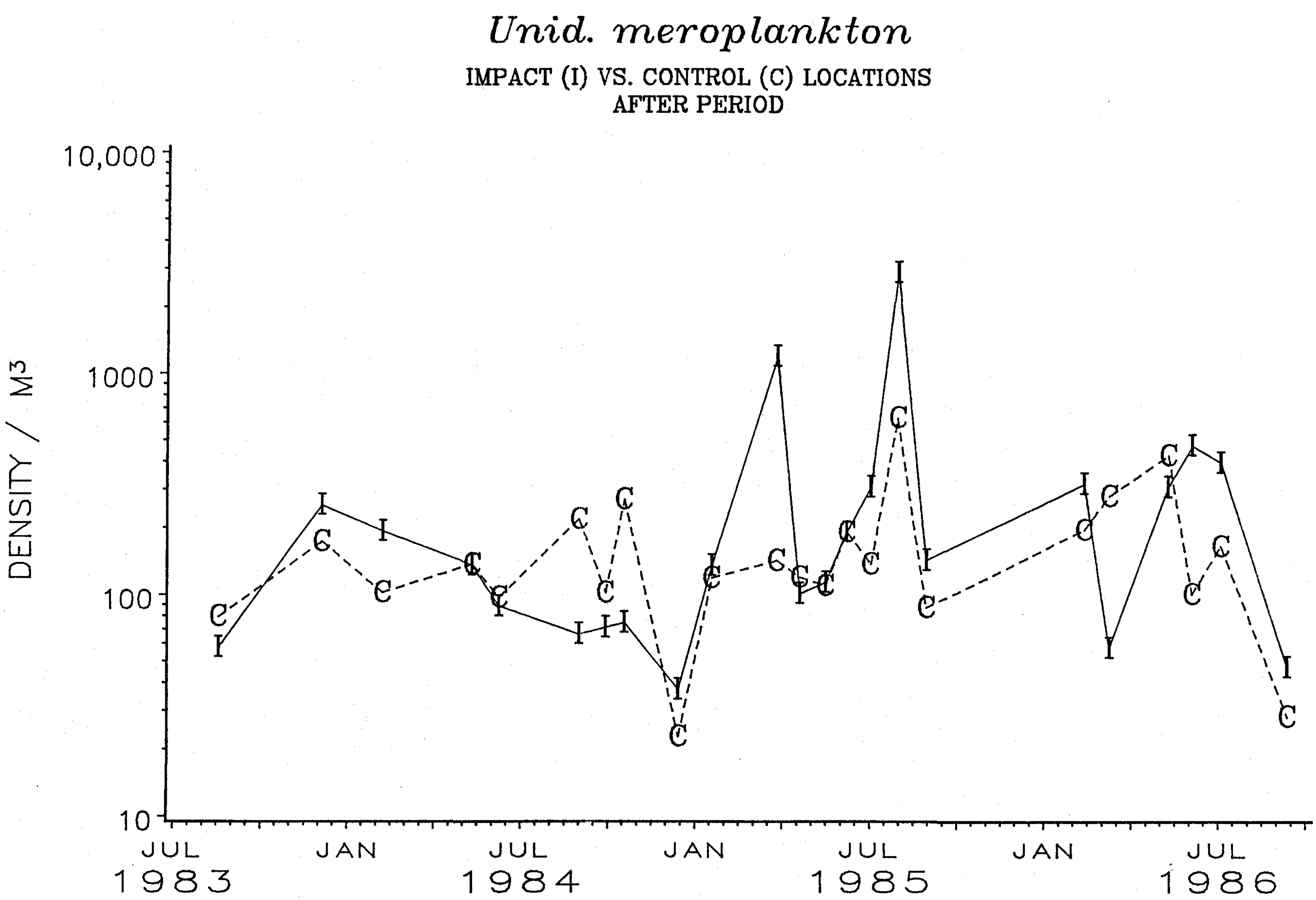
PLOT OF DELTAS (SONGS - CONTROL)
TRANSFORMATION LOG (X)



Unid. meroplankton

IMPACT (I) VS. CONTROL (C) LOCATIONS
BEFORE PERIOD




Unid. meroplankton
IMPACT (I) VS. CONTROL (C) LOCATIONS
AFTER PERIOD
DENSITY / M3
10,000
1000
100
10
JUL
JAN
JUL
JAN
JUL
JAN
JUL
1983
1984
1985
1986

SUMMARY OF BACI TEST

Total holoplankton

TRANSFORMATION	NUMBER OF OBSERVATIONS BEFORE	NUMBER OF OBSERVATIONS AFTER	TEST FOR ADDITIVITY P-LEVEL	TEST FOR SERIAL CORRELATION	TRENDS TEST P-LEVEL BEFORE	TRENDS TEST P-LEVEL AFTER
LOG(X+0.01)	18	23	0.180	p > 0.05	0.990	0.745
LOG(X+0.1)	18	23	0.180	p > 0.05	0.990	0.745
LOG(X+0)	18	23	0.180	p > 0.05	0.990	0.745
LOG(X+1)	18	23	0.181	p > 0.05	0.989	0.745
LOG(X+10)	18	23	0.182	p > 0.05	0.989	0.745
LOG(X+100)	18	23	0.191	p > 0.05	0.982	0.744

TRANSFORMATION	GEOMETRIC MEANS BEFORE SONGS	GEOMETRIC MEANS BEFORE CONTROL	GEOMETRIC MEANS AFTER SONGS	GEOMETRIC MEANS AFTER CONTROL	PERCENT CHANGE	SIGNIFICANCE TESTS T	SIGNIFICANCE TESTS Z
LOG(X+0.01)	3365.5	3316.79	4001	3800.35	3.8	0.812	0.783
LOG(X+0.1)	3365.5	3316.81	4001	3800.37	3.8	0.812	0.783
LOG(X+0)	3365.5	3316.79	4001	3800.35	3.8	0.812	0.783
LOG(X+1)	3365.9	3317.01	4001.2	3800.54	3.7	0.812	0.783
LOG(X+10)	3369.3	3318.96	4002.9	3802.18	3.7	0.814	0.783
LOG(X+100)	3401.2	3337.59	4020.3	3818.14	3.2	0.831	0.783

SUMMARY OF BACI TEST

Chlorophyll

TRANSFORMATION	NUMBER OF OBSERVATIONS BEFORE	AFTER	TEST FOR ADDITIVITY P-LEVEL	TEST FOR SERIAL CORRELATION	TRENDS TEST P-LEVEL BEFORE	AFTER
LOG(X+0.01)	25	15	0.899	$p > 0.05$	0.181	0.995
LOG(X+0.1)	25	15	0.927	$p > 0.05$	0.177	0.999
LOG(X+0)	25	15	0.894	$p > 0.05$	0.181	0.994
LOG(X+1)	25	15	0.885	$p > 0.05$	0.170	0.944
LOG(X+10)	25	15	0.403	$p > 0.05$	0.286	0.771
LOG(X+100)	25	15	0.116	$p > 0.05$	0.426	0.684

TRANSFORMATION	GEOMETRIC MEANS BEFORE SONGS	CONTROL	AFTER SONGS	CONTROL	PERCENT CHANGE	SIGNIFICANCE TESTS T	Z
LOG(X+0.01)	1.53	1.30	2.56	1.86	17.4	0.473	1.000
LOG(X+0.1)	1.57	1.35	2.69	1.95	17.4	0.456	1.000
LOG(X+0)	1.52	1.30	2.55	1.85	17.4	0.475	0.955
LOG(X+1)	1.84	1.59	3.42	2.47	16.3	0.383	0.801
LOG(X+10)	2.44	2.19	5.03	3.61	8.2	0.317	0.780
LOG(X+100)	2.79	2.64	6.11	4.29	1.6	0.278	0.823

APPENDIX I: BACIP Test results on samples sorted by current direction

DBMACZP.CRØØ3 – DBMACZP.CR213	MPC Databases
ZOSTRATA SAS	SAS program
ZOBACI.STRAT	temporary database
ZOXshelf SAS	SAS program
ZOBACI.Xshelf1	tempory database
BACIPLUM SAS	SAS program

APPENDIX I: BACIP Test results on Samples sorted by current direction

DBMACZP.CRØØ3 - DBMACZP.CR213	MRC Databases
ZOSTRATA SAS	SAS program
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ZOXShelf SAS	SAS program
ZOBACI.XShelf1	tempory database
BACIPLUM SAS	SAS program

APPENDIX I. COMPARISON OF BACIP TEST RESULTS ON SAMPLES SORTED BY CURRENT DIRECTION. Direction of change (disregarding alpha level of test result) indicated by BACIP test (d=decrease, i=increase, ?=not determined) on data from (1) all surveys, (2) surveys on days of upcoast currents and (3) upcoast currents.

	All dates	Up Coast (Plume)	Down Coast (Non-plume)
Cirriped nauplii	i*	i*	i
Cyphanautes larvae	i*	i	d
Evadne nordmanii	i*	i**	d
Evadne spinifera	d**	d	d**
Oithona plumifera	i	i**	d
Podon polyphemoides	i	i*	d
Total meroplankton	i**	i**	i
Unidentified meroplankton	i**	i**	d

** $p < 0.05$
* $0.05 < p < 0.10$

APPENDIX J. TAXA WHICH DID NOT DECLINE BY 50% PERCENT. The P values listed are associated with the test of the hypothesis that a 50% or greater decline occurred.

Taxa	P>t
Holoplankton	
Calanus pacificus	0.09
Corycaeus anglicus	0.10
Evadne nordmanni	0.001
Oithona plumifera	<0.001
Penillia avirostris	0.001
Podon polyphemoides	0.005
Saggitta euneritica	0.006
Unid. holoplankton	0.001
Total holoplankton	<0.001
Meroplankton	
Cirriped cypris	0.004
Cirriped nauplii	<0.001
Cyphopnautes larvae	<0.001
Unid. meroplankton	<0.001
Total meroplankton	<0.001
Total zooplankton	<0.001

APPENDIX K. CALCULATION OF INTAKE LOSS OF MICROZOOPLANKTON.

From Strickland (1967) there 5.9 mg of microzooplankton/m^3 in nearshore waters. To obtain the dry weight from the measure of carbon (A. Barnett, pers comm.) we multiply the carbon by two and divide by .9. Thus, there are 5.9 x 2/.9 = 13.1 mg dry weight /m^3.

This value is multiplied by the number of m^3 withdrawn by Units 2 and 3 per year (at 75% pumping). 13.1 mg/m^3 x 2.48 x 10^9 m^3 = 3.25 x 10^{10} mg/year or 32,500 kg/year.

To get wet weight, multiply dry weight by 10. So loss per year is 325 metric tons.

APPENDIX L. COMMENTS ON DIFFERENCES BETWEEN THE MRC AND MEC FINAL PLANKTON REPORT

As expected, there is a great degree of agreement between the MEC Final Report and this (MRC) report regarding the overall results and conclusions of the zooplankton program. However, because data, in some instances, were analyzed in different ways, some of the tabulated results differ between the two reports. The following discusses the major differences.

1. BACIP analyses were central to both reports. MEC reported one significant abundance change (cirriped nauplii) while we report four additional changes. One of the additional results the MRC reports is of a taxon not tested by MEC (Unidentified Meroplankton). Two others (cyphonautes larvae and Evadne nordmanni) result from the MRC reporting the result of a non-parametric test (Mann-Whitney U) not reported by MEC. The final difference (Evadne spinifera) arises from the MRC reporting the alpha level of the test associated with the transformation log (x+0.1) instead of that associated with log x reported by MEC (this latter transformation also displayed a p value less than 0.1 associated with a Mann-Whitney U test).

2. The size of the relative change in the abundance of cirriped nauplii is reported as -0.1% in the MEC report and >100% in the MRC report. This difference arises from different methods of calculating the percent relative change. The MRC back-transforms the log of the difference of the mean deltas (see Results section above for description and rationale). Instead of using geometric means like the MRC, MEC applied the arithmetic means of the Before, After, Impact and Control abundances to estimate the size of the change. (Their method is described in Section 3 of their Final Report.) We feel that this method is less desirable because those samples in which abundances are high will influence the estimate of relative change much more than samples with low abundances.

3. There are differences between the two reports regarding the analysis of distributional patterns. As described in the Fish Larvae Report, Appendix L, the MRC rejected the MEC approach (the use of a MANOVA on the ranked abundances among blocks and strata). We feel that this approach is not appropriate to testing for Plant effects. The mean rankings of the block/stratum combinations at the Impact site in the After period are compared to those resulting from combining the rankings from the After/Control, Before/Control, and Before/Impact transects. By making this comparison, plant effects are confounded with both location and period effects. A second problem with the use of a MANOVA, is the selection of the appropriate transformation (MEC chose a rank transformation). A third difficulty is in interpretation. Once a difference is detected with MANOVA it is often difficult to determine which block/stratum combinations are responsible.

For these reasons, the MRC chose to test a simpler hypothesis regarding distributional changes. We tested for changes in cross-shelf direction only and did so by testing for changes in the proportions of the cross-shelf abundances found the in the offshore blocks as described in the text.

4. Finally, MEC presents a table of mean abundances of the various taxa for both periods and both locations (Table 4-8, MEC Final Report)). The values in this table are different from those presented in Appendix F of the MRC report. The MRC values are averaged over all After and Before surveys, the MEC values are averaged over only those surveys on which the taxon was found at either one location or another.

APPENDIX M. DATABASES. The data on which this report are based are stored in the following databases:

SONGS power and pumping records are stored in DBSONGS

Longshore current records are stored in DBUVT

Zooplankton data are stored in DBMACZP

Chlorophyll data are stored in DBWATER

The programs used in analysis are stored (under the Appendix,Table or Figure title) on the MRC Report Disk.