SPATIAL AND TEMPORAL DISTRIBUTION OF BENTHIC MACROINVERTEBRATES AND SEDIMENTS COLLECTED IN THE VICINITY OF THE J.H. CAMPBELL PLANT, EASTERN LAKE MICHIGAN, 1979

By

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CONTENTS

INTRODUCTION

The J. H. Campbell Plant is comprised of three coal-fired operational units. While Units 1 and 2 have used and will continue to utilize Lake Michigan water drawn through Pigeon Lake for cooling purposes, Unit 3 draws cooling water from an intake structure located in approximately 11 m (1.1 km offshore) of water in Lake Michigan. Heated water from Units 1, 2, and 3 are discharged through the offshore discharge structure. While Unit 3 was not operational during 1979, in September 1980 all three units began discharging heated effluents at approximately 6 m (0.3 km offshore), thereby ending the preoperational period. Data have been collected for preoperational years 1978 and 1979.

This is the third in a series of benthos reports that began in 1977 concurrent with reports on larval, juvenile, and adult fish (Jude et al. 1978, 1979, and 1980). The first benthos report (Jude et al. 1978) was a pilot study ascertaining the approximate density and variety of benthic macroinvertebrates near the Campbell Plant during June 1977. In addition, variance and sample replicability were addressed. The second report, based on 1978 data (Winnell and Jude 1979), presented quantitative and qualitative differences between a treatment and two reference areas near the plant for benthic taxa and sediments. The purpose of this report is to present and analyze all preoperational data collected during 1978 and 1979. Analysis will be oriented toward determining monthly, depth, and regional distribution similarities for benthic and sediment parameters between control and treatment regions in 1979 and between the years 1978 and 1979. The overall purpose of this study is to determine whether density and species composition of benthos collected from 1978 and 1979 differ significantly from estimates covering the operational

period. Analyses will be conducted after collection of 1981 samples in accordance with the statistical analysis technique (Johnston 1973, 1974) utilized at the D.C. Cook Nuclear Power Plant, southeastern Lake Michigan [see METHODS - STATISTICAL ANALYSIS OF PREOPERATIONAL AND OPERATIONAL DATA, (1978-1981)].

The general distribution of benthos in southeastern and eastern Lake Michigan has been studied by Powers and Robertson (1965), Robertson and Alley (1966), Hiltunen (1967), Alley (1968), Mozley and Garcia (1972), Mozley and Winnell (1975), and Alley and Mozley (1975). However, the most comparable benthic studies were conducted in the immediate vicinity of the Campbell Plant by Truchan (1970) and Beak Inc. (Consumers Power Company 1975) to determine the effect of the shoreline thermal discharge on benthic macroinvertebrate distribution. While Truchan (1970) did find evidence of greater diversity near the discharge canal when compared with reference areas, he found no adverse impact on local benthos populations in the treatment area. In addition, studies completed by Beak Inc. from 1968 to 1974 indicated that, although some differences in benthic numbers were evident between treatment and reference areas, there appeared to be no "appreciable harm to the benthic community" due to shoreline thermal discharge (Consumers Power Company 1975). Based on information from the June 1977 pilot study, Jude et al. (1978) concurred with earlier conclusions made by Beak Inc. In the more extensive 1978 survey (Winnell and Jude 1979) we found that, although depth and time had the greatest impact on benthic macroinvertebrate density, region (i.e., treatment and reference areas) was an important consideration in several instances. Completion of benthos sampling in the second and final preoperational year (1979) ensured a sound data base, verified depth, time, and regional trends from 1978 to 1979, and noted regional differences and similarities within 1979

as they relate to benthos and sediments collected near the Campbell Plant. Significant differences between years or regions have been noted and tentative causes for these differences suggested. However, evaluation of any thermal effects due to plant operation must await collection and analysis of 1981 benthic samples.

METHODS

BENTHOS AND SEDIMENT SURVEY DESIGN

The survey was composed of 10 stations located along two transects perpendicular to the shoreline (Fig. 1). Along each transect, stations were located at 3-, 6-, 9-, 12- and 15-m depths. The first transect represented the treatment area (inner region) near the present thermal discharge. The second transect represented the reference area (outer region) located 5.0 km north of the discharge canal. During both April and July 1979, the inner transect was located 0.16 km north of the present thermal discharge canal. Due to construction activities during October 1979, it was necessary to move the inner transect 0.32 km north of the discharge canal.

The 1978 survey design was modified in 1979 by eliminating the intermediate region and including only inner and outer regions. In addition, during 1978, benthic and sediment parameters for each region were estimated from three replicates at each of two stations located equidistant north and south of the discharge canal at each depth. In 1979, the same parameters were estimated by one station sampled six times at each depth within a region. Since estimates of the benthos and sediments from 1978 were made by combining the two sets of three replicates collected at a selected depth and region, replication from 1978 to 1979 remained constant at six within a given region and depth.

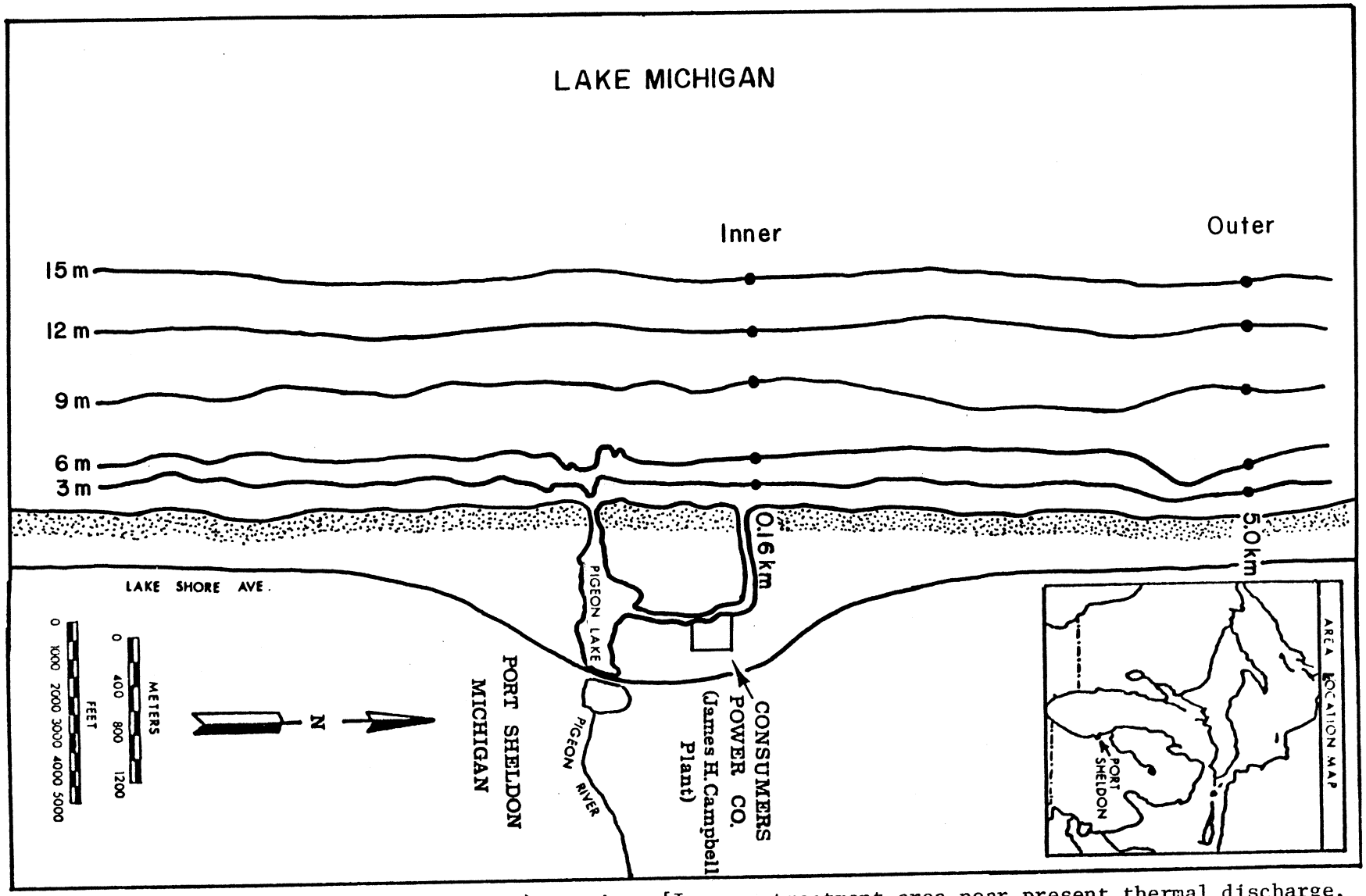


Fig. 1. Location of stations (solid dots), regions [Inner = treatment area near present thermal discharge, Outer = reference area] and depths sampled in the 1979 benthos and sediment survey design near the J. H. Campbell Plant, eastern Lake Michigan.

BENTHOS AND SEDIMENT SAMPLE COLLECTION AND PROCESSING

Benthic macroinvertebrate and sediment samples were collected on 19 April, 20 July, and 16 October 1979 in the vicinity of the J.H. Campbell Power Plant, eastern Lake Michigan. Sixty samples were collected for benthos and sediments during each sampling month from the University of Michigan's R/V Mysis. During 1979, 180 samples were collected for each parameter. No samples were lost due to breakage or spillage.

Benthos and sediment samples were collected using a triplex (three-chambered) Ponar grab sampler (Mozley and Chapelsky 1973). Each chamber of the Ponar grab samples 0.0165 m^2. A conversion factor of 60.6 was used to convert numbers of animals present in each grab to numbers per square meter. One side chamber of the Ponar grab was used to estimate numbers of benthic macroinvertebrates occurring in a square meter. Contents from the remaining two chambers of the Ponar were emptied into a tub and mixed, and approximately 30 g of sediment removed for sediment analysis. Six replicates (A-F) were collected to estimate benthic populations and sediments at any particular depth and region during each month sampled.

The portion of the Ponar grab used to estimate benthic macroinvertebrates was placed in a "funnel-shaped hopper" (see Mozley 1975 for details) aboard the R/V Mysis. Benthic samples were washed through a 0.2-mm mesh net to concentrate animals and remove excess sediment and debris. The mesh size of the net used to sieve organisms from sediments was reported as 0.35 mm in Jude et al. (1978) and Winnell and Jude (1979). However, the material supplied to us as 0.35-mm mesh and from which our nets were constructed was in fact 0.2 mm. Concentrated samples were stored in externally and internally labelled 1-pint Mason jars and preserved with carbonate-buffered, 4% formaldehyde solution.

Samples were returned to the Great Lakes Research Division benthos laboratory for sorting and identification.

Sorting and initial identification of organisms were performed using dissecting microscopes (3-30X). Specimens unidentified at the genus/species level (Chironomidae, Naididae, and Tubificidae) were mounted on slides with Amman's lactophenol clearing medium and identified using compound microscopes (40-1000X).

Initial generic identification of chironomids was determined using an unpublished trial key to the chironomids (A.L. Hamilton and O.A. Saether, personal communication, Freshwater Institute, Winnipeg, Manitoba, Canada and Zoological Museum and Department of Morphology, Systematics and Animal Ecology, University of Bergen, Bergen, Norway). In cases where species were determined for chironomid genera, "cf." refers to uncertain larval identification at the species level. Most species designations concur with reared specimens from the D.C. Cook Plant, southeastern Lake Michigan, which are maintained in the Great Lakes Research Division benthos laboratory's permanent collection. Larval, pupal, and adult chironomid associations at the D.C. Cook Plant have been reviewed by Mozley (1975). However, since none of the chironomid larvae from the J.H. Campbell Plant have been reared, identifications at the species level have been assigned the uncertainty designator "cf." The designator "gr.," which refers to a "group" of species undeterminable from larvae, was associated with the genera Polypedilum, Chironomus, and Paracladopelma. Morphology and taxonomy of other chironomid genera and species were determined from the following references: Lenz (1954), Roback (1957), Curry (1958), Beck and Beck (1969), Saether (1969, 1971, 1973, 1975, 1976, and 1977), Hirvenoja (1973), Jackson (1977), and Soponis (1977).

Naidids and tubificids were identified using an unpublished key to aquatic

oligochaetes of the Great Lakes (J.K. Hiltunen, personal communication, Great Lakes Fishery Laboratory, U.S. Fish and Wildlife Service, Ann Arbor, Michigan). Gastropods and pelecypods were identified using a key to molluscs of the Great Lakes being prepared at the Great Lakes Research Division (G. Mackie, D. White, and T. Zdeba, personal communication, University of Michigan, Ann Arbor, Michigan).

While aboard the R/V Mysis, sediments were stored in sealed plastic bags bearing external labels. Standard mechanical sieving of sediment samples was performed at the Great Lakes Research Division sediment laboratory. Folk, Inman, and moment measure statistics were computed for each sample collected. Data were expressed in terms of phi units following Krumbein (1938). Upchurch (1969), Coakley and Beal (1972), and Seibel et al. (1974) indicated that moment measure statistics were the "preferred method for deriving sediment textural parameters." Two moment measure statistics, mean grain size and standard deviation of the mean grain size, were used in this report. Standard deviation has been used as a measure of sorting, following Seibel et al. (1974). In addition to moment measure statistics, percentage of sediments occurring within any given sediment grain size based on units of phi has been included in this report. Description of sediment grain sizes followed that of Seibel et al. (1974), who adapted theirs from the standard Wentworth scale.

STATISTICAL ANALYSIS OF 1978-1979 PREOPERATIONAL DATA

The preoperational data set (1978-1979) was analysed for annual and regional differences, either within 1979 (inner vs. outer region comparisons) or differences between years (inner 1978 vs. inner 1979 and outer 1978 vs. outer 1979). To determine the presence of preoperational differences, Student's t tests were performed using the Michigan Interactive Data Analysis

System (MIDAS) on the AMDAHL 470V/7 computer at the University of Michigan. MIDAS computes Student's t tests according to the following equation given by Dixon and Massey (1969):

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S_p \sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$

t = calculated Student's t statistic
X_1 and X_2 = mean from populations 1 and 2, respectively
N_1 and N_2 = number of observations from populations 1 and 2, respectively
S_p^2 = pooled variance
where; $\alpha = 0.05$
such that, NS = no significance
* = $0.01 < P \leq 0.05$
** = $0.001 < P \leq 0.01$
*** = $P \leq 0.001$
\- = no test performed due to no variance or mean estimate available for one or both populations tested

All analyses were performed on log(x + 1) transformed values. Elliott (1971) considered the log transformation the most effective transformation when dealing with benthic data that are contagiously distributed, i.e., characterized by a variance to mean ratio significantly greater than one (χ^2 - test). Transformation of raw numbers to log (x + 1) transformed values is generally used to condense the range of values observed in the raw data in order to more fully meet assumptions of normality and homogeneously distributed variances upon which validity of the derived significance level for the t test is based. Because no transformation of raw data can guarantee that the transformed data set or subsets thereof meet the assumptions above, we prefer to consider inferences made in the 0.05 - 0.01 probability range as marginal.

Differences between populations based on probability for values of $p \geq 0.01$ are considered as significant in this study. It is thought that the differences observed at $p \geq 0.01$ were considered disparate enough in this system that improvement upon the assumptions by transformations would not alter the conclusion (Chang and Winnell 1980).

STATISTICAL ANALYSIS OF PREOPERATIONAL AND OPERATIONAL DATA (1978-1981)

In a previous report (Winnell and Jude 1979), we stated that data on benthic macroinvertebrates collected near the J.H. Campbell Plant from 1978 to 1981 would be analyzed statistically following Johnston (1974). With completion of the preoperational survey (1978-1979) and prior to presentation of operational survey data (1980-1981), examination of Johnston's model for the analysis of thermal discharge effects on benthic populations and its application to the Campbell survey area is appropriate. Although this subsection of the METHODS section will not be utilized in this report, it is presented in order to clarify the direction of the 4-yr benthic study design and the statistical methodology undergirding the study prior to the collection of operational data in 1980 and 1981.

Johnston's model has two major objectives. The first objective is to determine thermal effects using an F-ratio comparison derived from a mixed-model, nested analysis of variance (ANOVA). Completion of the analysis for the first objective provides the error mean square estimate used to calculate subsequent parameters used in second objective calculations. The second objective is to determine the sensitivity of the 4-yr survey design regarding the degree of change necessary to detect a thermal effect within treatment area benthic populations when compared with reference area benthic populations. Quantification of the sensitivity is determined by first

calculating Sokal and Rohlf's (1969) least detectable true difference (δ) from the equation:

$$\delta = \sigma \left(\frac{2}{n}\right)^{\frac{1}{2}} \{t_{\alpha[\nu]} + t_{2(1-P)[\nu]}\}^2$$

δ = least detectable true difference

σ = true error standard deviation

ν = degrees of freedom of the error mean square

n = number of observations at each of the two treatment levels

t = Student's t

α = significance level

P = power (the desired probability that a difference will be found to be significant)

and secondly by determining R from Johnston's derivation of Cohen's (1969) equations to:

$$R \geq 10^{\sqrt{2}\delta} \quad \text{or} \quad R \leq 10^{-\sqrt{2}\delta}$$

R = least detectable true ratio

δ = least detectable true difference

Johnston's mixed-model, nested ANOVA has five essential factors: construction time, year, month, depth, and region (treatment and control areas) (Table 1). The model assumes that the effect of month and depth are additive, thereby eliminating the difficulty of "assigning ecological interpretation" to higher-order interactions. Furthermore, Johnston uses Kirk's (1968) justification that once the investigator has selected the components expected to be major contributors to the total variance based on the investigator's knowledge of the system, all other components become part of the experimental error.

Of the model's five main effect factors, all are fixed-effect factors

TABLE 1. Major factors considered in the mixed-model, nested ANOVA to be applied to benthic populations surveyed from 1978-1981 near the J. H. Campbell Plant, eastern Lake Michigan (After Johnston 1974).

Name of factor	Factor abbreviation	Number of levels	Type of factor
Construction time (Before, After)	C	2 (Before, After)	Fixed
Year (1978 - 1982)	Y	2 (1978 - 1982)	Random (nested within C)
Region	R	2 (Inner, Outer)	Fixed
Month	M	3 (April, July, October)	Fixed
Depth	D	5 (3, 6, 9, 12, 15 m)	Fixed
Error	E	6 (Number of replicates)	--

Total number of observations = 2 x 2 x 2 x 3 x 5 x 6 = 720
Total degrees of freedom = 719

except year which is random and nested within construction time. In all, 32 interaction components are possible, but Johnston considered only nine essential for determination of heat effects (Table 2). The term used to determine thermal effects is the interaction (C x R) of construction time (C) and region (R). The null hypothesis assumes that $\theta_{CR} = 0$, i.e., the beginning of discharging heated water through the offshore discharge diffusers has had "no effect on the difference between the mean transformed benthic density" in the inner region (area of thermal discharge) and in the outer region (reference area). The F-ratio of the estimated mean squares (MS) for CR (Construction time x Region) and YR (Year x Region) interactions:

$$F = \frac{MS_{CR}}{MS_{YR}} = \frac{\sigma_\varepsilon^2 + 180\sigma^2_{CR} + 90\sigma^2_{YR}}{\sigma_\varepsilon^2 + 90\sigma^2_{YR}}$$

can be used to test the null hypothesis that $\theta_{CR} = 0$. Terms in the F-ratio measure sampling error variance or variability among replicates (σ_ε^2) and the annual variability of the "difference between inner and outer populations, averaged over all months and depths "(σ^2_{YR}). Since the null hypothesis assumes $\sigma_{CR} = 0$, then the F-ratio becomes $(\sigma_\varepsilon^2 + 90\sigma^2_{YR})/(\sigma_\varepsilon^2 + 90\sigma^2_{YR})$ distributed as

TABLE 2. Important sources of variation, their respective degrees of freedom and expected mean squares derived from the mixed-model ANOVA to be applied to benthic populations surveyed from 1978-1981 near the J. H. Campbell Plant, eastern Lake Michigan. Derivation of expected square coefficients assumes the depth factor (D) has five levels. See Table 1 for key for abbreviated source of variation factors (After Johnston 1974).

Source of variation	Degrees of freedom	Expected mean square
C	1	$\sigma_E^2 + 360\ \sigma_C^2 + 180\ \sigma_Y^2$
Y	2	$\sigma_E^2 + 180\ \sigma_Y^2$
R	1	$\sigma_E^2 + 360\ \sigma_R^2 + 90\ \sigma^2_{YR}$
M	2	$\sigma_E^2 + 240\ \sigma_M^2$
D	4	$\sigma_E^2 + 144\ \sigma_D^2$
CR	1	$\sigma_E^2 + 180\ \sigma^2_{CR} + 90\ \sigma^2_{YR}$
YR	2	$\sigma_E^2 + 90\ \sigma^2_{YR}$
E	706	σ_E^2
Total	719	

an F(1,2). Johnston uses $\sigma_{\varepsilon}^{2} + 90\sigma^{2}_{YR}$ in the denominator in the F-ratio, making the quantity $(\sigma_{\varepsilon}^{2} + 90\sigma^{2}_{YR})^{1/2}$ the appropriate error standard deviation (σ) for use in the power equation.

Calculation of the least detectable true change (δ) using the error standard deviation from the 4-yr design assumes a 5% significance level and 95% power, i.e., "is the minimum amount by which the true treatment means must differ if there is to be a 95% probability that the means of two samples of size n will be found significantly different at the 5% level." When δ (least detectable true change) is applied to R (least detectable true ratio), which is derived from Cohen (1969), resulting values of R will estimate the relative increase or decrease of the inner region benthic populations when compared with outer region benthic populations necessary to detect a heat effect using the 4-yr survey design.

Benthic populations and respective depths to be considered in the above analyses include: Chironomidae (3-15 m), Turbellaria (3-15 m), Naididae (3-15 m), total animals (3-15 m), Tubificidae (9-15 m), Pisidium (9-15 m), Pontoporeia hoyi (9-15 m), Gastropoda (12-15 m), Enchytraeidae (12-15 m), and Stylodrilus heringianus (15 m). Depths not included in the analyses of benthic groups for either 1978-1979 or 1978-1981 data have been excluded due to low density and frequency of occurrence under the assumption that it is more advisable to test for effects on the main body of a population than on the fringe of the population. Consequently, coefficients for the expected mean square term will differ for those populations where the number of depth factors included in the analysis are less than five. While the coefficients presented earlier were based on five depths, fewer depths tested will not change the F-ratio relationship (MS_{CR}/MS_{YR}) but will only alter the magnitude of the coefficients for the expected mean square term. The exception is S.

heringianus which has only one level (15 m) for depth. In this case, there will be no depth factor in the ANOVA.

RESULTS

TOTAL ANIMALS

The number of identified benthic macroinvertebrate taxa collected from samples taken near the Campbell Plant in 1979 (82) was slightly greater than the revised number of taxa collected during 1978 (76). Based on all samples collected from 1977 through 1979 (660), 105 benthic macroinvertebrate taxa have been collected and identified (Table 3). Representation of the 105 benthic taxa among major taxonomic groups was as follows: Chironomidae (37), Naididae (19), Pisidium (16), Tubificidae (13), Gastropoda (5), Sphaerium (3), and miscellaneous others (12). During 1979, 73 benthic forms were collected in each of the inner and outer regions (Table 4). Combining 1978 and 1979 surveys, the inner region was represented by 82 taxa and the outer region by 81 taxa. Comparing the number of taxa collected in the inner and outer region during 1979, the greatest difference was observed at 3 m. At 3 m, there were twice as many taxa present in the inner region (22) when compared with the outer region (11), which was mainly the result of regional chironomid and naidid taxa differences. Detail regarding these differences will be presented in the chironomid and naidid sections to follow.

Percent occurrence of major taxonomic groups (i.e., Chironomidae, Naididae, Tubificidae, Enchytraeidae, Stylodrilus heringianus, Pisidium, Sphaerium, Gastropoda, Pontoporeia hoyi, and Turbellaria) among months, depths, and regions sampled during 1979 near the Campbell Plant are summarized in Table 5. Chironomids, naidids, and turbellarians were the predominant forms at 3-6 m. A change in the dominant taxon observed at 9 m was primarily due to an

TABLE 3. Benthic macroinvertebrates identified from samples collected from 1977 through 1979 at 3 to 25 m near the J. H. Campbell Plant, eastern Lake Michigan.

- Coelenterata
  - Hydrozoa
    - Hydridae
      - *Hydra* sp.
- Platyhelminthes
  - Turbellaria
    - Unknown sp. 1
    - Unknown sp. 2
- Annelida
  - Oligochaeta
    - Enchytraeidae spp.
    - Lumbriculidae
      - *Stylodrilus heringianus*
    - Naididae
      - *Amphichaeta leydigii*
      - *Arcteonais lomondi*
      - *Chaetogaster diaphanus*
      - *Chaetogaster diastrophus*
      - *Chaetogaster setosus*
      - *Dero* sp. (?*digitata*)
      - *Nais communis*
      - *Nais elinguis*
      - *Nais pardalis*
      - *Nais simplex*
      - *Nais variabilis*
      - *Paranais litoralis*
      - *Paranais simplex*
      - *Piguetiella michiganensis*
      - *Pristina foreli*
      - *Pristina osborni*
      - *Stylaria lacustris*
      - *Uncinais uncinata*
      - *Vejdovskyella intermedia*
    - Tubificidae
      - *Aulodrilus limnobius*
      - *Aulodrilus pigueti*
      - *Limnodrilus angustipenis*
      - *Limnodrilus claparedeianus*
      - *Limnodrilus hoffmeisteri*
      - *Limnodrilus profundicola*
      - *Limnodrilus spiralis*
      - *Limnodrilus udekemianus*
      - *Peloscolex freyi*
      - *Peloscolex superiorensis*
      - *Potamothrix moldaviensis*
      - *Potamothrix vejdovskyi*
      - *Rhyacodrilus coccineus*
  - Hirudinea
    - Glossiphoniidae
      - *Helobdella stagnalis*
    - Other Hirudinea spp.
- Arthropoda
  - Acari
    - Hydracarina spp.
  - Crustacea
    - Amphipoda
      - Gammaridae
        - *Gammarus* sp.
      - Haustoriidae
        - *Pontoporeia hoyi*
    - Mysidacea
      - Mysidae
        - *Mysis relicta*
  - Insecta
    - Diptera
      - Chironomidae
        - Chironominae
          - Chironomini
            - *Chironomus fluviatilis*-gr.
            - *Chironomus halophilus*-gr.
            - *Cladopelma* sp.
            - *Cryptochironomus* sp. 1
            - *Cryptochironomus* sp. 2
            - *Cryptochironomus* sp. 3
            - *Cryptochironomus* cf. *rolli*
            - *Endochironomus* sp.
            - *Parachironomus* cf. *abortivus*
            - *Paracladopelma* cf. *nereis*
            - *Paracladopelma* cf. *undine*
            - *Paracladopelma* cf. *winnelli*
            - *Paratendipes* sp.
            - *Phaenopsectra* sp.
            - *Polypedilum* cf. *fallax*-gr.
            - *Polypedilum* cf. *halterale*
            - *Polypedilum* cf. *scalaenum*
            - *Polypedilum* sp. 2
            - *Robackia* cf. *demeijerei*
            - *Saetheria* cf. *tylus*
          - Tanytarsini
            - *Cladotanytarsus* sp.
            - *Micropsectra* sp.
            - *Tanytarsus* sp.
        - Orthocladiinae
            - *Cricotopus* (*C.*) sp.
            - *Cricotopus* (*C.*)/*Orthocladius* (*O.*) sp.
            - *Cricotopus* (*I.*) *sylvestris*-gr.
            - *Heterotrissocladius* cf. *changi*
            - *Heterotrissocladius* cf. *oliveri*
            - *Hydrobaenus* sp.
            - *Nanocladius* sp.
            - *Orthocladius* (*Euorthocladius*) sp.
            - *Orthocladiini* sp. 2
            - *Psectrocladius* sp.
            - *Thienemanniella* sp.

TABLE 3. Continued.

- Diamesinae
  - *Monodiamesa* cf. *tuberculata*
  - *Potthastia* cf. *longimanus*
- Tanypodinae
  - *Procladius* sp.
- Trichoptera
  - Molannidae
    - *Molanna* sp.
  - Leptoceridae
    - *Nectopsyche* sp.

Mollusca
- Gastropoda
  - Ctenobranchiata
    - Hydrobiidae
      - *Amnicola* sp.
      - *Bythinia tentaculata*
      - *Somatogyrus* sp.
    - Valvatidae
      - *Valvata sincera*
  - Pulmonata
    - Lymnaeidae
      - *Lymnaea* sp.
- Pelecypoda
  - Heterodonta
    - Sphaeriidae
      - *Pisidium adamsi*
      - *Pisidium casertanum*
      - *Pisidium compressum*
      - *Pisidium conventus*
      - *Pisidium fallax*
      - *Pisidium ferrugineum*
      - *Pisidium henslowanum*
      - *Pisidium idahoense*
      - *Pisidium lilljeborgi*
      - *Pisidium milium*
      - *Pisidium nitidum* f. *nitidum*
      - *Pisidium nitidum* f. *pauperculum*
      - *Pisidium subtruncatum*
      - *Pisidium supinum*
      - *Pisidium variabile*
      - *Pisidium walkeri*
      - *Sphaerium nitidum*
      - *Sphaerium striatinum*
      - *Sphaerium transversum*

TABLE 4. Number of identifiably different taxonomic units collected within each of the major taxonomic groups at 3-15 m and for all depths combined in the inner and outer regions during 1978 and 1979. Samples were collected during April, July and October of 1978 and 1979 from eastern Lake Michigan near the J. H. Campbell Plant.

	3 m						6 m					
	Inner Region			Outer Region			Inner Region			Outer Region		
Taxon	1978	1979	Total	1978	1979	Total	1978	1979	Total	1978	1979	Total
Chironomidae	14	12	17	10	6	10	14	15	22	15	13	17
Naididae	6	8	10	3	2	4	7	9	11	9	7	10
Tubificidae	0	0	0	0	0	0	1	3	4	3	0	3
Pisidium	0	0	0	0	0	0	2	0	2	2	2	3
Sphaerium	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	0	0	0	0	0	0	0	0	0	1	1	2
Others	2	2	2	1	3	3	4	3	5	2	5	5
Total	22	22	29	14	11	17	28	30	44	32	28	40

	9 m						12 m					
	Inner Region			Outer Region			Inner Region			Outer Region		
Taxon	1978	1979	Total	1978	1979	Total	1978	1979	Total	1978	1979	Total
Chironomidae	21	18	24	19	20	22	18	18	21	22	19	24
Naididae	8	9	10	10	10	11	8	12	13	8	12	13
Tubificidae	5	6	6	5	6	7	5	6	8	7	5	7
Pisidium	8	6	10	7	7	8	9	8	9	8	9	9
Sphaerium	1	0	1	1	0	1	0	2	2	1	1	1
Gastropoda	2	2	2	2	3	4	3	3	4	3	5	5
Others	6	4	7	5	5	6	5	4	6	5	6	6
Total	51	45	60	49	51	59	48	53	63	54	57	65

	15 m						All depths combined					
	Inner Region			Outer Region			Inner Region			Outer Region		
Taxon	1978	1979	Total	1978	1979	Total	1978	1979	Total	1978	1979	Total
Chironomidae	15	17	20	15	20	20	26	26	31	25	24	28
Naididae	11	9	12	10	8	12	12	13	15	13	12	14
Tubificidae	5	6	7	7	7	9	7	9	9	9	8	9
Pisidium	8	8	9	9	11	11	12	11	12	9	11	12
Sphaerium	1	2	2	2	3	3	1	2	2	2	3	3
Gastropoda	2	5	5	3	5	5	3	5	5	4	5	5
Others	6	6	7	7	8	9	7	7	8	7	10	10
Total	48	53	62	53	63	69	68	73	82	69	73	81

TABLE 5. Percent occurence of major taxonomic groups collected in 1979 at 3-15 m among inner (treatment area near present thermal discharge) and outer (reference area) regions in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan. Percentages expressed in terms of total animals.

	April									
	Inner					Outer				
Taxon	3 m	6 m	9 m	12 m	15 m	3 m	6 m	9 m	12 m	15 m
Chironomidae	100.0	72.8	25.8	51.8	52.7	91.7	52.6	67.5	64.5	40.2
Naididae		1.7	0.5	3.0	4.9	0.9	37.0	0.8	5.7	17.2
Tubificidae		1.7	14.3	15.8	7.1			12.9	11.0	21.6
Enchytraeidae			2.8	8.2	1.7		5.2	6.0	4.7	4.1
Stylodrilus heringianus					1.1					0.2
Pisidium			0.9	10.3	8.7			1.7	8.4	5.9
Sphaerium									0.3	
Gastropoda				1.2	1.9					1.3
Pontoporeia hoyi			55.3	9.7	13.2	0.9		7.7	4.2	7.4
Turbellaria		23.7	0.5		8.7	6.5	5.2	3.4	1.3	2.2
Others										

	July									
	Inner					Outer				
Taxon	3 m	6 m	9 m	12 m	15 m	3 m	6 m	9 m	12 m	15 m
Chironomidae	72.7	6.9	5.4	4.4	2.3	58.9	62.1	21.6	5.5	1.2
Naididae	26.0	91.2	68.4	26.3	17.2	0.7	27.5	40.8	33.5	17.8
Tubificidae		0.1	3.9	2.7	5.4		0.3	8.5	6.4	7.5
Enchytraeidae				0.3	2.2			0.4	1.8	2.9
Stylodrilus heringianus					2.0					2.0
Pisidium			0.3	3.7	6.2		0.3	0.9	5.4	4.8
Sphaerium					0.1					0.1
Gastropoda			0.3	2.0	0.9			0.4	1.9	0.8
Pontoporeia hoyi	1.3	1.6	19.4	57.5	56.8	1.7	8.8	26.7	38.3	57.6
Turbellaria		0.2	2.0	3.2	6.9	38.5	0.8	0.6	7.2	5.3
Others			0.3		0.3	0.2	0.3	0.1	0.1	0.1

	October									
	Inner					Outer				
Taxon	3 m	6 m	9 m	12 m	15 m	3 m	6 m	9 m	12 m	15 m
Chironomidae	54.5	69.6	36.5	3.6	4.3	37.5	37.0	19.0	3.7	2.0
Naididae		7.9	11.6	13.9	2.3		11.9	26.8	16.8	1.8
Tubificidae		4.7	23.1	19.8	6.8		17.9	22.1	31.2	10.5
Enchytraeidae				1.1	6.2			5.2	9.9	2.6
Stylodrilus heringianus					0.3					8.3
Pisidium			4.0	18.8	4.4		1.3	3.5	13.1	16.4
Sphaerium				0.2	0.1					0.1
Gastropoda			0.7	2.4	0.9		0.4	2.2	4.1	1.6
Pontoporeia hoyi	11.5	6.8	23.8	38.0	72.0	0.3	29.4	20.4	19.7	55.5
Turbellaria	34.2	2.1	0.3	2.3	2.7	62.3	2.1	0.9	1.4	0.9
Others		8.9			0.1				0.1	0.2

increase in percent occurrence of P. hoyi, which tended to be the dominant organism from 9 to 15 m. Other benthic forms, such as tubificids, naidids, Pisidium, and chironomids contributed to the benthos at 9-15-m depths, but not to the extent of P. hoyi. As in 1978, S. heringianus was numerous and occurred regularly at 15 m only. Within 9-15-m depths, greatest deviation from expected relative abundances of major taxonomic groups occurred at 12-15 m in April 1978 and 1979. Chironomids comprised a high percentage of the benthic population at 12-15 m which differed greatly from that observed during other months. Other than this difference, which also was observed during 1978, relative densities of the benthos were observed along the depth gradient in a manner similar to that of 1978.

The 1979 average density of total animals, i.e. the sum total of all benthic macroinvertebrates collected, generally was similar to 1978 estimates with respect to depth and month (Figs. 2 and 3, Appendix 1). However, mean densities at 3-9 m were lower than 1978 estimates, while at 12-15 m the average number of animals was greater. Total numbers of animals collected were significantly lower at 9 m and significantly higher at 15 m than observed during 1978. No significant differences were evident for monthly total animal mean density when comparing similar months across years. Overall, there was no significant difference in the yearly mean density of total macrobenthos collected between 1978 (6522 m^{-2}) and 1979 (7940 m^{-2}) (Table 6).

Examination of inner/outer regional benthos data indicated there were significant differences both within and between inner and outer regional means (Tables 7 and 8). In April, July, and October 1979 at 3 and 15 m there were significantly more benthic macroinvertebrates collected in the outer than in the inner region (Tables 9 and 10). In addition, at 6-12-m during July inner region mean density increased while the 6-12-m outer regional mean density decreased from 1978 estimates of total animals (Fig. 4).

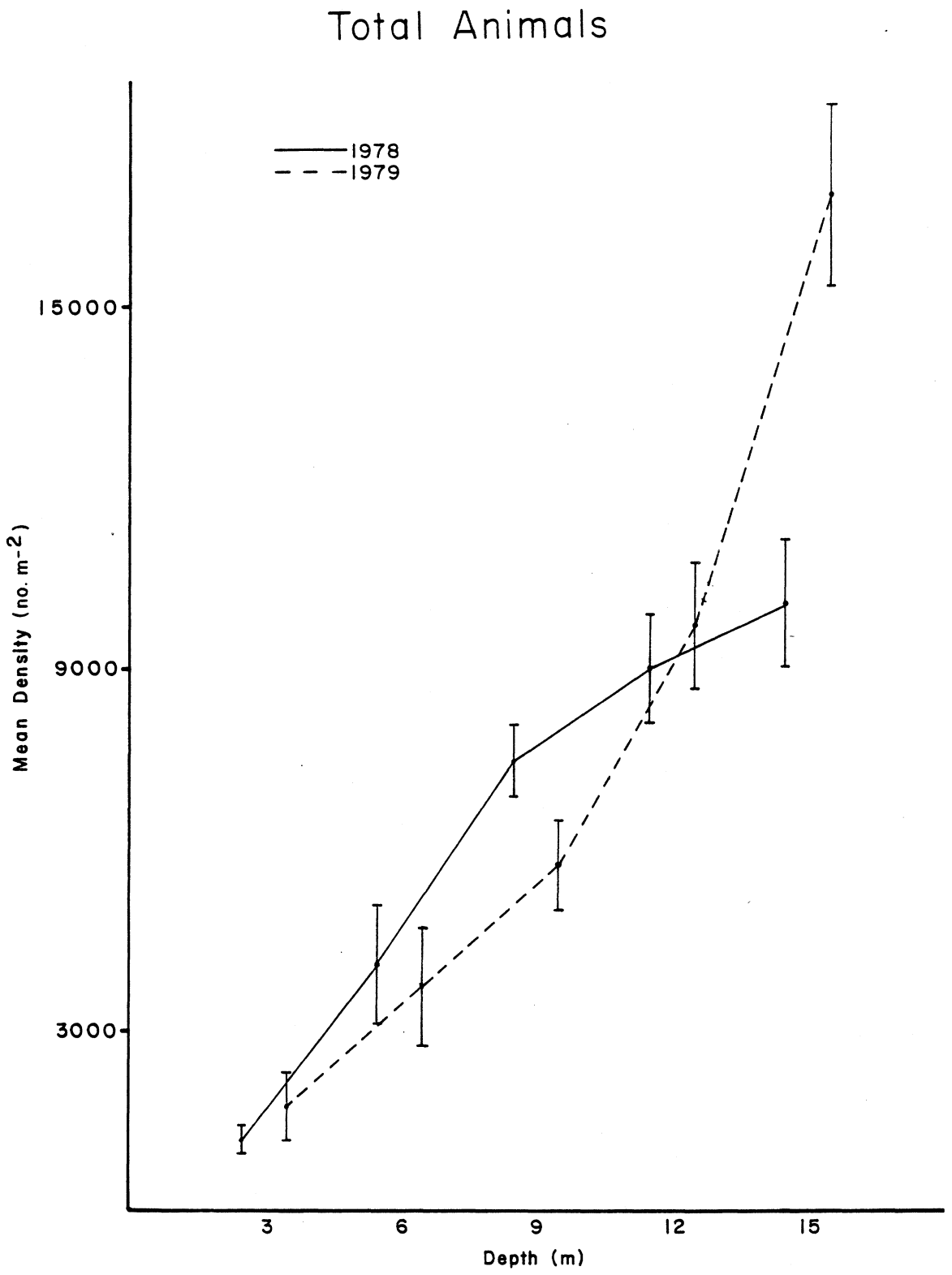


Fig. 2. Mean density (number m^{-2}) of total animals collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

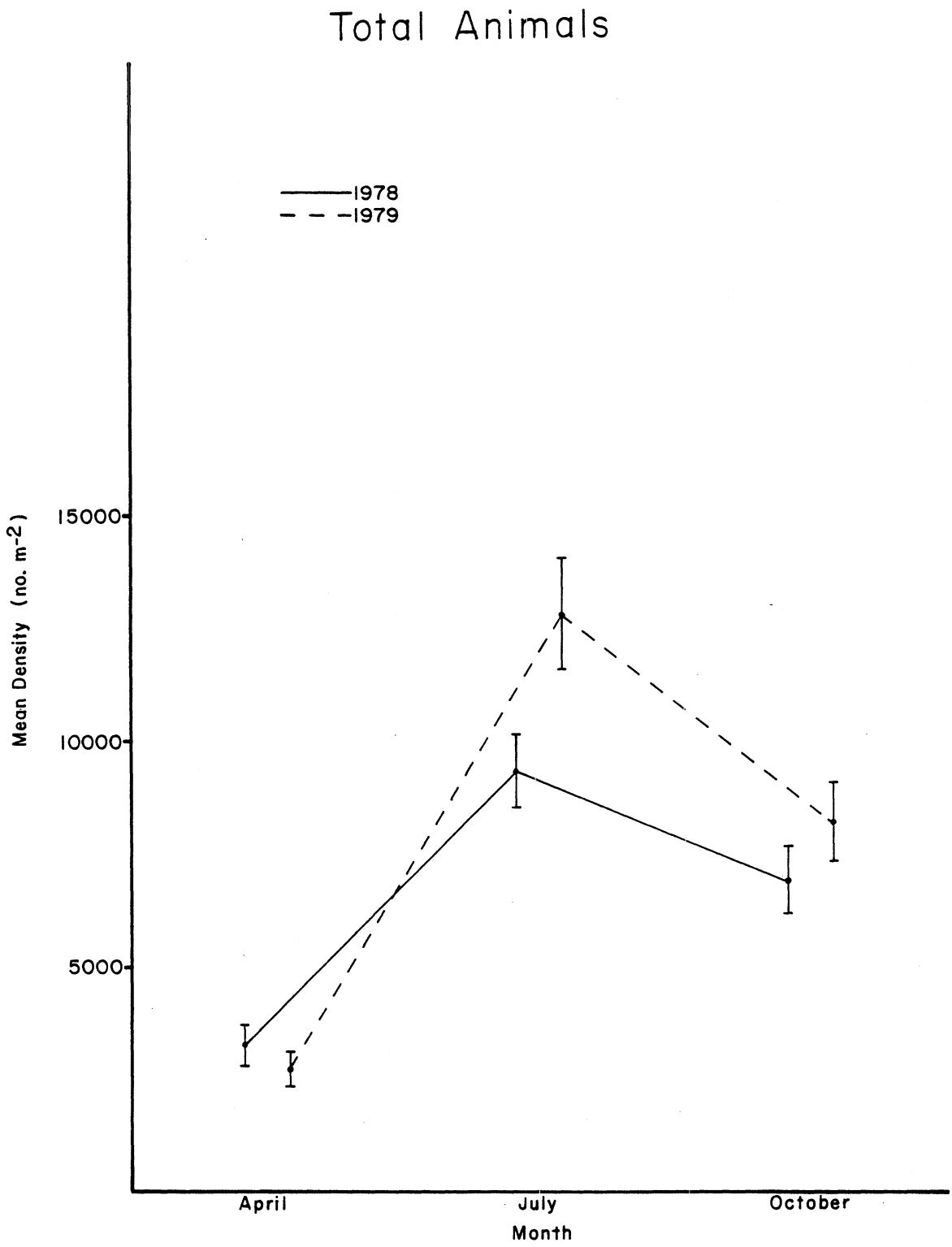


Fig. 3. Mean density (number m^{-2}) of total animals collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

TABLE 6. Student's *t* test comparisons for yearly mean densities of major taxonomic groups collected during 1978 and 1979 near the J. H. Campbell Plant, eastern Lake Michigan (n = number of observations, NS = no significance, * = 0.05 ≥ p > 0.01, ** = 0.01 ≥ p > 0.001, *** = p ≤ 0.001, - = no test performed due to zero variance or no mean estimate for one or both populations tested).

	ANNUAL COMPARISONS (1978 vs. 1979)								
		Month (n = 60)			Depth (m) (n = 36)				
TAXON	Year (n = 180)	April	July	October	3	6	9	12	15
Total Animals	NS	NS	NS	NS	NS	NS	**	NS	**
Chironomidae	*	NS	***	NS	NS	NS	***	***	NS
Turbellaria	***	***	***	NS	**	**	NS	NS	***
Naididae	NS	NS	NS	NS	NS	NS	*	NS	NS
Tubificidae	NS	NS	NS	NS			*	NS	*
Enchytraeidae	***	***	-	NS				***	***
Stylodrilus heringianus	NS	-	NS	NS					NS
Gastropoda	NS	*	NS	**				*	NS
Pisidium	NS	NS	NS	*			**	***	NS
Pontoporeia hoyi	***	NS	NS	**			*	NS	*

TABLE 7. Statistical analyses (Student's *t* test comparisons) presented in this table summarize trends for annual mean densities of major taxonomic groups collected during 1979 near the J. H. Campbell Plant, eastern Lake Michigan. Data for the outer region were averaged over all months within a specified depth range (Year), within each month they were averaged over a specified depth range (Month) and at a specific depth they were averaged over all months (Depth). Depth ranges correspond to depths of frequent and numerous occurrence for each taxon considered. The number of samples (n) used for statistical tests varies for year and month (April, July and October) comparisons and appears in the column immediately to the right of each category following the significance attained symbol (NS = no significance, * = 0.05 $\geq$ p > 0.01, ** = 0.01 $\geq$ p > 0.001, *** = p $\leq$ 0.001, - = no test performed due to zero variance or no mean estimate for one or both populations tested).

	OUTER REGION ANNUAL COMPARISONS (outer 1978 vs. outer 1979)											
				Month				Depth (m) (n = 18)				
TAXON	Depth range (m)	Year	(n)	April	July	October	(n)	3	6	9	12	15
Total Animals	3-15	NS	(90)	NS	NS	NS	(30)	**	NS	**	NS	**
Chironomidae	3-15	NS	(90)	NS	***	NS	(30)	**	NS	***	***	NS
Turbellaria	3-15	***	(90)	-	***	NS	(30)	***	NS	NS	*	*
Naididae	3-15	NS	(90)	NS	NS	NS	(30)	NS	NS	NS	NS	NS
Tubificidae	9-15	NS	(54)	NS	NS	NS	(18)			**	NS	**
Enchytraeidae	12-15	***	(36)	***	-	NS	(12)				***	***
Stylodrilus heringianus	15	NS	(18)	-	NS	NS	(6)					NS
Gastropoda	12-15	NS	(36)	NS	*	***	(12)				NS	*
Pisidium	9-15	NS	(54)	NS	NS	**	(18)			NS	*	NS
Pontoporeia hoyi	9-15	**	(54)	**	NS	***	(18)			*	NS	*

TABLE 8. Statistical analyses (Student's *t* test comparisons) presented in this table summarize trends for annual mean densities of major taxonomic groups collected during 1979 near the J. H. Campbell Plant, eastern Lake Michigan. Data for the inner region were averaged over all months within a specified depth range (Year), within each month they were averaged over a specified depth range (Month) and at a specific depth they were averaged over all months (Depth). Depth ranges correspond to depths of frequent and numerous occurrence for each taxon considered. The number of samples (n) used for statistical tests varies for year and month (April, July and October) comparisons and appears in the column immediately to the right of each category following the significance attained symbol (NS = no significance, * = $0.05 \geq p > 0.01$, ** = $0.01 \geq p > 0.001$, *** = $p \leq 0.001$, – = no test performed due to zero variance or no mean estimate for one or both populations tested).

	INNER REGION ANNUAL COMPARISONS (inner 1978 vs. inner 1979)											
				Month				Depth (m) (n = 18)				
TAXON	Depth range (m)	Year	(n)	April	July	October	(n)	3	6	9	12	15
Total Animals	3-15	NS	(90)	NS	NS	NS	(30)	*	NS	NS	NS	NS
Chironomidae	3-15	***	(90)	NS	***	NS	(30)	*	NS	***	*	NS
Turbellaria	3-15	***	(90)	***	***	NS	(30)	NS	**	NS	NS	***
Naididae	3-15	NS	(90)	NS	NS	NS	(30)	NS	NS	NS	NS	NS
Tubificidae	9-15	NS	(54)	NS	NS	NS	(18)			NS	NS	NS
Enchytraeidae	12-15	***	(36)	–	–	NS	(12)				NS	***
Stylodrilus heringianus	15	NS	(18)	–	NS	*	(6)					NS
Gastropoda	12-15	NS	(36)	NS	NS	NS	(12)				**	NS
Pisidium	9-15	NS	(54)	NS	NS	*	(18)			*	***	NS
Pontoporeia hoyi	9-15	NS	(54)	NS	NS	**	(18)			NS	NS	NS

TABLE 9. Statistical analyses (Student's *t* test comparisons) presented in this table summarize trends for annual mean densities of major taxonomic groups collected during 1979 near the J. H. Campbell Plant, eastern Lake Michigan. Data for inner and outer regions were averaged over all months within a specified depth range (Region), within each month they were averaged over a specified depth range (Month) and at a specific depth they were averaged over all months (Depth). Depth ranges correspond to depths of frequent and numerous occurrence for each taxon considered. The number of samples (n) used for statistical tests varies for year and month (April, July and October) comparisons and appears in the column immediately to the right of each category following the significance attained symbol (NS = no significance, * = $0.05 \geq p > 0.01$, ** = $0.01 \geq p > 0.001$, *** = $p \leq 0.001$, - = no test performed due to zero variance or no mean estimate for one or both populations tested).

		SUMMARY 1979 REGIONAL COMPARISONS (inner 1979 vs. outer 1979)										
				Month				Depth (m) (n = 18)				
TAXON	Depth range (m)	Region	(n)	April	July	October	(n)	3	6	9	12	15
Total Animals	3-15	NS	(90)	NS	NS	*	(30)	***	NS	NS	NS	*
Chironomidae	3-15	*	(90)	NS	**	NS	(30)	**	NS	NS	NS	NS
Turbellaria	3-15	NS	(90)	NS	NS	NS	(30)	***	NS	NS	NS	NS
Naididae	3-15	NS	(90)	NS	NS	NS	(30)	**	NS	NS	NS	NS
Tubificidae	9-15	**	(54)	NS	*	NS	(18)			NS	NS	***
Enchytraeidae	12-15	NS	(36)	NS	*	NS	(12)				NS	NS
Stylodrilus heringianus	15	NS	(18)	NS	NS	***	(6)					NS
Gastropoda	12-15	NS	(36)	NS	NS	NS	(12)				NS	NS
Pisidium	9-15	NS	(54)	NS	NS	NS	(18)			NS	NS	NS
Pontoporeia hoyi	9-15	NS	(54)	NS	NS	NS	(18)			NS	NS	NS

TABLE 10. Statistical analyses (Student's *t* test comparisons) presented in this table summarize mean density trends for major taxonomic groups collected at each depth within each month for inner and outer regions near the J. H. Campbell Plant, eastern Lake Michigan, 1979. Comparisons were performed only for depths at which taxa occurred frequently and abundantly. Each comparison is represented by six samples. (NS = no significance, * = $0.05 \geq p > 0.01$, ** = $0.01 \geq p > 0.001$, *** = $p \leq 0.001$, - = no test performed due to zero variance or no mean estimate for one or both populations tested).

	REGIONAL COMPARISONS FOR 1979 (inner 1979 vs. outer 1979)														
	3 m			6 m			9 m			12 m			15 m		
TAXON	Apr	Jul	Oct	Apr	Jul	Oct	Apr	Jul	Oct	Apr	Jul	Oct	Apr	Jul	Oct
Total Animals	***	*	***	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	**	*
Chironomidae	**	*	***	NS	**	NS	NS	***	NS	NS	NS	NS	NS	NS	NS
Turbellaria	-	-	**	***	NS	NS	NS	*	NS	-	NS	NS	*	NS	NS
Naididae	-	NS	-	NS	*	NS	NS	**	*	NS	NS	NS	NS	**	NS
Tubificidae							NS	NS	NS	NS	NS	NS	**	NS	*
Enchytraeidae										NS	*	NS	NS	NS	NS
Stylodrilus heringianus													NS	NS	***
Gastropoda										-	NS	NS	NS	NS	NS
Pisidium							NS	NS	NS	NS	NS	**	NS	NS	**
Pontoporeia hoyi							NS	NS	NS	NS	**	***	NS	***	NS

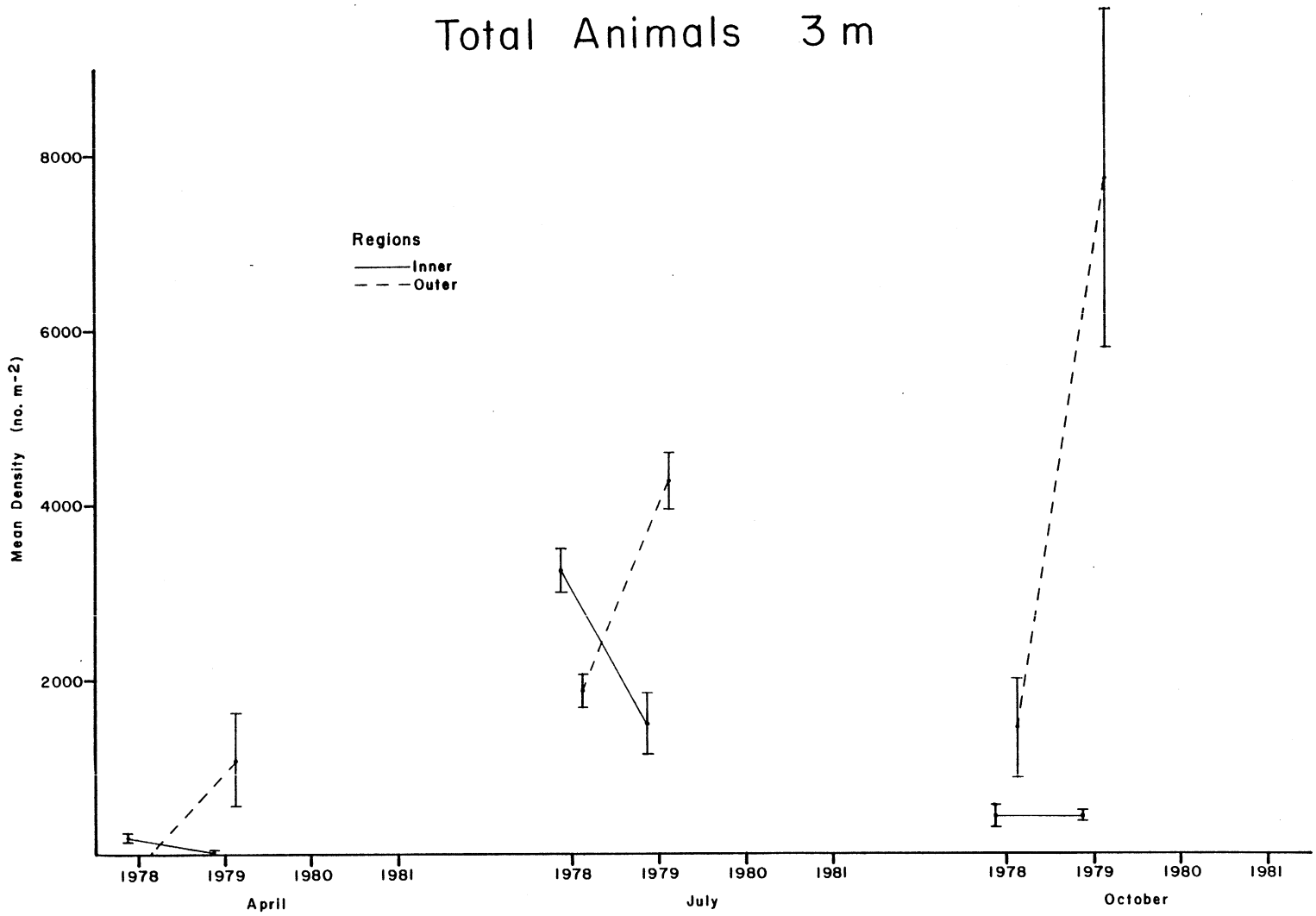


Fig. 4. Inner and outer regional mean densities (number m^{-2}) of total animals collected in April, July and October 1978 and 1979 from eastern Lake Michigan at 3-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.

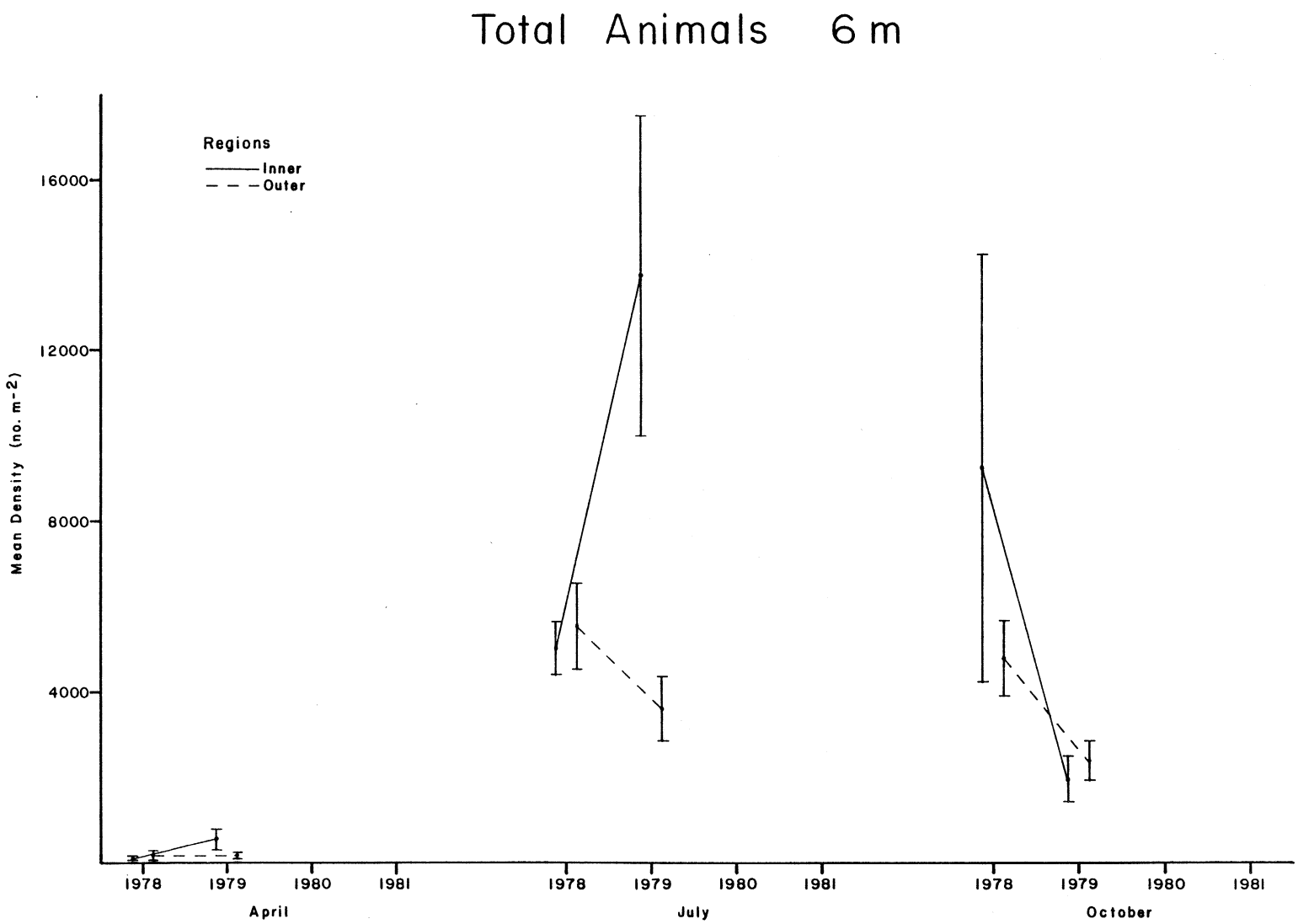
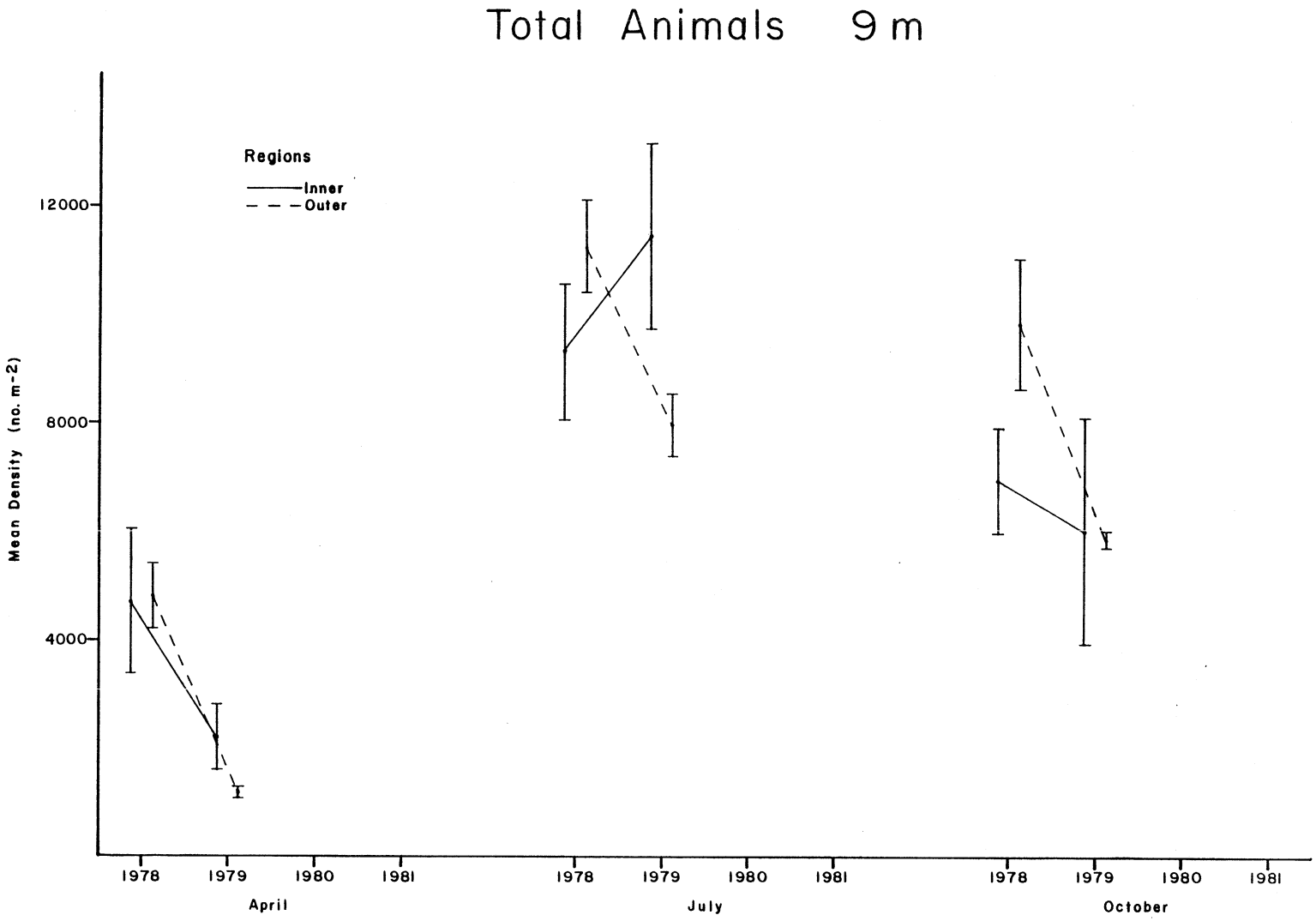


Fig. 4. Continued.



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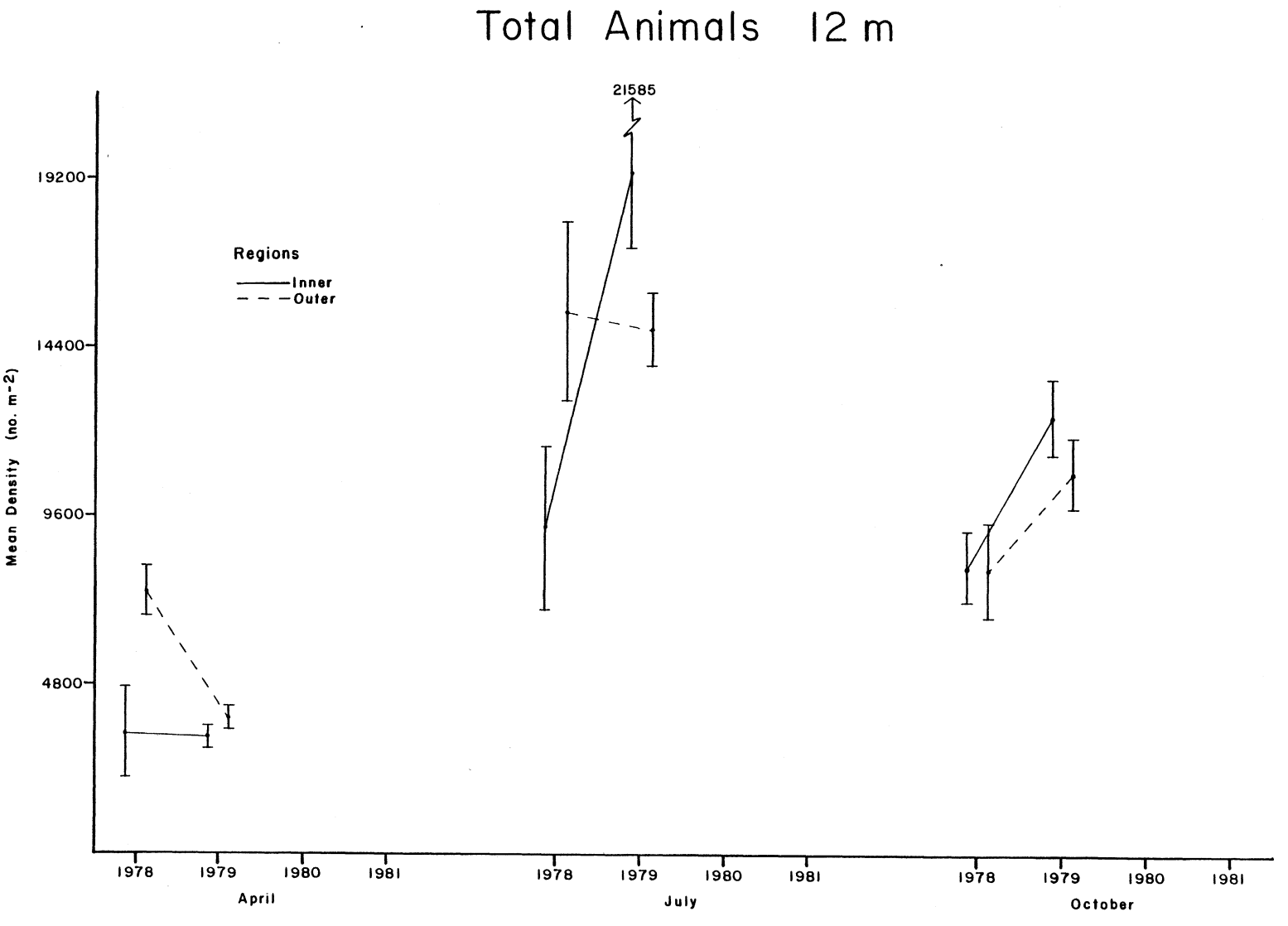

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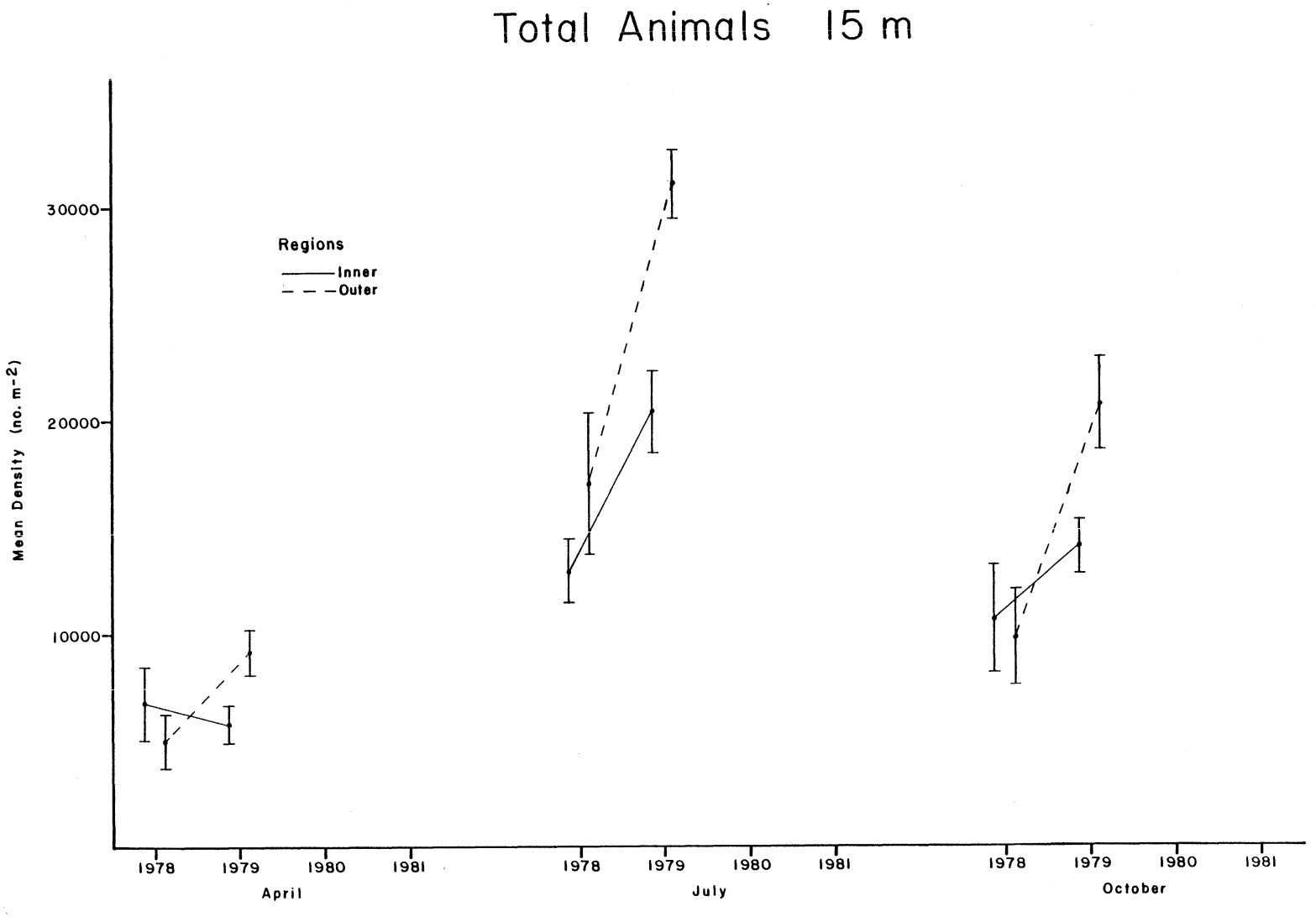


Fig. 4. Continued.

CHIRONOMIDAE

Chironomids were represented in 95% and 94% of the samples collected during 1978 and 1979, respectively (Table 11). While chironomids comprised 34% of the 1978 annual benthic mean density, the relative abundance of chironomids decreased to 15% of the 1979 annual benthic mean density.

TABLE 11. Frequency of occurrence of major taxonomic groups among benthic samples (n = 180) collected during 1979 in eastern Lake Michigan near the J. H. Campbell Plant.

Taxon	%	Taxon	%
Chironomidae	94.4	Gastropoda	37.8
Oligochaeta	79.4	*S. heringianus*	13.9
P. hoyi	78.9	*Sphaerium*	5.6
Naididae	71.1	Hydracarina	4.4
Tubificidae	64.4	*Hydra*	2.8
Turbellaria	64.4	Hirudinea	1.7
Pisidium	52.2	*M. relicta*	0.6
Enchytraeidae	42.8	Samples with Animals	96.7

The chironomid genera/species list has been revised and updated from 1978 (Table 3). The primary revisions have been to condense *Parakiefferiella* sp. and *Orthacladius* (*O.*) sp. 1 and sp. 2 into *Cricotopus*/*Orthocladius* (*O.*) sp. 1. Previously, there had been some confusion in that early and late instars differed morphologically. Having seen instar and depth association patterns over 2 yr has helped coalesce some differences observed previously. In addition, what had been thought to be an early instar orthocladiini (sp. 2) has subsequently been noted to be a last instar individual as yet unidentified (only one specimen has been collected).

A total of 37 chironomid taxa have been identified from 1977 to 1979 (Table 3). Generally, the number of chironomid taxa collected was similar between years for a given depth and regional comparison (Table 4). The largest difference occurred at 3 m where the inner region had 17 taxa present and the outer region had only 10 taxa present over both years. Examination of these regional differences did not appear to indicate any significant differences between regions based on kinds of chironomids observed.

Twenty-six chironomid taxa were found in the inner region over all depths and months in 1978 and 1979. In the outer region 25 chironomid taxa were observed in 1978 and 24 during 1979. Overall, in the inner region chironomids have been represented by 31 taxa, while 28 chironomid taxa have been identified in the outer region.

Based on annual chironomid mean density, *Chironomus fluviatilis*-gr., *Cryptochironomus* sp. 2, *Paracladopelma camptolabis*-gr., *Polypedilum* cf. *scalaenum*, *Robackia* cf. *demeijerei*, and *Saetheria* cf. *tylus* were the most numerous chironomids collected in each year. Relative importance of these taxa differed between years with *S.* cf. *tylus* (24%), *P. camptolabis*-gr. (18%), *C. fluviatilis*-gr. (12%), and *P.* cf. *scalaenum* (12%) most abundant in 1978. During 1979, *S.* cf *tylus* (25%), *R.* cf. *demeijerei* (24%), *P.* cf. *camptolabis*-gr. (10%), and *Cryptochironomus* sp. 2 (10%) were the most numerous chironomid taxa (Appendix 2). The greatest change observed was a decrease in relative abundance of *C. fluviatilis*-gr. and an increase for *R.* cf. *demeijerei*.

Distribution of chironomids with respect to depth and month during 1979 differed from the pattern observed in 1978 (Figs. 5 and 6). While the largest mean chironomid densities were observed at 6-12 m during 1978, all depths had a similar average abundance of chironomids in 1979. In particular, the 1979 9- and 12-m mean density estimates were significantly lower when compared with

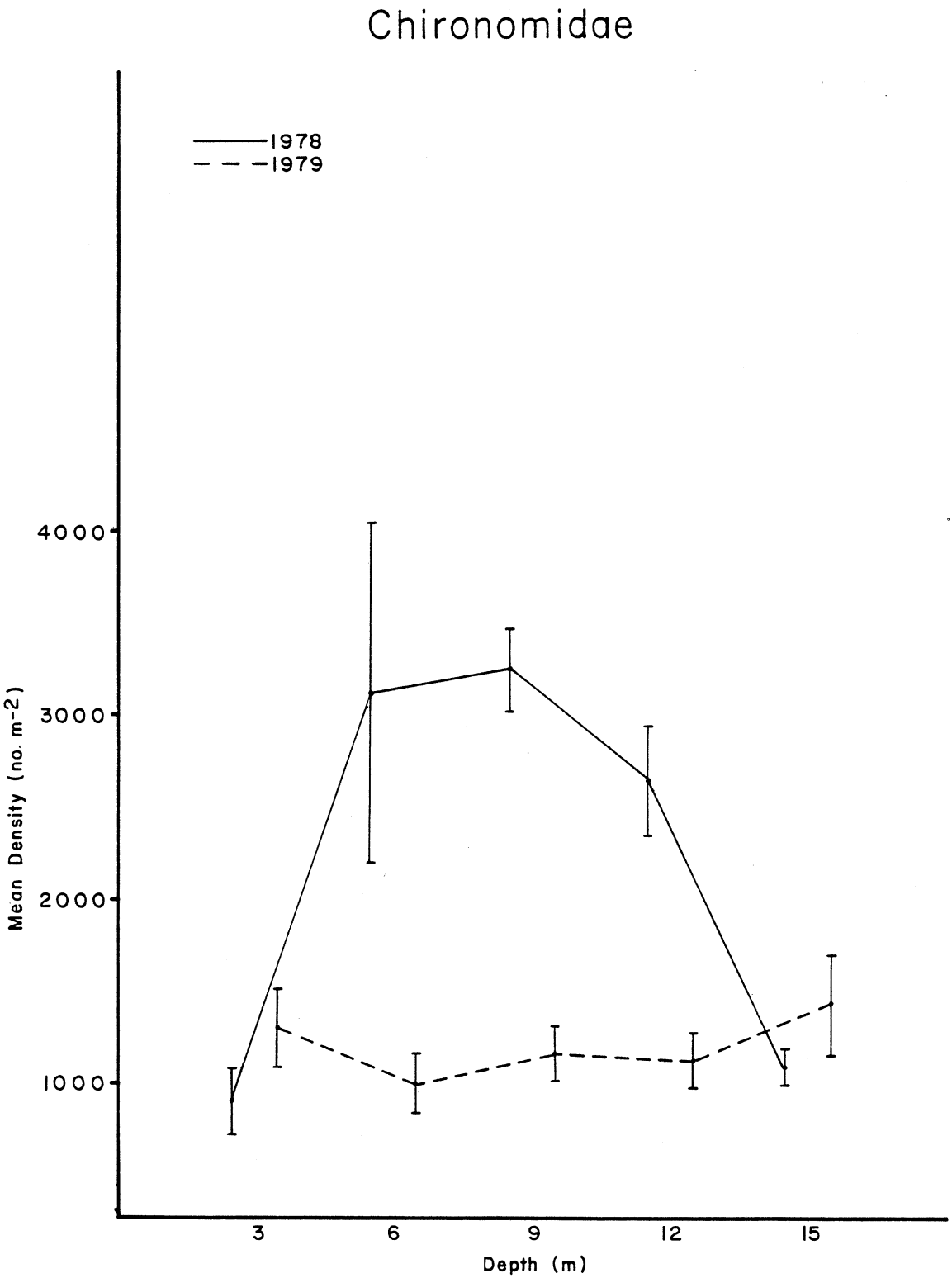


Fig. 5. Mean density (number m^{-2}) of chironomids collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

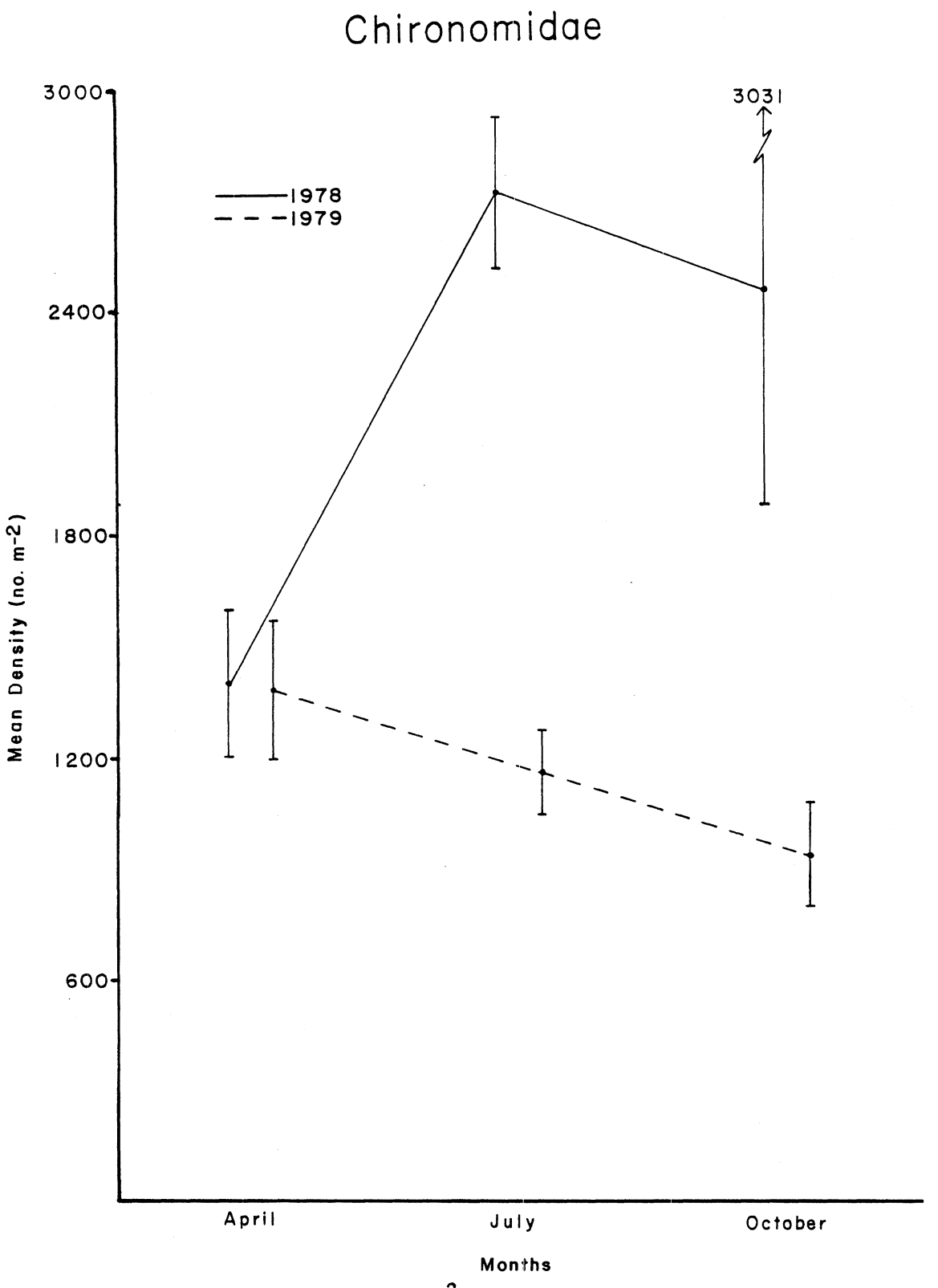


Fig. 6. Mean density (number m^{-2}) of chironomids collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

1978 values (Table 6). The 6-m average chironomid density was not significantly different between years, although densities were much lower in 1979 than 1978, due to the large variation associated with the 1978 6-m estimate. Overall, the 1979 annual mean chironomid density (1203 m^{-2}) was significantly less than that observed during 1978 (2198 m^{-2}).

Monthly mean density of chironomids was significantly lower in July 1979 when compared with July 1978. The October 1979, 6-m mean chironomid abundance was not different from the October 1978 estimate due to the large variation associated with the latter (Table 6).

Comparing inner and outer regional mean densities over all depths and months sampled during 1979, the outer region had a significantly greater number of chironomids than did the inner region. This difference was most evident during July (summed over all depths) and at 3 m (summed over all months) (Table 9). Analysis of July inner/outer regional mean chironomid densities indicated that during 1979, 3- and 6-m chironomid abundances were significantly greater in the outer when compared with inner region values (Table 10). No significant differences were found among remaining depths for July 1978/1979 comparisons. With respect to observed 3-m mean density differences for chironomids, however, the trend observed during July was also evident during April and October. Inner/outer comparisons for chironomids at 3 m indicated a consistent monthly trend of a decreasing inner region mean density and an increasing outer region mean density from 1978 to 1979. Chironomid abundances at remaining depths tended to increase or decrease in a similar manner from 1978 to 1979 (Fig. 7).

Variation in percent occurrence of chironomid species within a given month between inner and outer regions was most extreme during July. The chironomid, Robackia cf. demeijerei, displayed the most consistent inner/outer difference of all chironomid species. The outer region had a consistently greater percent

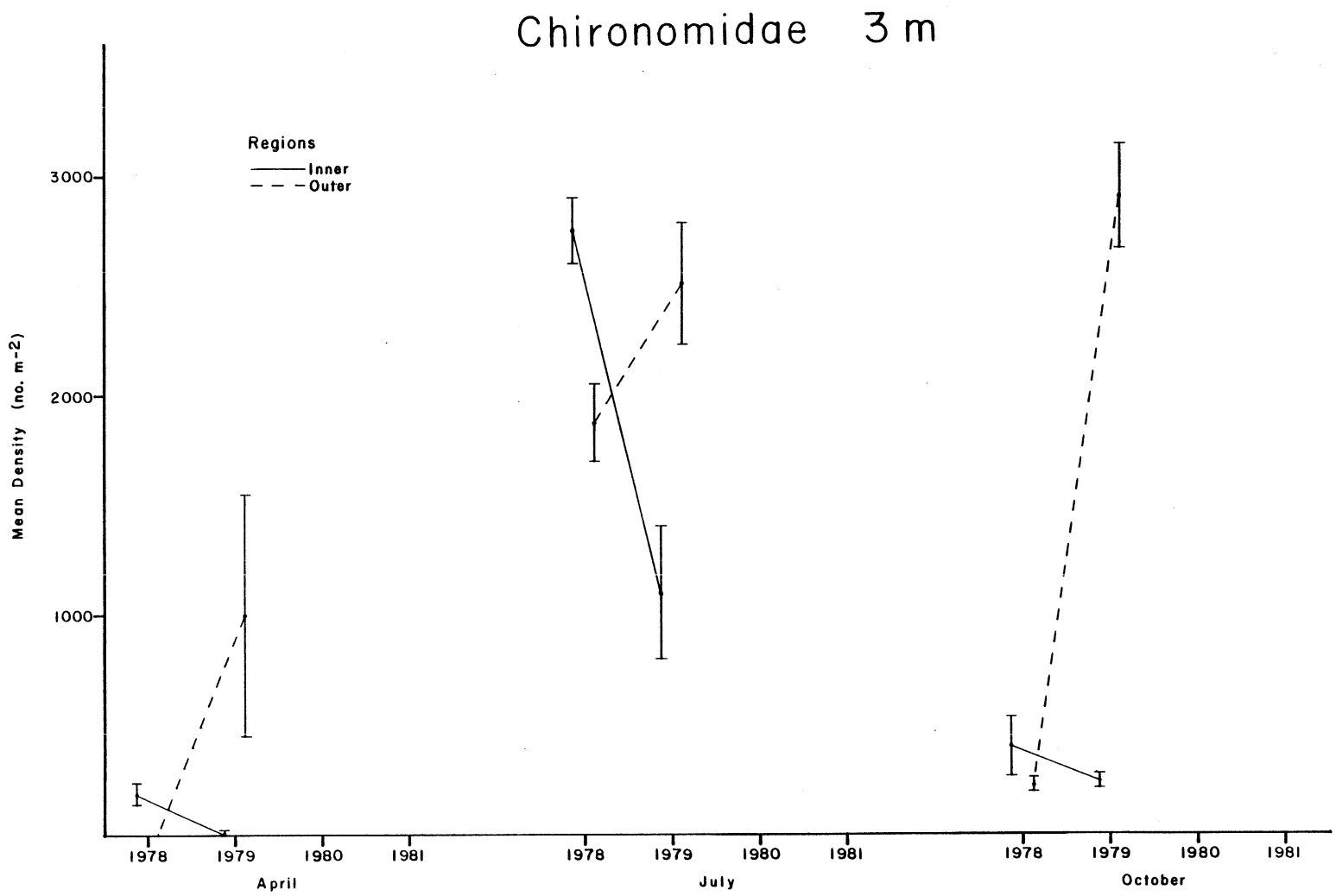
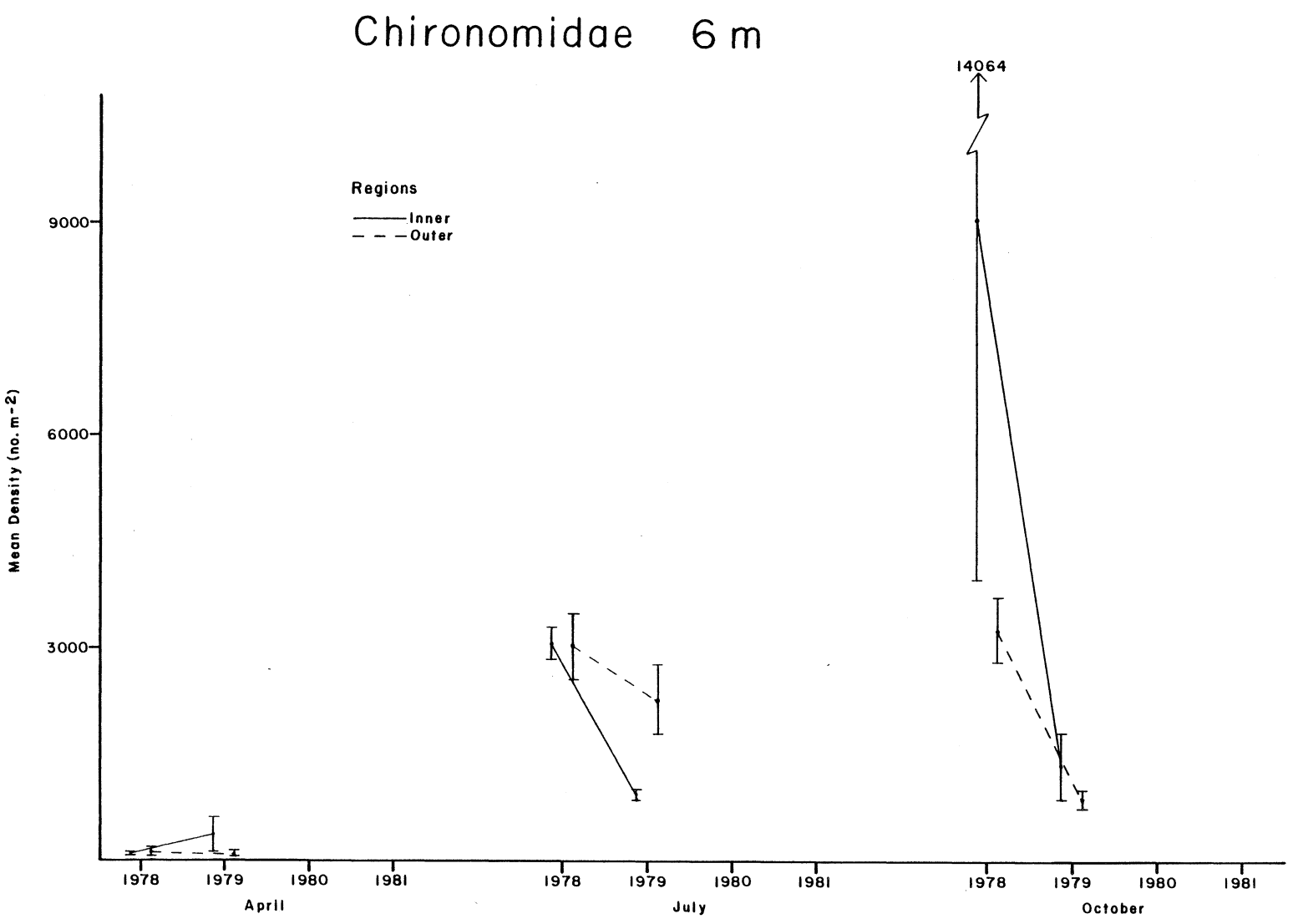


Fig. 7. Inner and outer regional mean densities (number m^{-2}) of chironomids collected in April, July and October 1978 and 1979 from eastern Lake Michigan at 3-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.



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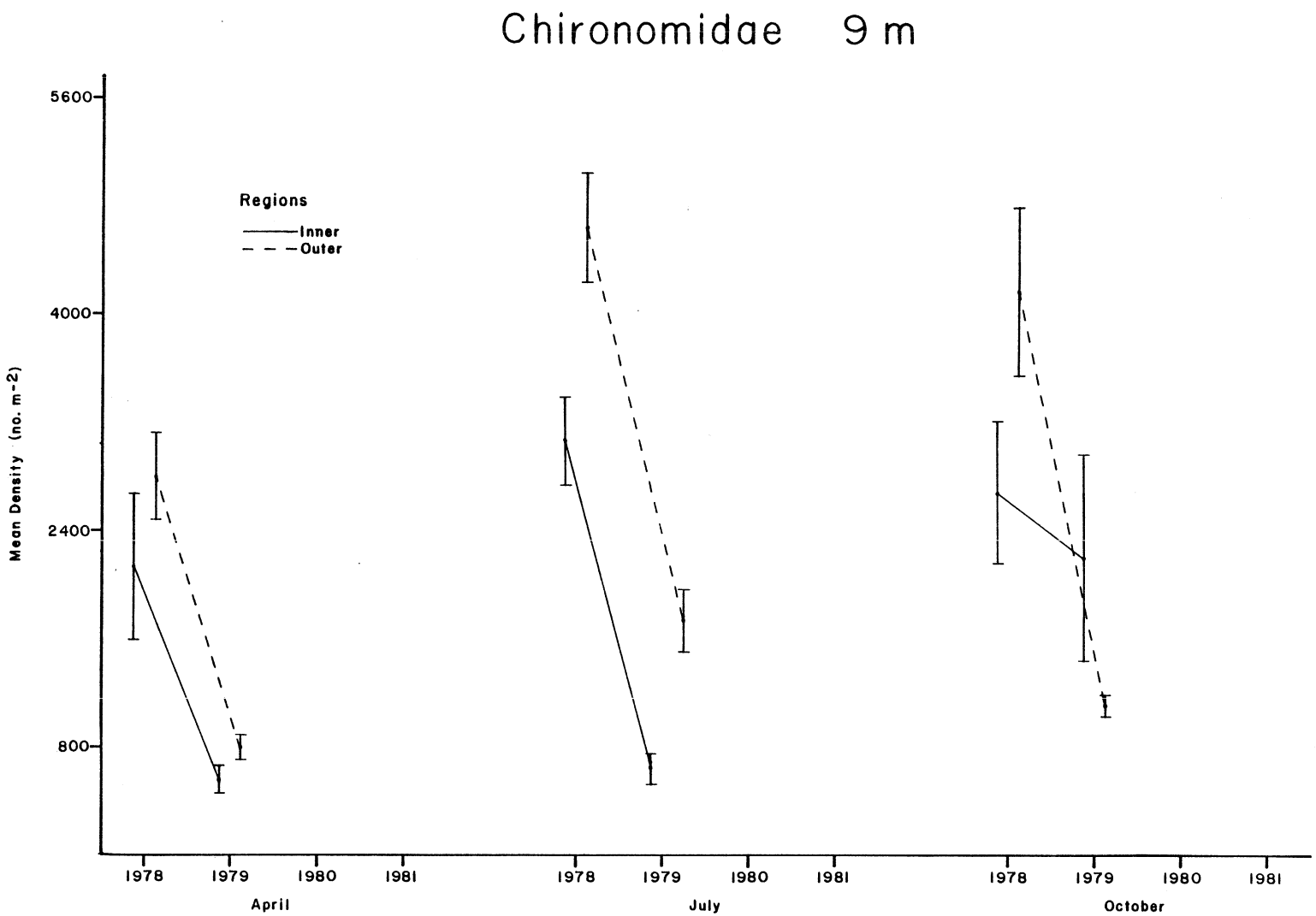

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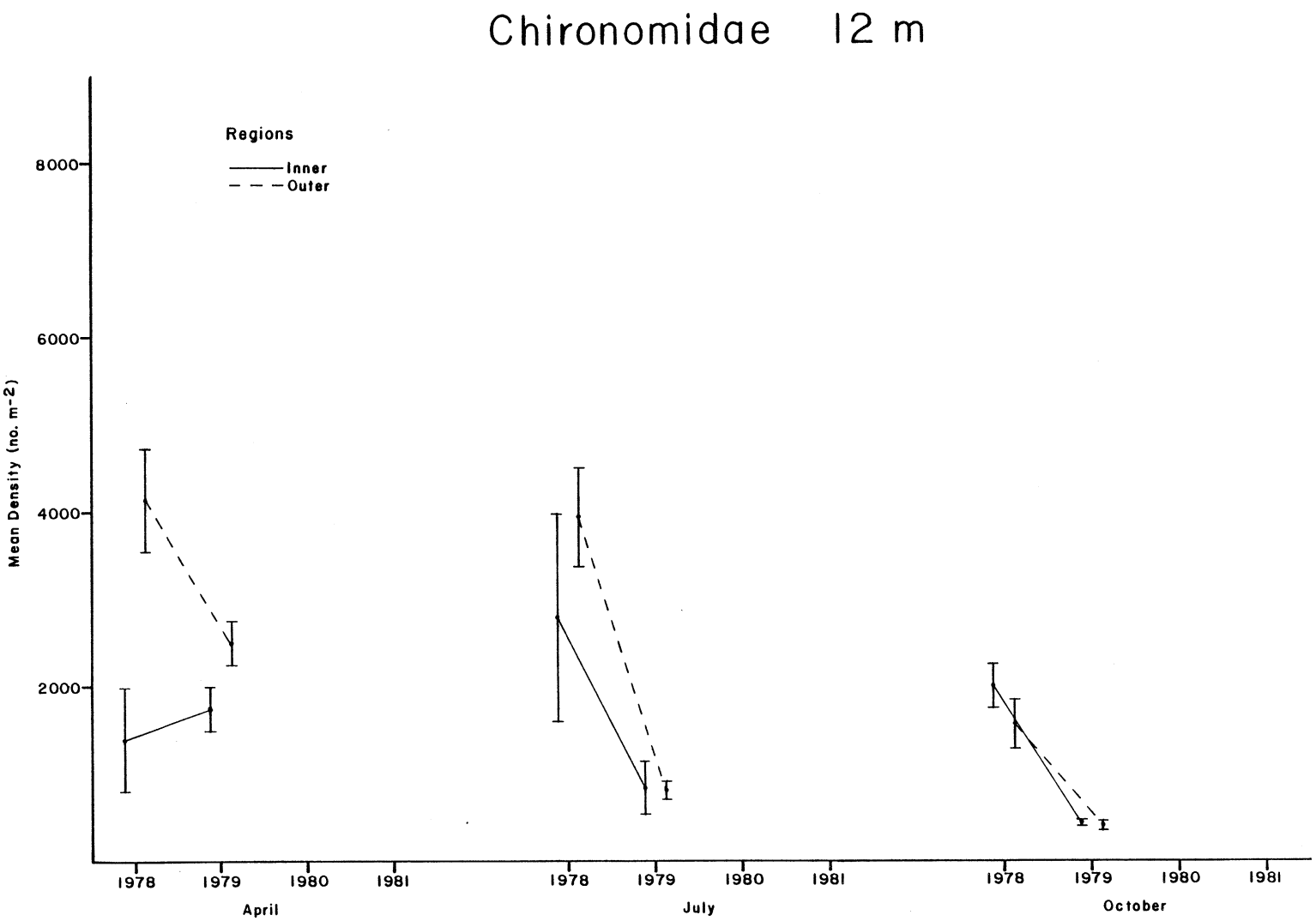

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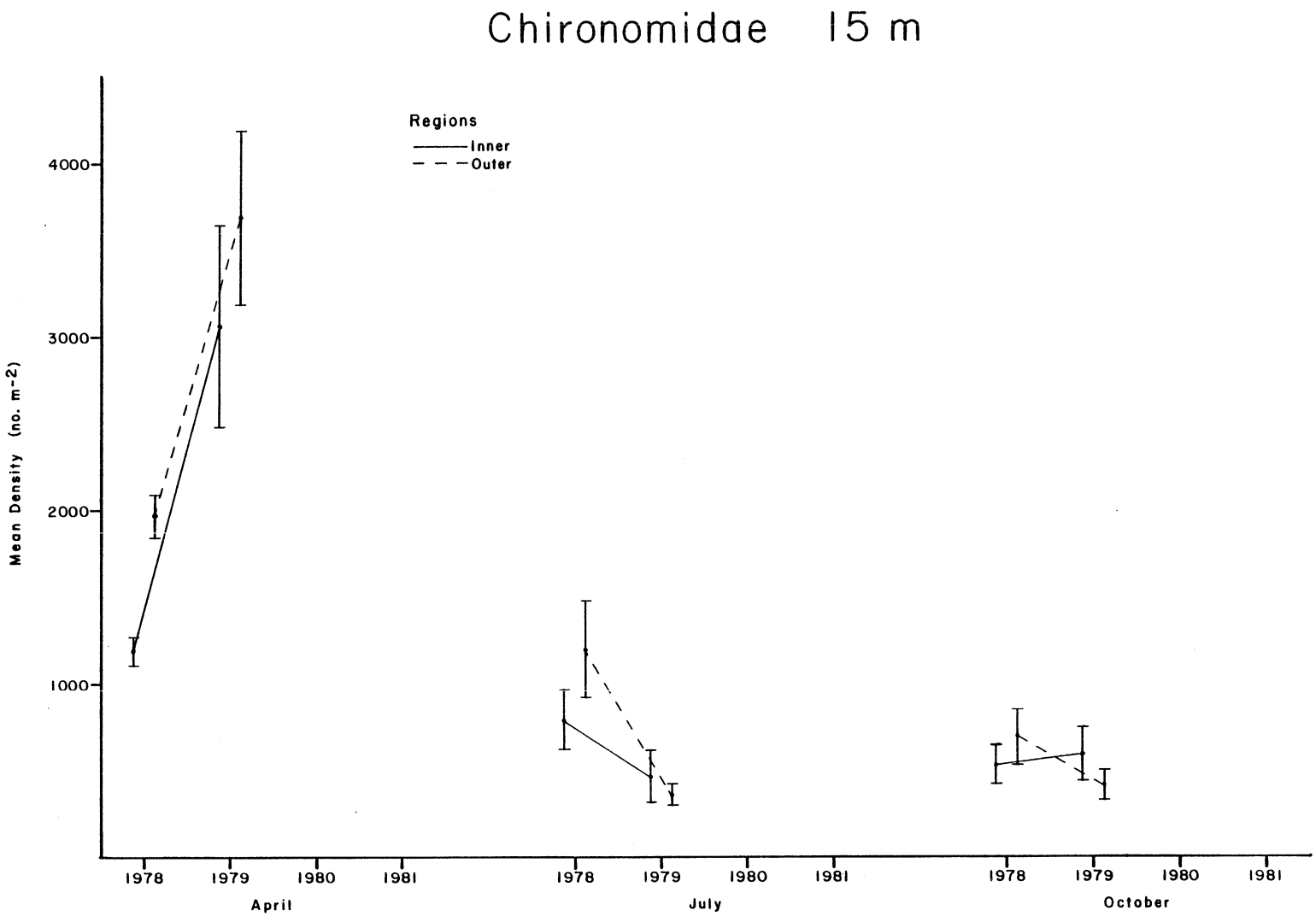

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occurrence of R. cf. demeijerei than the inner with this difference becoming more extreme with each month sampled. The absolute difference in this chironomid's density between regions was 10% in April, 32% in July, and 42% in October. Another chironomid species, Cryptochironomus sp. 1, that occurs with R. cf. demeijerei and comprised 3-7% of the overall chironomid density during July and October, also was notably absent from the inner region. With the exception of R. cf. demeijerei, there were no obvious differences regarding percent occurrence among regions for chironomid species during April (Appendix 2).

In addition to regional differences observed for R. cf. demeijerei and Cryptochironomus sp. 1, the inner region at 3-9 m during July had a disproportionate increase in percent occurrence of chironomid taxa normally found at finer sand depths (9-15 m) when compared with the outer region (39% and 11%, respectively). Chironomid species showing increases in the inner region at 3-9 m during July were Cyptochironomus sp. 2, Heterotrissocladius cf. changi, Hydrobaenus sp., Micropsectra sp., Monodiamesa cf. tuberculata, Polypedilum cf. scalaenum, Potthastia cf. longimanus, and Procladius sp. These same differences were observed in October but were reduced in intensity.

NAIDIDAE

Naidids comprised 22% of the 1979 annual benthic density and occurred in 71% of the samples collected during 1979 (Table 11). Of 19 species of naidids collected from 1977 to 1979, 15 species were identified from the inner region and 14 species from the outer region during 1979 (Tables 3 and 4).

Compared with 1978, there was a change in naidid species composition in the survey area. Whereas in 1978 Piguetiella michiganensis (49%), Chaetogaster diaphanus (17%), Stylaria lacustris (15%), and Uncinais uncinata (12%) were the most abundant naidid species, samples collected in 1979 were dominated by

Vejdovskyella intermedia (52%) and P. michiganensis (23%) (Appendix 3). All other naidid species comprised less than 10% of the annual naidid mean density. It also appeared that at 3 m, in 1978 and 1979 combined, the inner region consistently supported a greater number of naidid species (10) than the outer region (4). While the first three of the four 3-m outer region naidid species (Amphichaeta leydigii, P. michiganensis, C. diaphanus, and C. diastrophus) were also found in the inner region, Nais elinguis, Nais pardalis, Nais simplex, Nais variabilis, S. lacustris, U. uncinata, and V. intermedia were identified only from the inner region at 3 m. However, all of the above naidid species, with the exception of N. simplex, occurred at one or more other depths in both regions. Although all remaining depths had similar numbers of naidid species, there were additional qualitative regional differences which will be discussed after an analysis of quantitative annual and regional depth and monthly differences.

Mean annual density of naidids observed during 1979 (1782 m^{-2}) was somewhat greater but not significantly different from 1978 average density (1134 m^{-2}) (Table 6). The depth distributional pattern for naidids collected during both years followed the same pattern although there was a significant difference noted at 9 m (Fig. 8). Monthly naidid mean abundances were similar and followed the same trend during both years (Table 6, Fig. 9).

Annual within-region comparisons for year, month, or depth indicated that neither the 1979 inner nor outer naidid densities were significantly different from naidid densities in corresponding regions in 1978. Within 1979, although there were no regional naidid density differences for year, month, or at the 6-, 9-, 12-, and 15-m depths, there were significantly more naidids in the inner compared with the outer region at 3 m (Tables 7-9). Further analysis of regional naidid density differences at each depth sampled in each month

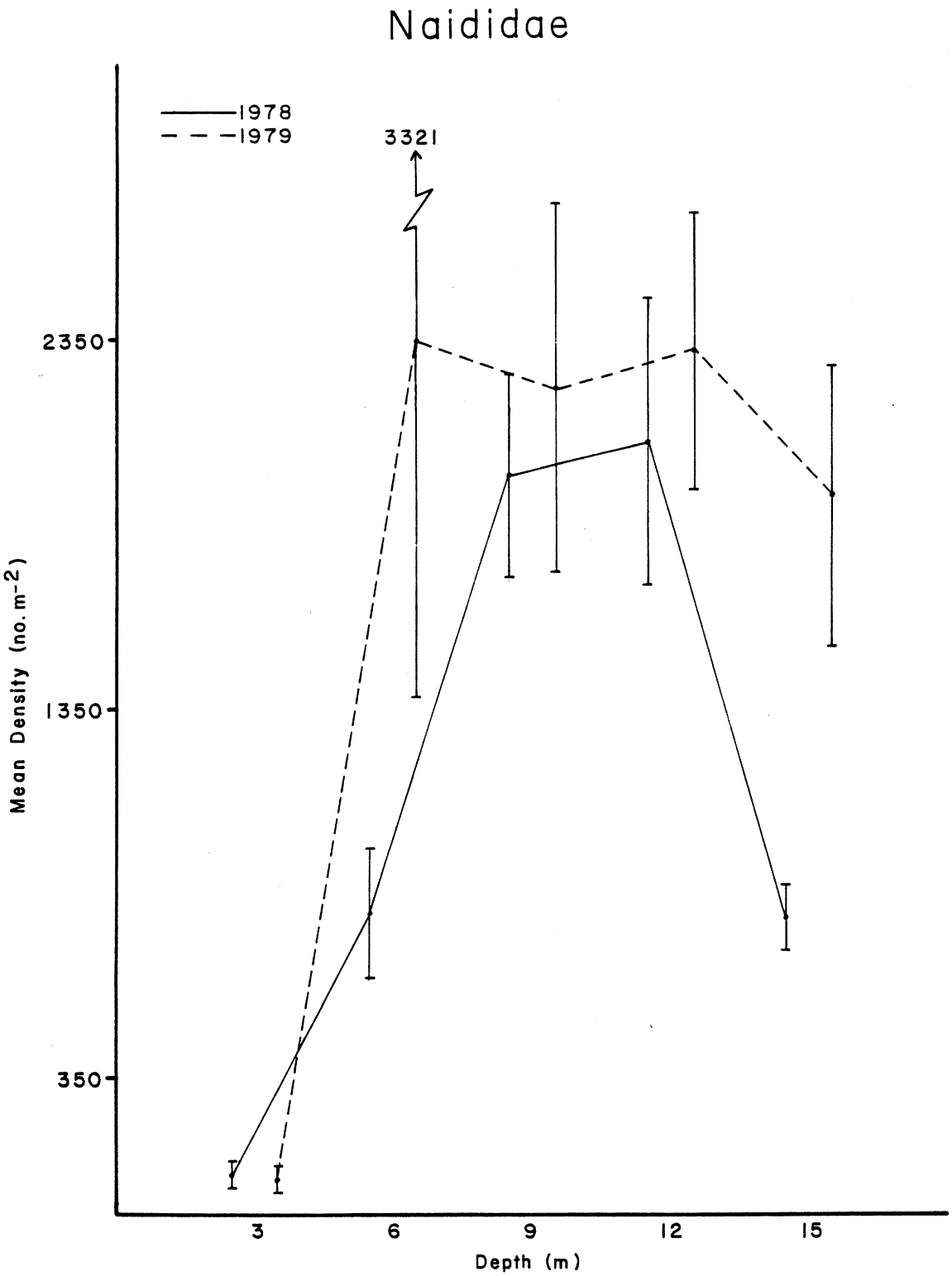


Fig. 8. Mean density (number m^{-2}) of naidids collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

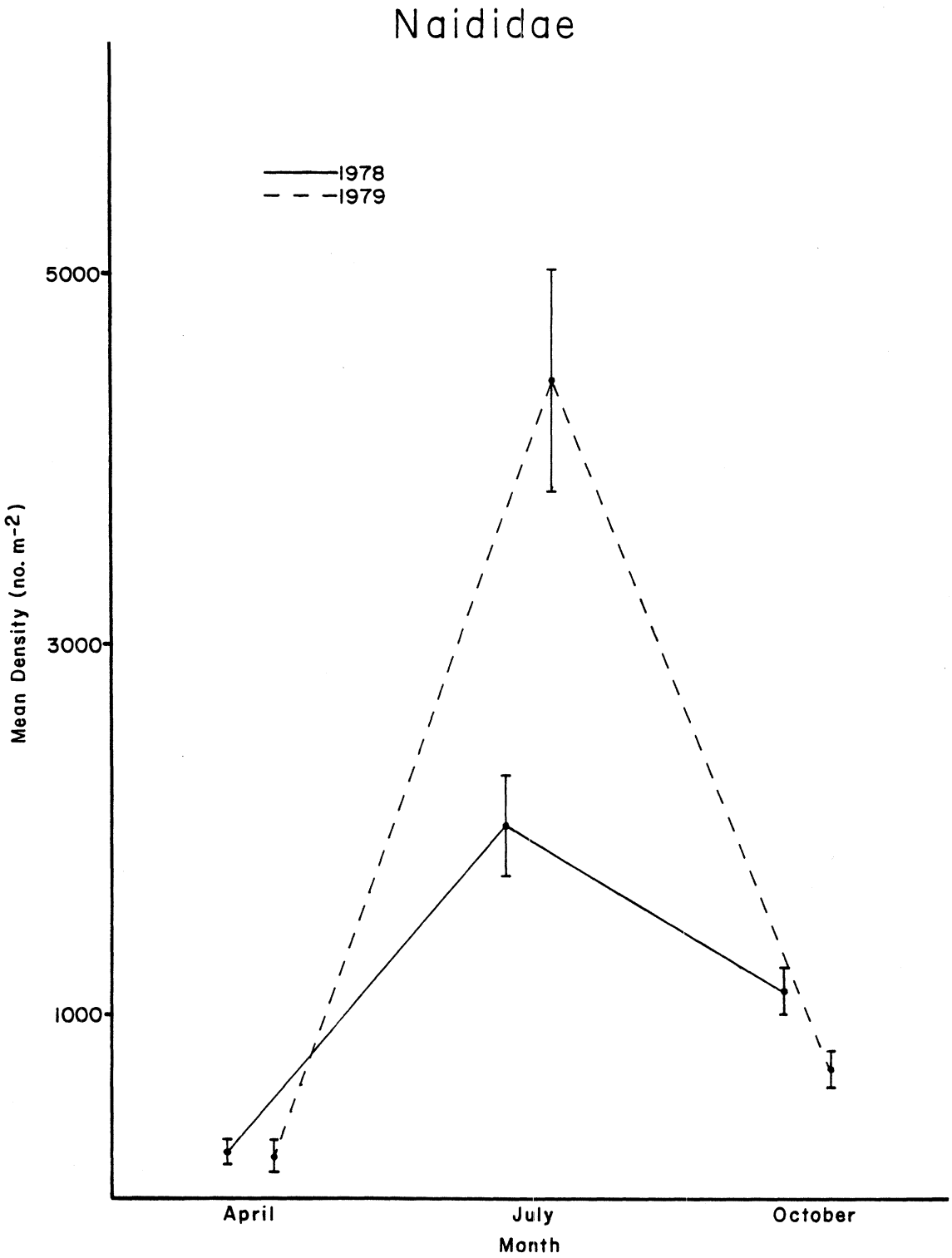


Fig. 9. Mean density (number m^{-2}) of naidids collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

indicated the pattern observed at 3 m during July 1978 was maintained in July 1979 (Table 10). Naidid densities at 3 m in July were consistently greater in the inner region compared with the outer region in both years (Fig. 10). However, during July 1978 at 3 m the naidid species, Uncinais uncinata, was the dominant naidid taxon (70%); whereas, during 1979, Vejdovskyella intermedia (39%) and Amphichaeta leydigii (33%) were dominant. Dominance of U. uncinata at 3-9 m in 1978 was replaced by V. intermedia in 1979, particularly during July when U. uncinata was most abundant. Comparing inner and outer regions and combining the 3-9-m depths during July 1979 indicated that V. intermedia was also an abundant species in the outer region (32%), but not to the extent it was in the inner region (77%). In the inner region, V. intermedia and A. leydigii comprised 89% of the July naidid mean density at 3-9 m. In the outer region, the same two species comprised only 33%. Other naidid species such as C. diaphanus (35%), U. uncinata (10%), P. michiganensis (9%), and S. lacustris (9%) comprised significant portions of the naidid abundance when considered separately or as a whole at 3-9 m in the outer region during July 1979. These four naidid species comprised 94% of the inner naidid density and 98% of the outer naidid density at 3-9 m combined during July 1978, while V. intermedia and A. leydigii comprised 3% and 1% of the inner and outer naidid densities, respectively, at the same depth and time period. The 1979 percentage of naidid density for these species at 3-9 m in the outer region (63%) more closely approximated 1978 outer region estimates (98%) than did 1978 (94%) and 1979 (8%) inner region percentage comparisons. Significant inner/outer regional naidid mean density differences observed at 3-9 m during July 1979 were due to larger increases of V. intermedia in the inner compared with the outer region. Additional significant differences in mean abundance of naidids observed between inner/outer regions at 15 m in July and 9 m in October were due to the

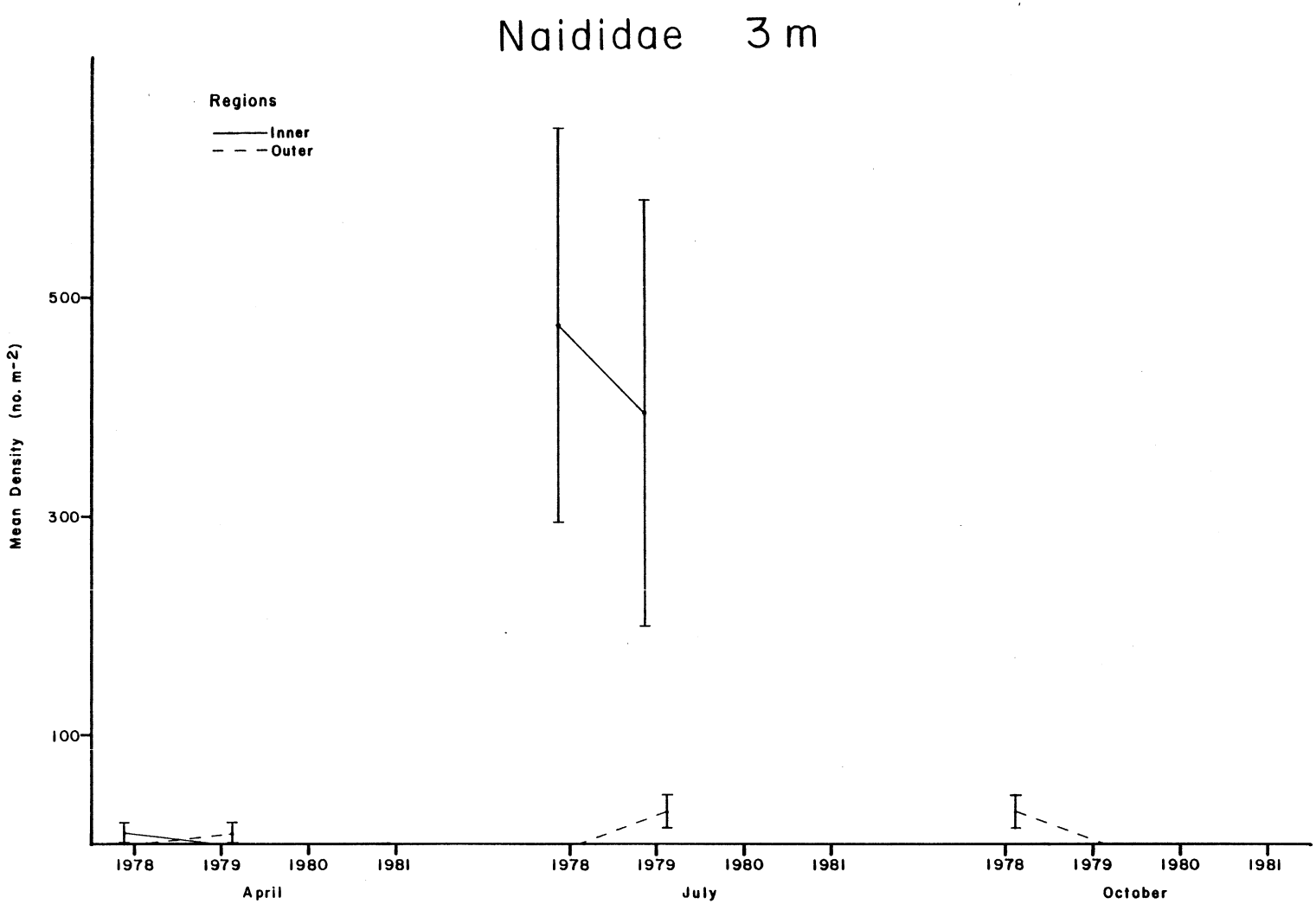
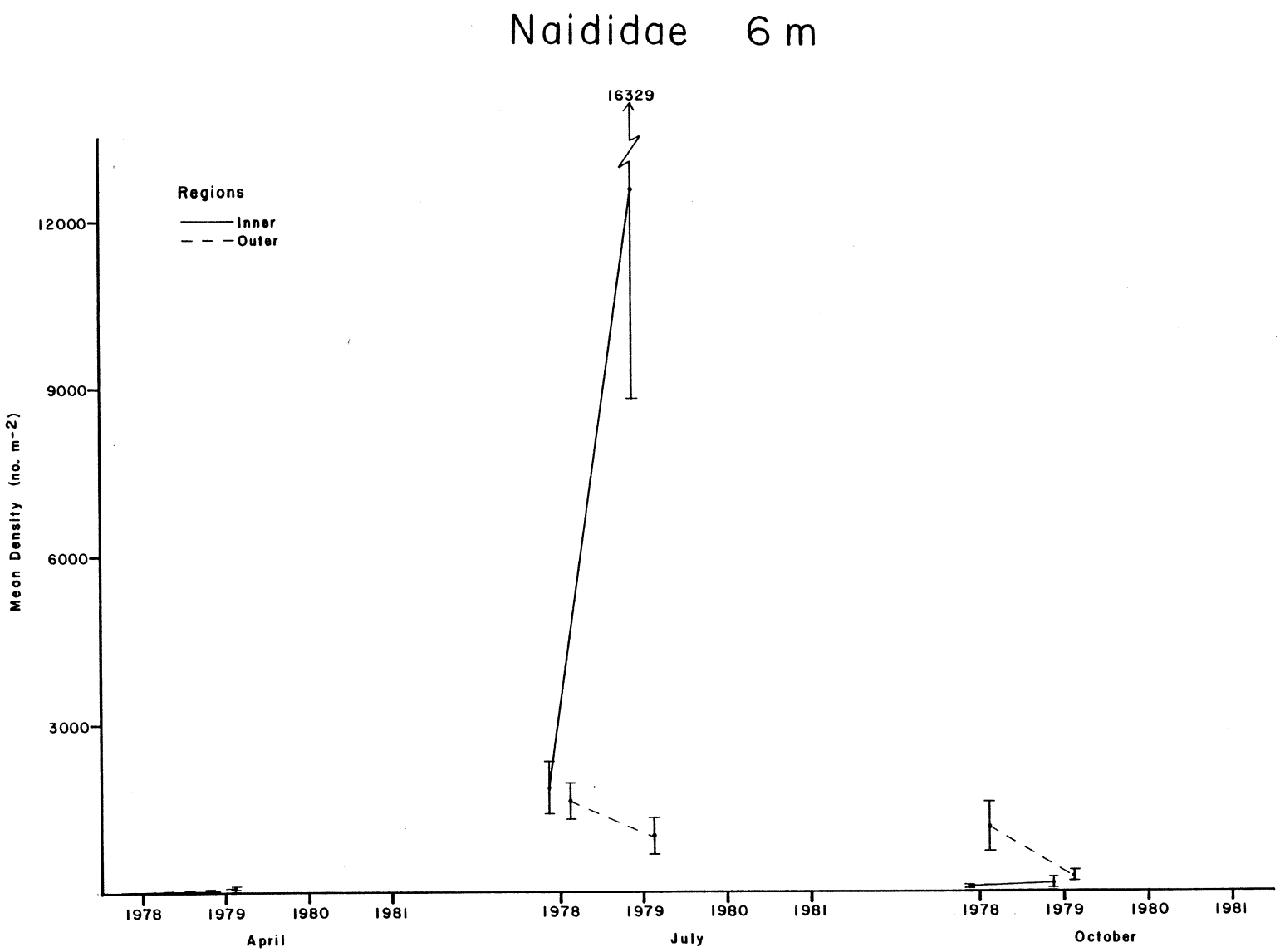


Fig. 10. Inner and outer regional mean densities (number m^{-2}) of naidids collected in April, July and October 1978 and 1979 from eastern Lake Michigan at 3-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.



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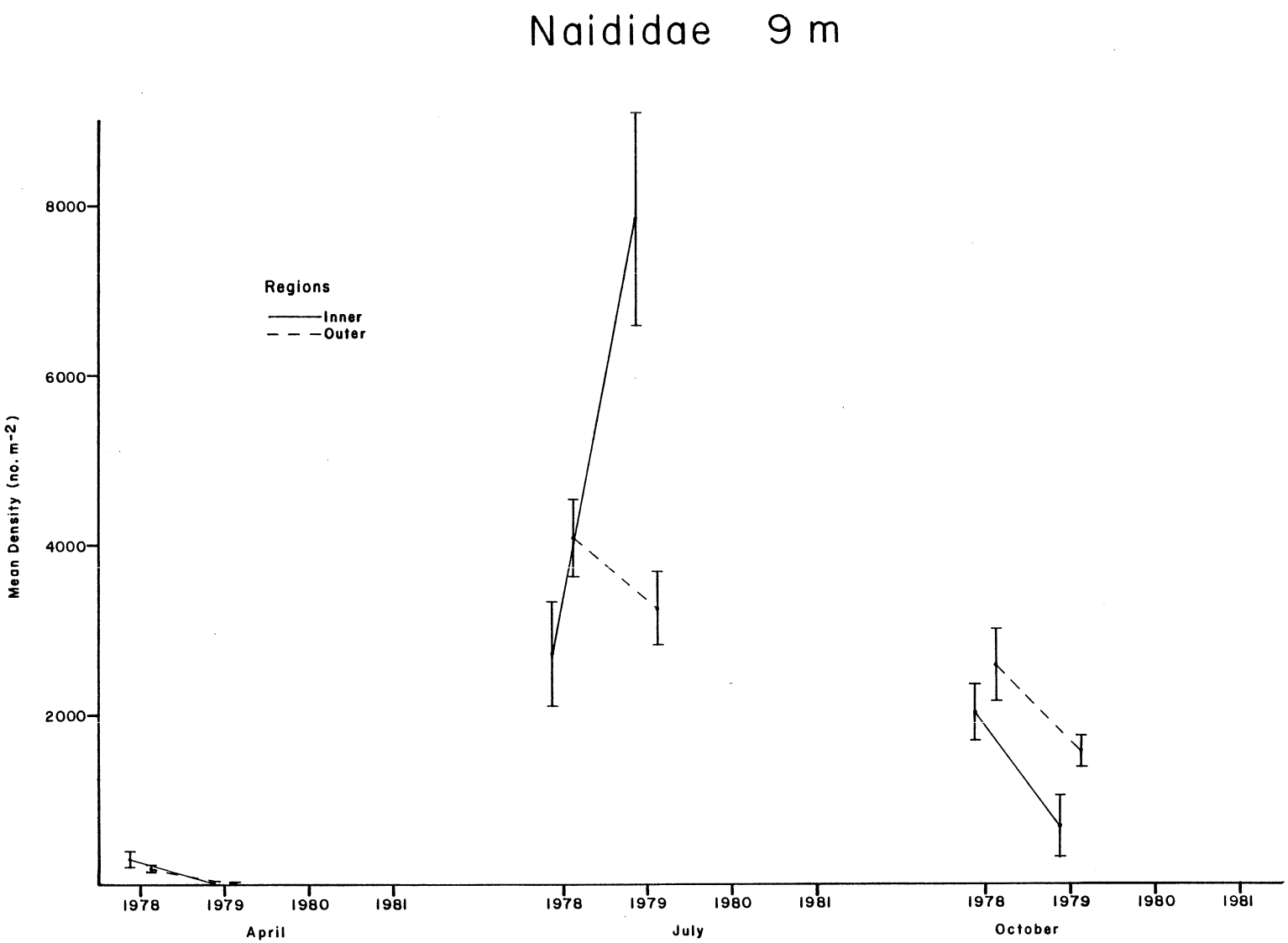

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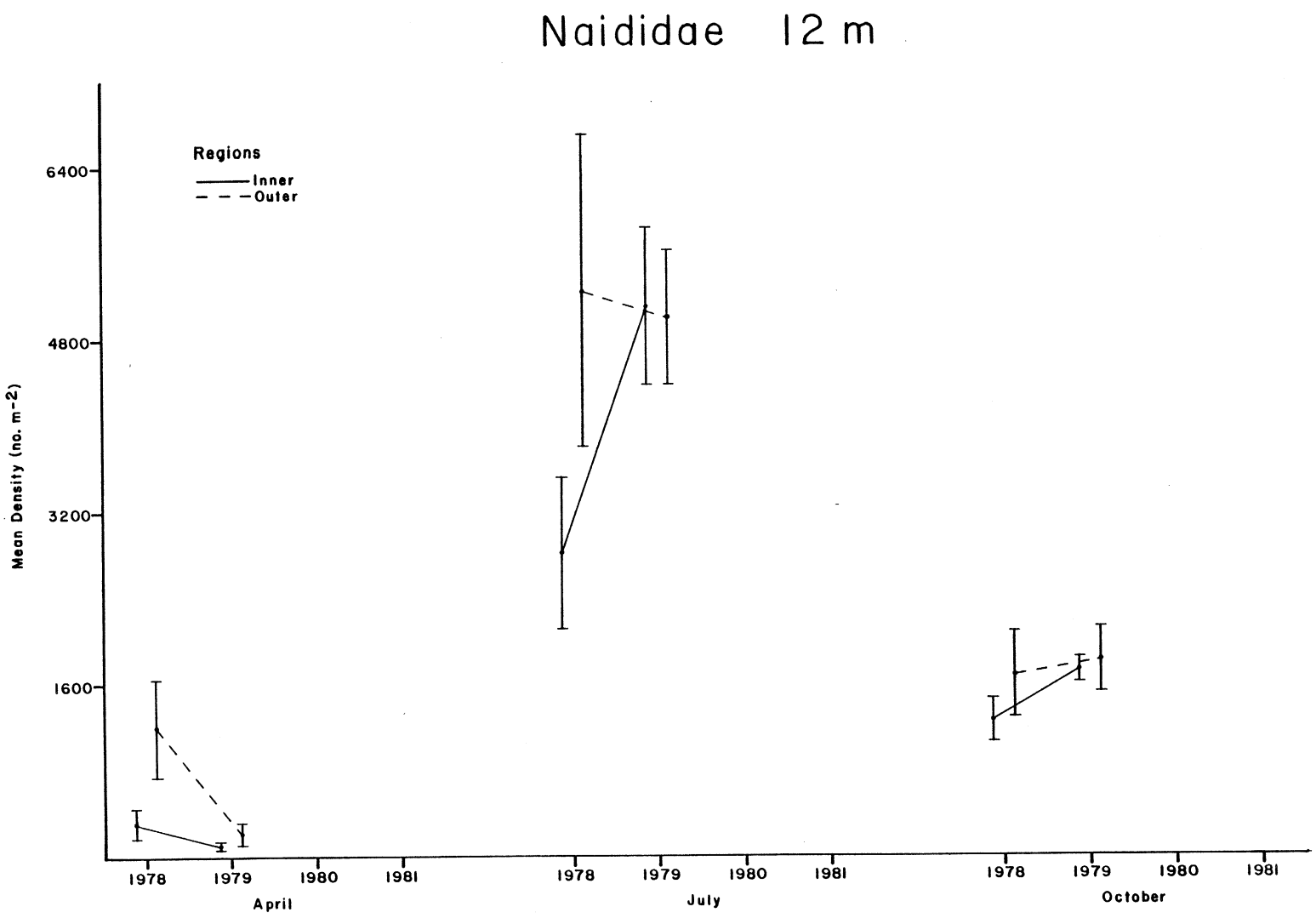

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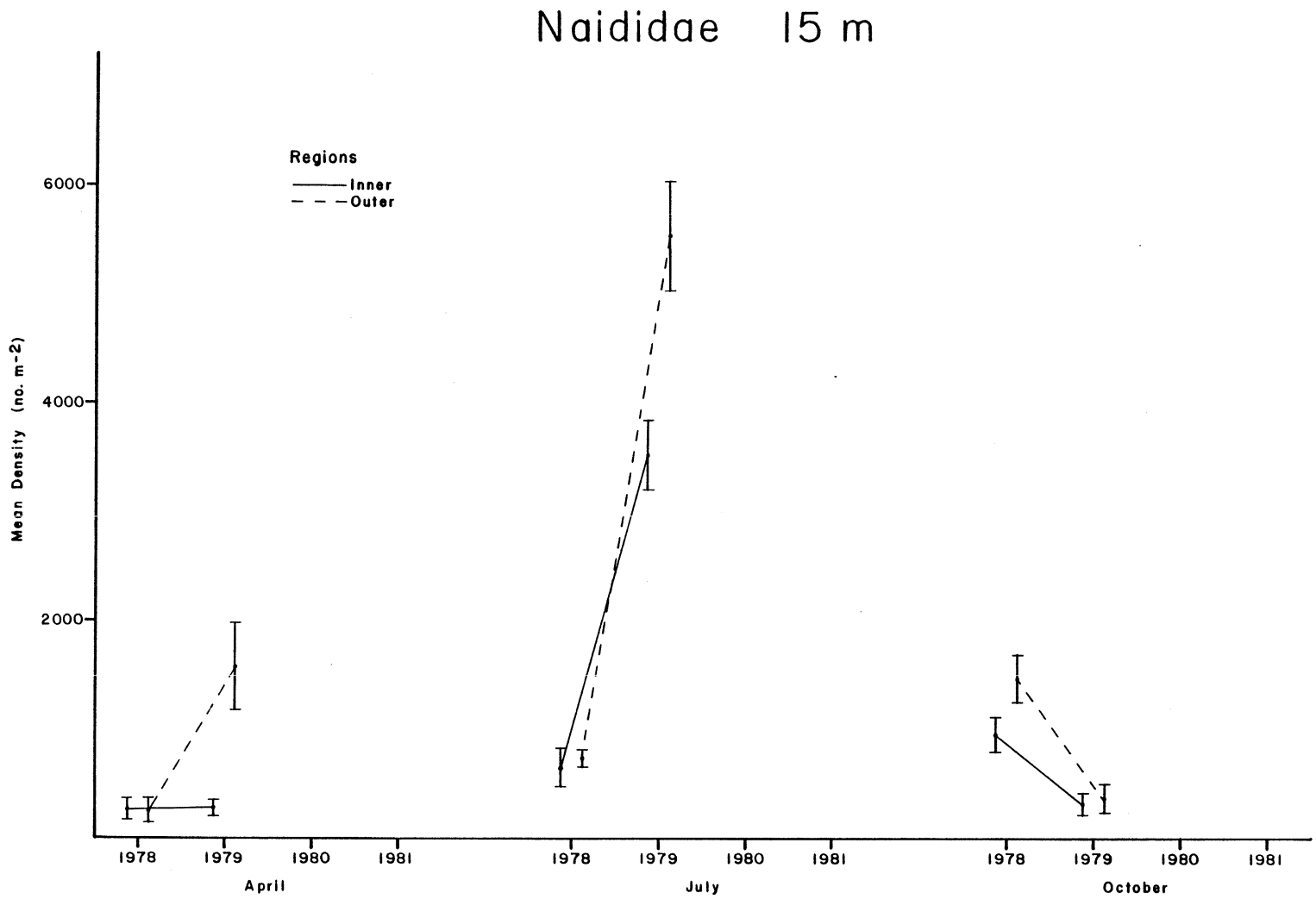


Fig. 10. Continued.

much greater numbers of P. michiganensis present in the outer region compared with the inner region. Exclusive of the above observed differences, all other comparisons were not significantly different and exhibited consistently increasing or decreasing trends across regions.

TUBIFICIDAE

Tubificids comprised 9% of the 1979 annual mean benthic density and occurred in 64% of the samples collected (Table 11). Thirteen species of tubificids have been identified from 1977 to 1979 (Table 3). The most numerous of nine tubificid species collected in 1979 was Potamothrix moldaviensis, having an annual mean density of 21 m^{-2}. Although tubificids were more numerous in 1978 (859 m^{-2}) than during 1979 (735 m^{-2}), there was no significant difference between estimated annual densities (Table 6). While the depth distribution of tubificids was similar between years, there were significantly more tubificids present at 9 m in 1978 when compared with 1979 and at 15 m in 1979 compared with 1978 (Fig. 11, Table 6). The tubificid density difference found at 9 and 15 m between years was related to yearly regional depth differences. Monthly mean densities for 1978 and 1979 followed similar seasonal abundance trends with no significant differences noted among respective monthly tubificid abundance comparisons (Fig. 12).

Tubificids exhibited similar abundances in the outer region from 1978 to 1979 and in the inner region from 1978 to 1979 (Tables 7 and 8). In the outer region tubificids were significantly more numerous at 9 and 15 m in 1979 than in 1978. Overall, the outer region had significantly more tubificids (1485 m^{-2}) than did the inner region (903 m^{-2}) based on a yearly average over the combined depths 9-15 m.

The difference between 1979 inner and outer regions was most apparent during July (averaged over 9-15 m) and at 15 m (averaged over all months)

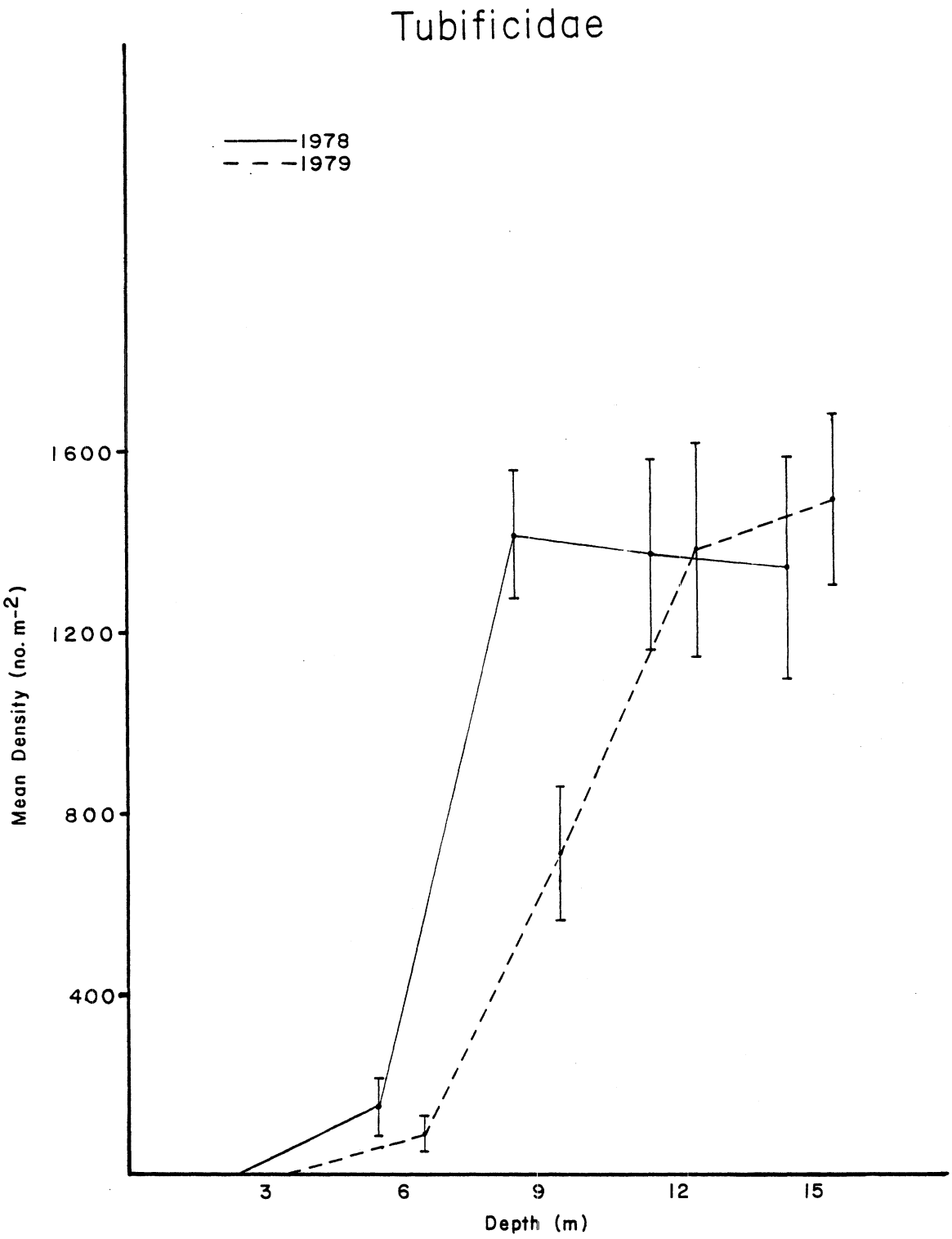


Fig. 11. Mean density (number m^{-2}) of tubificids collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

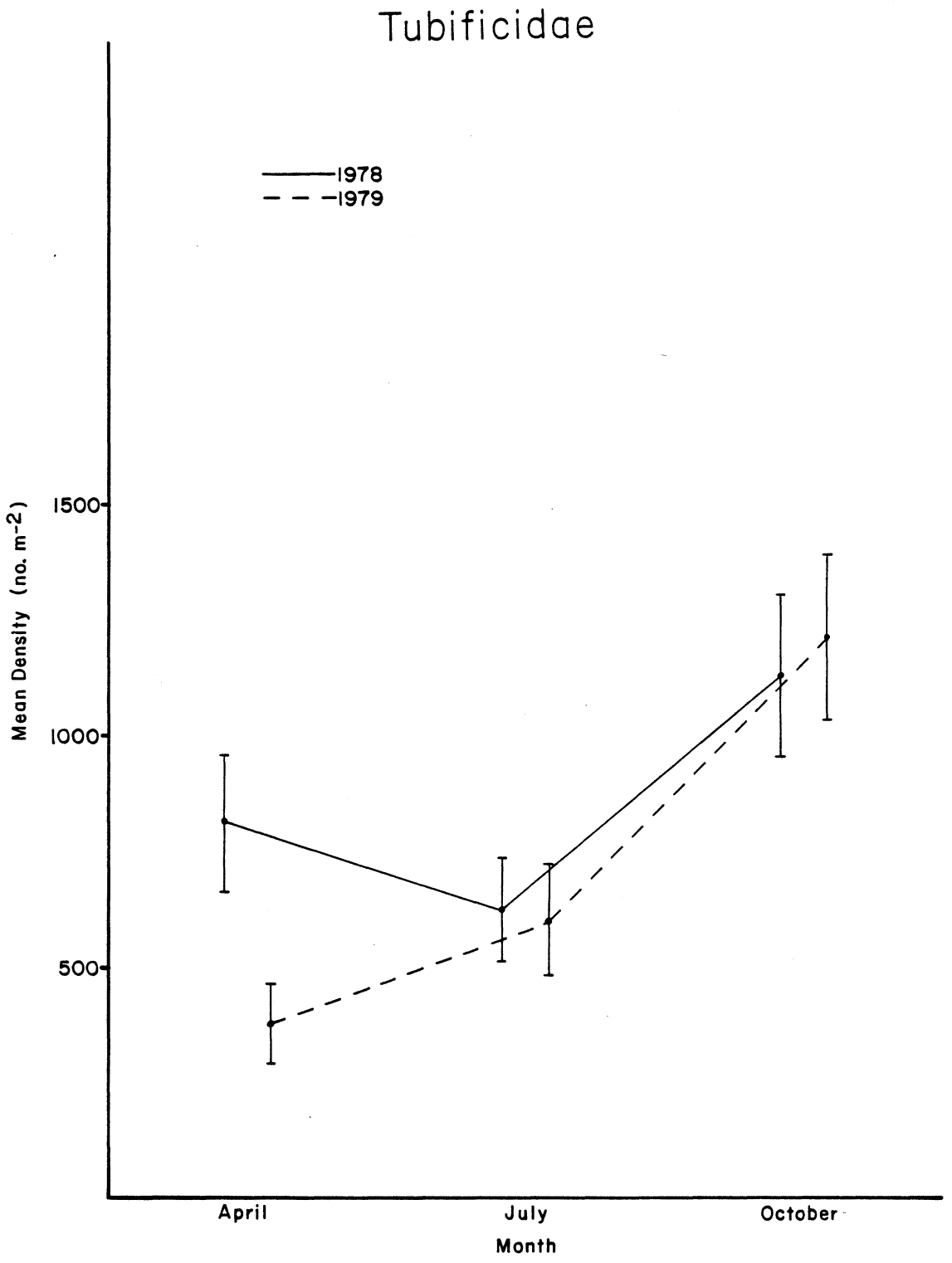


Fig. 12. Mean density (number m^{-2}) of tubificids collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

(Fig. 13). During July, there were significantly more tubificids observed in the outer region for the combined depths 9-15 m when compared with the inner region (Table 9). Averaging over months, the greatest density difference was observed at 15 m where outer region tubificids were more numerous than those in the inner region. Specific comparisons between 1979 inner/outer tubificid densities within each month at each depth sampled indicated that only at 15 m during April and October were there significant density differences (Table 10). Inner/outer trends paralleled one another from 1978 to 1979 at 9 and 12 m, but were in opposing directions during April and October 1979 at 15 m (Fig. 13).

TURBELLARIA

Turbellarians occurred in 64% of the samples collected during 1979 (Table 11), but comprised only 6% of the 1979 annual mean density of macroinvertebrates. Two morphologically different turbellarian species were identified, with species 1 found primarily at 3-9 m and species 2 at 9-15 m during all months (Appendix 1). Compared with 1978, there were significantly more turbellarians collected during 1979, which may reflect increased recognition of nearshore species 1 turbellarians. Turbellarian density differences between 1978 and 1979 were significant at 3, 6, and 15 m (Fig. 14). In addition, during April and July, significant increases in turbellarian mean density were observed (Fig. 15, Table 6); however, with respect to 1979 monthly inner/outer regional mean density comparisons over all depths combined (3-15 m), no difference in turbellarian abundance was found. When turbellarian abundance was averaged over all months at each depth in 1979, the only significant difference occurred at 3 m where the outer region mean density was greater than the inner region mean density (Table 9). Inner/outer density trends tended to be in the same direction from 1978 to 1979 (Fig. 16).

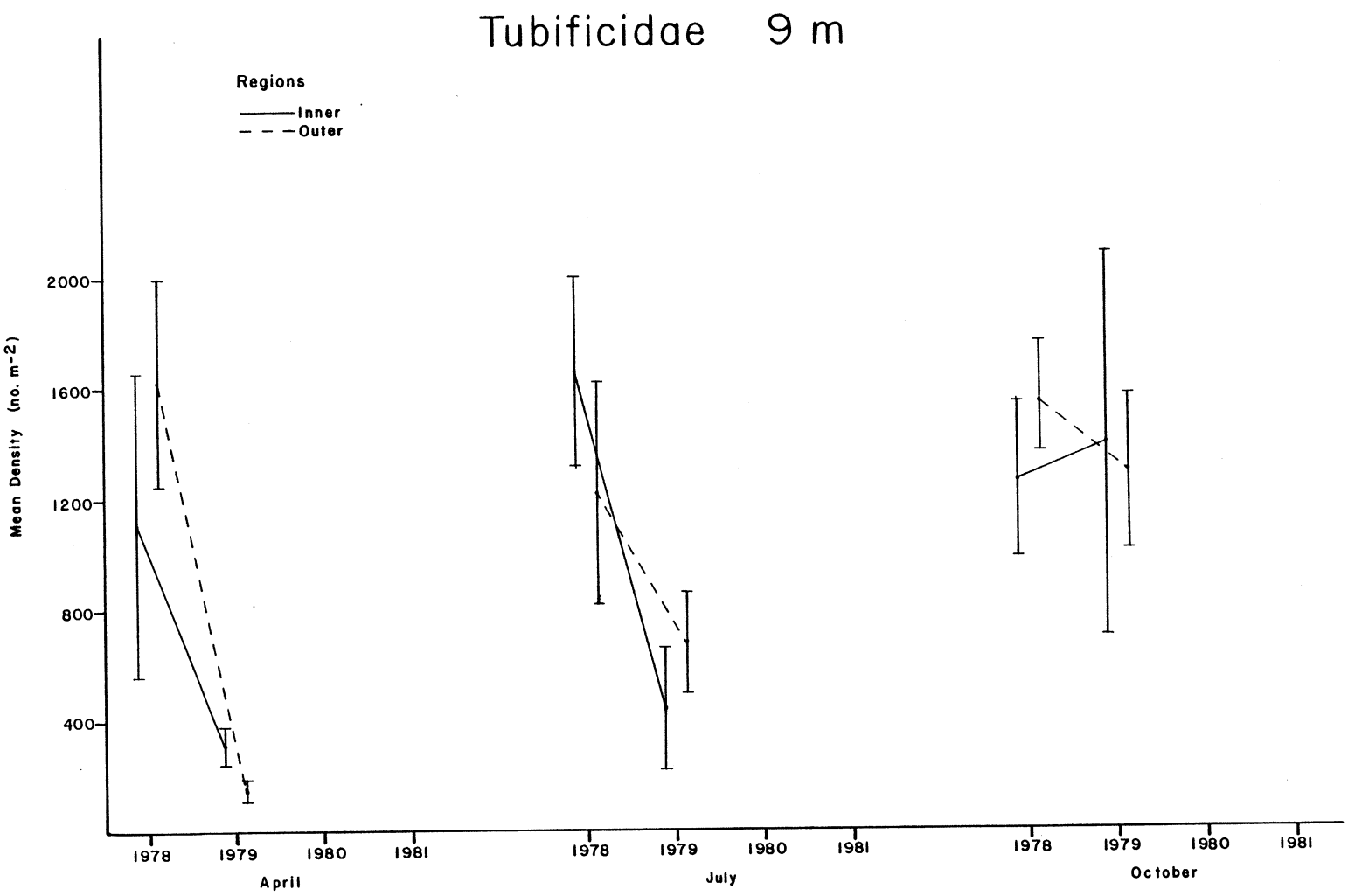
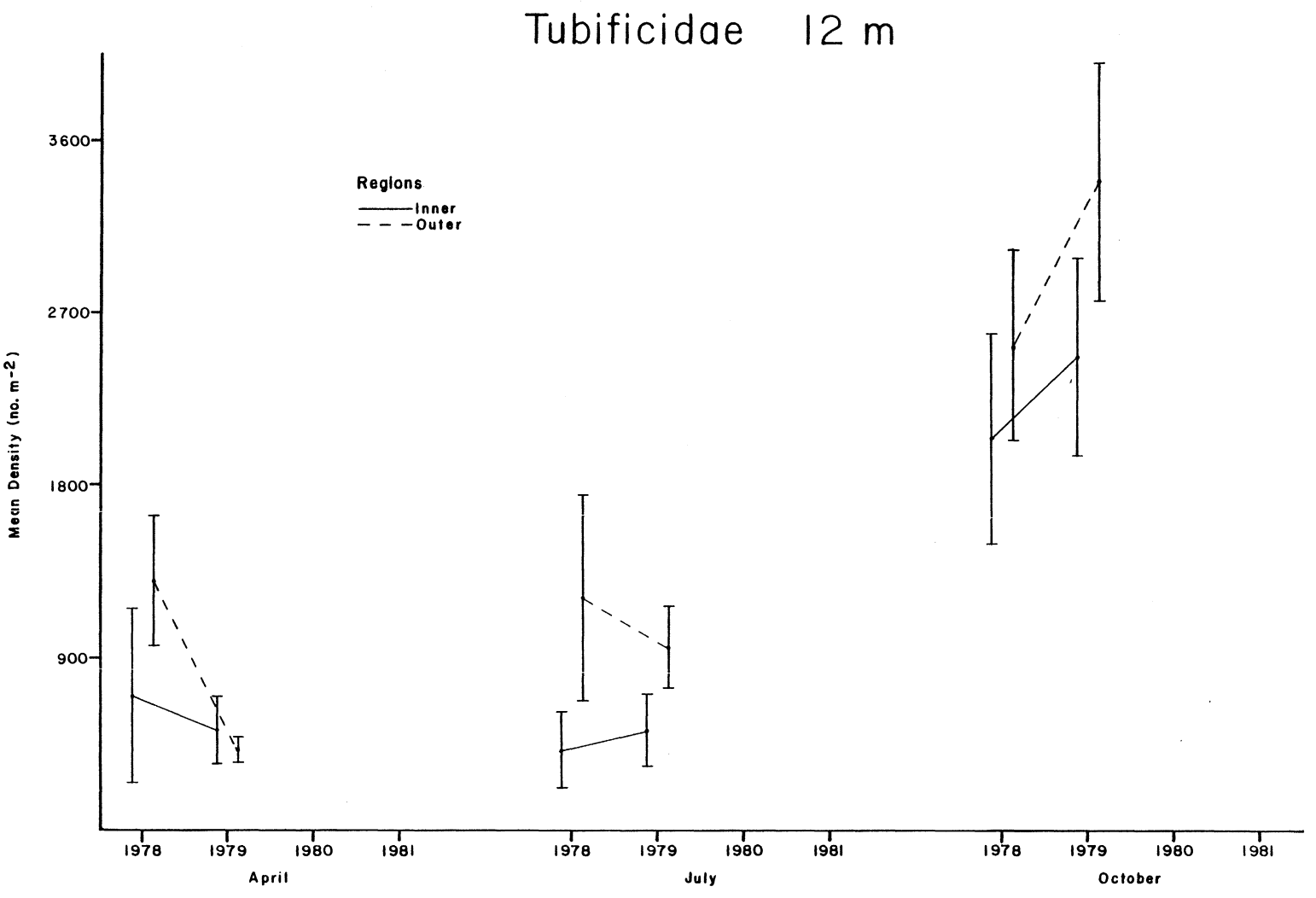


Fig. 13. Inner and outer regional mean densities (number m^{-2}) of tubificids collected in April, July and October 1978 and 1979 from eastern Lake Michigan at 9-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.



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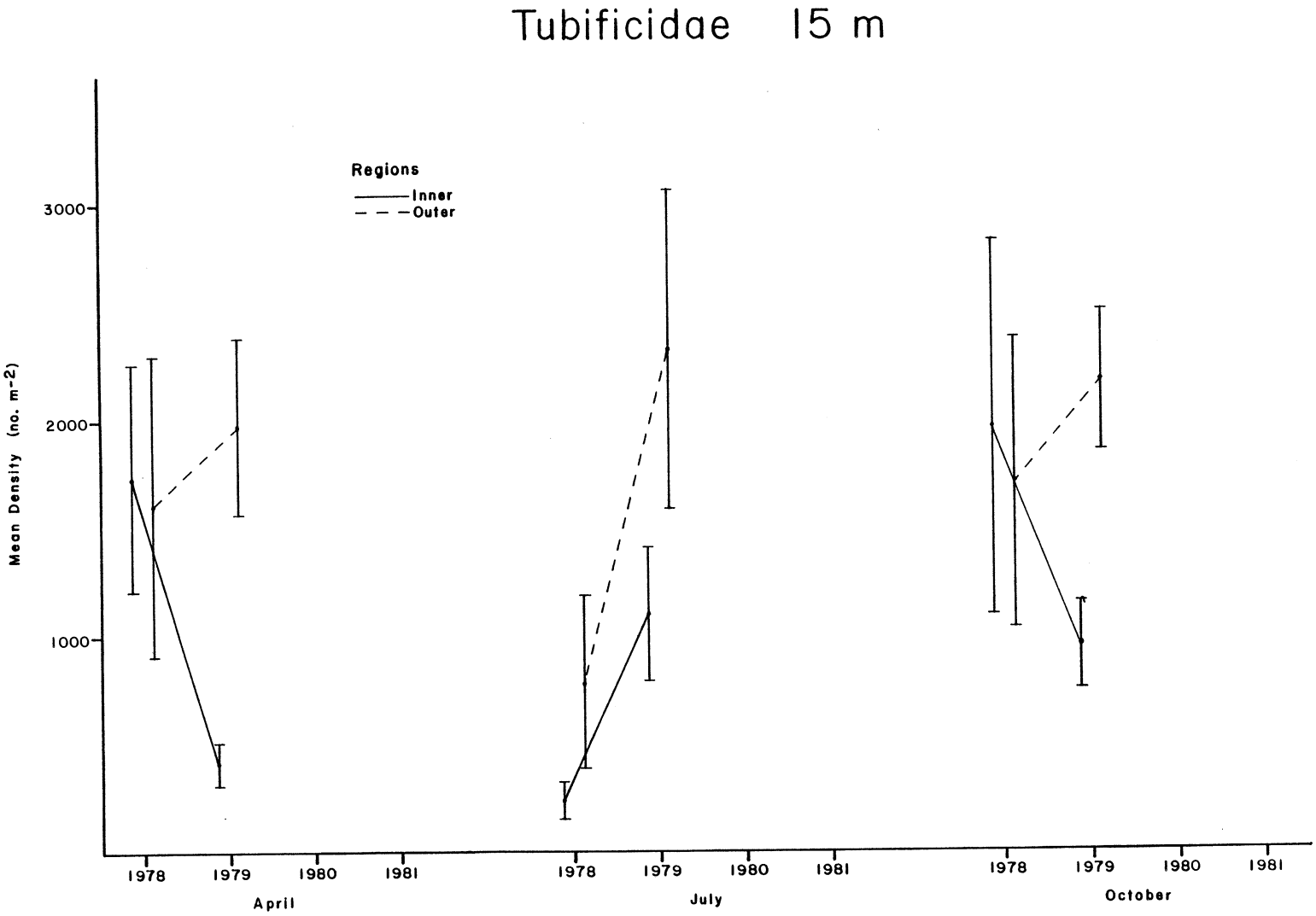

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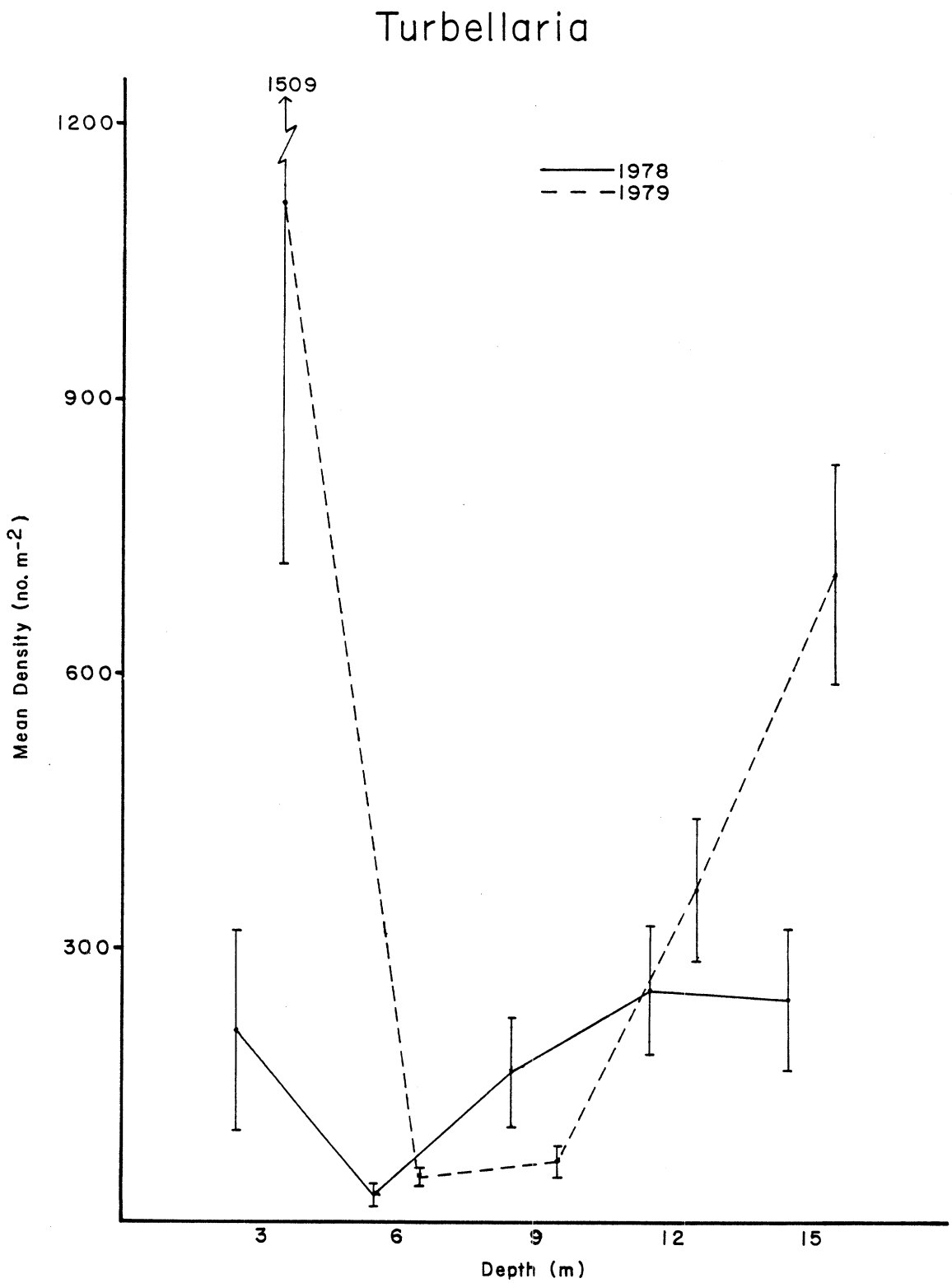


Fig. 14. Mean density (number m^{-2}) of turbellarians collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

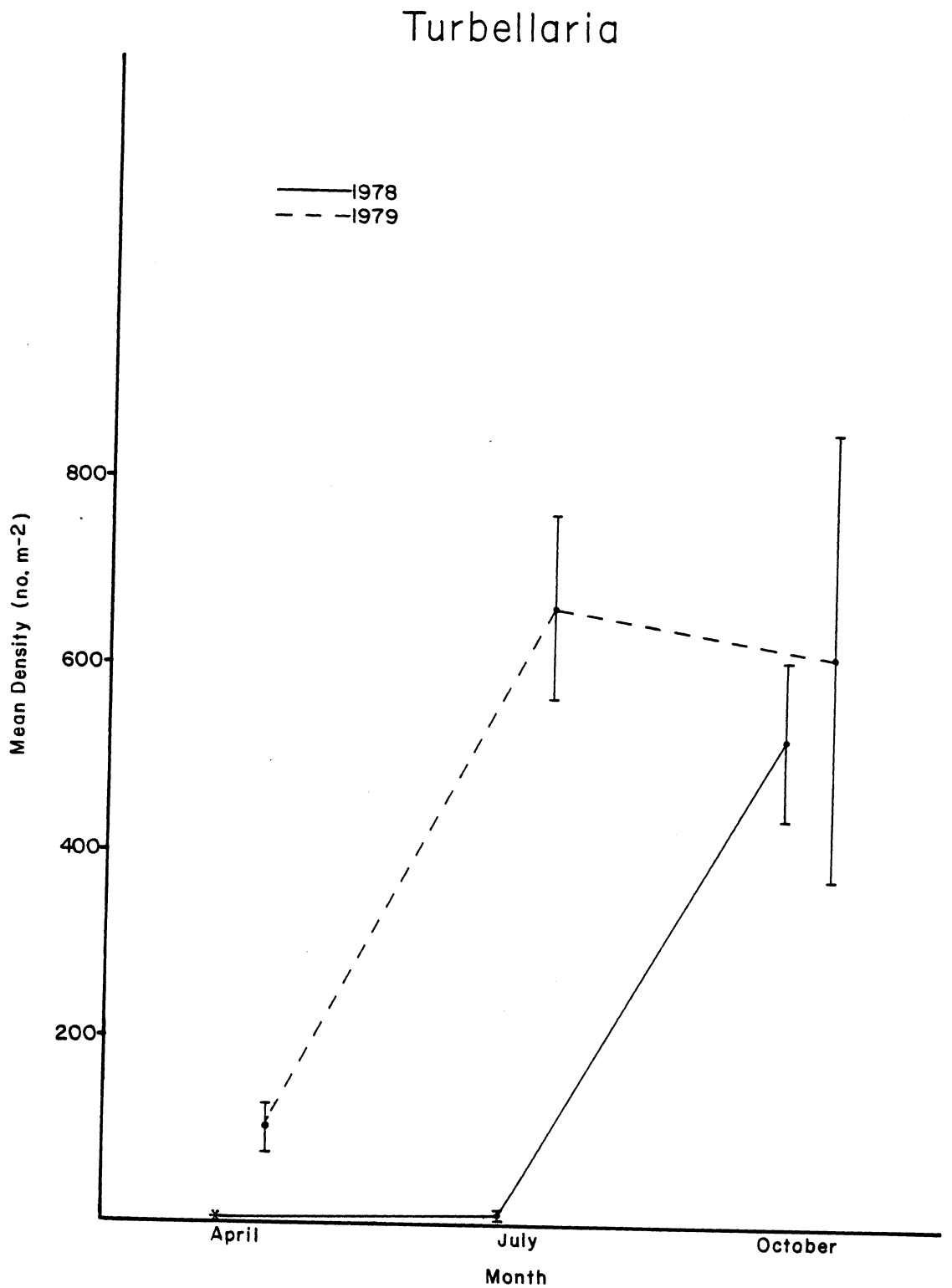


Fig. 15. Mean density (number m^{-2}) of turbellarians collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

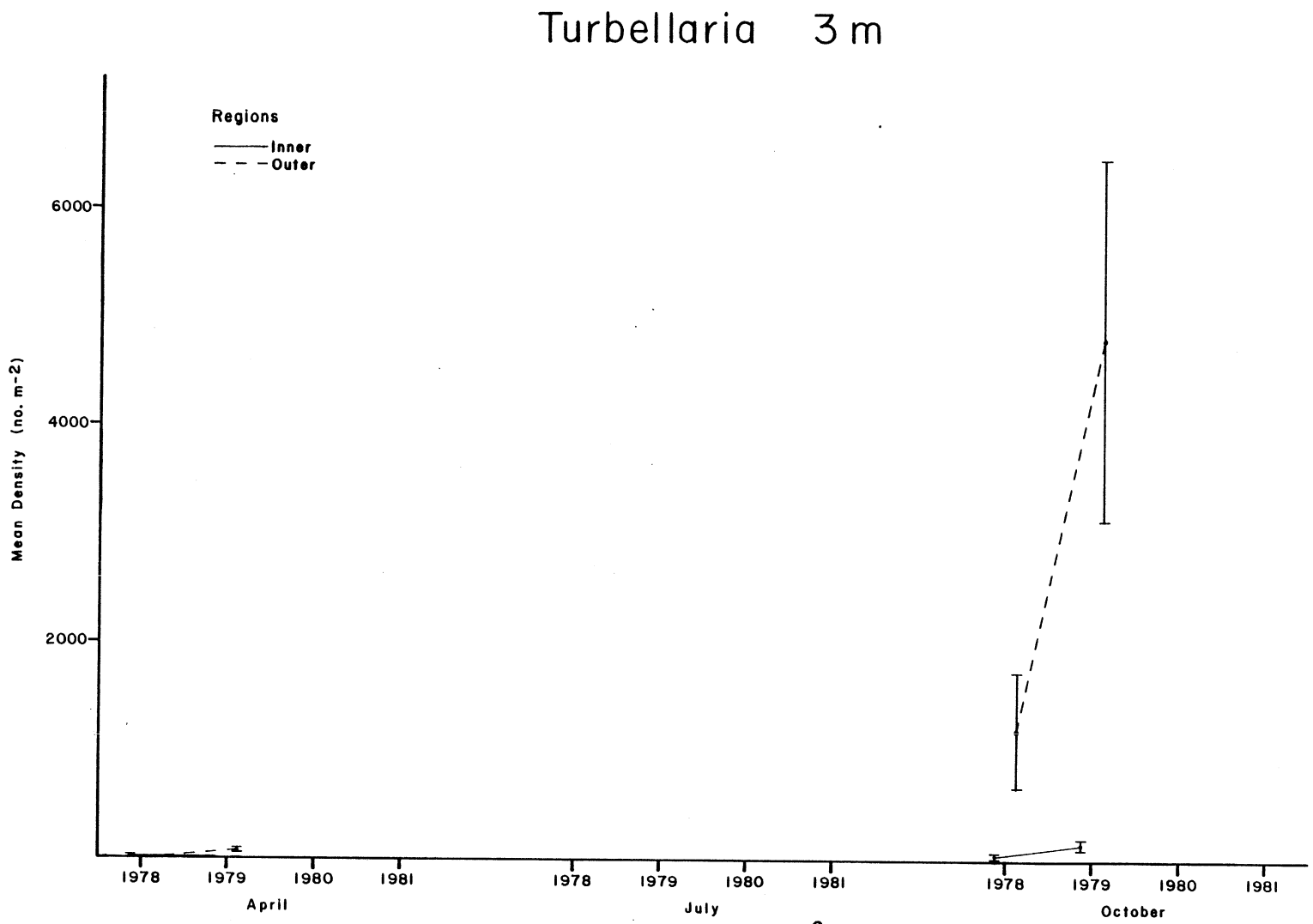
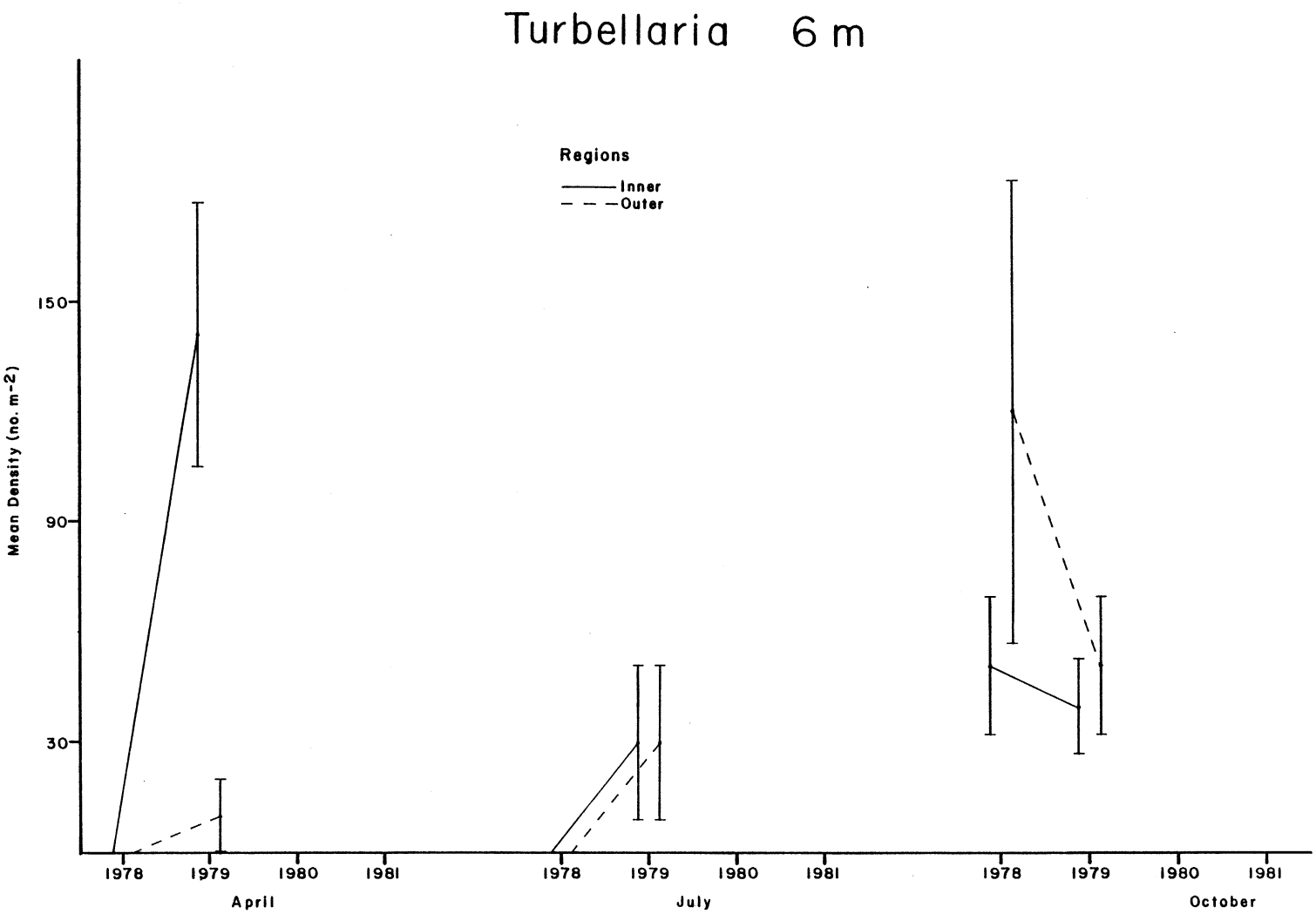


Fig. 16. Inner and outer regional mean densities (number m^{-2}) of turbellarians collected in April, July and October 1978 and 1979 in eastern Lake Michigan at 3-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.



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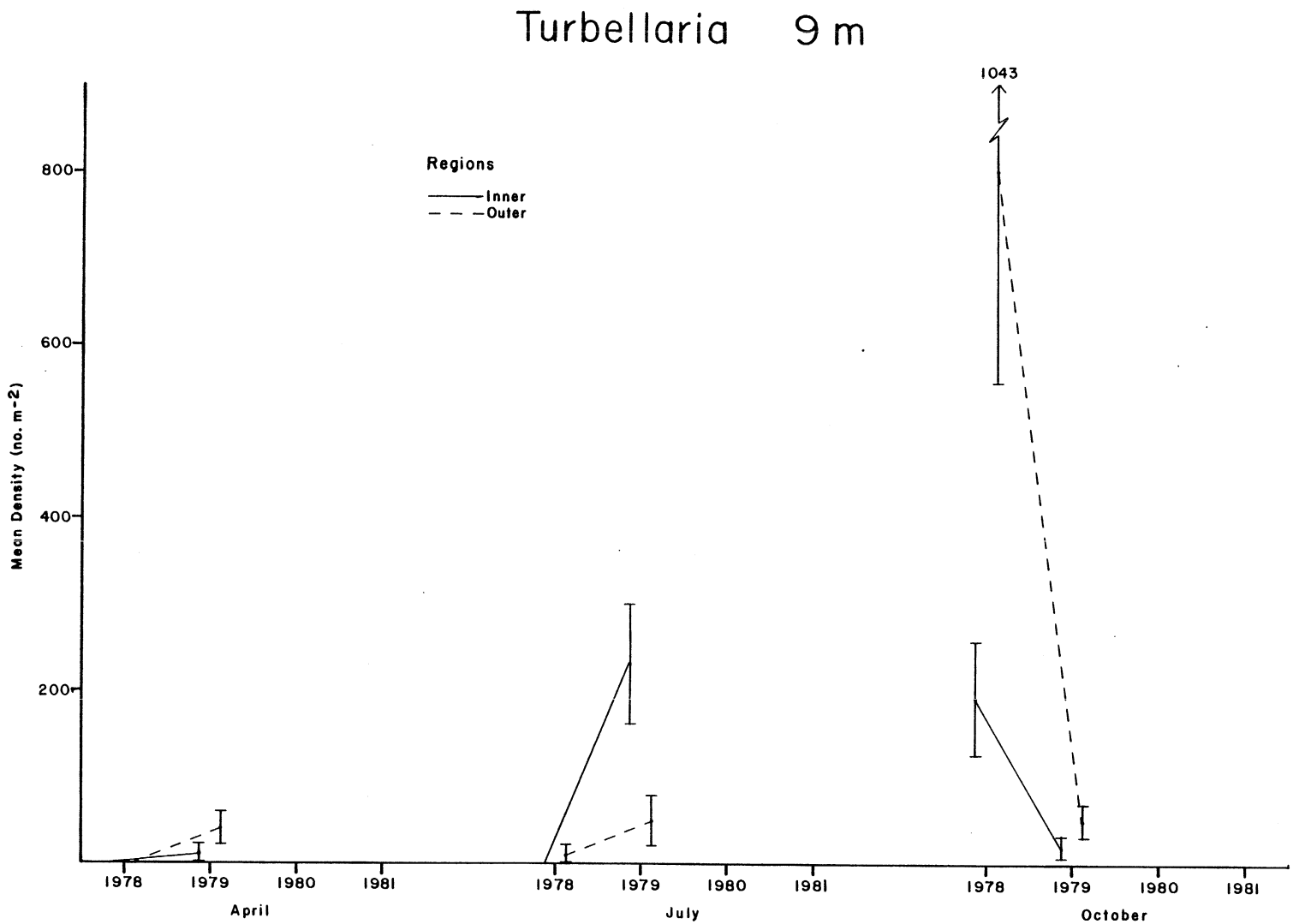

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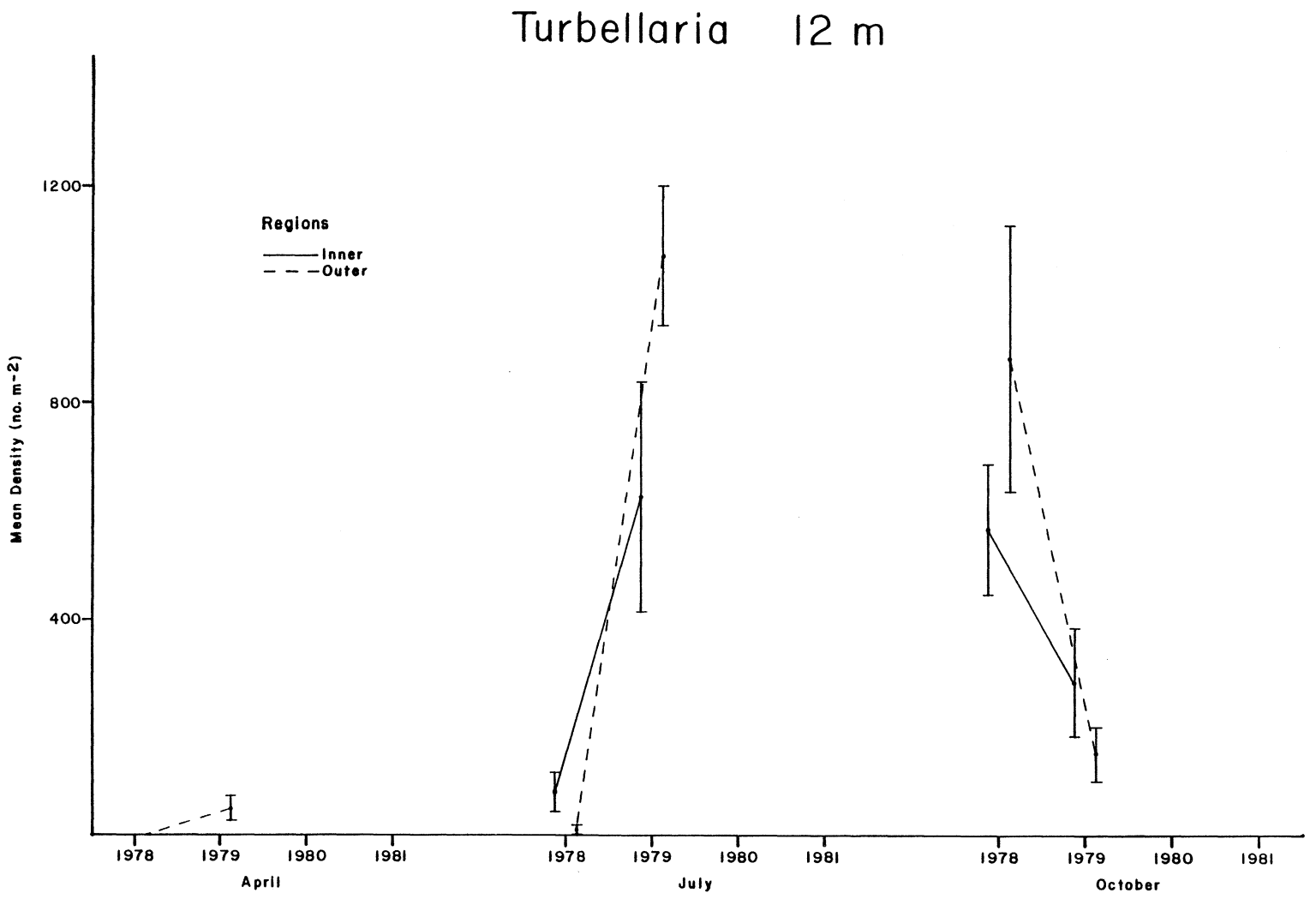

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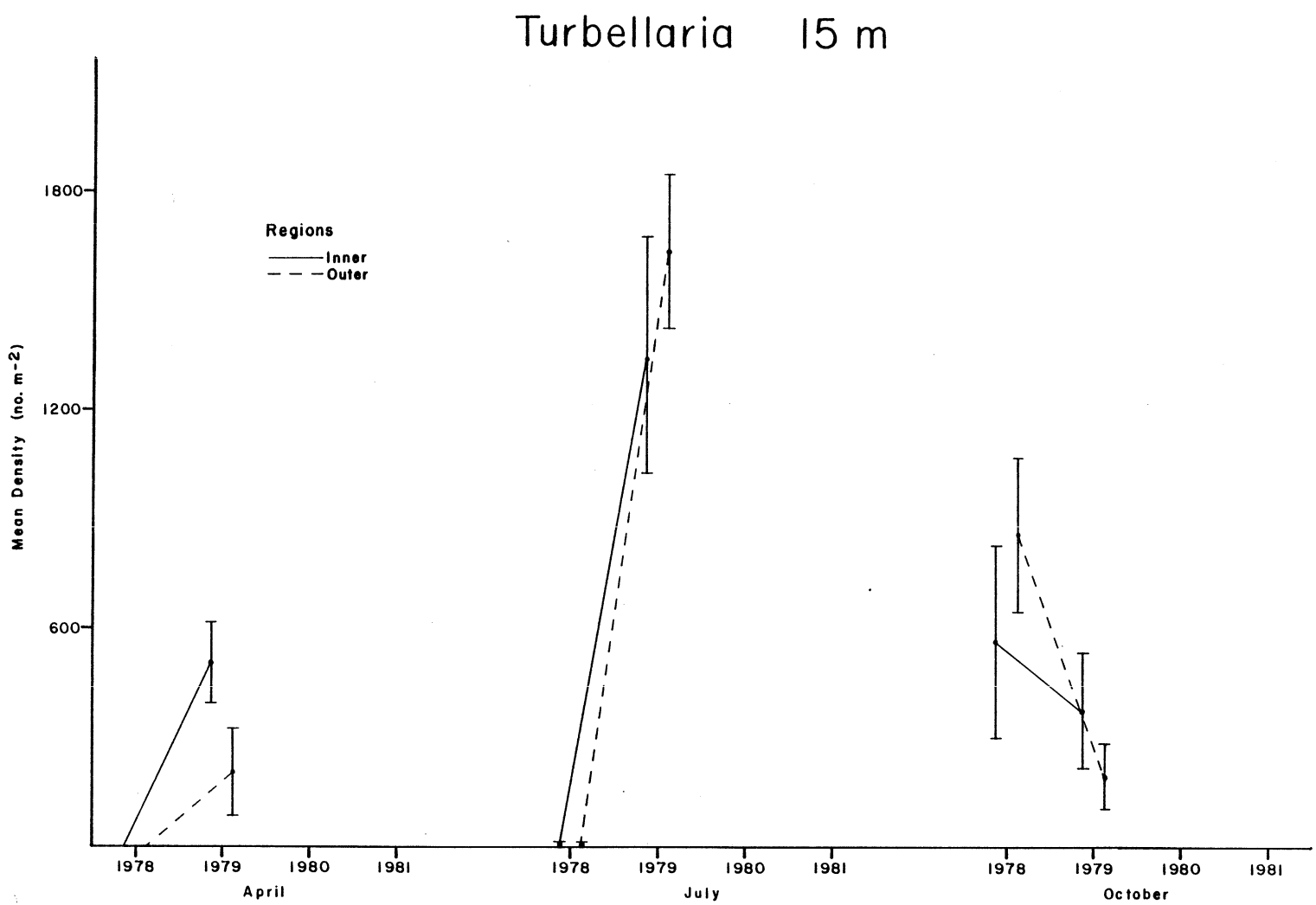


Fig. 16. Continued.

ENCHYTRAEIDAE

Occurring much more frequently in samples collected during 1979 (43%) than during 1978 (14%) (Table 11), enchytraeids comprised 2.4% of the annual 1979 benthic density and were significantly more numerous when compared with 1978 populations (Table 6). Although low abundance of enchytraeids was noted at 6-9 m, regular occurrence and increased densities were observed primarily at 12-15 m (Fig. 17, Appendix 3). As in 1978, maximum abundance of enchytraeids occurred during October (Fig. 18). During 1979, significantly higher numbers of enchytraeids were observed at both 12 and 15 m and during April when compared with 1978 (Table 6). While a *t* test could not be computed for July data, it was obvious that July 1979 samples had significantly more enchytraeids than were present during July 1978. No enchytraeid density difference between years was observed in October.

Both the inner and outer regions during 1979 had significantly greater numbers of enchytraeids present when compared with their respective regions during 1978 (Tables 7 and 8). Comparison of 1979 inner and outer enchytraeid mean density at 12 and 15 m indicated no significant density differences between regions (Table 9). A similar comparison of monthly densities over the combined depth range 12-15 m indicated that only during July were there significant inner/outer differences, with the outer region having significantly more enchytraeids than the inner region. The July enchytraeid density difference was most evident at 12 m with outer region organisms significantly more numerous than in the inner region (Table 10). Increasing or decreasing enchytraeid density trends from 1978 to 1979 tended to be similar or have broadly overlapping standard errors for all comparisons made, with the exception of the 12-m July comparison (Fig. 19).

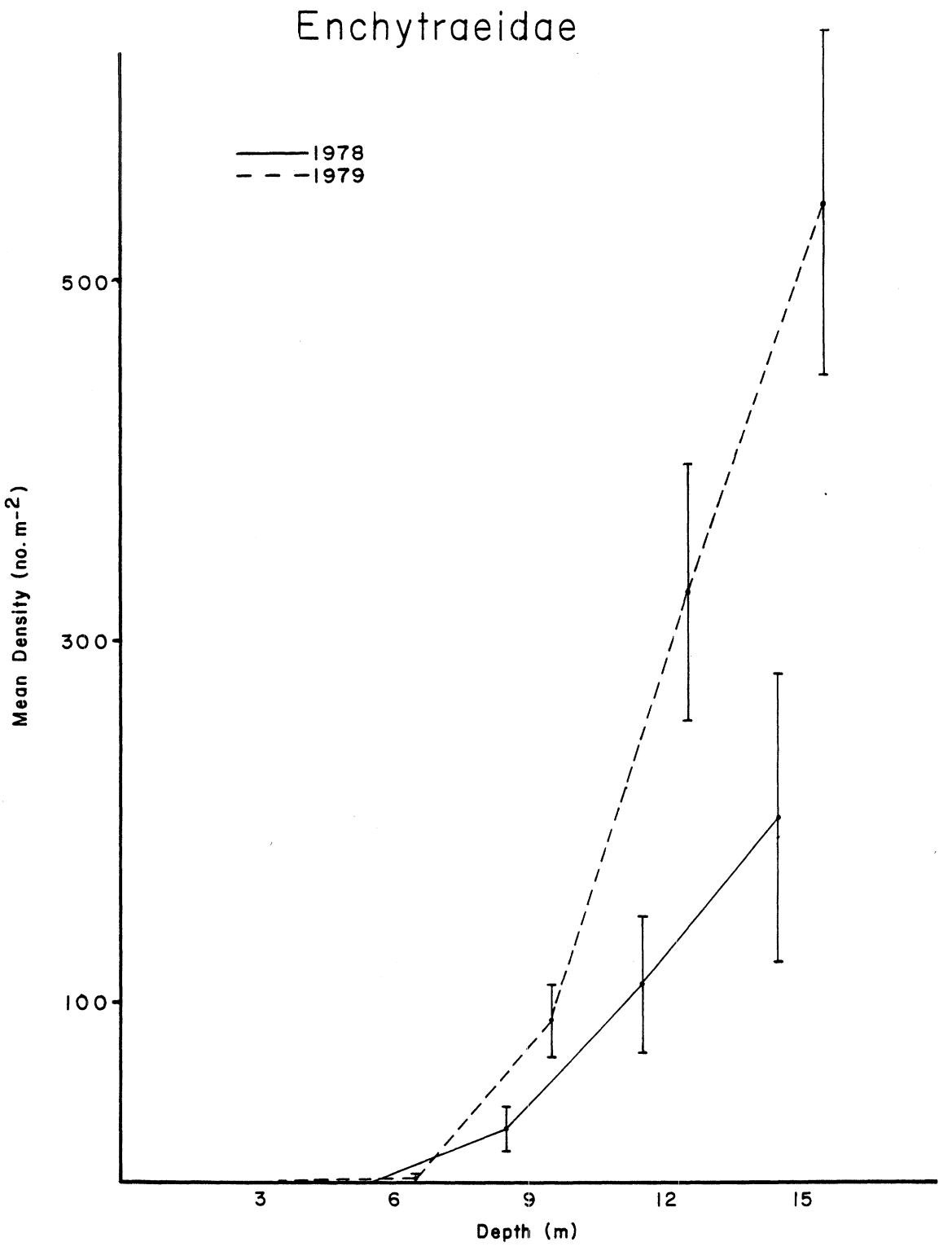


Fig. 17. Mean density (number m^{-2}) of enchytraeids collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

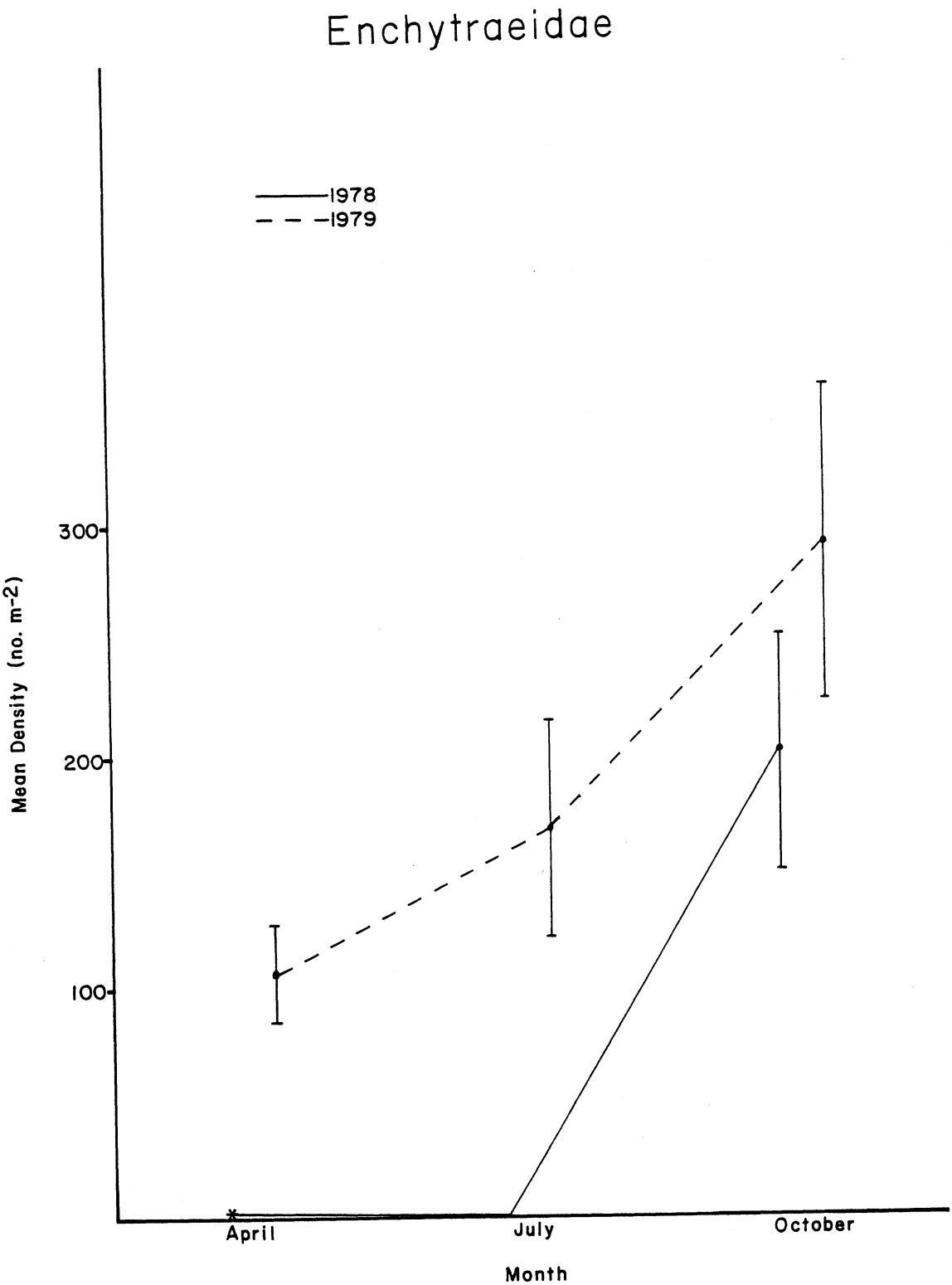


Fig. 18. Mean density (number m^{-2}) of enchytraeids collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

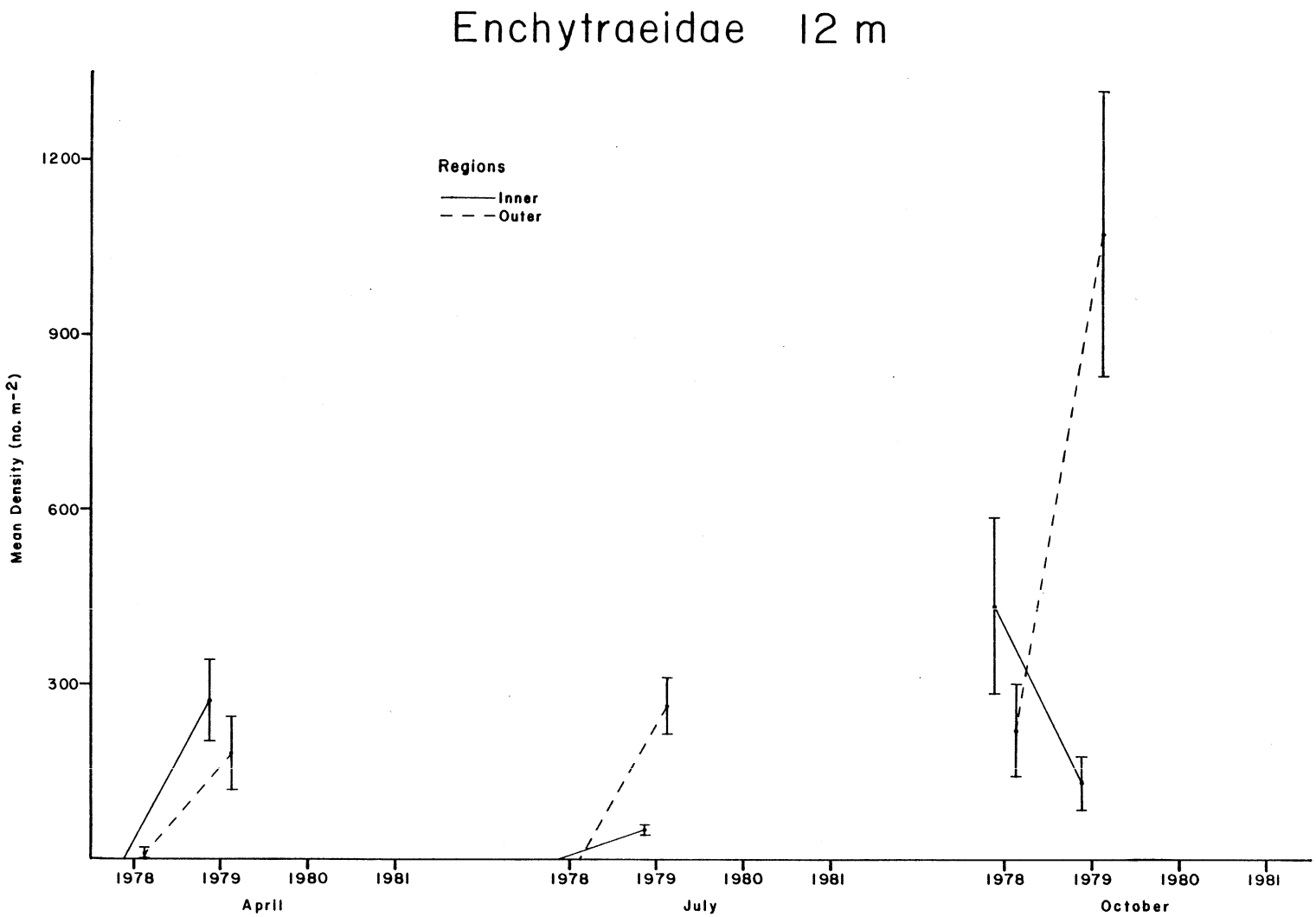


Fig. 19. Inner and outer regional mean densities (number m^{-2}) of enchytraeids collected in April, July and October 1978 and 1979 from eastern Lake Michigan at 12-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.

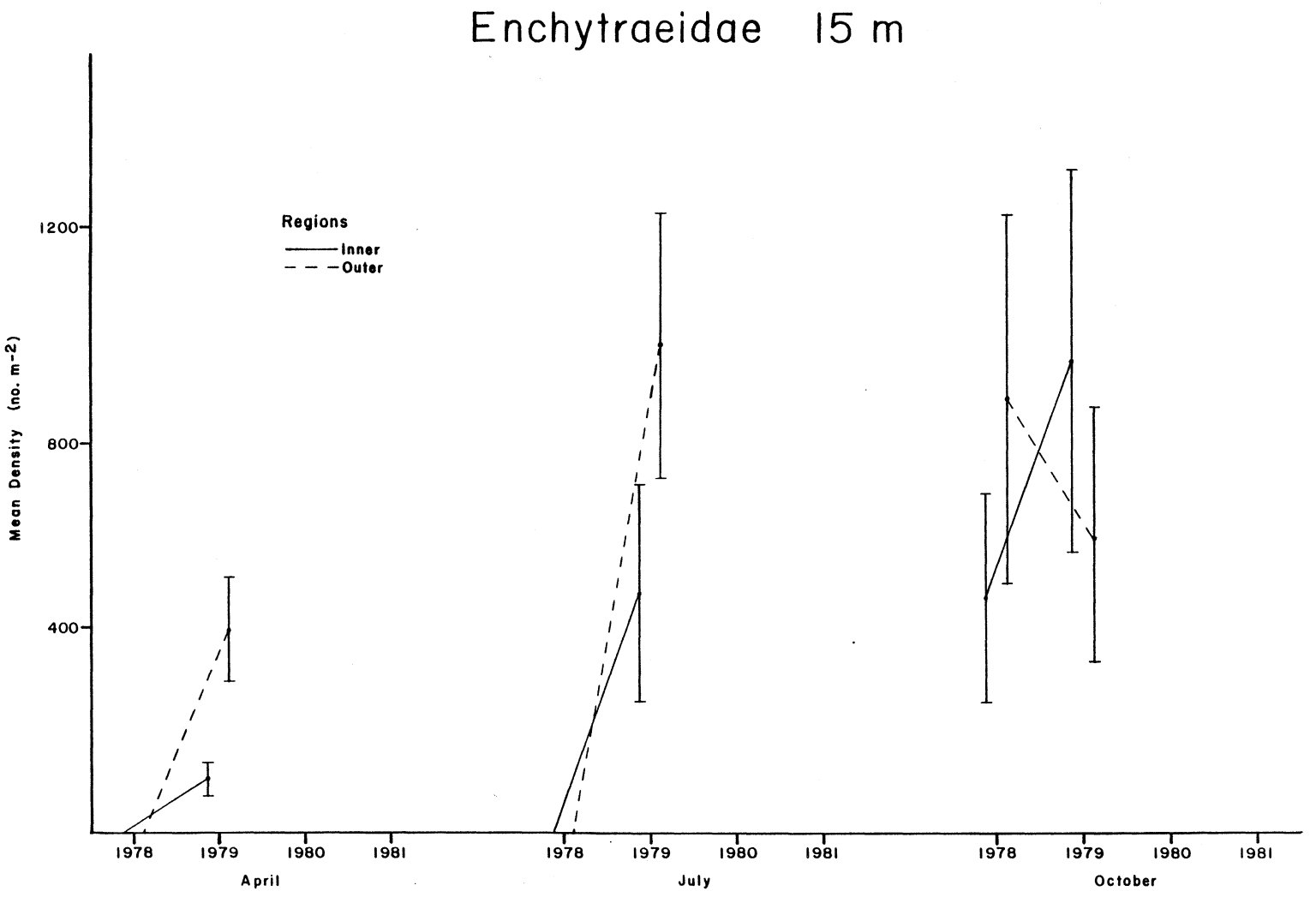


Fig. 19. Continued.

STYLODRILUS HERINGIANUS

Stylodrilus heringianus was found in 14% of the samples collected and comprised 1.2% of the macrobenthos during 1979 (Table 11). In 1978, S. heringianus was found at 9 and 12 m in very low densities, with the major occurrence during both years at 15 m (Fig. 20). In 1979, S. heringianus occurred only at 15 m (Appendix 3). Monthly distribution of S. heringianus in 1979 was very similar to that observed during 1978, with low densities in April increasing to a maximum in October (Fig. 21). Annual density comparisons for year, month, and depth (15 m) indicated there were no significant density differences even though there were fewer individuals collected during 1979. Most year, depth, and month comparisons for S. heringianus indicated there were few significant regional density differences (Tables 7-10), except during October when the 1978 inner region had significantly more S. heringianus than did the 1979 inner region. When comparing regions in 1979, it was noted that the inner region had significantly fewer S. heringianus when compared with the outer region, and that this difference was most pronounced during October at 15 m (Table 10, Fig. 22).

PISIDIUM

Pisidium comprised 6% of the benthic invertebrates collected during 1979 and occurred in 52% of the samples (Table 11). The pisidia were represented by 13 species in 1979, bringing the total number of Pisidium species identified from the survey area to 16 (Table 3). Based on annual mean density, Pisidium casertanum (130 m^{-2}), Pisidium fallax (89 m^{-2}), and Pisidium nitidum (80 m^{-2}) were the most abundant pisidia during 1979 (Appendix 4).

During 1978, Pisidium nitidum (83 m^{-2}), Pisidium casertamun (62 m^{-2}), and Pisidium fallax (28 m^{-2}) were the three most abundant pisidia based on annual

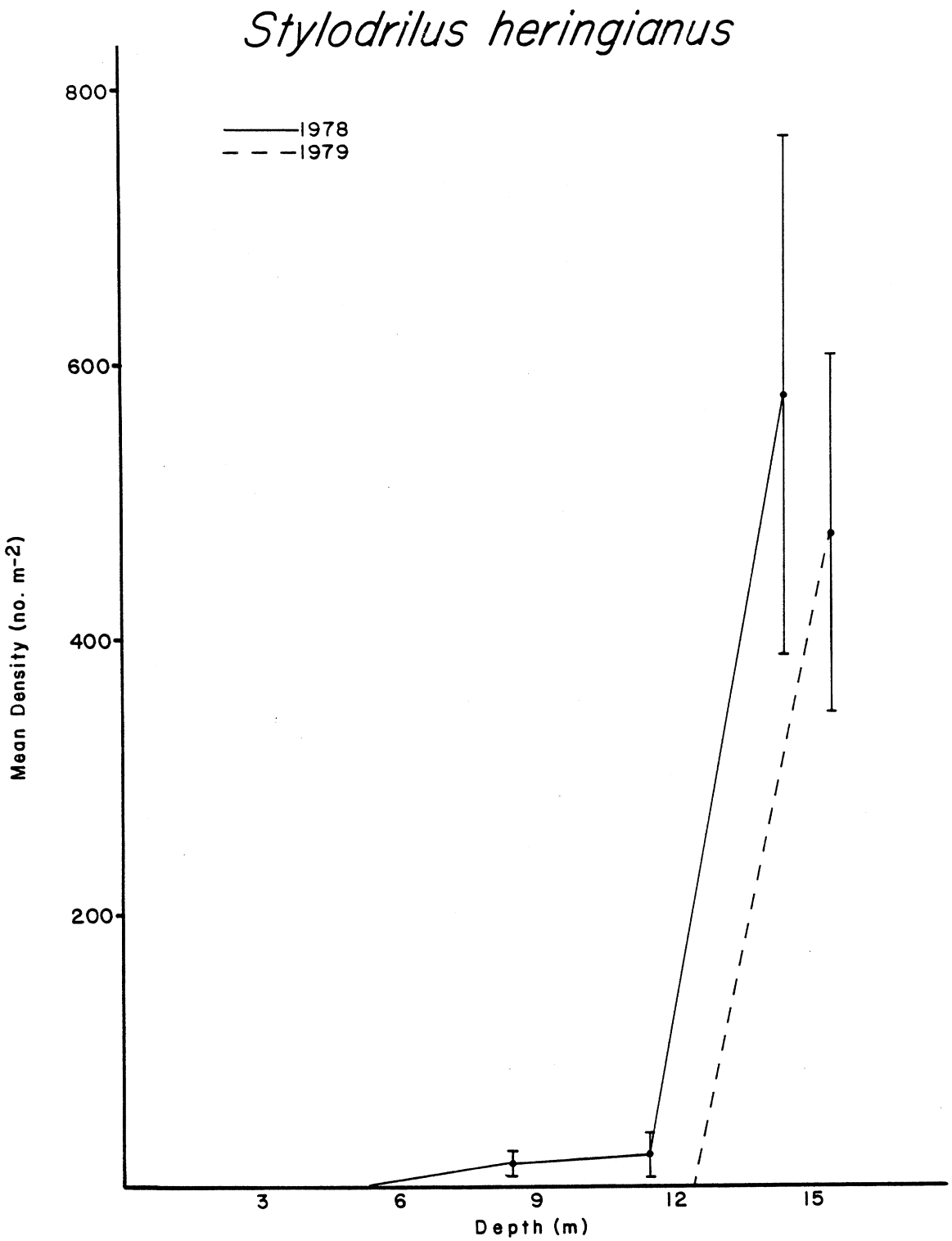


Fig. 20. Mean density (number m^{-2}) of S. heringianus collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

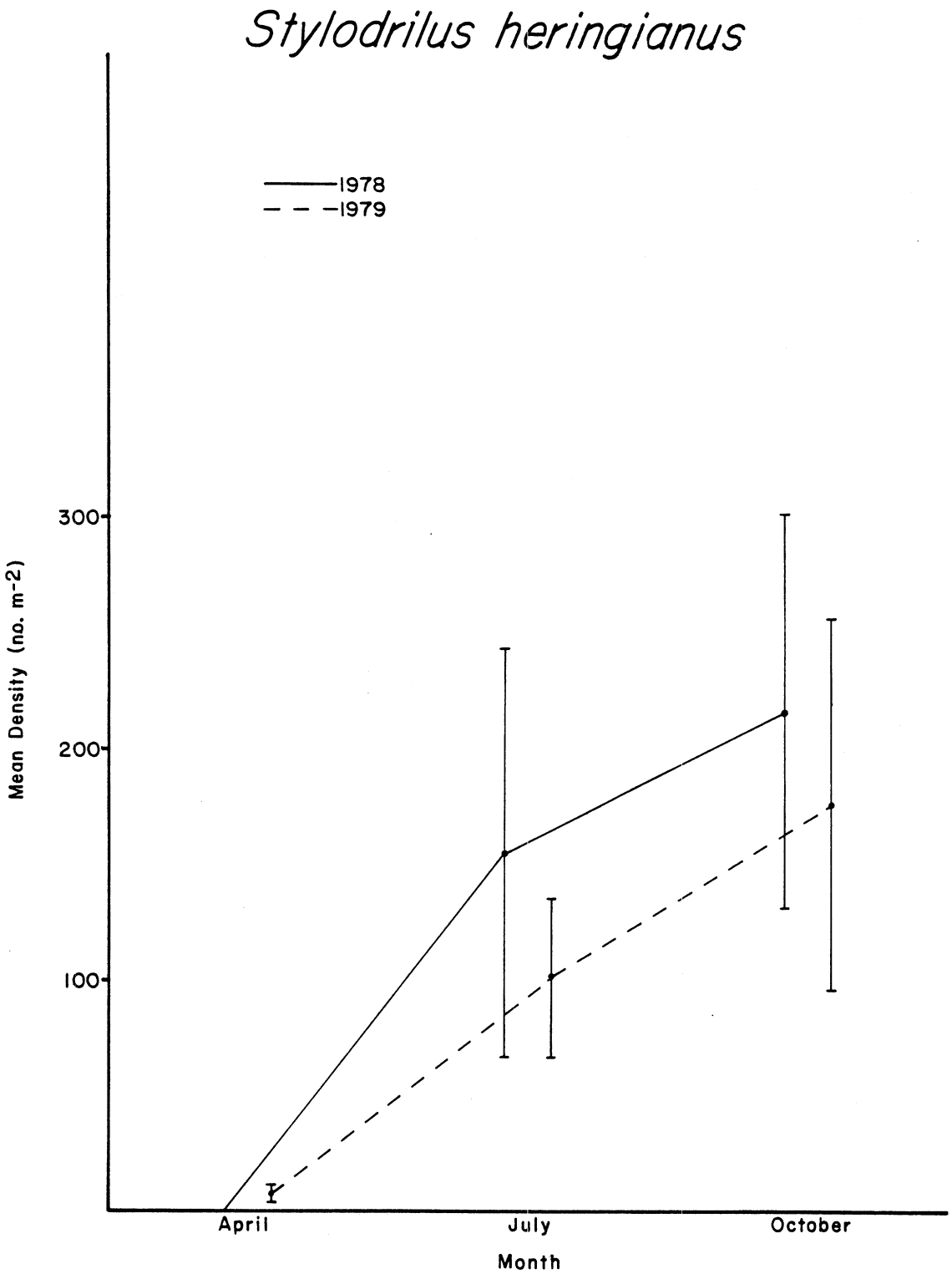


Fig. 21. Mean density (number m^{-2}) of S. heringianus collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

Stylodrilus heringianus

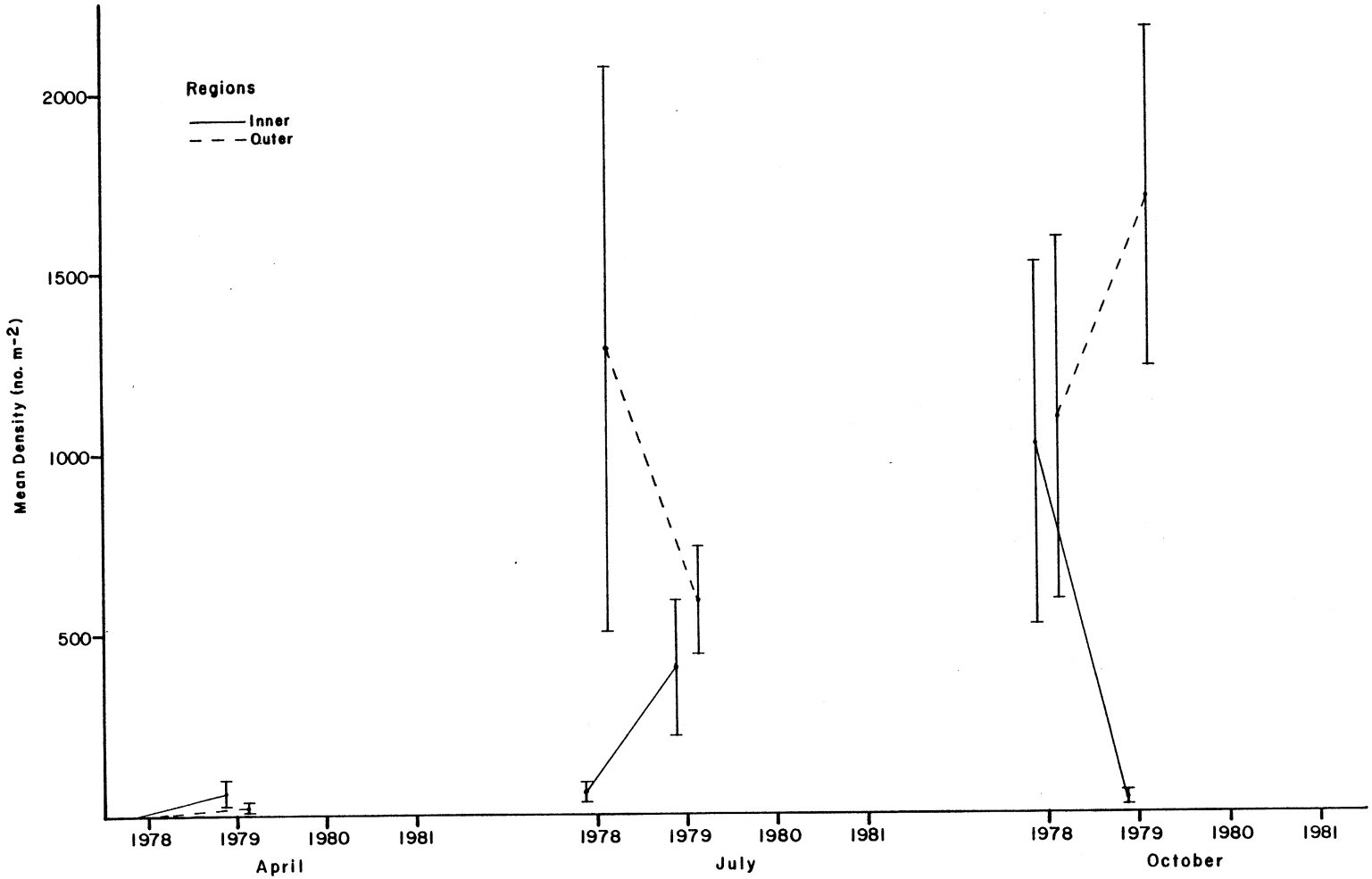


Fig. 22. Inner and outer regional mean densities (number m^{-2}) of S. heringianus collected in April, July and October 1978 and 1979 in eastern Lake Michigan at 15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.

mean density. While P. nitidum annual mean density (80 m^{-2}) was similar between years, the 1979 density of P. casertanum (130 m^{-2}) and P. fallax (89 m^{-2}) increased greatly. Comparison of percent composition of the three dominant Pisidium spp. between regions in 1978 indicated each region was composed of these three species in very similar proportions; P. nitidum (31-33%), P. casertanum (20-26%), and P. fallax (10-11%). In the 1979 inner region, the percentage of P. nitidum (10%) was reduced when compared with the 1979 outer region percentage (22%) and when compared with 1978 inner region percentage (33%). However, the 1979 regional difference in relative abundance of P. nitidum appeared to be related primarily to a large percent increase in P. nitidum during October in the outer region. Remaining monthly, inner, and outer regional percent comparisons of the three dominant Pisidium spp. were very similar within 1979. Overall, during 1979 the relative dominance of Pisidium casertanum and Pisidium fallax increased over 1978 levels while Pisidium nitidum decreased.

When annual mean density in 1979 (480 m^{-2}) was compared with that of 1978 (266 m^{-2}), there was no significant difference in the average number of Pisidium collected (Table 6). However, while the depth distribution pattern observed between years was similar for Pisidium, significantly more were collected at 9 m during 1978 than during 1979 with the opposite pattern observed at 12 m (Fig. 23). In addition, there was a significantly greater number of pisidia collected during October 1979 when compared with October 1978 (Fig. 24). Both regions had significantly more pisidia in 1979 when compared to 1978 at 12 m during October (Tables 7 and 8).

Inner and outer regional comparisons for Pisidium collected during 1979 indicated there were no inner/outer regional mean density differences within any month averaged over the depths 9-15 m combined, or within any depth

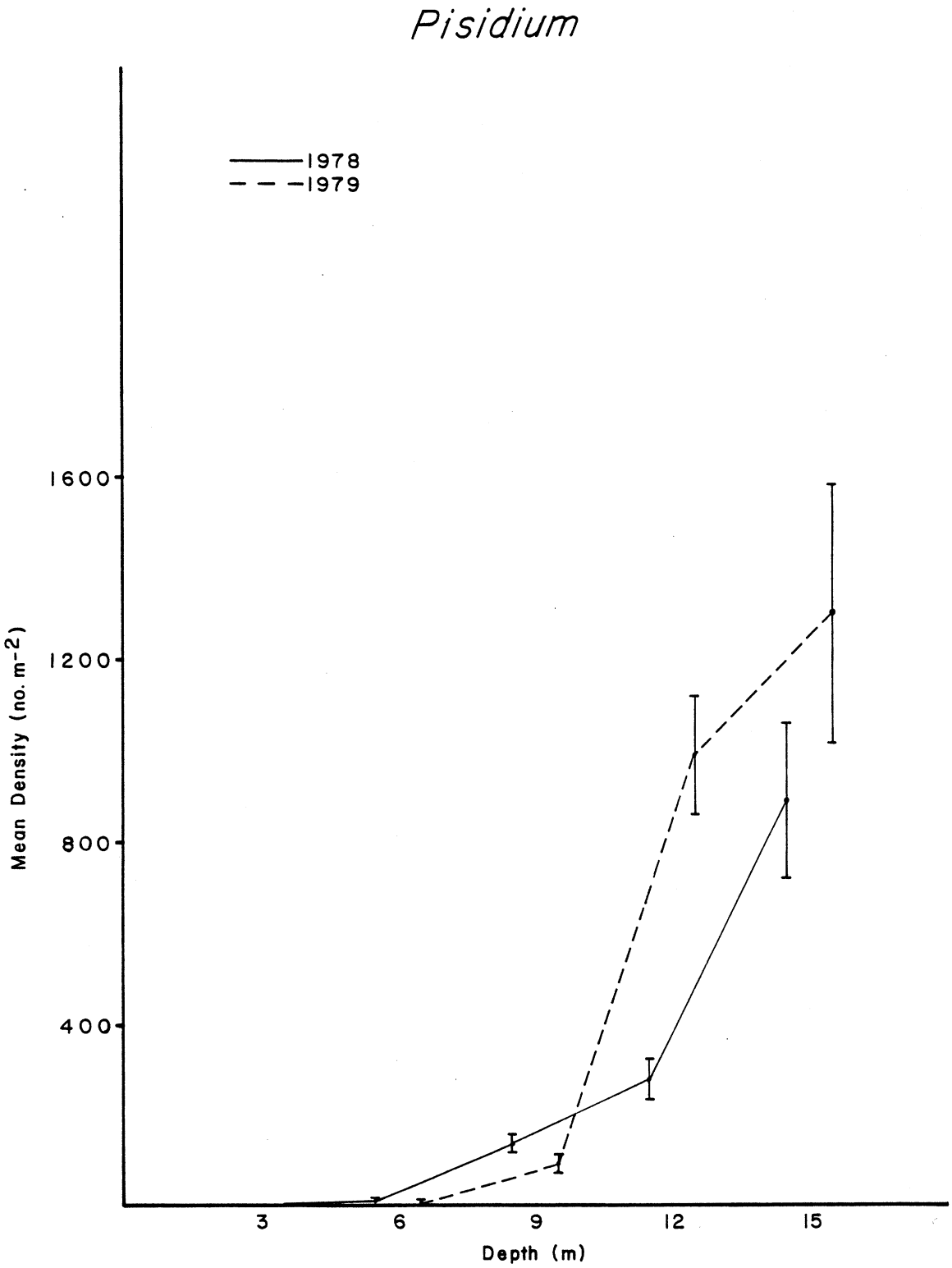


Fig. 23. Mean density (number m^{-2}) of Pisidium collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

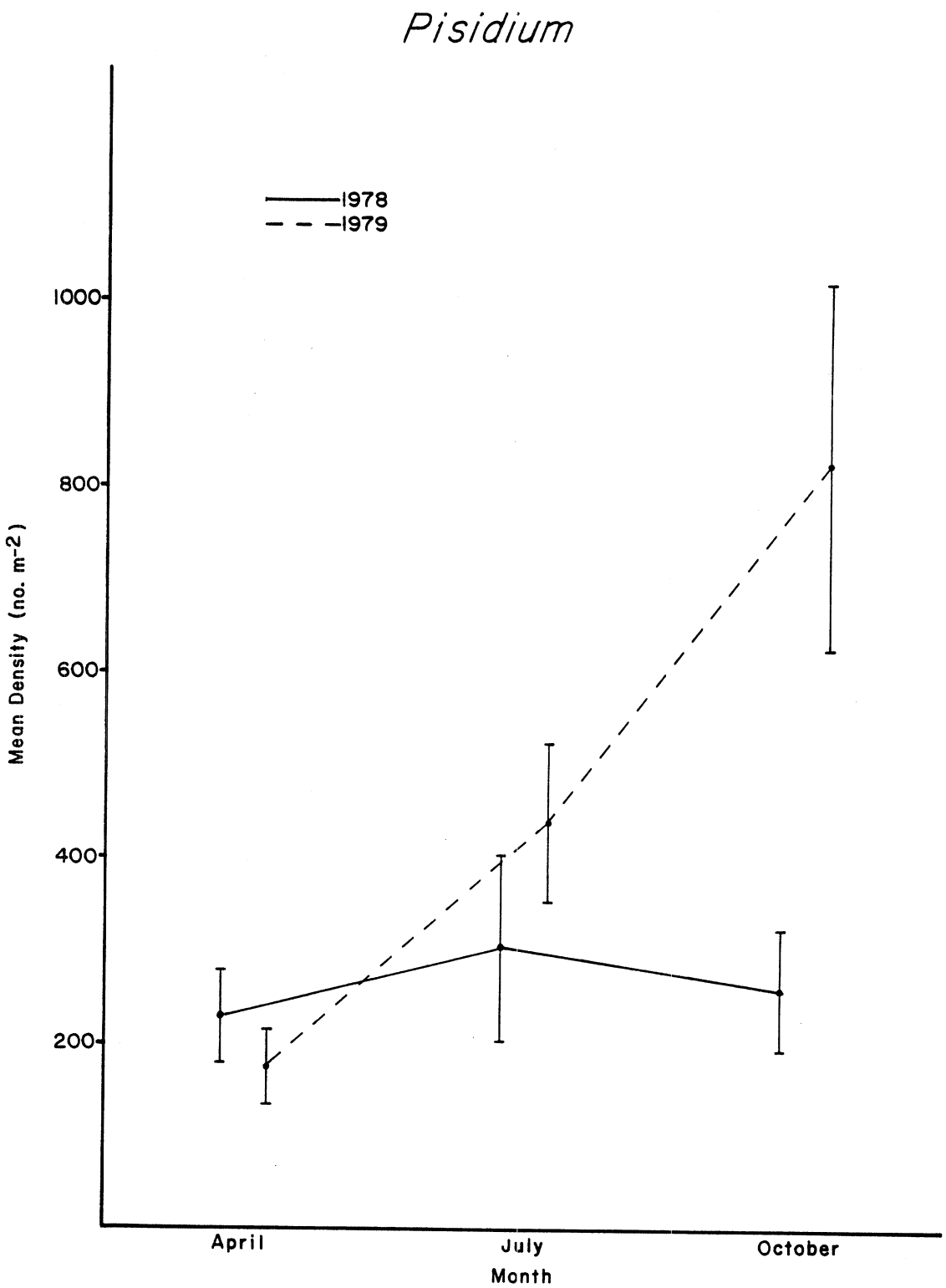


Fig. 24. Mean density (number m^{-2}) of Pisidium collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

averaged over all months (Tables 7 and 8). However, inner/outer regional comparisons made within each month and depth sampled indicated that, although both regional mean densities increased during October at 12 m, the inner region Pisidium density was significantly greater than that observed in the outer region; the opposite trend was noted at 15 m during October (Fig. 25, Table 10). Remaining inner/outer regional comparisons of Pisidium mean densities indicated similar density trends or widely overlapping standard errors.

SPHAERIUM

Sphaerium occurred in 6% of all samples collected in both 1978 and 1979 (Table 11). In addition, very low annual mean densities of Sphaerium were recorded (4-5 m^{-2}) during both years. A similar depth distribution pattern was observed in 1978 and 1979 (Fig. 26). Sphaerium striatinum exhibited highest abundance among Sphaerium in both years. Although Sphaerium transversum was not observed in the inner or outer region during 1978, it was collected in equal densities from both regions (1 m^{-2}) during 1979 and was the second-most numerous Sphaerium species (Appendix 4). Sphaerium nitidum annual mean density decreased during 1979 (0.3 m^{-2}) when compared with 1978 (1.3 m^{-2}). Since all three species occurred infrequently in the survey area, it was difficult to assess the significance of annual changes. Inner/outer regional comparisons were not made for Sphaerium.

GASTROPODA

Gastropods were found in 38% of the samples taken in 1979 (Table 11) which was similar to the frequency of occurrence noted for 1978 (32%). The benthos was comprised numerically of only 1.2% gastropods, with the majority of gastropods occurring from 12 to 15 m. Of the five species of gastropods

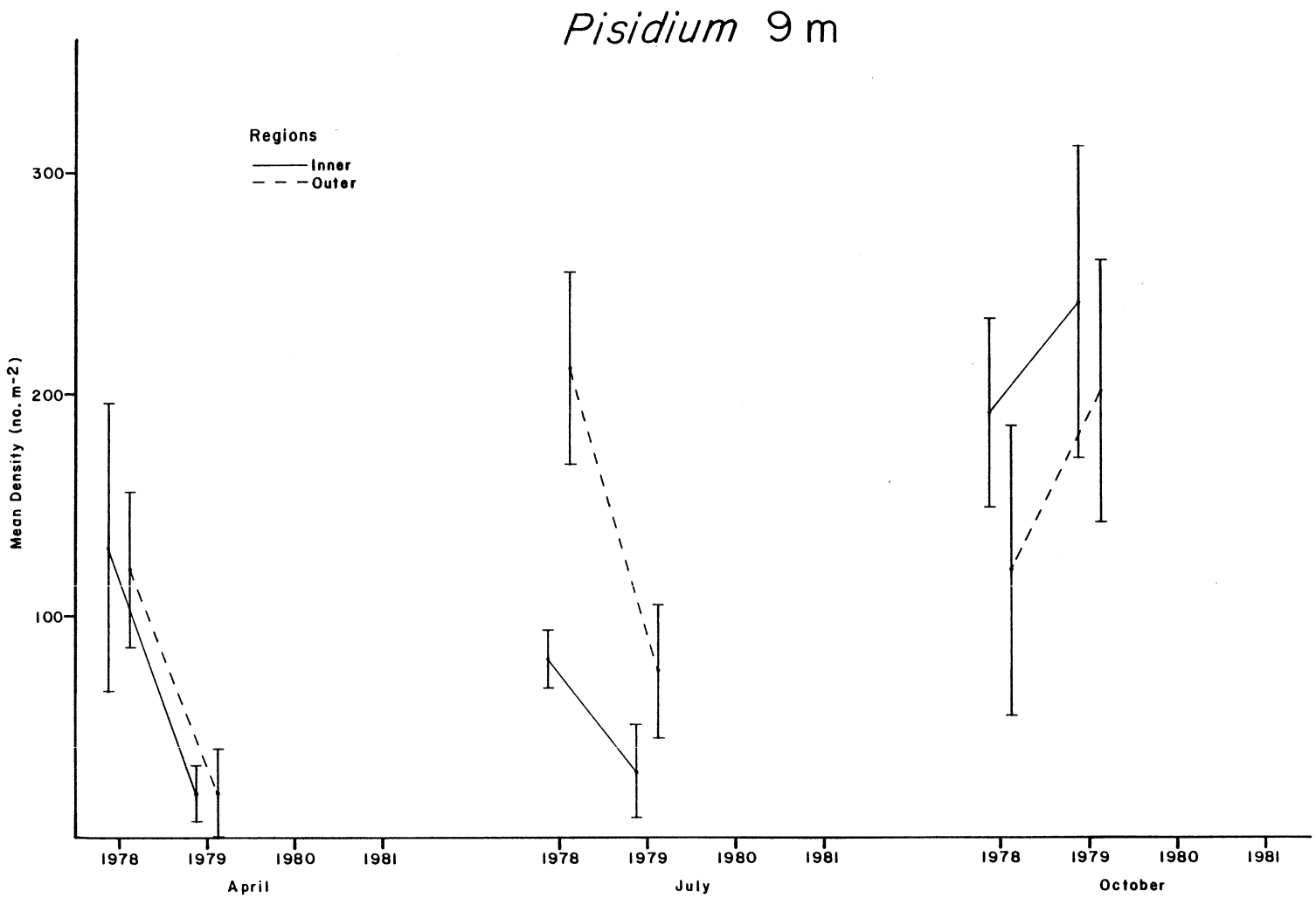
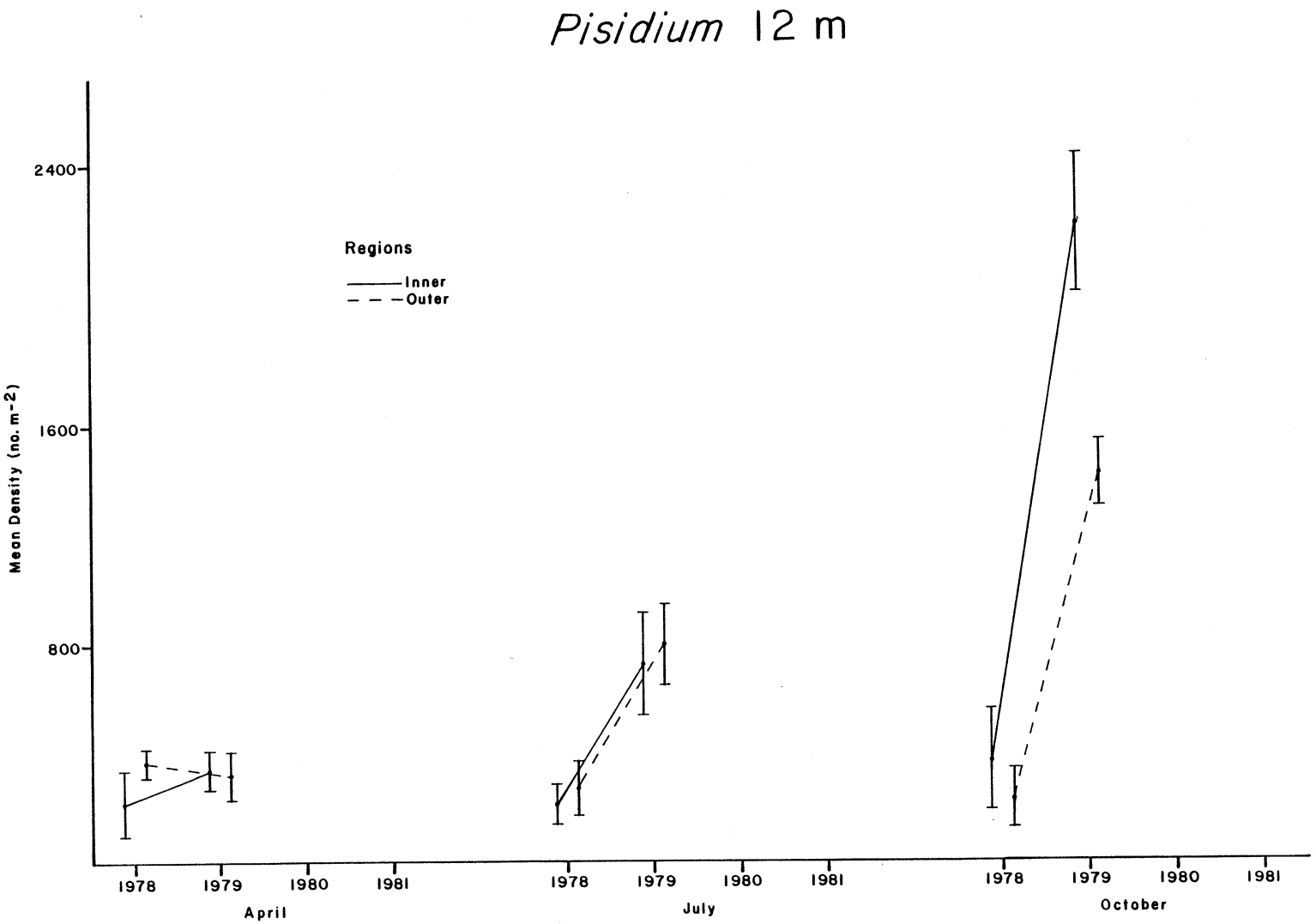


Fig. 25. Inner and outer regional mean densities (number m^{-2}) of Pisidium collected in April, July and October 1978 and 1979 from eastern Lake Michigan at 9-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.



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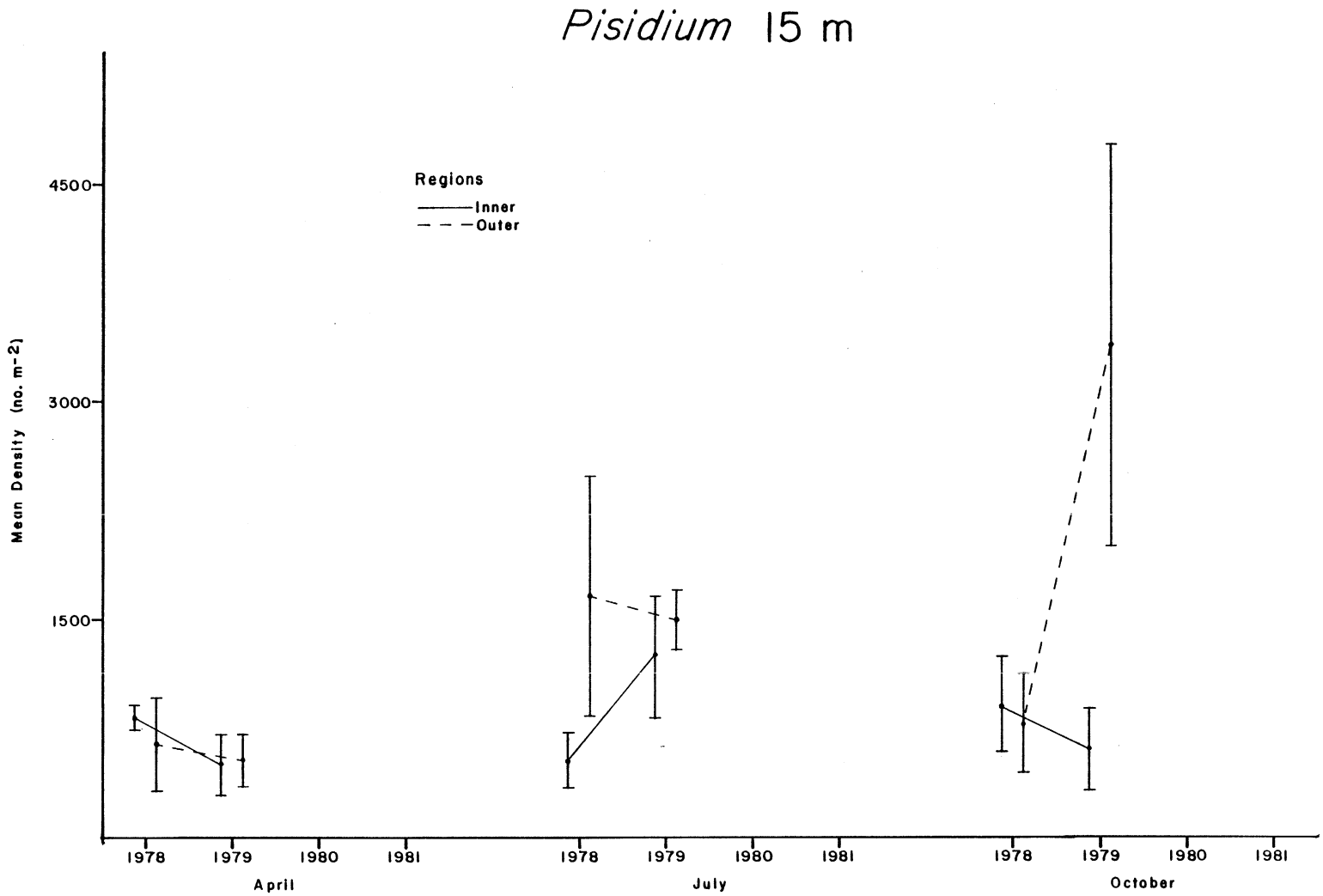

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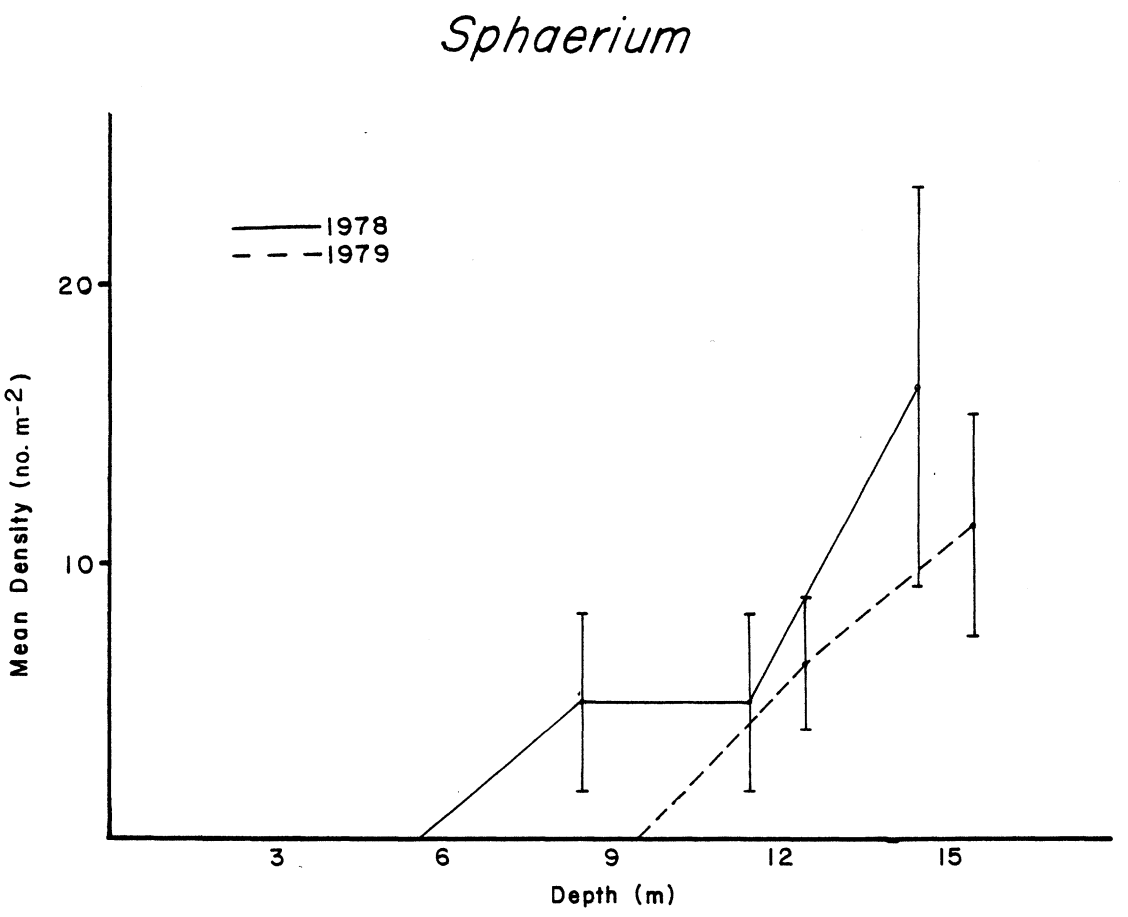

Fig. 26. Mean density (number m^{-2}) of Sphaerium collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

identified during 1979, only Somatogyrus sp. was not identified in 1978 (Table 3). However, the distinction between Somatogyrus sp. and small individuals of Amnicola sp. is difficult, subject to error, and was not made in 1978. Although each individual identified as Somatogyrus sp. definitely had a shell aperature greater than one-half the longitudinal length of shell height, distinction between Somatogyrus sp. and small individuals of Amnicola sp. still remains questionable.

Valvata sinera was the dominant snail found in 1978 (73%) and 1979 (57%) in both regions. The second-most numerous gastropod in 1978 was Amnicola sp., comprising 23% of the gastropod population over the year. However, from 1978 to 1979 there was a shift from Amnicola sp. (9%) to Lymnaea sp. (27%) as the second-most numerous snail (Appendix 4). Even if Somatogyrus sp. was added to Amnicola sp., Amnicola sp. would only comprise 12% of the snail population, or approximately one-half its relative composition in 1978. As in 1978, both regions had similar percent occurrences of the three most abundant gastropods.

Although there was no significant difference between annual mean densities of gastropods from 1978 (70 m^{-2}) to 1979 (94 m^{-2}), depth and month differences were observed (Table 6). Gastropods followed the same depth distribution pattern during both years, i.e., few snails at 3-6 m, some at 9 m, and the great majority of specimens at 12-15 m; there were significantly more at 12 m in 1979 than in 1978 (Fig. 27). During April 1979 there were significantly fewer gastropods than during April 1978. No difference was observed in gastropod numbers between years in July, but a significantly greater number of gastropods was collected in October 1979 when compared with October 1978 (Fig. 28).

Annual comparisons made between regions at 12-15-m depths combined indicated that when there were significant differences in either region, the

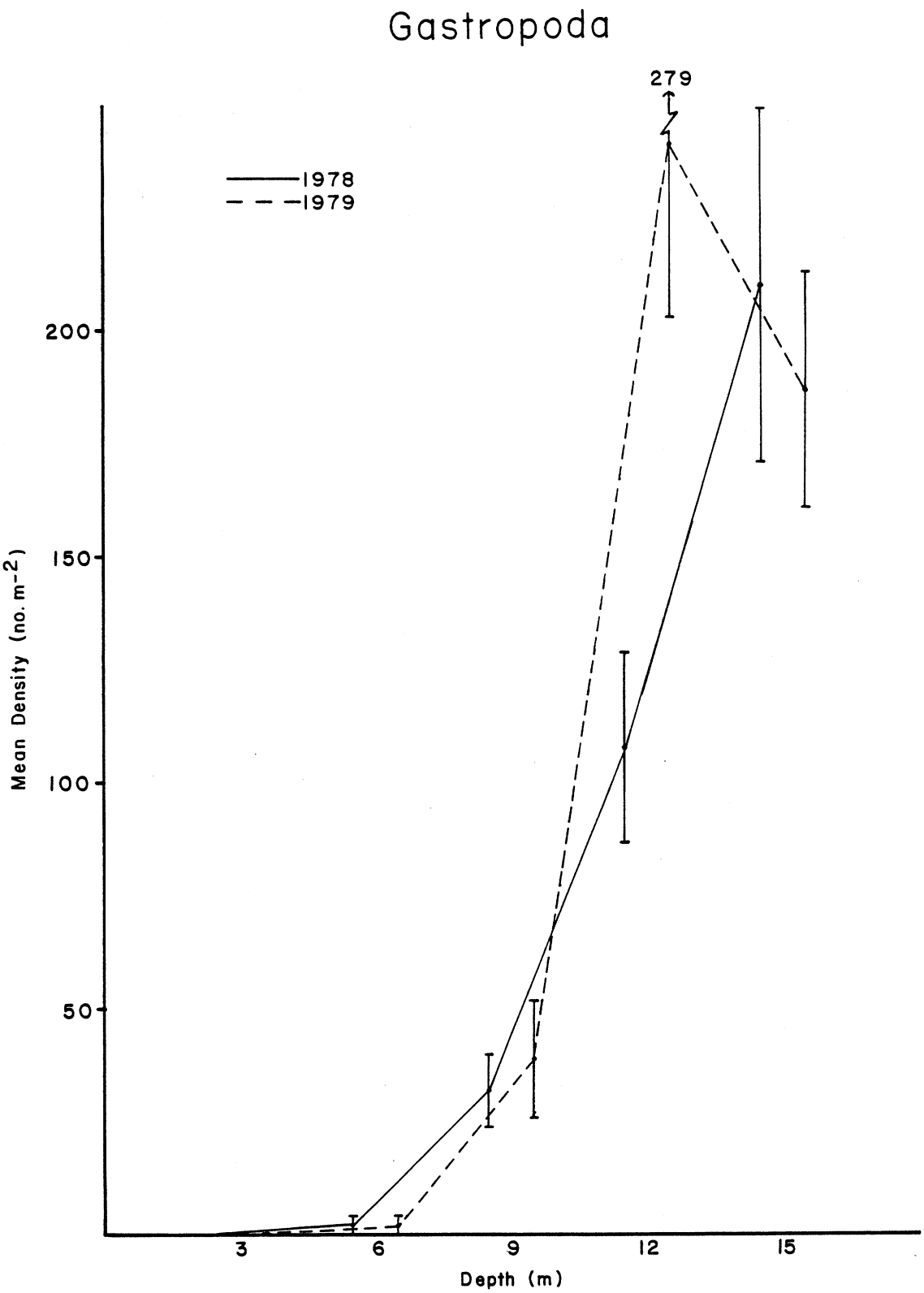

Fig. 27. Mean density (number m^{-2}) of gastropods collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

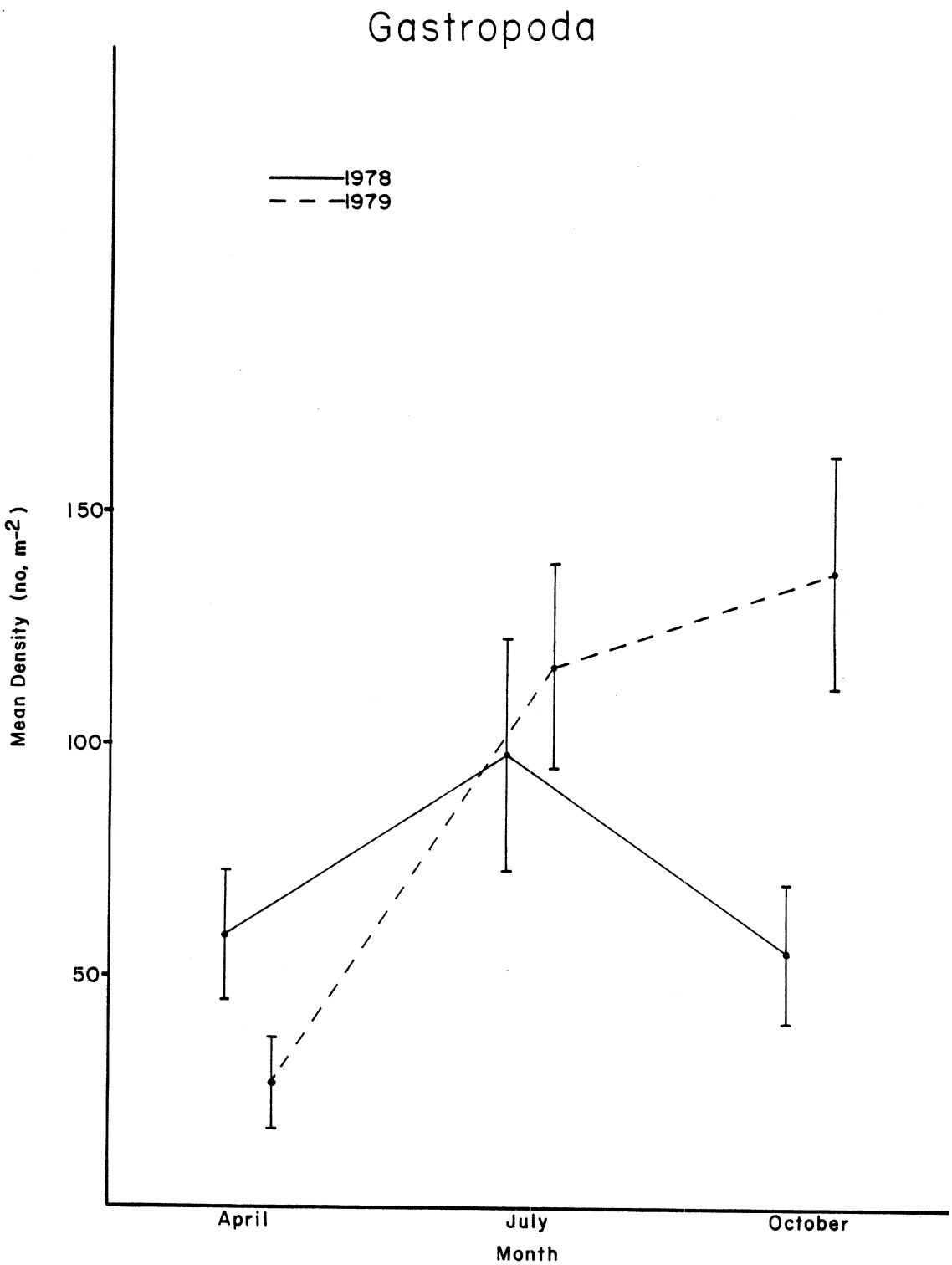

Fig. 28. Mean density (number m^{-2}) of gastropods collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

1979 density estimates were always the highest. Within the inner region there were no yearly mean difference or monthly mean difference, but there were significantly more gastropods at 12 m in 1979 than in 1978 (Table 8). In the outer region, while there were no yearly differences, July and October averaged over 12-15 m had a greater gastropod density in 1979 than during 1978 (Table 7). In addition, more snails were present in the outer region at 15 m in 1979 than in 1978. However, within the year 1979, comparisons between inner and outer regions for year, month, and depth showed no apparent differences (Table 9). All inner/outer regional density estimates had the same increasing or decreasing density trends from 1978 to 1979 except at 15 m during October (Fig. 29).

PONTOPOREIA HOYI

Pontoporeia hoyi was more prevalent in 1979 samples (79%) (Table 11) than in 1978 samples (62%) and comprised a greater percentage of the benthic population in the survey area in 1979 compared with 1978 (36% and 25%, respectively). Annual mean density for *P. hoyi* during 1978 was 1602 m^{-2}, while the 1979 estimate was 2883 m^{-2}, an 80% increase from 1978 to 1979 (Appendix 1). The difference between years for *P. hoyi* density was highly significant ($p \leq .001$) (Table 6). Although within each region the total number of animals collected increased 22%, the inner region *P. hoyi* abundance increased 58% while outer region *P. hoyi* density increased 110% from 1978 to 1979.

Although having similar depth and monthly distribution patterns in 1978 and 1979 (Figs. 30 and 31), *P. hoyi* densities were significantly greater at 9 and 15 m averaged over the year and during October averaged over all depths when compared with 1978 densities (Table 6). Differences in yearly *P. hoyi* densities were less apparent in the inner 1978 to 1979 regional comparisons

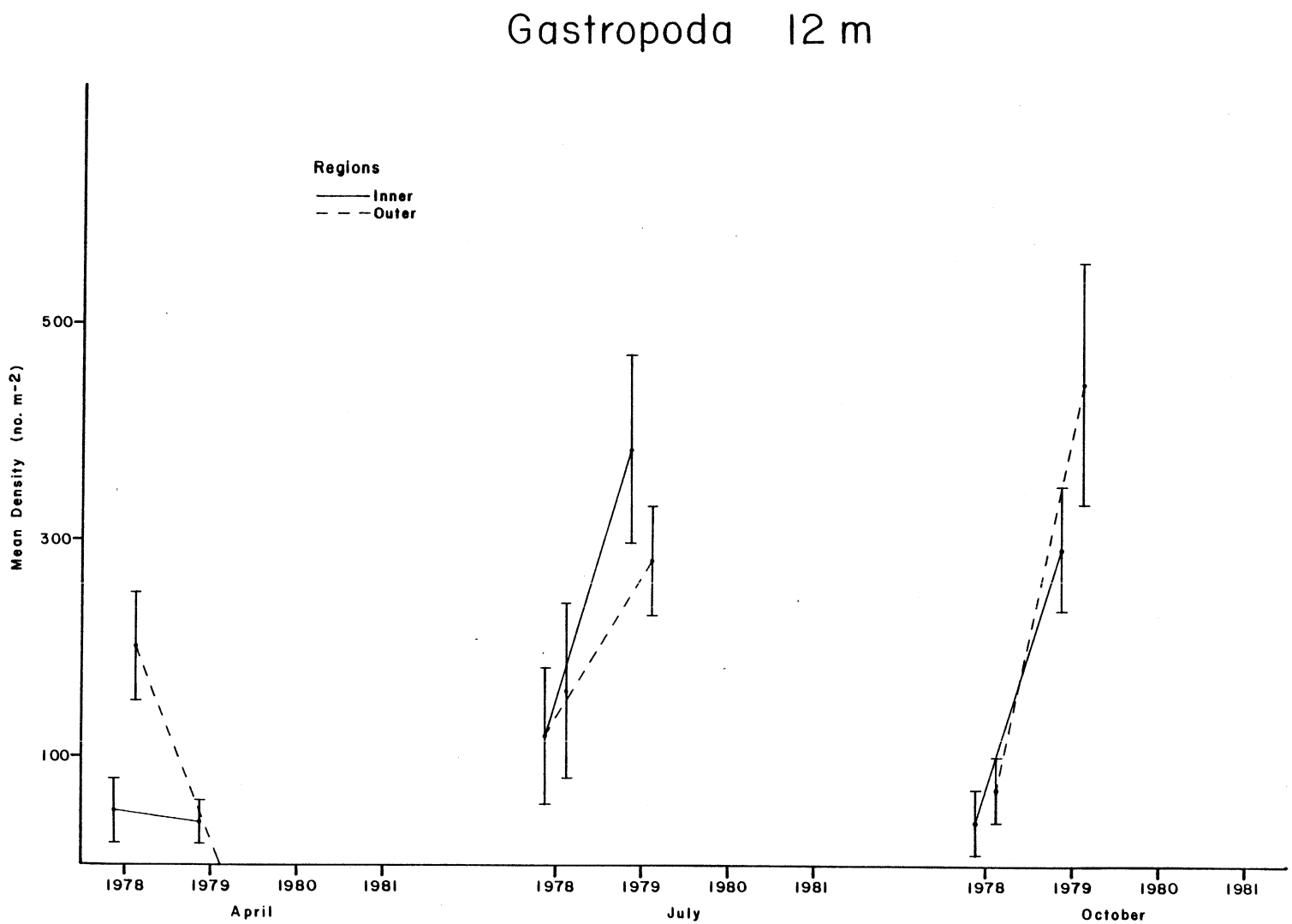

Fig. 29. Inner and outer regional mean densities (number m^{-2}) of gastropods collected in April, July and October 1978 and 1979 from eastern Lake Michigan at 12-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.

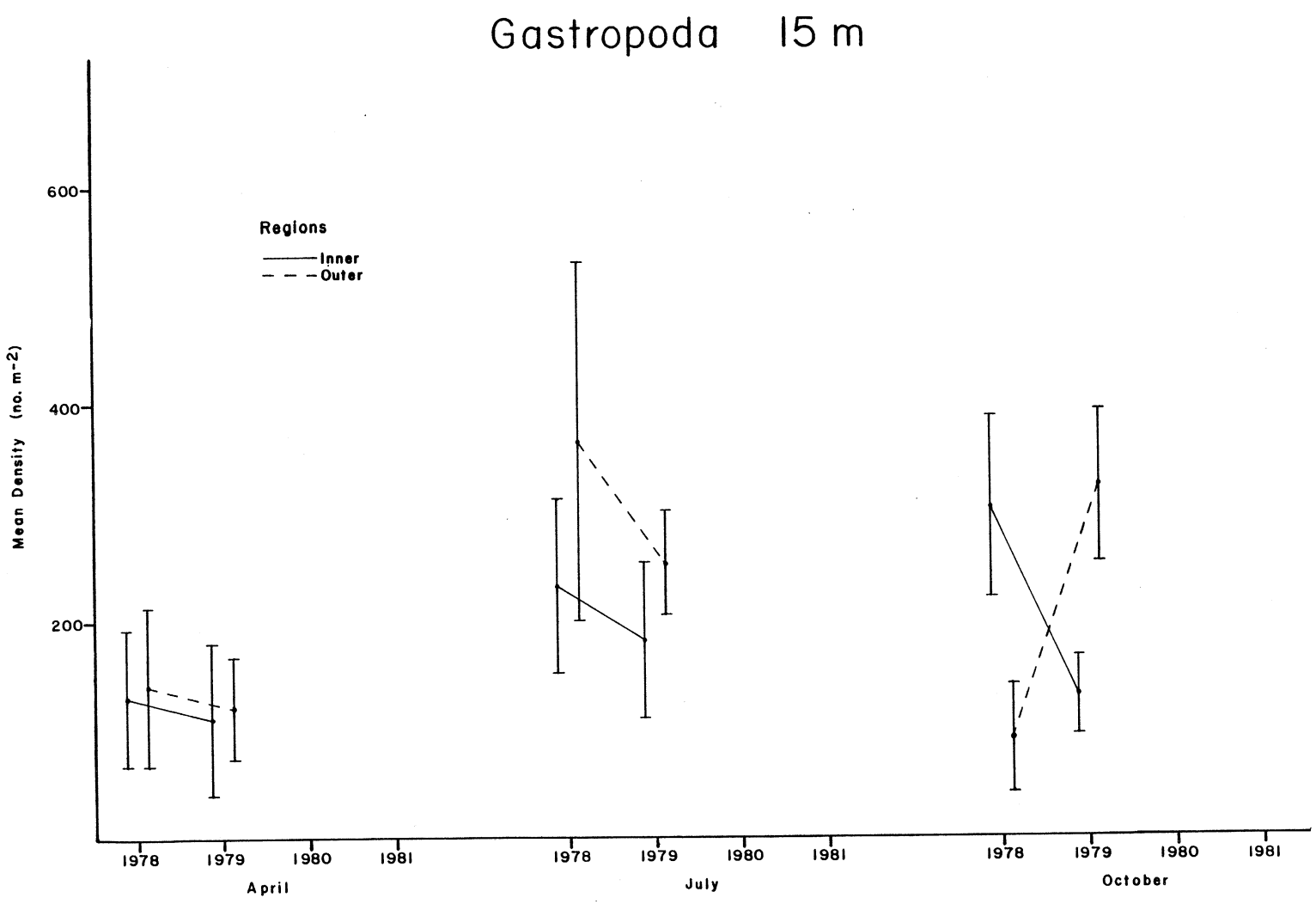

Fig. 29. Continued.

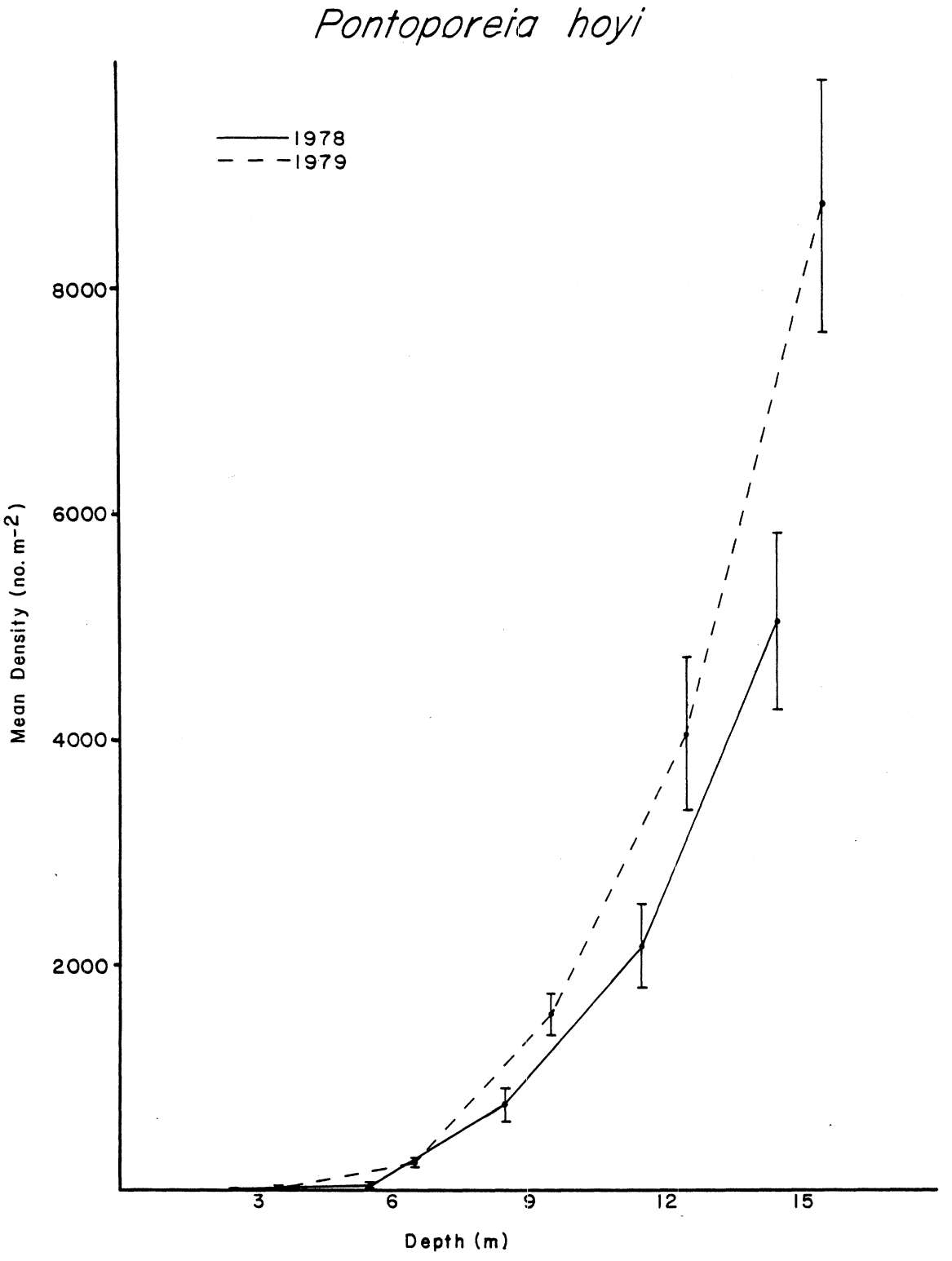

Fig. 30. Mean density (number m^{-2}) of P. hoyi collected at 3-15 m during 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates at each depth were computed by averaging over all months within each year (n = 36). Standard error denoted by vertical bar.

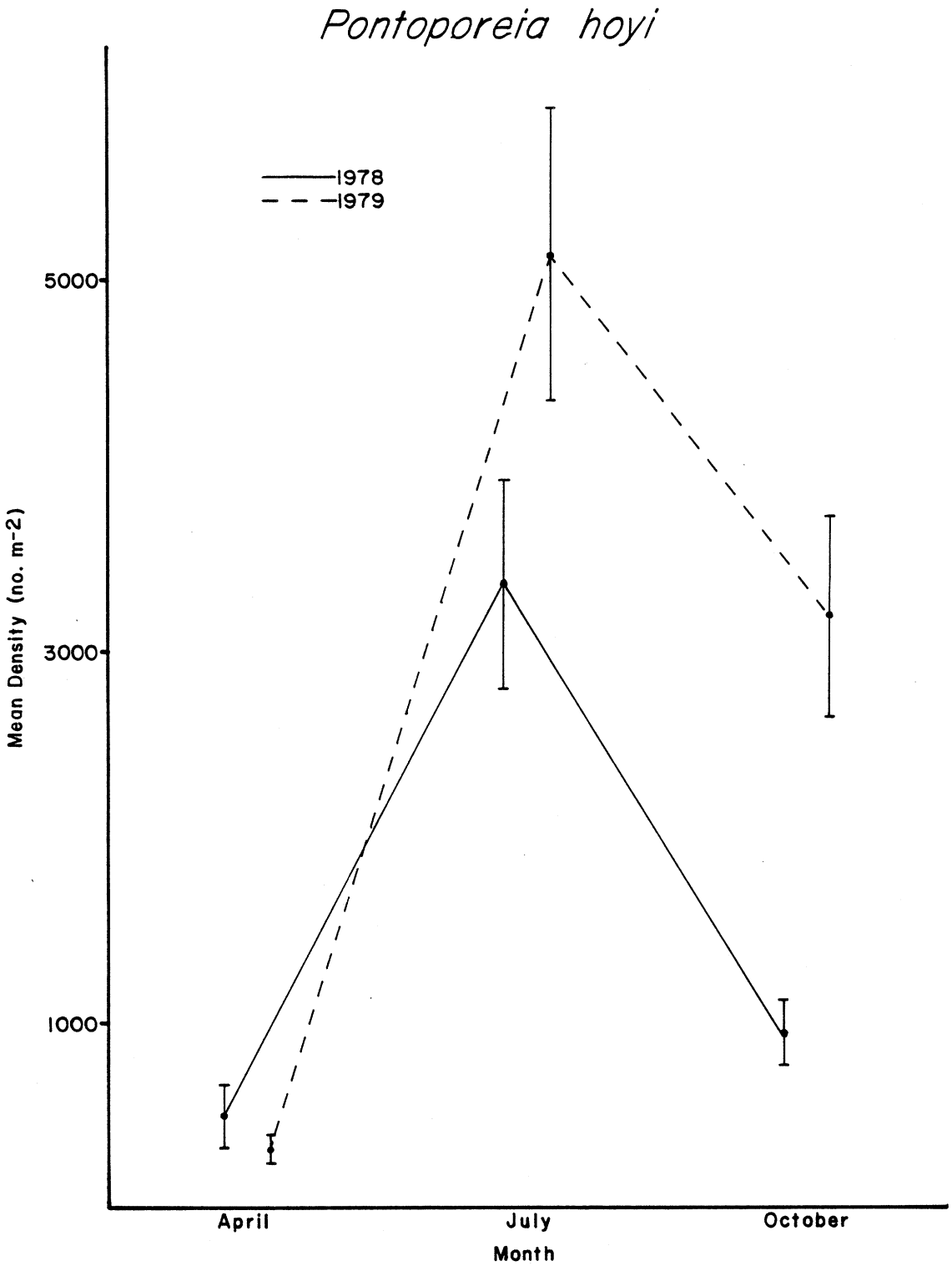

Fig. 31. Mean density (number m^{-2}) of P. hoyi collected during April, July and October 1978 and 1979 in eastern Lake Michigan near the J. H. Campbell Plant. Density estimates for each month were computed by averaging over all depths within each year (n = 60). Standard error denoted by vertical bar.

than in outer 1978 to 1979 regional comparisons when averaged over months, combined depths 9-15 m, or both (Tables 7 and 8). In fact, only the outer region showed an overall significant increase in P. hoyi density between years, which was most evident in April and October. While yearly within-region changes were extensive, 1979 regional comparisons of P. hoyi mean density for months, depths, and regions indicated there were no significant regional differences in 1979 (Table 9). However, analysis of each month and depth sampled in 1979 indicated that at 12 and 15 m during July 1979 P. hoyi mean density was significantly greater in the inner region when compared with the outer region (Table 10). While the outer region generally had a greater abundance of P. hoyi in 1979, only at 15 m in October did the outer region density significantly exceed inner region density (Table 10, Fig. 32).

Analysis of P. hoyi size classes in 1978 indicated a large percentage of P. hoyi in the inner region was one size class larger than in the outer region (Fig. 33). This trend was particularly evident during April at 9-15 m and in July at 9-12 m, but not at these depths in October 1978.

Analysis of P. hoyi size classes in 1979 suggested a pattern similar to but not exactly like that observed during 1978. During April 1979, P. hoyi individuals in the outer region at 9-15 m were primarily gravid having not released their brood as of 19 April. While this same condition prevailed at 12 and 15 m in the inner as well as the outer region, individuals collected at 9 m in the inner region were either spent females (i.e., having already released their young) or young, recently released P. hoyi (< 3 mm).

Subsequent collections made in July further suggested that there was an inner/outer P. hoyi size-class difference, not only at 9 m but at 12 and 15 m also. However, the percent composition differences for a given size class were not as extreme as those observed during April at 9 m. It was also noted at

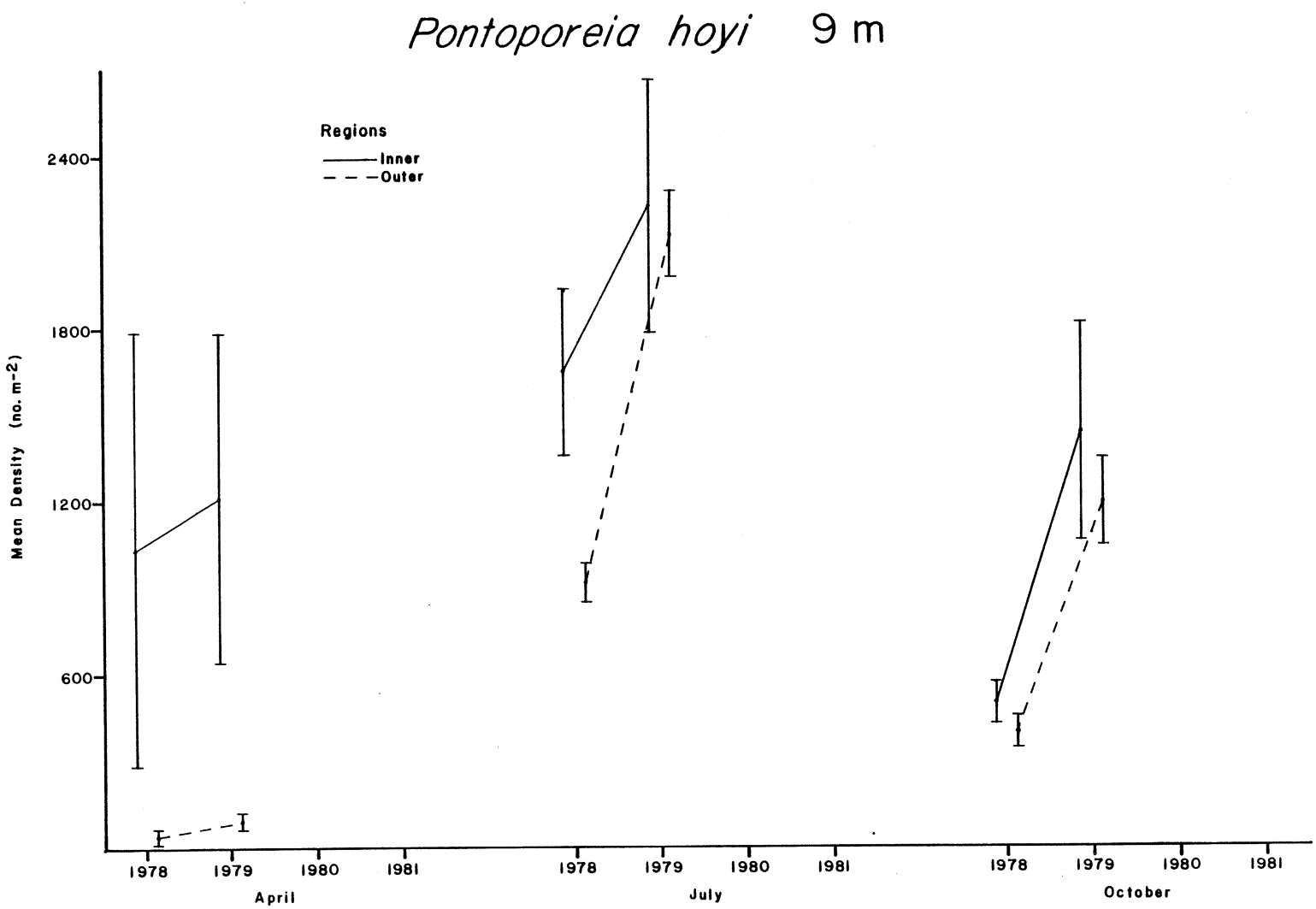

Fig. 32. Inner and outer regional mean densities (number m^{-2}) of P. hoyi collected in April, July and October 1978 and 1979 from eastern Lake Michigan at 9-15 m near the J. H. Campbell Plant. Standard error denoted by vertical bar (n = 6). Inner region corresponds to treatment area near present thermal discharge. Outer region corresponds to reference area. Density estimates for 1980 and 1981 will be added concurrently to figure as data become available.

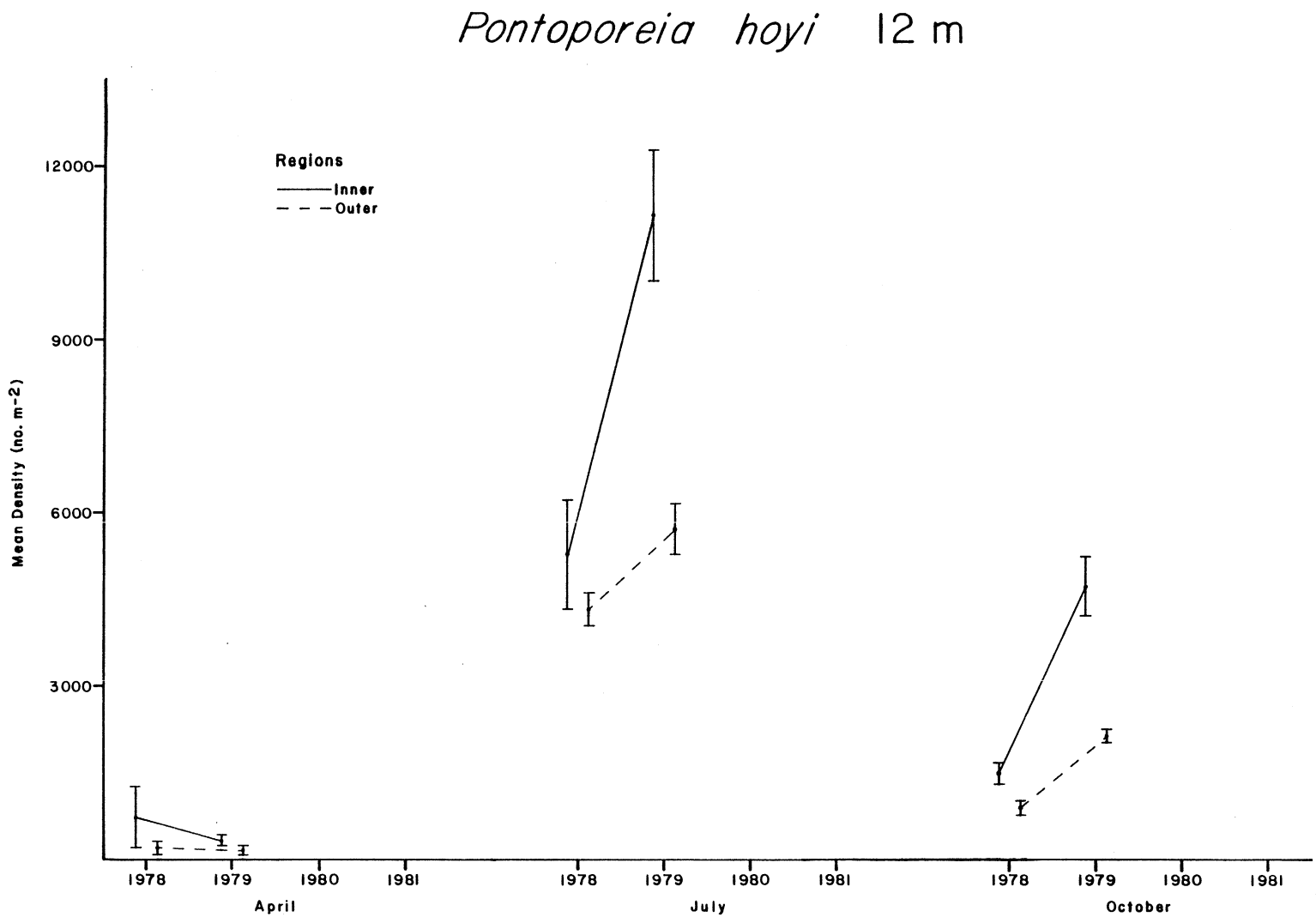

Fig. 32. Continued.

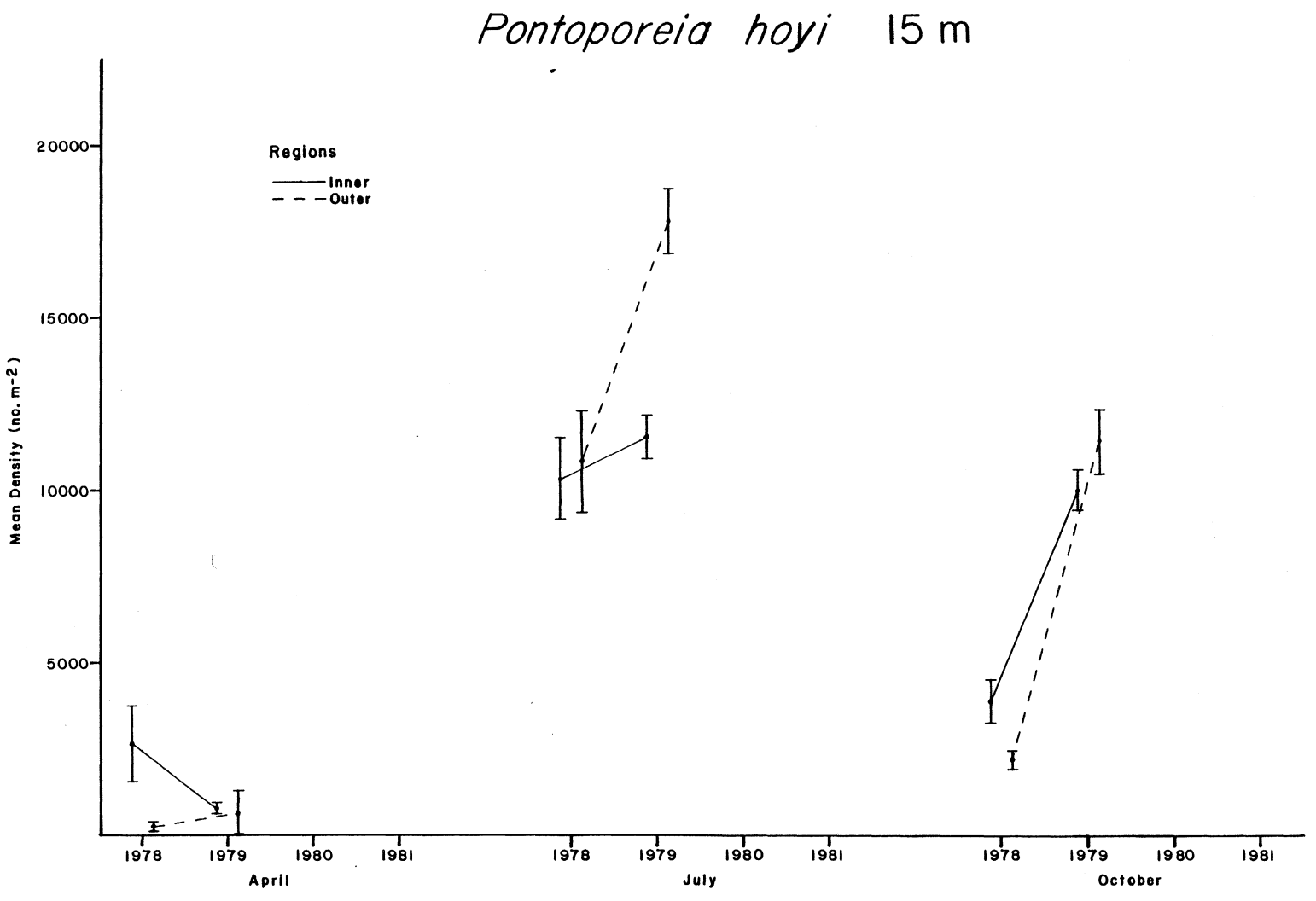

Fig. 32. Continued.

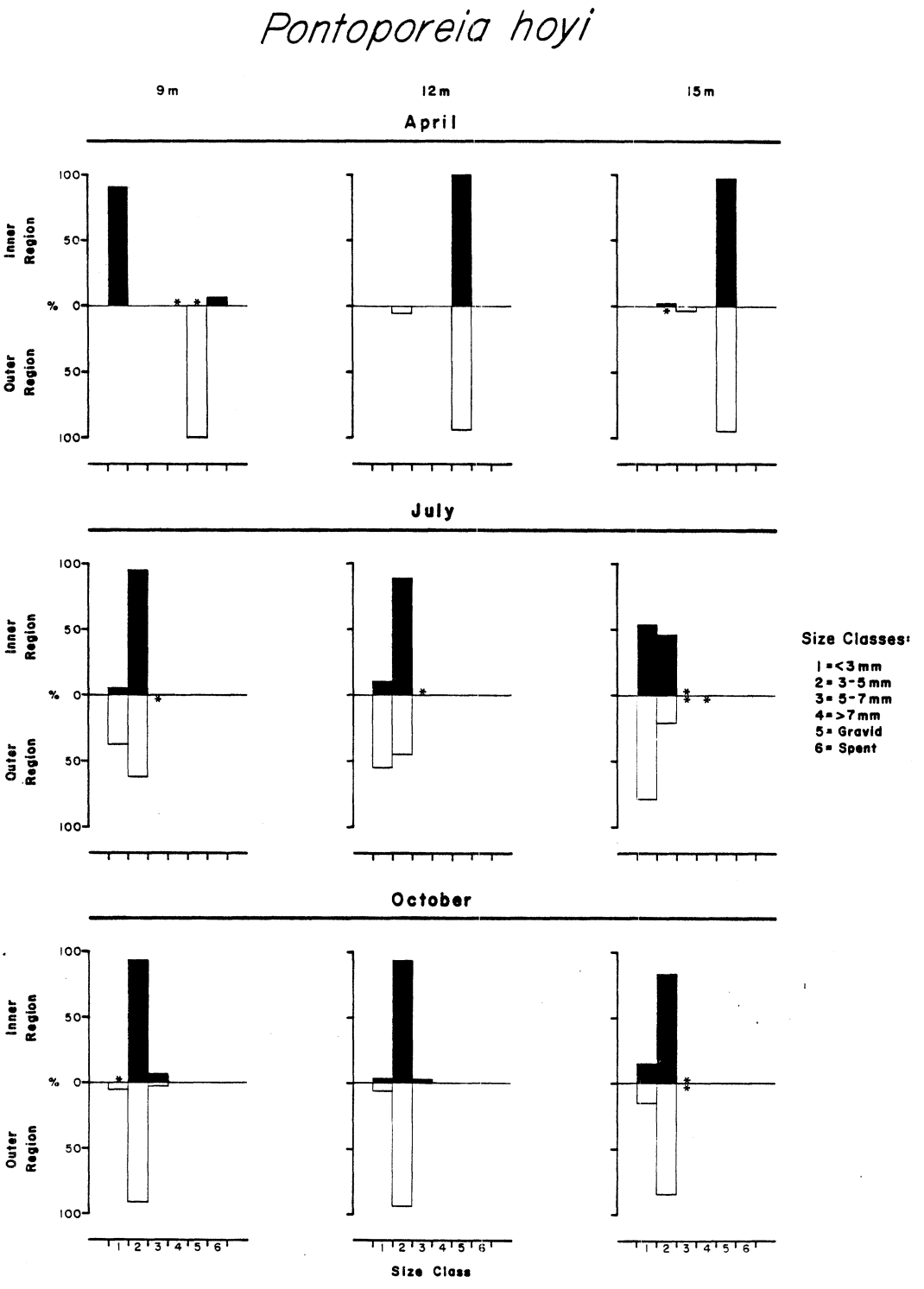

Fig. 33. Percent distribution of P. hoyi size classes in the inner and outer regions at 9-15 m during April, July and October 1979. Samples were collected from eastern Lake Michigan near the J. H. Campbell Plant. (* = <2%).

9-15 m in 1979 that P. hoyi individuals were more advanced in their life cycle in the shallower depths when compared with those from deeper water in the inner region during April, in both regions during July, and only very slightly in both regions during October. A similar pattern was observed during 1978 for both regions in April and July, but not October. Finally, in 1979 as well as in 1978, P. hoyi size classes were nearly identical between regions during October at 9-15 m.

It appeared that growth and development of P. hoyi occurring in both regions at 9-15 m on 19 April 1979 were reduced relative to 18 April 1978. By 18 April 1978, the majority of P. hoyi individuals were either spent females or newly released young. However, on 19 April 1979 when compared with 18 April 1978, there were more gravid specimens, fewer spent ones and fewer newly released individuals in samples.

SEDIMENT DISTRIBUTION

The general sediment distribution pattern near the Campbell Plant during 1979 was similar to that observed during 1978. Sediments collected during both years were described as well to moderately sorted, fine sand. Depth zonation of sediment types (i.e., grain size as measured by weight percent distribution among phi size classes) was evident. The 3-m zone was characterized by medium and fine sands, 6 m by coarse to fine sands, 9 m by fine sand, 12 m by fine to very fine sands, and 15 m by medium to very fine sands. Composition of sediments from the 6- and 9-m depths during 1979 deviated distinctly from those same depths sampled in 1978. In 1979, 6-m sediments tended toward a finer type than observed in 1978. The 1979 9-m depth had only small amounts of very fine sand and large amounts of fine sand and was consequently slightly coarser than was found in 1978 (Table 12).

TABLE 12. Average percent composition of sediments distributed among sediment grain sizes, average mean grain size and average standard deviation of mean grain size (n = 6) for sediments collected in 1979 at 3-15 m in the inner (treatment area near present thermal discharge) and outer (reference area) regions near the J. H. Campbell Plant, eastern Lake Michigan. (SD = standard deviation).

	Month: April									
	3 m		6 m		9 m		12 m		15 m	
Sediment grain size (Phi units)	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region
-3										
-3--2			0.34	0.01	0.03	0.07	0.01	0.01		
-2--1	0.01	0.01	0.97	0.01	0.10	0.03	0.06	0.01	0.08	0.09
-1-0	0.01	0.09	3.77	0.24	0.19	0.08	0.04	0.03	0.19	0.19
0-1	0.08	1.49	11.03	3.59	0.48	0.19	0.09	0.16	1.01	1.04
1-2	12.02	45.48	29.68	6.50	1.66	1.33	1.96	1.81	25.06	16.59
2-3	63.85	52.50	44.69	87.43	87.77	93.29	86.94	88.06	53.26	50.03
3-4	22.55	0.42	8.65	2.19	8.96	4.94	10.71	9.54	19.97	31.66
4-5	1.49	0.01	0.88	0.03	0.75	0.07	0.21	0.10	0.43	0.41
5-6										
6-7										
7-8										
8-9										
9										
Mean	2.59	2.03	1.89	2.38	2.55	2.52	2.58	2.58	2.42	2.62
SD	0.59	0.52	0.87	0.49	0.41	0.31	0.38	0.35	0.72	0.73

TABLE 12. Continued.

Sediment grain size (Phi units)	Month: July									
	3 m		6 m		9 m		12 m		15 m	
	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region
-3										
-3--2				0.08				0.05		0.07
-2--1	0.63			0.14		0.02	0.02	0.01	0.26	0.14
-1-0	0.66	0.06	0.01	1.18		0.07	0.02	0.05	0.30	0.18
0-1	7.68	2.38	0.04	16.50	0.01	0.15	0.12	0.39	1.40	1.21
1-2	23.43	69.42	0.81	16.79	0.28	1.02	1.82	4.59	13.26	11.81
2-3	50.80	28.08	18.50	63.50	13.08	92.13	63.55	76.95	46.29	44.27
3-4	14.44	0.06	58.57	1.73	71.29	6.49	31.55	17.70	31.45	41.85
4-5	2.34	0.01	8.85	0.06	4.58	0.11	2.93	28.03	3.32	0.47
5-6			2.91		1.34				0.37	
6-7			0.79		0.51				0.11	
7-8			1.50		0.28				0.14	
8-9			0.23		0.25				0.31	
9			7.91		8.39				9.27	
Mean	2.19	1.76	3.54	1.97	3.48	2.55	2.77	2.62	2.68	2.76
SD	0.75	0.49	0.81	0.64	0.62	0.30	0.55	0.49	0.80	0.75

TABLE 12. Continued.

Sediment grain size (Phi units)	Month: October									
	3 m		6 m		9 m		12 m		15 m	
	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region	Inner region	Outer region
-3			0.93							
-3--2			1.32			0.03				
-2--1	0.03	0.02	4.67	0.02	0.03	0.07	0.21	0.09		
-1-0	0.15		11.07	1.03	0.33	0.12	0.43	0.22	0.08	0.26
0-1	1.42	0.48	39.44	3.32	1.71	0.18	1.60	1.30	1.39	2.18
1-2	31.68	43.23	20.05	4.77	5.08	0.83	7.86	9.93	23.40	13.51
2-3	65.05	55.73	21.08	80.72	41.54	90.42	47.12	54.45	55.13	45.80
3-4	1.62	0.52	1.27	9.43	48.17	8.27	41.25	33.77	19.14	37.57
4-5	0.05	0.02	0.18	0.72	3.16	0.11	1.56	0.24	0.81	0.65
5-6										
6-7										
7-8										
8-9										
9										
Mean	2.17	2.06	0.88	2.44	2.85	2.56	2.77	2.70	2.42	2.68
SD	0.54	0.51	0.96	0.58	0.71	0.35	0.74	0.68	0.65	0.76

The most striking sediment distribution pattern was observed in the inner region during July 1979. Since dredging operations were being conducted concurrent with installation of offshore intake and discharge units, sediment samples were collected at approximately 0.16 km north of the present onshore discharge canal. Sediments collected in the inner region in 1979 were decidedly uncharacteristic of the 1978 sediment types at 3, 6, and 9 m, and in particular at the outer region during July 1979. While 6- and 9-m inner region depths were characterized as predominantly moderately sorted, very fine sand with an unusually high amount of silt and clay, sediments collected at 3 m contained a large amount of very fine sand (14%) and silt (2.3%) compared with previous months. In addition to uncommon amounts of very fine sand (approximately 60-70%) at the 6-m and 9-m depths, these depths were comprised of approximately 14.1% and 6.7% silt and 8.1% and 8.6% clay, respectively. While no abnormal sediments were noted at 12 m in the inner region, increased amounts of silt (3.9%) and clay (9.6%) were present at 15 m. Samples collected during October required a relocation of the inner transect slightly north to avoid a wide sand bar in the inner region that altered expected lake depth from 6 to 9 m to approximately 3 m. Since samples could not have been collected at 3-9-m depths, for purposes of comparability and safety precautions regarding operation of the R/V Mysis (i.e., the vessel draws 1.8 m leaving only 1.2 m clearance along an uncertain lake bottom), the inner transect was relocated. Although sediments collected along the relocated inner transect were generally similar to those collected along the outer transect in October, both the 9- and 12-m inner region depths had noticably higher quantities of silt (3.2% and 1.6%, respectively) than did the same depths along the outer transect (0.1% and 0.2%, respectively) (Table 12).

DISCUSSION

Several differences were observed in the survey area when 1978 findings were contrasted with 1979 regarding benthic macroinvertebrate and sediment parameters. The most prominent differences were an increase in the abundance of total macrobenthos, increased density of *Pontoporeia hoyi*, enchytraeids, and turbellarians, continued *Pontoporeia hoyi* size-class differences between regions, decreased chironomid density, a shift of dominant taxa within specified depth/time regimes for chironomids, naidids, *Pisidium*, and gastropods, and increased amounts of finer sediment types present in the inner region of the study area.

The entire survey area had an increase in the number of macrobenthos from 1978 to 1979, with the total increase not apparent in one region more than the other. Turbellarians, enchytraeids, *P. hoyi*, and chironomids contributed most to the change in macrobenthic increased density observed from 1978 to 1979.

From 1978 to 1979, the major difference found in the inner region was a significant decline in the abundance of chironomids. Although the density of *P. hoyi* increased in the inner region, it was not a significant increase.

Within the outer region from 1978 to 1979, the primary difference noted was a significant increase in the density of *P. hoyi*. While there was a decline in the number of chironomids in the outer region, the decrease was not significant. Both regions had similar significant increases in the number of turbellarians and enchytraeids.

In 1979, primary regional differences were observed with chironomid and tubificid densities and *P. hoyi* size classes. Sediment type changes and species dominance differences were also documented. Chironomid populations were significantly reduced in the inner region while tubificid populations were

significantly higher in the outer region. P. hoyi in the outer region were approximately one size class behind those in the inner region during April (9 m) and July (9-15 m).

While the entire survey area in 1979 experienced an increased benthic density over 1978 levels, chironomids declined in number in both regions. Factors such as winter harshness, storm and wave activity, poor availability of food, adverse weather conditions for adult breeding swarms in 1978, or natural year-to-year variability may have caused decreased abundance of chironomids. However, since the decline in 1979 within the inner region was more extensive than in the outer region, whether comparing 1978 with 1979 or regions within 1979, other factors may have contributed to the inner region decline in chironomid populations. Even though both regions in 1979 had a significant decrease in the number of chironomids present during July but not during April or October, the outer region still had significantly more chironomids than did the inner region, particularly at 3-9 m. While a general decline in chironomid abundance may have been caused by any of the factors previously mentioned, a portion of the difference noted for chironomids between regions appeared to be related to the change in sediment type noted during July 1979 at 3-9 m. With a finer sediment type present in the inner region during July, chironomid taxa usually found at 3-9 m were found in greater density in the outer than the inner region. In addition, chironomids normally found in the finer sediments at 9-15 m were now found more frequently in higher numbers at 3-9 m in the inner region than in the outer region. Thus, it appeared that construction activities altered the usual chironomid community structure at 3-9 m and reduced the density of chironomids in the inner region. Although chironomid and sediment differences were observed during October as well, they were less extreme, thereby suggesting recovery from construction activities as normal

sediment conditions returned.

Concurrent with the chironomid community structure changes, naidid community structure also appeared to be altered at 3-9 m during July 1979 when comparing inner and outer region densities. Within the entire survey area, Vejdovskyella intermedia density increased, but a proportionally higher increase in densities was observed in the inner region, particularly at 3-9 m in July. Outer region naidid community structure, although having more V. intermedia present in 1979 than 1978, resembled the 1978 naidid community structure much more closely than did the inner region in 1979. It would appear that there were natural decreases and increases for certain naidid species in the survey area that altered naidid community structure. Regardless of what may have been natural changes in naidid community structure, changes in the inner region were more extreme than those recorded in the outer region at 3-9 m in July. It seems reasonable to hypothesize that construction activities may also have altered naidid community structure in the inner region in addition to whatever natural changes were inherently in progress in the entire survey area.

It is yet unresolved why differences were observed among Pontoporeia hoyi size classes. Based on 2 yr of observations it does appear that gravid P. hoyi present in the 9-15-m inner region during April tended to release their brood sooner than their counterparts in the outer region (5 km north). Possibly, warmer water and increased food availability in the inner region caused slightly more rapid development of P. hoyi. The size-class difference was also present during July at 9-15 m, but not in October. Since no size-class difference was noted in October, the end result of regional P. hoyi size-class differences appeared to be minimal as both regions had similar densities and size-class distributions of P. hoyi. The same conclusion was reached after examining 1978 P. hoyi data and was first noted by Mozley (1974) near the D.C.

Cook Nuclear Power Plant. He stated that early or late released P. hoyi result in a similar size-class structure by late summer to fall. This conclusion appeared to be applicable to P. hoyi collected from the Campbell survey area during 1979. Although the average yearly P. hoyi density was significantly greater in 1979 when compared with 1978, during 1979 there was no statistical difference between overall mean regional P. hoyi densities even though the inner region density of the amphipod was greater than the outer region abundance. However, the outer region experienced highly significant P. hoyi density increases from 1978 to 1979, in particular during April and October. The inner region also had highly significant density increases for P. hoyi during October. Whether natural or other conditions favored a disproportionate increase in the outer region from 1978 to 1979 or prevented proportionally similar increases in the inner region is unknown given current knowledge. During July, when construction activities appeared to affect benthos to the greatest degree, P. hoyi densities in the inner and outer regions were not only similar to each other, but also to 1978 densities, thereby indicating no detectable difference due to this aspect of construction activities. Based upon normal sediment distribution patterns, it would have been expected that P. hoyi would have moved into an area of finer sediment type assuming an appropriate bacterial fauna was established (Marzolf 1965) as silty sands have been shown to be preferred by P. hoyi (Alley 1968, Henson 1970, Mozley and Alley 1973, and Mozley and Howmiller 1977). However, increased physical stress by wave action, increased light, and temperature regimes, coupled with questionable availability of food material on freshly deposited fine sediments and very high sedimentation rates, may have functioned to keep P. hoyi densities similar from 1978 to 1979 in the inner region during July.

Density and community structure changes for chironomids and naidids

appeared to be related to construction activities, particularly at 3-9 m during July. Sediment descriptions from samples collected in the inner region at 3-15 m during July were very different from either the previous year or the outer region. Although sedimentary changes in the inner region did not appear to affect the density of P. hoyi, there was a proportionately greater increase in P. hoyi in the outer region than in the inner region. In addition, there was a P. hoyi size-class difference evident in 1979 similar to that observed in 1978. P. hoyi occurring in the inner region were generally one size class advanced during April (9 m) and July (9-15 m) when compared with outer region P. hoyi densities. Both regions had increased numbers of turbellarians and enchytraeids as well as P. hoyi that helped contribute to an overall increase in the macrobenthos from 1978 to 1979. Although tubificid density differences were noted between regions, these differences appeared to be inconclusive and will require more data. While there was a change in gastropod community structure from V. sincera/Amnicola sp. dominance in 1978 to V. sincera/Lymnaea sp. dominance in 1979, and in the Pisidium community structure from P. nitidum, P. casertanum, and P. fallax in 1978 to P. casertanum, P. fallax, and P. nitidum in 1979 (order of numerical importance), these changes were similar throughout the survey area and apparently were unrelated to construction processes. In conclusion, changes observed for chironomids and naidids were apparently related to construction activities, while density changes observed for P. hoyi, turbellarians, and enchytraeids and changes in gastropod and Pisidium community structure were apparently unrelated to plant processes. These changes are likely the result of natural or undetermined processes occurring across the whole survey area. Reasons for the P. hoyi size-class differences observed between regions remain unexplained.

Overall, 1979 data when contrasted with 1978 data indicated there was

considerable year-to-year variability in preoperational data as might be expected (Mozley 1974, 1975). This was particularly evident not only for some major taxonomic groups, but for many species. Construction activities increased the complexity of interpreting results by introducing additional variability in addition to natural variability. Future analysis will need to reconsider conclusions reached once construction operations cease. With completion of 1980 data collection and analysis, permanency and impact of construction activities will become clearer. Based on observations made during October 1979, it appeared as though physical processes in the lake would cause a return to normal sedimentary patterns and presumably normal macrobenthic distributions. With increased wave or storm activity, much of the silt and clay as well as finer sands may well be moved offshore and deposited beyond the survey area. In addition, given a northerly current the finer sands, silt and clay may be transported along shore toward the outer region. It is likely that there is sufficient physical energy in the form of waves to transport the majority of these particles offshore as opposed to alongshore. If this is the case, effect of construction activities would likely be minimal and temporary in nature. Lake-wide processes affecting natural variability should have equal effects in both regions and, presuming that there were not thermal plume effects on benthos, then benthic populations will be affected equally in both regions.

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APPENDIX 1. Mean densities (number m^{-2}) of *P. hoyi*, miscellaneous taxa and total animals collected during April, July and October 1979 in the inner (treatment area near present thermal discharge) and outer (reference area) regions at 3-15 m near the J. H. Campbell Plant, eastern Lake Michigan. In addition to mean and standard error, size classes of *P. hoyi* and turbellarian species in each region have been expressed as percentages of total *P. hoyi* and total turbellarians, respectively. (X = mean, SE = standard error, n = 6).

Month: April

Taxa	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total *Pontoporeia hoyi*				10	10								1212	585		91	21	
P. hoyi <3 mm													1111	557	91.7			
P. hoyi 3-5 mm																		
P. hoyi 5-7 mm																		
P. hoyi >7 mm													10	10	0.8			
P. hoyi gravid				10	10	100.0							10	10	0.8	91	21	100.0
P. hoyi spent													81	43	6.7			
Miscellaneous taxa				71	24		141	37		10	10		10	10		40	20	
Total Turbellaria				71	24		141	37		10	10		10	10		40	20	
Turbellaria sp. 1				71	24	100.0	141	37	100.0	10	10	100.0				40	20	100.0
Turbellaria sp. 2													10	10	100.0			
Hydracarina																		
Hydra sp.																		
Mysis relicta																		
Other Insecta																		
Total Animals	10	10		1091	556		596	267		192	57		2192	611		1182	114	

Taxa	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total *Pontoporeia hoyi*	323	88		162	56		768	140		677	102	
P. hoyi <3 mm												
P. hoyi 3-5 mm				10	10	6.2	20	20	2.6	10	10	1.5
P. hoyi 5-7 mm										20	13	3.0
P. hoyi >7 mm												
P. hoyi gravid	323	88	100.0	152	46	93.8	747	149	97.3	646	101	95.4
P. hoyi spent												
Miscellaneous taxa				51	24		505	112		202	121	
Total Turbellaria				51	24		505	112		202	121	
Turbellaria sp. 1												
Turbellaria sp. 2				51	24	100.0	505	112	100.0	202	121	100.0
Hydracarina												
Hydra sp.												
Mysis relicta												
Other Insecta												
Total Animals	3333	338		3868	342		5808	858		9181	1071	

APPENDIX 1. Continued.

Month: July

Taxa	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total *Pontoporeia hoyi*	20	13		71	24		222	49		323	101		2222	421		2121	154	
P. hoyi <3 mm	10	10	50.0	30	14	42.3	40	30	18.0	91	51	28.2	121	0	5.4	798	79	37.6
P. hoyi 3-5 mm	10	10	50.0	40	13	56.3	182	31	82.0	232	57	71.8	2101	421	94.6	1313	146	61.9
P. hoyi 5-7 mm																10	10	0.5
P. hoyi >7 mm																		
P. hoyi gravid																		
P. hoyi spent																		
Miscellaneous taxa				1656	264		30	21		40	20		273	62		61	31	
Total Turbellaria				1646	266		30	21		30	21		232	71		51	29	
Turbellaria sp. 1				1646	266	100.0				10	10	33.3						
Turbellaria sp. 2							30	21	100.0	20	20	66.7	232	71	100.0	51	29	100.0
Hydracarina				10	10					10	10		40	26		10	10	
Hydra sp.																		
Mysis relicta																		
Other Insecta																		
Total Animals	1515	355		4272	326		13797	3797		3676	750		11453	1699		7949	574	

Taxa	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total *Pontoporeia hoyi*	11160	1149		5717	428		11605	626		17857	9526	
P. hoyi <3 mm	1293	133	11.6	3111	193	54.4	6201	509	53.4	14019	1100	78.5
P. hoyi 3-5 mm	9858	1094	88.3	2606	312	45.6	5393	302	46.5	3798	809	21.3
P. hoyi 5-7 mm	10	10	0.1				10	10	0.1	30	14	0.2
P. hoyi >7 mm										10	10	0.1
P. hoyi gravid												
P. hoyi spent												
Miscellaneous taxa	626	212		1081	126		1414	289		1656	228	
Total Turbellaria	626	212		1071	129		1343	328		1636	212	
Turbellaria sp. 1	10	10	1.6				10	10	0.7			
Turbellaria sp. 2	616	203	98.4	1071	129	100.0	1333	320	99.3	1636	212	100.0
Hydracarina				10	10		71	59				
Hydra sp.												
Mysis relicta										20	20	
Other Insecta												
Total Animals	19422	216		14908	1050		20422	1796		31017	1569	

APPENDIX 1. Continued.

Month: October

Taxa	Depth: 3 m, Inner region $\bar{X}$	SE	%	Depth: 3 m, Outer region $\bar{X}$	SE	%	Depth: 6 m, Inner region $\bar{X}$	SE	%	Depth: 6 m, Outer region $\bar{X}$	SE	%	Depth: 9 m, Inner region $\bar{X}$	SE	%	Depth: 9 m, Outer region $\bar{X}$	SE	%
Total *Pontoporeia hoyi*	51	20		20	20		131	43		697	137		1434	380		1192	151	
P. hoyi <3 mm										61	22	8.8	10	10	0.7	71	29	6.0
P. hoyi 3-5 mm	51	20	100.0	20	20	100.0	121	144	92.4	606	134	86.9	1333	349	93.0	1091	137	91.5
P. hoyi 5-7 mm							10	10	7.6	30	14	4.3	91	34	6.3	30	14	2.5
P. hoyi >7 mm																		
P. hoyi gravid																		
P. hoyi spent																		
Miscellaneous taxa	152	46		4818	1668		212	111		51	19		20	13		51	19	
Total Turbellaria	152	46		4818	1668		40	13		51	19		20	13		51	19	
Turbellaria sp. 1	152	46	100.0	4818	1668	100.0	30	14	75.0	20	20	39.2				20	13	39.2
Turbellaria sp. 2							10	10	25.0	30	14	58.8	20	13	100.0	30	14	58.2
Hydracarina																		
Hydra sp.							172	110	81.1									
Mysis relicta																		
Other Insecta																		
Total Animals	444	60		7737	1891		1929	555		2373	454		6030	2072		5848	178	

Taxa	Depth: 12 m, Inner region $\bar{X}$	SE	%	Depth: 12 m, Outer region $\bar{X}$	SE	%	Depth: 15 m, Inner region $\bar{X}$	SE	%	Depth: 15 m, Outer region $\bar{X}$	SE	%
Total *Pontoporeia hoyi*	4727	518		2141	155		10070	579		11474	868	
P. hoyi <3 mm	172	19	3.6	141	37	6.6	1596	309	15.8	1818	182	15.8
P. hoyi 3-5 mm	4424	504	93.6	2000	154	93.4	8393	610	83.3	9635	746	84.0
P. hoyi 5-7 mm	131	40	2.8				81	34	0.8	20	13	0.2
P. hoyi >7 mm												
P. hoyi gravid												
P. hoyi spent												
Miscellaneous taxa	283	106		152	49		384	155		212	88	
Total Turbellaria	283	106		152	49		374	155		192	90	
Turbellaria sp. 1				10	10	6.6	374	155	100.0			
Turbellaria sp. 2	283	106	100.0	141	40	92.8				192	90	100.0
Hydracarina							10	10				
Hydra sp.												
Mysis relicta												
Other Insecta										10	10	
Total Animals	12443	1096		10847	1026		13988	1259		20665	2160	

APPENDIX 2. Mean densities (number m^{-2}) of chironomid taxa collected during April, July and October 1979 in the inner (treatment area near present thermal discharge) and outer (reference area) regions at 3-15 m near the J. H. Campbell Plant, eastern Lake Michigan. In addition to mean and standard error, chironomid taxa in each region have been expressed as a percentage of total chironomids. (X = mean, SE = standard error, n = 6).

	Month: April																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
Taxa	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Chironomidae	10	10		1000	557		434	266		101	37		566	119		798	103	
Chironomus sp.													30	14	5.4	10	10	1.3
Chironomus fluviatilis-gr.													71	24	12.5	81	37	10.1
Cryptochironomus sp. 1																		
Cryptochironomus sp. 2							10	10	2.3				192	53	33.9	323	40	40.5
Cryptochironomus sp. 3													30	21	5.4	20	13	2.5
Cryptochironomus cf. *rolli*													30	14	5.4	30	14	3.8
Endochironomus sp.							10	10	2.3									
Parachironomus cf. *abortivus*																		
Paracladopelma cf. *nereis*																		
Paracladopelma cf. *undine*																		
Paracladopelma camptolabis-gr.										10	10	10.0	51	19	8.9	51	24	6.3
Paracladopelma cf. *winnelli*																		
Phaenopsectra sp.																		
Robackia cf. *demeijerei*				990	560	99.0	121	68	27.9	10	10	10.0	20	13	3.6	51	29	6.3
Saetheria cf. *tylus*				10	10	1.0	263	193	60.5	51	24	50.0	131	29	23.2	111	46	13.9
Polypedilum cf. *scalaenum*													10	10	1.8	20	20	2.5
Polypedilum fallax-gr.																		
Polypedilum sp. 2																30	14	3.8
Cladotanytarsus sp.										10	10	10.0						
Micropsectra sp.																		
Psectrocladius sp.																		
Cricotopus (*C.*) sp.																		
Cricotopus (*C.*)/*Orthocladius* (*O.*) sp.	10	10	100.0				20	20	4.7	10	10	10.0				40	20	5.1
Cricotopus (*I.*) *sylvestris*-gr.							10	10	2.3									
Heterotrissocladius cf. *changi*																		
Hydrobaenus sp.																		
Nanocladius sp.										10	10	10.0						
Thienemanniella sp.																		
Monodiamesa cf. *tuberculata*																10	10	1.3
Potthastia cf. *longimanus*																10	10	1.3
Procladius sp.																10	10	1.3
Others																		

APPENDIX 2. Continued.

	Month: April											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
Taxa	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Chironomidae	1727	257		2495	262		3060	583		3687	495	
Chironomus sp.												
Chironomus fluviatilis-gr.	20	13	1.0	40	30	1.6	30	21	1.0	10	10	0.3
Cryptochironomus sp. 1												
Cryptochironomus sp. 2	212	60	12.3	202	84	8.1	121	56	4.0	172	55	4.7
Cryptochironomus sp. 3							10	10	0.3	10	10	0.3
Cryptochironomus cf. *rolli*										10	10	0.3
Endochironomus sp.												
Parachironomus cf. *abortivus*												
Paracladopelma cf. *nereis*												
Paracladopelma cf. *undine*												
Paracladopelma camptolabis-gr.	444	95	25.7	667	73	26.7	475	85	15.5	798	208	21.6
Paracladopelma cf. *winnelli*										20	13	0.5
Phaenopsectra sp.							10	10	0.3			
Robackia cf. *demeijerei*	30	21	1.7	131	48	5.3	152	58	5.0	71	36	1.9
Saetheria cf. *tylus*	677	130	39.2	990	168	39.7	1667	441	54.5	1866	400	50.6
Polypedilum cf. *scalaenum*	141	27	8.2	273	113	10.9	81	37	2.6	253	40	6.9
Polypedilum fallax-gr.										10	10	0.3
Polypedilum sp. 2	10	10	0.6	10	10	0.4	10	10	0.3	10	10	0.3
Cladotanytarsus sp.	51	19	3.0	30	21	1.2	30	21	1.0	61	31	1.7
Micropsectra sp.												
Psectrocladius sp.												
Cricotopus (*C.*) sp.				10	10	0.4						
Cricotopus (*C.*)/*Orthocladius* (*O.*) sp.	71	36	4.1	91	34	3.6	30	14	1.0	10	10	0.3
Cricotopus (*I.*) *sylvestris*-gr.												
Heterotrissocladius cf. *changi*	10	10	0.6	10	10	0.4	40	13	1.3	61	22	1.7
Hydrobaenus sp.	30	21	1.7	30	21	1.2	323	68	10.6	172	33	4.7
Nanocladius sp.										10	10	0.3
Thienemanniella sp.				10	10	0.4						
Monodiamesa cf. *tuberculata*	20	13	1.2				71	24	2.3	111	43	3.0
Potthastia cf. *longimanus*	10	10	0.6							30	21	0.8
Procladius sp.							10	10	0.3			
Others												

APPENDIX 2. Continued.

Taxa	Month: July																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Chironomidae	1101	305		2515	271		949	87		2283	488		616	99		1717	210	
Chironomus sp.	30	30	2.7				162	84	17.1				10	10	1.6	10	10	0.6
Chironomus fluviatilis-gr.	152	41	13.8	51	19	2.0	71	59	7.5	131	55	5.7	10	10	1.6	61	16	3.6
Cryptochironomus sp. 1	10	10	0.9	475	129	18.9				40	20	1.8						
Cryptochironomus sp. 2	242	54	22.0	71	19	2.8	323	51	34.0	232	61	10.2	152	34	24.7	354	53	20.6
Cryptochironomus sp. 3	10	10	0.9	51	19	2.0				10	10	0.4				30	21	1.7
Cryptochironomus cf. *rolli*																		
Endochironomus sp.																		
Parachironomus cf. *abortivus*													10	10	1.6			
Paracladopelma cf. *nereis*																		
Paracladopelma cf. *undine*										51	29	2.2				20	13	1.2
Paracladopelma camptolabis-gr.	10	10	0.9							30	14	1.3				10	10	0.6
Paracladopelma cf. *winnelli*	10	10	0.9				20	20	2.1	40	26	1.8	51	19	8.3	50	19	2.9
Phaenopsectra sp.																		
Robackia cf. *demeijerei*	374	203	34.0	1778	266	70.7	141	40	14.9	1323	544	58.0	91	14	14.8	394	71	22.9
Saetheria cf. *tylus*	152	64	13.8	91	26	3.6	30	21	3.2	343	110	15.0	10	10	1.6	131	36	7.6
Polypedilum cf. *scalaenum*	40	13	3.6							40	20	1.8	101	46	16.4	323	117	18.8
Polypedilum fallax-gr.																		
Polypedilum sp. 2																		
Cladotanytarsus sp.													10	10	1.6	91	26	5.3
Micropsectra sp.							20	13	2.1							20	13	1.2
Psectrocladius sp.	10	10	0.9				51	40	5.4	10	10	0.4	40	30	6.5	101	56	5.9
Cricotopus (*C.*) sp.																		
Cricotopus (*C.*)/*Orthocladius* (*O.*) sp.	10	10	0.9				10	10	1.1	30	14	1.3	10	10	1.6	101	37	5.9
Cricotopus (*I.*) *sylvestris*-gr.																		
Heterotrissocladius cf. *changi*							61	22	6.4				51	29	8.3	10	10	0.6
Hydrobaenus sp.													40	30	6.5	10	10	0.6
Nanocladius sp.																		
Thienemanniella sp.																		
Monodiamesa cf. *tuberculata*							40	13	4.2				10	10	1.6			
Potthastia cf. *longimanus*	10	10	0.9															
Procladius sp.	40	20	3.6				20	13	2.1				20	13	3.2			
Others																		

APPENDIX 2. Continued.

Taxa	Month: July											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Chironomidae	848	306		818	110		475	133		364	56	
Chironomus sp.				30	14	3.7	30	21	6.3	10	10	2.7
Chironomus fluviatilis-gr.	30	21	3.5	20	13	2.4	20	13	4.2			
Cryptochironomus sp. 1												
Cryptochironomus sp. 2	162	81	19.1	91	21	11.1	30	21	6.3	101	26	27.7
Cryptochironomus sp. 3												
Cryptochironomus cf. *rolli*												
Endochironomus sp.												
Parachironomus cf. *abortivus*												
Paracladopelma cf. *nereis*												
Paracladopelma cf. *undine*				40	20	4.9	20	13	4.2	10	10	2.7
Paracladopelma camptolabis-gr.										10	10	2.7
Paracladopelma cf. *winnelli*	10	10	1.2							10	10	2.7
Phaenopsectra sp.												
Robackia cf. *demeijerei*	61	22	7.2	202	37	24.7	20	13	4.2	61	31	16.8
Saetheria cf. *tylus*				20	13	2.4	10	10	2.1	20	13	5.5
Polypedilum cf. *scalaenum*	485	197	57.2	182	96	22.2	212	107	44.6	51	29	14.0
Polypedilum fallax-gr.				10	10	1.2	51	24	10.7	10	10	2.7
Polypedilum sp. 2												
Cladotanytarsus sp.	10	10	1.2	40	26	4.9						
Micropsectra sp.	10	10	1.2									
Psectrocladius sp.	51	19	6.0	81	30	9.9						
Cricotopus (*C.*) sp.												
Cricotopus (*C.*)/*Orthocladius* (*O.*) sp.				61	27	7.5						
Cricotopus (*I.*) *sylvestris*-gr.												
Heterotrissocladius cf. *changi*				10	10	1.2				10	10	2.7
Hydrobaenus sp.										10	10	2.7
Nanocladius sp.												
Thienemanniella sp.												
Monodiamesa cf. *tuberculata*				10	10	1.2	71	36	14.9	61	16	16.8
Potthastia cf. *longimanus*	10	10	1.2									
Procladius sp.	20	13	2.4	20	20	2.4						
Others							10	10	2.1			

APPENDIX 2. Continued.

Taxa	Month: October																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Chironomidae	242	31		2899	237		1343	479		875	126		2202	768		1111	82	
Chironomus sp.	10	10	4.1				10	10	0.7				61	31	2.8			
Chironomus fluviatilis-gr.	30	21	12.4				10	10	0.7	91	40	10.4	606	225	27.5	91	21	8.2
Cryptochironomus sp. 1										141	60	16.0						
Cryptochironomus sp. 2							10	10	0.7	20	20	2.3	131	45	5.9	131	29	11.8
Cryptochironomus sp. 3													20	13	0.9			
Cryptochironomus cf. *rolli*													30	21	1.4			
Endochironomus sp.																		
Parachironomus cf. *abortivus*																		
Paracladopelma cf. *nereis*																		
Paracladopelma cf. *undine*																		
Paracladopelma camptolabis-gr.				20	13	0.7	30	21	2.2	303	49	34.5	202	46	9.2	424	41	38.2
Paracladopelma cf. *winnelli*							10	10	0.7	10	10	1.1	10	10	0.5	50	24	4.5
Phaenopsectra sp.																		
Robackia cf. *demeijerei*	51	24	21.1	2424	283	83.6	51	29	3.8	61	61	6.9				10	10	0.9
Saetheria cf. *tylus*	152	38	62.8	455	96	15.7	1192	440	88.8	192	33	21.8	81	20	3.7	162	40	14.6
Polypedilum cf. *scalaenum*							20	13	1.5	30	14	3.4	788	488	35.8	71	36	6.4
Polypedilum fallax-gr.							10	10	0.7				30	14	1.4	71	36	6.4
Polypedilum sp. 2																		
Cladotanytarsus sp.										20	13	2.3	20	13	0.9			
Micropsectra sp.																10	10	0.9
Psectrocladius sp.																		
Cricotopus (*C.*) sp.																		
Cricotopus (*C.*)/*Orthocladius* (*O.*) sp.										10	10	1.1	121	27	5.5	10	10	0.9
Cricotopus (*I.*) *sylvestris*-gr.																		
Heterotrissocladius cf. *changi*													30	14	1.4	20	13	1.8
Hydrobaenus sp.																		
Nanocladius sp.																		
Thienemanniella sp.																		
Monodiamesa cf. *tuberculata*													61	22	2.8	61	22	5.5
Potthastia cf. *longimanus*													10	10	0.5			
Procladius sp.																		
Others																		

APPENDIX 2. Continued.

Taxa	Month: October											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Chironomidae	444	26		404	38		596	158		414	82	
Chironomus sp.	10	10	2.3	30	21	7.4	20	20	3.4			
Chironomus fluviatilis-gr.	40	13	9.0	10	10	2.5						
Cryptochironomus sp. 1				10	10	2.5						
Cryptochironomus sp. 2	91	38	20.5	30	21	7.4	40	20	6.7	20	13	4.8
Cryptochironomus sp. 3												
Cryptochironomus cf. *rolli*	10	10	2.3									
Endochironomus sp.												
Parachironomus cf. *abortivus*												
Paracladopelma cf. *nereis*												
Paracladopelma cf. *undine*												
Paracladopelma camptolabis-gr.	40	20	9.0	20	13	5.0						
Paracladopelma cf. *winnelli*	30	14	6.8				20	13	3.4	61	27	14.7
Phaenopsectra sp.												
Robackia cf. *demeijerei*				20	13	5.0						
Saetheria cf. *tylus*	40	13	9.0	71	29	17.6	71	29	11.9	40	20	9.7
Polypedilum cf. *scalaenum*	20	13	4.5	61	22	15.1	20	20	3.4	30	14	7.2
Polypedilum fallax-gr.	10	10	2.3	20	13	5.0	131	59	22.0	40	20	9.7
Polypedilum sp. 2												
Cladotanytarsus sp.										10	10	2.4
Micropsectra sp.										30	21	7.2
Psectrocladius sp.												
Cricotopus (*C.*) sp.												
Cricotopus (*C.*)/*Orthocladius* (*O.*) sp.				20	20	5.0						
Cricotopus (*I.*) *sylvestris*-gr.												
Heterotrissocladius cf. *changi*	40	13	9.0	20	13	5.0	152	58	25.5	51	19	12.3
Hydrobaenus sp.	10	10	2.3	10	10	2.5						
Nanocladius sp.												
Thienemanniella sp.												
Monodiamesa cf. *tuberculata*	101	40	22.7	71	29	17.6	141	73	23.7	121	52	29.2
Potthastia cf. *longimanus*				10	10	2.5						
Procladius sp.										10	10	2.4
Others												

APPENDIX 3. Mean densities (number m^{-2}) of annelid taxa collected during April, July and October 1979 in the inner (treatment area near present thermal discharge) and outer (reference area) regions at 3-15 m near the J. H. Campbell Plant, eastern Lake Michigan. In addition to mean and standard error, naidid and tubificid taxa in each region have been expressed as a percentage of total naidids and total tubificids, respectively. ($\bar{X}$ = mean, SE = standard error, n = 6).

	Month: April																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
Taxa	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Naididae				10	10		10	10		71	24		10	10		10	10	
Amphichaeta leydigii										51	24	71.8				10	10	100.0
Chaetogaster diaphanus																		
Chaetogaster diastrophus																		
Nais communis																		
Nais elinguis																		
Nais pardalis																		
Nais simplex																		
Nais variabilis																		
Paranais litoralis																		
Paranais simplex																		
Piguetiella michiganensis													10	10	100.0			
Stylaria lacustris																		
Uncinais uncinata																		
Vejdovskyella intermedia				10	10	100.0	10	10	100.0	20	20	28.2						
Total Tubificidae							10	10					313	72		152	38	
Immature w/o hair chaetae													293	57	93.6	141	37	92.8
Immature w/ hair chaetae																		
Aulodrilus pigueti																		
Limnodrilus angustipenis																		
Limnodrilus hoffmeisteri													10	10	3.2			
Limnodrilus profundicola																		
Limnodrilus spiralis																		
Peloscolex freyi																		
Potamothrix moldaviensis													10	10	3.2			
Potamothrix vejdovskyi							10	10	100.0									
Rhyacodrilus coccineus																10	10	6.6
Stylodrilus heringianus																		
Enchytraeidae										10	10		61	27		71	36	
Hirudinea																		

APPENDIX 3. Continued.

Taxa	Month: April											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Naididae	101	37		222	97		283	71		1576	412	
Amphichaeta leydigii				10	10	4.5						
Chaetogaster diaphanus												
Chaetogaster diastrophus												
Nais communis	10	10	9.9									
Nais elinguis												
Nais pardalis												
Nais simplex	10	10	9.9									
Nais variabilis							10	10	3.5			
Paranais litoralis												
Paranais simplex				40	40	18.0	10	10	3.5	30	14	1.9
Piguetiella michiganensis	81	26	80.2	162	81	73.0	162	74	57.2	1535	409	97.4
Stylaria lacustris												
Uncinais uncinata				10	10	4.5						
Vejdovskyella intermedia							101	26	35.7	10	10	0.6
Total Tubificidae	525	177		424	70		414	103		1980	407	
Immature w/o hair chaetae	475	169	90.5	374	53	88.2	364	112	87.9	1929	393	97.4
Immature w/ hair chaetae												
Aulodrilus pigueti												
Limnodrilus angustipenis												
Limnodrilus hoffmeisteri							10	10	2.4			
Limnodrilus profundicola												
Limnodrilus spiralis				51	19	12.0	30	14	7.2	20	20	1.0
Peloscolex freyi	10	10	1.9									
Potamothrix moldaviensis	40	13	7.6							20	20	1.0
Potamothrix vejdovskyi							10	10	2.4	10	10	0.5
Rhyacodrilus coccineus												
Stylodrilus heringianus							61	38		20	13	
Enchytraeidae	273	73		182	63		101	30		374	96	
Hirudinea												

APPENDIX 3. Continued.

Taxa	Month: July																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Naididae	394	196		30	14		12585	3744		1010	321		7838	1170		3242	412	
Amphichaeta leydigii	131	86	33.2				1838	776	14.6				475	189	6.1	30	14	0.9
Chaetogaster diaphanus	20	13	5.1	20	13	66.7	343	96	2.7	505	188	50.0	949	175	12.1	980	218	30.2
Chaetogaster diastrophus																10	10	0.3
Nais communis																		
Nais elinguis	30	30	7.6				30	14	0.2									
Nais pardalis	10	10	2.5				141	95	1.1				263	34	3.4	10	10	0.3
Nais simplex																		
Nais variabilis	20	13	5.1				121	54	1.0	71	50	7.0	10	10	0.1	81	13	2.5
Paranais litoralis																		
Paranais simplex													20	13	0.3	20	13	0.6
Piguetiella michiganensis							10	10	0.1	121	35	12.0	30	21	0.4	263	64	8.1
Stylaria lacustris	10	10	2.5							121	65	12.0	182	73	2.3	283	99	8.7
Uncinais uncinata	20	20	5.1				20	13	0.2	10	10	1.0	91	26	1.2	404	73	12.5
Vejdovskyella intermedia	152	75	38.6	10	10	33.3	10080	2834	80.1	182	91	18.0	5818	1232	74.2	1162	196	35.8
Total Tubificidae							10	10		10	10		444	222		677	179	
Immature w/o hair chaetae										10	10	100.0	323	126	72.7	444	136	65.6
Immature w/ hair chaetae																		
Aulodrilus pigueti							10	10	100.0									
Limnodrilus angustipenis													10	10	2.3	30	30	4.4
Limnodrilus hoffmeisteri													71	71	16.0	71	59	10.5
Limnodrilus profundicola													10	10	2.3	10	10	1.5
Limnodrilus spiralis																		
Peloscolex freyi													20	13	4.5	101	66	14.9
Potamothrix moldaviensis																20	13	3.0
Potamothrix vejdovskyi																		
Rhyacodrilus coccineus													10	10	2.3			
Stylodrilus heringianus																		
Enchytraeidae																30	21	
Hirudinea																		

APPENDIX 3. Continued.

Taxa	Month: July											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Naididae	5101	733		4989	624		3515	323		5535	508	
Amphichaeta leydigii	71	50	1.4	10	10	0.2	30	30	0.9	30	14	0.5
Chaetogaster diaphanus	71	217	1.4	495	154	9.9	131	55	3.7	61	16	1.1
Chaetogaster diastrophus												
Nais communis												
Nais elinguis				10	10	0.2						
Nais pardalis	40	20	0.8				61	31	1.7	30	14	0.5
Nais simplex												
Nais variabilis				30	14	0.6	20	13	0.6			
Paranais litoralis				10	10	0.2						
Paranais simplex	71	19	1.4	10	10	0.2	30	21	0.9	71	19	1.3
Piguetiella michiganensis	283	60	5.5	1414	191	28.3	525	124	14.9	2485	323	44.9
Stylaria lacustris	323	155	6.3	515	218	10.3	606	362	17.2	434	176	7.8
Uncinais uncinata	263	79	5.2	283	40	5.7	111	36	3.2	111	43	2.0
Vejdovskyella intermedia	3343	663	65.5	2212	510	44.3	2000	438	56.9	2313	402	41.8
Total Tubificidae	525	185		960	212		1101	309		2323	734	
Immature w/o hair chaetae	465	149	88.6	798	187	83.1	859	206	78.0	2030	602	87.4
Immature w/ hair chaetae										10	10	0.4
Aulodrilus pigueti												
Limnodrilus angustipenis	10	10	1.9							40	20	1.7
Limnodrilus hoffmeisteri	20	13	3.8	40	20	4.2	30	21	2.7	40	20	1.7
Limnodrilus profundicola				10	10	1.0	40	13	3.6	10	10	0.4
Limnodrilus spiralis												
Peloscolex freyi												
Potamothrix moldaviensis	20	20	3.8	101	49	10.5				81	53	3.5
Potamothrix vejdovskyi												
Rhyacodrilus coccineus	10	10	1.9	10	10	1.0	172	104	15.6	111	99	4.8
Stylodrilus heringianus							414	185		606	146	
Enchytraeidae	51	20		263	49		444	202		899	245	
Hirudinea												

APPENDIX 3. Continued.

Taxa	Month: October																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Naididae							152	79		283	96		697	308		1566	174	
Amphichaeta leydigii													10	10	1.4			
Chaetogaster diaphanus							10	10	6.6									
Chaetogaster diastrophus																10	10	0.6
Nais communis							10	10	6.6				10	10	1.4			
Nais elinguis																		
Nais pardalis							61	49	40.1				253	182	36.3			
Nais simplex																		
Nais variabilis							30	13	19.7				20	13	2.9			
Paranais litoralis																		
Paranais simplex																		
Piguetiella michiganensis							20	13	13.2	192	92	67.8	253	86	36.3	1394	151	89.0
Stylaria lacustris																		
Uncinais uncinata							10	10	6.6	91	30	32.2	91	49	13.1	162	66	10.3
Vejdovskyella intermedia							10	10	6.6				61	31	8.8			
Total Tubificidae							91	58		424	192		1394	690		1293	280	
Immature w/o hair chaetae							81	49	89.0	424	192	100.0	1384	681	99.3	1293	280	100.0
Immature w/ hair chaetae																		
Aulodrilus pigueti																		
Limnodrilus angustipenis																		
Limnodrilus hoffmeisteri							10	10	11.0				10	10	0.7			
Limnodrilus profundicola																		
Limnodrilus spiralis																		
Peloscolex freyi																		
Potamothrix moldaviensis																		
Potamothrix vejdovskyi																		
Rhyacodrilus coccineus																		
Stylodrilus heringianus																		
Enchytraeidae																303	52	
Hirudinea																		

APPENDIX 3. Continued.

Taxa	Month: October											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Naididae	1727	118		1818	308		323	97		374	131	
Amphichaeta leydigii	30	21	1.7									
Chaetogaster diaphanus							10	10	3.1	20	20	5.3
Chaetogaster diastrophus	30	13	1.7	20	13	1.1						
Nais communis												
Nais elinguis												
Nais pardalis	30	14	1.7							10	10	2.7
Nais simplex												
Nais variabilis	20	13	1.2	10	10	0.6	10	10	3.1			
Paranais litoralis												
Paranais simplex												
Piguetiella michiganensis	1495	127	86.6	1667	295	91.7	263	100	81.4	172	79	46.0
Stylaria lacustris												
Uncinais uncinata	30	21	1.7	51	24	2.8						
Vejdovskyella intermedia	101	43	5.8	71	40	3.9	40	20	12.4	172	79	46.0
Total Tubificidae	2464	514		3384	608		949	202		2172	323	
Immature w/o hair chaetae	2434	524	98.8	3232	575	95.5	899	210	94.7	1899	295	87.4
Immature w/ hair chaetae							10	10	1.1	10	10	0.5
Aulodrilus pigueti												
Limnodrilus angustipenis												
Limnodrilus hoffmeisteri												
Limnodrilus profundicola												
Limnodrilus spiralis												
Peloscolex freyi												
Potamothrix moldaviensis	10	10	0.4	152	41	4.5	40	20	4.2	141	73	6.5
Potamothrix vejdovskyi	20	13	0.8							121	31	5.6
Rhyacodrilus coccineus												
Stylodrilus heringianus							40	20		1717	474	
Enchytraeidae	131	45		1071	245		869	353		545	242	
Hirudinea										30	21	

APPENDIX 4. Mean densities (number m^{-2}) of gastropod and pelecypod taxa collected during April, July and October 1979 in the inner (treatment area near present thermal discharge) and outer (reference area) regions at 3-15 m near the J. H. Campbell Plant, eastern Lake Michigan. In addition to mean and standard error, the taxa beneath total Gastropoda, total *Pisidium* and total *Sphaerium* in each region have been expressed as a percentage of their respective summed totals. ($\bar{X}$ = mean, SE = standard error, n = 6).

	Month: April																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
Taxa	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Gastropoda																		
Amnicola sp.																		
Bythinia tentaculata																		
Lymnaea sp.																		
Somatogyrus sp.																		
Valvata sincera																		
Valvata sp.																		
Total Pelecypoda													20	13		20	20	
Total *Pisidium*													20	13		20	20	
Pisidium adamsi																		
Pisidium casertanum													10	10	50.0			
Pisidium compressum													10	10	50.0			
Pisidium conventus																		
Pisidium fallax																		
Pisidium ferrugineum																		
Pisidium henslowanum																10	10	50.0
Pisidium idahoense																10	10	50.0
Pisidium lilljeborgi																		
Pisidium nitidum f. *nitidum*																		
Pisidium nitidum f. *pauperculum*																		
Pisidium supinum																		
Pisidium variabile																		
Pisidium walkeri																		
Pisidium spp.																		
Total *Sphaerium*																		
Sphaerium nitidum																		
Sphaerium striatinum																		
Sphaerium transversum																		

APPENDIX 4. Continued.

Taxa	Month: April											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Gastropoda	40	20					111	69		121	47	
Amnicola sp.							20	20	18.0			
Bythinia tentaculata												
Lymnaea sp.	20	13	50.0							40	20	33.1
Somatogyrus sp.												
Valvata sincera	20	13	50.0				91	51	82.0	81	37	66.9
Valvata sp.												
Total Pelecypoda	343	71		333	82		505	212		545	168	
Total *Pisidium*	343	71		323	87		505	212		545	168	
Pisidium adamsi												
Pisidium casertanum	131	33	38.2	111	43	34.4	202	81	40.0	172	48	31.6
Pisidium compressum										10	10	1.8
Pisidium conventus	10	10	2.9				51	24	10.1	10	10	1.8
Pisidium fallax	152	38	44.3	121	47	37.5	61	22	12.1	121	56	22.2
Pisidium ferrugineum												
Pisidium henslowanum							71	59	14.1	61	27	11.2
Pisidium idahoense												
Pisidium lilljeborgi							20	20	4.0			
Pisidium nitidum f. *nitidum*	30	21	8,7	10	10	3.1	51	24	10.1	121	56	22.2
Pisidium nitidum f. *pauperculum*							10	10	2.0			
Pisidium supinum												
Pisidium variabile				30	21	9.3				30	21	5.5
Pisidium walkeri												
Pisidium spp.	20	20	5.8	51	10	15.8	40	30	7.9	20	13	3.7
Total *Sphaerium*				10	10							
Sphaerium nitidum												
Sphaerium striatinum				10	10	100.0						
Sphaerium transversum												

APPENDIX 4. Continued.

Taxa	Month: July																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Gastropoda													30	30		30	21	
Amnicola sp.																		
Bythinia tentaculata																		
Lymnaea sp.																10	10	33.3
Somatogyrus sp.																		
Valvata sincera													30	30	100.0	20	20	66.7
Valvata sp.																		
Total Pelecypoda										10	10		30	21		71	29	
Total *Pisidium*										10	10		30	21		71	29	
Pisidium adamsi																		
Pisidium casertanum													10	10	33.3	40	20	56.3
Pisidium compressum													10	10	33.3			
Pisidium conventus																		
Pisidium fallax										10	10	100.0				10	10	14.1
Pisidium ferrugineum																		
Pisidium henslowanum																		
Pisidium idahoense																		
Pisidium lilljeborgi																		
Pisidium nitidum f. *nitidum*																		
Pisidium nitidum f. *pauperculum*																		
Pisidium supinum																		
Pisidium variabile																10	10	14.1
Pisidium walkeri													10	10	33.3			
Pisidium spp.																10	10	14.1
Total *Sphaerium*																		
Sphaerium nitidum																		
Sphaerium striatinum																		
Sphaerium transversum																		

APPENDIX 4. Continued.

Taxa	Month: July											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Gastropoda	384	87		282	51		182	72		253	48	
Amnicola sp.				20	13	7.1	91	30	50.0	91	44	36.0
Bythinia tentaculata												
Lymnaea sp.	242	68	63.0	141	43	50.0						
Somatogyrus sp.												
Valvata sincera	141	46	36.7	121	35	42.9	91	46	50.0	162	37	64.0
Valvata sp.												
Total Pelecypoda	727	187		798	148		1273	394		1525	212	
Total *Pisidium*	727	187		798	148		1263	400		1495	201	
Pisidium adamsi												
Pisidium casertanum	303	147	41.7	202	34	25.3	384	186	30.4	404	89	27.0
Pisidium compressum				20	20	2.5				20	20	1.3
Pisidium conventus	111	36	15.3	111	36	13.9	182	49	14.4	202	51	13.5
Pisidium fallax	111	36	15.3	192	48	24.1	182	73	14.4	242	77	16.2
Pisidium ferrugineum												
Pisidium henslowanum							212	110	16.8	172	59	11.5
Pisidium idahoense												
Pisidium lilljeborgi							40	30	3.2	61	31	4.1
Pisidium nitidum f. *nitidum*	20	13	2.8	182	91	22.8	131	76	10.4	111	36	7.4
Pisidium nitidum f. *pauperculum*	40	20	5.5	20	20	2.5	40	20	3.2	61	22	4.1
Pisidium supinum	10	10	1.4									
Pisidium variabile	40	26	5.5	40	20	5.0	20	20	1.6	81	43	5.4
Pisidium walkeri												
Pisidium spp.	91	30	12.5	30	14	3.8	71	29	5.6	141	40	9.4
Total *Sphaerium*							10	10		30	21	
Sphaerium nitidum												
Sphaerium striatinum										10	10	33.3
Sphaerium transversum							10	10	100.0	20	13	66.7

APPENDIX 4. Continued.

Taxa	Month: October																	
	Depth: 3 m						Depth: 6 m						Depth: 9 m					
	Inner region			Outer region			Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Gastropoda										10	10		40	30		131	45	
Amnicola sp.																		
Bythinia tentaculata																20	13	15.3
Lymnaea sp.										10	10	100.0	10	10	25.0			
Somatogyrus sp.																		
Valvata sincera													30	21	75.0	111	36	84.7
Valvata sp.																		
Total Pelecypoda										30	21		242	70		202	58	
Total *Pisidium*										30	21		242	70		202	58	
Pisidium adamsi																		
Pisidium casertanum										20	13	66.7	71	45	29.3	51	33	25.2
Pisidium compressum																		
Pisidium conventus																		
Pisidium fallax										10	10	33.3	40	20	16.5	51	33	25.2
Pisidium ferrugineum																		
Pisidium henslowanum																		
Pisidium idahoense																		
Pisidium lilljeborgi																		
Pisidium nitidum f. *nitidum*													20	20	8.3	40	30	19.8
Pisidium nitidum f. *pauperculum*																10	10	5.0
Pisidium supinum																		
Pisidium variabile													10	10	4.1	20	20	9.9
Pisidium walkeri																		
Pisidium spp.													101	26	41.7	30	21	14.9
Total *Sphaerium*																		
Sphaerium nitidum																		
Sphaerium striatinum																		
Sphaerium transversum																		

APPENDIX 4. Continued.

Taxa	Month: October											
	Depth: 12 m						Depth: 15 m					
	Inner region			Outer region			Inner region			Outer region		
	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%	$\bar{X}$	SE	%
Total Gastropoda	293	57		444	112		131	36		323	71	
Amnicola sp.				20	20	4.5				10	10	3.1
Bythinia tentaculata	10	10	3.4	10	10	2.3	10	10	7.6	51	19	15.8
Lymnaea sp.	71	19	24.2	162	103	36.5	20	20	15.3	20	13	6.2
Somatogyrus sp.				30	14	6.8	40	30	30.5	10	10	3.1
Valvata sincera	202	49	68.9	222	58	50.0	61	27	46.6	232	74	71.8
Valvata sp.	10	10	3.4									
Total Pelecypoda	2374	251		1424	124		626	261		3404	1376	
Total *Pisidium*	2343	255		1424	124		616	258		3384	1380	
Pisidium adamsi												
Pisidium casertanum	768	58	32.8	232	63	16.3	131	71	21.3	657	241	19.4
Pisidium compressum												
Pisidium conventus	40	26	1.7	71	48	5.0	10	10	1.6	253	162	7.5
Pisidium fallax	596	59	25.4	323	68	22.7	91	58	14.8	354	175	10.5
Pisidium ferrugineum										10	10	0.3
Pisidium henslowanum	182	56	7.8	141	20	9.9	141	70	22.9	414	85	12.2
Pisidium idahoense												
Pisidium lilljeborgi							20	20	3.2	10	10	0.3
Pisidium nitidum f. *nitidum*	333	111	14.2	414	29	29.1	30	21	4.9	919	395	27.2
Pisidium nitidum f. *pauperculum*				30	14	2.1	10	10	1.6	212	165	6.3
Pisidium supinum												
Pisidium variabile	61	27	2.6	20	20	1.4	20	20	3.2	40	20	1.2
Pisidium walkeri				40	30	2.8				10	10	0.3
Pisidium spp.	364	38	15.5	152	41	10.7	162	102	26.3	505	200	14.9
Total *Sphaerium*	30	14					10	10		20	13	
Sphaerium nitidum										10	10	50.0
Sphaerium striatinum	20	13	66.7				10	10	100.0	10	10	50.0
Sphaerium transversum	10	10	33.3									