MONITORING THE AQUATIC FOOD BASE IN THE COLORADO RIVER, ARIZONA DURING FISCAL YEAR 1999

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ABSTRACT

Discharge from Glen Canyon Dam (GCD) strongly influences the lower trophic levels (phytobenthos and macroinvertebrates) of the aquatic ecosystem in Grand Canyon National Park. The aquatic food base in the Colorado River is affected by the duration and timing of low releases from GCD, as well as the range of daily fluctuations. The overall objectives of this project are to seasonally monitor the effect of discharge characteristics below GCD, under modified low fluctuating flow criteria, on the distribution, standing mass and composition of primary and secondary producers in the benthos and drift, and to examine the linkages between lower and higher trophic levels. This information is critical because the lower aquatic trophic levels provide essential resources to both aquatic and terrestrial components of the fluvial ecosystem in Grand Canyon National Park.

Water quality monitoring of the Colorado River below GCD is within the typical seasonal ranges for temperature, conductivity, pH and dissolved oxygen. We have insufficient baseline data to determine if nutrient concentrations are within typical ranges. Secchi depths and light intensity data indicated seasonally turbid water typical of a wetter than normal year (1999) as evidenced by the Little Colorado and Paria River spates this past summer and winter.

Dam discharges were highly variable between months with the first use of the E.I. S. selected flows starting in September 1997. These included higher than normal monthly discharges including daily flow fluctuations over 560 $m^3 \cdot s^{-1}$. These flows have returned instability in the benthic community as indicated by high variability of Cladophora, detritus and Oscillatoria. Macroinvertebrate mass estimates were greater than the 1991 reference data in March at RKM 98.6, just above the Little Colorado River confluence and in June RKM 3.1, just below the Paria River. All other macroinvertebrate estimates are equal to or below 1991 data at those sites. This is probably a combination of high energy discharges and a wet monsoon season creating turbid conditions.

Taxa richness among macroinvertebrates increased during Interim Flows (1992-1997) but now we are seeing a return to low diversity. Drift in 1997 miscellaneous macroinvertebrates (Trichoptera, Ephemeroptera, terrestrial insects, etc.) contributed more to macroinvertebrate portion of CPOM since 1995 (Shannon et al 1998). However, this trend is changing to aquatic diptera larvae, pharate pupae and adults comprising the majority of the CPOM macroinvertebrate drift; October 1998 33%; 60% March 1999; 77% June 1999. These patterns are very similar to those of 1991; low benthic biomass and taxa richness with high variability.

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Micheal Kersley, of NAU, provided us within near shore vegetation estimates through Grand Canyon. Owen Gorman and Dennis Stone of the U.S. Fish and Wildlife Service provided various fish specimens from Grand Canyon for our food web construction. Ted McKinney and Bill Persons of Arizona Game and Fish provided us with fish specimens from Glen Canyon for dual stable isotope analysis. Tom Maddox of the University of Georgia processed our dual stable isotope samples.

INTRODUCTION

Discharge from Glen Canyon Dam (GCD) strongly influences the lower trophic levels of the aquatic ecosystem in Grand Canyon National Park (Blinn et al. 1992, 1993, 1994, 1995a,b,1998, Shannon et al. 1996a). The aquatic food base in the Colorado River is affected by the duration and timing of low releases from GCD, as well as the range of daily fluctuations. The objectives of this project is to seasonally monitor the effects of discharge characteristics below GCD, under the Bureau of Reclamation's modified low fluctuating flow criteria, on the composition, distribution and standing mass of primary and secondary producers in the benthos and drift. This information is valuable because the lower aquatic trophic levels provide essential resources for both aquatic and terrestrial components of the fluvial ecosystem.

Grand Canyon National Park's Colorado River Management Plan (NPS 1989) states that its resource management goals are "to preserve the natural resources and environmental processes of the Colorado River corridor and the associated riparian and river environments.... (and) to protect and preserve the river corridor environment (NPS 1989:9). Among its objectives are:
1) "establish.....a long-term monitoring program to assess changes in the status of natural....resources. This program will require definition of present resource status (NPS 1989:10)"; and 2) "advocate and support operational objectives for the Glen Canyon Dam (GCD) which are most compatible with protection of the intrinsic resources of the Colorado River within Grand Canyon National Park (NPS 1989:10). The aquatic food base is an integral part of the natural resources in Grand Canyon National Park.

The Secretary of the Interior authorized implementation of modified low fluctuating flow criteria from Glen Canyon Dam (GCD) in August 1996 based on the recommendations set forth by the Environmental Impact Statement (1990-1992). These flows are designed to mitigate impacts of dam operations on downstream riverine resources. The flows consist of low-, medium-, and high-volume months, with low flows during the spring and late fall, moderate flows in May and September, and high flows during mid-summer and mid-winter. These flows have a maximum discharge of 566 $m^3 s^{-1}$, a reduced range of daily fluctuation, and reduced up- and down-ramping rates.

The Environmental Impact Statement (USBR,1995) on the operation of GCD identified the aquatic food base as an "indicator resource" and important habitat for wildlife. Wildlife linked directly to the aquatic food base include native and non-native fish, insectivorous birds and bats, reptiles and waterfowl. Indirect links to the aquatic food base include peregrine falcons feeding on waterfowl, swifts, swallows

and bats, as well as king fishers, great blue herons, osprey and bald eagles preying on fish.

The National Park Service and the Bureau of Reclamation have both stated the importance of understanding the aquatic food base in the Colorado River below GCD through Grand Canyon National Park. This can only be accomplished through continued monitoring which will add to the established data base and provide the foundation for long-term adaptive management planning.

This report provides information on the following objectives;

Objective 1:	Monitor the effects of modified low fluctuating flows from Glen Canyon Dam (GCD) on the benthic community in the Colorado River between Glen Canyon Dam and Diamond Creek.
Objective 2:	Monitor the effects of modified low fluctuating flows from GCD on the organic drift in the Colorado River between GCD and Diamond Creek.
Objective 3.	Assess the benthos and drift of major tributaries in Grand Canyon National Park.
Objective 4.	Construction of an aquatic/riparian food web using stable isotope analysis.

METHODS

Objective 1: Monitor the effects of modified low fluctuating flows from Glen Canyon Dam (GCD) on the benthic community in the Colorado River between Glen Canyon Dam and Diamond Creek.

Biomass, composition, and habitat requirements of primary and secondary producers were monitored during the low to moderate flow months of March, June and October of each year within the mainstem of the Colorado River (n = 3 sampling trips per year). Seven sites will be monitored at the start and end of three major sections below GCD, including Glen, Marble, and Grand Canyons (n = 6 sites), and in Middle Granite Gorge (n = 1 site, Table 1).

These locations generally correspond with the monitoring sites used by Blinn et al. (1993, 1994, 1995b) and Shannon et al. (1996b) with the following modifications. The collection sites at the USGS gauging stations previously used by the NAU Aquatic Food Base Program will be dropped because they provide limited information (Blinn et al. 1992, 1993, 1994, Shannon et al. 1996b). These sites were originally selected for continuous flow across the channel and uniform depth in a pool above a rapid for gauging purposes, whereas pools below debris fans provide slow water velocities that collect fine organic and sediment particles. The previous gauging sites will be replaced with a site in the Middle Granite Gorge (RKM 203) to assess the food base of the largest mainstem humpback chub aggregation (Valdez and Ryel 1995). Sites were selected that will provide the most amount of information about the food base and for fish monitoring programs based on the past seven years of collecting in the Grand Canyon, and the allowed budget while decreasing river user days (Table 1).

Three habitat types (pools, riffles, and near shore habitats) were monitored at each site. Sampling was conducted along three transects 30 m apart in each habitat type. Petersen or Petit Ponar dredges will be used in the fine sediment and Hess substrate samplers will be utilized on cobble bar riffles. Pool habitats were sampled at five locations along the three transects; thalweg, <28 m^3/s, baseflow (142 m^3/s), lower-varial (~280 m^3/s), and upper-varial (~500 m^3/s). Cobble riffle collections were taken at the greatest depth possible with three paired samples along with lower and upper-varial samples.

Table 1. Collection Sites, River Kilometer (RKM), Elevation (m), Orientation, Reach Type, and Habitat in the Colorado River Below Glen Canyon Dam for Cobble Riffles, Pools and Tributaries within Glen, Marble and Grand Canyons, Arizona. Habitat describes area of collecting activity.

			GLEN CANYON		
Name	**RKM**	**Elevation**	**Orientation**	**Reach Type**	**Habitat**
1. Glen Canyon Gauge	-23.2	953	Southwest	Narrow	Drift
2. Lees Ferry	0.0L	947	Southwest	Wide	Pool/Drift
Lees Ferry Cobble	0.8R				Cobble
Paria River	1.0R				Tributary
			MARBLE CANYON		
Name	**RKM**	**Elevation**	**Orientation**	**Reach Type**	**Habitat**
3. Two-mile Wash	2.9R	876	South	Wide	Drift
Two-mile Cobble	3.1R				Cobble
Two-mile Pool	3.1L				Pool
Cathedral Island	4.0L				Shore
Vasey's Paradise	50.8R				Tributary
4. 60 Mile Gauge	95.7L	831	South	Wide	Pool
Gauge above LCR	98.4L				Shore/Drift
LCR Island	98.6C				Cobble
LCR	98.6L	826			Tributary
			GRAND CANYON		
Name	**RKM**	**Elevation**	**Orientation**	**Reach Type**	**Habitat**
Lava Chuar	104.0R	815			Tributary
5. Tanner Canyon	108.8R	808	Southwest	Wide	Pool/Shore
Tanner Cobble	109.6L				Cobble/Drift
Bright Angel Creek	140.8R	739			Tributary
6. 127 Mile Rapid	202.9R	616	Northeast	Narrow	Cobble/Drift
Middle Granite Gorge	203.2L				Pool/Shore
Tapeats Creek	214.8R	610			Tributary
Kanab Creek	231.2R	572			Tributary
Havasu Creek	249.6L	544			Tributary
7. Spring Canyon	326.4R	454	South	Wide	Pool/Shore
205 Mile Rapid	328.8R				Cobble/Drift
Spring Canyon Creek	327.2L	454			Tributary
Diamond Creek	361.6L	424			Tributary

Samples were processed live within 48 h and sorted into five biotic categories: C. glomerata, Oscillatoria spp., detritus, miscellaneous algae and macrophytes, and macroinvertebrates which were numerated into Gammarus lacustris, chironomid larvae, simuliid larvae, and miscellaneous invertebrates. Miscellaneous invertebrates included lumbriculids, tubificids, physids, trichopterans, terrestrial insects and unidentifiable animals. Detritus was composed of both autochthonous (algal/bryophyte/macrophyte fragments) and allochthonous (tributary upland and riparian vegetation) flotsam. Each biotic category was oven-dried at 60°C and weighed to determine dry weight biomass. Samples were then ashed (500°C, 1 h), and reweighed for ash free dry mass estimates. Preservatives alter biomass estimates and accurate dry weights are required for building an energetics model. Adult and pharate specimens will be collected with sweep nets, white and UV lights, spot samples, and Thienemann collections for taxonomic verification. Specimens are housed at NAU and logged according to NPS requirements.

Water temperature, dissolved oxygen, pH, specific conductance, substratum type, microhabitat conditions, Secchi depth, water velocity or stage, depth, date, site, and time of day will be recorded at each sample site. Depth integrated light intensity data loggers will be deployed at five collection sites. These sites corresponded with those initiated in the FY97 Steady High Flow Program. Benthic biomass estimates were compared between clear and turbid water sites with light as a predictor variable. The protocol outlined above will help depict the relationship between benthic biomass, discharge and light variability.

Nutrient levels were monitored at each collection site. The following nutrients were analyzed; ammonia, phosphate and nitrate-nitrogen. Triplicate samples were collected, acidified and analyzed within one month of collecting on a Technicon Auto Analyzer II™ after digestion.

Shoreline habitats were sampled for invertebrates in emergent vegetation, fine sediments and tychoplankton. These nearshore habitats have become quite extensive throughout the river corridor due to steady, low fluctuating flows and preliminary observations indicate they provide an important habitat for fish; similar to return current channels, but with greater stability. These low velocity near-shore habitats, composed primarily of Equisetum (horsetails) may provide similar habitat to backwaters, but are more abundant and readily available for invertebrate and small fish colonization. Presently, only minimal data exists for these abundant shoreline habitats. The following collections will be made from kayaks in an effort to reduce damage to this fragile and potentially critical habitat.

1)Triplicate harvests of shoreline emergent vegetation were taken in circular stovepipe samplers (0.02 m^2 area) just above the sediment, and screened as it's pulled through the water column in an effort to capture macroinvertebrates associated with the vegetation.

2)Triplicate plankton collections (156 μm,) were taken along the outer interface of shoreline vegetation. Samples were preserved in 70% EtOH and sorted in the lab with a dissecting scope into the following categories: Copepoda (Calanoida, Cyclopoida, Harpacticoida), Cladocera, Ostracoda, and miscellaneous zooplankton which include small chironomids, Gammarus lacustris, planaria, hydra, etc. Large samples were split with either 1 ml, 5 ml or 10 ml sub-samples sorted from a 100 ml dilution. Zooplankton densities of each category, general condition, reproductive state and presence of nauplii were recorded. Samples were processed for dry mass estimates and converted to ash-free dry mass using regression equations (Shannon et al, 1996b). The remaining organic material was filtered through a 1 mm sieve to remove CPOM and then filtered onto glass fiber filter (Whatman® GF/A, μm mesh) with a Millipore Swinex® system. These filters were dried at 60°C and combusted for 1 h at 500° C. Volumetric estimates (mass/m^3/s) were estimated from hand-pumping 15L of river water at each transect.

3)Triplicate sediment samples were taken with a Petite Ponar (0.02 m^2 area) and sieved for benthic macroinvertebrates. Macroinvertebrates were processed with the same protocol as emergent vegetation collections. Sediment was dried and sieved for clast fractioning.

4) Six minnow traps (0.48 m x 0.22 m) were set at an adjacent near-shore habitat for 12 h overnight to determine if fish utilize the habitat. Size, weight, total length, and standard length of each fish species were determined. General condition factors were determined for each fish population with the following equation:

$$K = \frac{W \cdot X}{L^3},$$

where W = weight in grams, L = total length in millimeters and constant X = 10^5 (Moyle and Cech, 1988). This information will determine the importance of the shoreline habitat for fish as a food resource and refuge. Appropriate permits were obtained from Arizona Game and Fish and US Fish and Wildlife Service.

Multivariate statistical analysis (MANOVA) using abiotic predictor variables and biotic response variables were used to determine significant patterns in composition, distribution and biomass of the benthic community. Also, relationships between AFDM of biotic components and the physical, chemical, spatial and temporal variables were examined with multivariate canonical correspondence analysis (CANOCO, Ter

Braak 1992, Palmer 1993). The SYSTAT computer software package (Version 5.1, Wilkenson 1989) and/or the NAU mainframe was used for all calculations.

Objective 2: Monitor the effects of modified low fluctuating flows from GCD on the organic drift in the Colorado River between GCD and Diamond Creek.

Drift was collected on each river trip from sites at or near the above sampling stations (Table 1). Two components of stream drift were assessed:
1) Coarse Particulate Organic Matter (CPOM).
Near-shore surface drift samples (0-0.5 m deep) were collected at each pool site for CPOM during each collection trip. Collections were taken in triplicate between 1000 h and 1500 h at each site to establish the affects of discharge on drift. Collections were made with a circular tow net (48 cm diameter opening with 500 μm mesh) held in place behind a moored pontoon raft or secured to the river bank. Samples were sorted and processed live for biota as outlined for the shoreline emergent vegetation in Objective 1. Current velocity was measured with a Marsh-McBirney electronic flow meter and collection duration were measured for volumetric calculations (mass/m^3/s).

2) Fine Particulate Organic Matter (FPOM). FPOM drift was collected at the same time and with the same general protocol as CPOM ($n = 3$). The net has a 30 cm diameter opening with 153 μm mesh. Samples were preserved in 70% EtOH and sorted in the lab with a dissecting scope according to procedures outlined in Objective 1 for plankton tows near shoreline vegetation.

Multivariate statistical analysis as outlined in Objective 1 was employed to determine significant patterns in the composition, distribution and biomass of drift along the river corridor.

OBJECTIVE 3. Assess the benthos and drift of major tributaries in Grand Canyon National Park.

Benthic Collections: Aquatic macroinvertebrates, phytobenthos and detritus were collected during January 1999 from 11 major tributaries of the Colorado River through Grand Canyon. At each tributary, two Hess samples were taken along three transects, 30 m apart ($n = 6$). All tributary transects were located above the influence of the mainstem ($\geq$2,265 m^3/s), starting at least 10 m above the mesquite line at the old high water zone. Biomass samples were sorted into the five biotic categories as

outline for benthic collections (Objective 1) in the Colorado River for comparison with benthos in the mainstem.

Taxonomic samples were collected, preserved in 70% alcohol, identified to the lowest taxonomic level possible, counted, and measured for total length. Water temperature, dissolved oxygen (DO), pH, specific conductance, and time of day were measured at each sampling site. Current velocity and depth was measured at each sample location.

Drift Collections: Both CPOM ($n = 3$) and FPOM ($n = 3$) collections were made following the same protocol as used in the mainstem (Objective 2). Tributary discharge were estimated by measuring the channel geometry and water velocity along a transect perpendicular to flow.

Past collections in the tributaries in Grand Canyon were made bimonthly in 1991 and annually in June 1992, 1993, 1994, 1996, and 1997 by the NAU Aquatic Food Base Monitoring Program. Shannon et al. (1996b) reported the month of January had the highest biomass and biodiversity which supported findings by Hofknecht (1981). This may result from low hydrologic disturbance during this period. June tributary discharge changes were dependant on the timing and amount of snow-melt. Changing the collection period is not only sound science but is also wise from a river ethic standpoint. June is the peak commercial river running season and all of the perennial streams in Grand Canyon are attraction sites.

This work is proposed to provide additional abiotic and biotic information on 11 major tributaries of the Colorado River through Grand Canyon National Park. These tributaries vary widely in physicochemical characteristics and yield a variety of different biotic communities, all of which may potentially invade the mainstem under favorable conditions (Shannon et al. 1996b). The information collected in this study will help characterize the seasonal abiotic conditions of tributaries in the Canyon and will provide information on their suitability as a habitat for native and exotic fishes. It will also provide knowledge on the diversity and biomass of macroinvertebrates that serve as food for native and exotic fishes in Grand Canyon. Some tributaries are highly susceptible to flash floods and periods of reduced or no flow which are common to many southwestern desert streams, while other spring-fed tributaries have more stable flow conditions. A comparison of these widely disparate systems will not only provide distributional information on aquatic macroinvertebrates within the Grand Canyon but will offer valuable information on abiotic variables that might determine their distribution.

Monitoring these tributaries is also a valuable management tool for assessing biota that are sensitive to changes within a given watershed. Therefore changes in land practices

both within and outside the boundaries of Grand Canyon National Park may be monitored. Management decisions such as seasonally adjusted steady flows, as described in the U.S. Fish and Wildlife Service Biological Opinion, or the installation of multiple withdrawal structures on GCD will have an impact on the aquatic food base in the Colorado River. Both of these management options will have an influence on at least the temperature range within the mainstem. Recruitment of aquatic macroinvertebrates into the mainstem will initially be from the tributaries. Understanding these tributaries may help resource managers determine reasonable ranges for important variables such as seasonal water temperature and discharge regimes.

OBJECTIVE 4. Construction of an aquatic/riparian food web using stable isotope analysis.

A valuable management tool, for critical ecosystem level decisions, is the development of a comprehensive food web. To date, a data based food web has not been constructed for the Colorado River ecosystem through the Grand Canyon aquatic/riparian community. Blinn et al. (1994) presented an aquatic energetics model for the tailwaters, Angradi (1994) developed a dual isotope model for Glen and Marble Canyons, and the NAU Aquatic Food Base Program used dual stable isotopes to track the origin and composition of organic drift (Shannon et al. 1996b). The above data sets were used to further expand our understanding of a system-wide food web with an emphasis on native fish food habitats. Schell and Ziemann (1993) used $\delta^{13}C$ natural isotope abundances to derive a food web in the Arctic coastal plain, which is similar to the Colorado River ecosystem in terms of simplicity.

Food web construction using stable isotopes has the advantage of defining the source of organic drift, which is visually uniform and a critical carbon source in lotic ecosystems. Stable isotope analysis also depicts what is assimilated by an organism, which eliminates "last meal" bias, and the complication of digestion rates that gut-analysis alone can lead to (Rosenfield and Roff 1992).

All potential major carbon sources within the aquatic/riparian communities of the Colorado River ecosystem were collected and analyzed for $\delta^{13}C$, $\delta^{15}N$, and $\delta^{33}S$ natural isotopic ratios. Triplicate samples of major plant and animal components of the riparian and upland vegetation, the benthic community in the river, and plankton from Lake Powell were taken throughout the Colorado River ecosystem. Fish and bird samples were obtained from incidental deaths from the projects monitoring these animals. The technique does not require the release of radioactive tracers to follow the path of ^{13}C, ^{15}N and ^{33}S through a food web. Samples were

air-dried immediately after collection in the field or laboratory and ground to a powder (<0.05 mm particle size) with a Whir-L-Bug™. Samples were analyzed with a mass-spectrophotometer. We obtained muscle plugs or fin clips from endangered fish for non-lethal data in cooperation with the fish monitoring projects.

Establishing Reference Data

Although the management objective for the aquatic food base states that it should be "maintained or enhanced" the exact levels were not defined. After analysis of our data from 30-plus river trips and 80-plus collections in the Lees Ferry area we have concluded that the data defining the aquatic food base in 1991 was the most degraded. It was during this time period of the GCES/ BOR sand movement research flows that included two 3-d steady 142 $m^3 \cdot s^{-1}$ flows each month, highly variable ramping rates and flows up to 934 $m^3 \cdot s^{-1}$. We have since learned that these flow regimes are the worst possible for the aquatic food base. It was also during this time period that the trout in Glen Canyon were in poor condition and native fish down river were also in poor health from an increase in parasitism. Therefore a reference data set has been developed for both pool and cobble habitats for each site which should be maintained or enhanced.

A reference data set was developed by using the mean biomass for each bi-monthly collection trip in 1991 for Cladophora, Oscillatoria, detritus and macroinvertebrates at each site. Miscellaneous algae, macrophytes and bryophytes or MAMB were not a separate category in 1991 so the means from the 1992 seasonal collections from each site were used. This procedure results in six data points being used at each site for each biotic category. MANOVA was then run for each monitoring collection trip against the 1991 reference data.

Results of the MANOVA for each biotic factor or univariate probability would indicate if the biotic resource was enhanced significantly, maintained or nonsignificant change and if the biotic resource was degraded significantly. This determination was made after comparing the mean data for the monitoring trip and the 1991 reference data. **An increase in biomass of the biotic categories during monitoring would indicate an enhanced resource. Oscillatoria is the only biotic factor that is does not enhance the aquatic food base with increasing biomass, therefore reduced Oscillatoria biomass over 1991 reference data would be an enhanced resource.**

RESULTS

Objective 1: Monitor the effects of modified low fluctuating flows from Glen Canyon Dam (GCD) on the benthic community in the Colorado River between Glen Canyon Dam and Diamond Creek.

Water quality patterns were consistent with past collections; however, a decrease in conductivity and an increase in dissolved oxygen concentrations were detected at all collection sites (pages A1-A50)

Pool and cobble habitat biomass estimates either were maintained or degraded during October 1998. This was probably because of very turbid conditions from tributary input of sediment (A38) scouring the benthos. Discharge was also reduced during the collection period with daily flows as low as 280 $m^3 \cdot s^{-1}$ (~10K cfs). These low flows then expose any benthic colonization of the varial zone that may have occurred during the summer.

Macroinvertebrate biomass estimates from March and June 1999 were maintained in comparison to 1991 reference data (Table 2, Appendices). Most of the variability was in the Cladophora, Oscillatoria and detrital estimates. These biotic categories are sensitive to dam operations, with Oscillatoria increasing in the varial zone due to daily fluctuating flows and detritus from tributaries moving through the study site. Also you do not see Cladophora and Oscillatoria enhanced for a collection site.

Comparing June 1996 benthic biomass estimates to the 1991 reference data showed the biotic categories to either be maintained or enhanced (Table 3). This collection trip generally had the highest biomass estimates documented through the study site and macroinvertebrate biomass was enhanced at allcobble sites. We can attribute this pattern to consistent flows with little daily fluctuations and possibly a result of clear water conditions from scour after the 1996 Spike Flow. These results indicate that if during normal dam operations, including management or research flow scenerios, the biotic factors comprising the food base were degraded at enough to warrant remediation then we recommend steady flows of at least 400 $m^3 \cdot s^{-1}$ for several months.

Table 2. Comparison of benthic biomass from 1991 reference data to monitoring data collected from October 1998, March 1999 and June 1999 at nine sites in the Colorado River through Grand Canyon. Results of MANOVA are depicted as follows for each biotic factor; (+) resource enhanced significantly, (=) resource maintained, nonsignificant change and (-) resource degraded significantly. Miscellaneous algae, macrophytes and bryophytes are depicted by MAMB. Pool habitats are indicated by P and cobble habitats by C. **Oscillatoria is the only biotic factor that does not enhance the aquatic food base with increasing biomass, therefore a + means reduced Oscillatoria biomass over 1991 reference data.**

Site/Date	Cladophora	Oscillatoria	Detritus	MAMB	Macroinvertebrates
October 1998					
Rkm 0.0 P	–	–	=	=	=
Rkm 0.8 C	=	=	=	=	=
Rkm 3.1 C	=	=	=	=	–
Rkm 95.7 P	–	=	=	=	–
Rkm 98.6 C	=	–	=	=	=
Rkm 108.8 P	=	=	=	=	=
Rkm 109.6 C	=	+	=	=	=
Rkm 326.4 P	=	+	+	=	=
Rkm 328.8 C	=	=	–	=	=
March 1999					
Rkm 0.0 P	=	=	=	=	=
Rkm 0.8 C	=	=	=	+	=
Rkm 3.1 C	+	=	=	+	=
Rkm 95.7 P	–	+	=	=	=
Rkm 98.6 C	+	–	=	=	+
Rkm 108.8 P	=	+	=	=	=
Rkm 109.6 C	=	–	=	=	=
Rkm 326.4 P	=	+	+	=	=
Rkm 328.8 C	=	–	=	=	=

Table 2 continued

Site/Date	Cladophora	Oscillatoria	Detritus	MAMB	Macroinvertebrates
June 1999					
Rkm 0.0 P	–	+	=	=	=
Rkm 0.8 C	+	=	+	–	=
Rkm 3.1 C	+	=	+	+	+
Rkm 95.7 P	–	+	+	=	=
Rkm 98.6 C	=	=	+	=	=
Rkm 108.8 P	+	+	+	+	=
Rkm 109.6 C	=	–	=	+	=
Rkm 326.4 P	=	+	+	=	=
Rkm 328.8 C	+	=	=	=	=

Table 3. Comparison of benthic biomass from 1991 reference data to data collected in June 1996 at nine sites in the Colorado River through Grand Canyon. **This analysis demonstrates how reduced daily flow fluctuations can enhance the aquatic food base.** Results of MANOVA are depicted as follows for each biotic factor; (+) resource enhanced significantly, (=) resource maintained, nonsignificant change and (-) resource degraded significantly. Miscellaneous algae, macrophytes and bryophytes are depicted by MAMB. Pool habitats are indicated by P and cobble habitats by C. **Oscillatoria is the only biotic factor that does not enhance the aquatic food base with increasing biomass, therefore a + means reduced Oscillatoria biomass over 1991 reference data.**

Site/Date	Cladophora	Oscillatoria	Detritus	MAMB	Macroinvertebrates
June 1996					
Rkm 0.0 P	-	=	=	-	=
Rkm 0.8 C	=	=	=	=	+
Rkm 3.1 C	=	=	+	+	+
Rkm 95.7 P	=	=	=	=	=
Rkm 98.6 C	=	=	+	+	+
Rkm 108.8 P	=	=	=	=	=
Rkm 109.6 C	=	=	+	+	+
Rkm 326.4 P	=	+	=	=	=
Rkm 328.8 C	=	=	+	=	+

Objective 2: **Monitor the effects of modified low fluctuating flows from GCD on the organic drift in the Colorado River between GCD and Diamond Creek.**

Organic drift in the Colorado River below Glen Canyon Dam reflects both the productivity of the benthos and scouring effects of daily fluctuating flows (Shannon et al. 1996; A202-A320). October 1998 CPOM estimates for all sites was 0.13 $g \cdot m^3 \cdot s^{-1}$ (SE± 0.04) with 85% of the mass in the form of detritus. This is a reflection tributaries in spate contributing to the organic budget of the mainstem. March 1999 CPOM estimates for all sites was 0.04 $g \cdot m^3 \cdot s^{-1}$ (SE± 0.005) with 75% of the mass in the form of detritus. June 1999 CPOM estimates for all sites was 0.07 $g \cdot m^3 \cdot s^{-1}$ (SE± 0.02) with 15% of the mass in the form of detritus. In June 84% of the drift was MAMB or carbon produced within the river channel (autochthonous). This is a reflection of more phytobenthic diversity in the past couple of years (Shannon et al 1997). These estimates vary about the annual average from 1993-1996 of 0.09 $g \cdot m^3 \cdot s^{-1}$ (± 0.04).

In 1997 miscellaneous macroinvertebrates (Trichoptera, Ephemeroptera, terrestrial insects, etc.) contributed more to macroinvertebrate portion of CPOM since 1995 (Shannon et al 1998). However, this trend is changing to aquatic diptera larvae, pharate pupae and adults comprising the majority of the CPOM macroinvertebrate drift; October 1998 33%; 60% March 1999; 77% June 1999.

Objective 3. **Assess the benthos and drift of major tributaries in Grand Canyon National Park.**

We collected in January 1999. This dataset will be analyzed with the summary report all tributary data collected during the past 20 years. This report is scheduled for completion in December 2001, with an addtional trip in January 2001.

Objective 4. **Construction of an aquatic/riparian food web using stable isotope analysis.**

Preliminary analysis of 96 samples indicate a typical aquatic/riparian food web in the Coloroda River through Grand Canyon National Park (Fig. 1). Carbon and nitrogen values for algae and aquatic invertebrates indicate that most of the invertebrates assimilate carbon from algae. Riparian vegetation is similar to algae because these samples were from the shoreline (horsetail, sedges, and reeds) and are getting there

carbon directly from the river. Woody riparian vegetation litter, Tamarisk, willow and cottonwood, show less of a riverine carbon source.

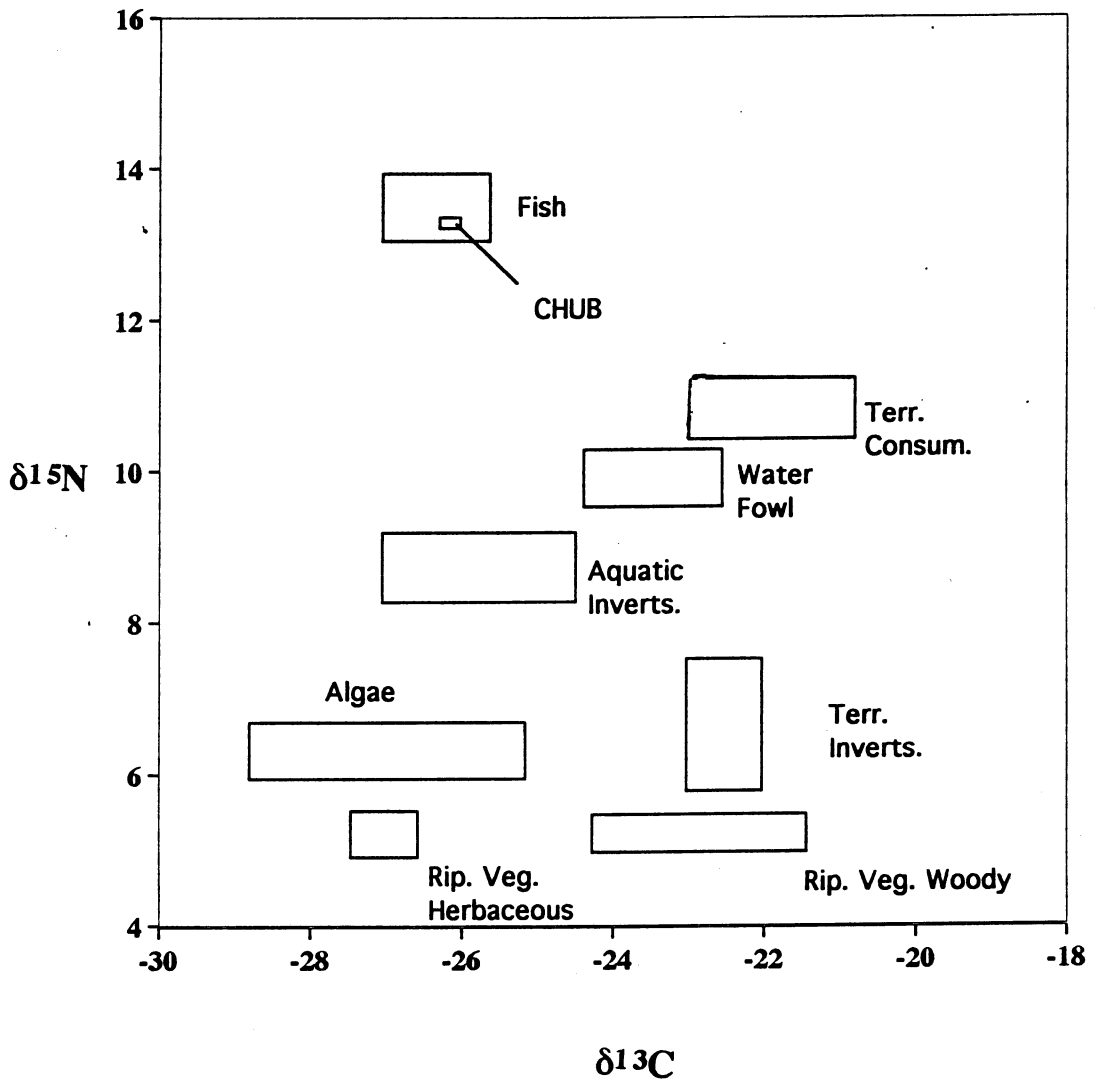

Figure 1. Dual stable isotope plots for $\delta^{15}N$ and $\delta^{13}C$ from the Colorado River in Grand Canyon National Park. Boxes for each trophic level indicate the standard deviation of the mean, with the mean in the center of each box.

Terrestrial insects do not appear to be an important part of the food web for the samples analyzed so far. Water fowl and terrestrial consumers both are comprised of carbon from aquatic invertebrates. Fish show a riverine carbon source not terrestrial and are nitrogen enriched (~ +5 o/oo). This amount of nitrogen enrichment between trophic levels is high, indicating piscivory. Although several investigators have reported terrestrial insects in the guts of Colorado River fish (Valdez and Hoffnagle 1999; Valdez and Ryle 1995) they do not contribute to the mass of the fish. These fish may not consume enough terrestrial insects to be assimilated into the flesh of the organism or they can not process terrestrial insects.

Chapter Three: Management Considerations
Aquatic Food Base Project Northern Arizona University

During the past year of monitoring and research we continue to develop a large data base to compare patterns which will add to our general knowledge of the aquatic community structure in the Colorado River through Grand Canyon. This knowledge can then be used in assisting the adaptive management process in determining how best to operate Glen Canyon Dam to conserve aquatic resources.

Status Of Aquatic Food Base: Patterns are very similar to those of 1991; low benthic biomass and taxa richness with high variability. Data from 1991 and 1999 are comparable and indicate the lowest biomass estimates for the decade

Discharge: Fluctuating flows above 566 $m^3 \cdot s^{-1}$ (20K cfs) do not conserve the aquatic food base. In 1997, we got our first exposure to the full use of the E.I.S. mandated flow regimes. These flows included a minimum flow of 142 $m^3 \cdot s^{-1}$ (5K cfs) with a maximum flow of 708 $m^3 \cdot s^{-1}$ (25K cfs) with an up-ramp of no more than 114 $m^3 \cdot s^{-1}$ (4K cfs) per hour and a down ramp of no more than 43 $m^3 \cdot s^{-1}$ (1.5K cfs) per hour. Total daily fluctuations were to not exceed 142, 170, 227 $m^3 \cdot s^{-1}$ (5K, 6K, or 8K cfs) for low, moderate or high delivery months respectively. We usually find an annual peak in benthic mass during June, however in 1999 that did not happen (Table 3). This is probably because the June collections usually follow a period of relatively low early spring flows from Glen Canyon Dam. This was true until mid-May when the discharge pattern was elevated so the daily maximum of April and May (~500 $m^3 \cdot s^{-1}$; 18K cfs) was the daily minimum through the rest of the summer. These flows were in response to above average snow pack in the upper-basin.
Recommendation: When flows from Glen Canyon Dam need to be elevated to gain capacity in Lake Powell, flows over 566 m3·s-1 (20K cfs) should be steady.

Spike Flow: Conditions in 2000 are not favorable for a quick recovery of the benthos from the scouring a spike flow will cause. Prior to the 1996 Spike Flow the food base biomass was above levels ever recorded before, because of successive years of high and reduced fluctuating flows. This prolific growth coupled with little tributary run-off that would reduce light penetration and steady flows allowed for re-growth faster than expected. We do not have an area of high benthic biomass for recolonization (Table 3). From past experiments on recolonization we would expect the food base to take up to a year for full recovery.
Recommendation: Sixty days of steady flows at the same magnitude as the steady flows following the Spike Flow would improve the rate of food base recovery.

Record of Decision Flows: Prior to any long term experimental flows a critical evaluation of the E.I.S. record of decision discharge regime needs to occur. It would be prudent to document how these flows have affected each resource area that GCMRC and the adaptive management stakeholders are responsible for. Especially considering that there is no long term monitoring plan in place to evaluate large scale changes in dishcarge regime; thermal modification, seasonal adjusted steady flows, etc. An evaluation metric needs to be developed so that all resource groups have the same way of examining flows. For example we have found the largest range of daily flows in the month prior to collecting is a good variable for assessing dam operation affects.
Recommendation: All resource groups analyze there data with the same metric of dam operations as a predictor variable for a uniform and repeatable evaluation of all resources.

Table 3. Comparison of benthic biomass from 1991 reference data to monitoring data collected from October 1998, March 1999 and June 1999 at nine sites in the Colorado River through Grand Canyon. Results of MANOVA are depicted as follows for each biotic factor; (+) resource enhanced significantly, (=) resource maintained, nonsignificant change and (-) resource degraded significantly. Miscellaneous algae, macrophytes and bryophytes are depicted by MAMB. **Oscillatoria is the only biotic factor that does not enhance the aquatic food base with increasing biomass, therefore a + means reduced Oscillatoria biomass over 1991 reference data.** This table includes only cobble collections because these habitats provide the most area and mass to the aquatic food base.

Site/Date	Cladophora	Oscillatoria	Detritus	MAMB	Macroinvertebrates
October 1998					
Rkm 0.8 C	=	=	=	=	=
Rkm 3.1 C	=	=	=	=	–
Rkm 98.6 C	=	–	=	=	=
Rkm 109.6 C	=	+	=	=	=
Rkm 328.8 C	=	=	=	=	=
March 1999					
Rkm 0.8 C	=	=	=	+	=
Rkm 3.1 C	+	=	=	+	=
Rkm 98.6 C	+	–	=	=	+
Rkm 109.6 C	=	–	=	=	=
Rkm 328.8 C	=	–	=	=	=
June 1999					
Rkm 0.8 C	+	=	+	–	=
Rkm 3.1 C	+	=	+	+	+
Rkm 98.6 C	=	=	+	=	=
Rkm 109.6 C	=	–	=	+	=
Rkm 328.8 C	+	=	=	=	=

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APPENDICES

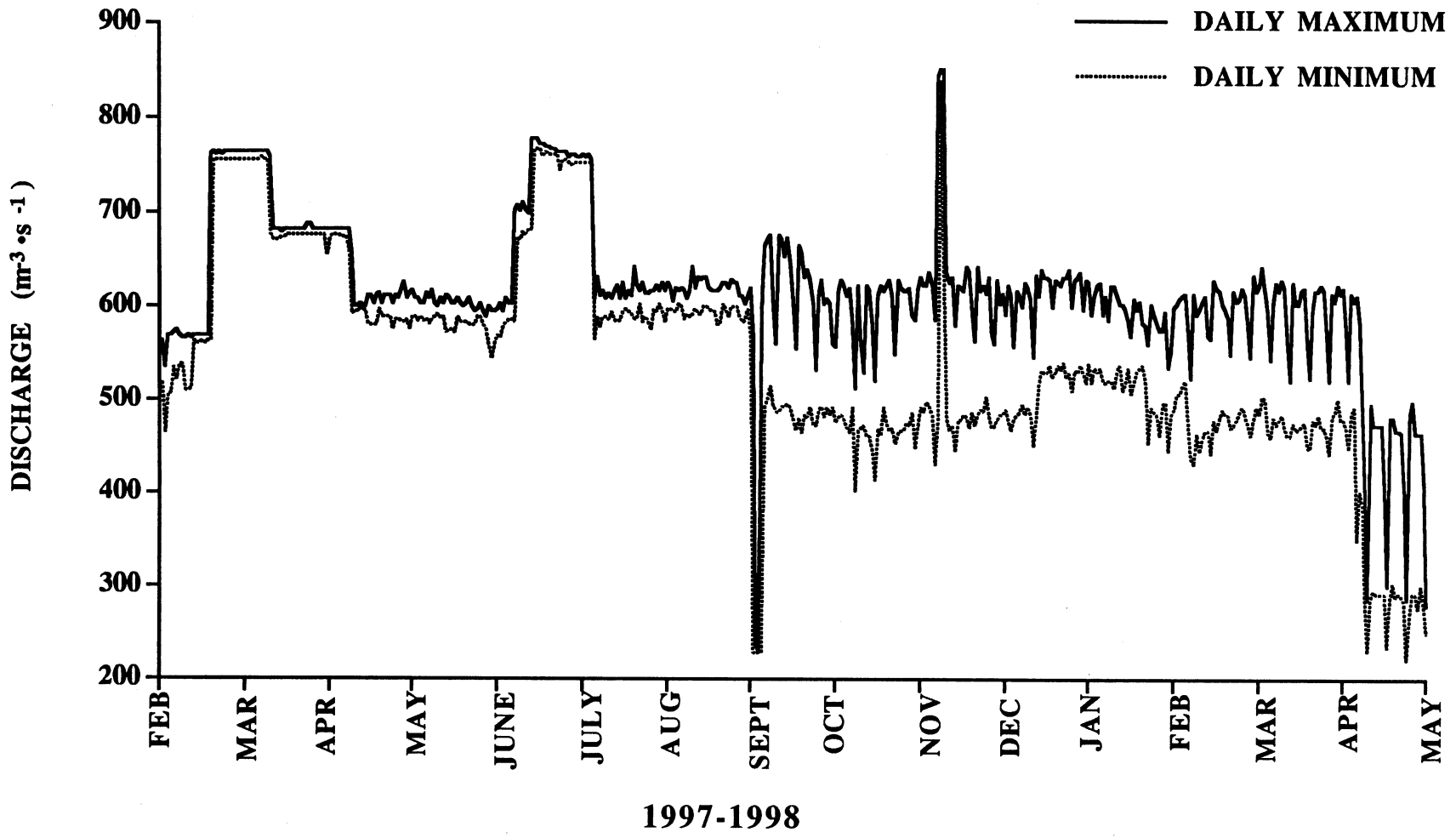

Figure 1. Daily maximum and daily minimum discharge ($m^{-3} \cdot s^{-1}$) from Lees Ferry Gauging Station Rkm 0.0 from February 1997 to May 1998, obtained from the USGS ADAPS program.

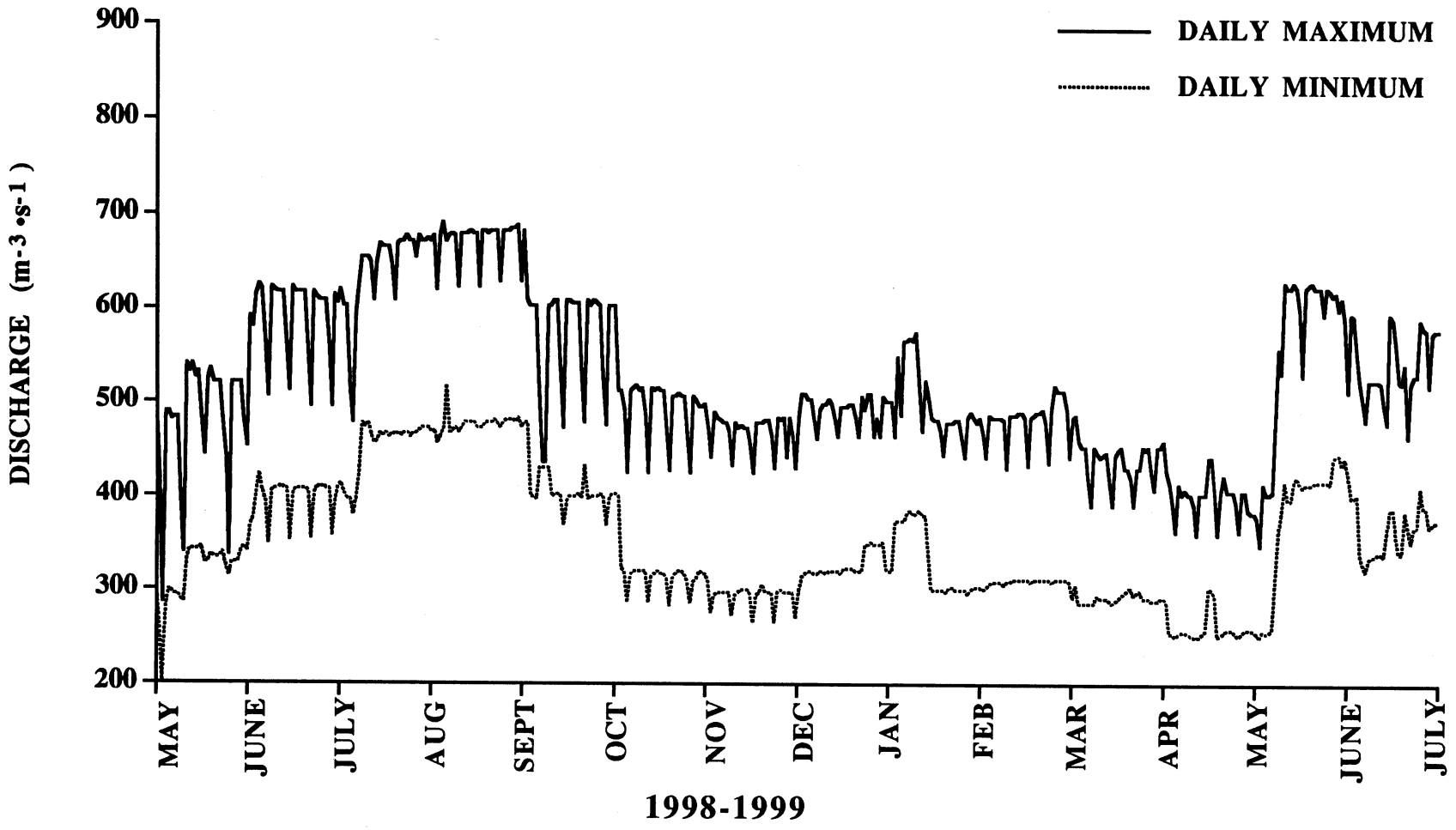

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Figure 1. Daily maximum and daily minimum discharge ($m^{-3} \cdot s^{-1}$) from Lees Ferry Gauging Station Rkm 0.0 from May 1998 to July 1999, obtained from the USGS ADAPS program.

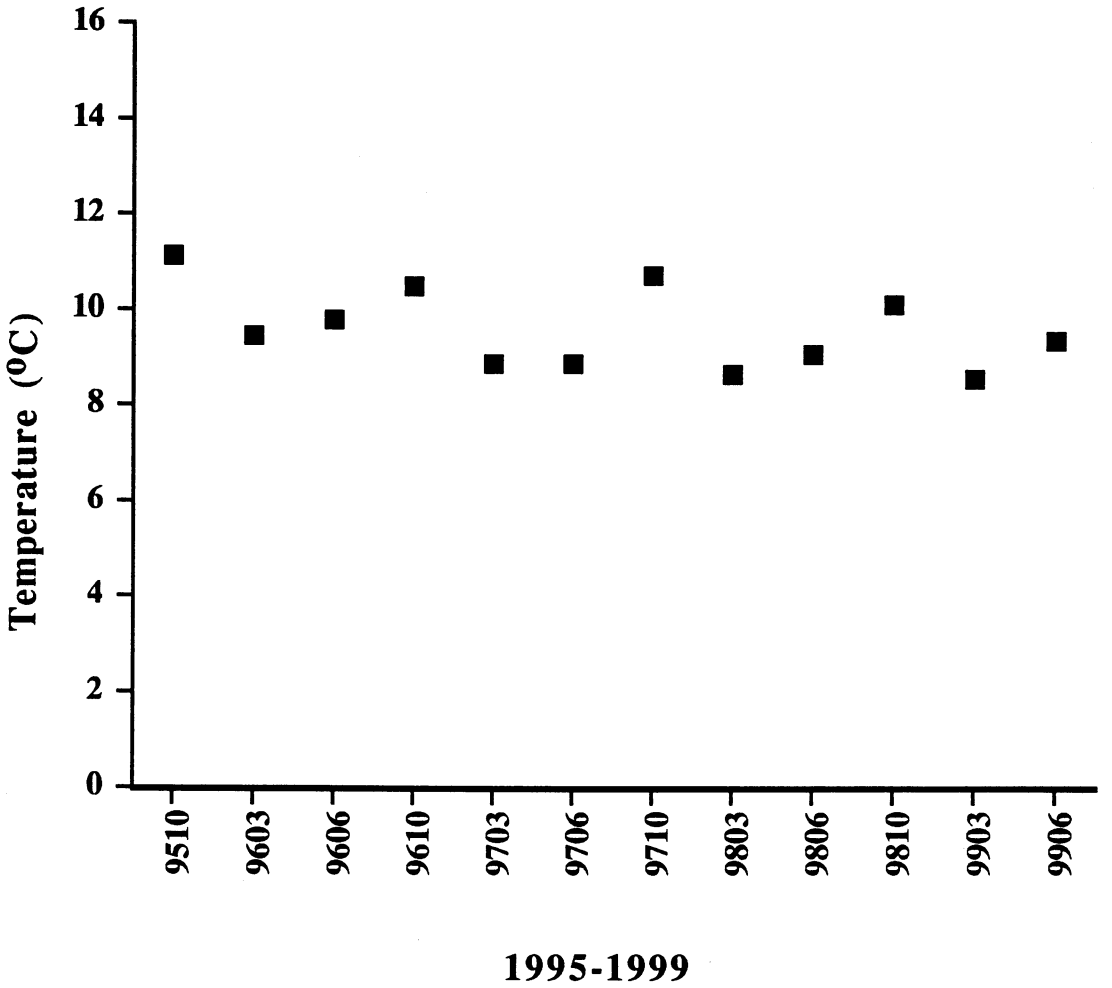

Figure 2. Water temperature (°C) collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

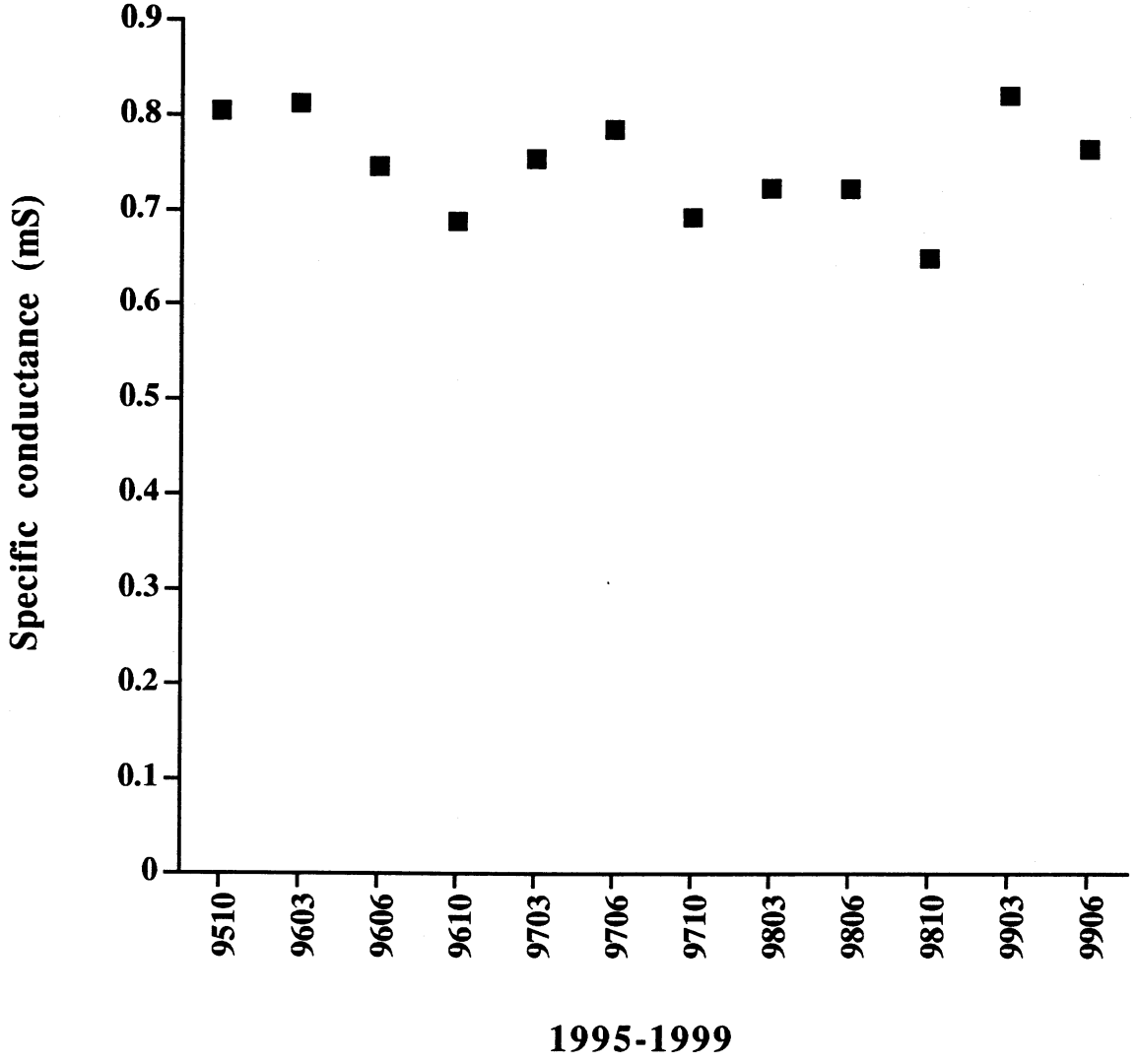

Figure 3. Specific conductance (mS) collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

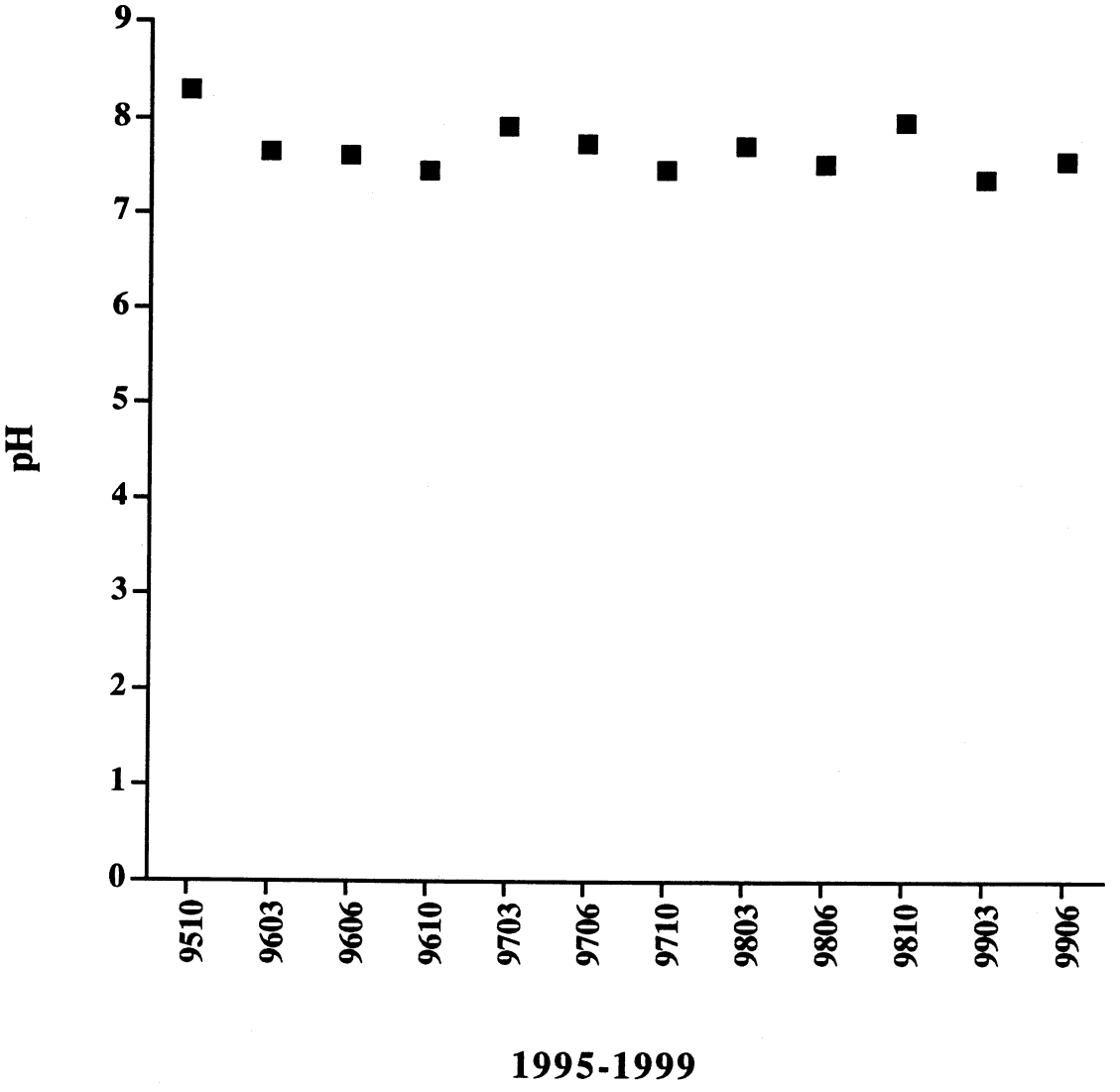

Figure 4. pH collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

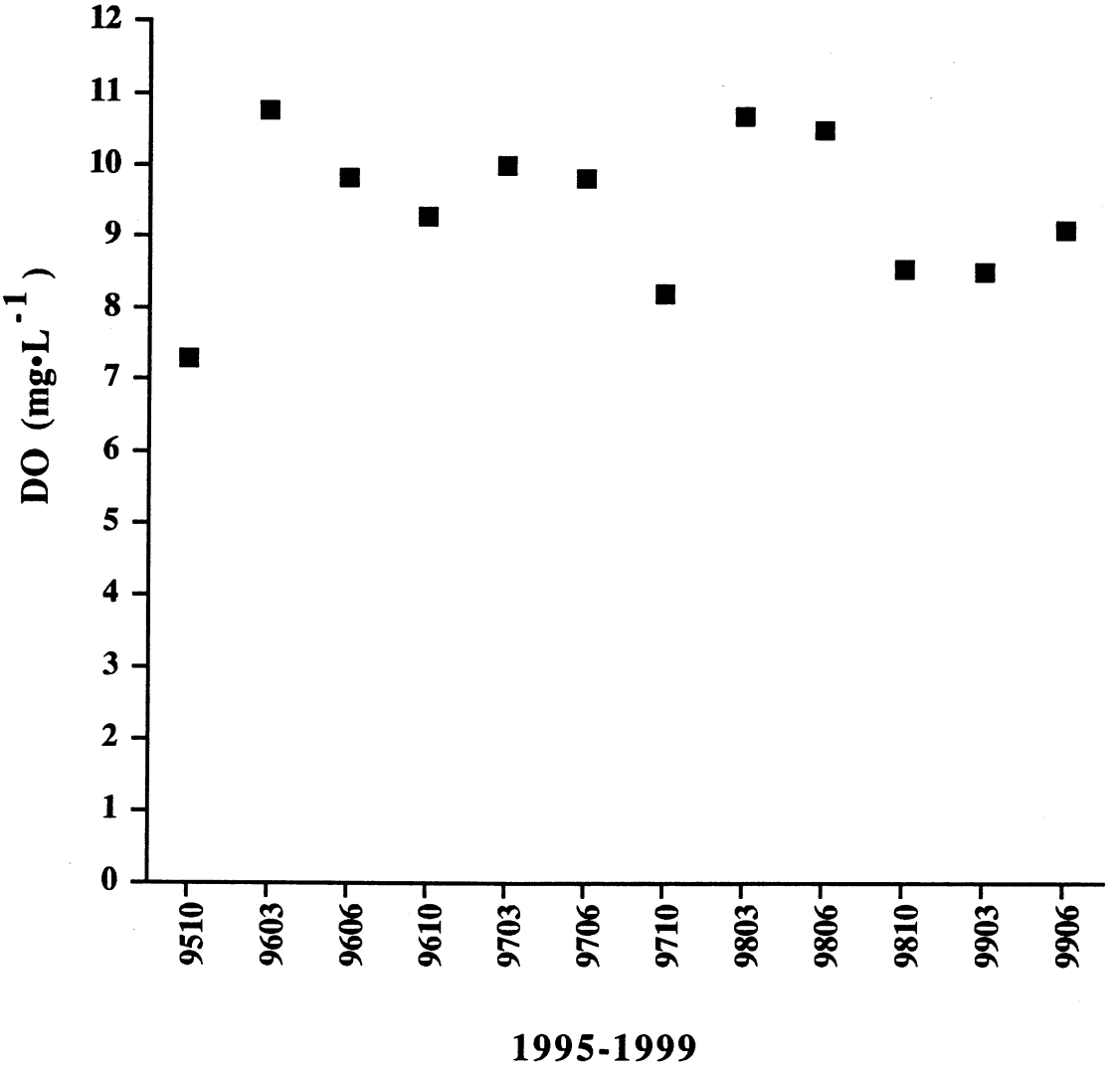

Figure 5. Dissolved oxygen ($mg \cdot L^{-1}$) collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

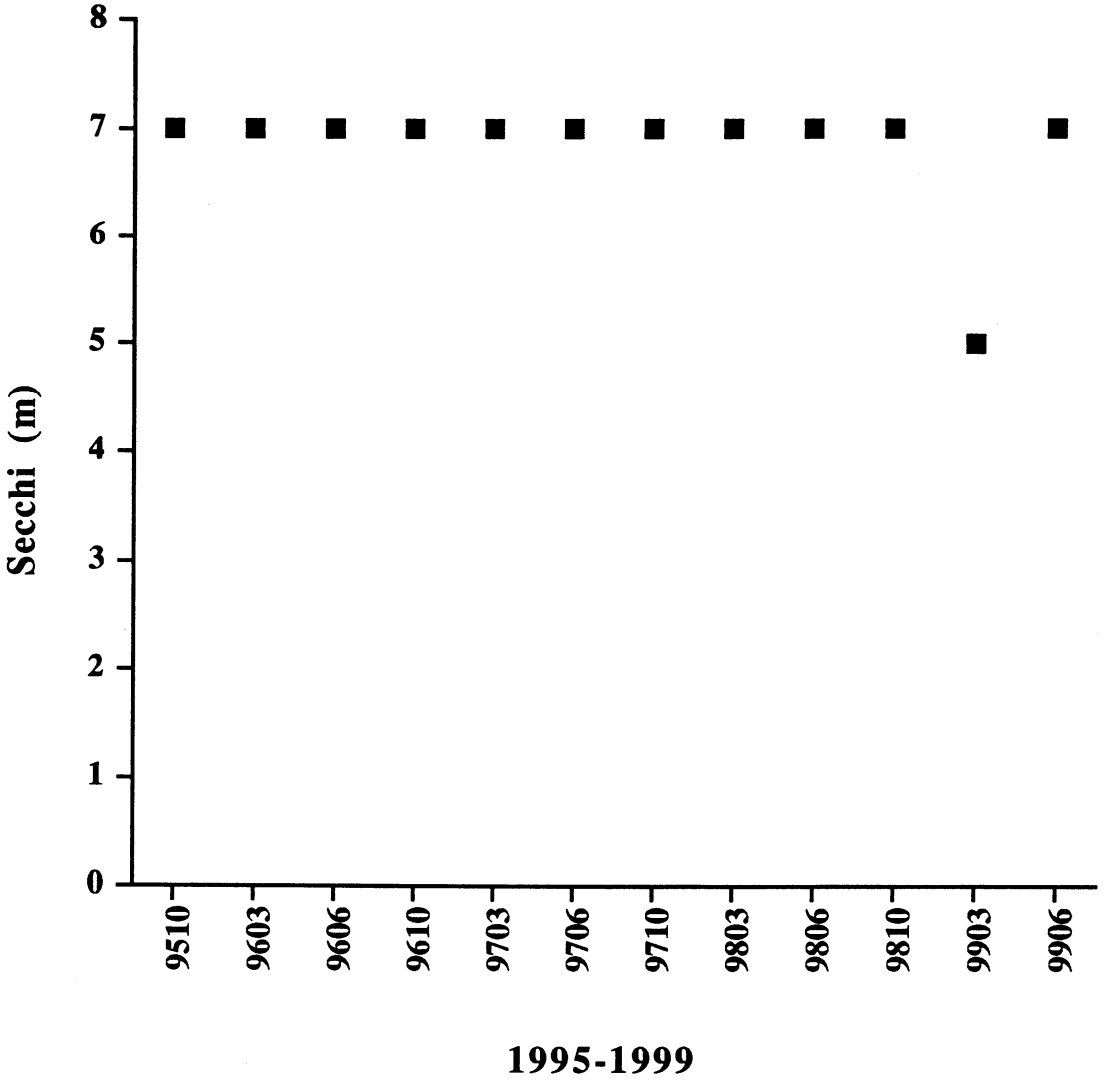

Figure 6. Secchi depth (m) collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

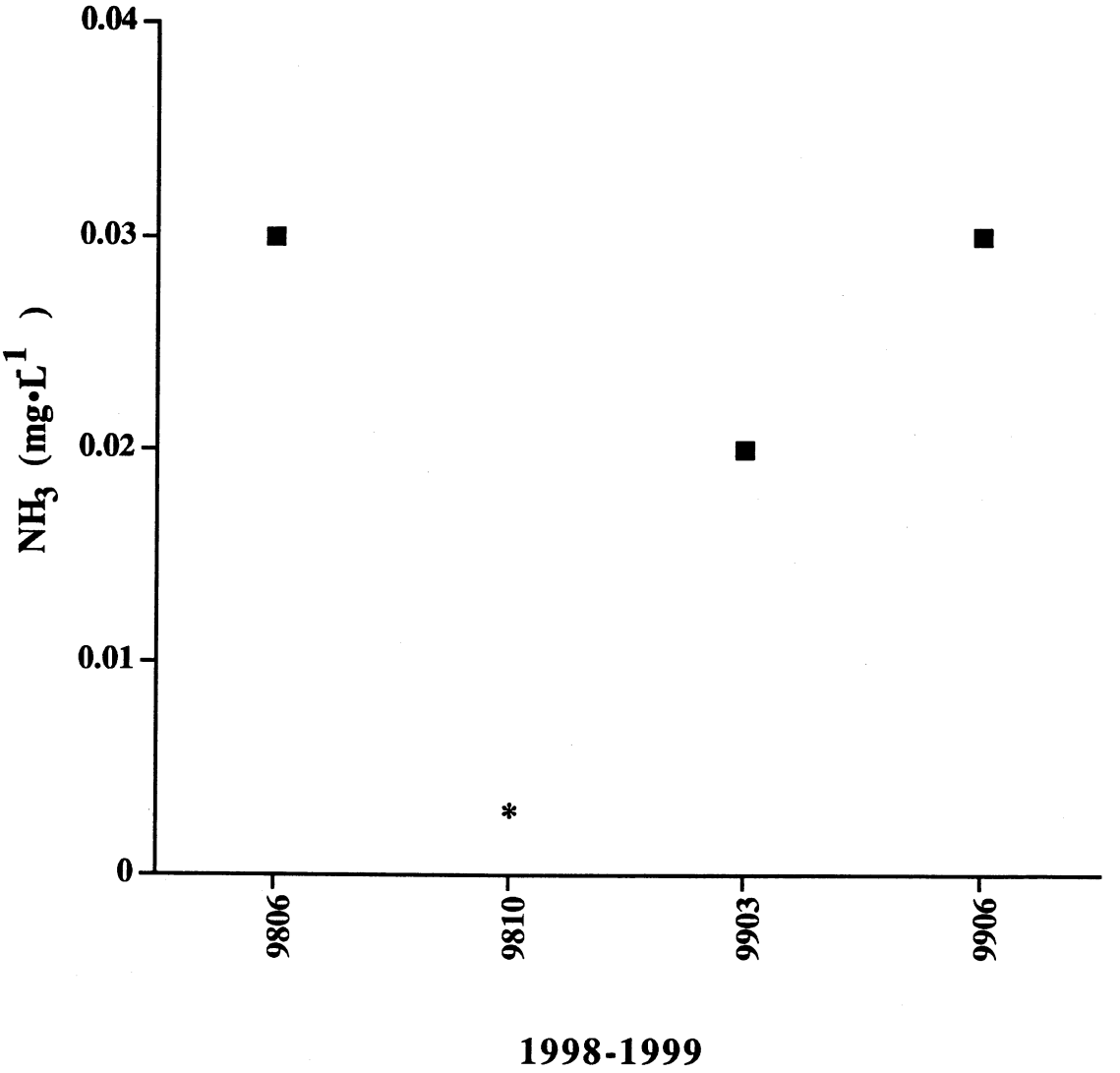

Figure 7. Ammonia (NH_3 mg•L^{-1}) collected at Glen Canyon Gauge Rkm -23.2 from June 1998 to June 1999. Samples below detectable levels are represented by (*).

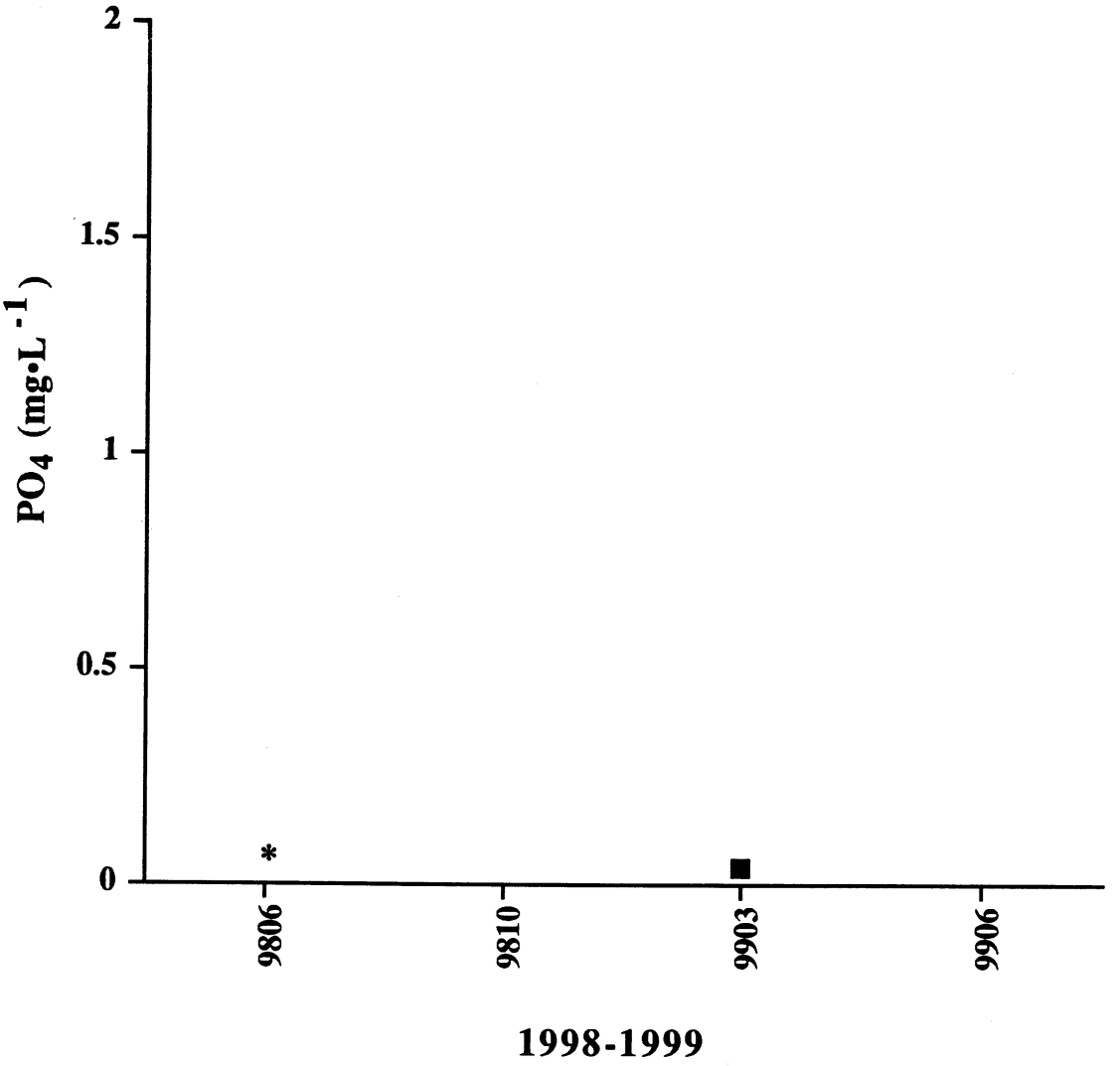

Figure 8. Phosphate (PO_4 mg•L^{-1}) collected at Glen Canyon Gauge Rkm -23.2 from June 1998 to June 1999. Samples below detectable levels are represented by (*).

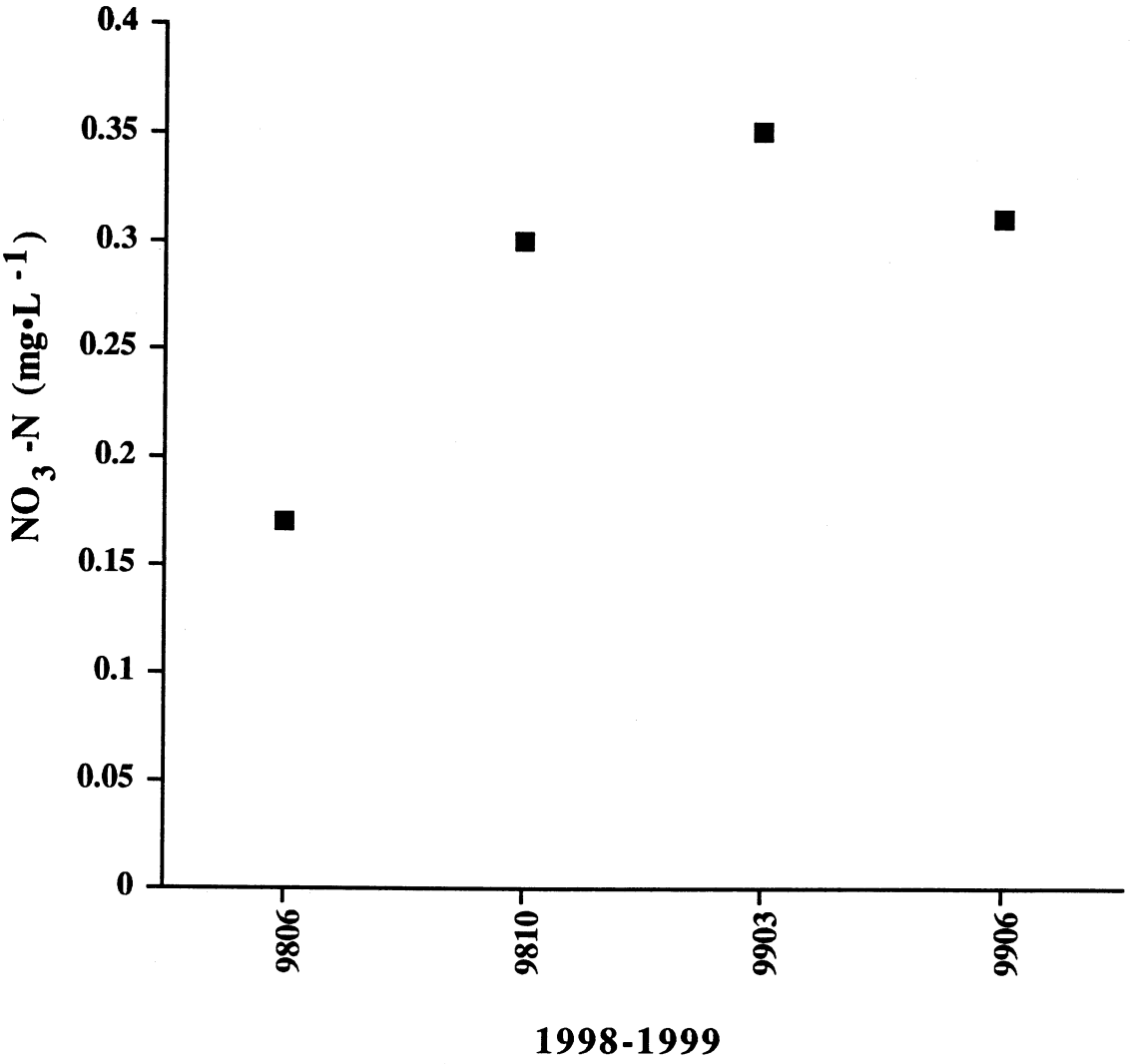

Figure 9. Nitrate-nitrogen (NO_3-N mg•L^{-1}) collected at Glen Canyon Gauge Rkm -23.2 from June 1998 to June 1999.

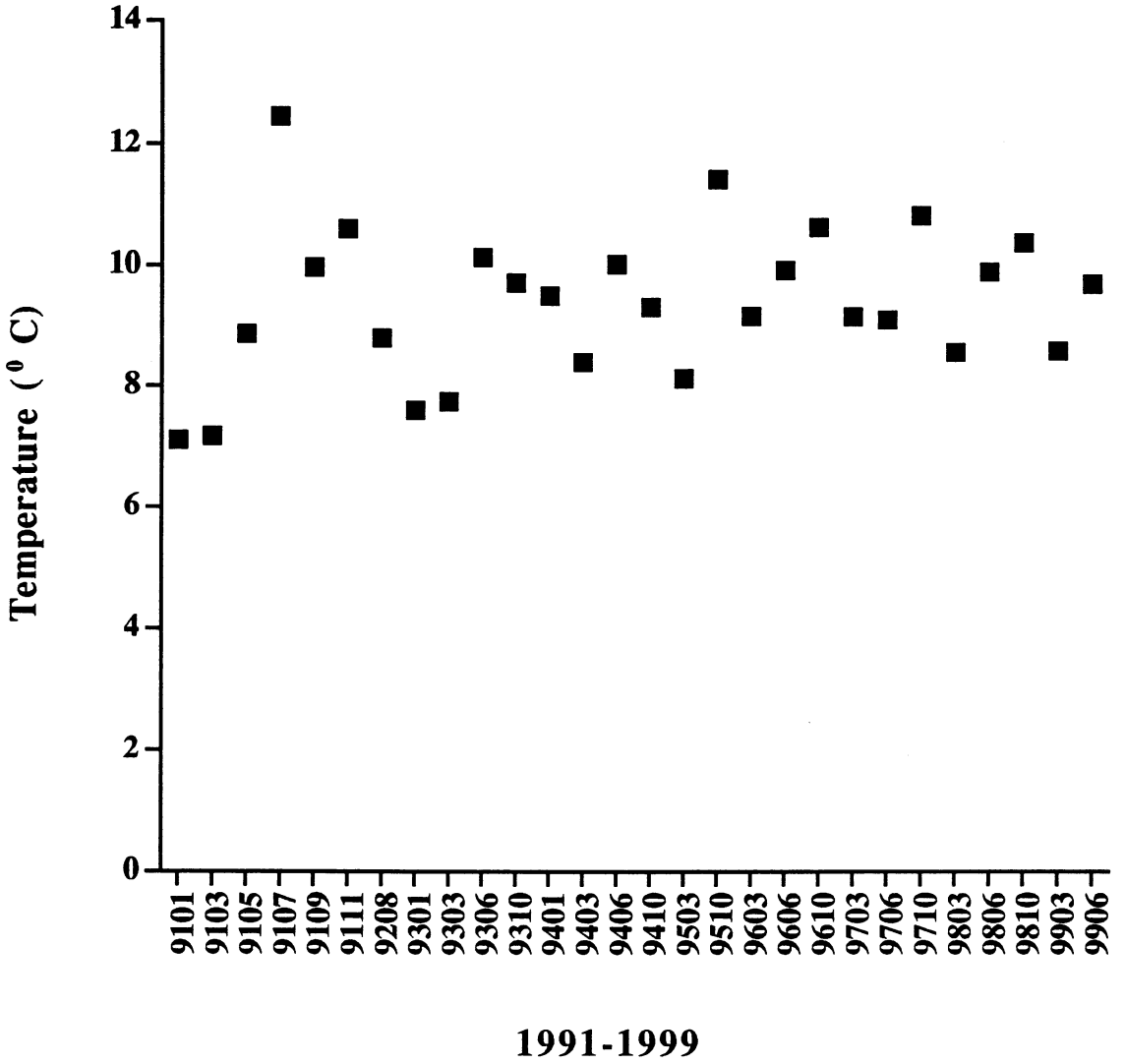

Figure 10. Water temperature (^{0}C) collected at Lees Ferry Rkm 0.0 from January 1991 to June 1999.

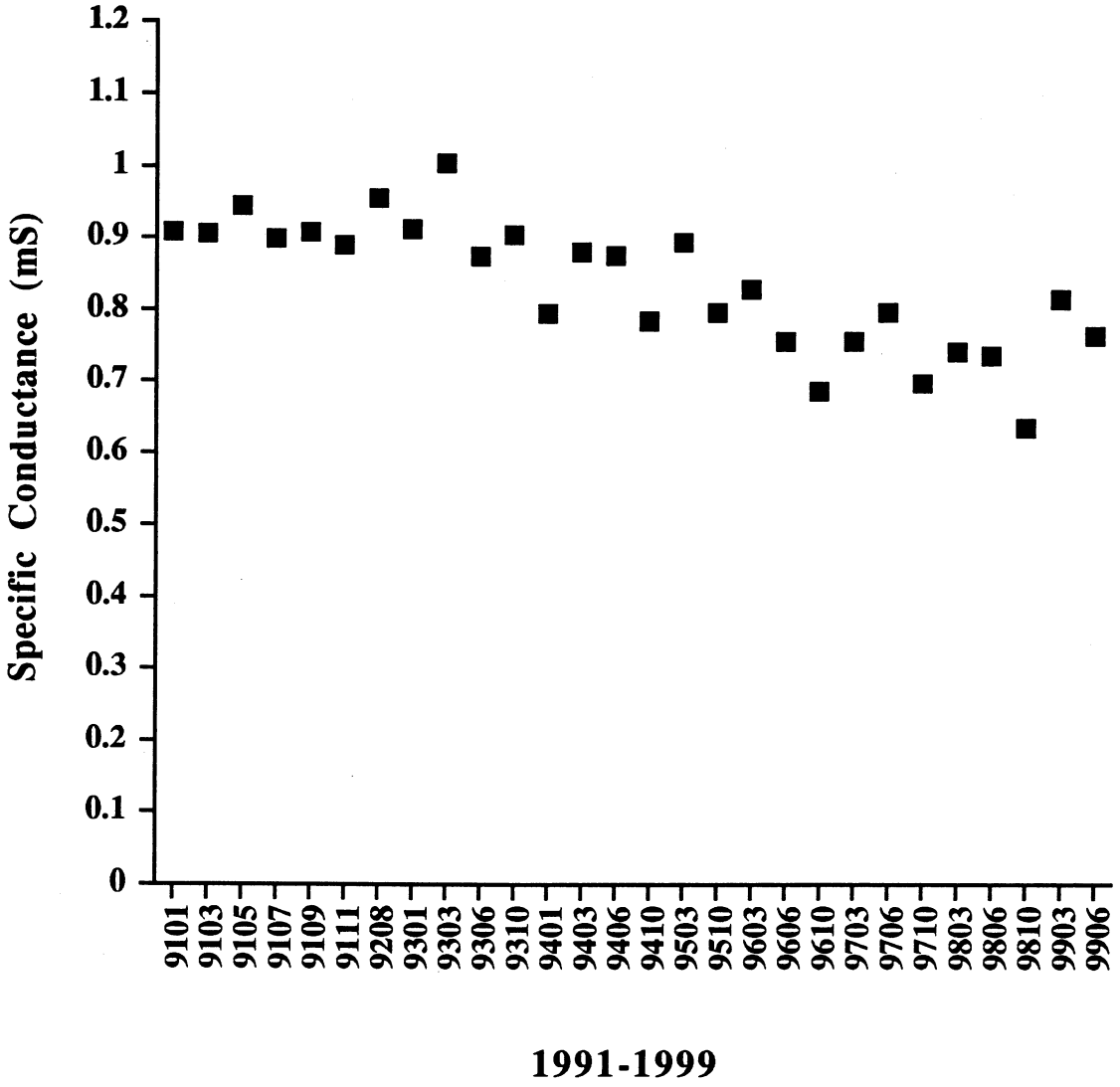

Figure 11. Specific conductance (mS) collected at Lees Ferry Rkm 0.0 from January 1991 to June 1999.

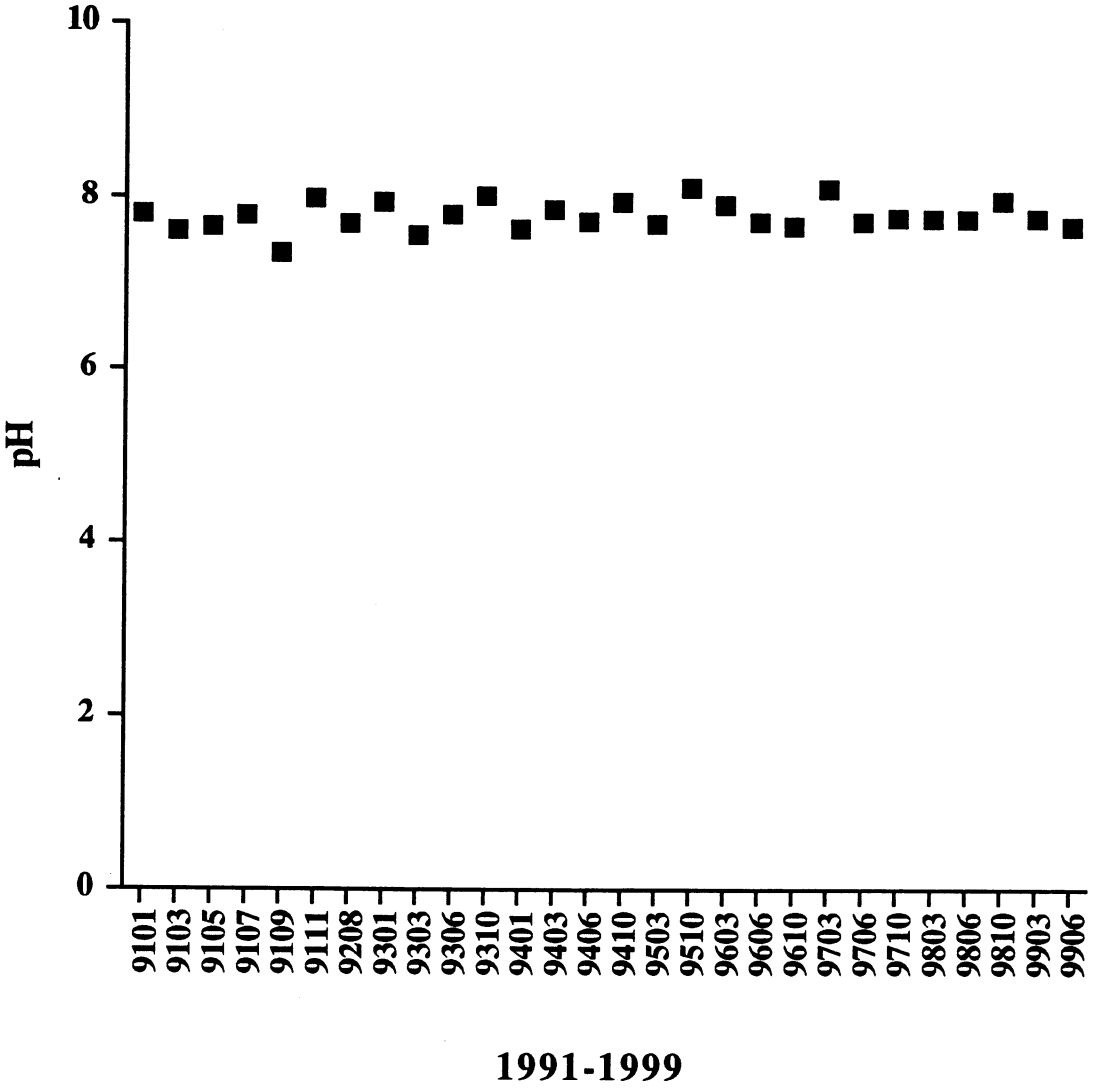

Figure 12. pH collected at Lees Ferry Rkm 0.0 from January 1991 to June 1999.

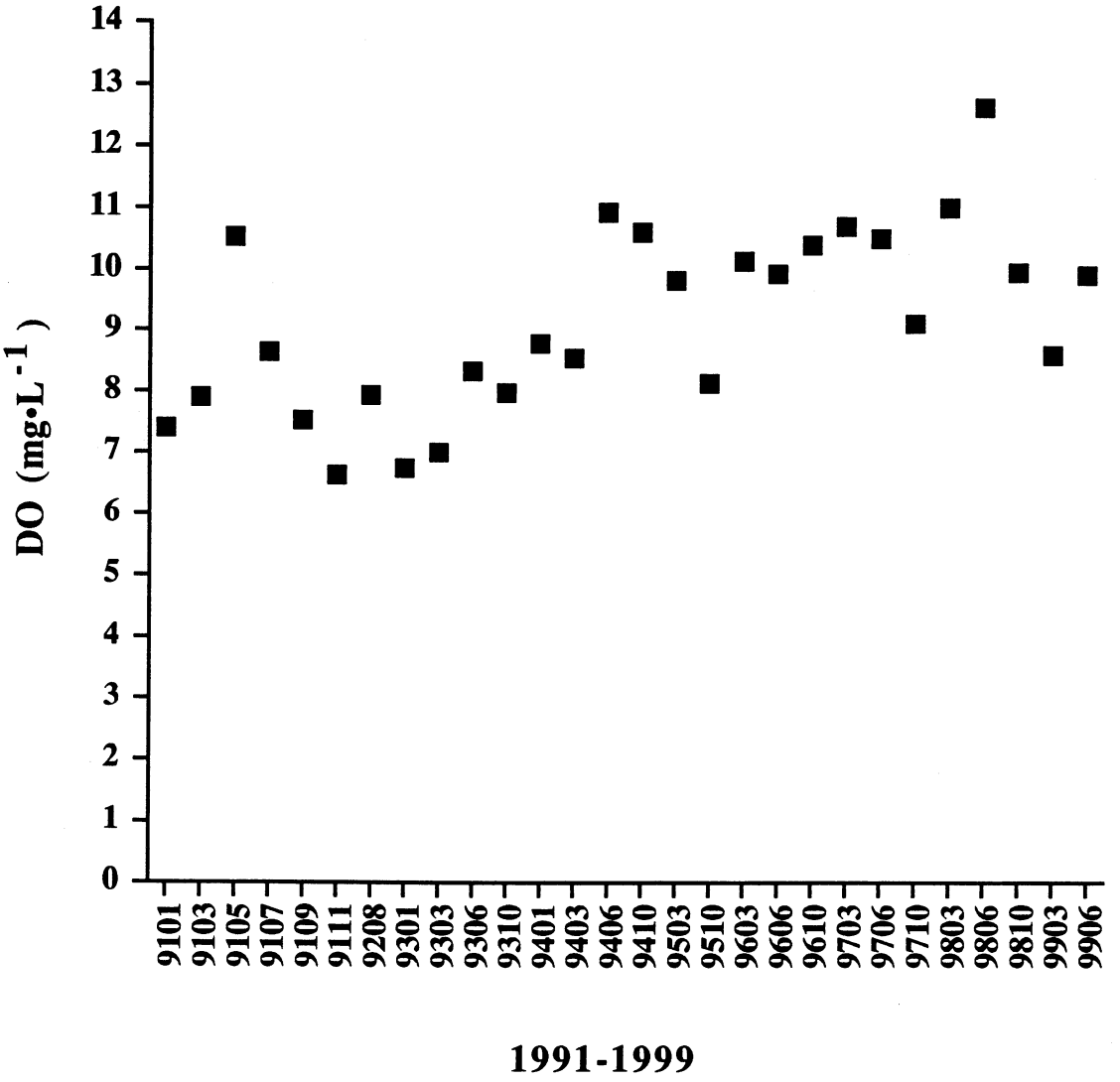

Figure 13. Dissolved oxygen ($mg \cdot L^{-1}$) collected at Lees Ferry Rkm 0.0 from January 1991 to June 1999.

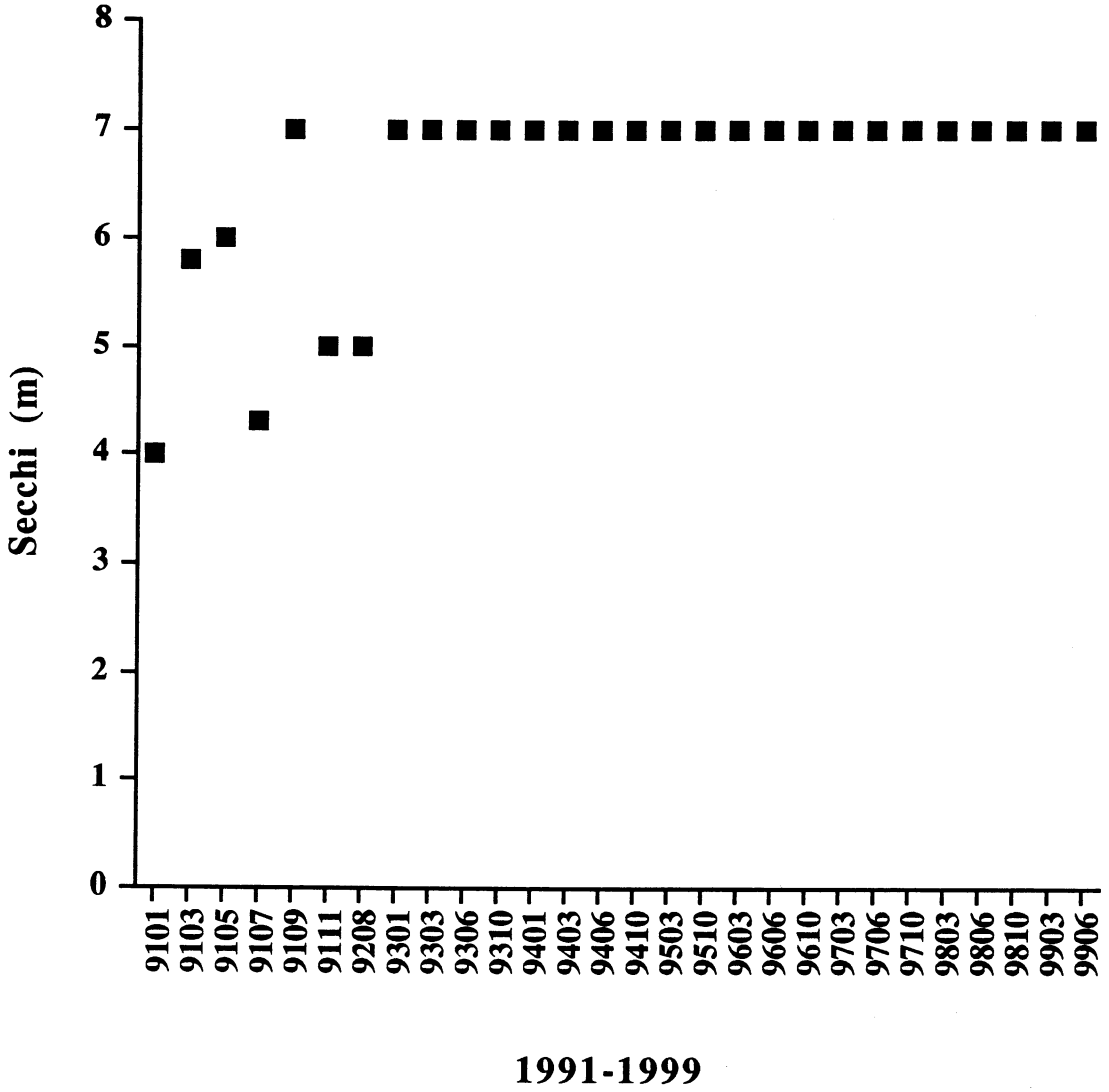

Figure 14. Secchi depth (m) collected at Lees Ferry Rkm 0.0 from January 1991 to June 1999. Lees Ferry clear water conditions allow Secchi depth readings to bottom of channel. Prior to 1992, high fluctuating flows decreased this depth to less than 7 meters.

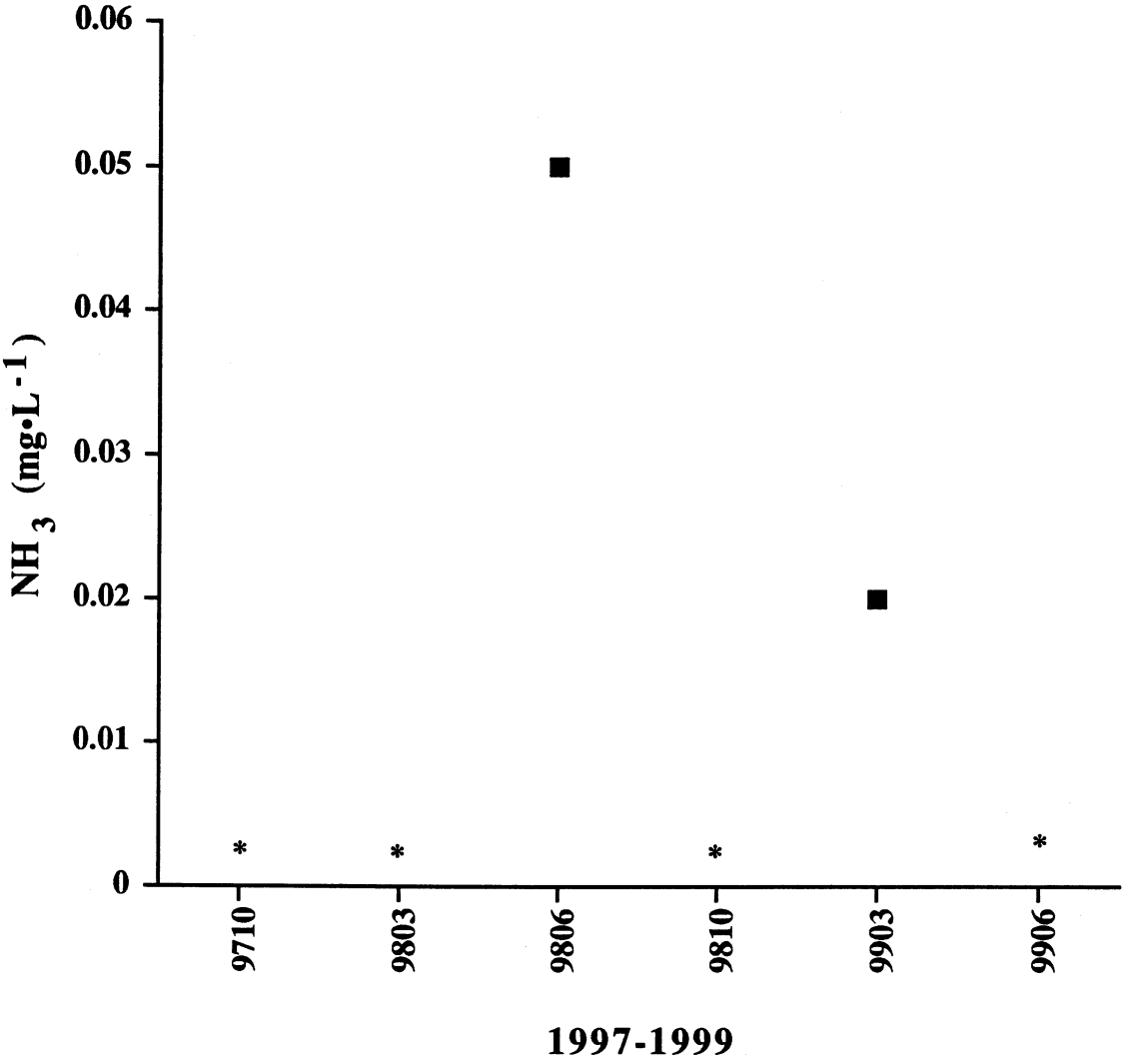

Figure 15. Ammonia (NH_3 mg•L^{-1}) collected at Lees Ferry Rkm 0.0 from October 1997 to June 1999. Samples below detectable levels are represented by a (*).

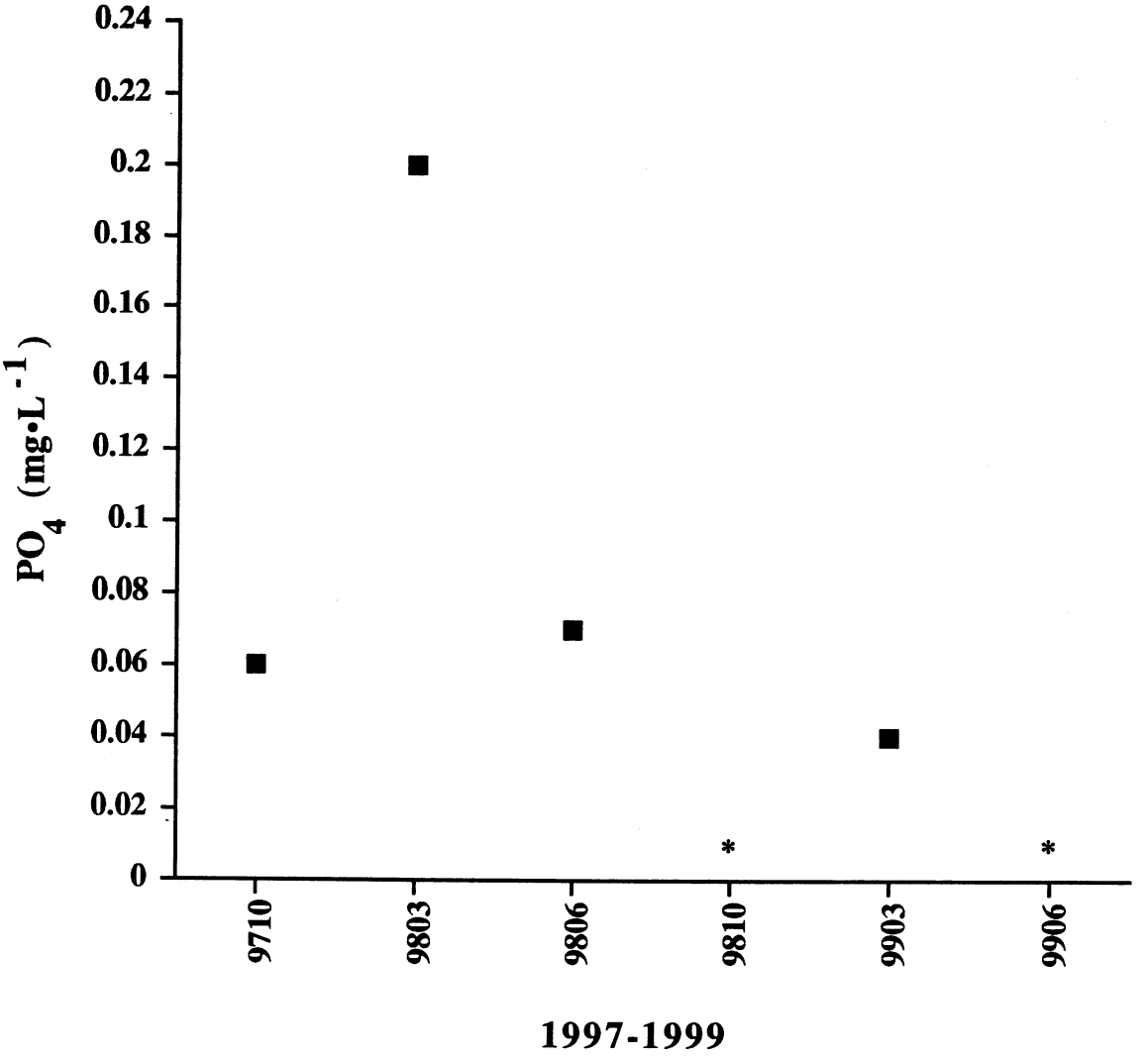

Figure 16. Phosphate (PO_4 mg•L $^{-1}$) collected at Lees Ferry Rkm 0.0 from October 1997 to June 1999. Samples below detectable levels are represented be a (*).

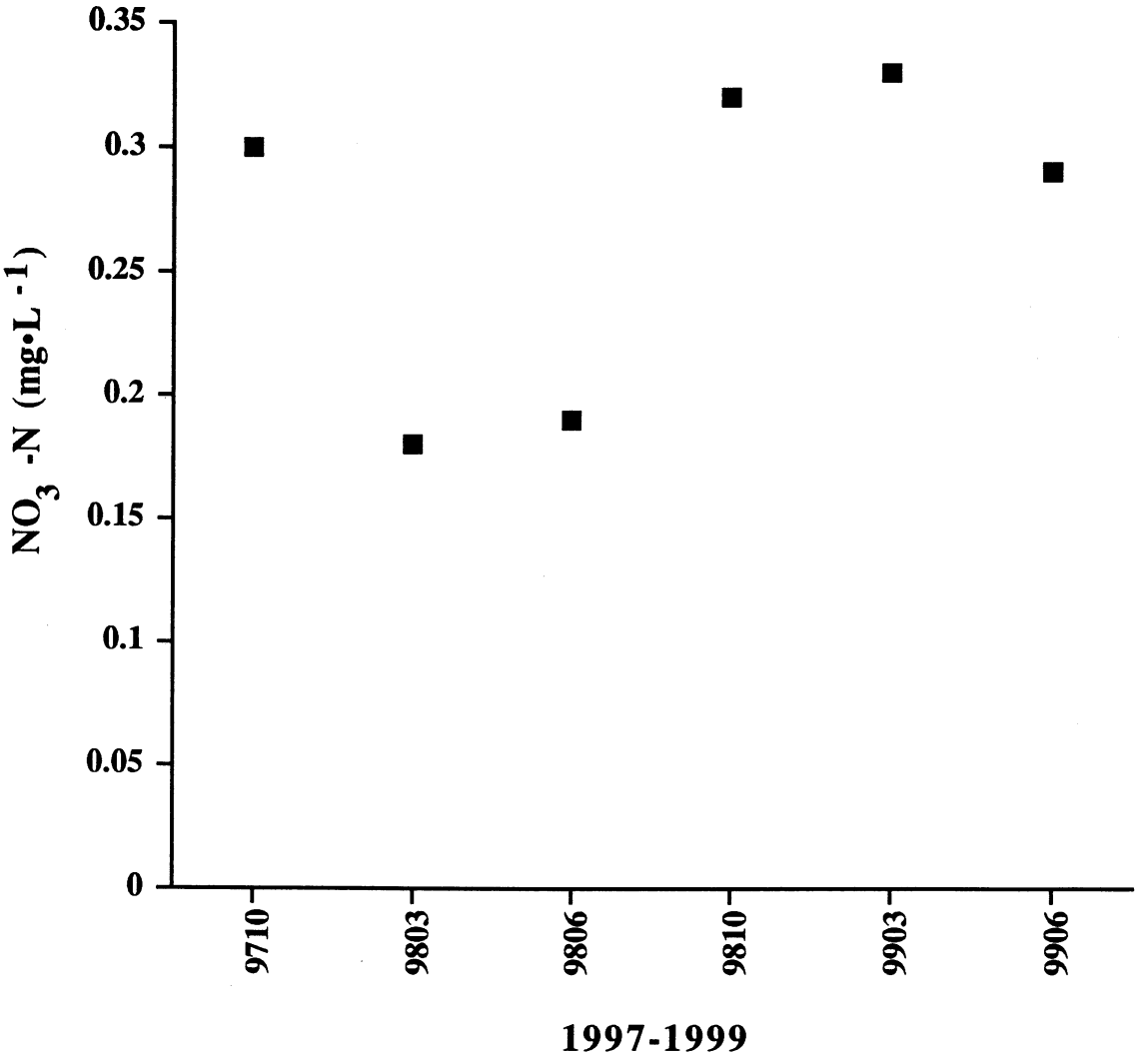

Figure 17. Nitrate-nitrogen (NO_3-N mg•L^{-1}) collected at Lees Ferry Rkm 0.0 from October 1997 to June 1999.

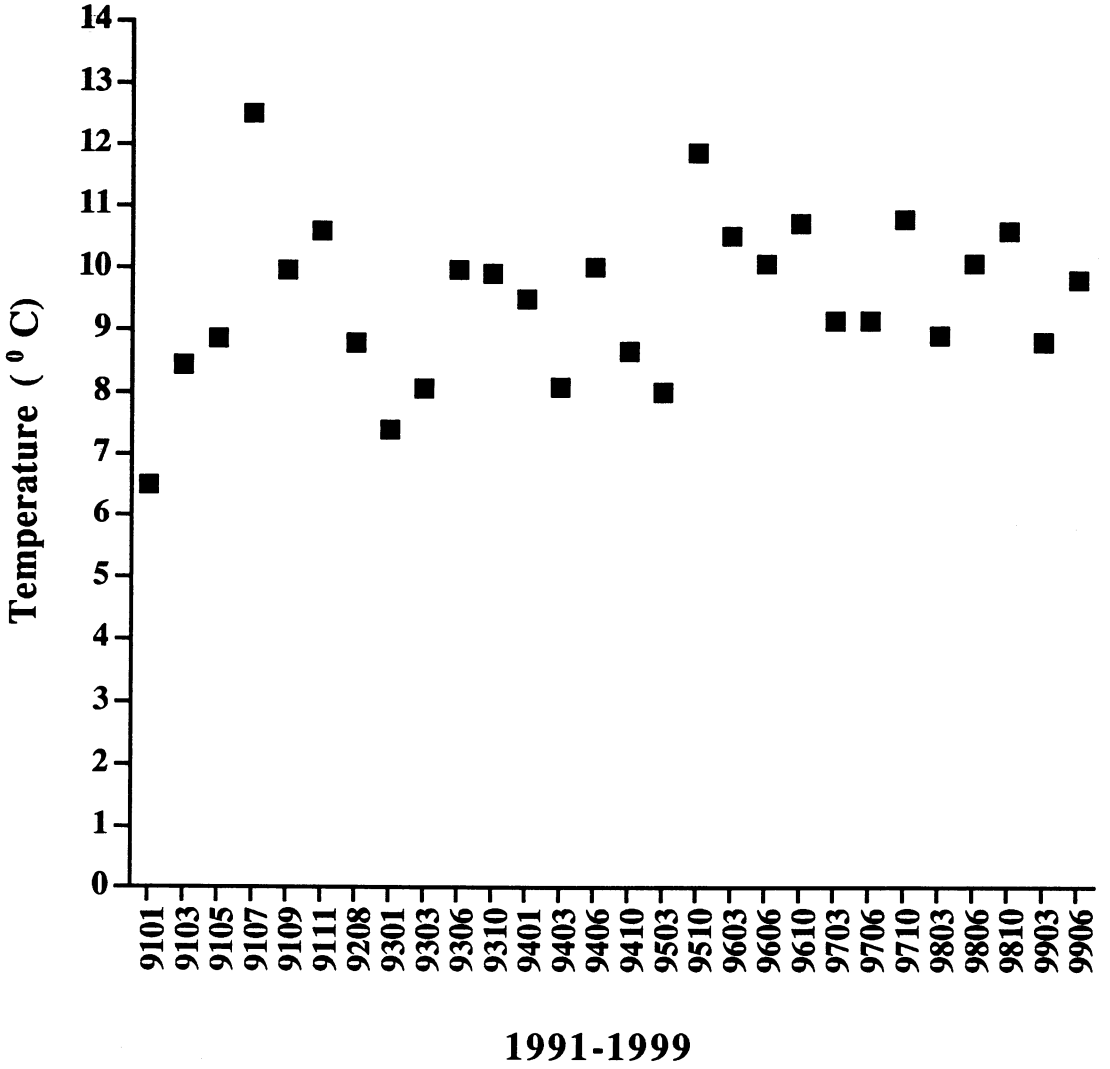

Figure 18. Water temperature (⁰C) collected at Two-Mile Wash Rkm 3.1 from January 1991 to June 1999.

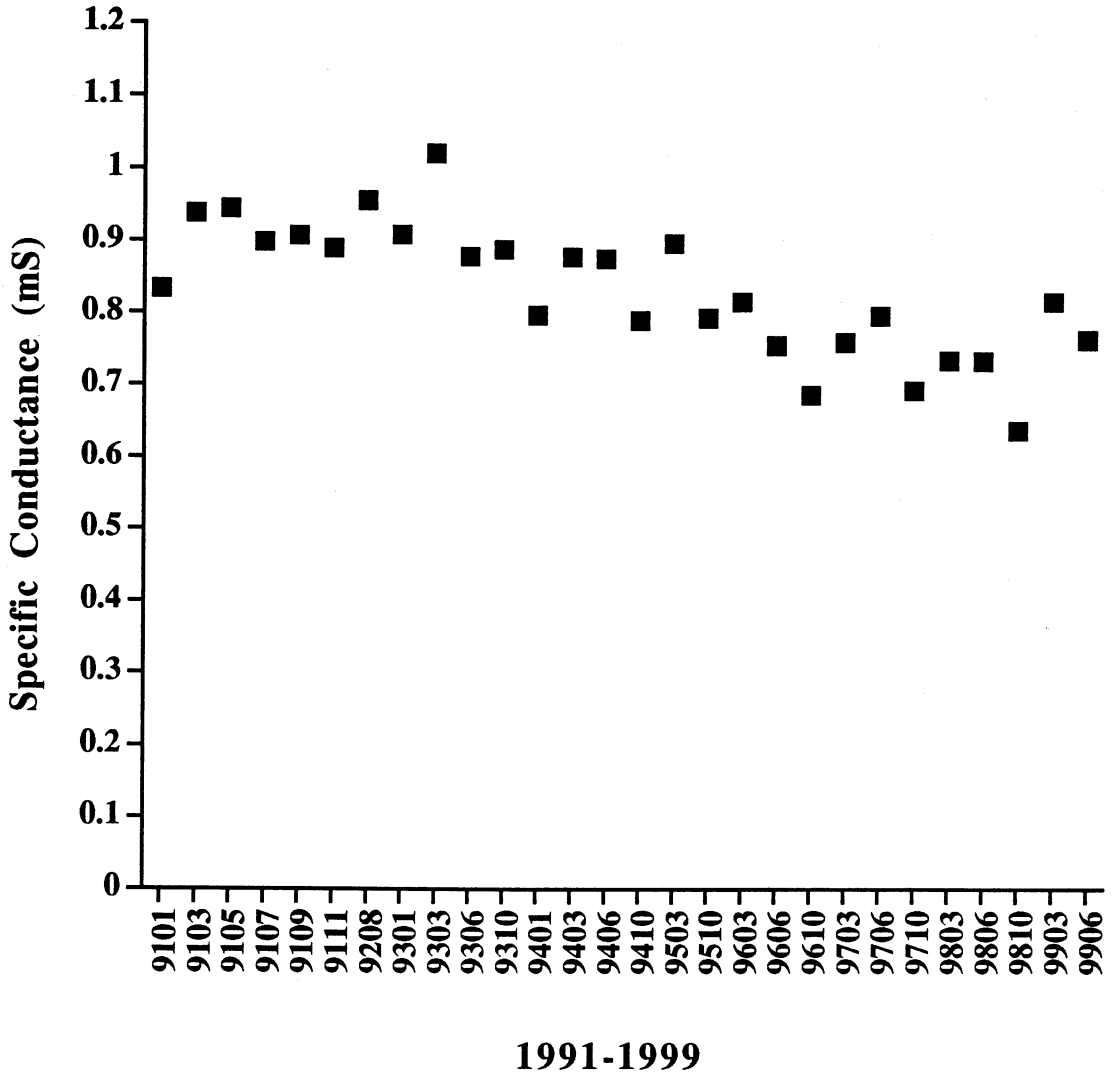

Figure 19. Specific conductance (mS) collected at Two-Mile Wash Rkm 3.1 from January 1991 to June 1999.

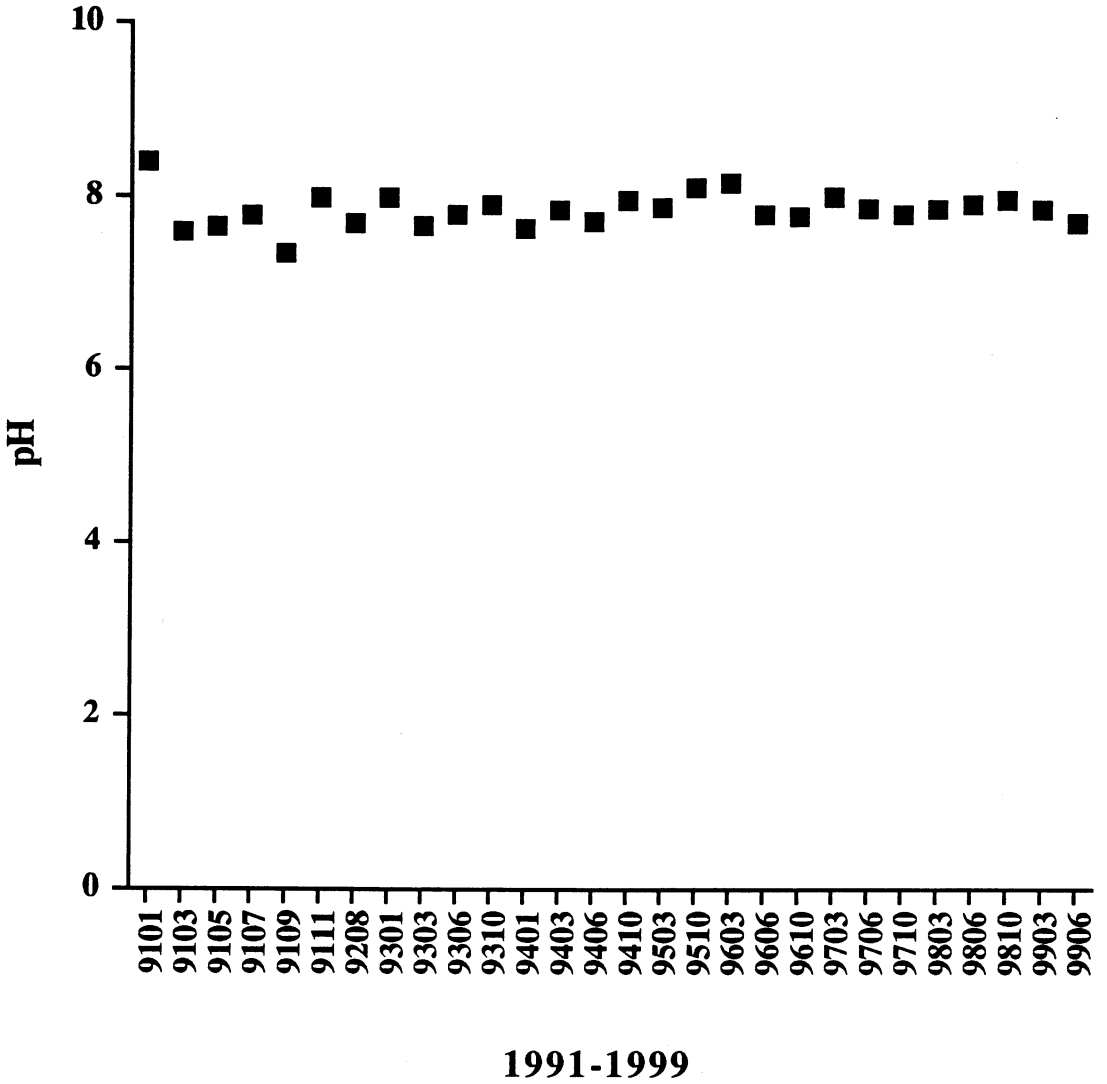

Figure 20. pH collected at Two-Mile Wash Rkm 3.1 from January 1991 to June 1999.

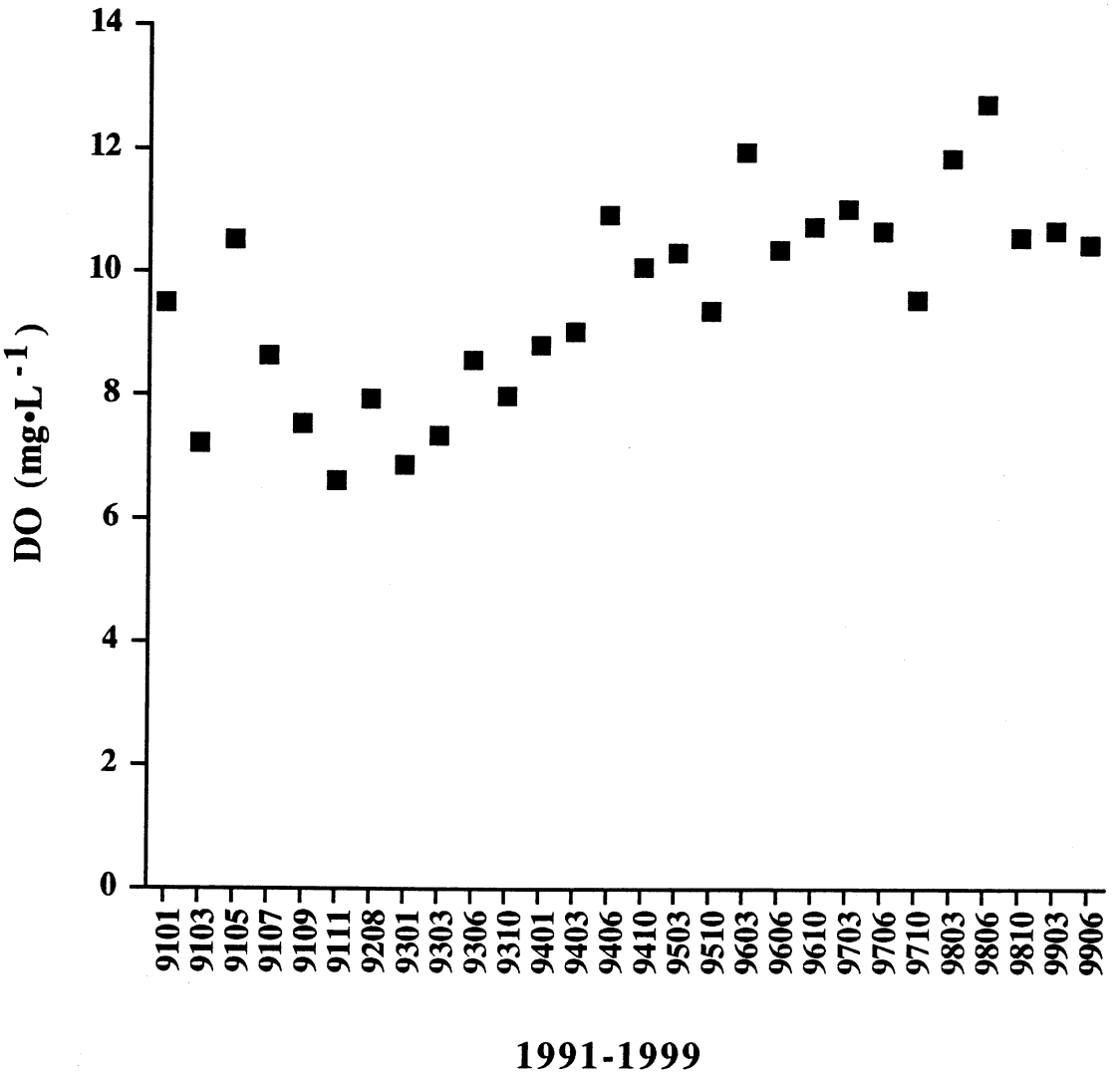

Figure 21. Dissolved oxygen ($mg \cdot L^{-1}$) collected at Two-Mile Wash Rkm 3.1 from January 1991 to June 1999.

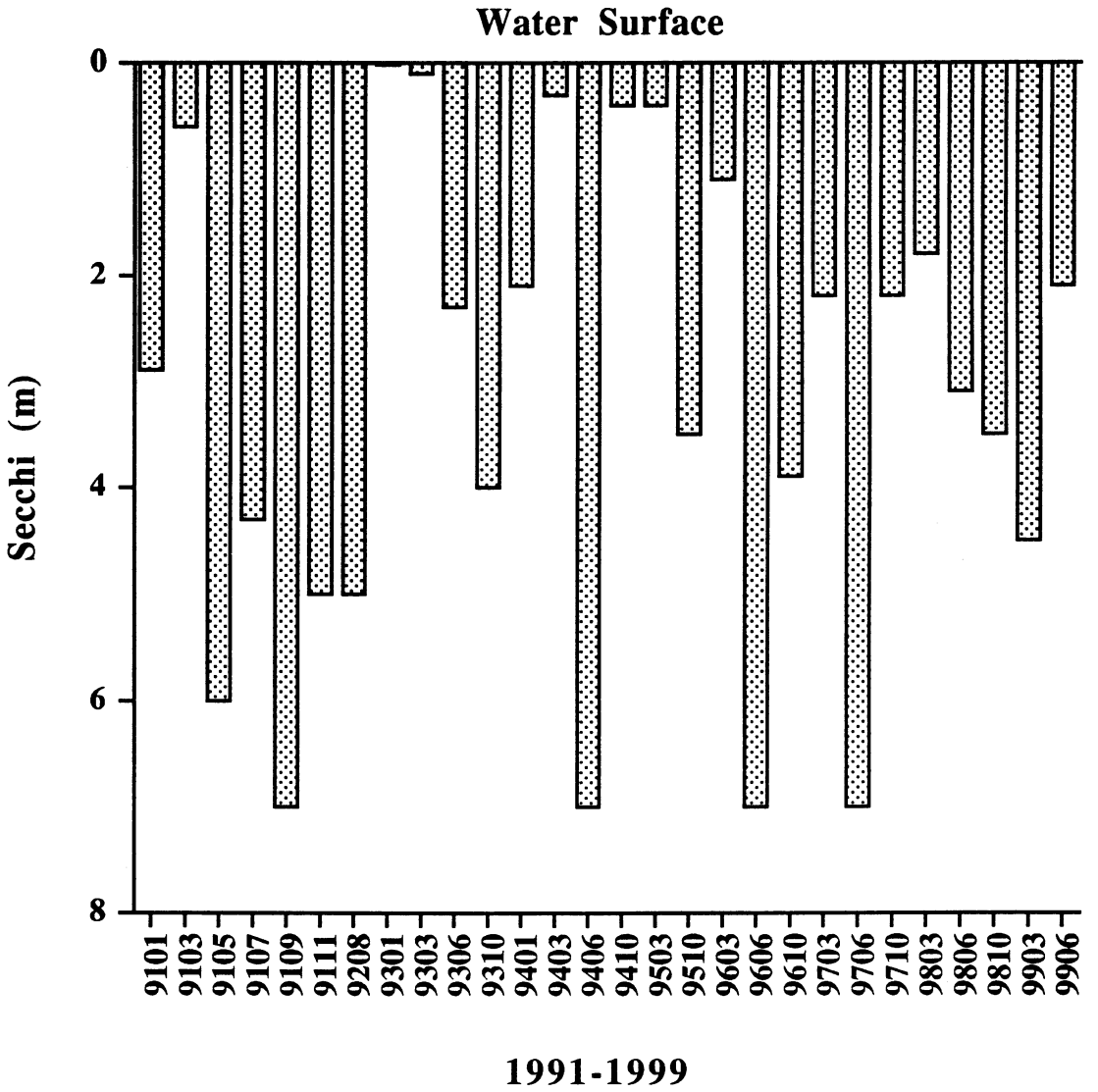

Figure 22. Secchi depth (m) collected at Two-Mile Wash Rkm 3.1 from January 1991 to June 1999.

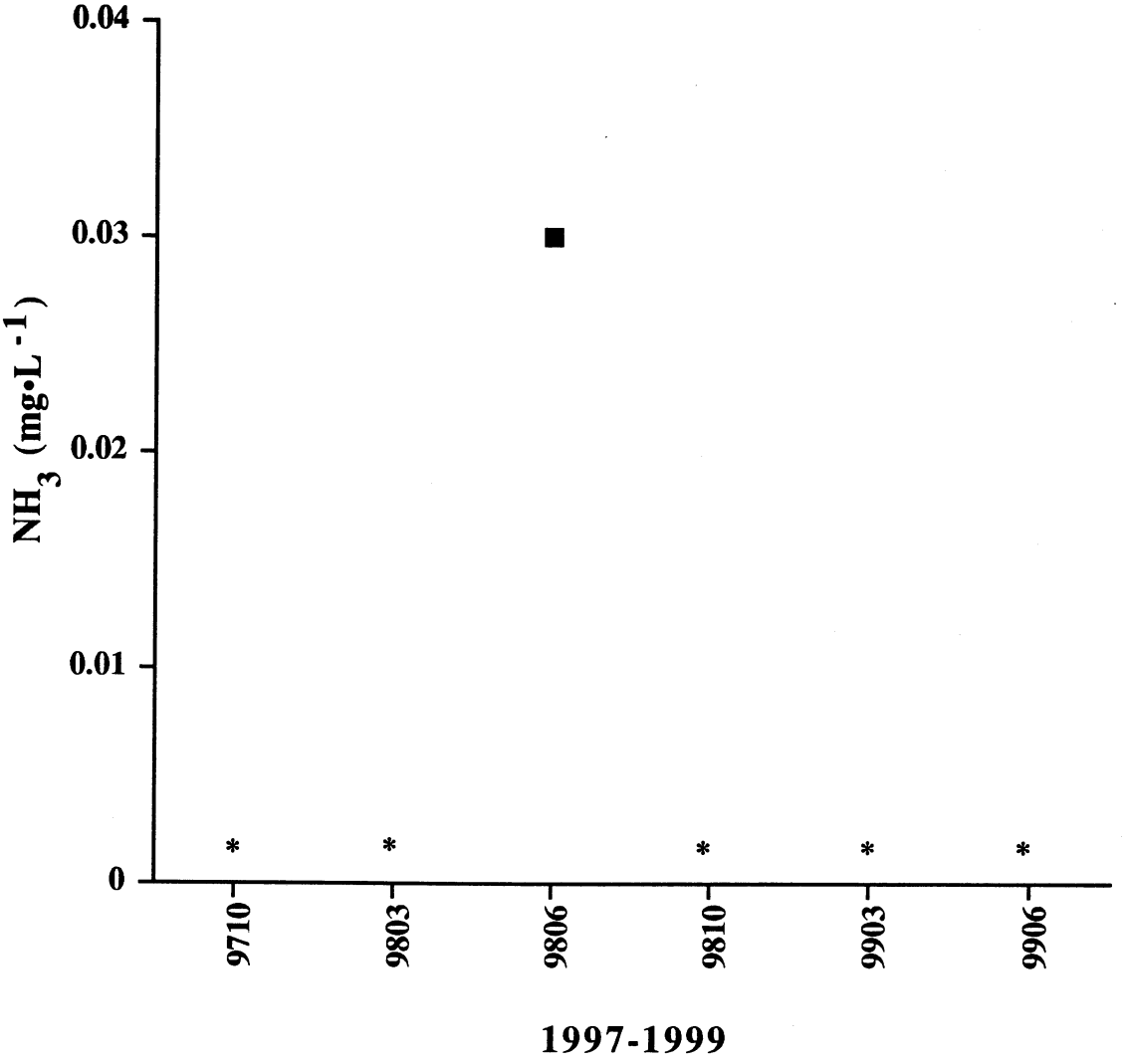

Figure 23. Ammonia (NH_3 mg•L^{-1}) collected at Two-Mile Wash Rkm 3.1 from October 1997 to June 1999. Samples below detectable levels are represented by a (*).

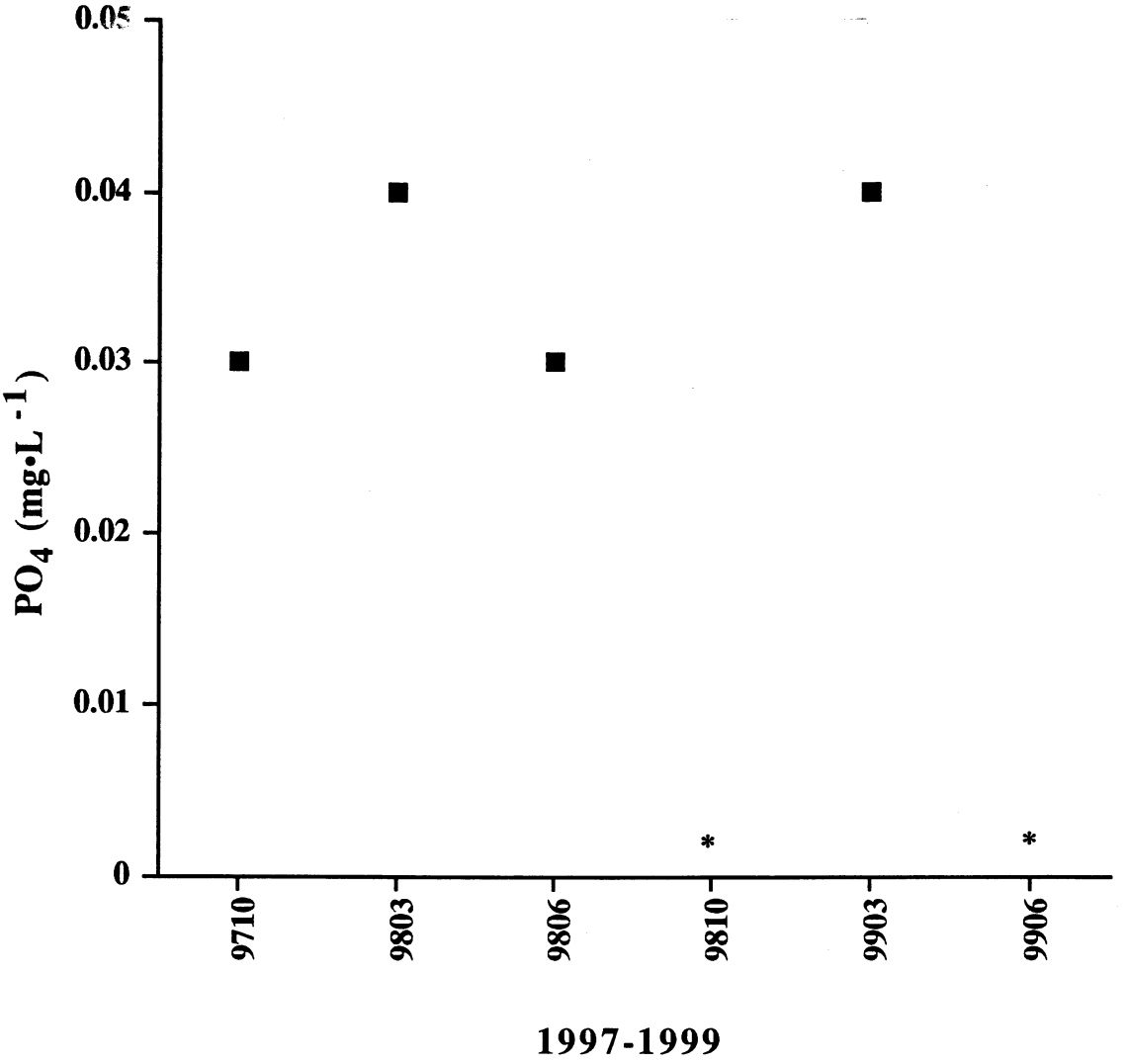

Figure 24. Phosphate (PO_4 mg•L^{-1}) collected at Two-Mile Wash Rkm 3.1 from October 1997 to June 1999.

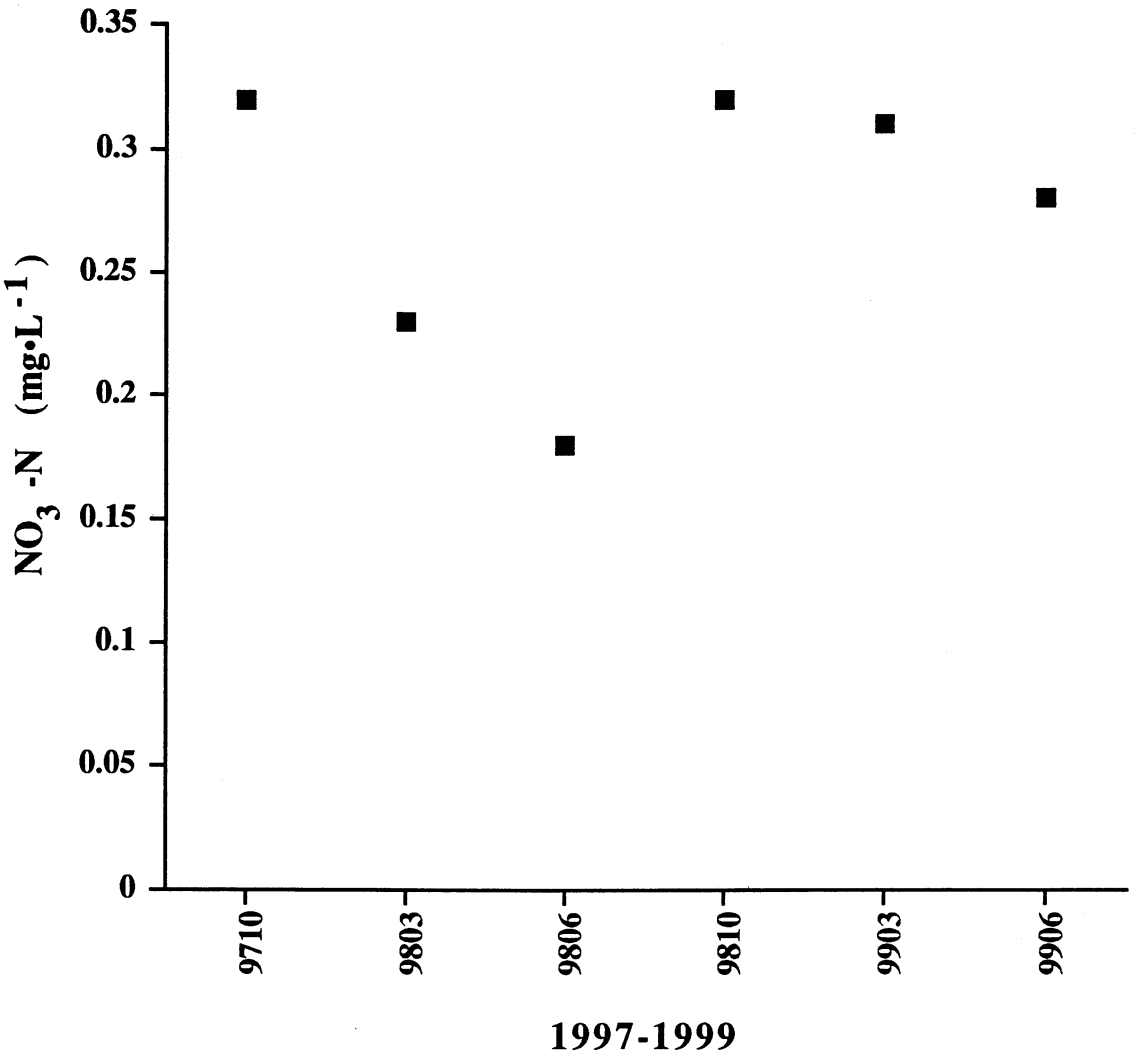

Figure 25. Nitrate-nitrogen (NO_3-N mg•L^{-1}) collected at Two-Mile Wash Rkm 3.1 from October 1997 to June 1999.

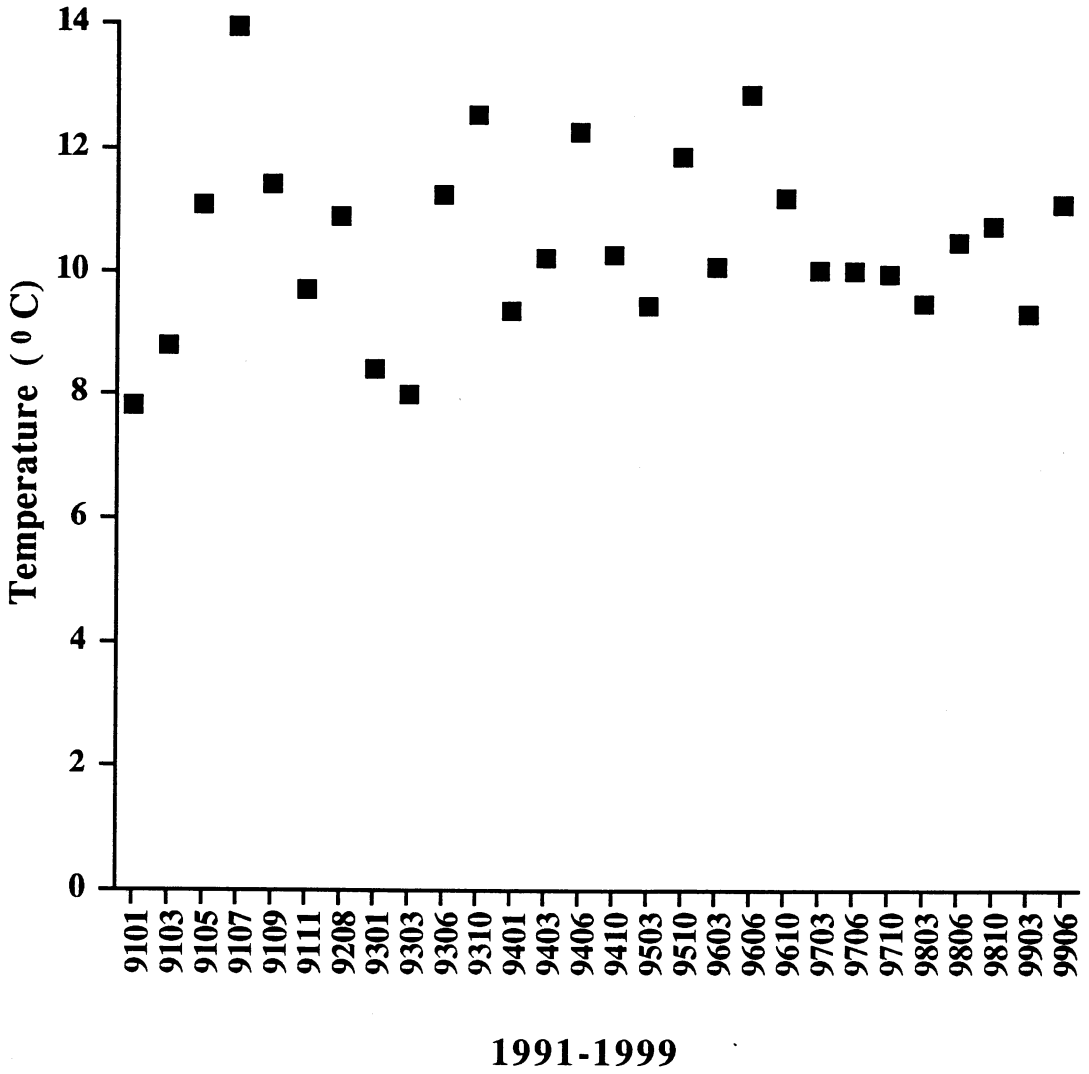

Figure 26. Water temperature (0C) collected at the Gauge Above LCR Rkm 98.4 from January 1991 to June 1999.

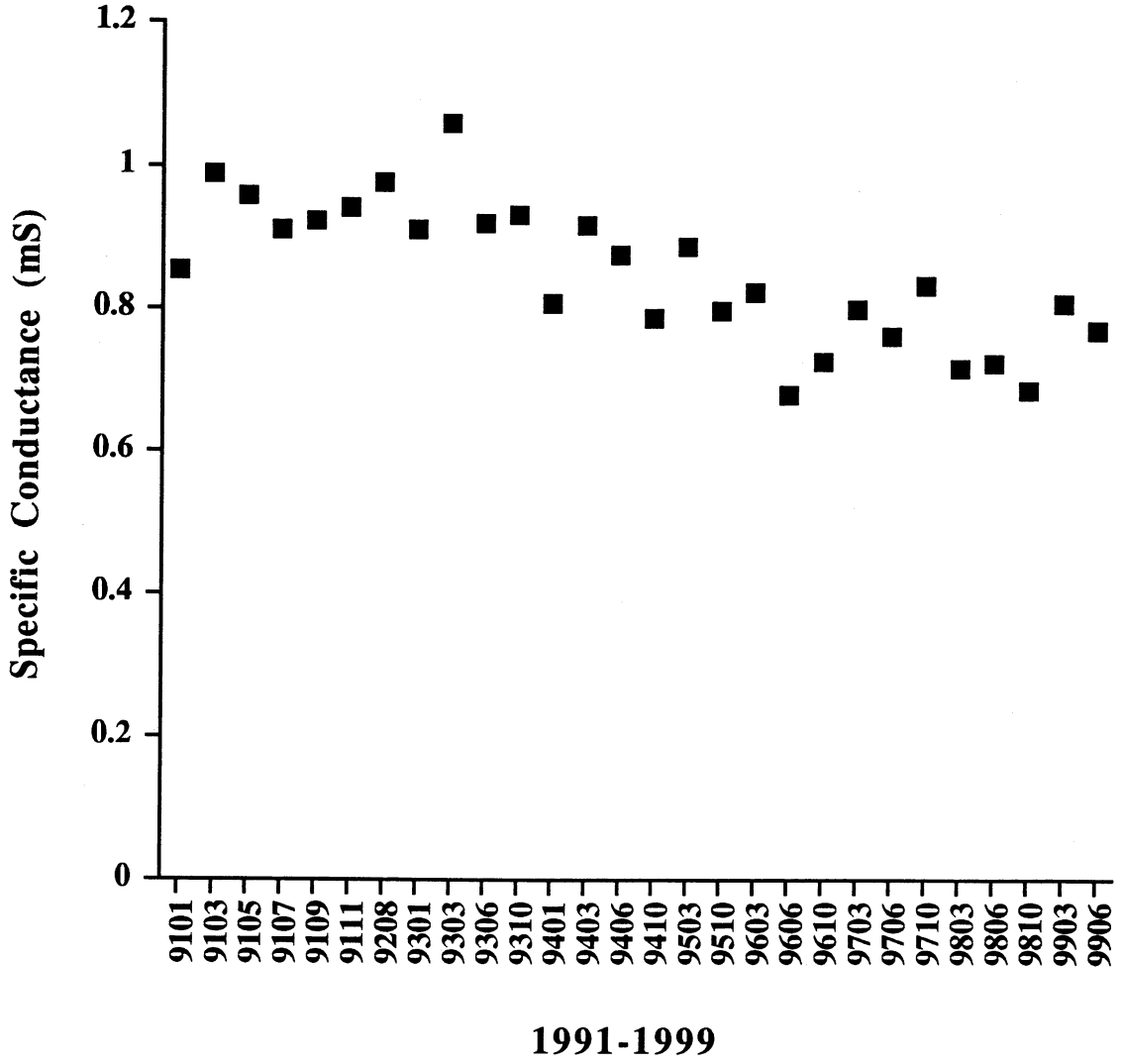

Figure 27. Specific conductance (mS) collected at the Gauge Above LCR Rkm 98.4 from January 1991 to June 1999.

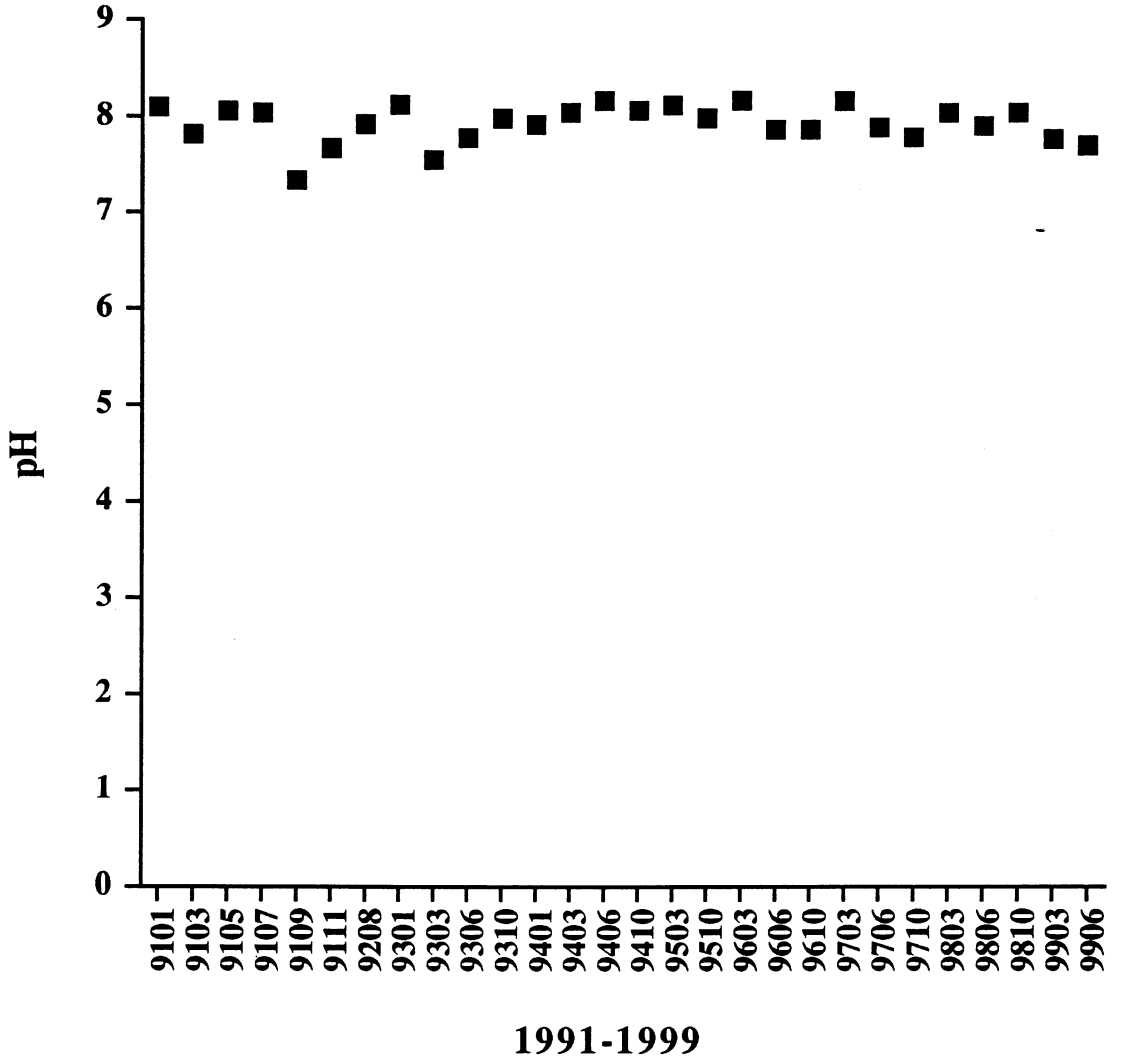

Figure 28. pH collected at the Gauge Above LCR Rkm 98.4 from January 1991 to June 1999.

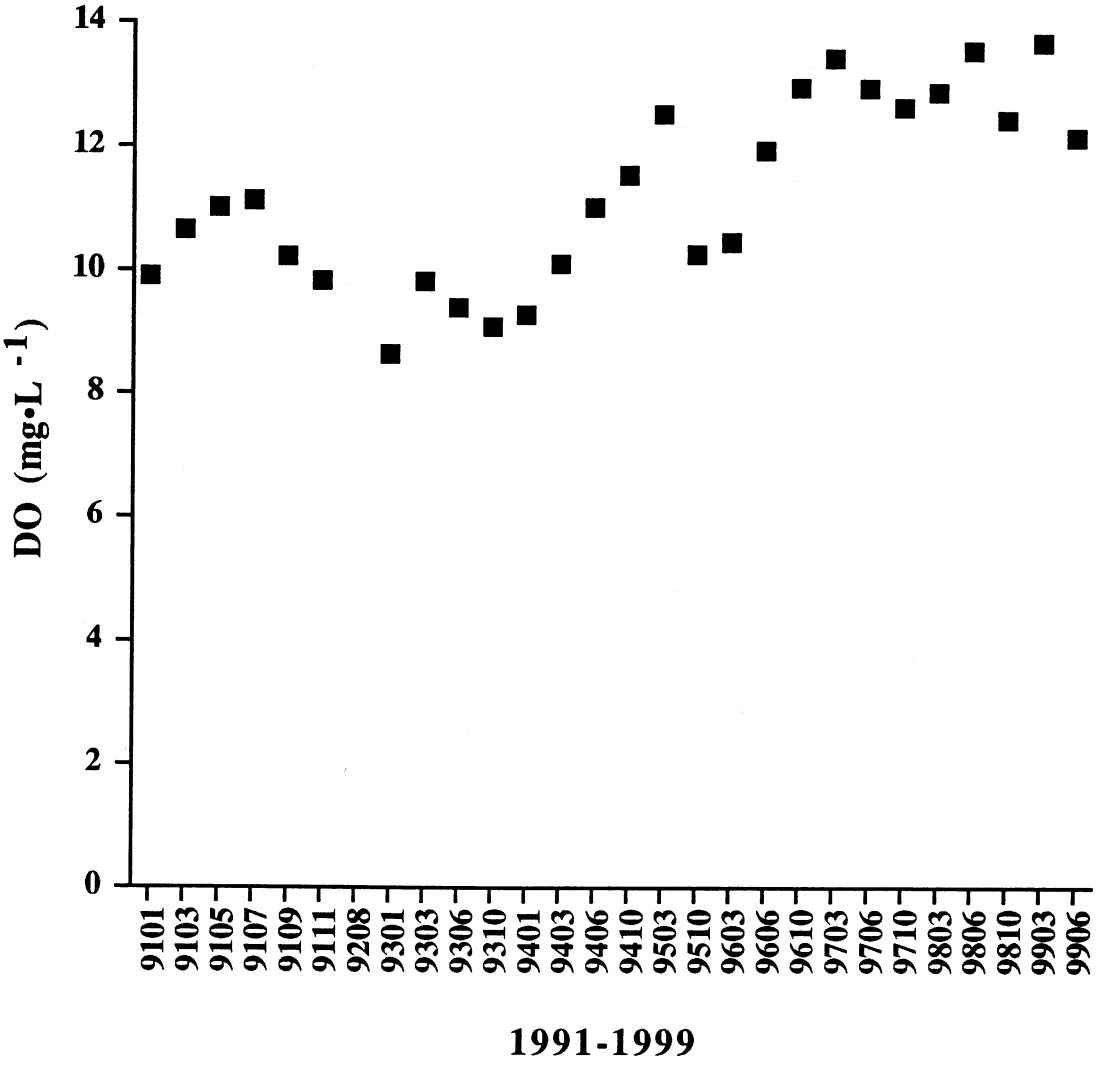

Figure 29. Dissolved oxygen (DO mg•L^{-1}) collected at the Gauge Above LCR Rkm 98.4 from January 1991 to June 1999.

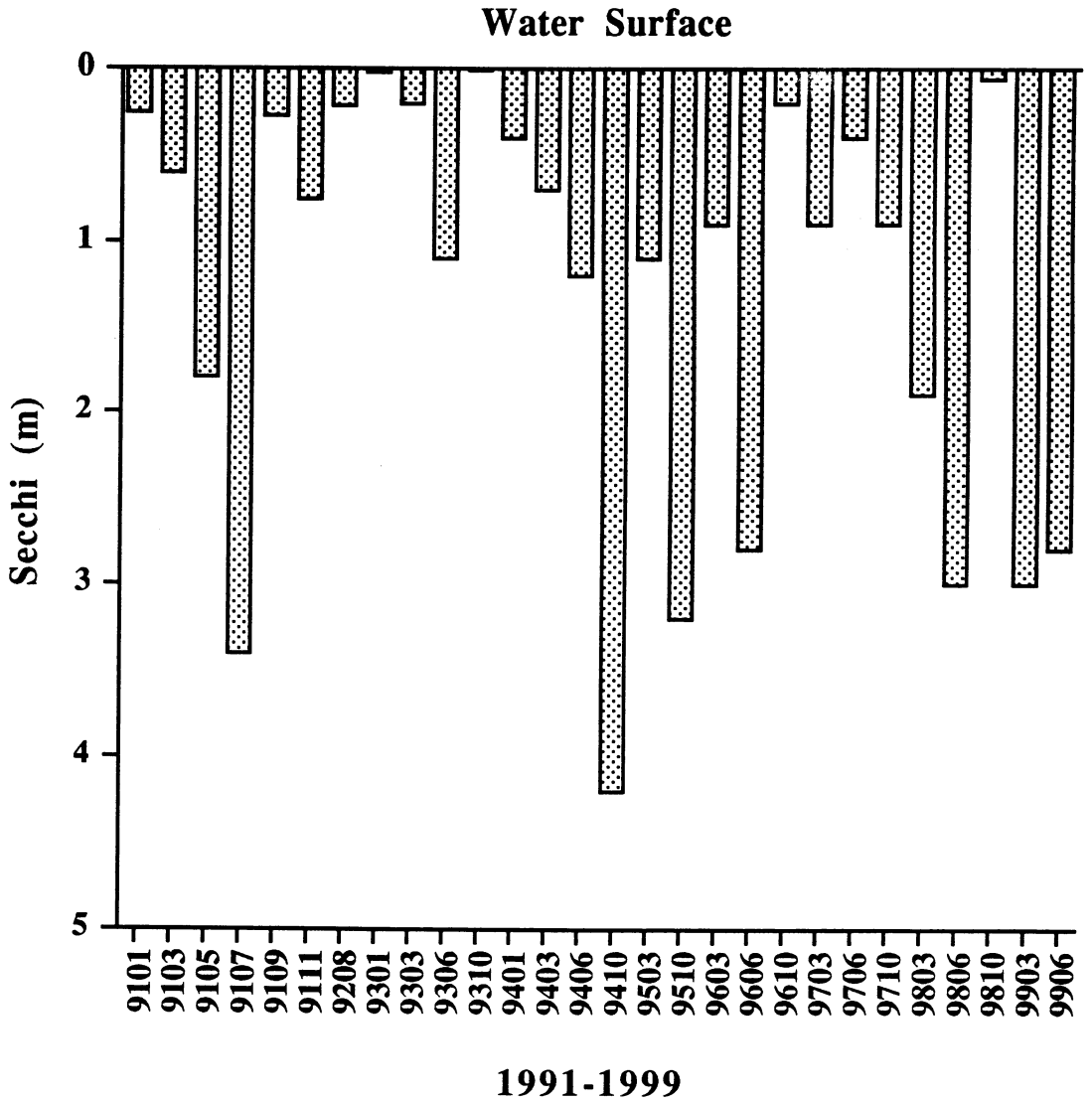

Figure 30. Secchi depth (m) collected at the Gauge Above LCR Rkm 98.4 from January 1991 to June 1999.

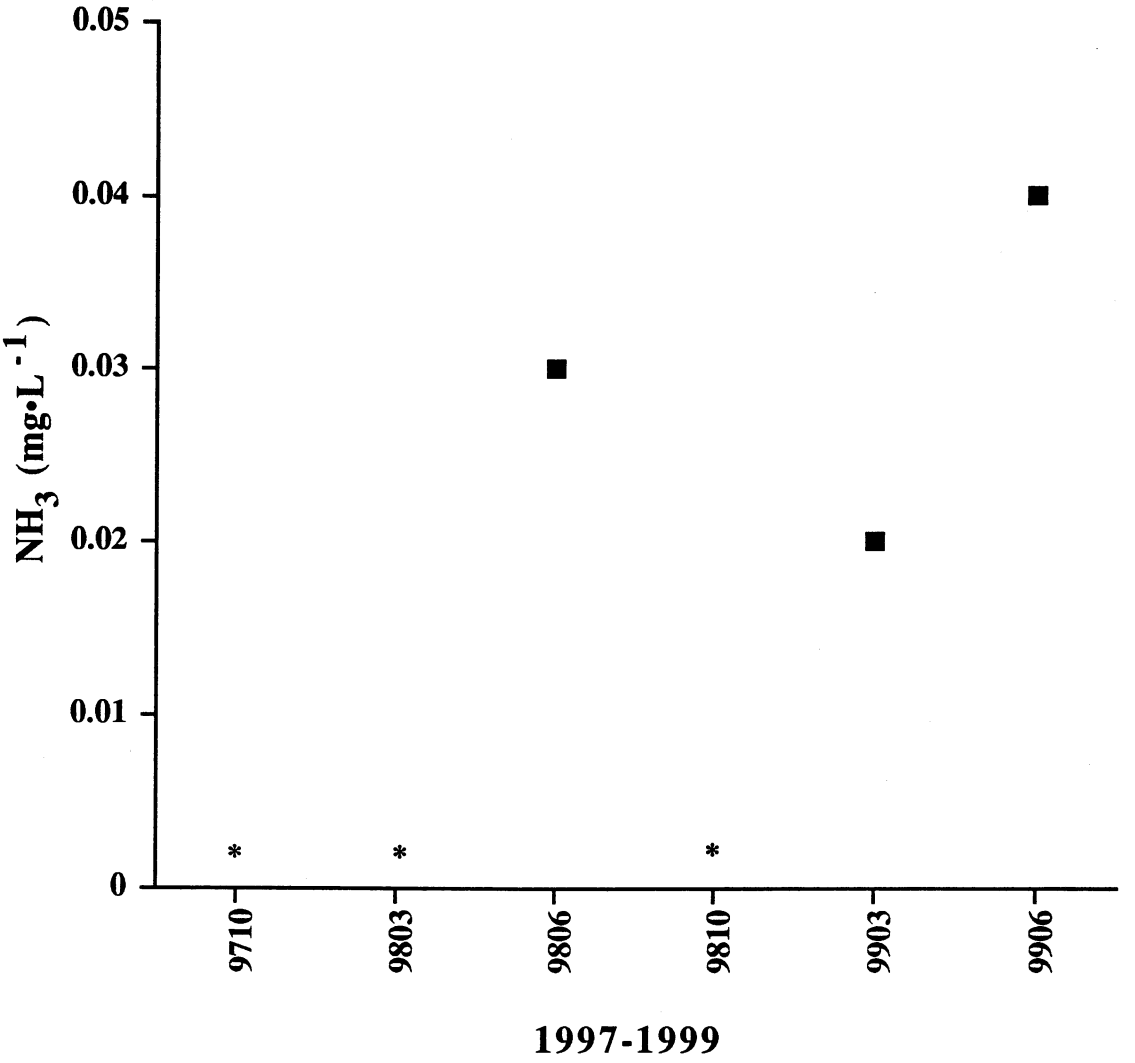

Figure 31. Ammonia (NH_3 mg•L^{-1}) collected at the Gauge above LCR Rkm 98.4 from October 1997 to June 1999. Samples below detection levels are represented by (*).

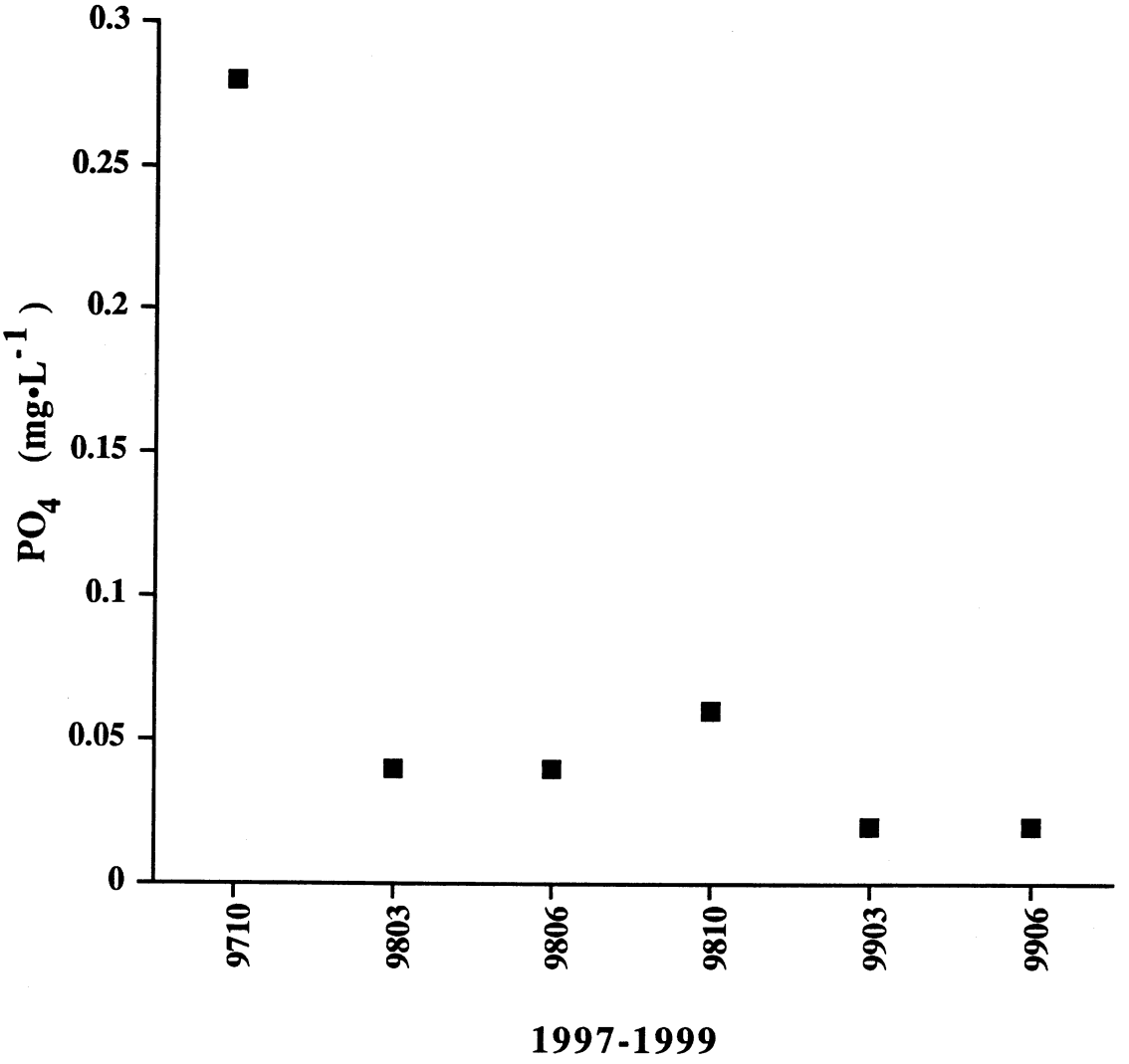

Figure 32. Phosphate (PO_4 mg•L^{-1}) collected at the Gauge above LCR Rkm 98.4 from October 1997 to June 1999.

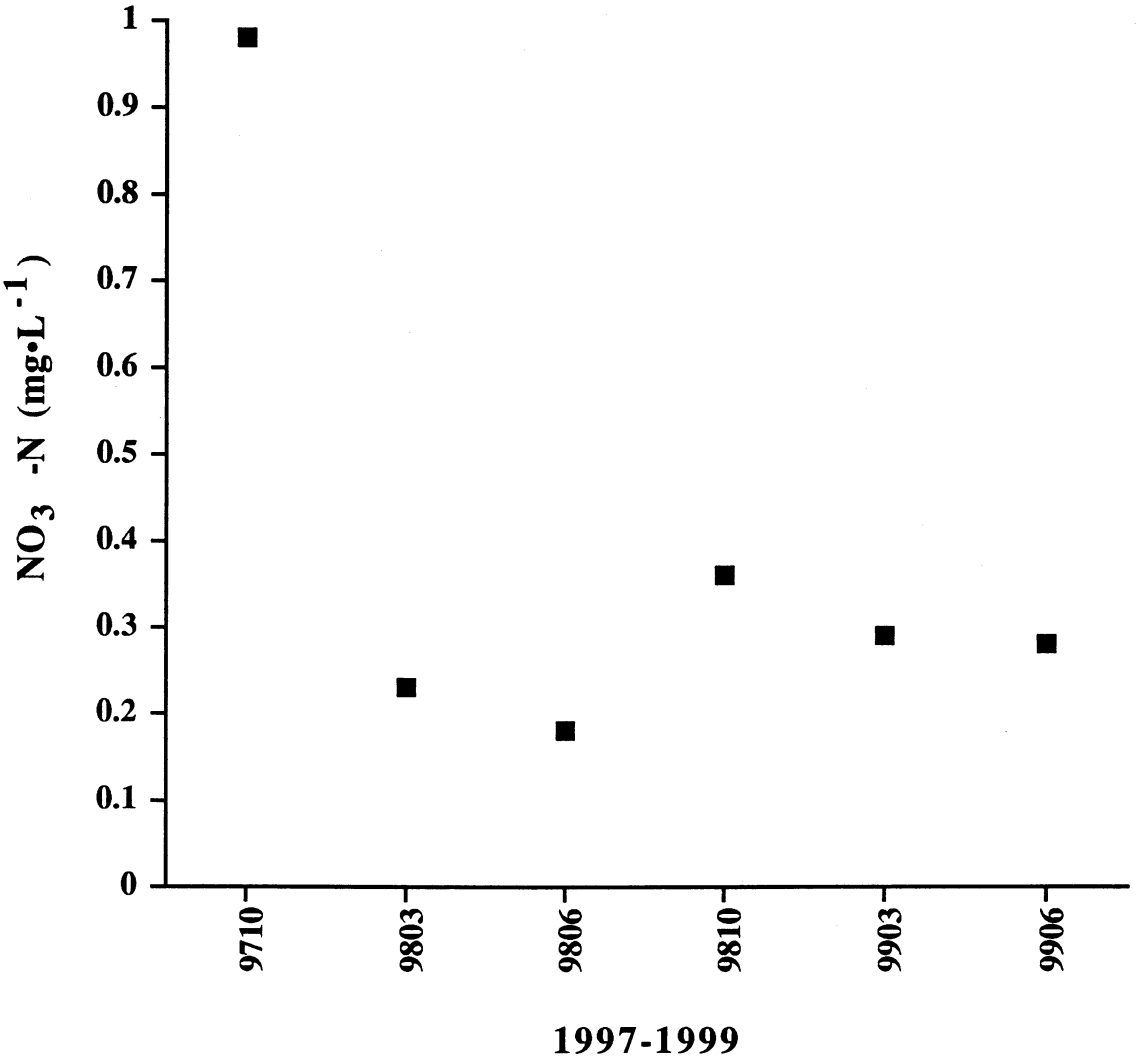

Figure 33. Nitrate-nitrogen (NO_3 -N mg•L^{-1}) collected at the Gauge above LCR Rkm 98.4 from October 1997 to June 1999.

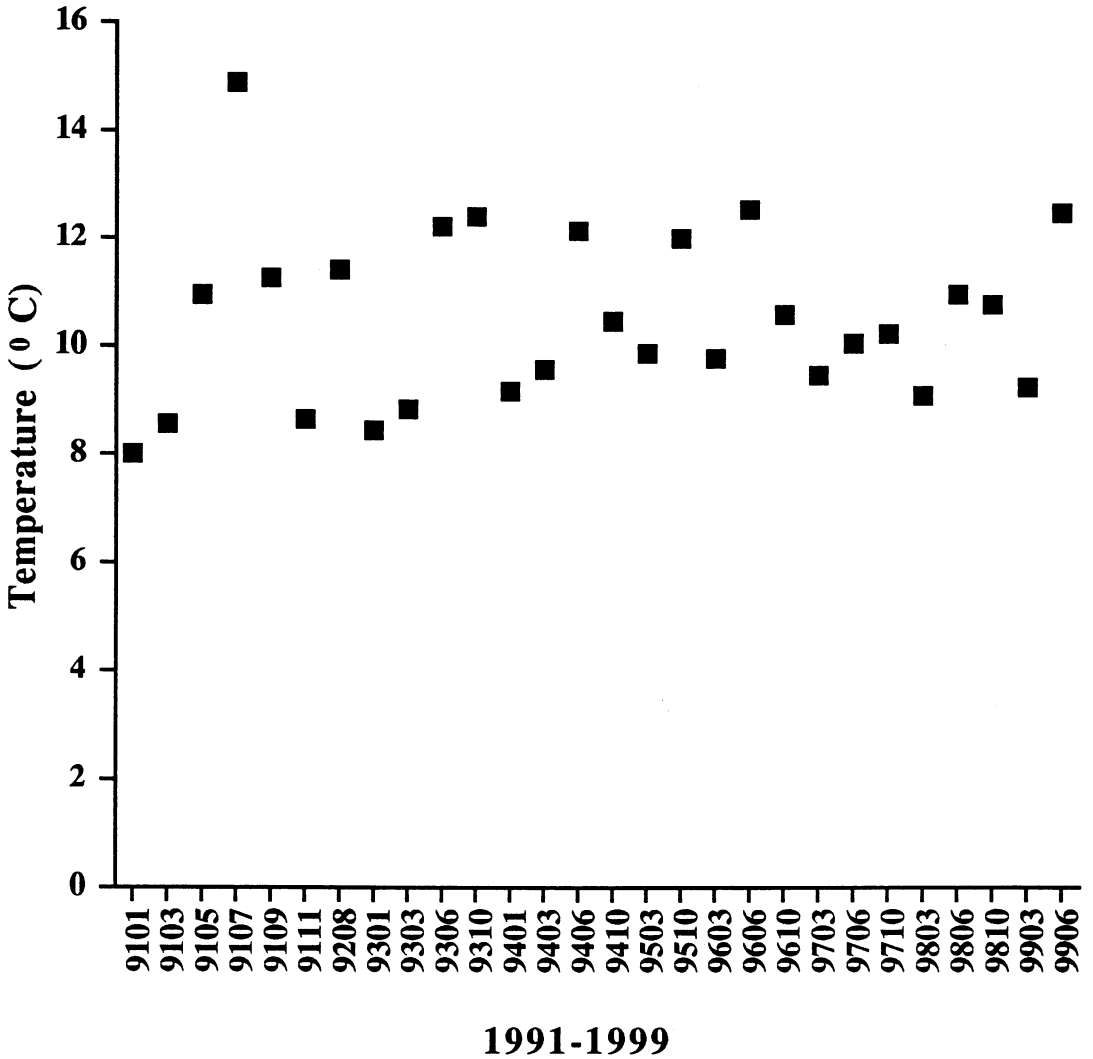

Figure 34. Water temperature (^{0}C) collected at Tanner Canyon Rkm 108.8 from January 1991 to June 1999.

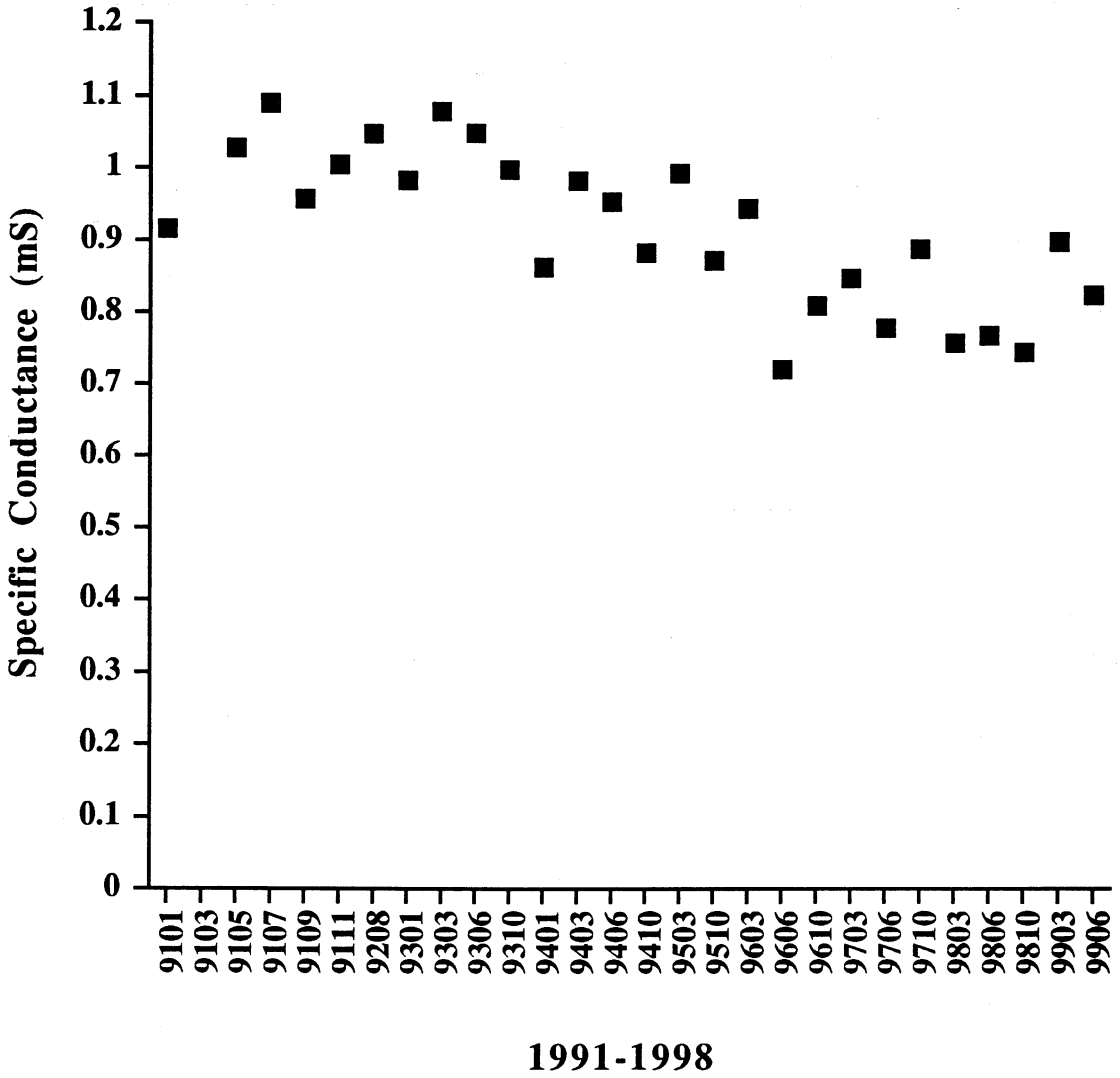

Figure 35. Specific conductance (mS) collected at Tanner Canyon Rkm 108.8 from January 1991 to June 1998.

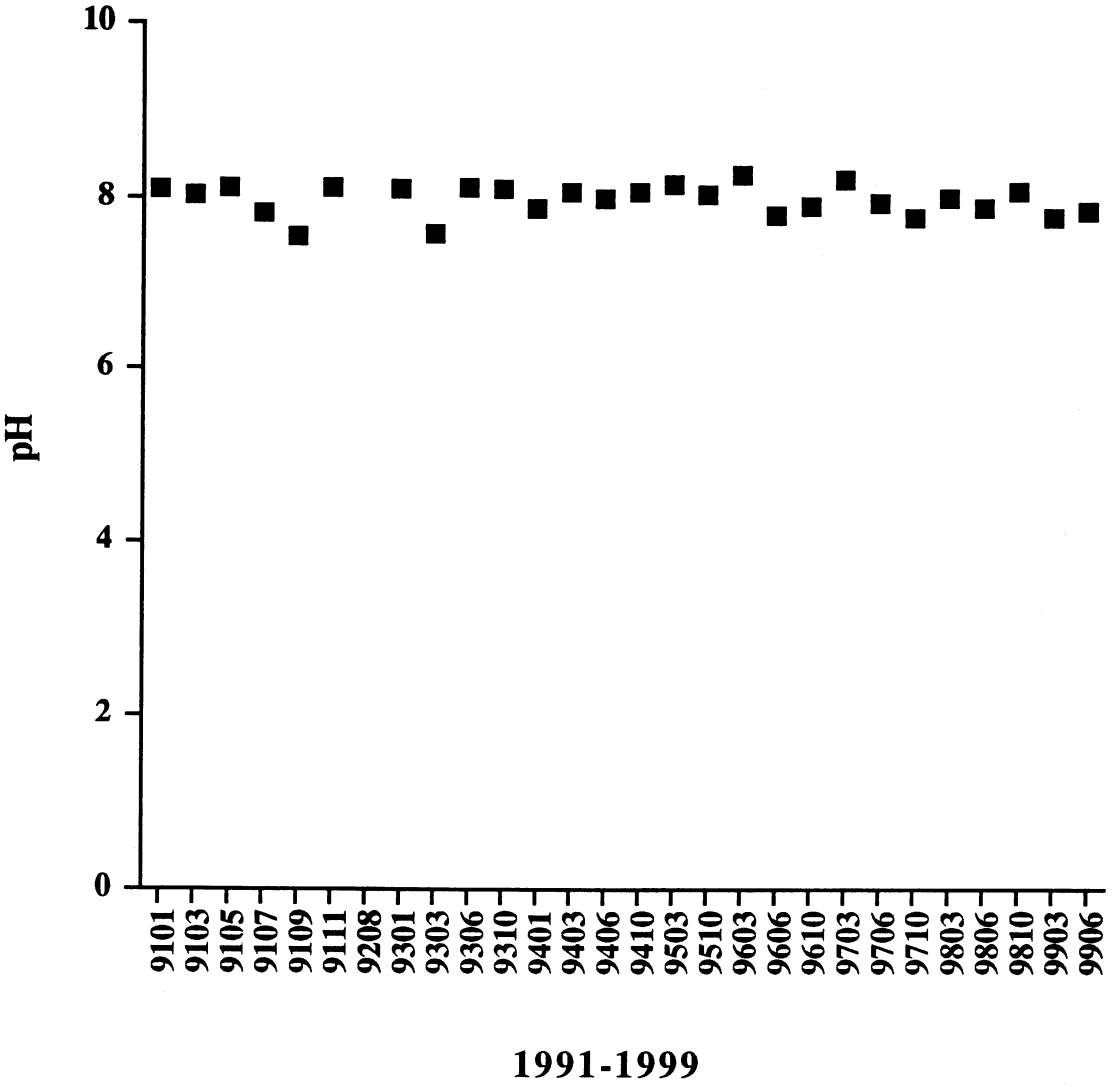

Figure 36. pH collected at Tanner Canyon Rkm 108.8 from January 1991 to June 1999.

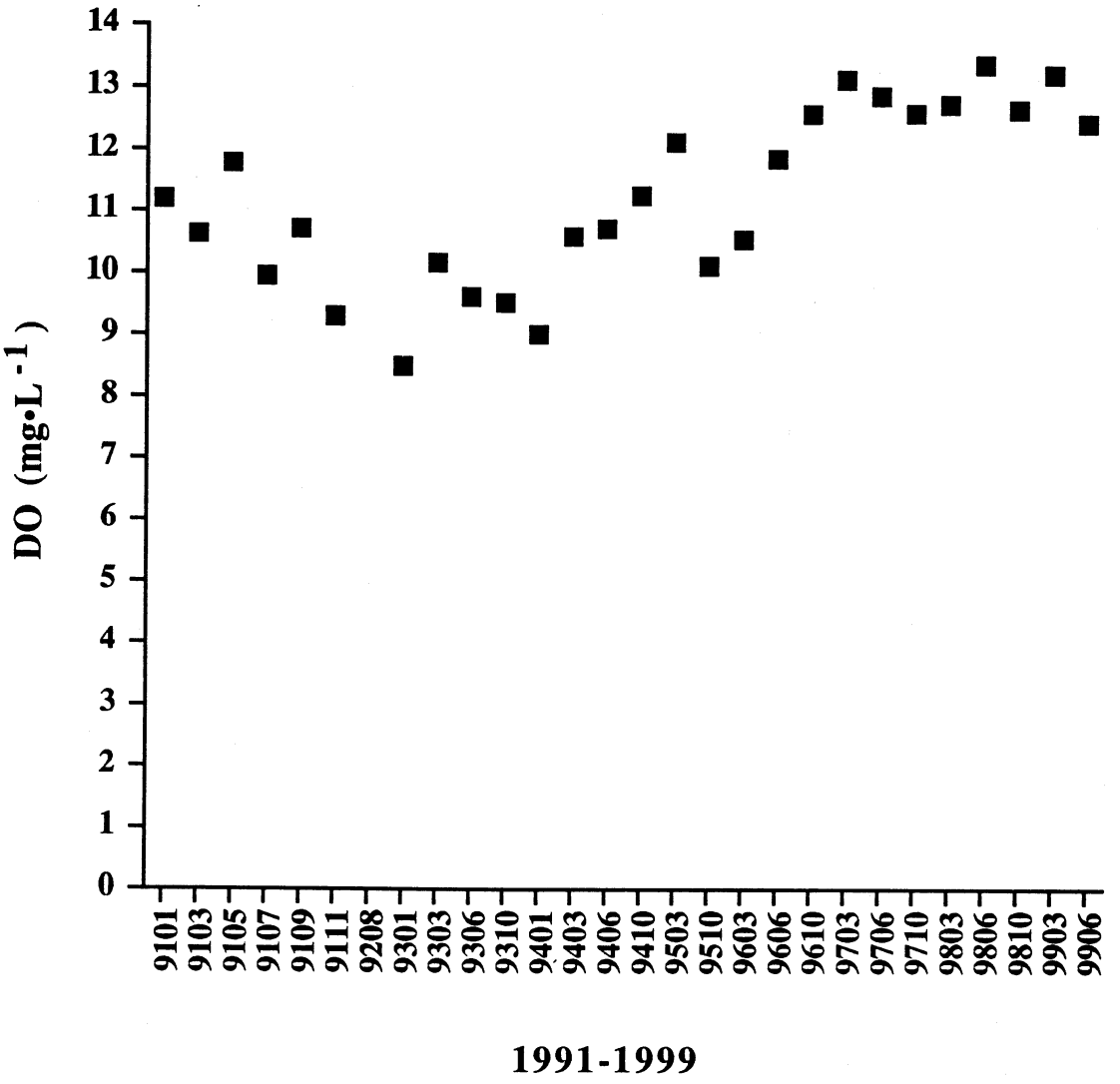

Figure 37. Dissolved oxygen ($mg \cdot L^{-1}$) collected at Tanner Canyon Rkm 108.8 from January 1991 to June 1999.

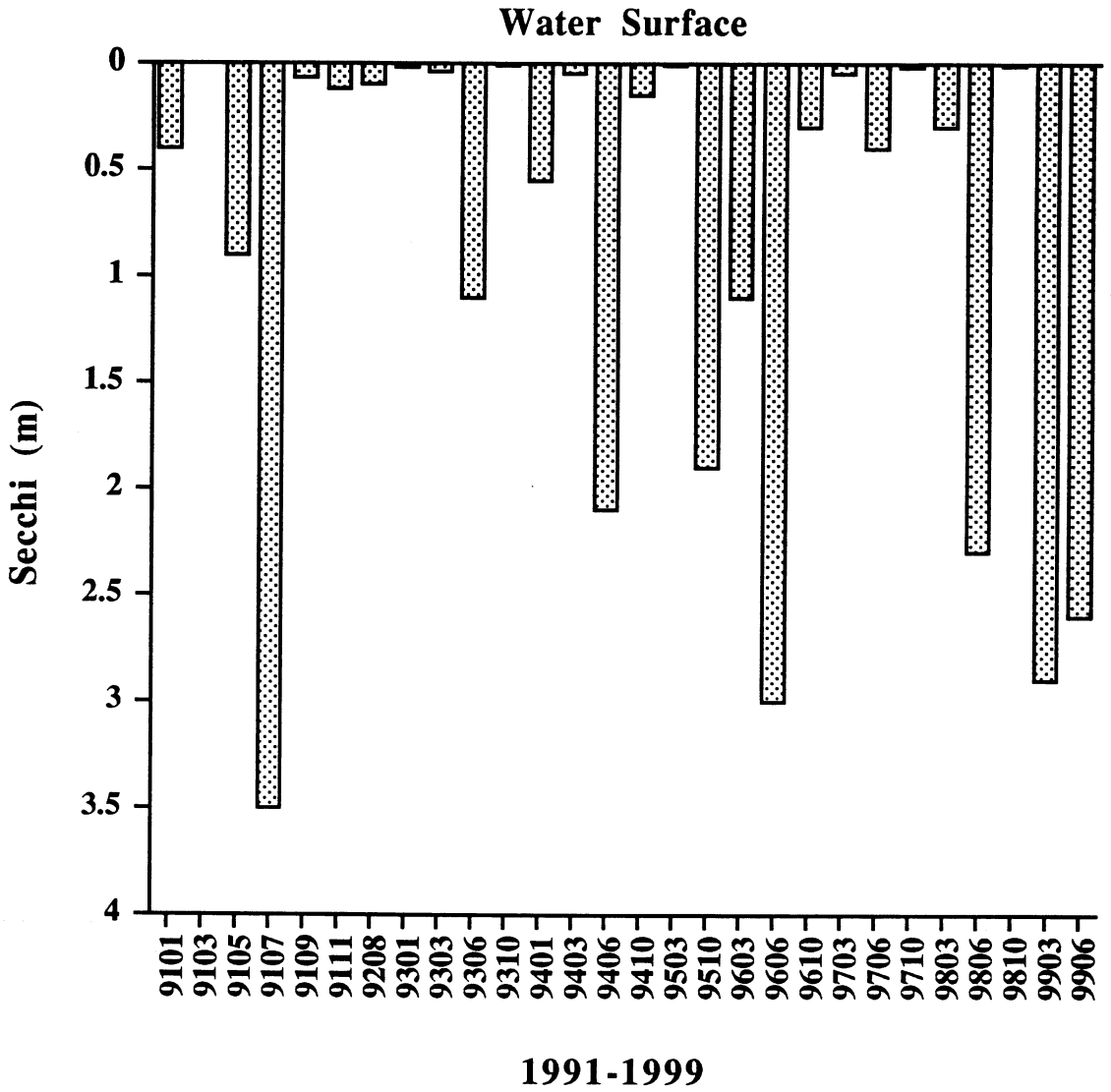

Figure 38. Secchi depth (m) collected at Tanner Canyon Rkm 108.8 from January 1991 to June 1999.

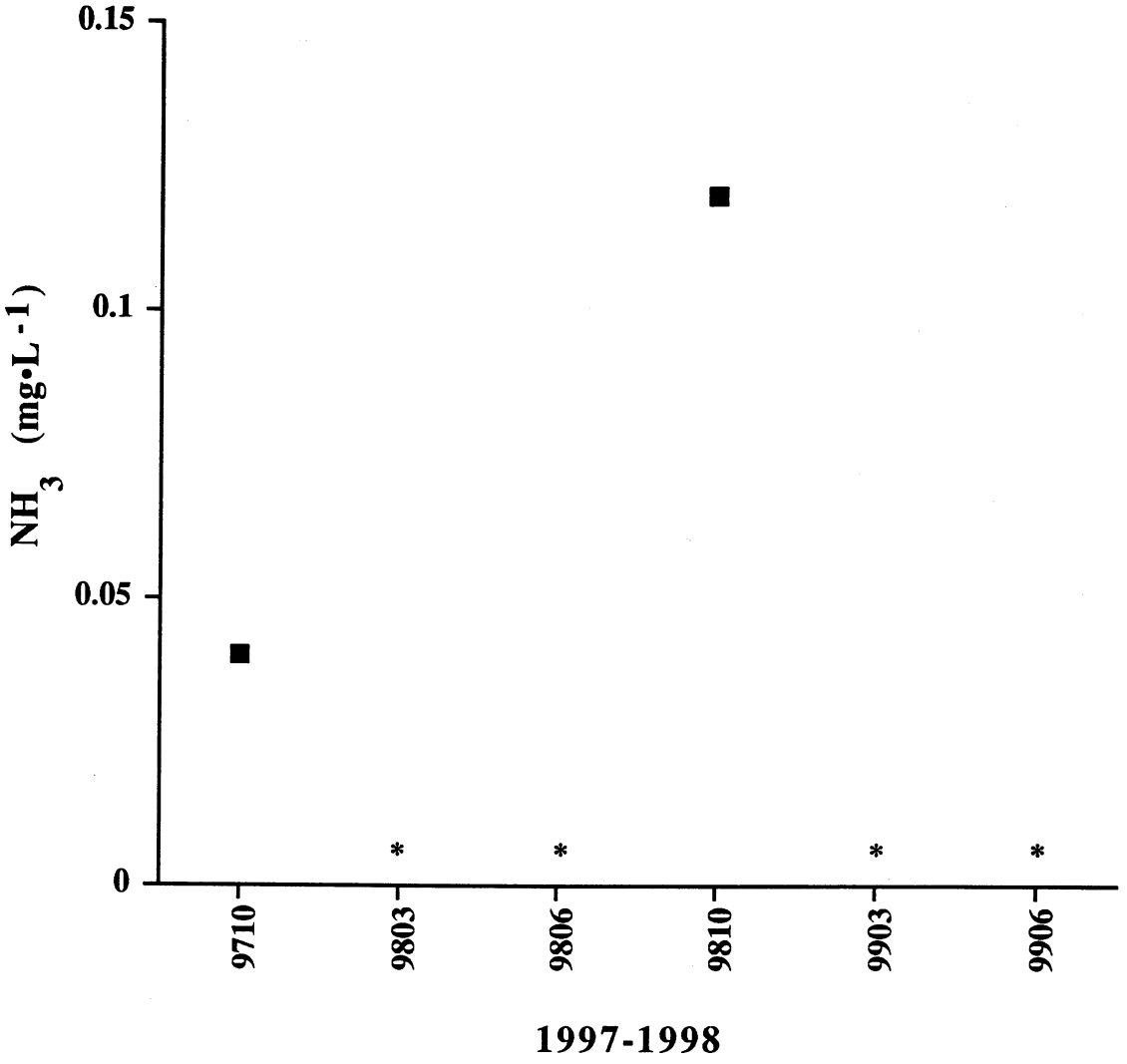

Figure 39. Ammonia (NH_3 mg•L^{-1}) collected at Tanner Canyon Rkm 108.8 from October 1997 to June 1998. Samples below detectable levels are represented by a (*).

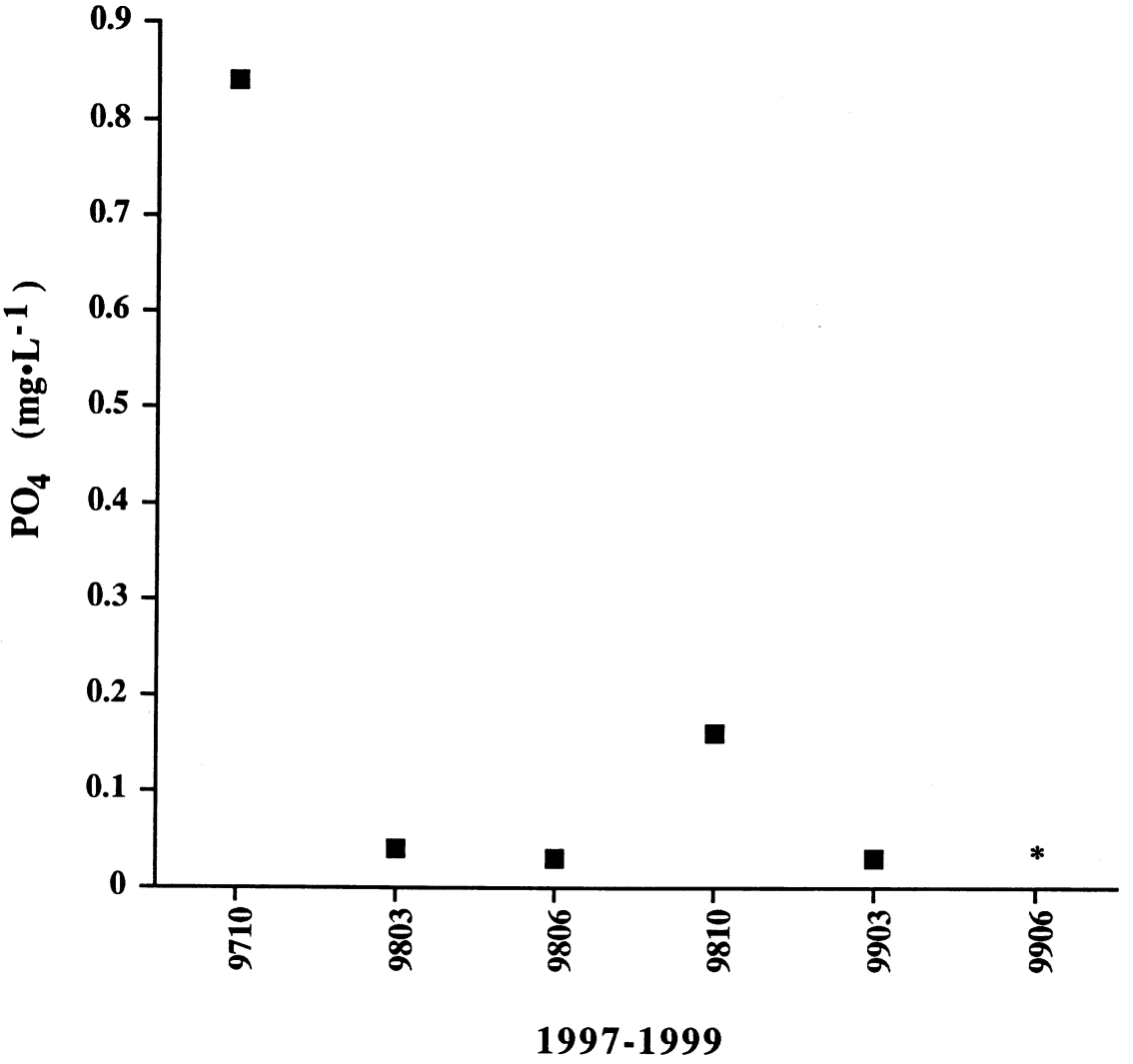

Figure 40. Phosphate (PO_4 mg•L^{-1}) collected at Tanner Canyon Rkm 108.8 from October 1997 to June 1999. Samples below detectable levles are represented by a (*).

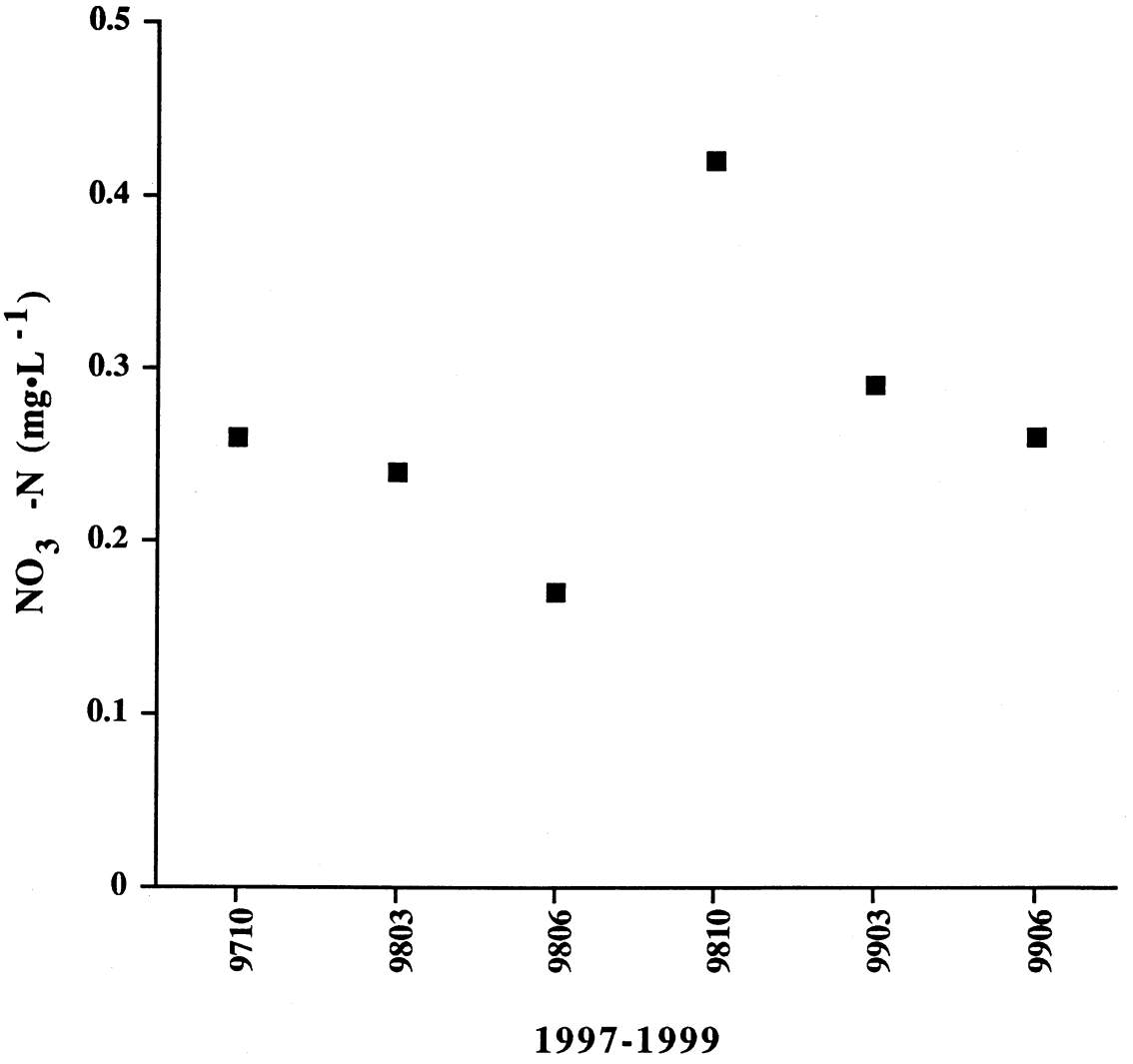

Figure 41. Nitrate-nitrogen (NO_3 -N mg•L^{-1}) collected at Tanner Canyon Rkm 108.8 from October 1997 to June 1999.

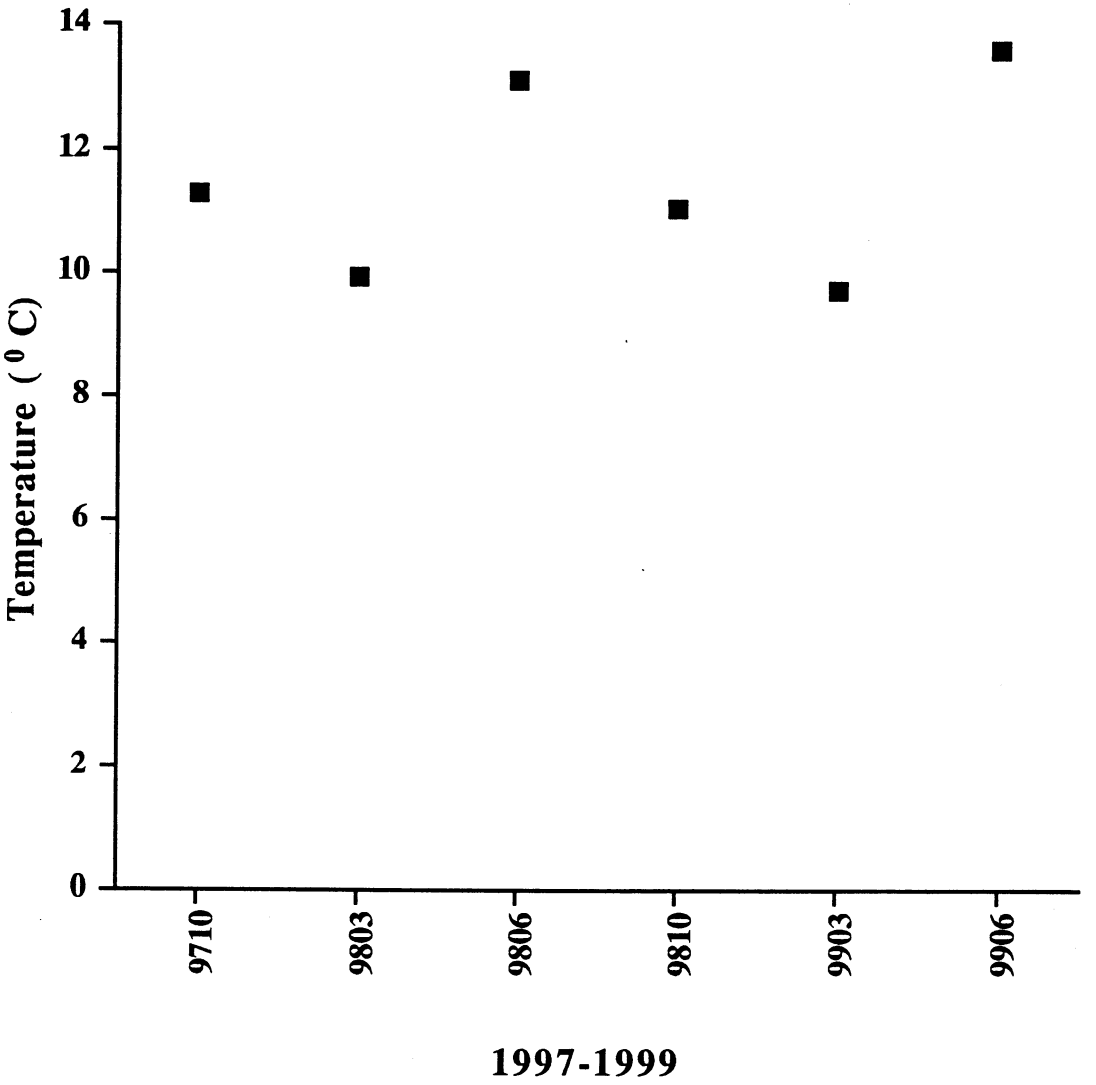

Figure 42. Water temperature (^{0}C) collected at 127 Mile Rkm 202.9 from October 1997 to June 1999.

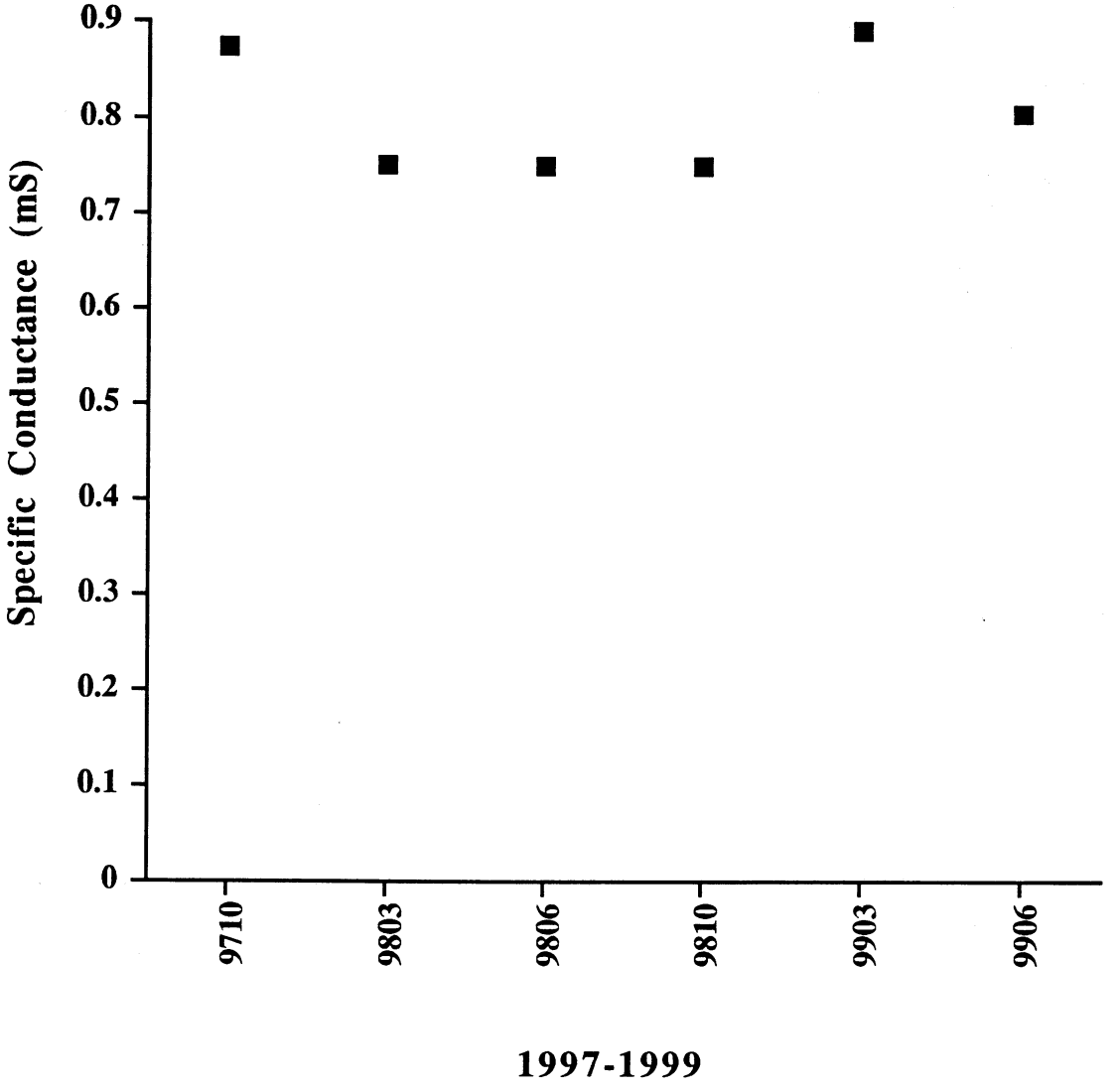

Figure 43. Specific conductance (mS) collected at 127 Mile Rkm 202.9 from October 1997 to June 1999.

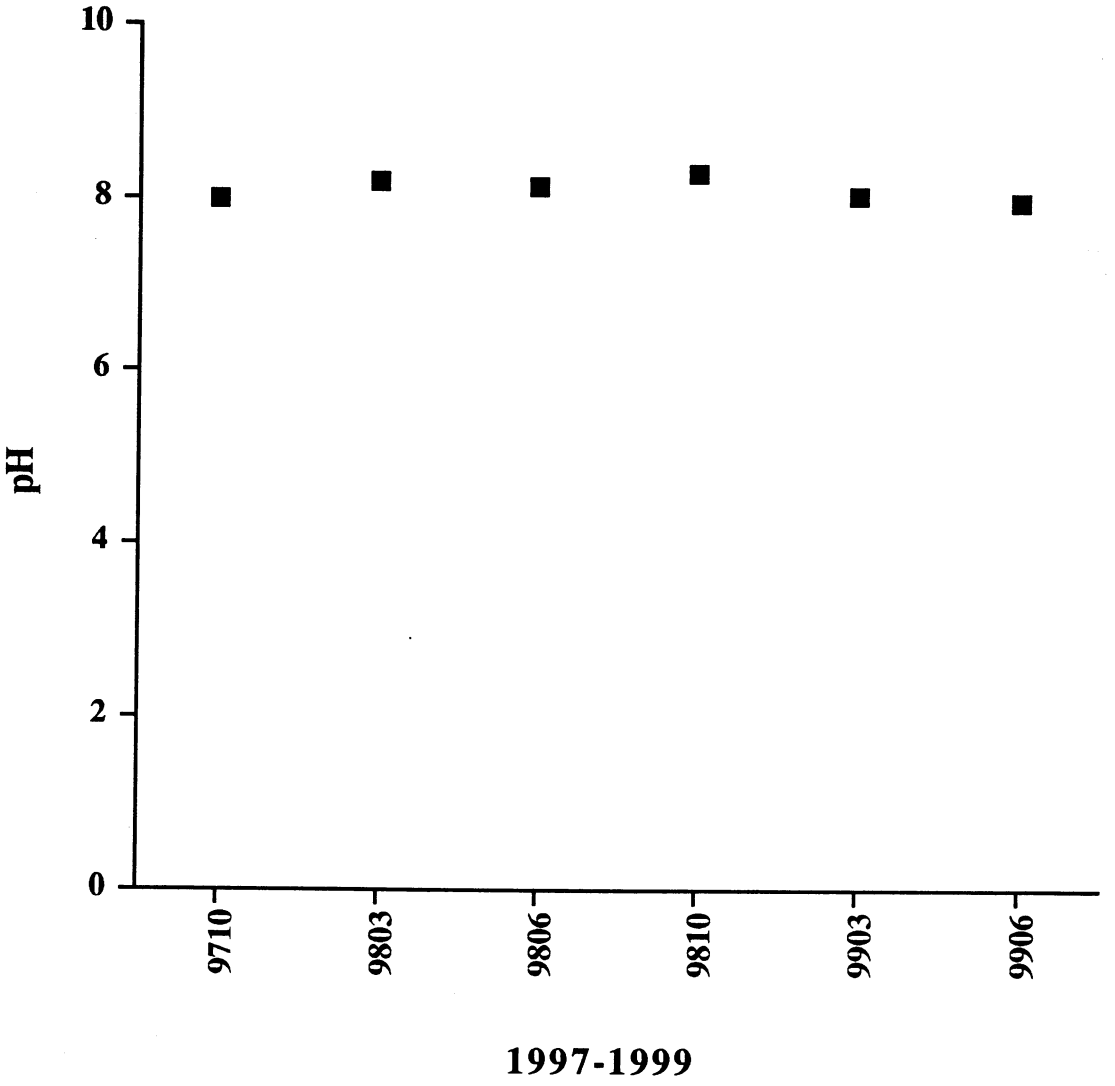

Figure 44. pH collected at 127 Mile Rkm 202.9 from October 1997 to June 1999.

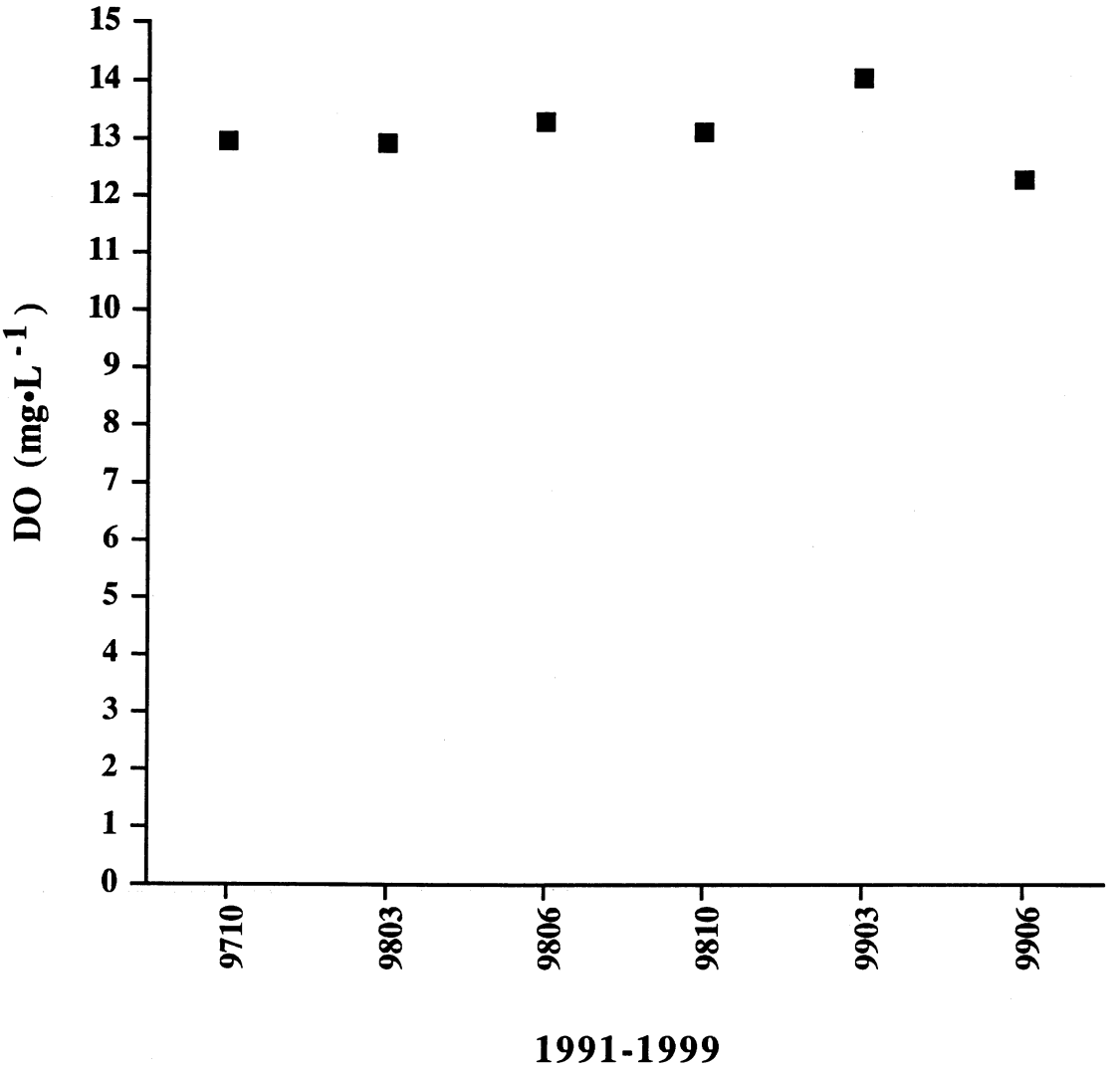

Figure 45. Dissolved oxygen ($mg \cdot L^{-1}$) collected at 127 Mile Rkm 202.9 from October 1997 to June 1999.

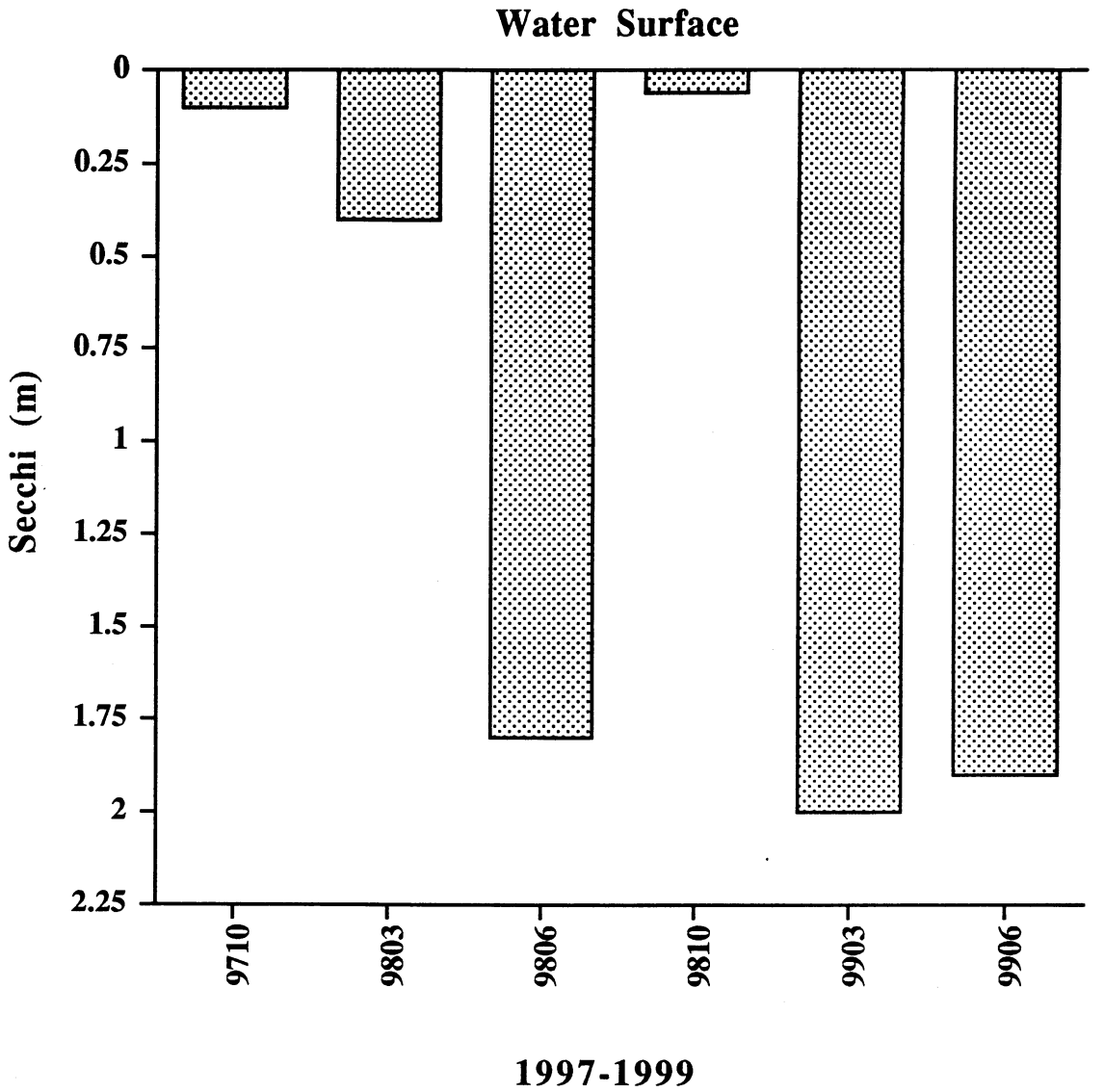

Figure 46. Secchi depth (m) collected at 127 Mile Rkm 202.9 from October 1997 to June 1999.

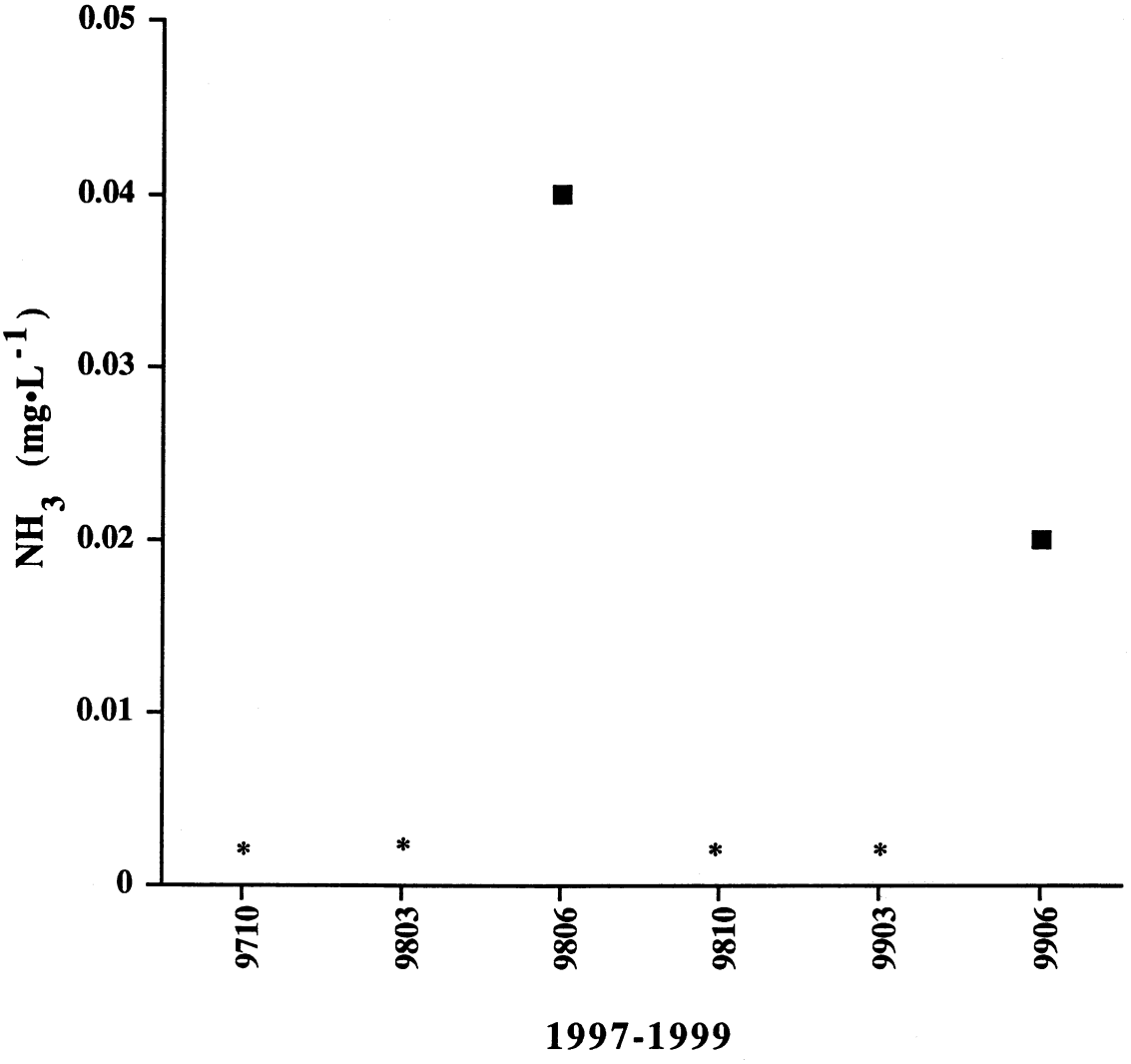

Figure 47. Ammonia (NH_3 mg•L^{-1}) collected at 127 Mile Rkm 202.9 from October 1997 to June 1999. Samples below detectable levels are represented by a (*).

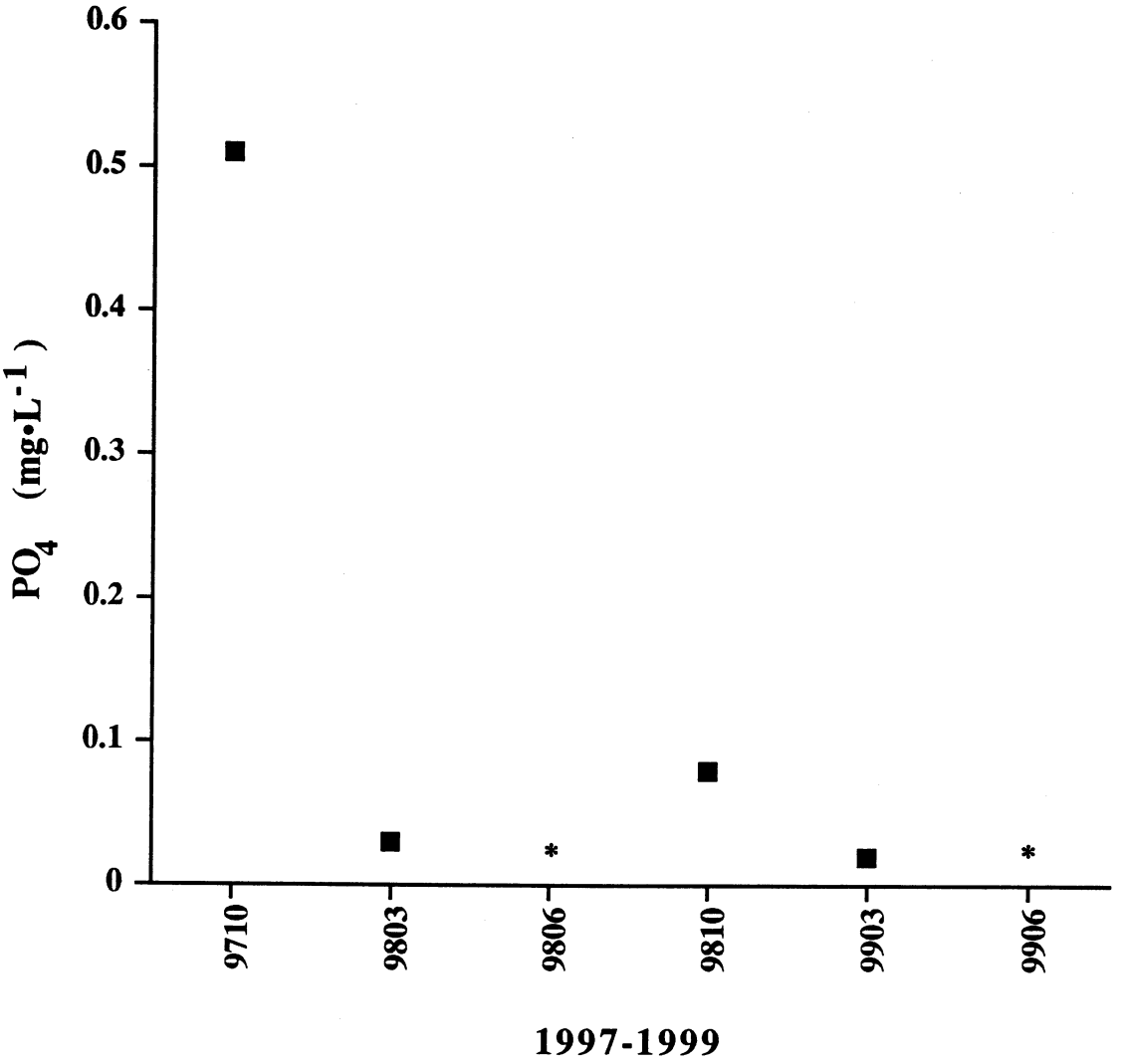

Figure 48. Phosphate (PO_4 mg•L^{-1}) collected at 127 Mile Rkm 202.9 from October 1997 to June 1999. Samples below detectable levels are represented by a (*).

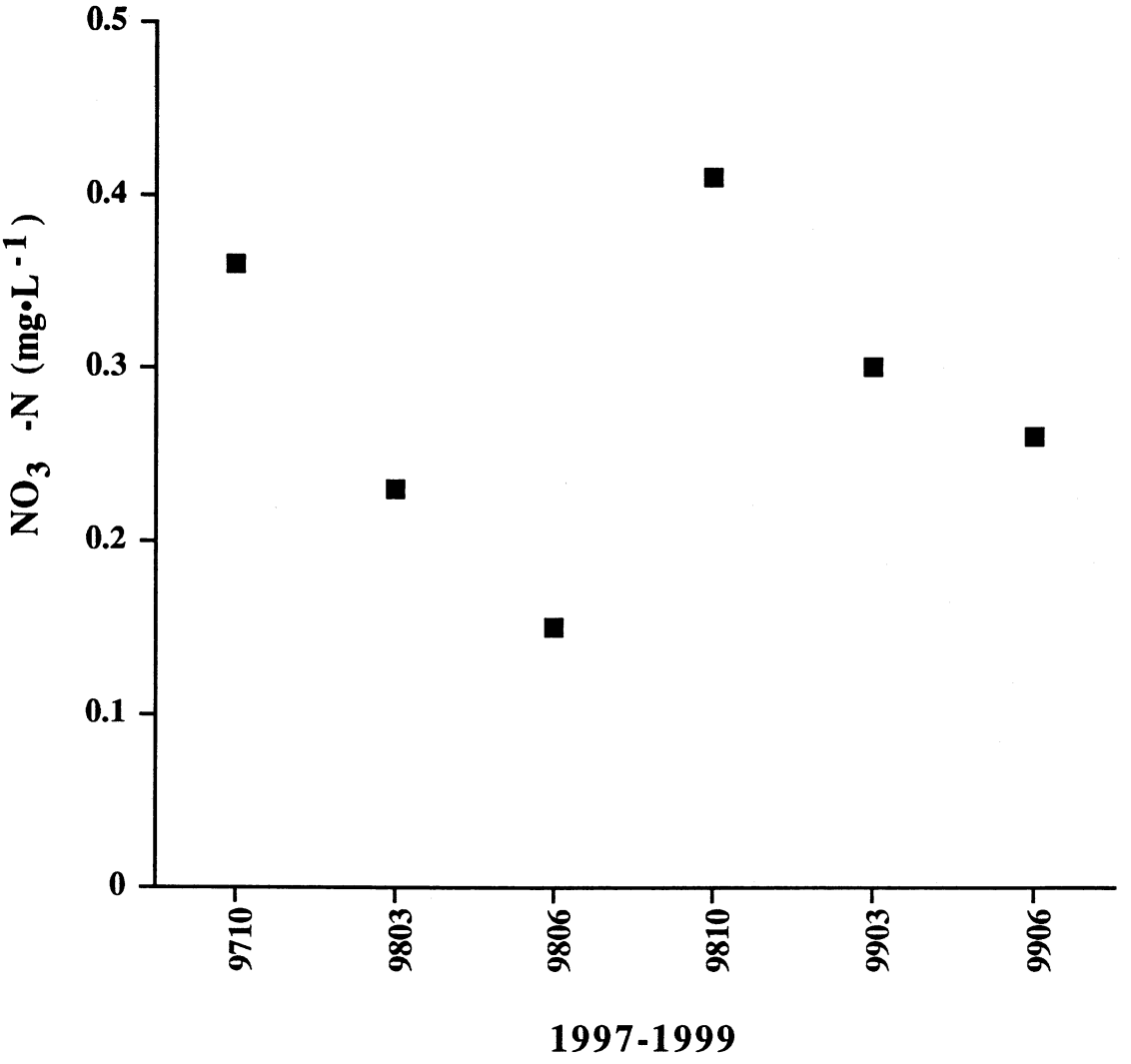

Figure 49. Nitrate-nitrogen (NO_3 -N mg•L^{-1}) collected at 127 Mile Rkm 202.9 from October 1997 to June 1999.

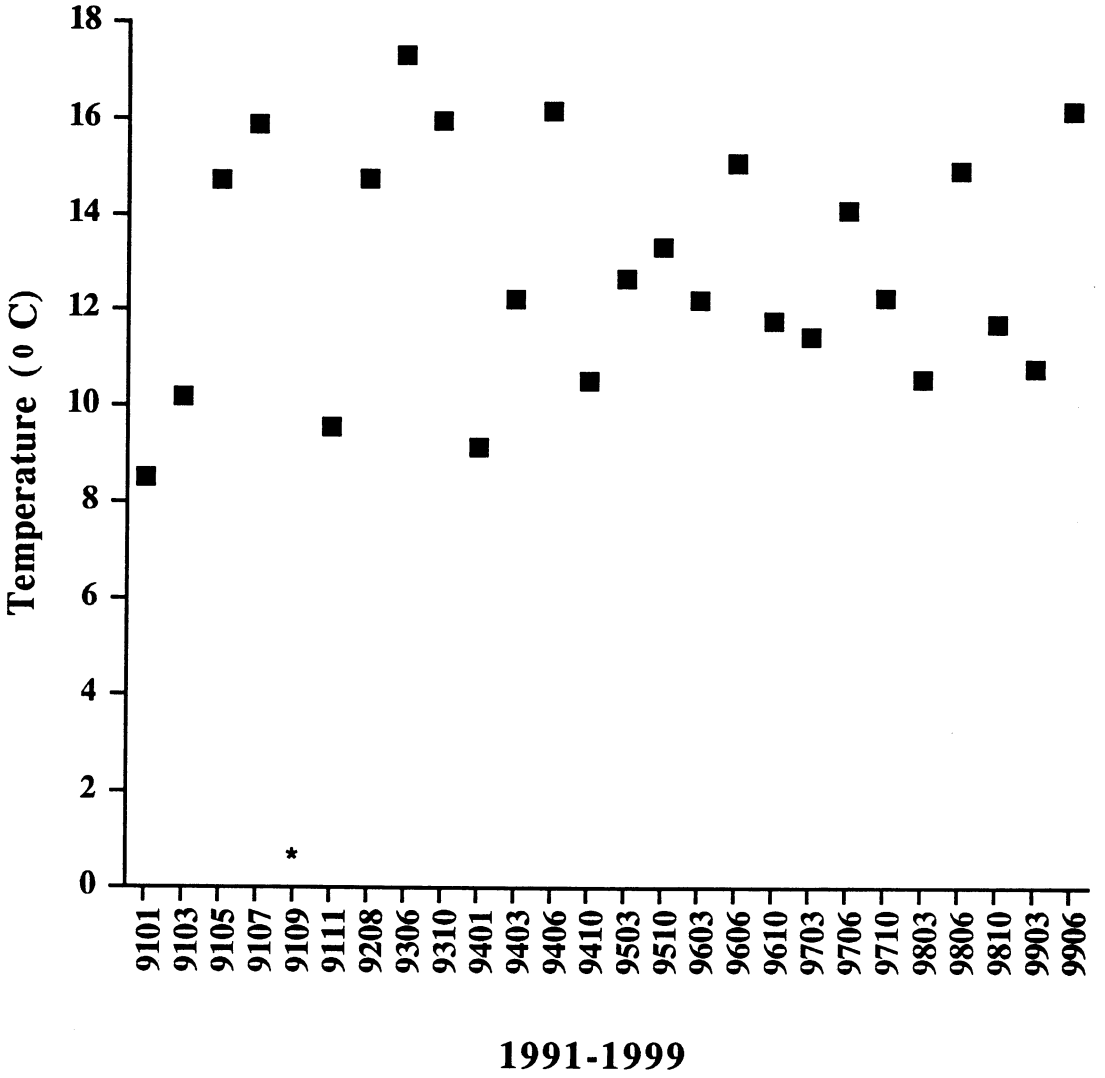

Figure 50. Water temperature (°C) collected at 205 Mile Rkm 328.8 from January 1991 to June 1999. Asterisk (*) represents missing data point.

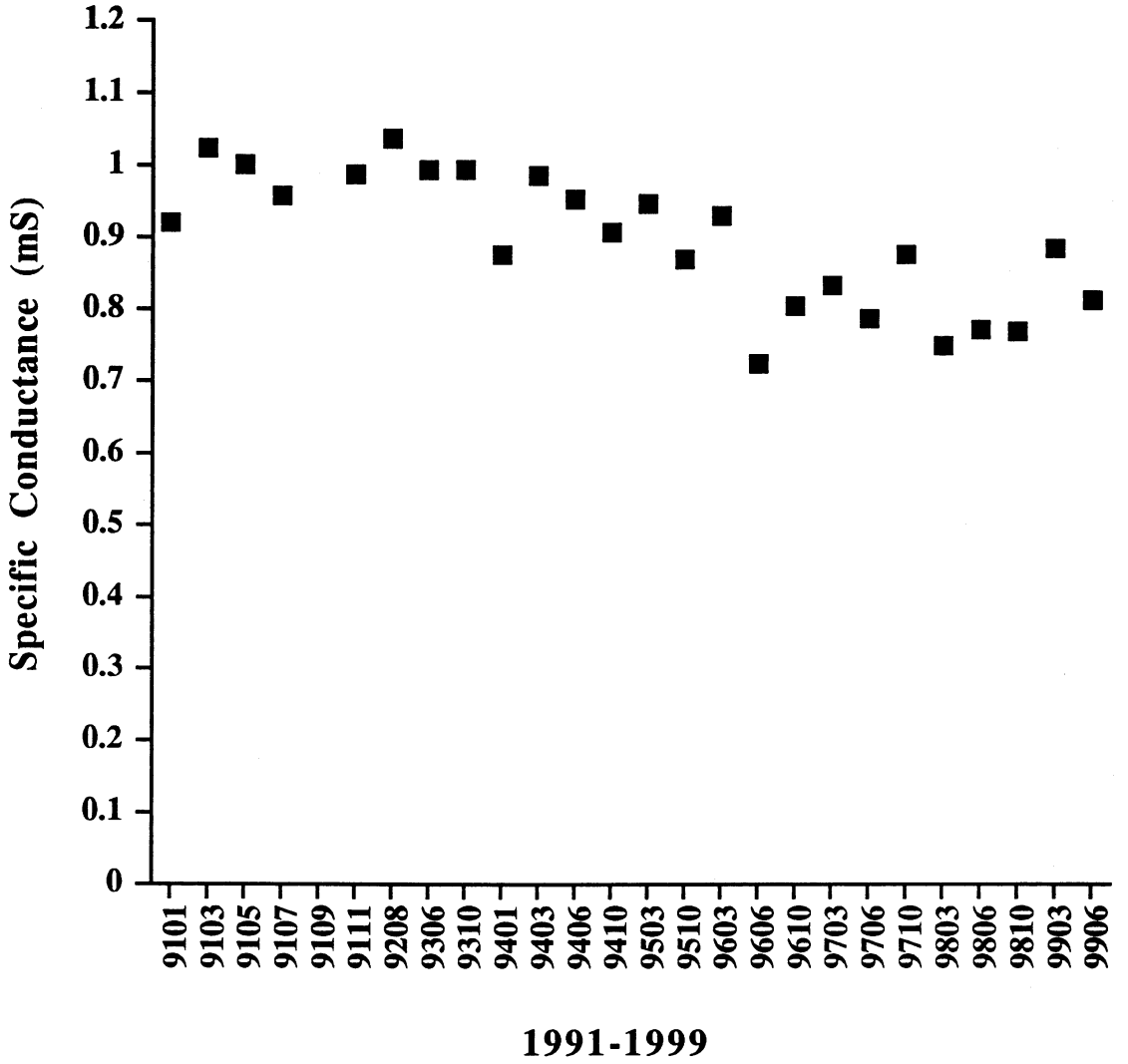

Figure 51. Specific conductance (mS) collected at 205 Mile Rkm 328.8 from January 1991 to June 1999.

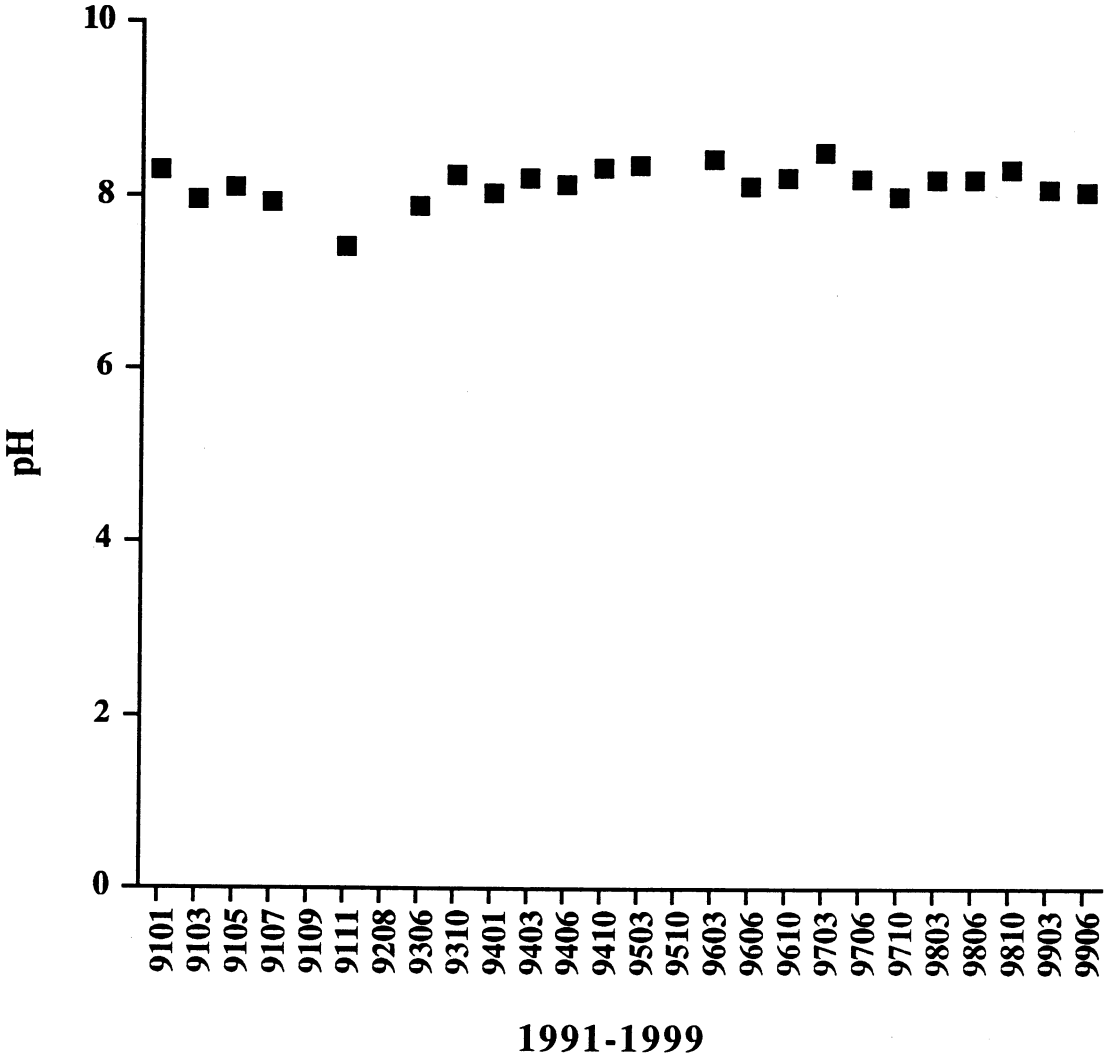

Figure 52. pH collected at 205 Mile Rkm 328.8 from January 1991 to June 1999.

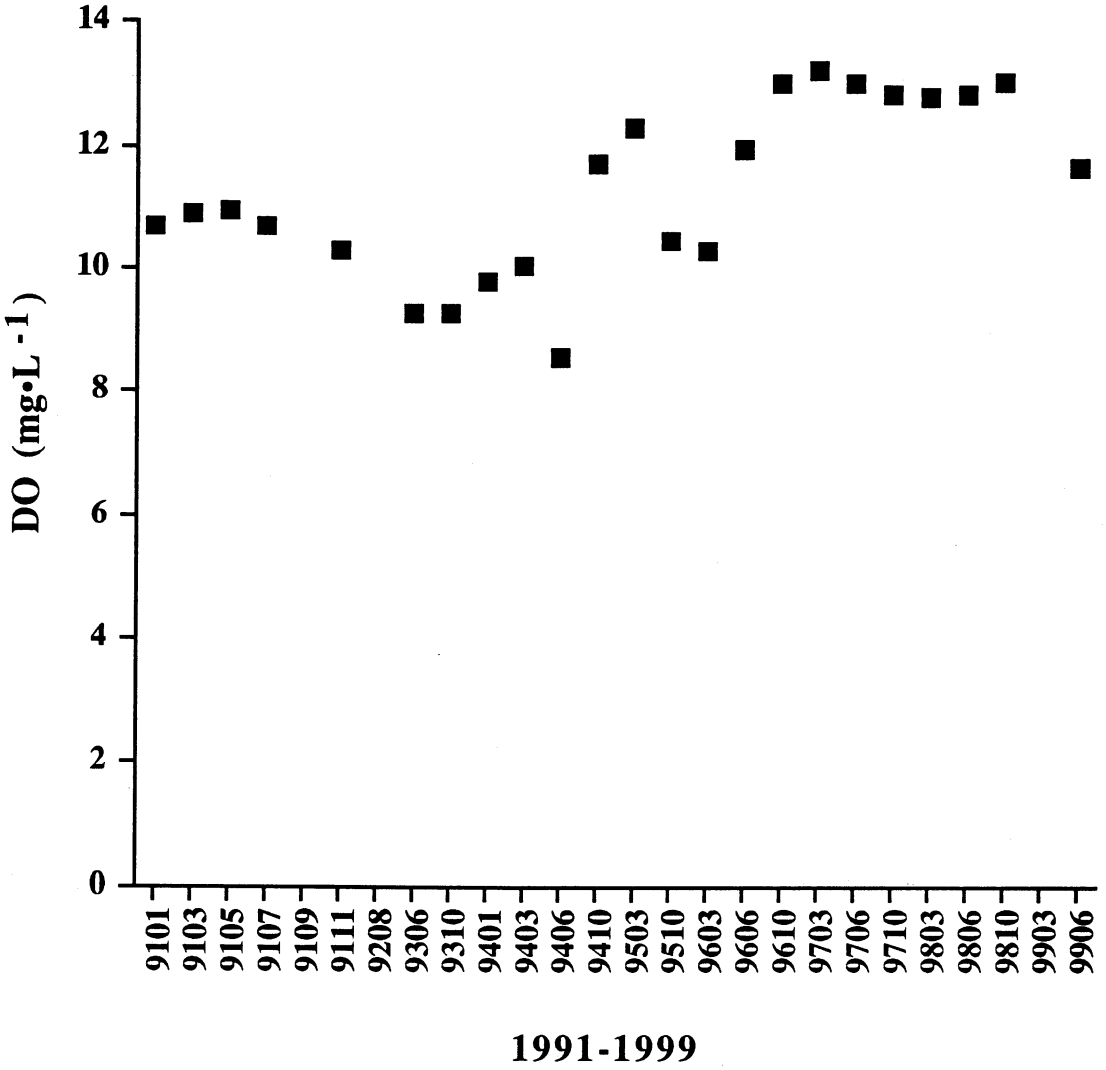

Figure 53. Dissolved oxygen (mg•L^{-1}) collected at 205 Mile Rkm 328.8 from January 1991 to June 1999.

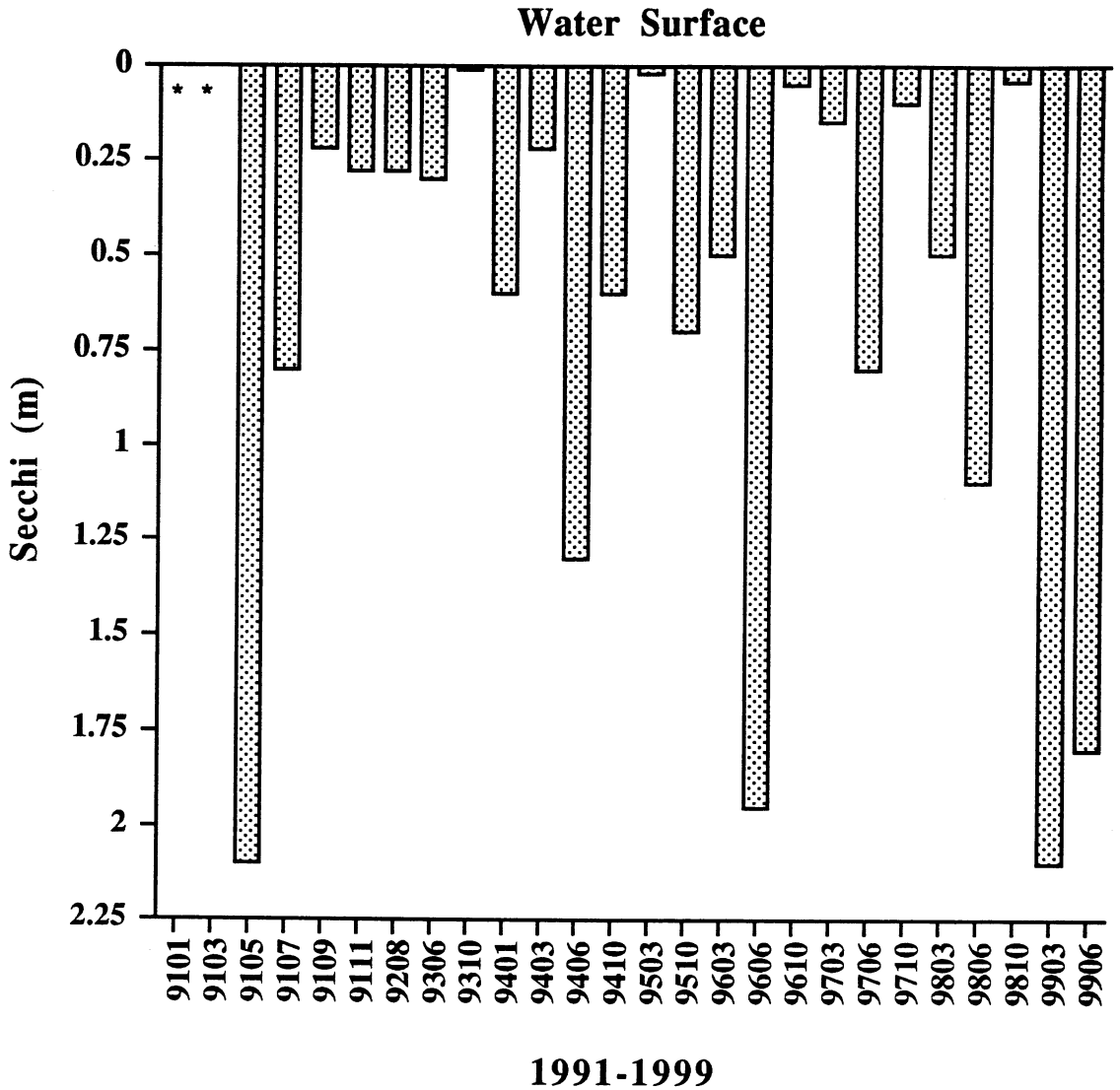

Figure 54. Secchi depth (m) collected at 205 Mile Rkm 328.8 from January 1991 to June 1999. Asterisk (*) represents missing data point.

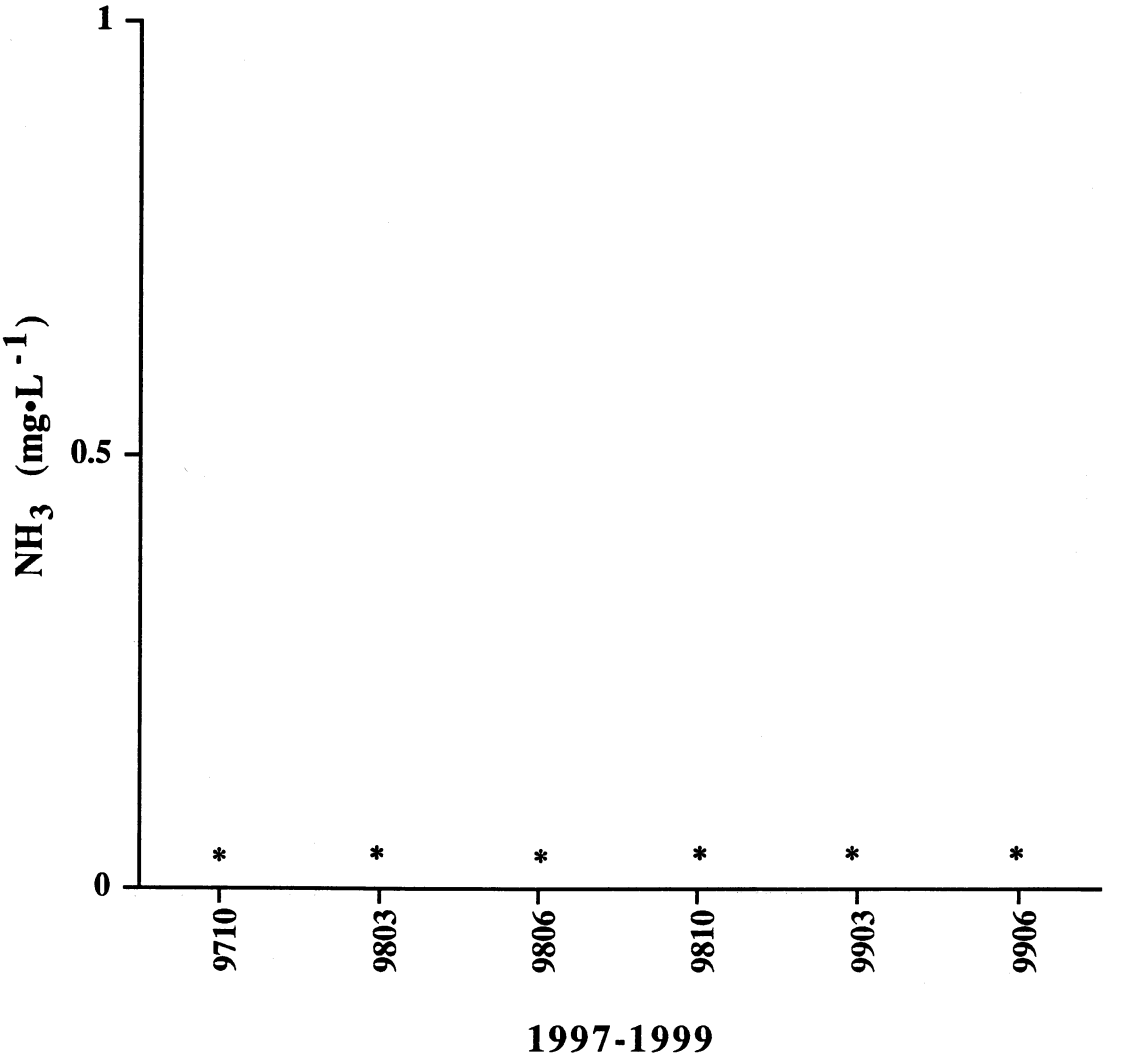

Figure 55. Ammonia (NH_3 mg•L^{-1}) collected at 205 Mile Rkm 328.8 from October 1997 to June 1999. Samples below detectable levels are represented by (*).

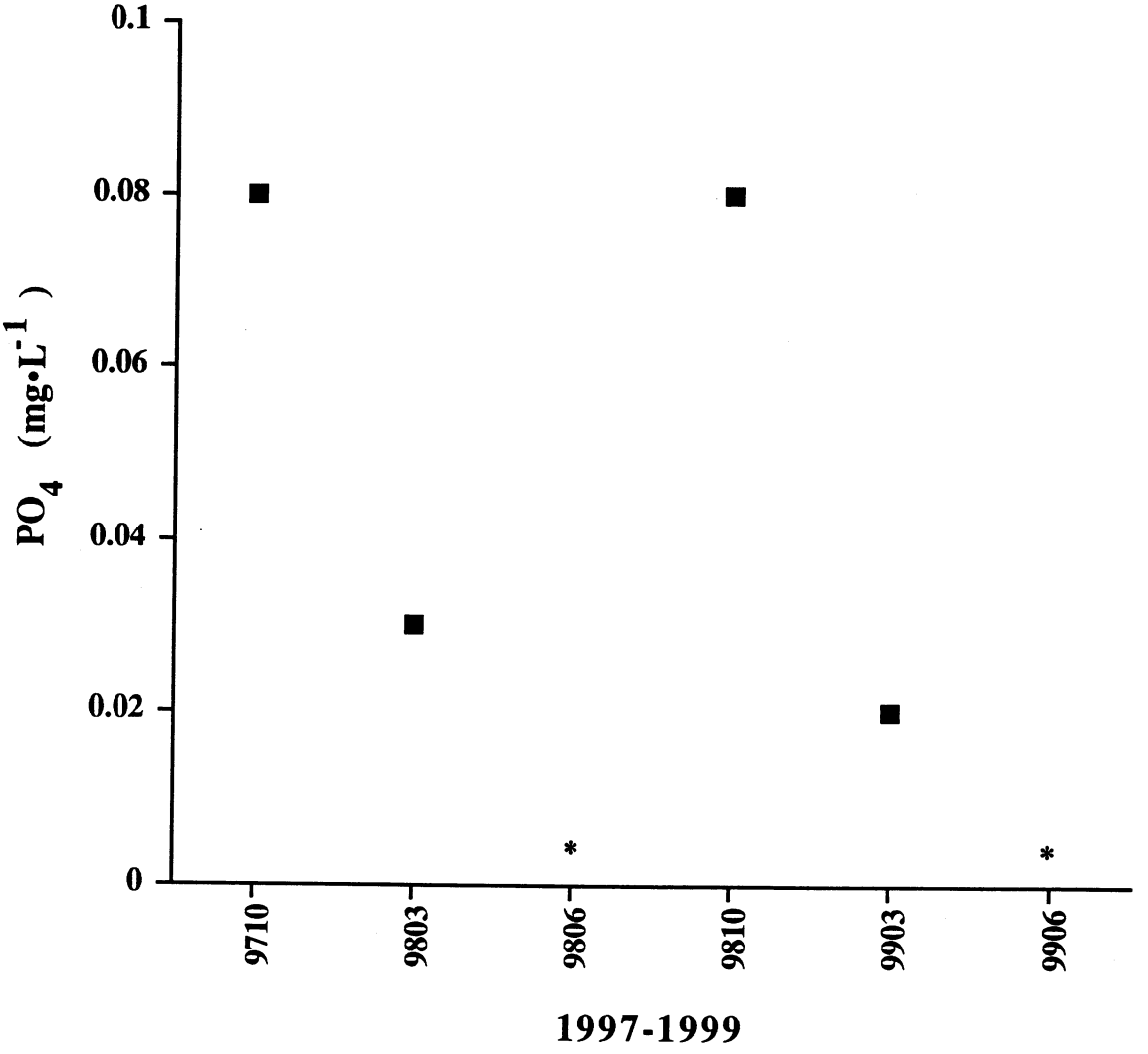

Figure 56. Phosphate (PO_4 mg•L^{-1}) collected at 205 Mile Rkm 328.8 from October 1997 to June 1999. Samples below detectable levels are represented by a (*).

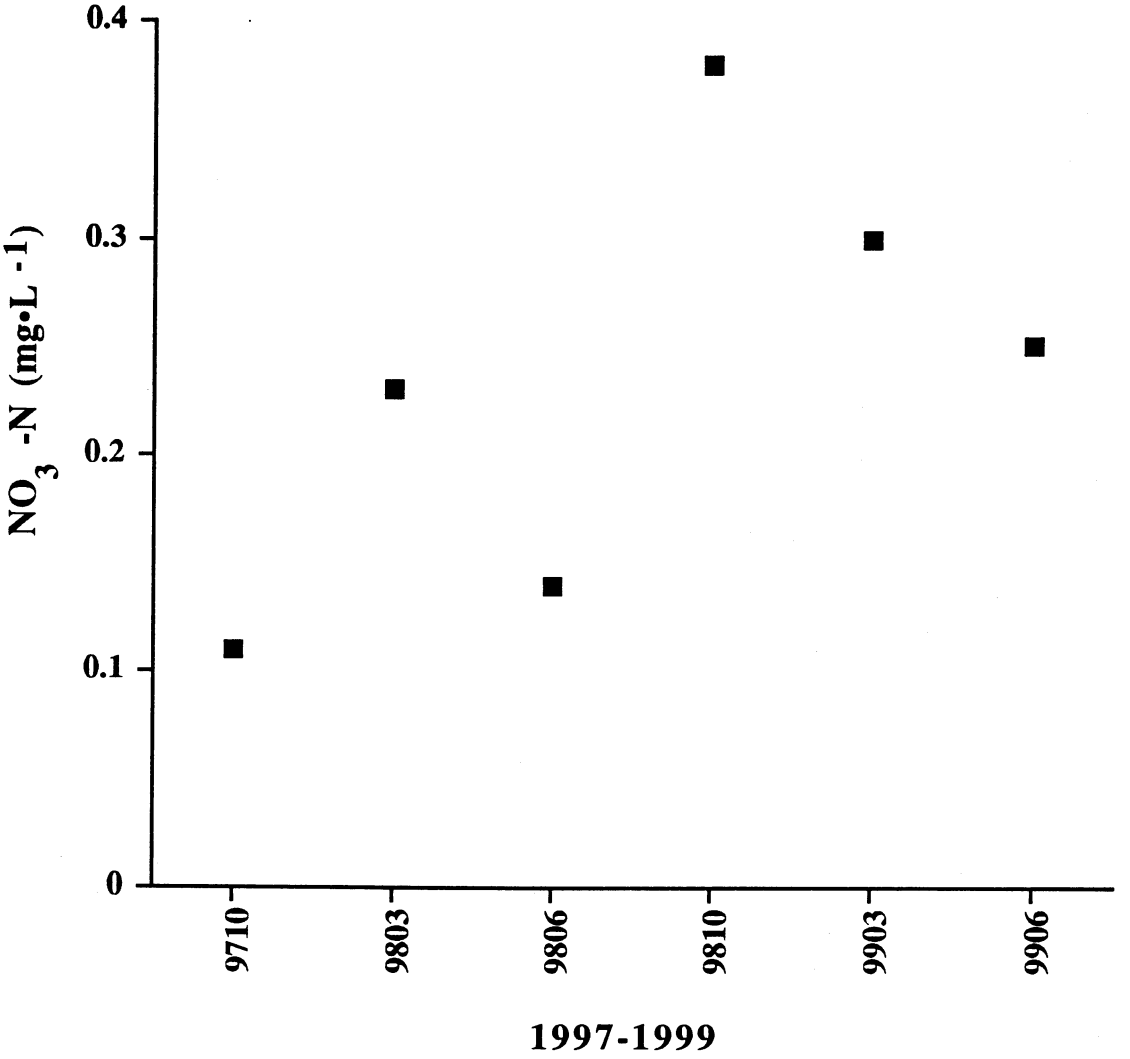

Figure 57. Nitrate-nitrogen (NO_3 -N mg•L^{-1}) collected at 205 Mile Rkm 328.8 from October 1997 to June 1999.

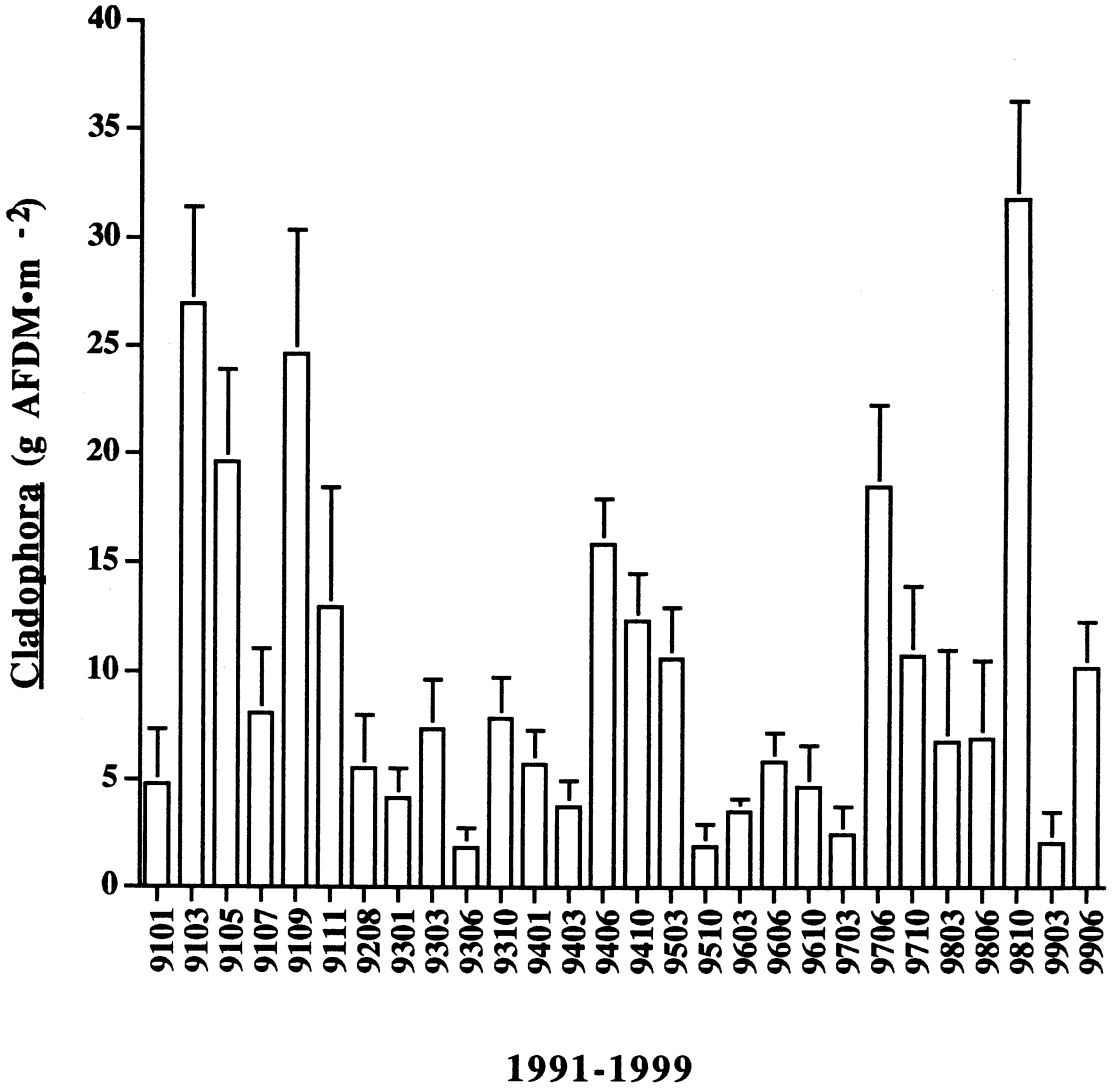

Figure 58. Cladophora biomass estimates (g AFDM•m^{-2}) at Lees Ferry cobble Rkm 0.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

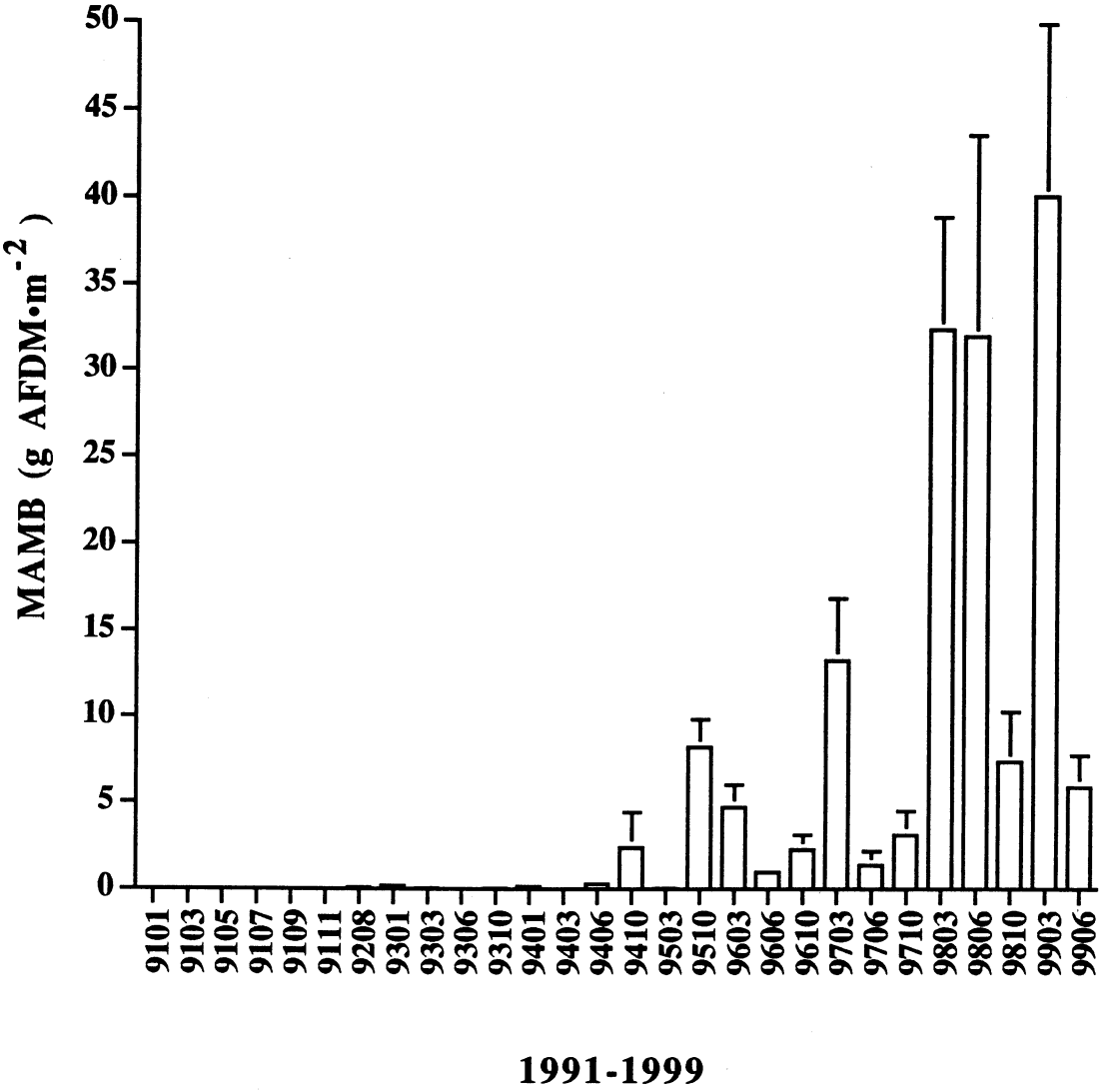

Figure 59. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m-2) at Lees Ferry cobble Rkm 0.8 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=6).

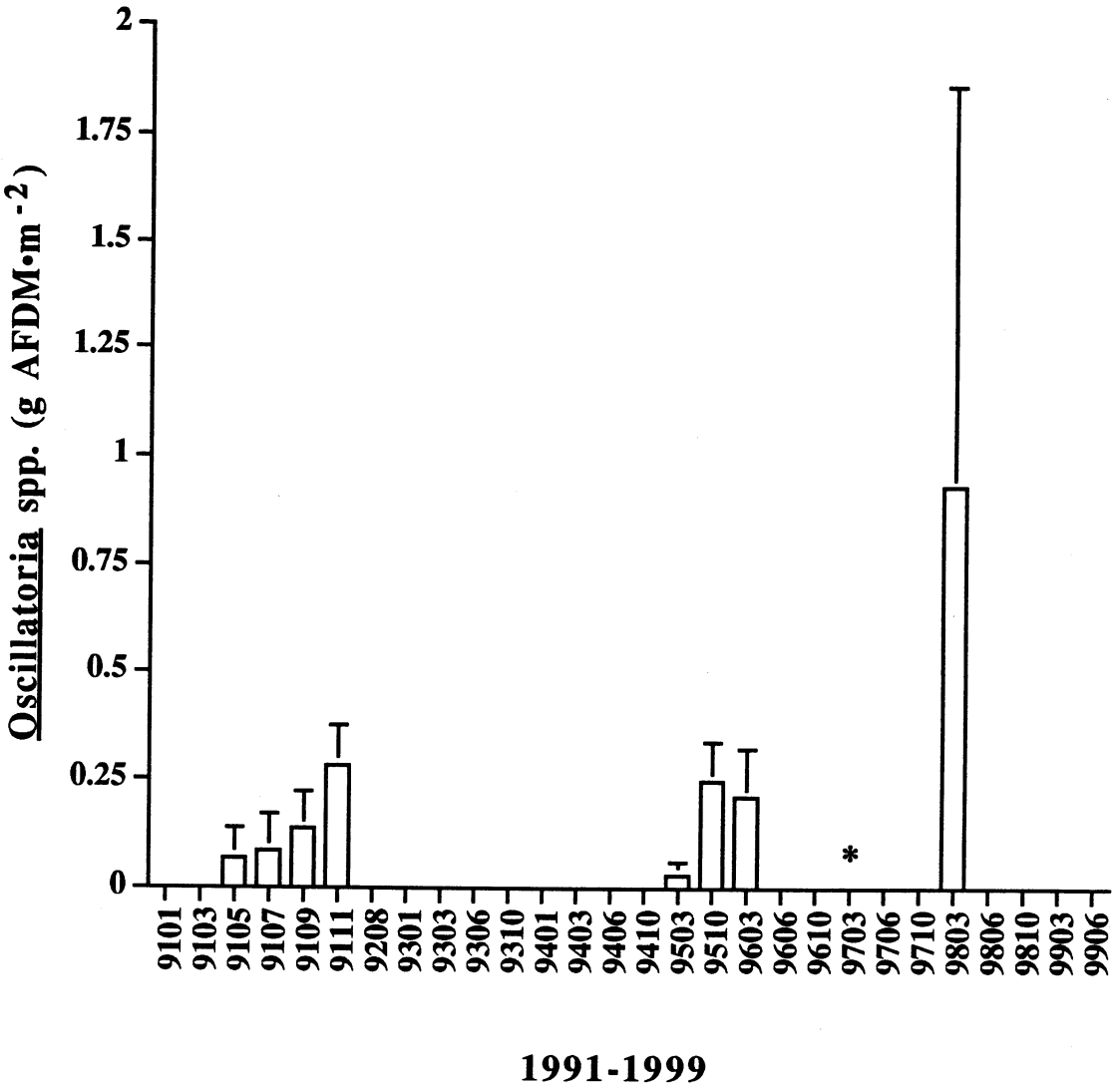

Figure 60. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at Lees Ferry cobble Rkm 0.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 7 g AFDM•m^{-2}(± 4 SE).

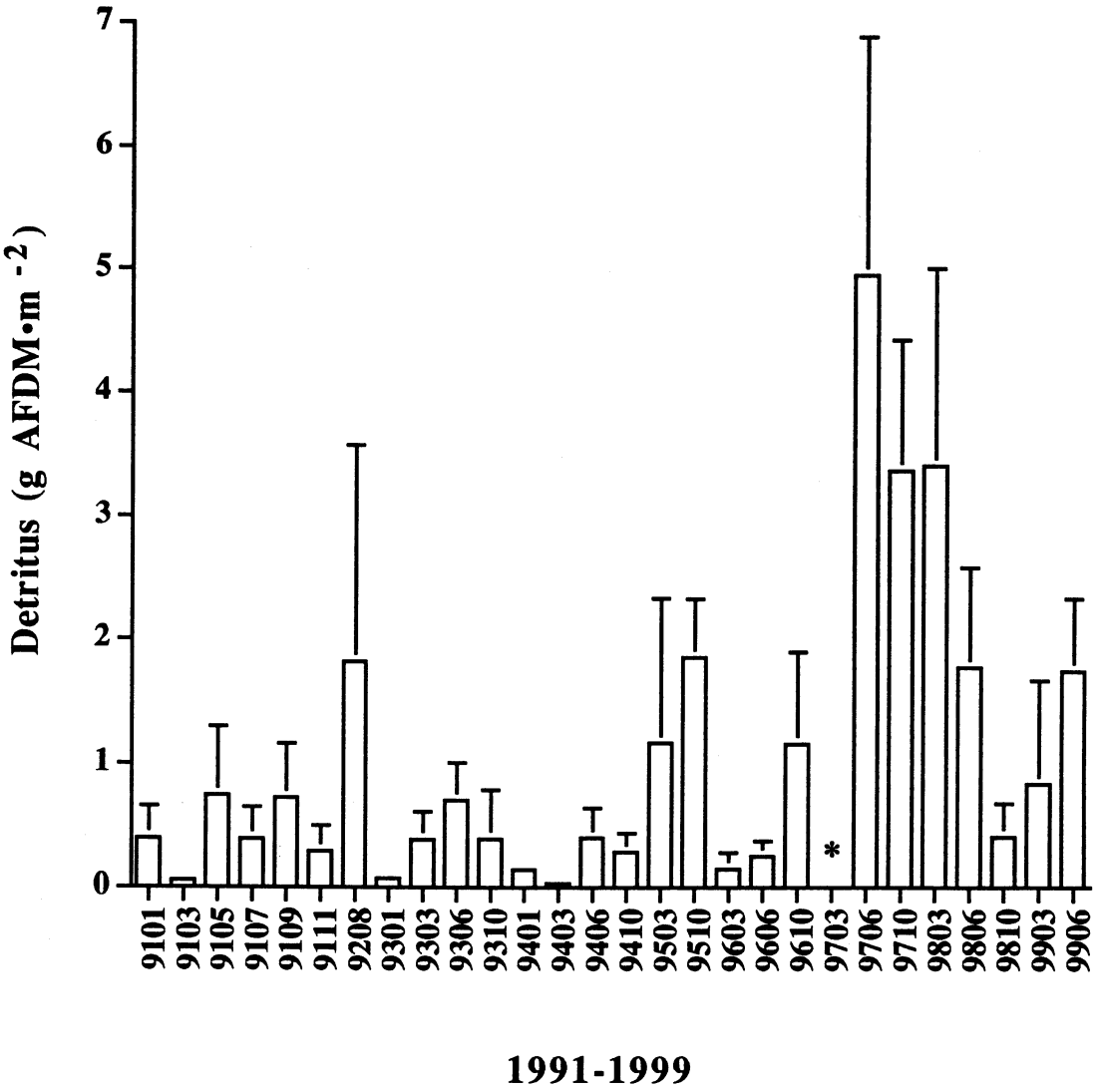

Figure 61. Detritus biomass estimates (g AFDM•m^{-2}) at Lees Ferry cobble Rkm 0.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 15 g AFDM•m^{-2} (± 8 SE).

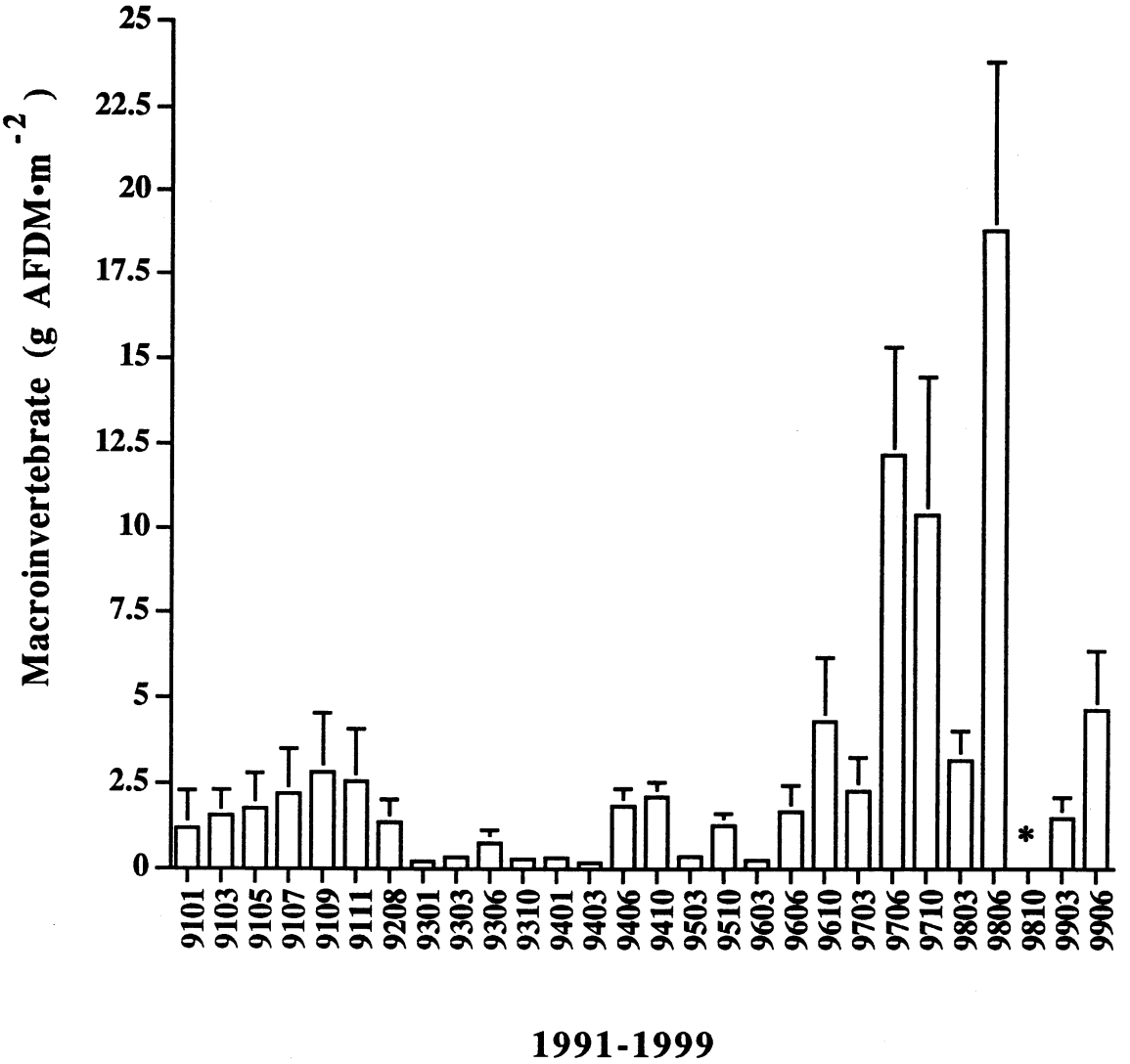

Figure 62. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at Lees Ferry cobble Rkm 0.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 52 g AFDM•m^{-2} (± 7 SE).

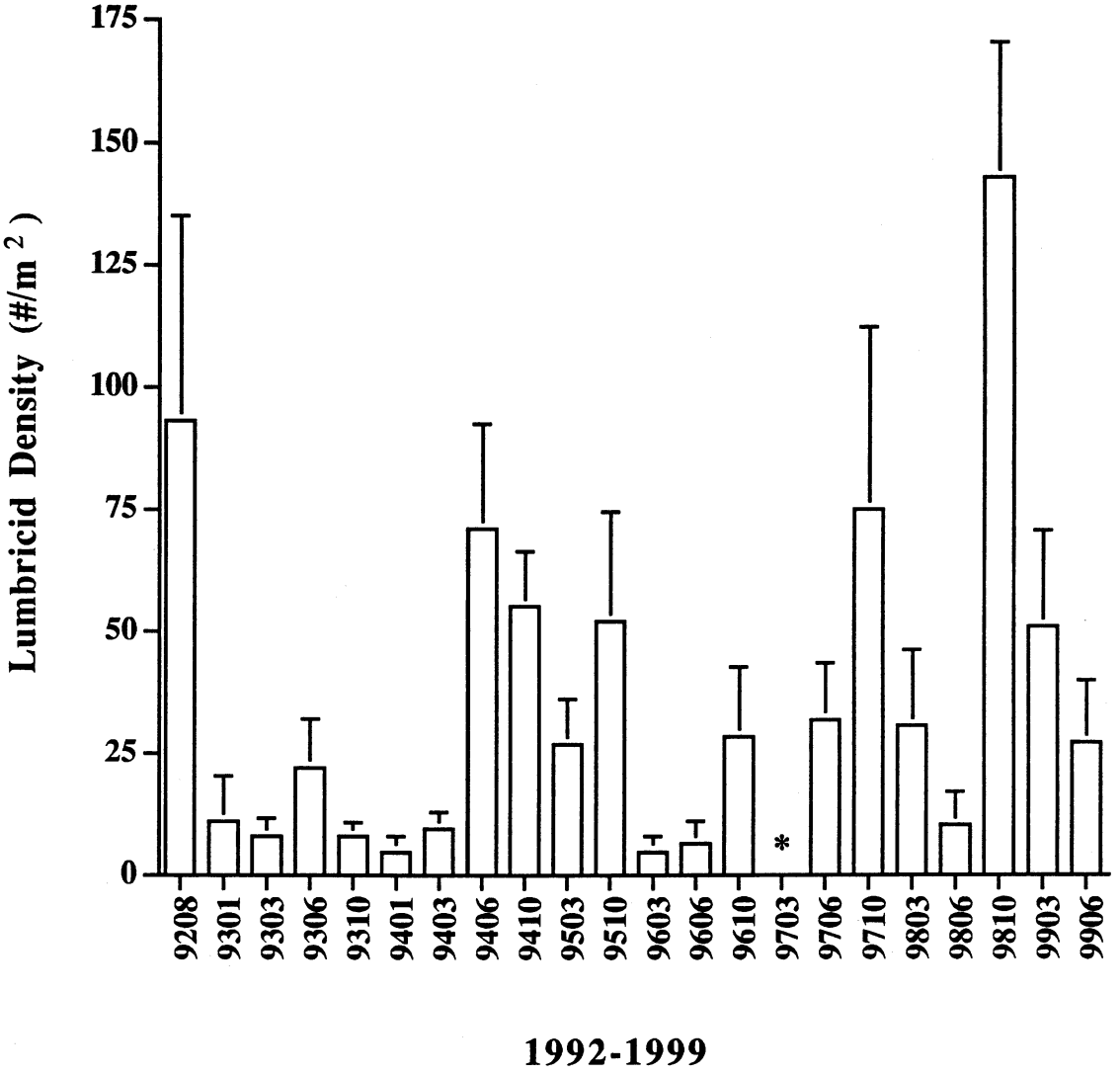

Figure 63. Lumbricid densities (#/m ^{2}) collected at Lees Ferry cobble Rkm 0.8 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 374/m^2 (± 269 SE).

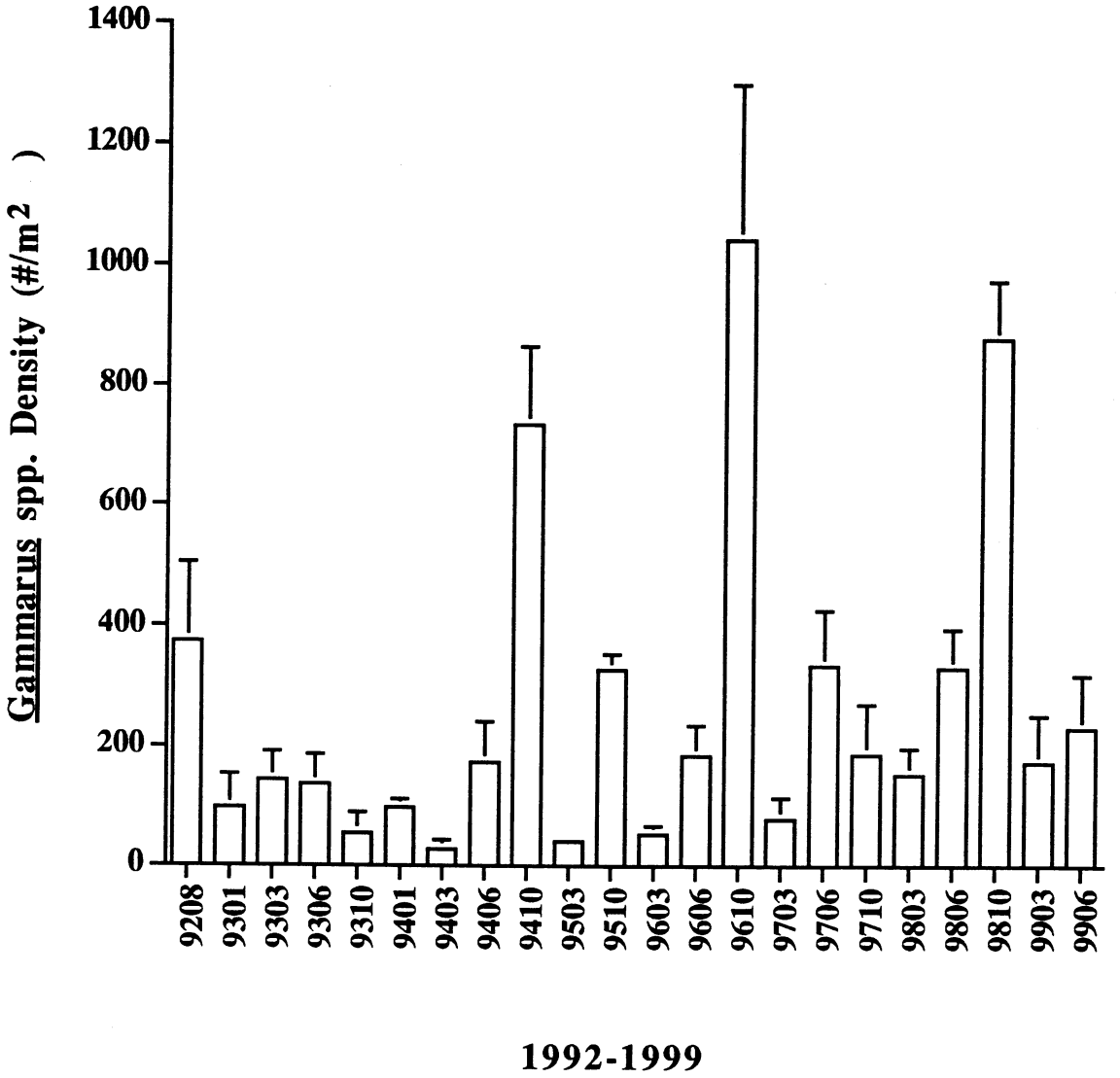

Figure 64. Gammarus spp. densities (#/m^2) collected at Lees Ferry cobble Rkm 0.8 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

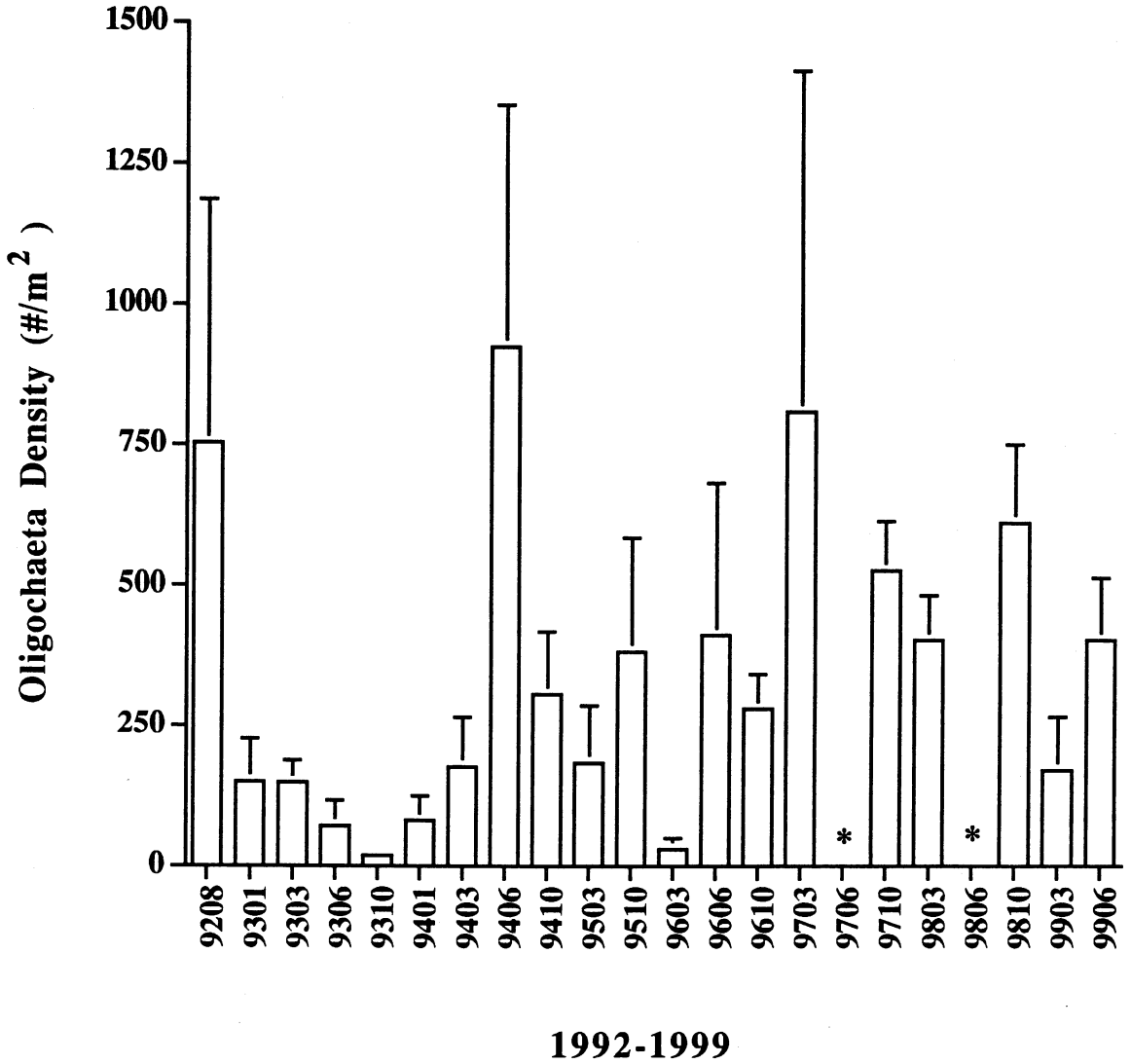

Figure 65. Oligochaeta densities (#/m^2) collected at Lees Ferry cobble Rkm 0.8 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) at 9706 represents 3761/m^2 (± 2202 SE) and at 9806 represents 2683/m^2 (± 1581 SE).

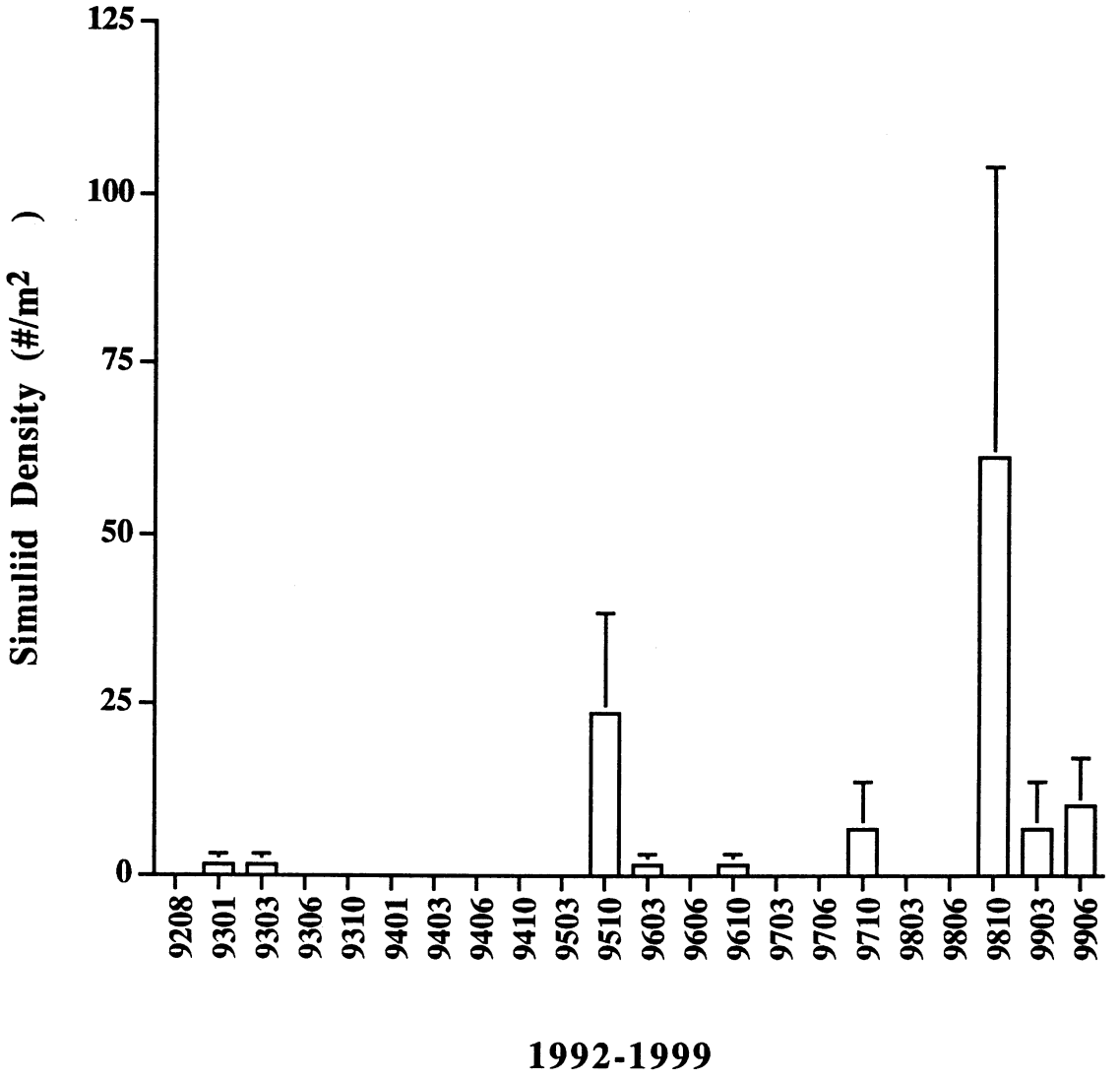

Figure 66. Simuliid densities (#/m^2) collected at Lees Ferry cobble Rkm 0.8 from August 1992 to June 1996. Error bars represent (± 1 SE, n=6).

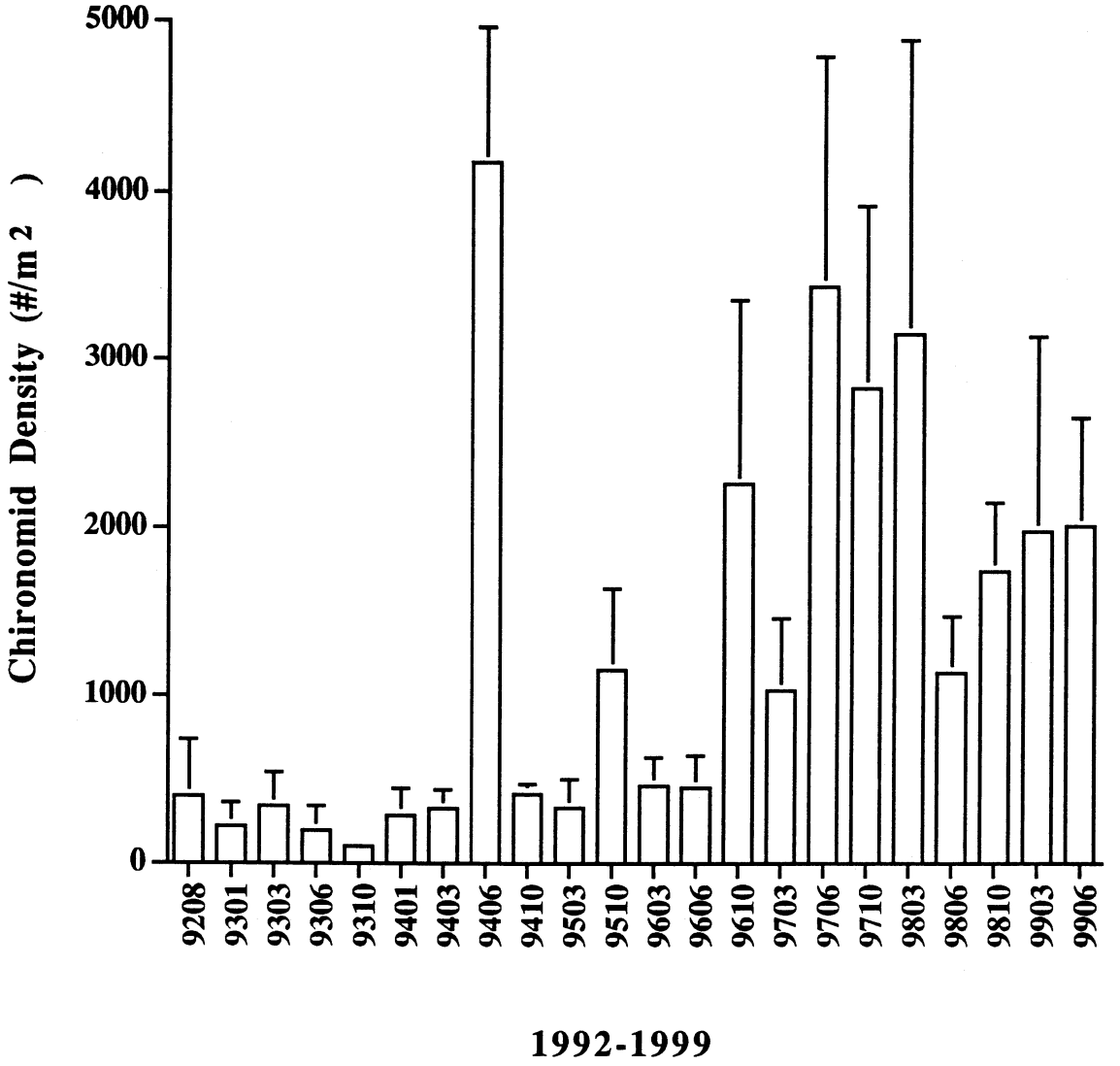

Figure 67. Chironomid densities (#/m^2) collected at Lees Ferry cobble Rkm 0.8 from August 1992 to June 1996. Error bars represent (± 1 SE, n=6).

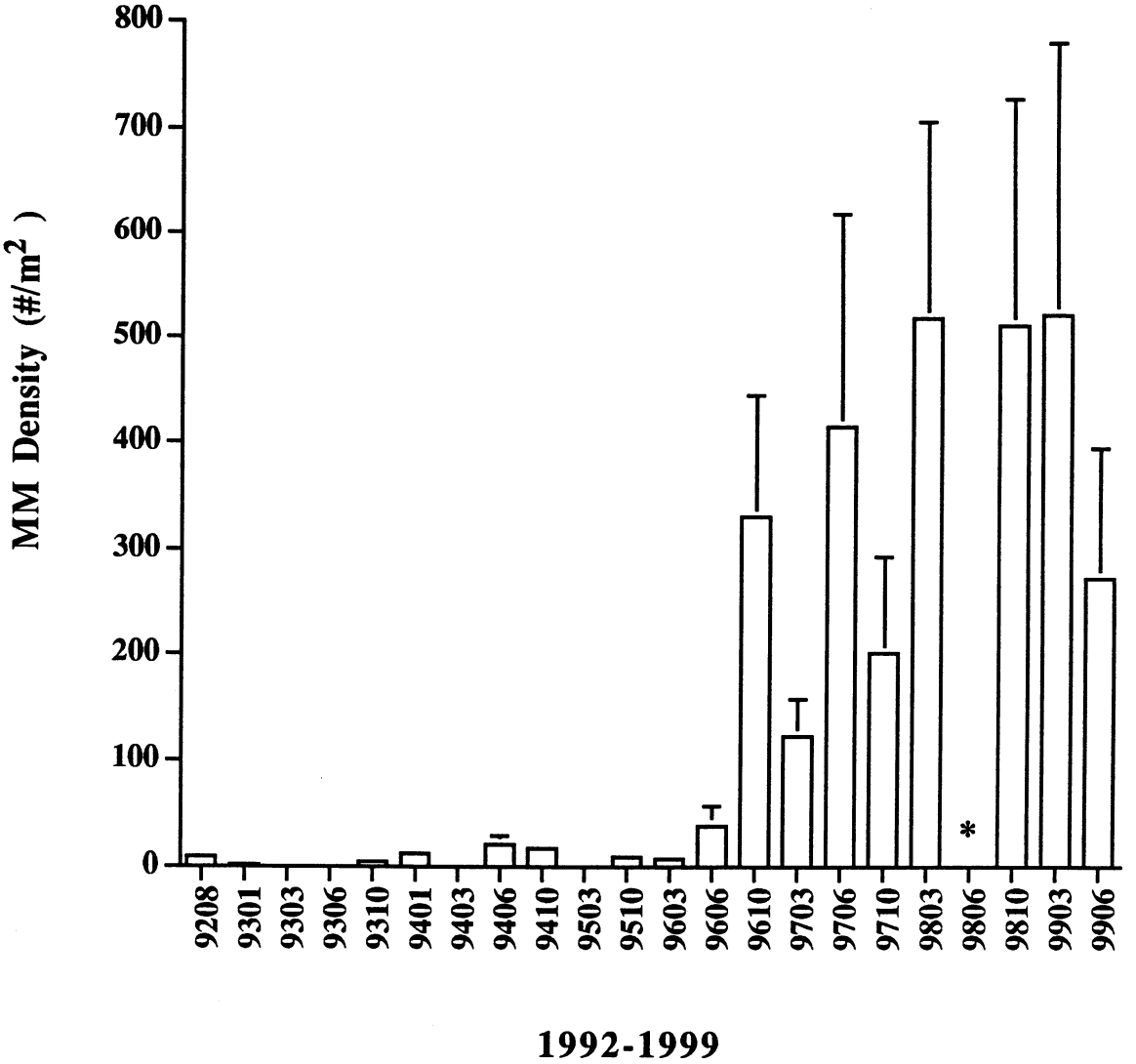

Figure 68. Miscellaneous macroinvertebrate (MM) densities (#/m^2) collected at Lees Ferry cobble Rkm 0.8 from August 1992 to June 1996. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 2013/m^2 (± 1560 SE).

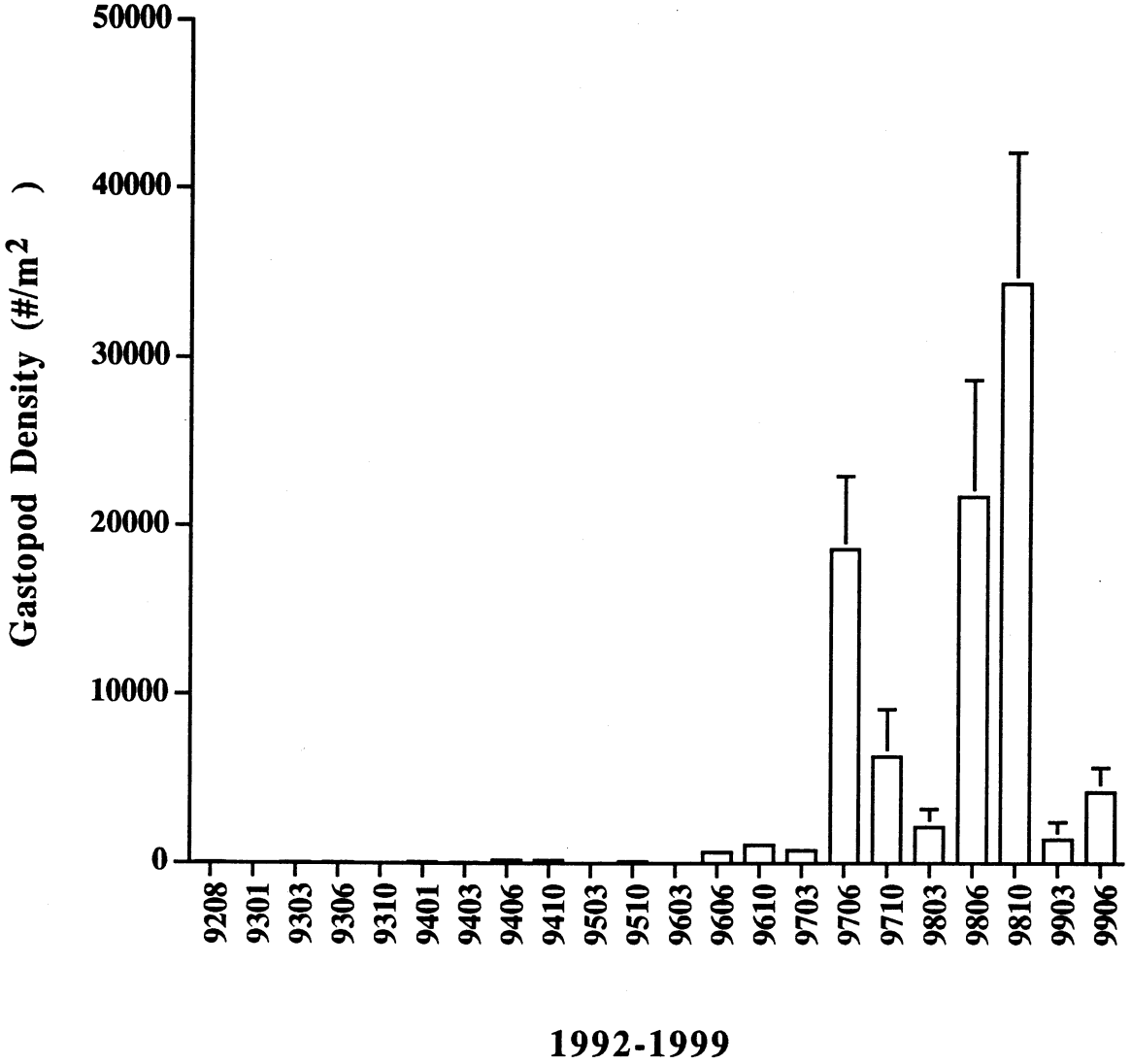

Figure 69. Gastropod densities (#/m ^{2}) collected at Lees Ferry cobble Rkm 0.8 from August 1992 to June 1996. Error bars represent (± 1 SE, n=6).

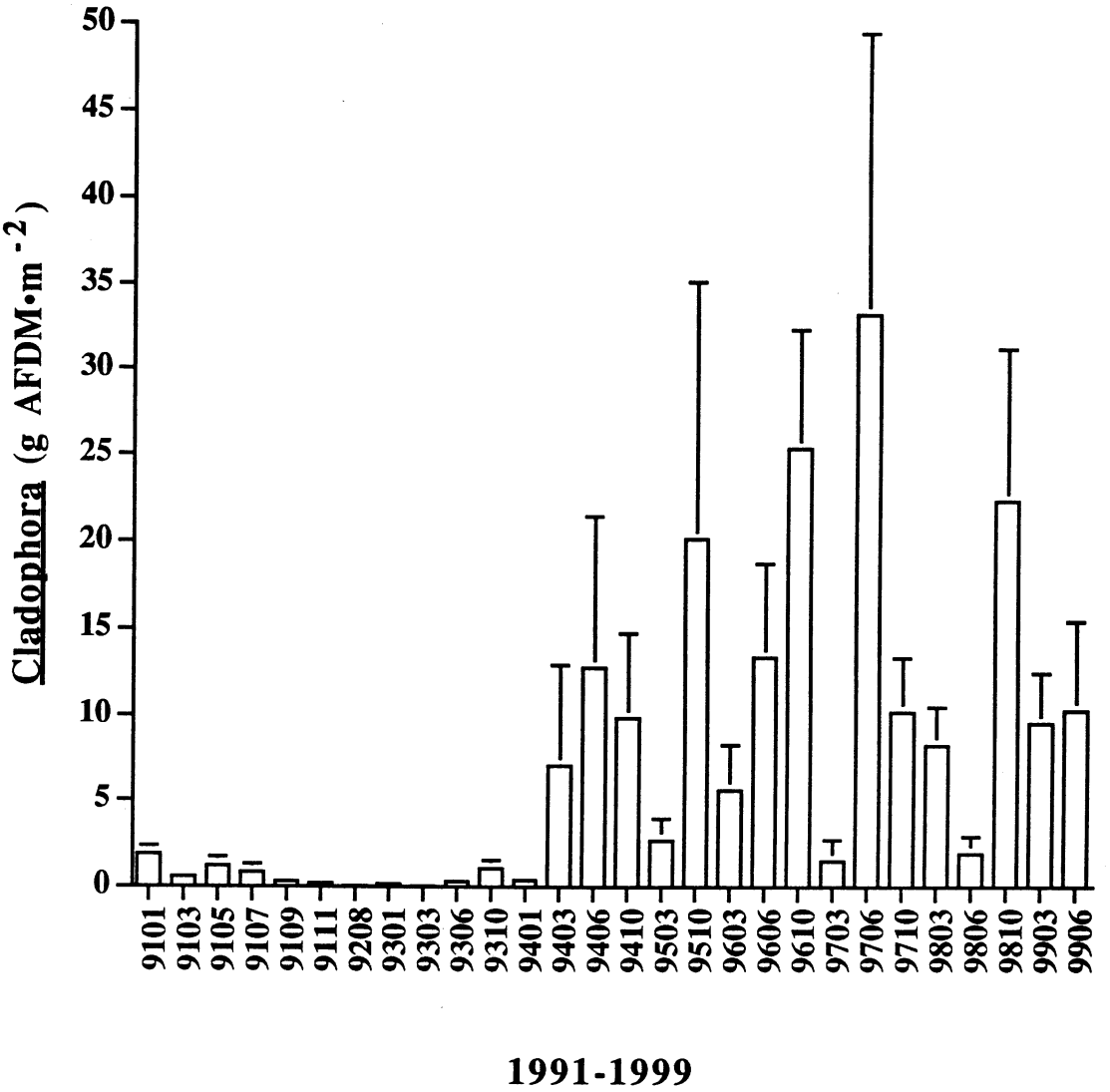

Figure 70. Cladophora biomass estimates (g AFDM•m^{-2}) at Two-Mile Wash cobble Rkm 3.1 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

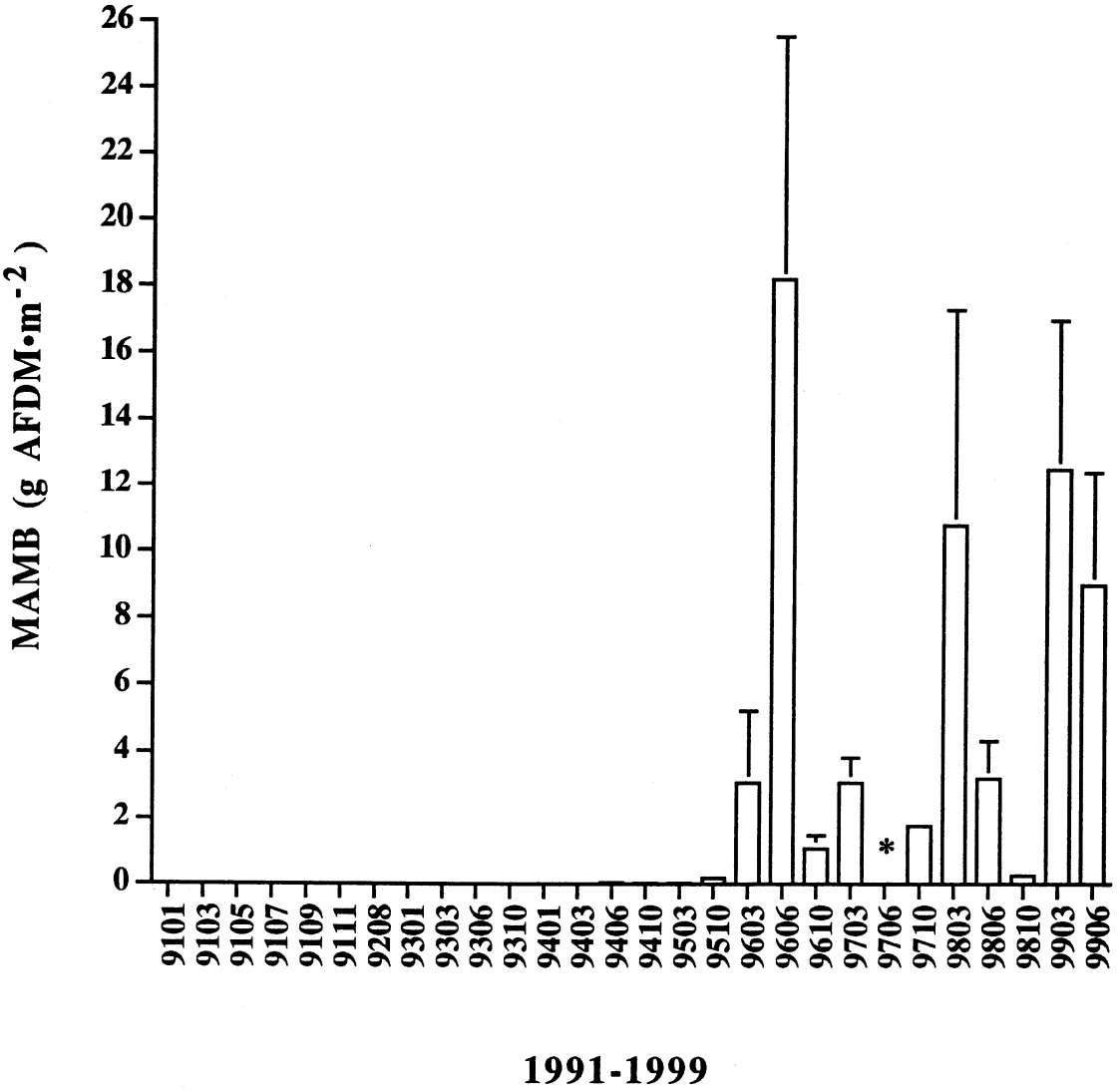

Figure 71. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at Two-Mile Wash cobble Rkm 3.1 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 65 g AFDM•m^{-2} (± 23).

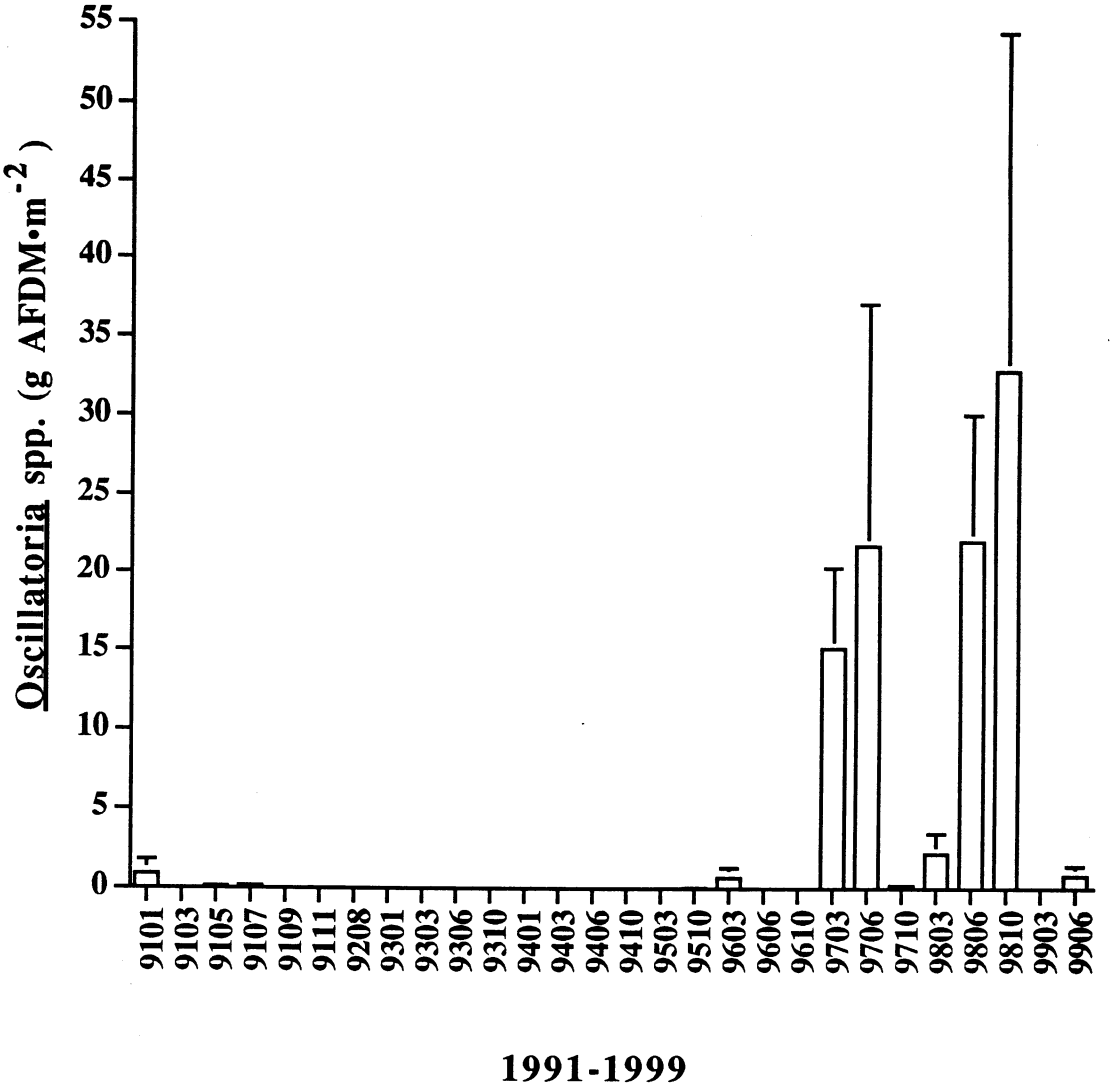

Figure 72. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at Two-Mile Wash cobble Rkm 3.1 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

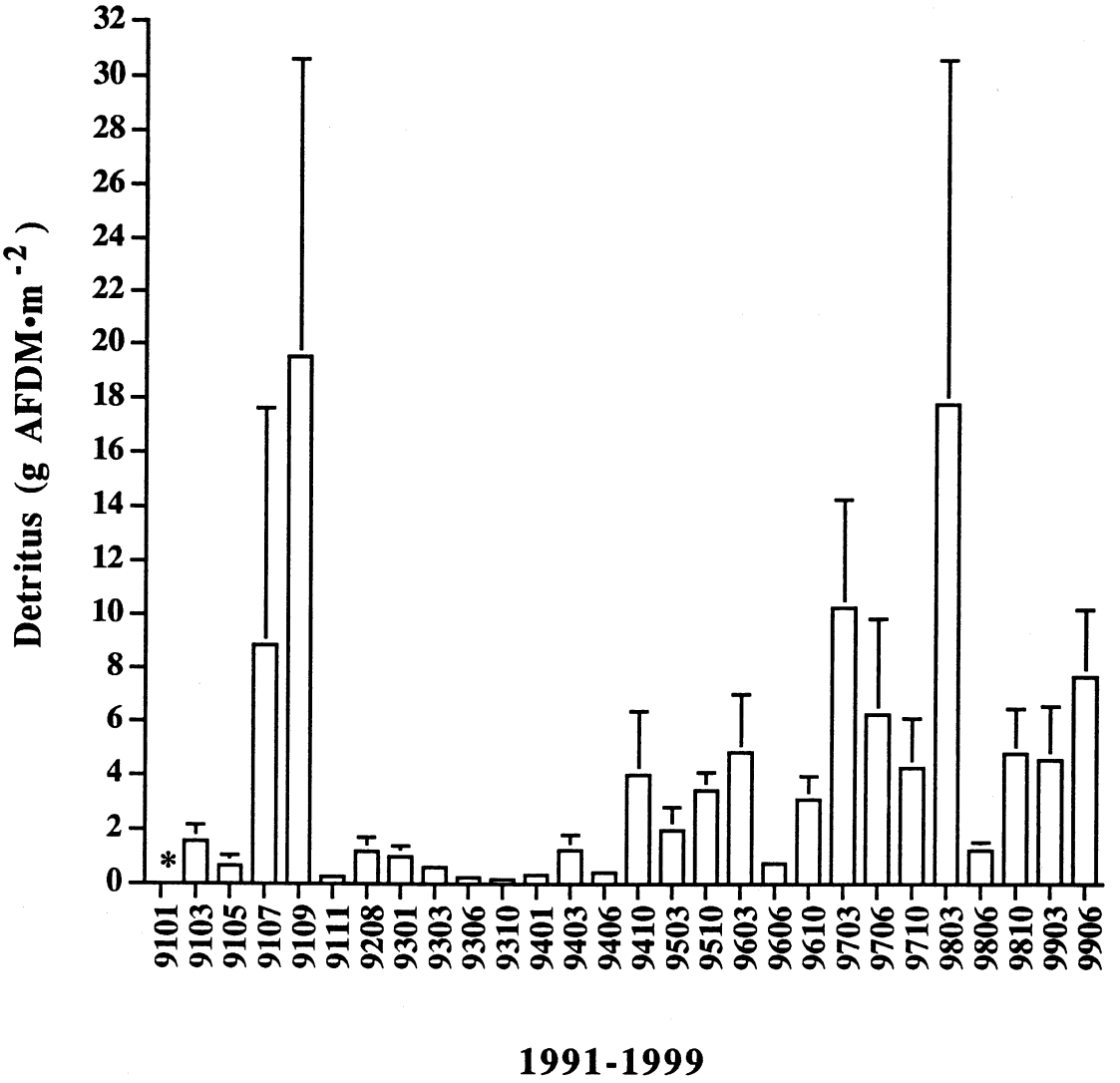

Figure 73. Detritus biomass estimates (g AFDM•m^{-2}) at Two-Mile Wash cobble Rkm 3.1 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 29 g AFDM•m^{-2} (± 25).

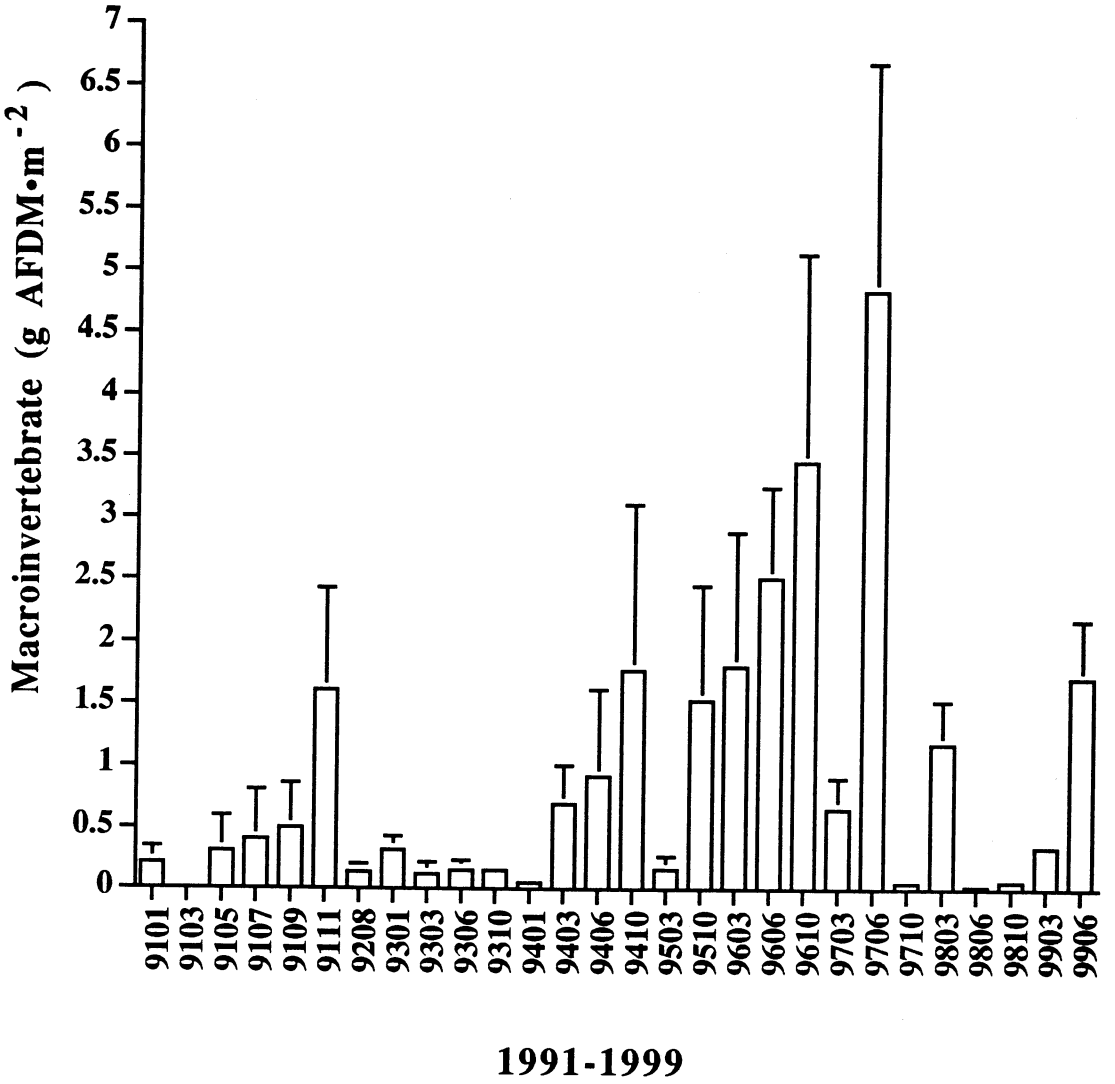

Figure 74. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at Two-Mile Wash cobble Rkm 3.1 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

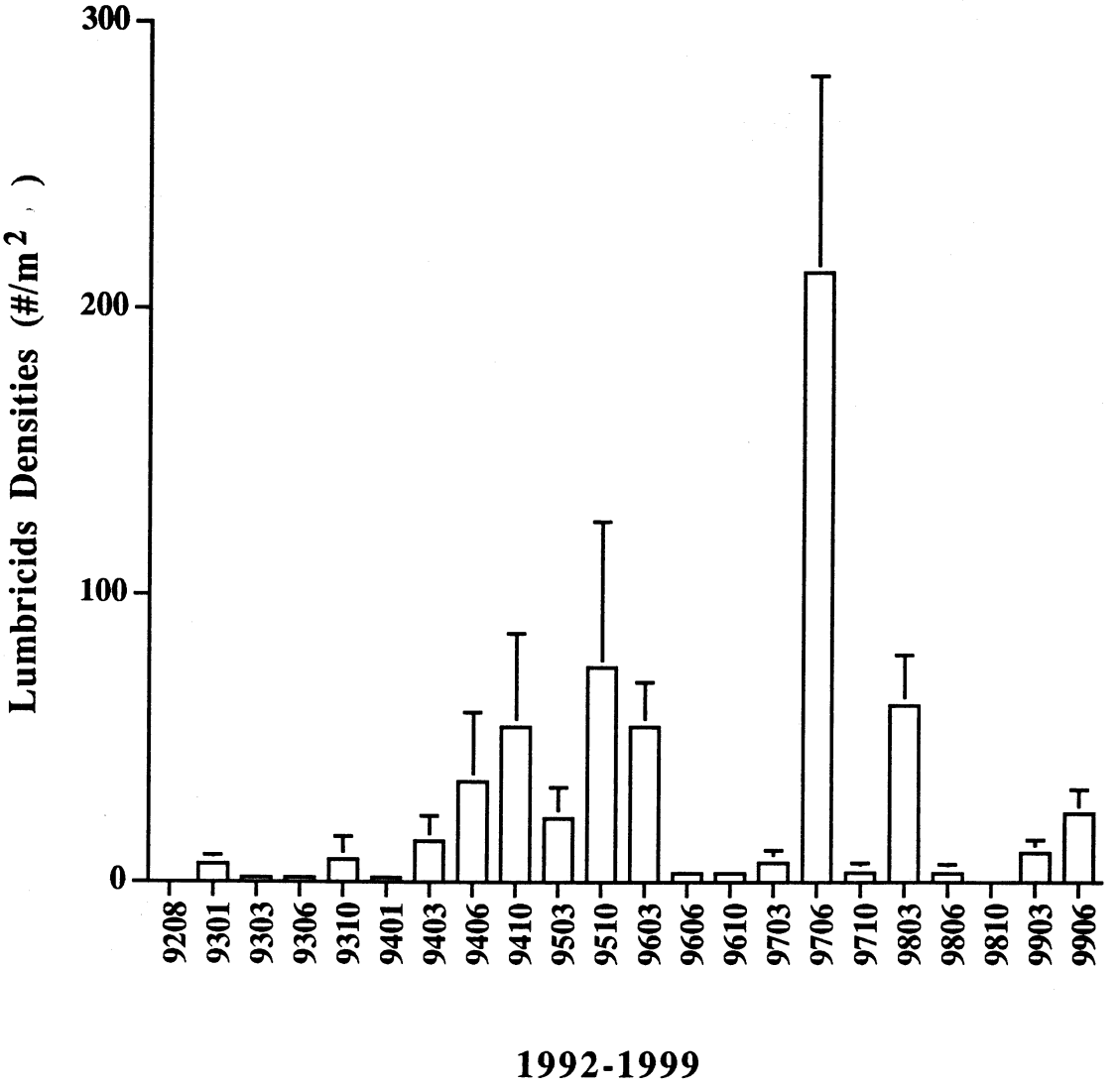

Figure 75. Lumbricid densities (#/m^2) collected at Two-Mile Wash cobble Rkm 3.1 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

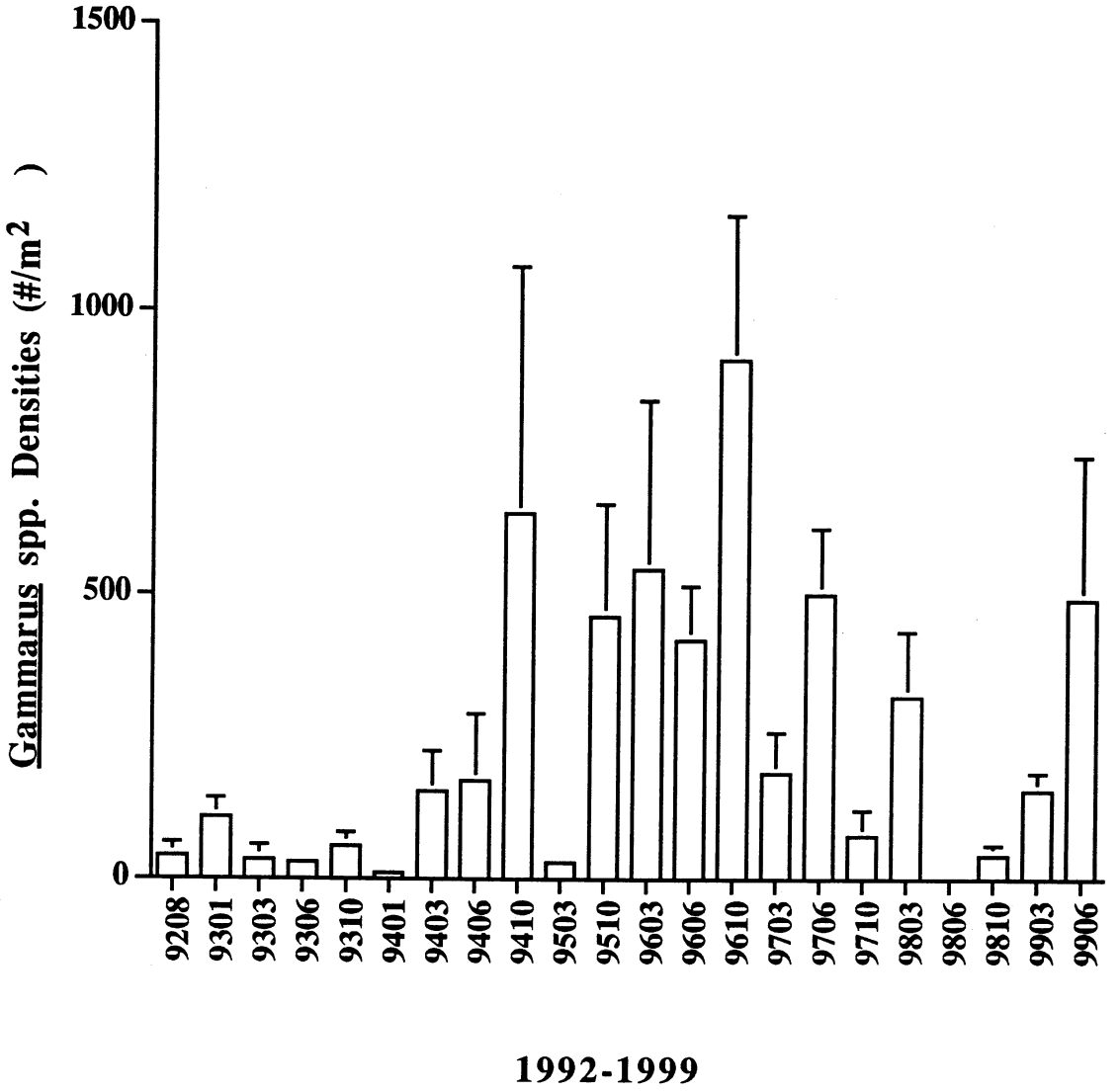

Figure 76. Gammarus spp. densities (#/m^2) collected at Two-Mile Wash cobble Rkm 3.1 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

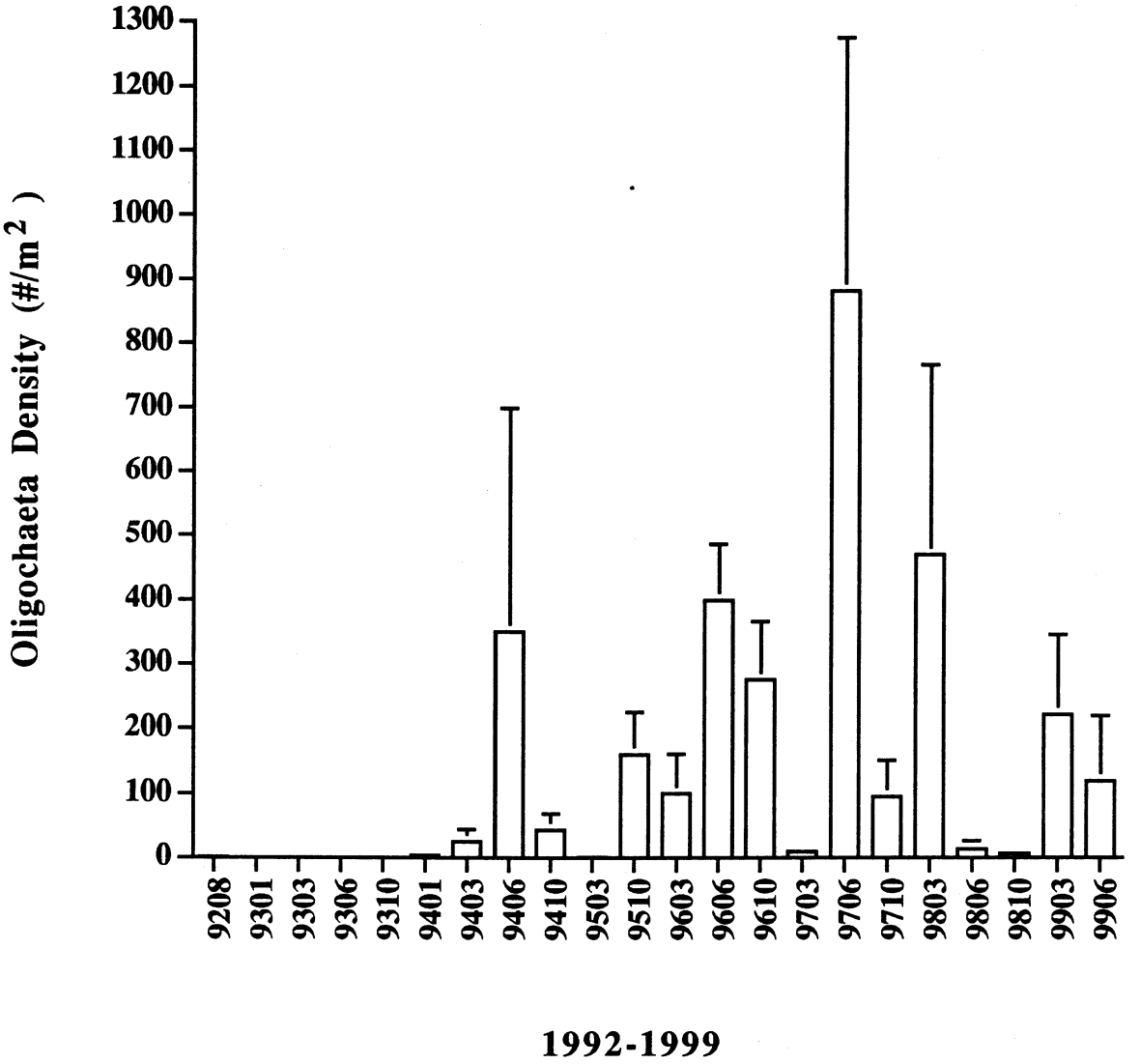

Figure 77. Oligochaeta densities (#/m^2) at Two-Mile Wash cobble Rkm 3.1 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

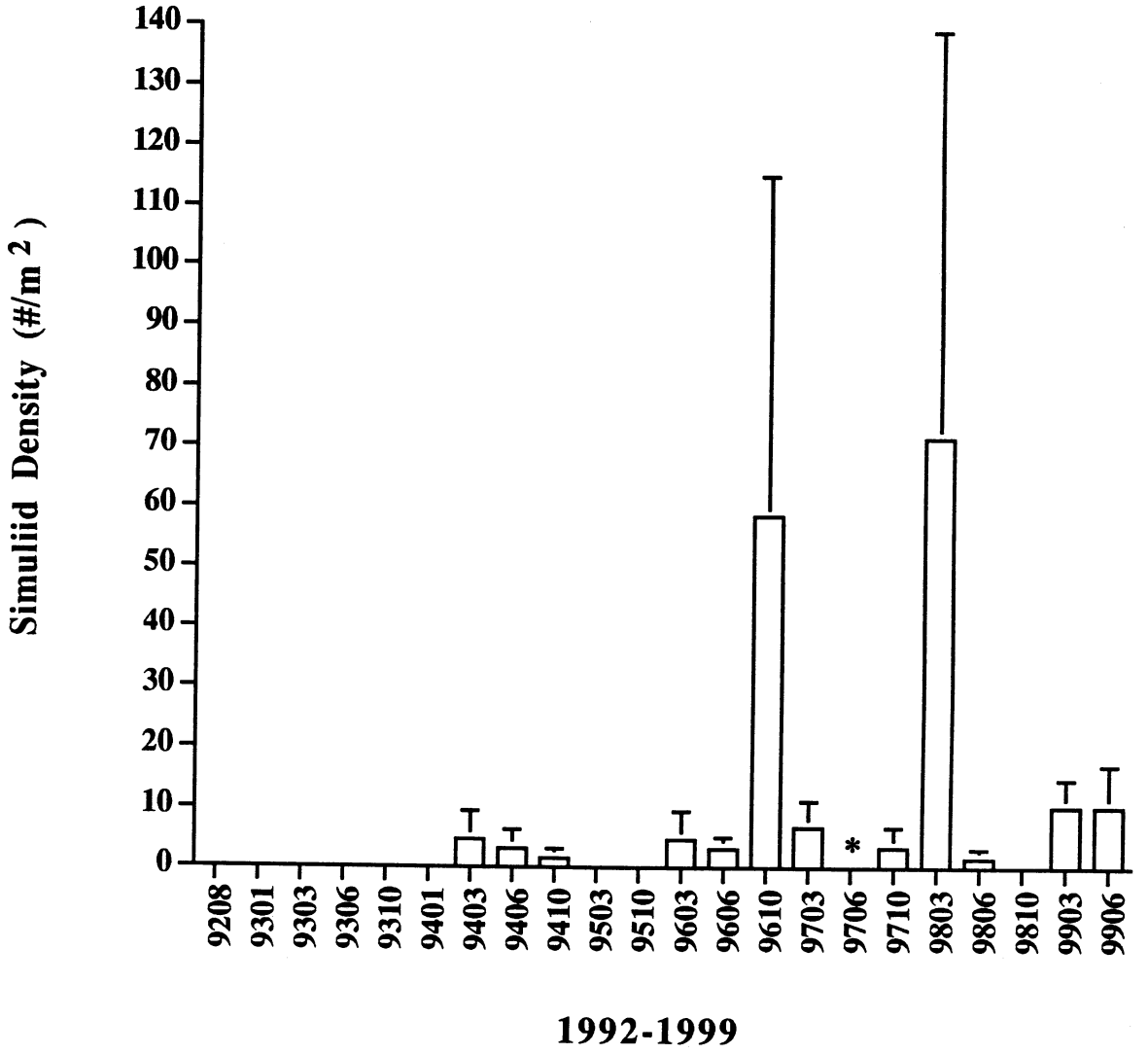

Figure 78. Simuliid densities (#/m2) at Two-Mile Wash cobble Rkm 3.1 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 753/m2 (± 721 SE).

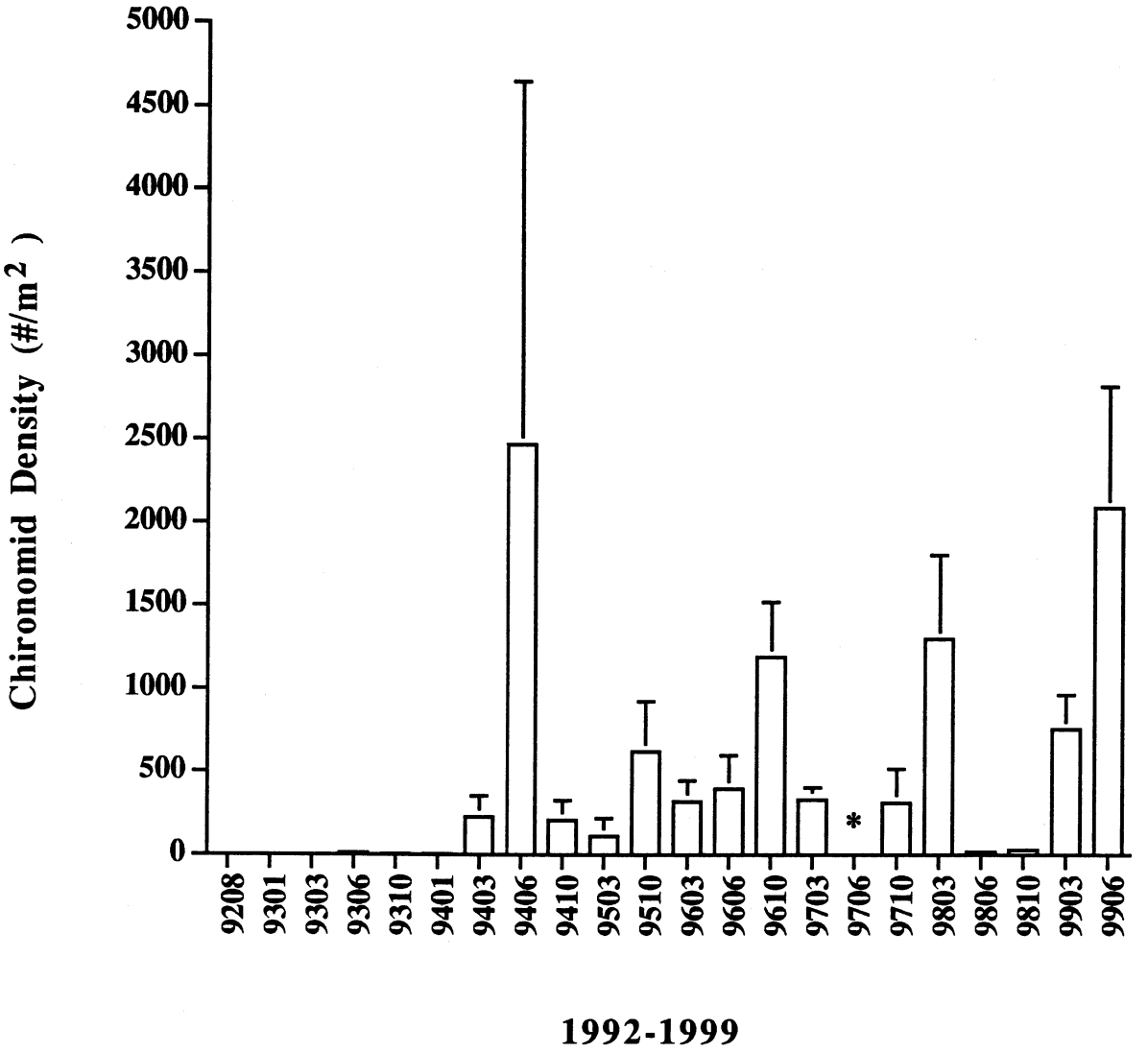

Figure 79. Lumbricid densities (#/m^2) at Two-Mile Wash cobble Rkm 3.1 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) 9628/m^2(± 4184 SE).

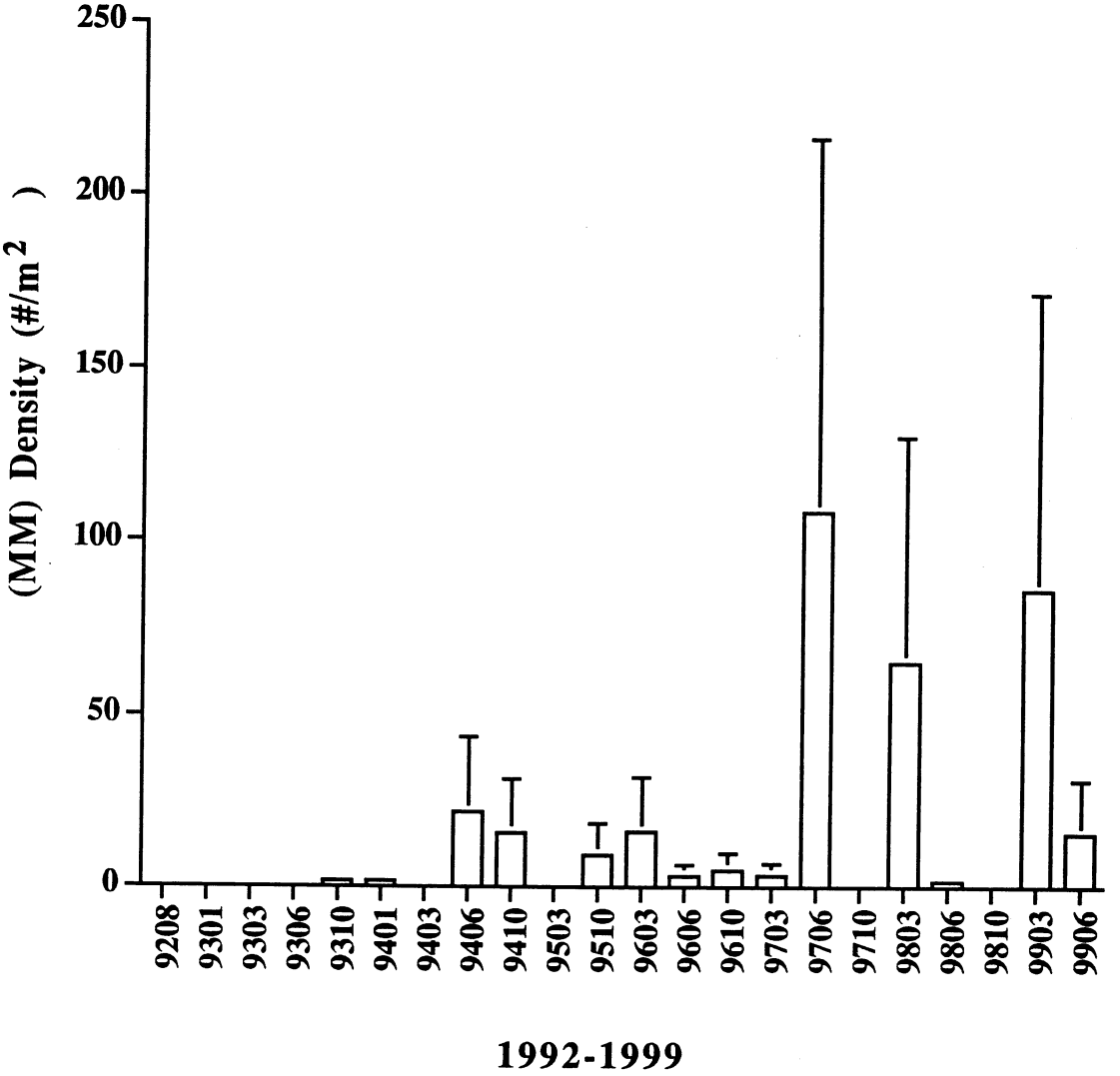

Figure 80. Miscellaneous macroinvertebrate (MM) densities (#/m^2) at Two-Mile Wash cobble Rkm 3.1 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

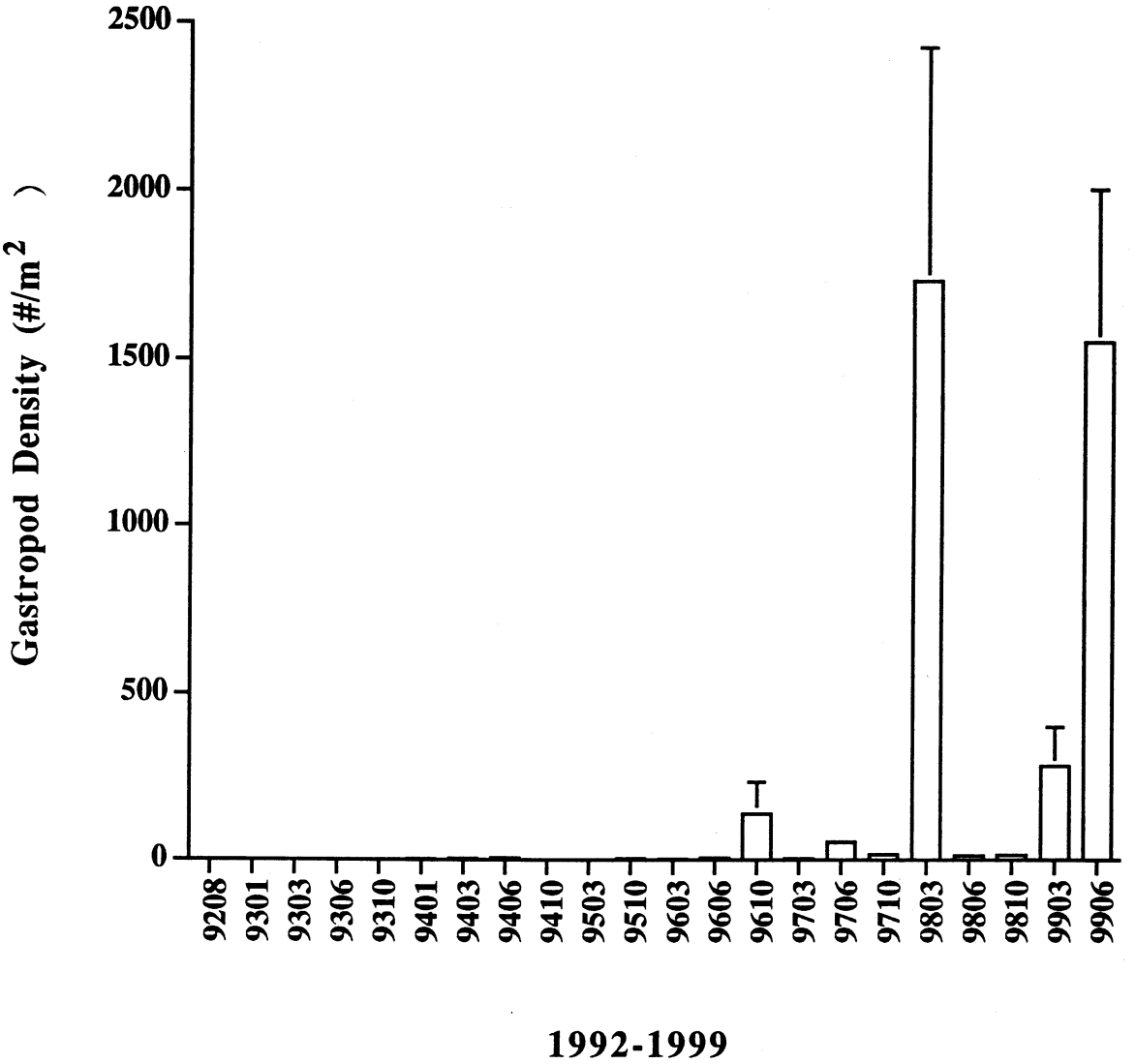

Figure 81. Gastropod densities (#/m^2) at Two-Mile Wash cobble Rkm 3.1 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

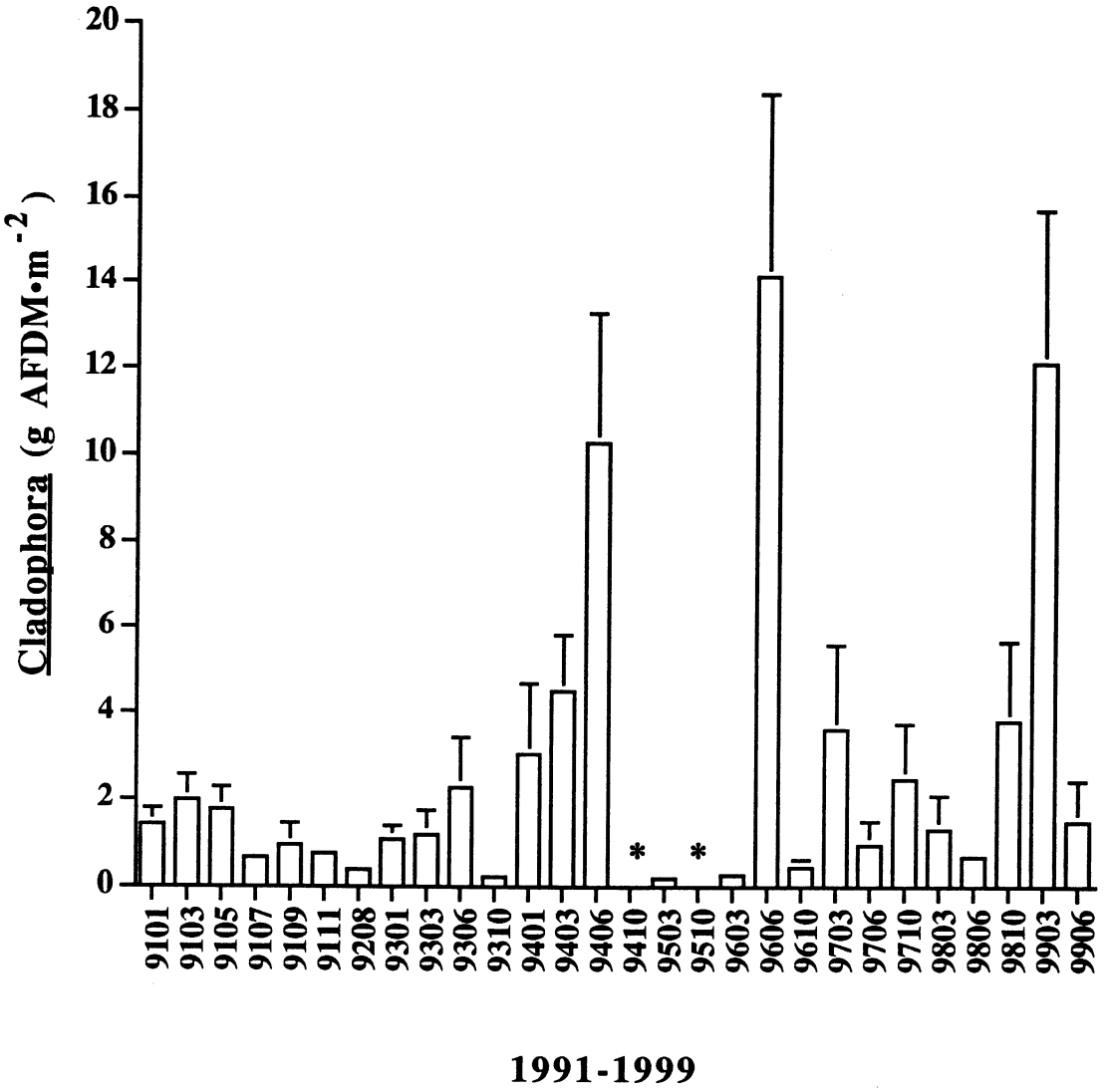

Figure 82. Cladophora biomass estimates (g AFDM•m^{-2}) at LCR Island cobble Rkm 98.6 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) at 9410 represents 32 g AFDM•m^{-2} (± 11 SE) and at 9510 represents 96 g AFDM•m^{-2} (± 38 SE).

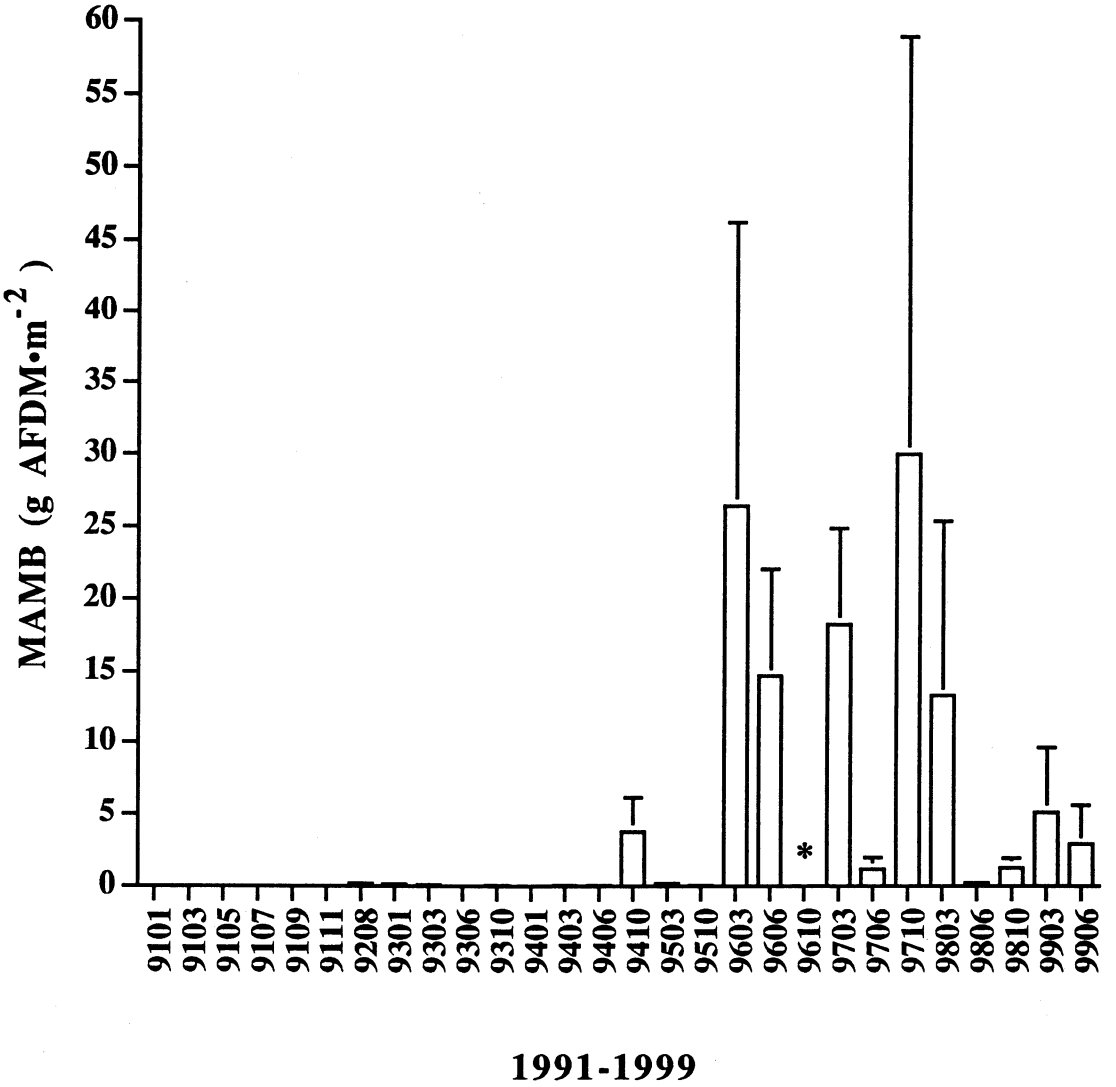

Figure 83. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at LCR Island cobble Rkm 98.6 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 91 g AFDM•m^{-2} (± 26 SE).

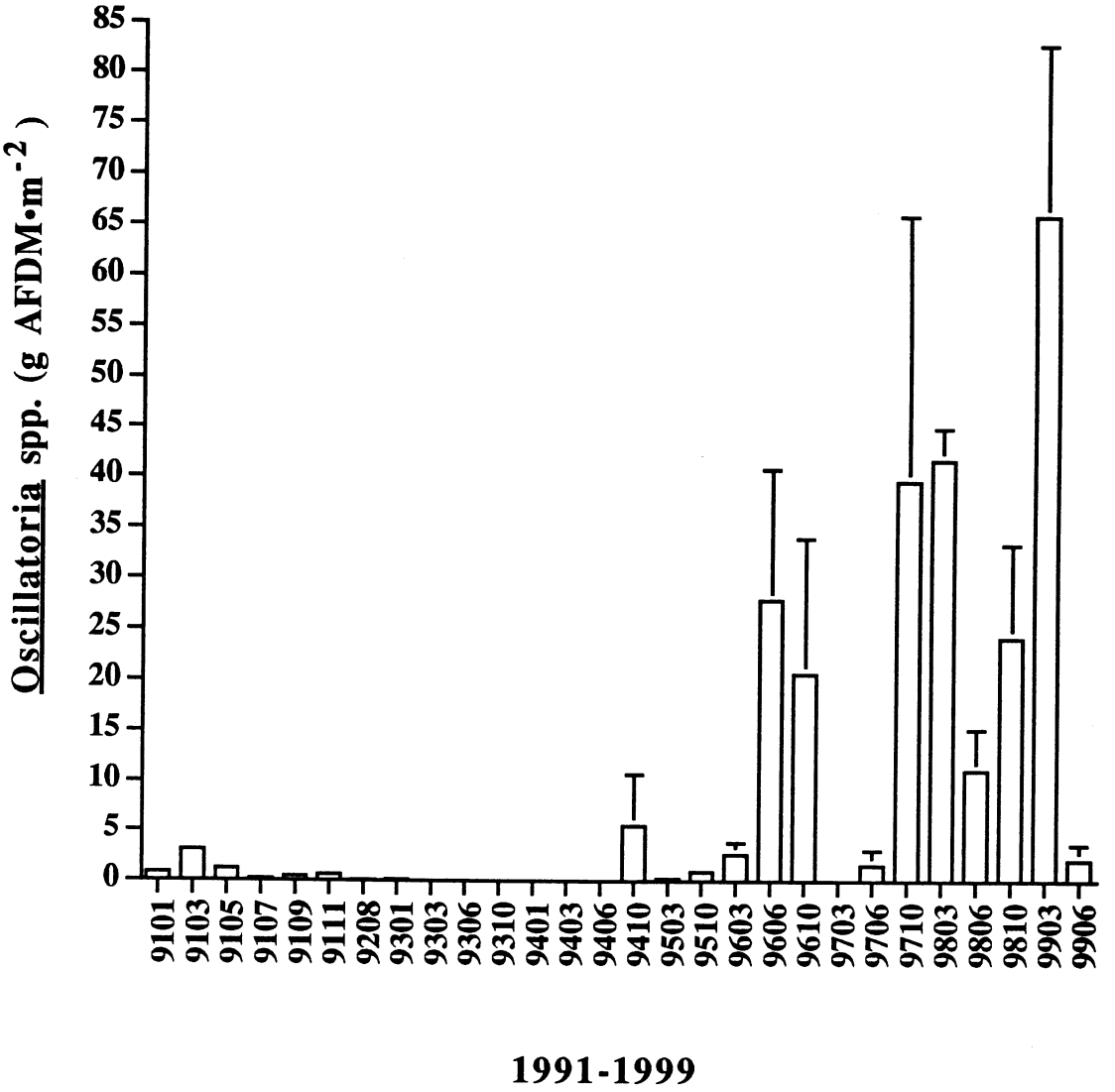

Figure 84. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at LCR Island cobble Rkm 98.6 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

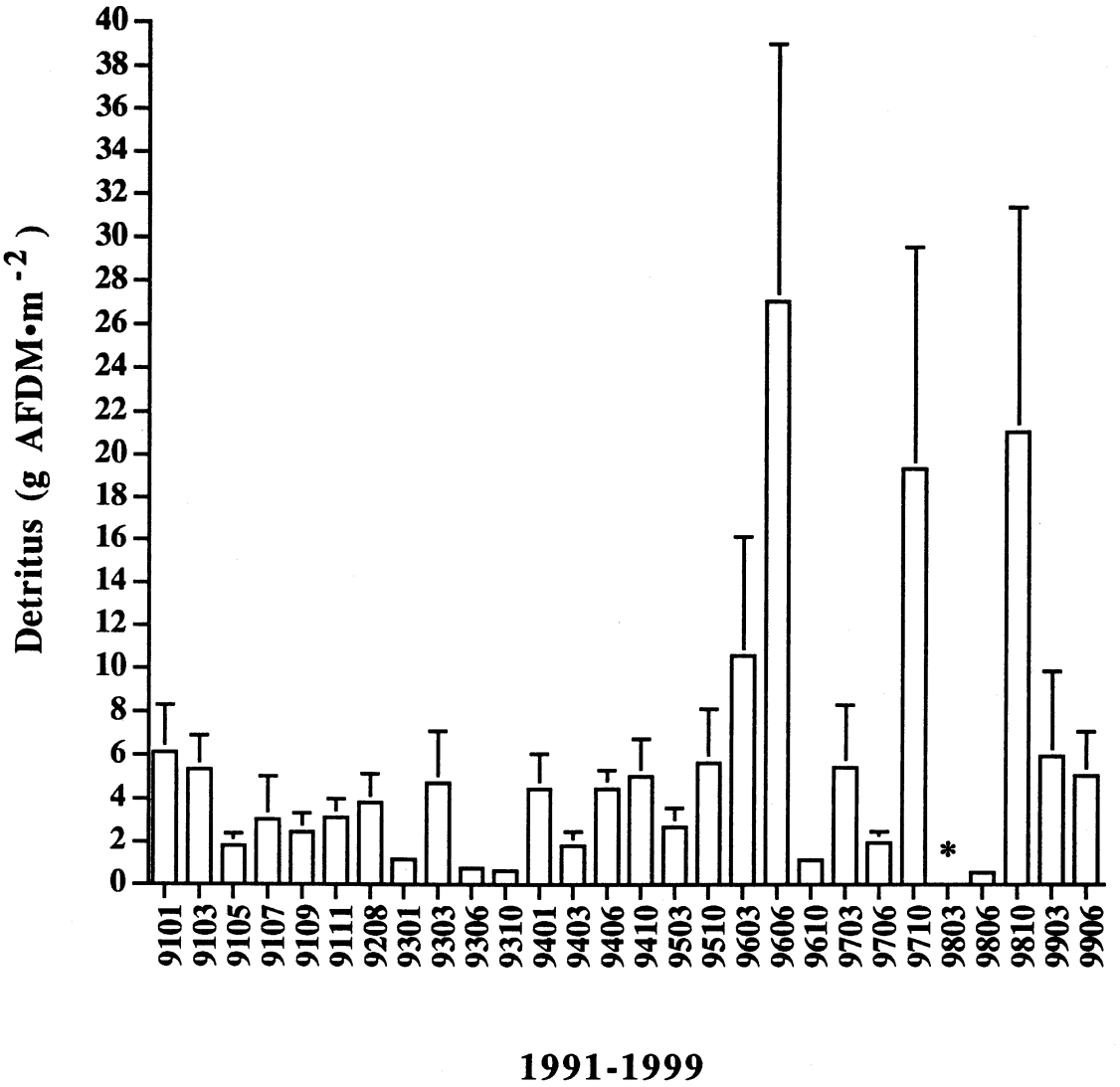

Figure 85. Detritus biomass estimates (g AFDM•m^{-2}) at LCR Island cobble Rkm 98.6 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 39 g AFDM•m^{-2} (± 31 SE).

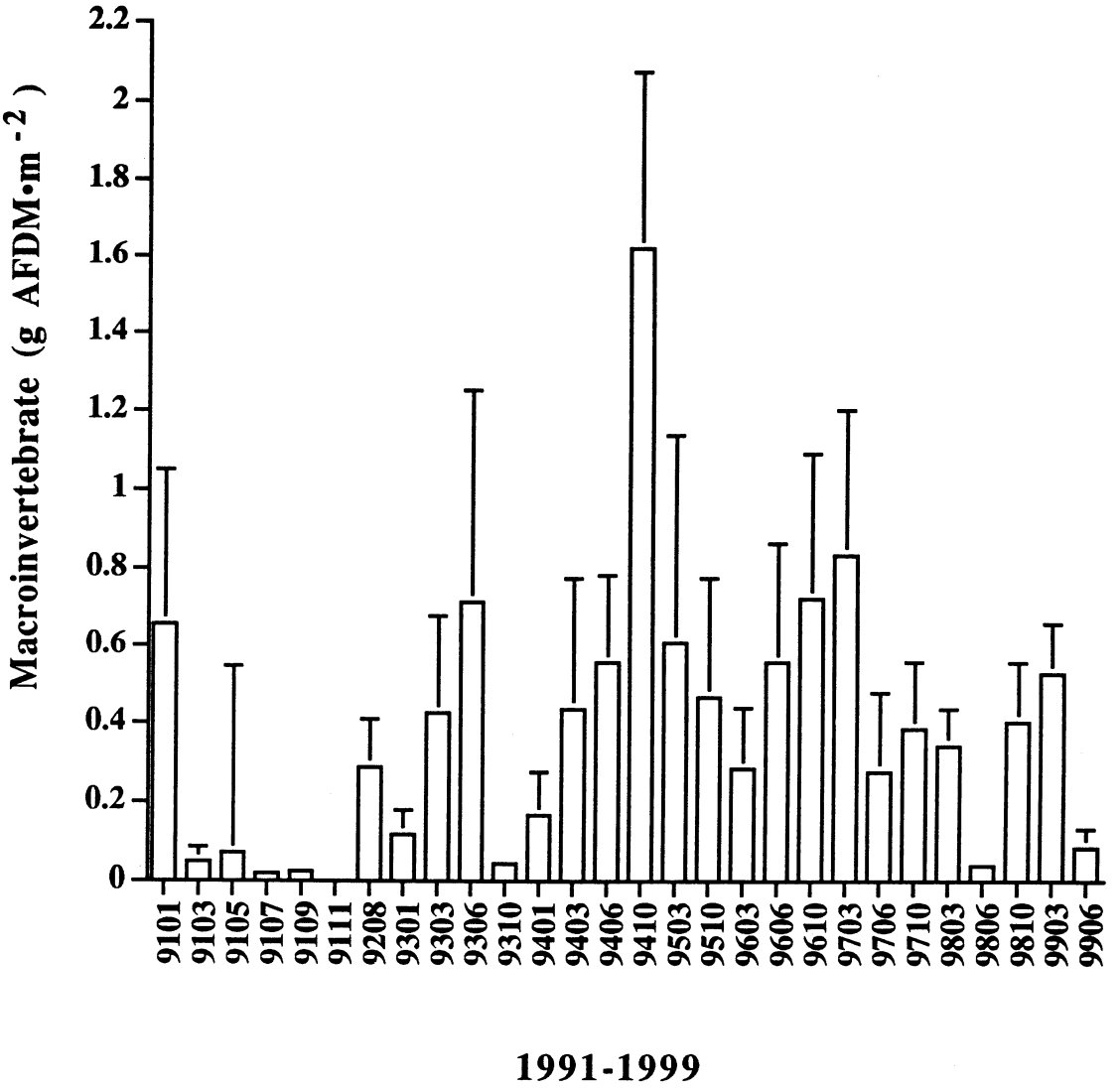

Figure 86. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at LCR Island cobble Rkm 98.6 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

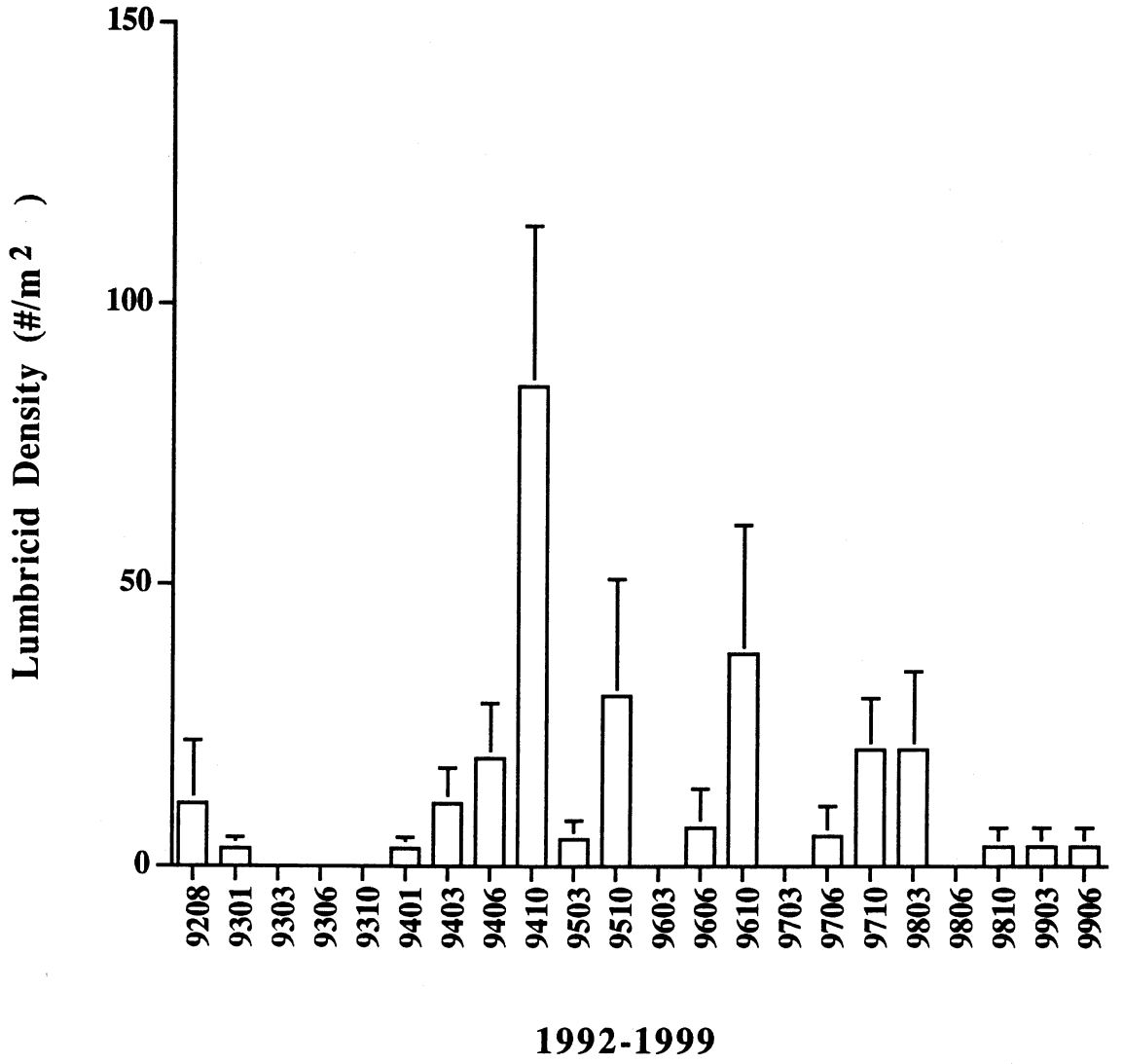

Figure 87. Lumbricid densities (#/m^2) collected at LCR Island cobble Rkm 98.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

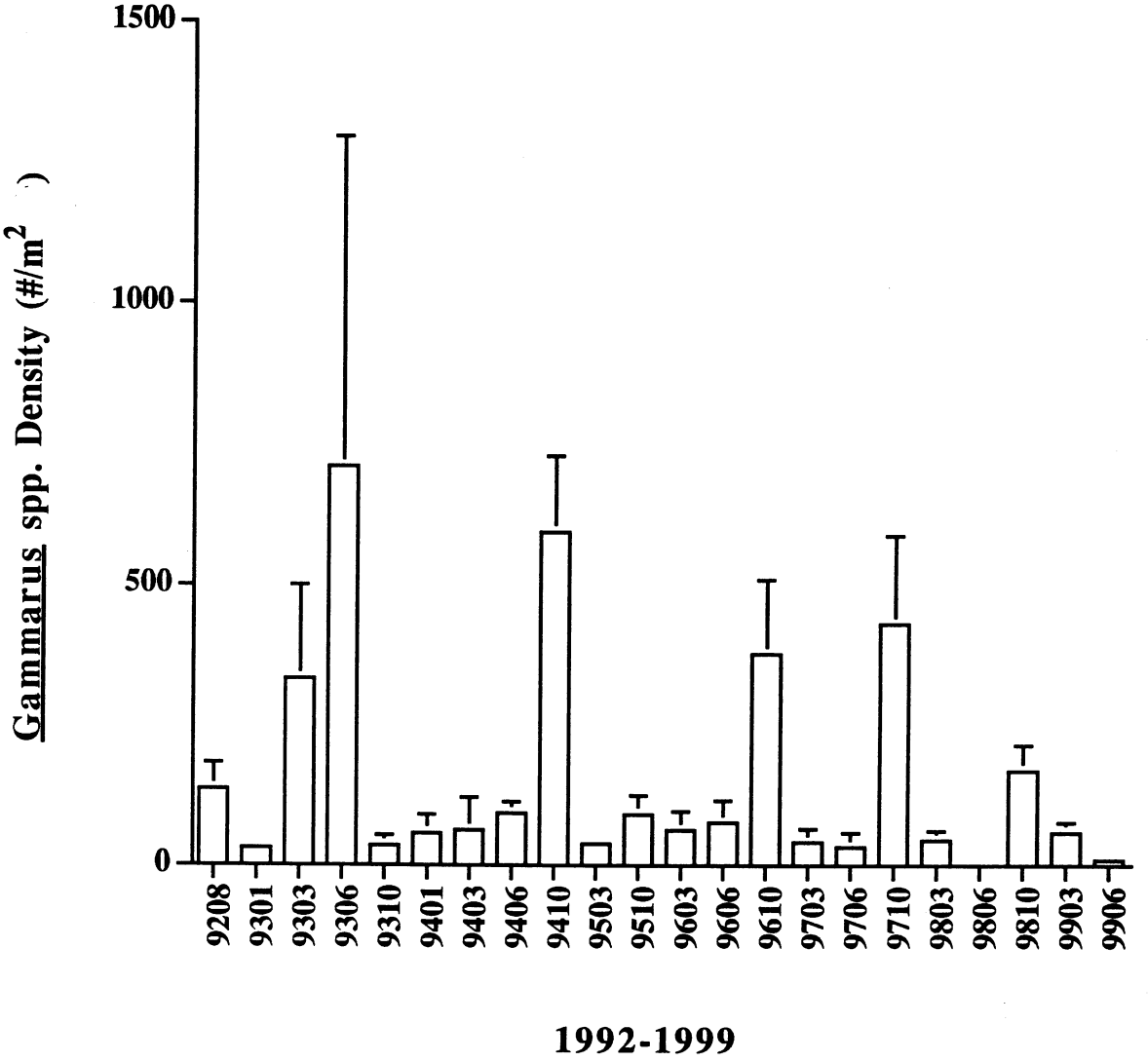

Figure 88. Gammarus spp. densities (#/m^2) collected at LCR Island cobble Rkm 98.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

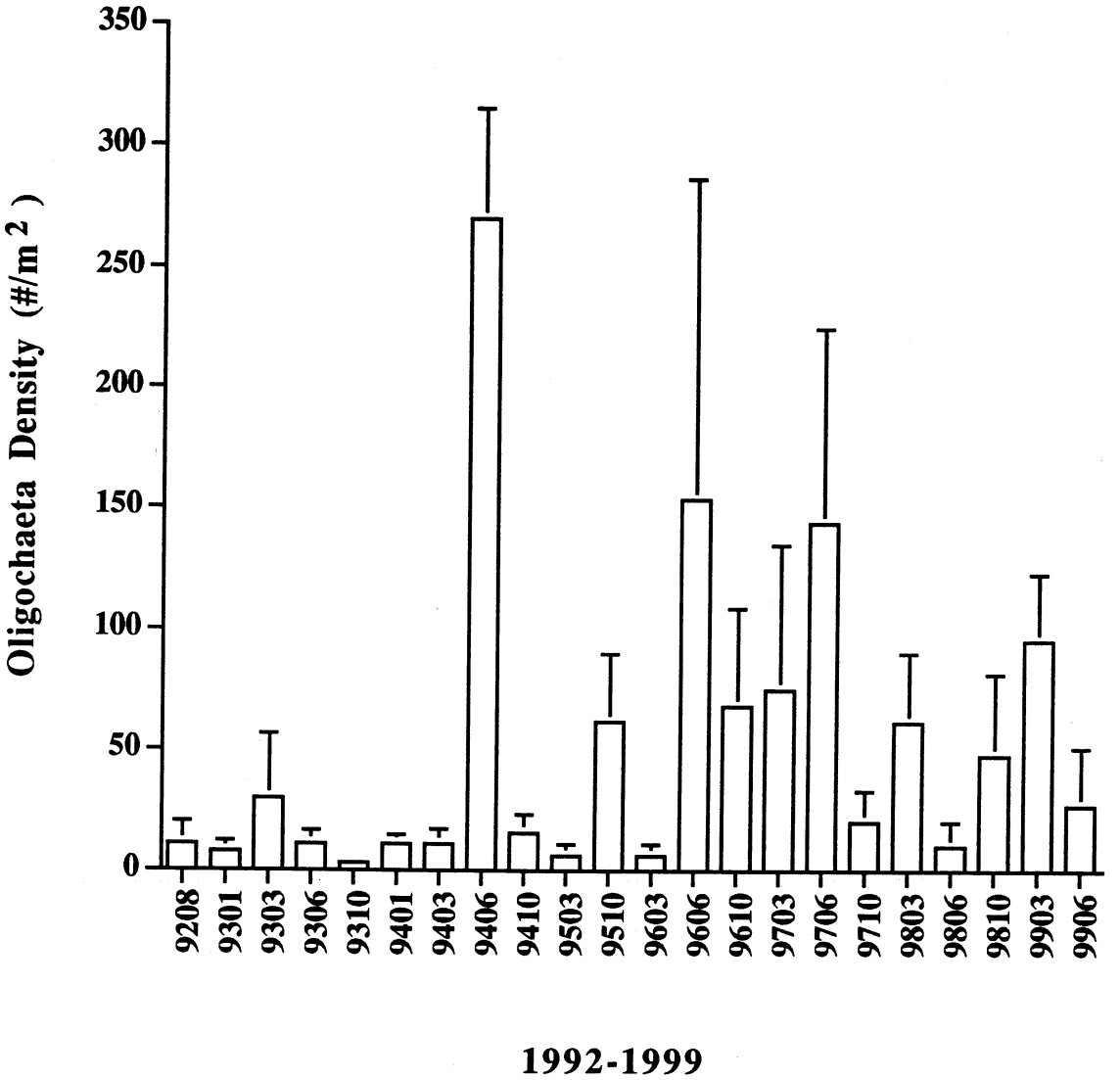

Figure 89. Oligochaeta densities (#/m^2) collected at LCR Island cobble Rkm 98.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

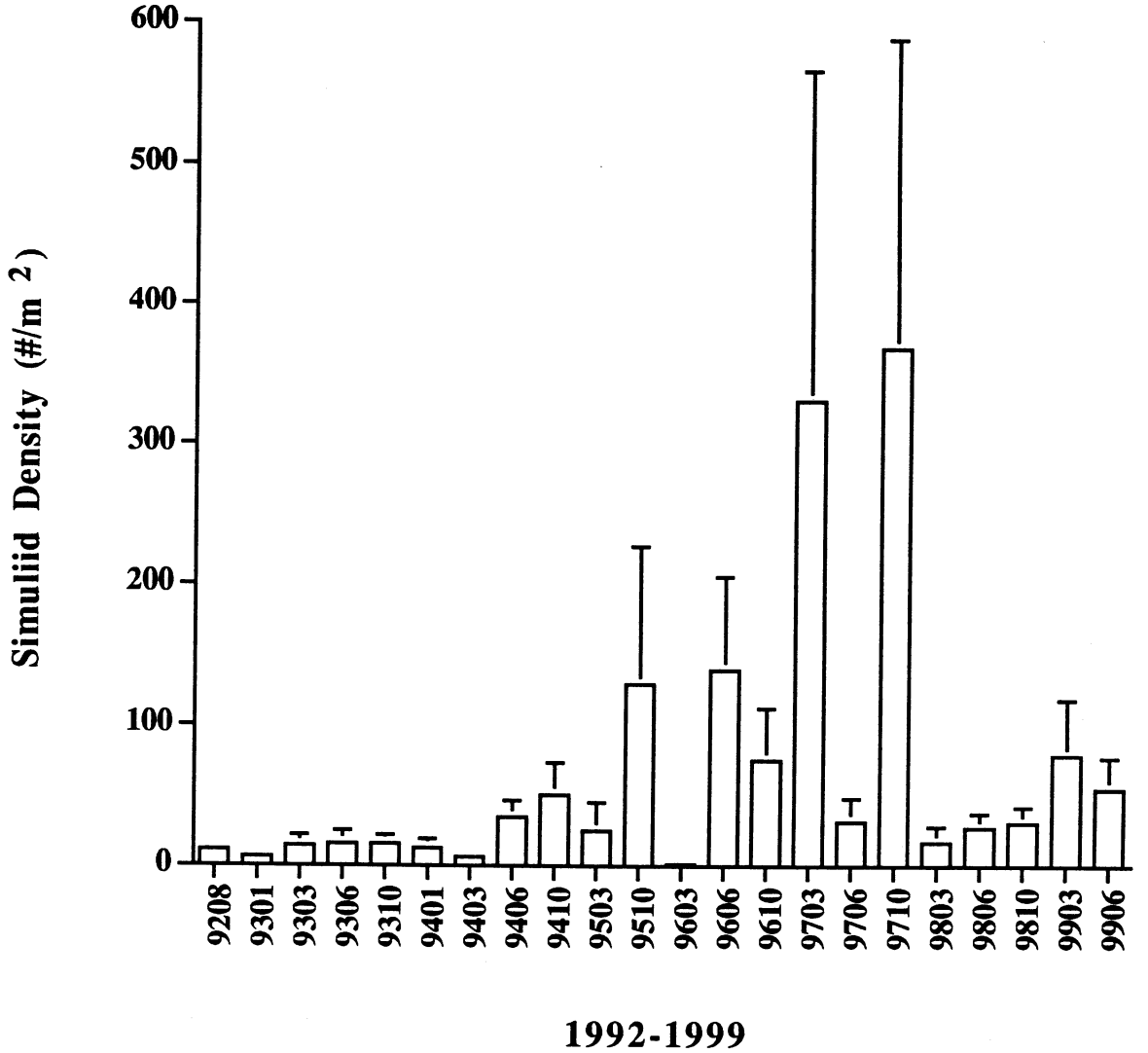

Figure 90. Simuliid densities (#/m^2) collected at LCR Island cobble Rkm 98.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

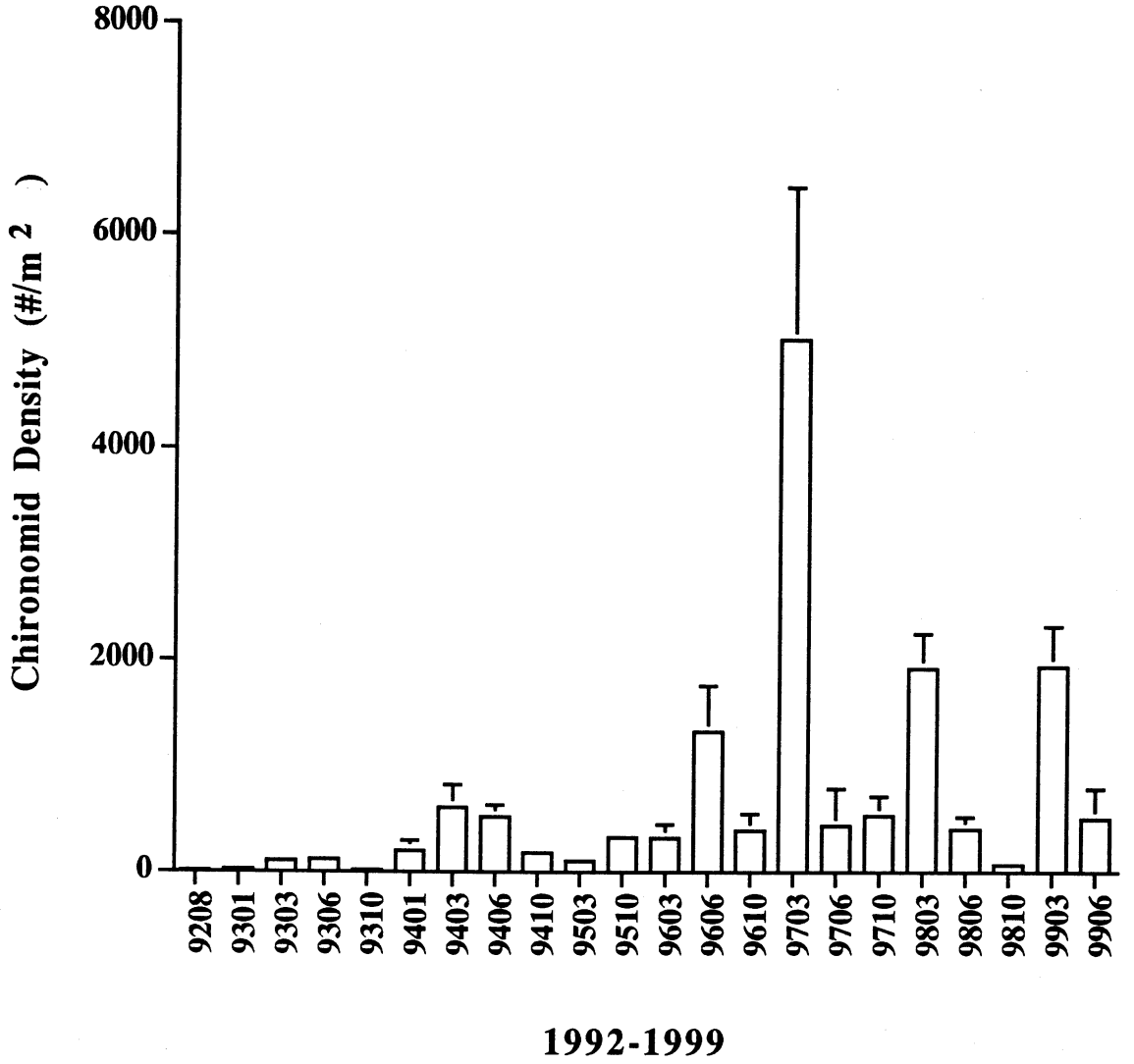

Figure 91. Chironomid densities (#/m^2) collected at LCR Island cobble Rkm 98.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

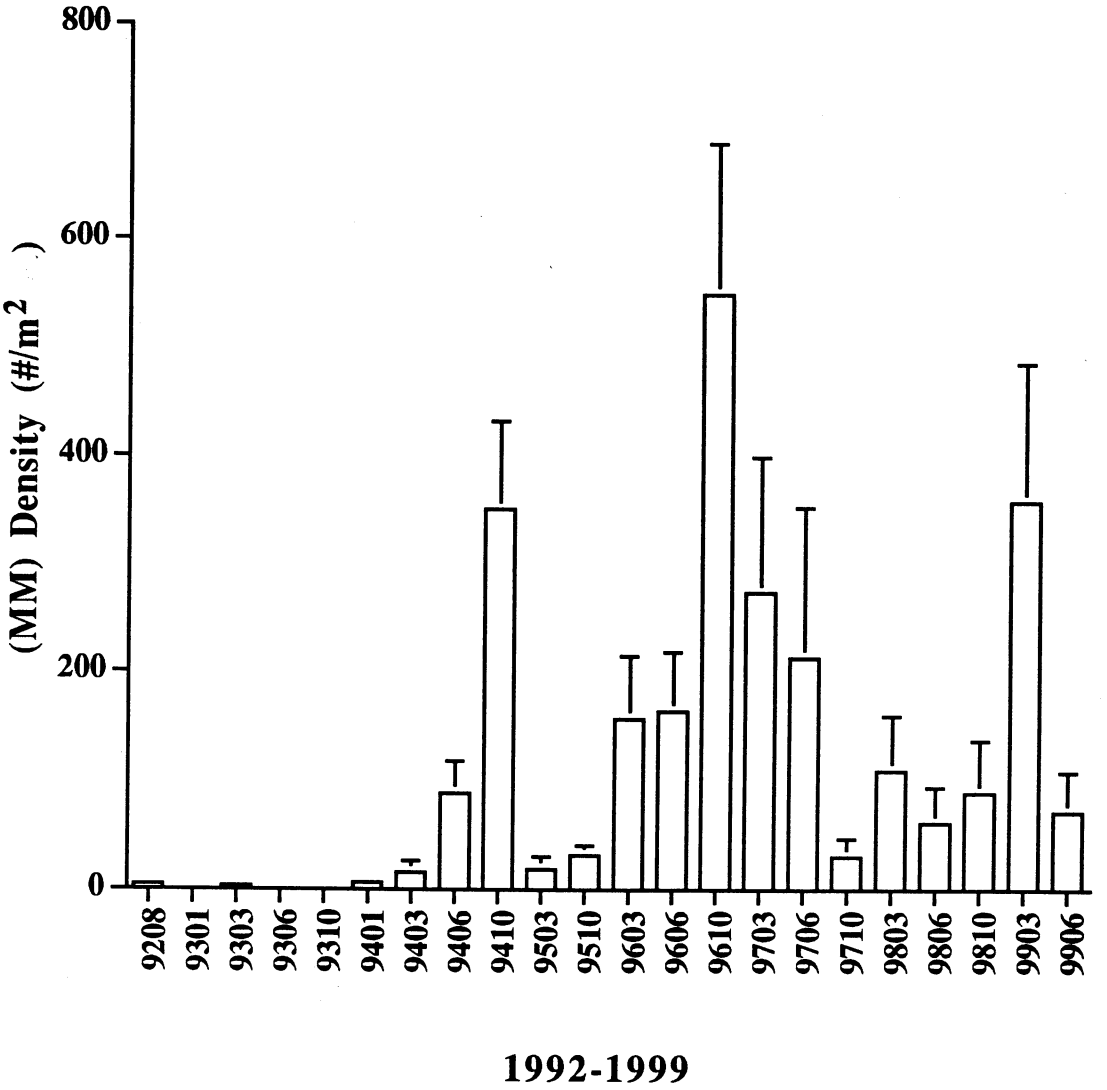

Figure 92. Miscellaneous macroinvertebrate densities (#/m^2) collected at LCR Island cobble Rkm 98.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

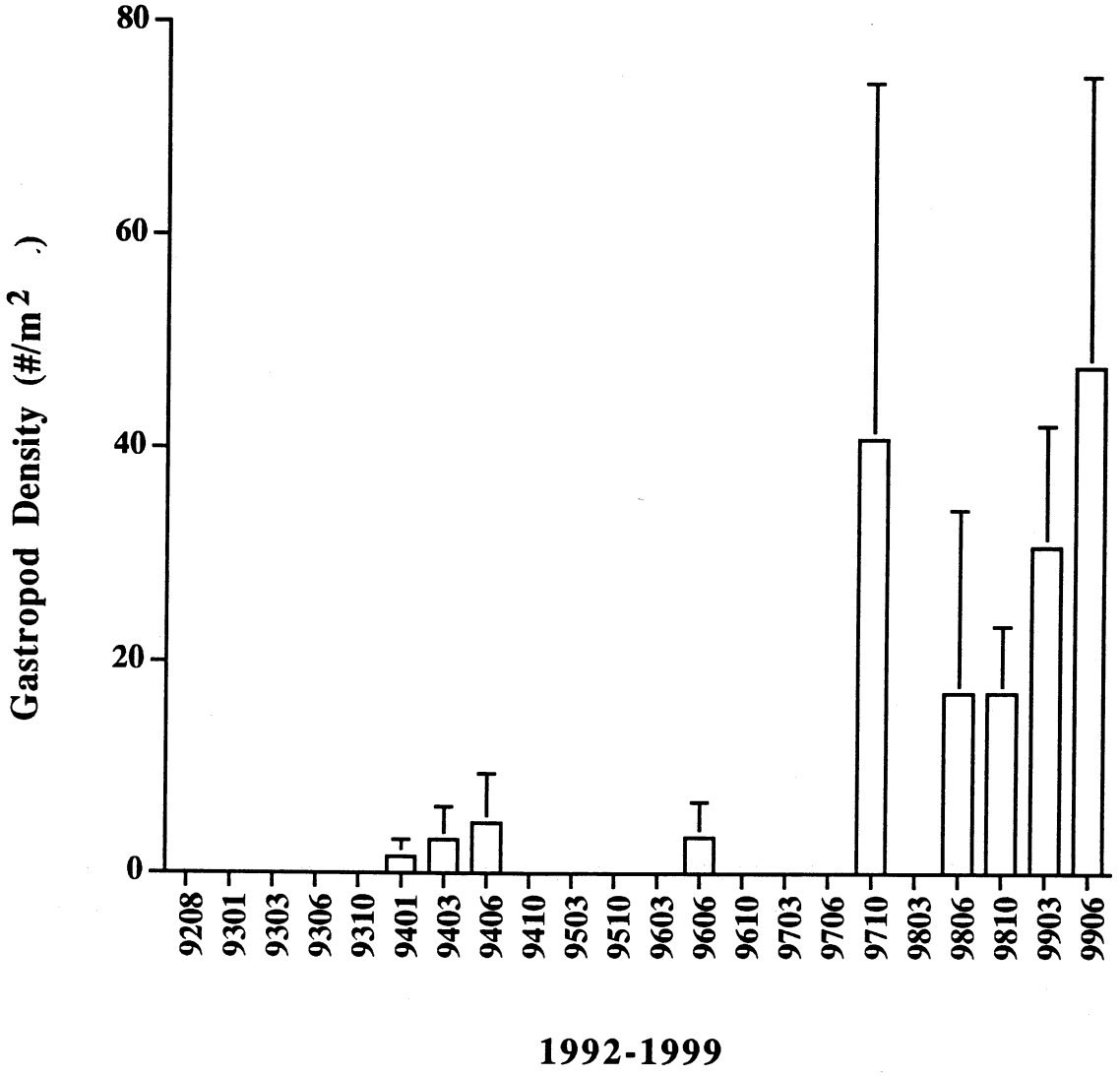

Figure 93. Gastropod densities (#/m^2) collected at LCR Island cobble Rkm 98.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

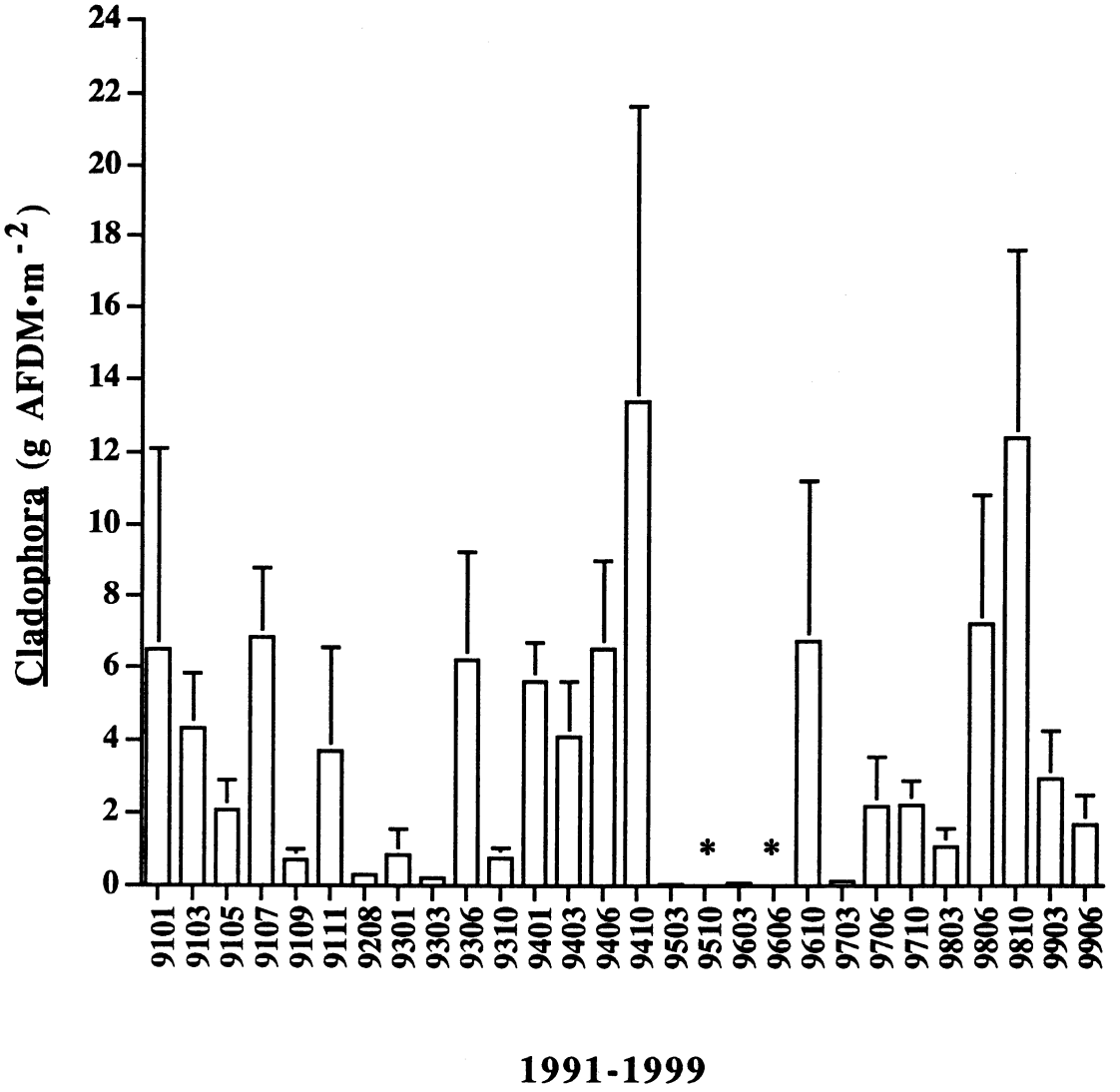

Figure 94. Cladophora biomass estimates (g AFDM•m^{-2}) at Tanner cobble Rkm 109.6 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) at 9510 represents 53 g AFDM•m^{-2} (± 17 SE) and at 9606 represents 75 g AFDM•m^{-2} (± 59 SE).

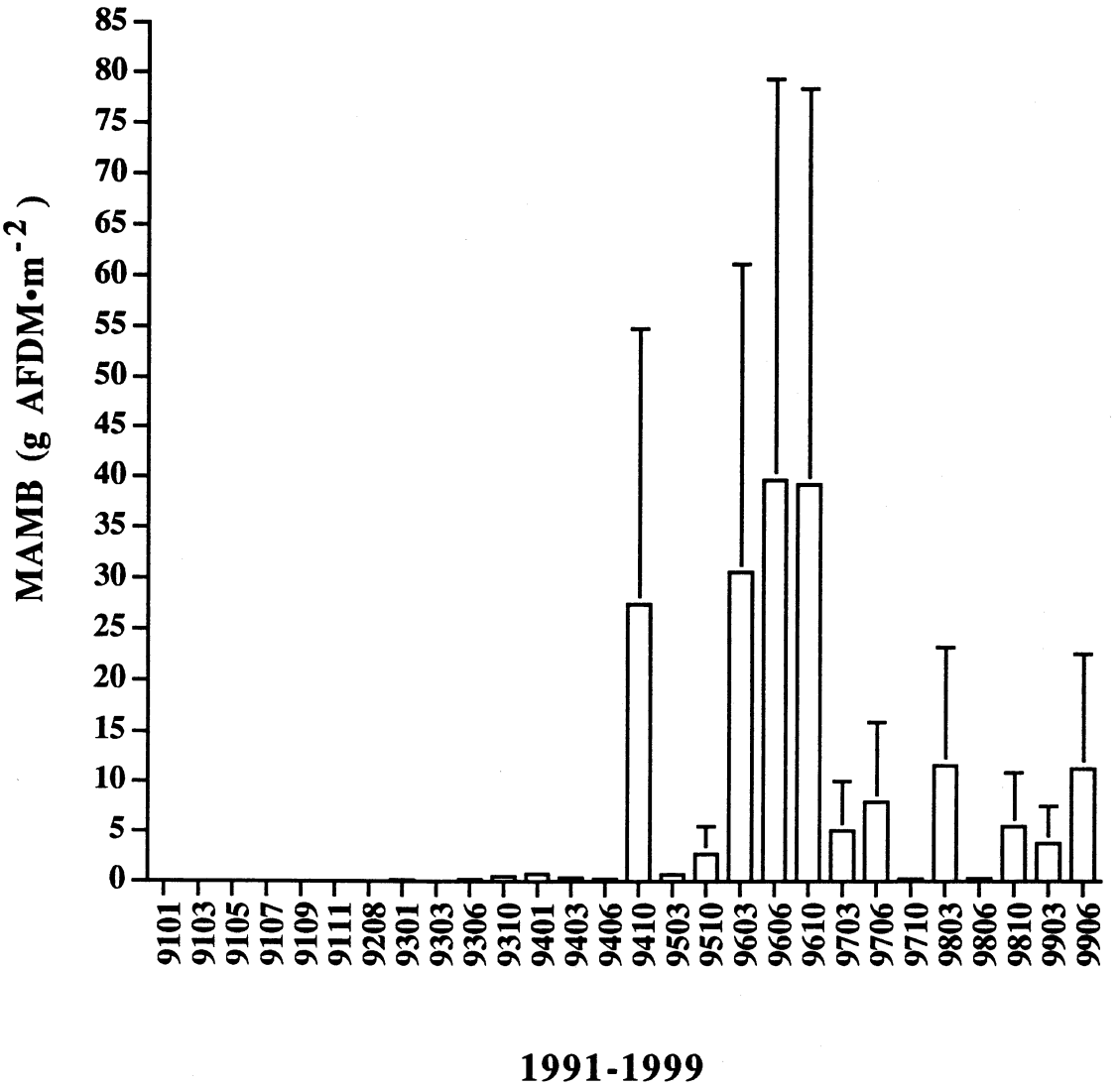

Figure 95. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at Tanner cobble Rkm 109.6 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=6).

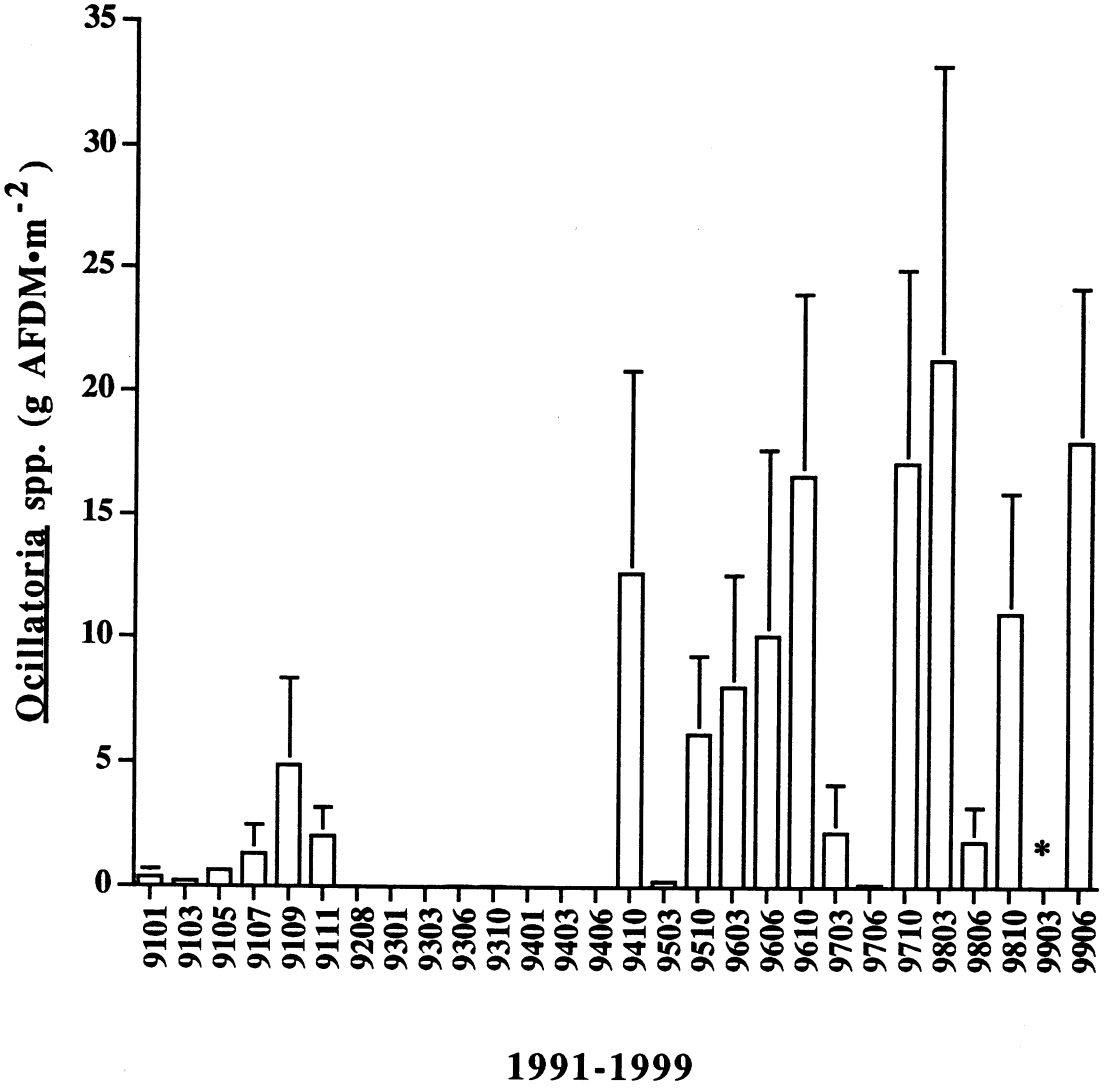

Figure 96. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at Tanner cobble Rkm 109.6 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 82 g AFDM•m^{-2} (± 45 SE).

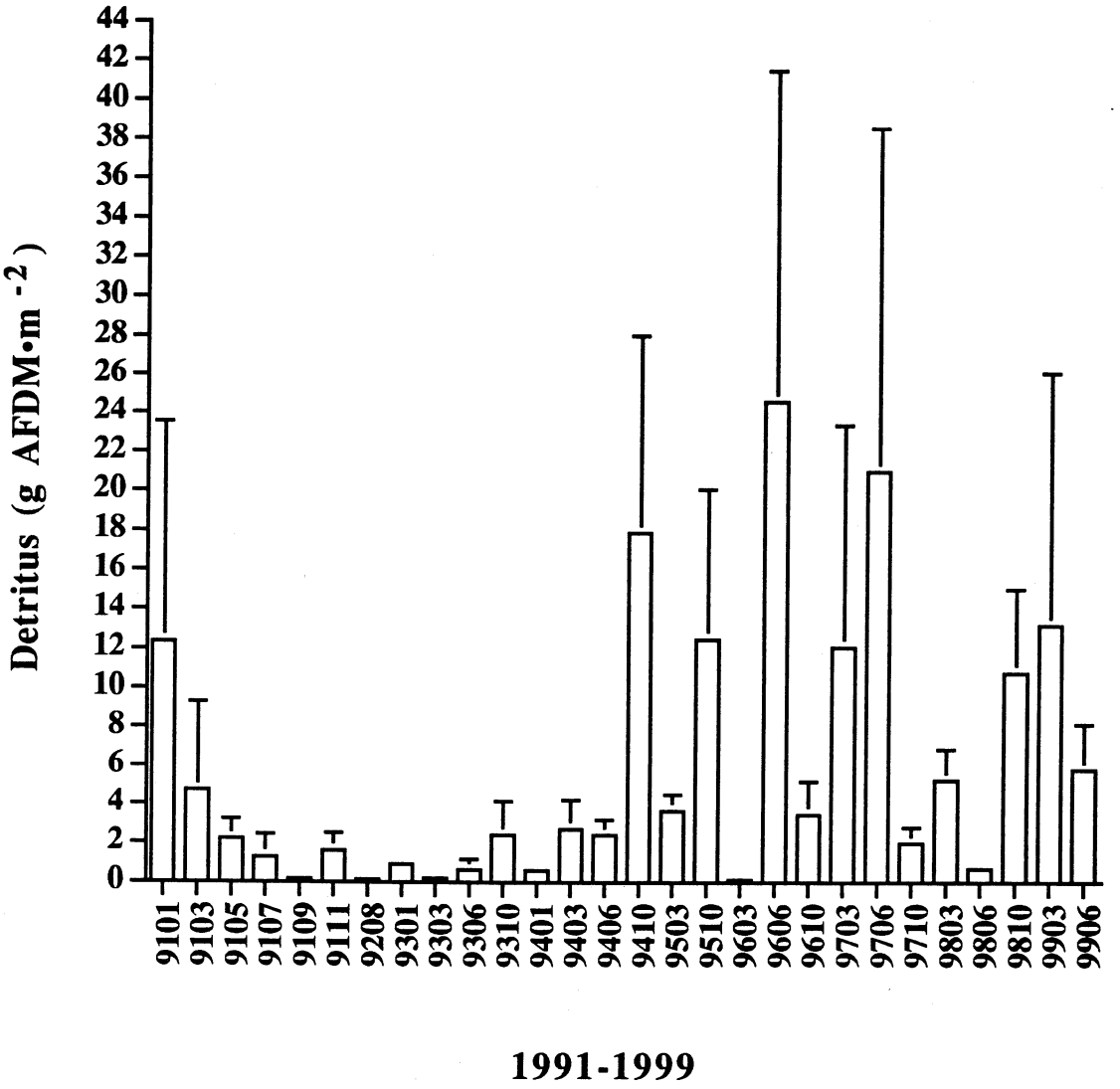

Figure 97. Detritus biomass estimates (g AFDM•m^{-2}) at Tanner cobble Rkm 109.6 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

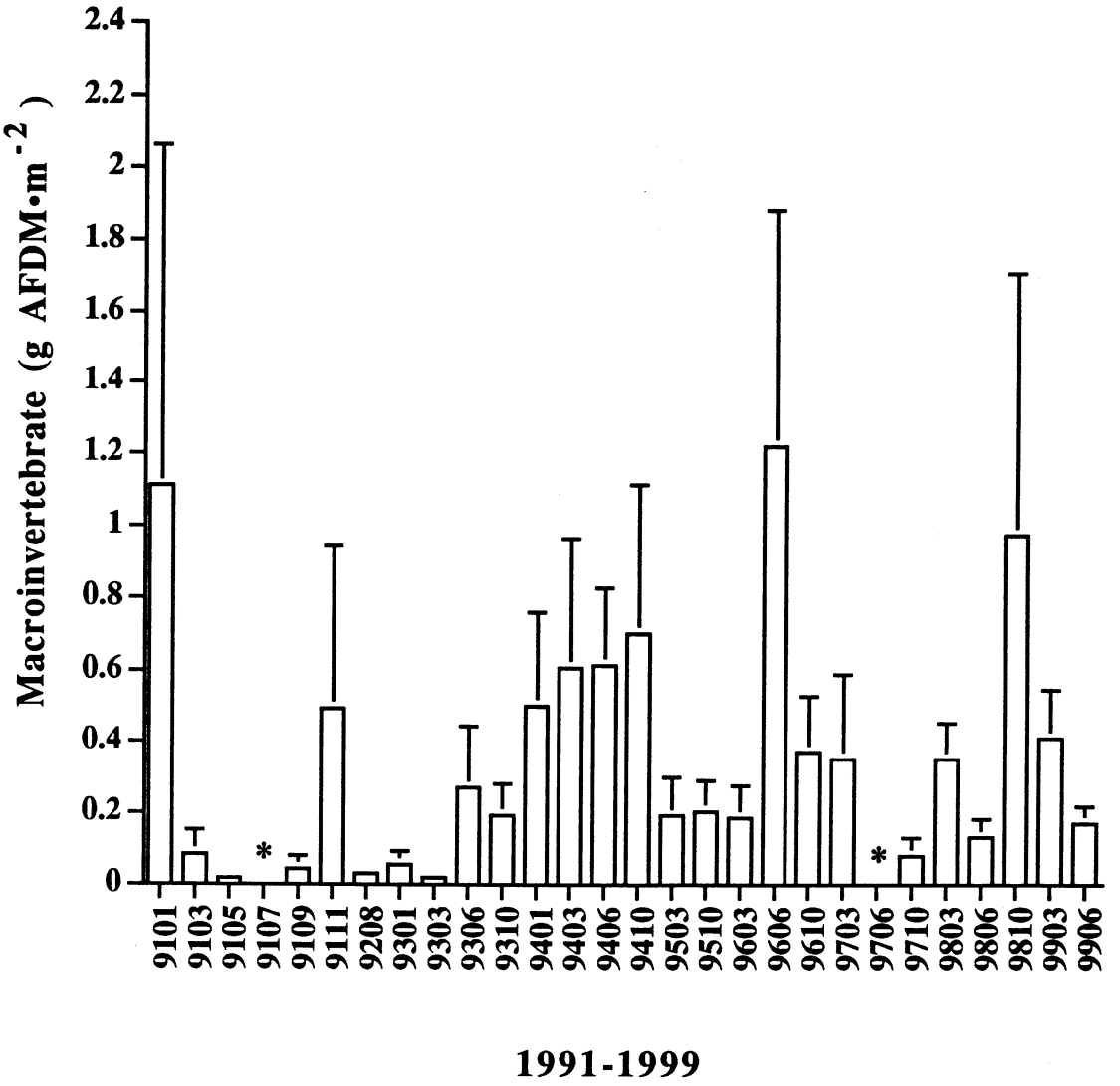

Figure 98. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at Tanner cobble Rkm 109.6 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) at 9107 represents 7 g AFDM•m^{-2} (± 2 SE) and at 9706 represents 2.5 g AFDM•m^{-2} (± 2 SE).

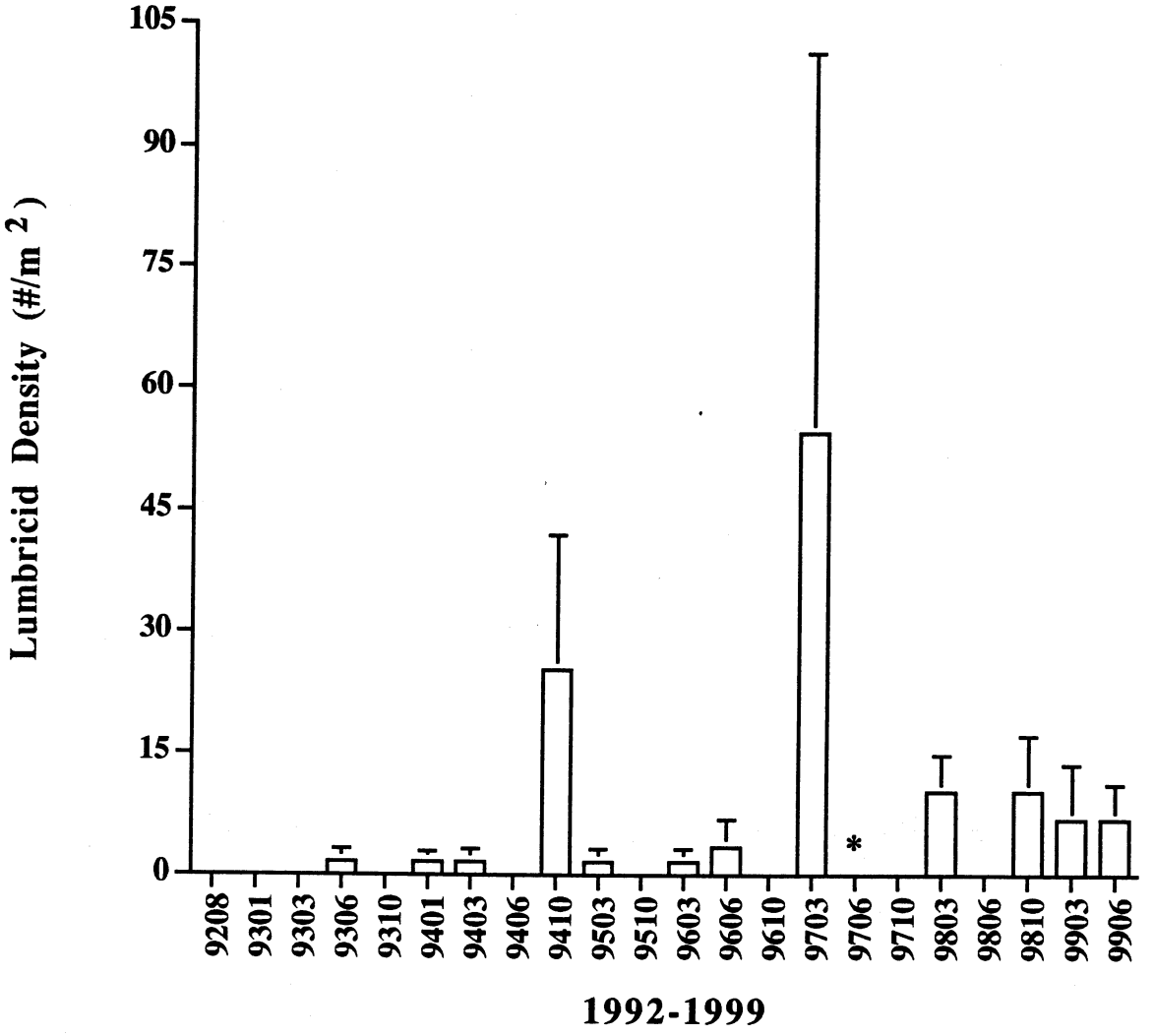

Figure 99. Lumbricid densities (#/m^2) collected at Tanner cobble Rkm 109.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 249/m^2 (± 212 SE).

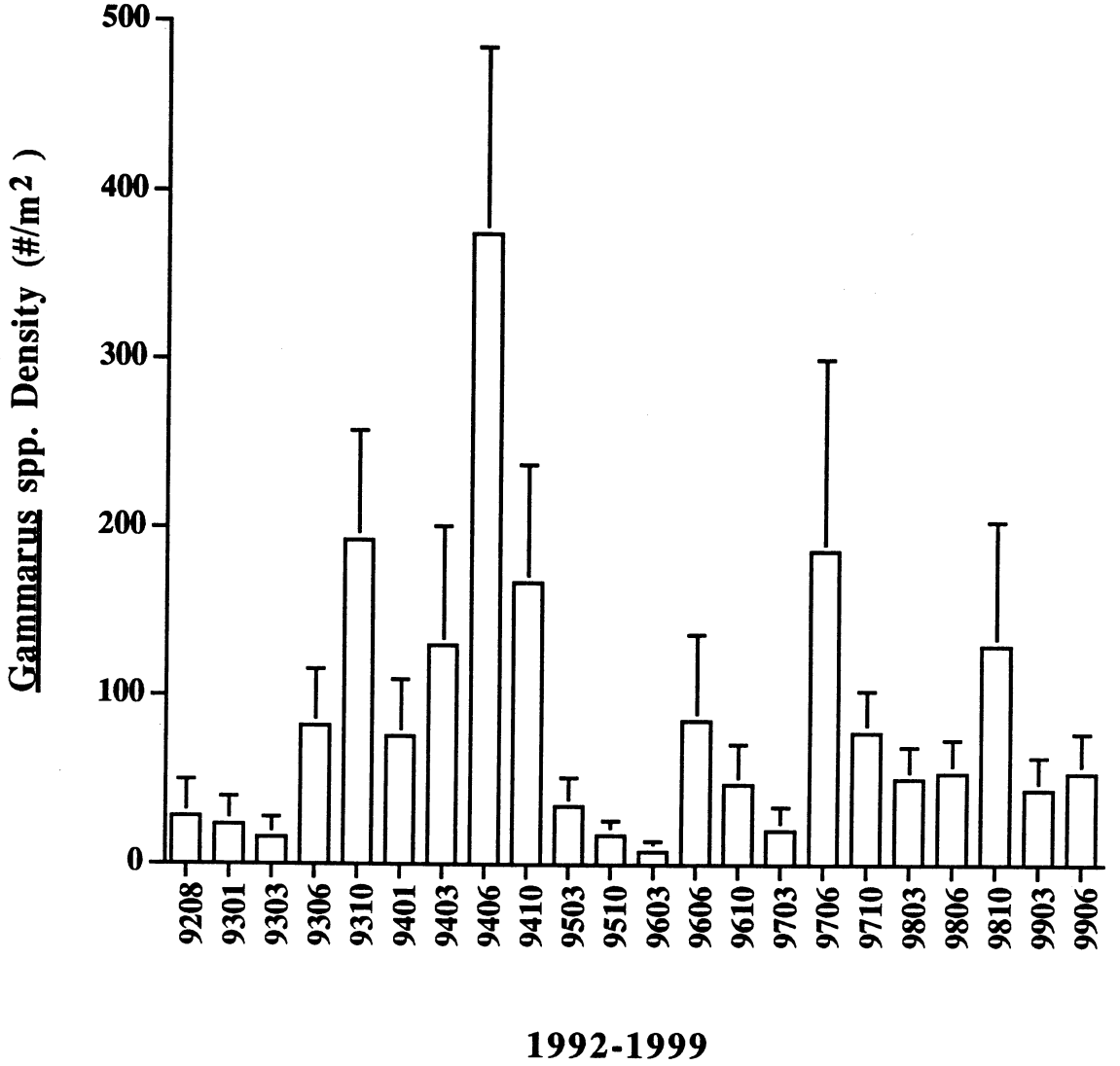

Figure 100. Gammarus spp. densities (#/m^2) collected at Tanner cobble Rkm 109.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

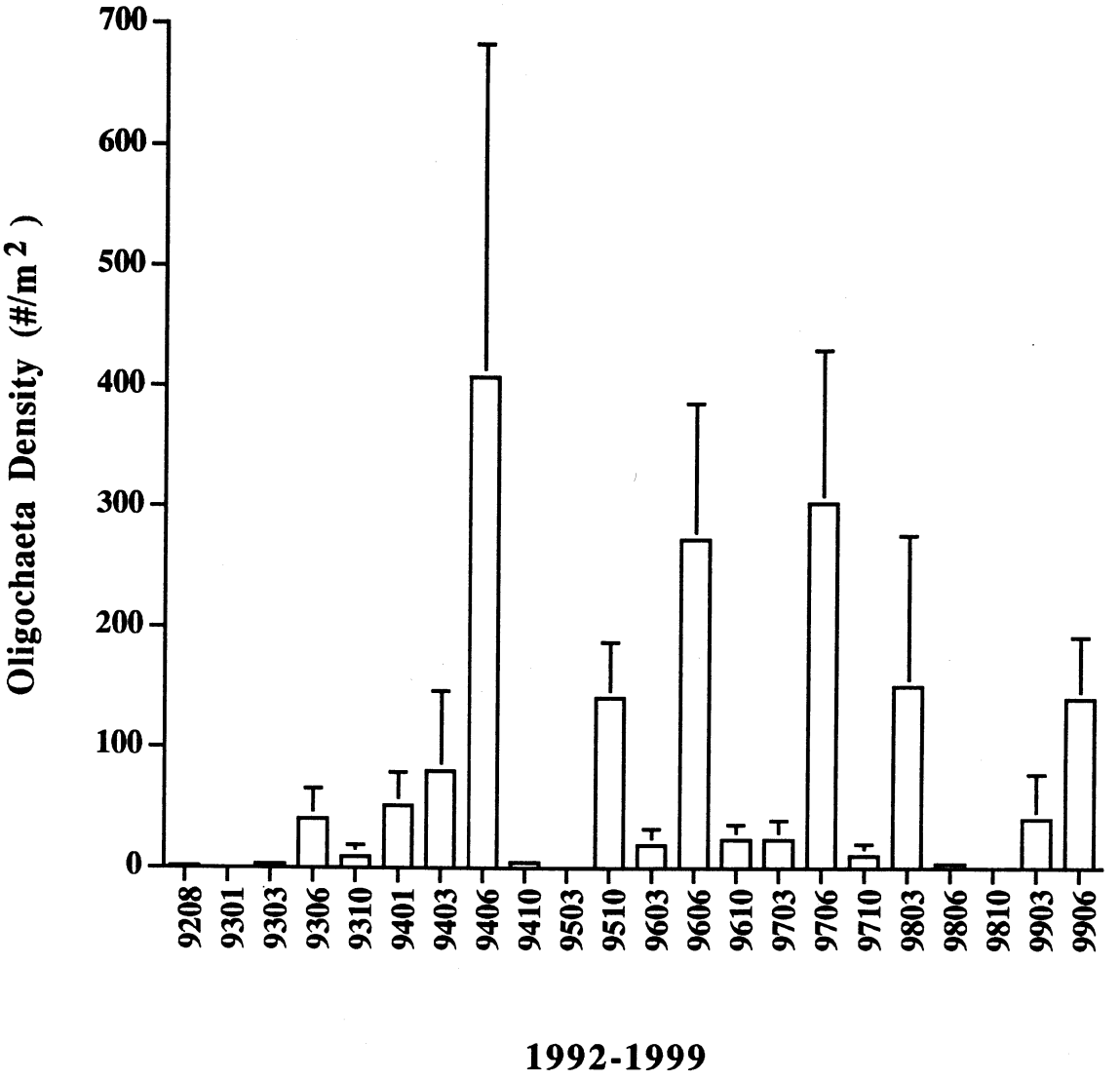

Figure 101. Oligochaeta densities (#/m^2) collected at Tanner cobble Rkm 109.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

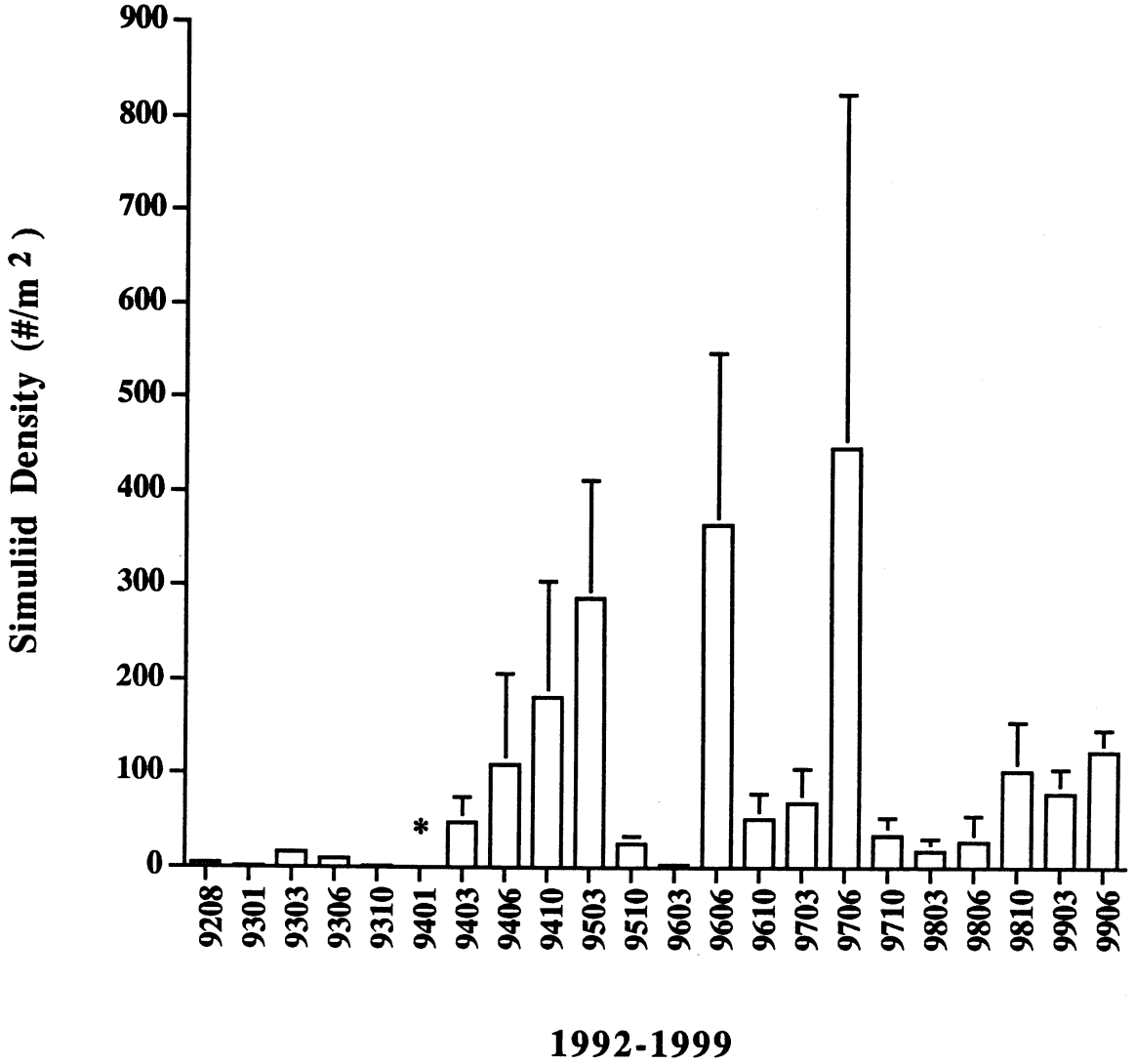

Figure 102. Simuliid densities (#/m^2) at Tanner cobble Rkm 109.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

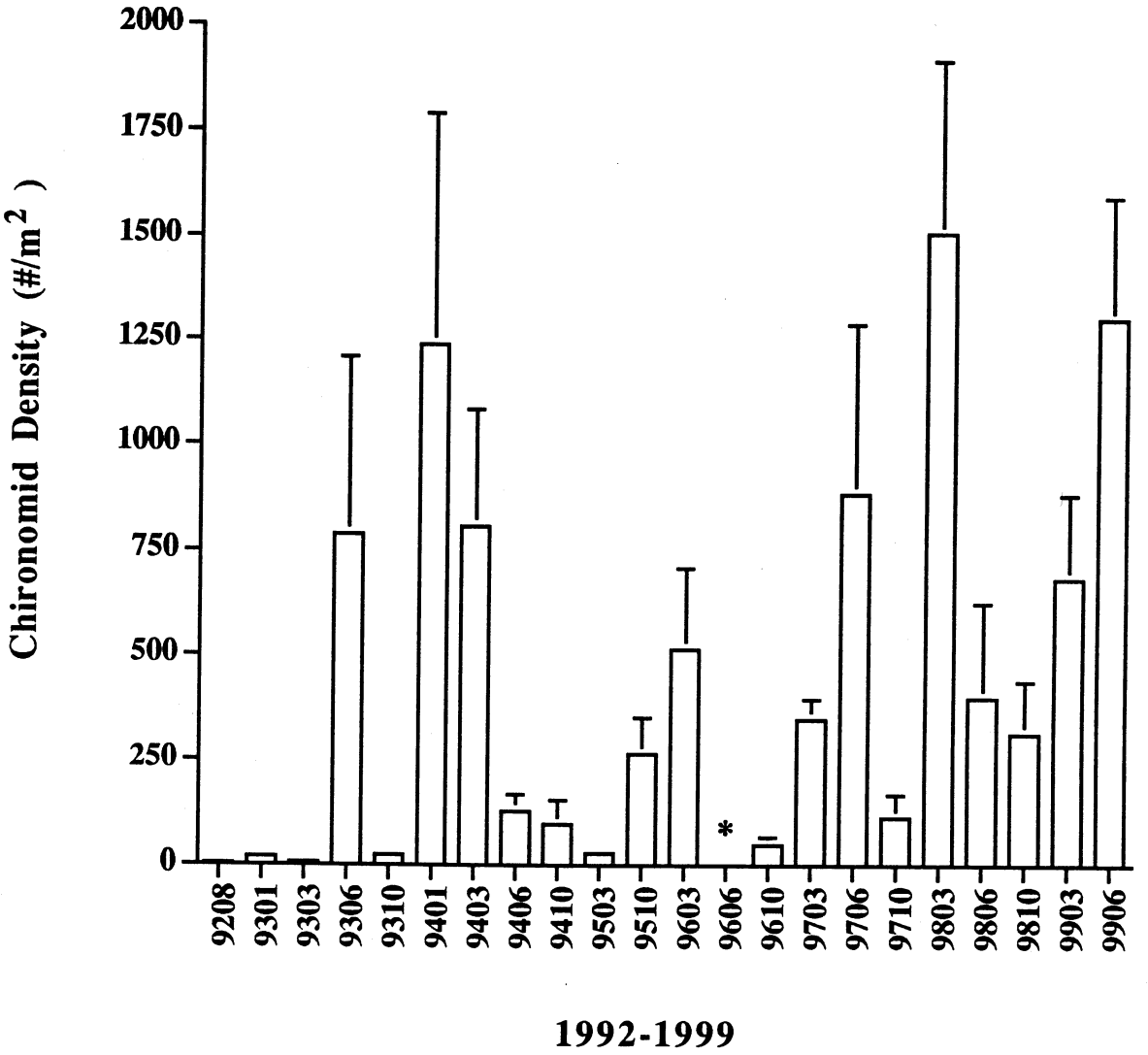

Figure 103. Chironomid densities (#/m^2) collected at Tanner cobble Rkm 109.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

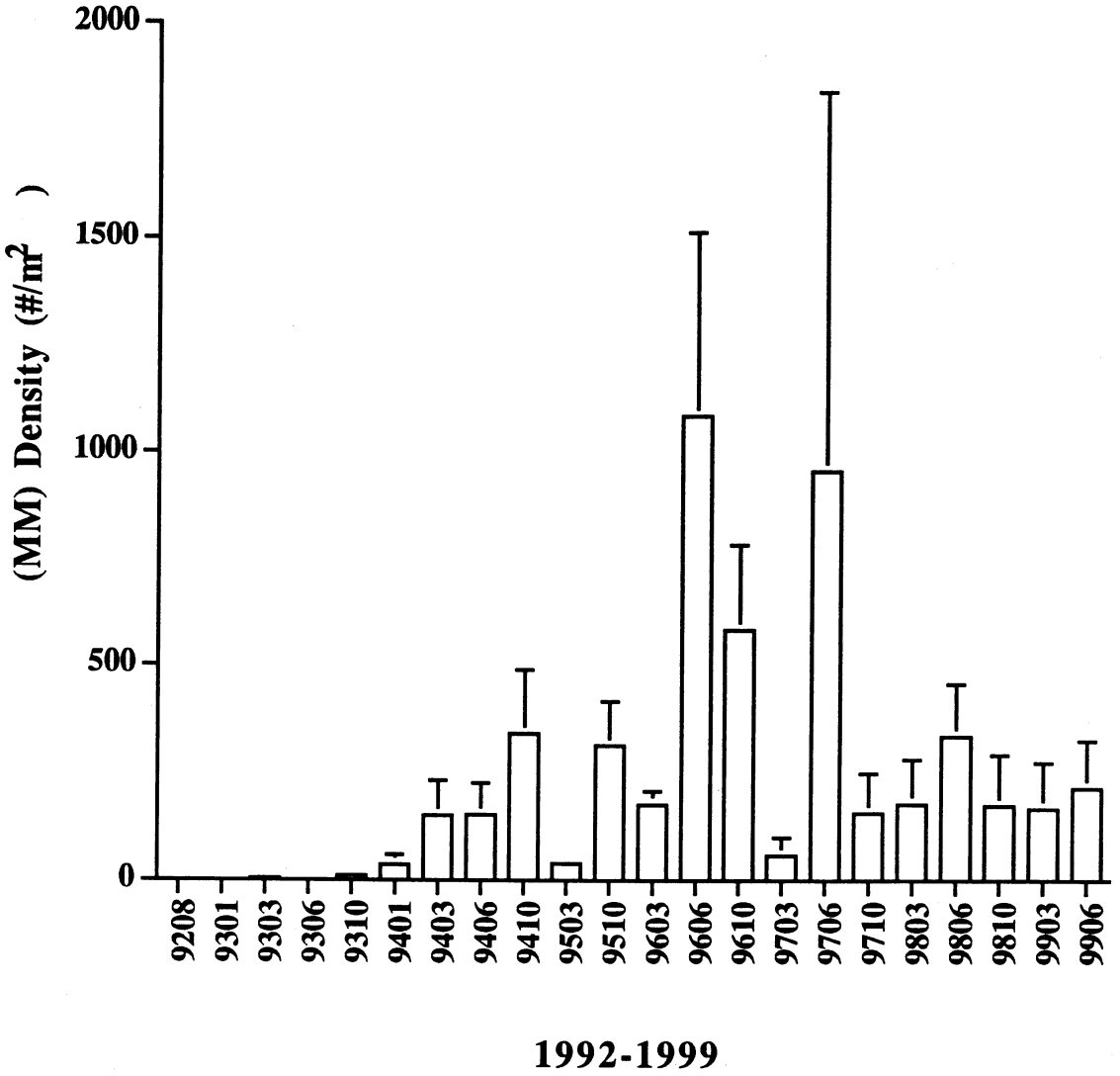

Figure 104. Miscellaneous macroinvertebrate (MM) densities (#/m^2) collected at Tanner cobble Rkm 109.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

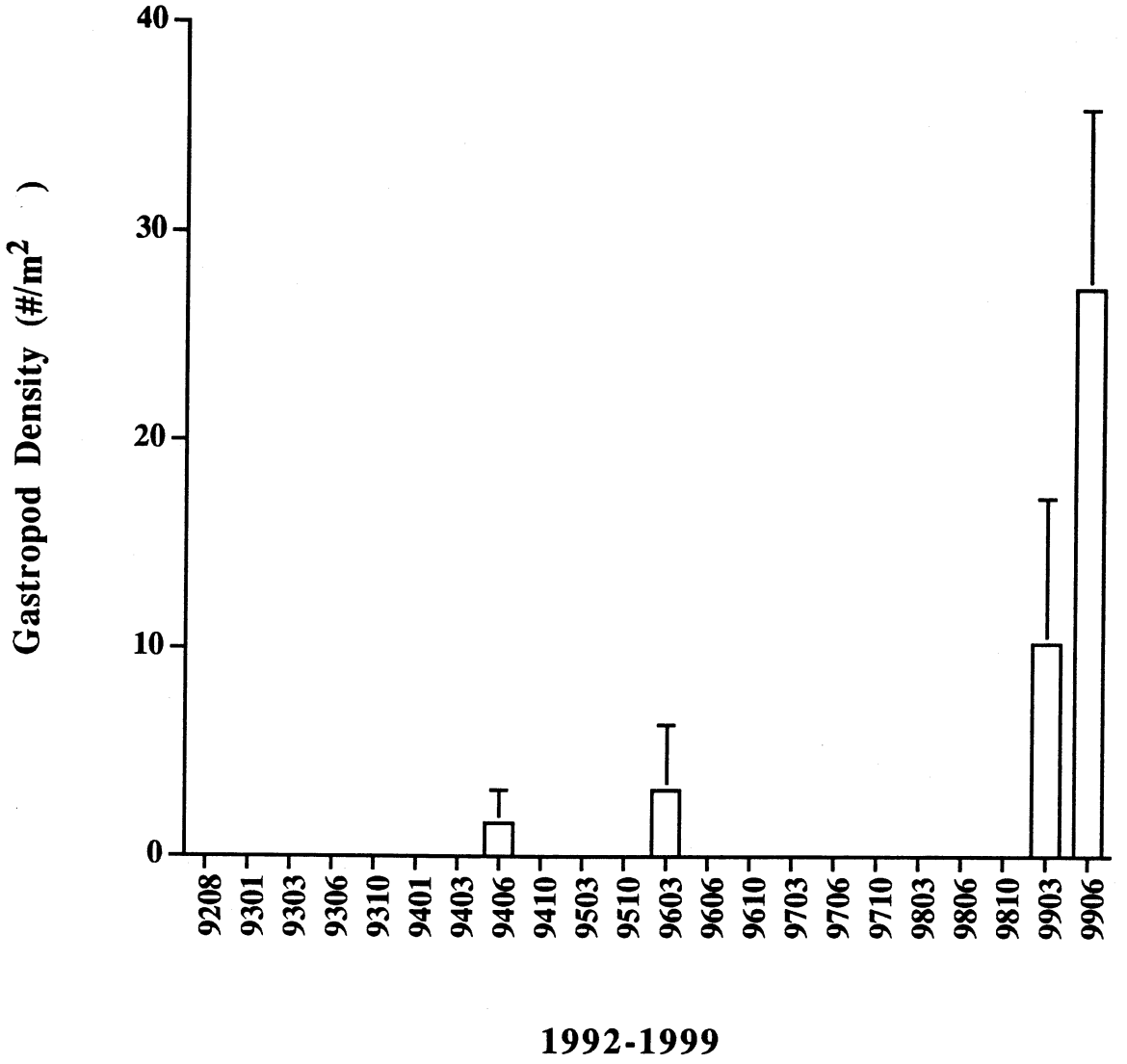

Figure 105. Gastropod densities (#/m^2) collected at Tanner cobble Rkm 109.6 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6).

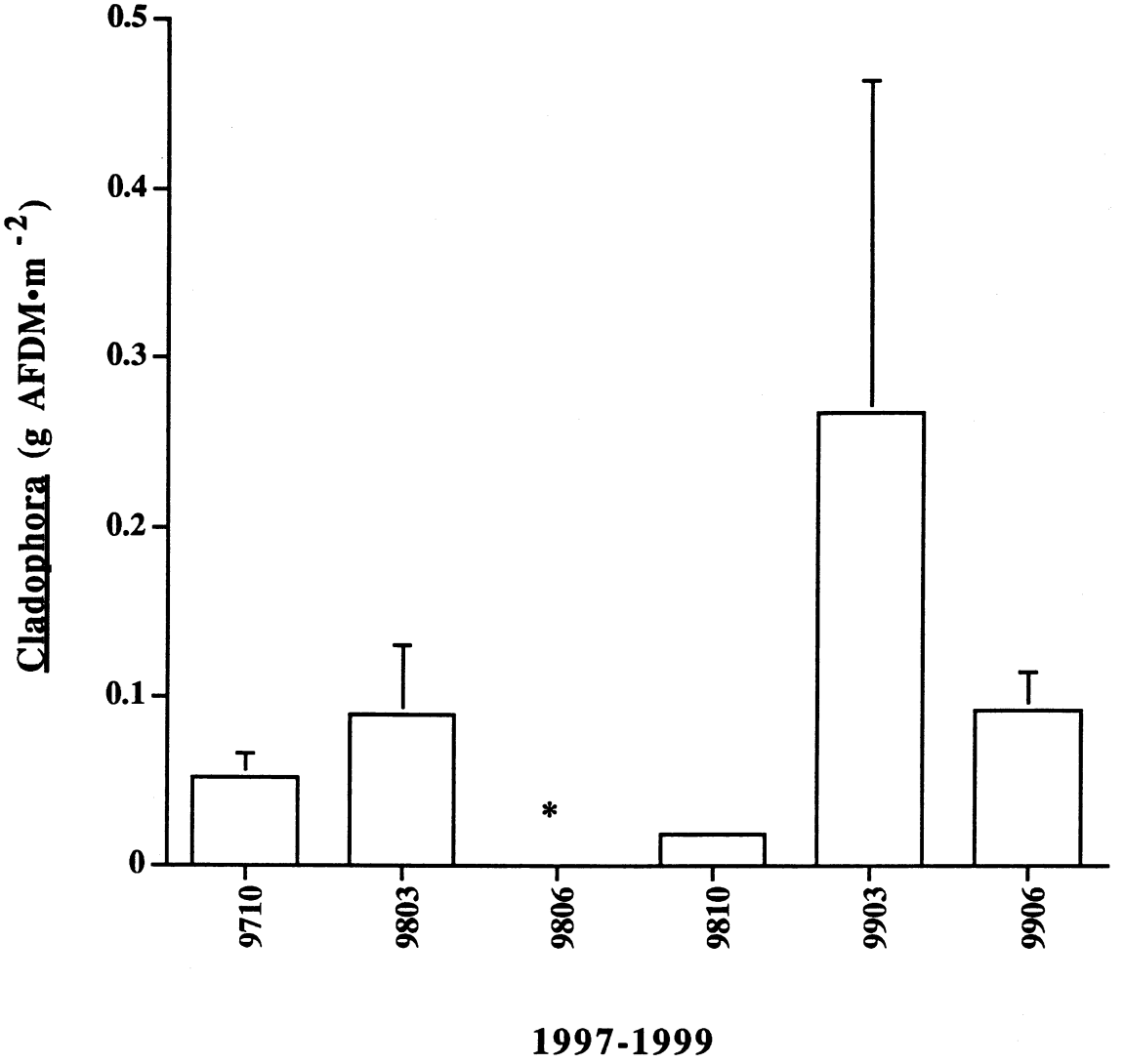

Figure 106. Cladophora biomass estimates (g AFDM•m^{-2}) at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) repesents 3 g AFDM•m^{-2} (± 1.5 SE).

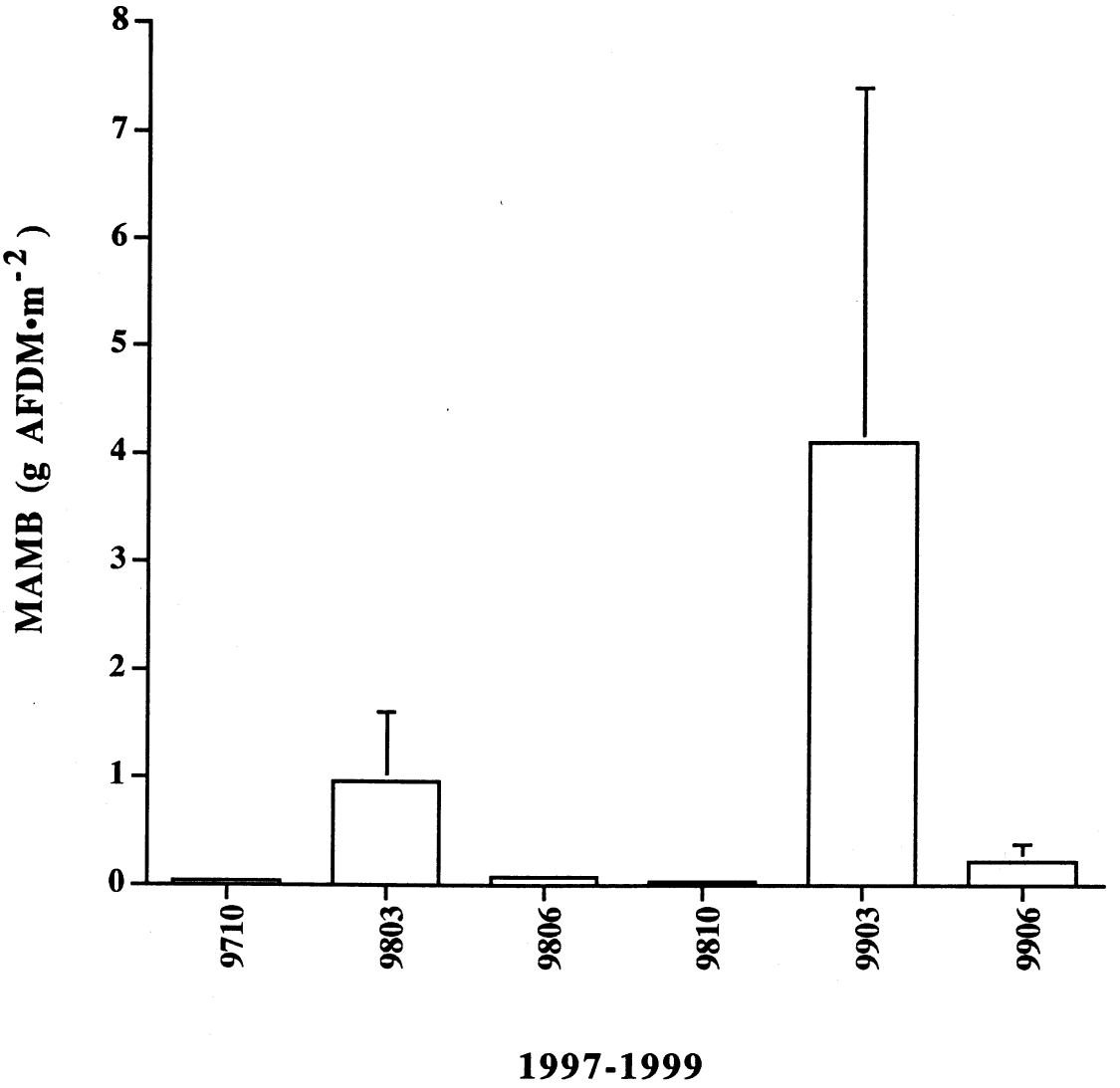

Figure 107. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

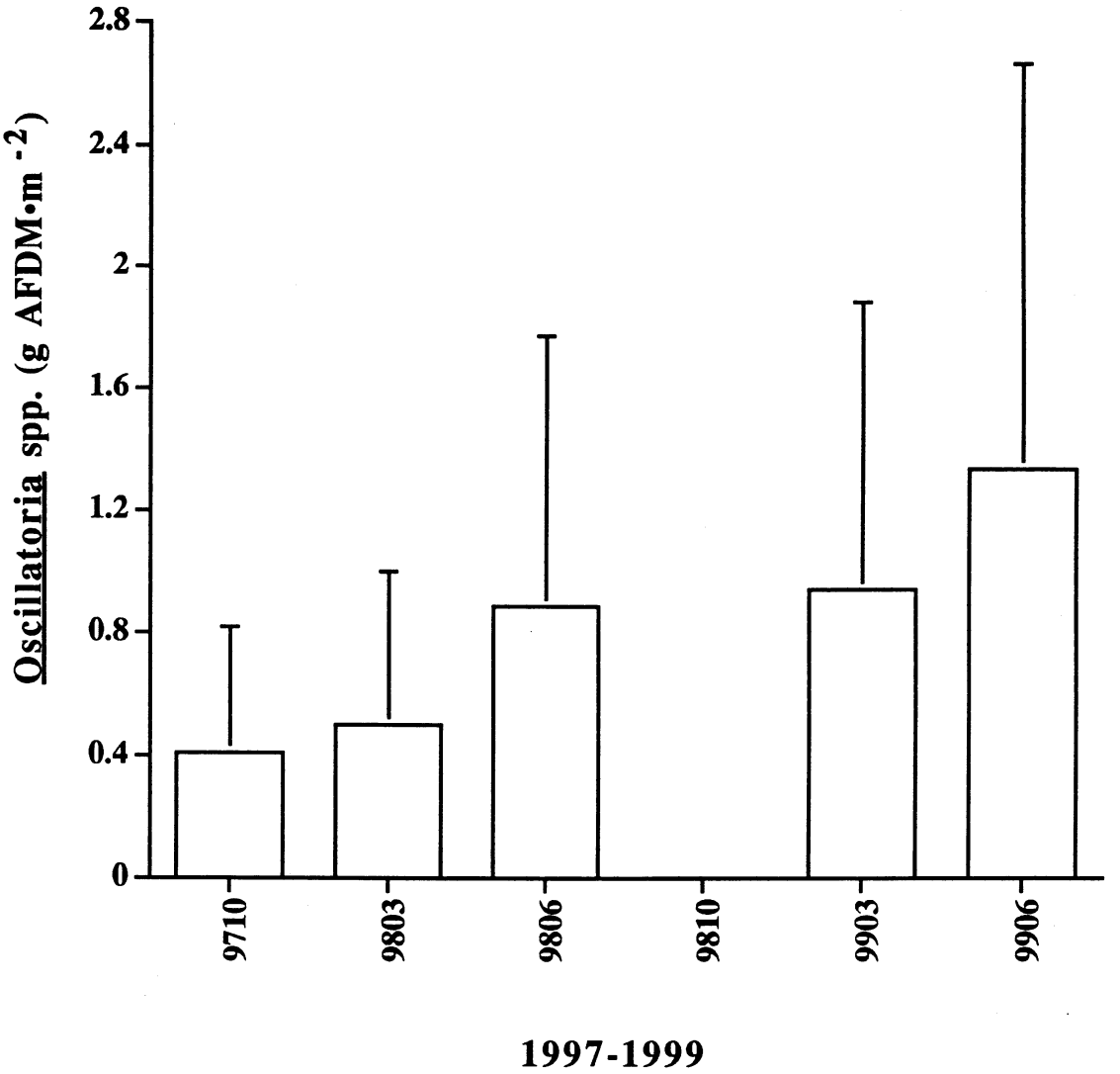

Figure 108. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

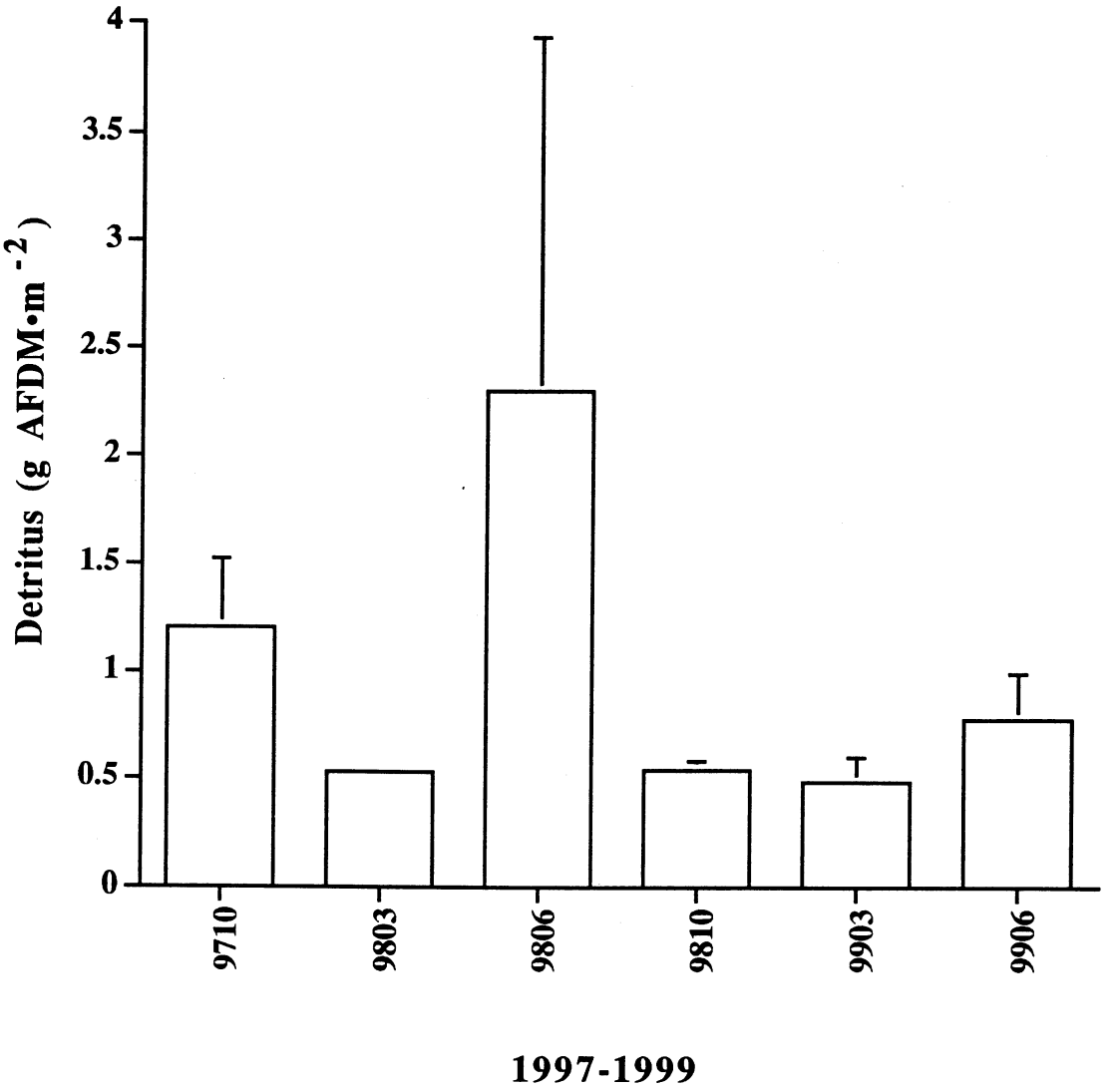

Figure 109. Detritus biomass estimates (g AFDM•m^{-2}) at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

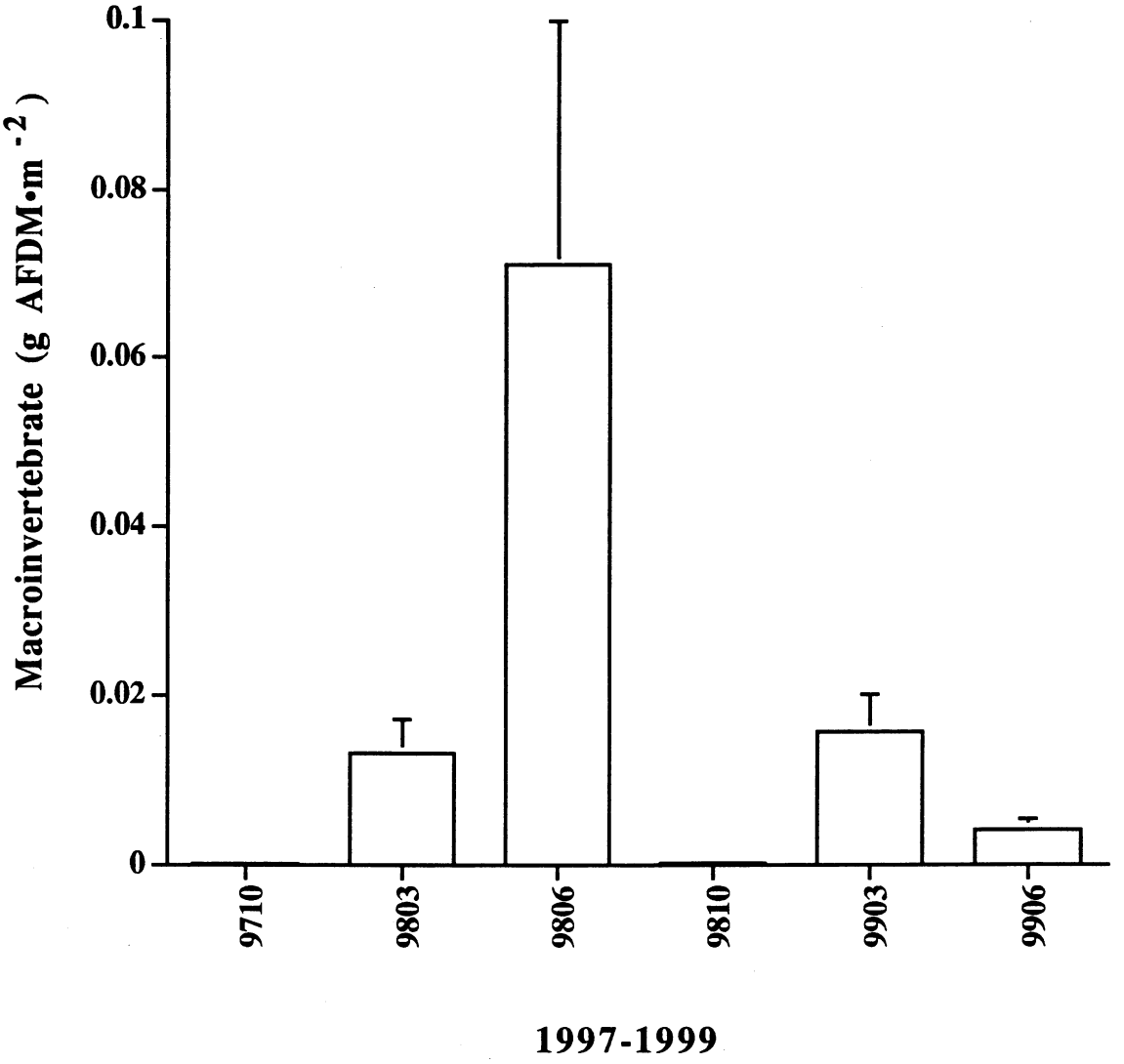

Figure 110. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

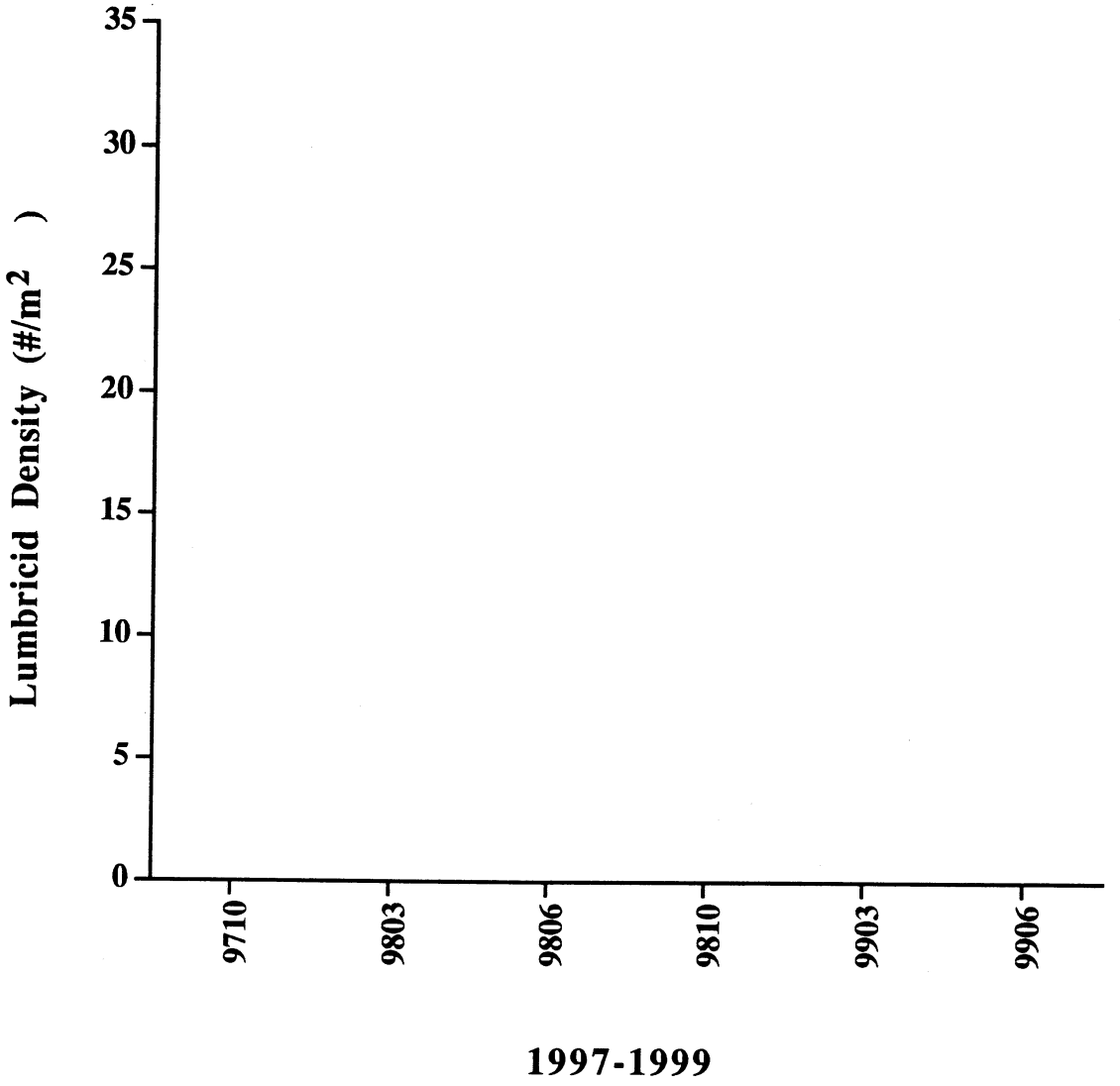

Figure 111. Lumbricid densities (#/m ^{2}) collected at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. No Lumbricid abundances were found at this site during our collection dates.

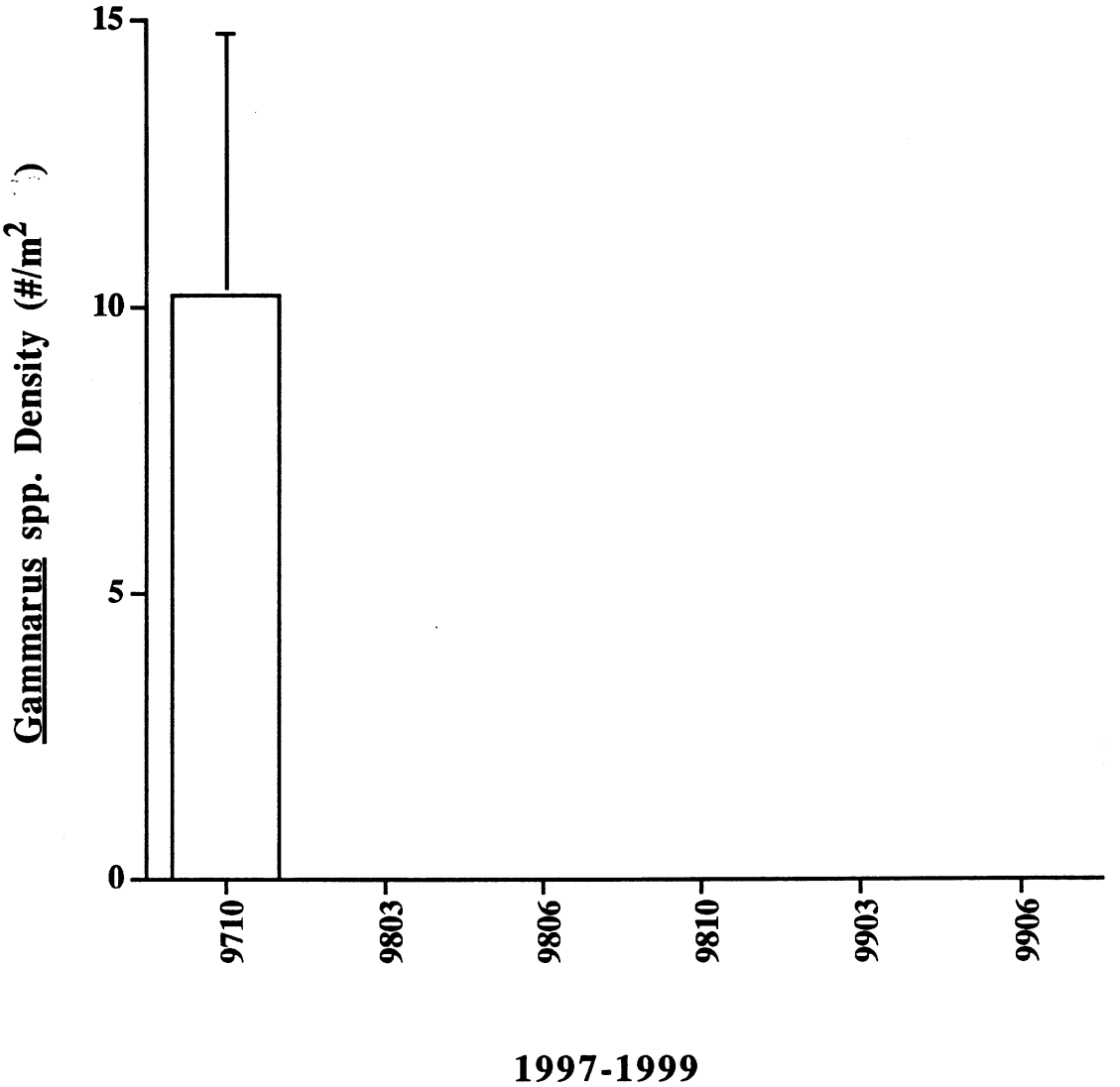

Figure 112. Gammarus spp. densities (#/m^2) collected at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

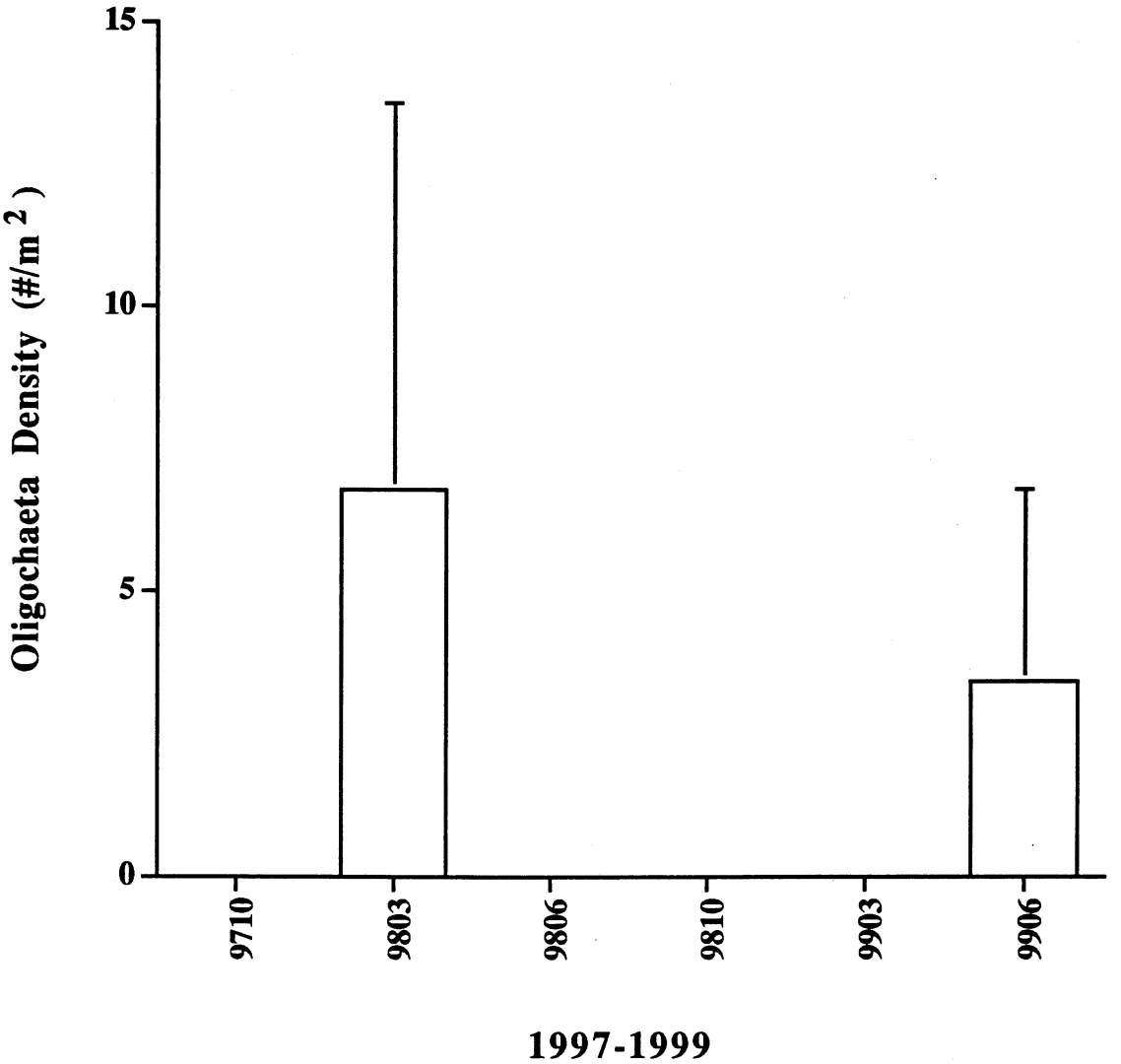

Figure 113. Oligochaeta densities (#/m^2) collected at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

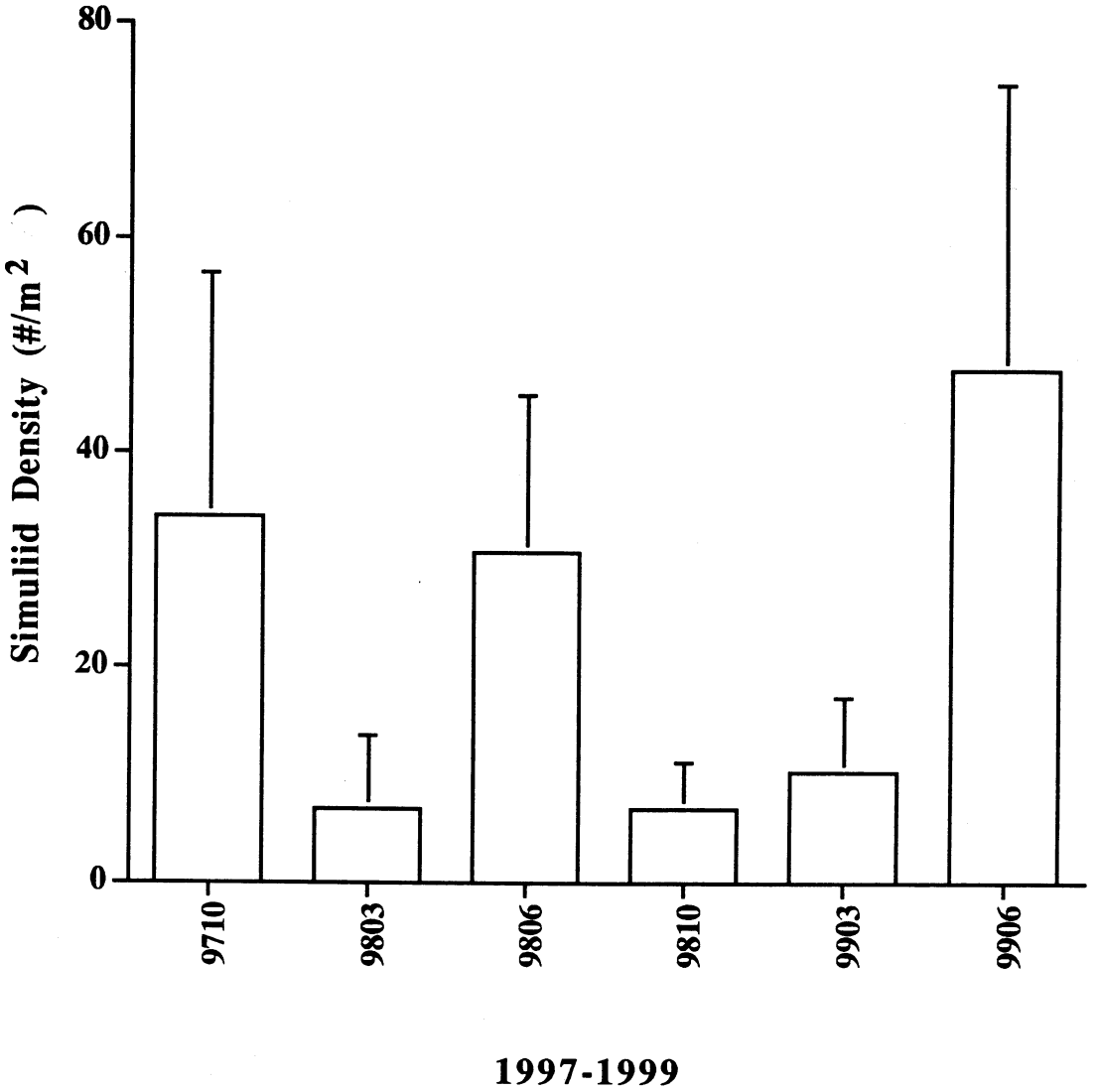

Figure 114. Simuliid densities (#/m^2) collected at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

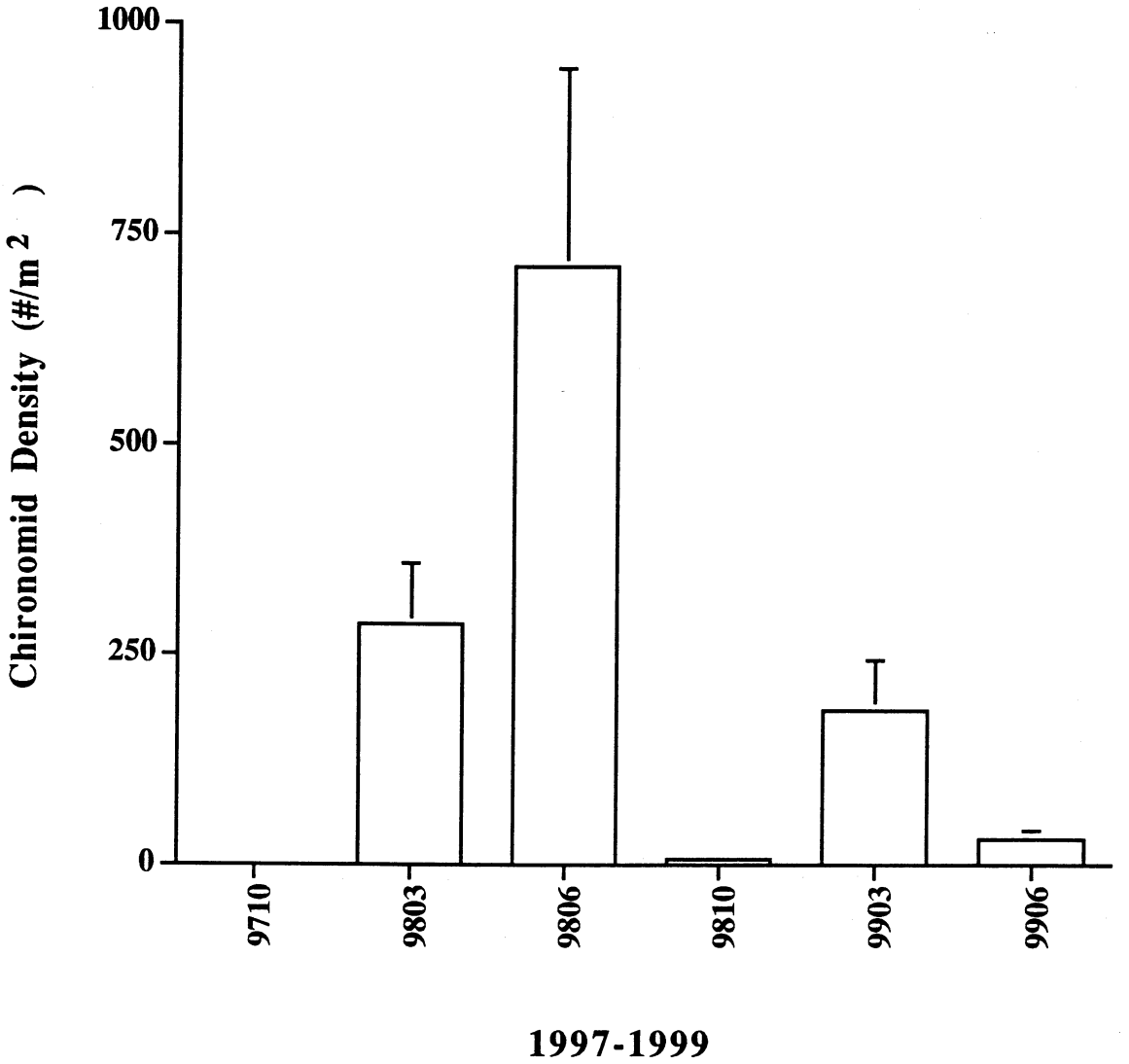

Figure 115. Chironomid densities (#/m^2) collected at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

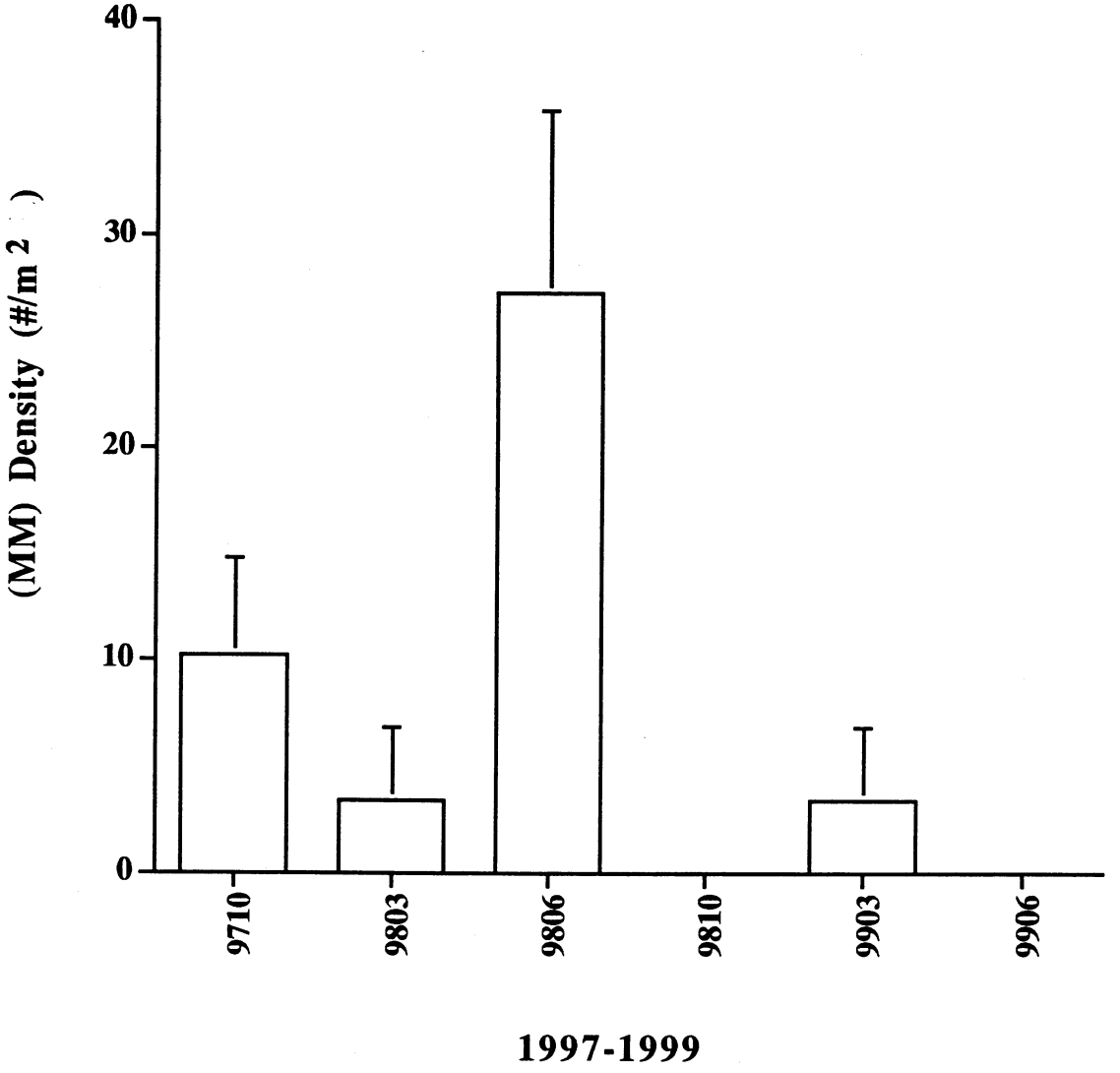

Figure 116. Miscellaneous macroinvertebrate (MM) densities (#/m^2) collected at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6).

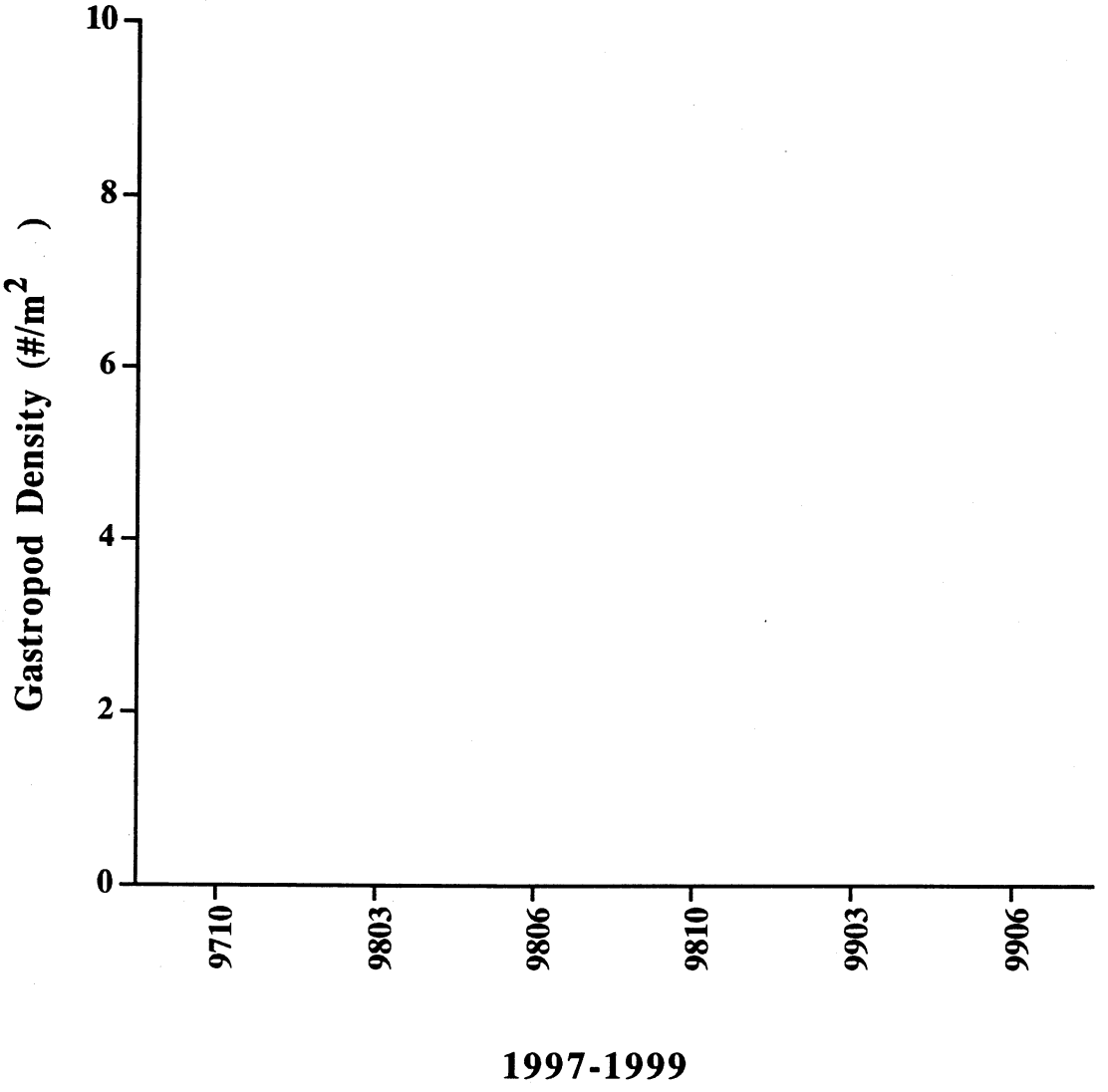

Figure 117. Gastropod densities (#/m^2) collected at 127 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. No Gastropod abundances were found at this site during our collection dates.

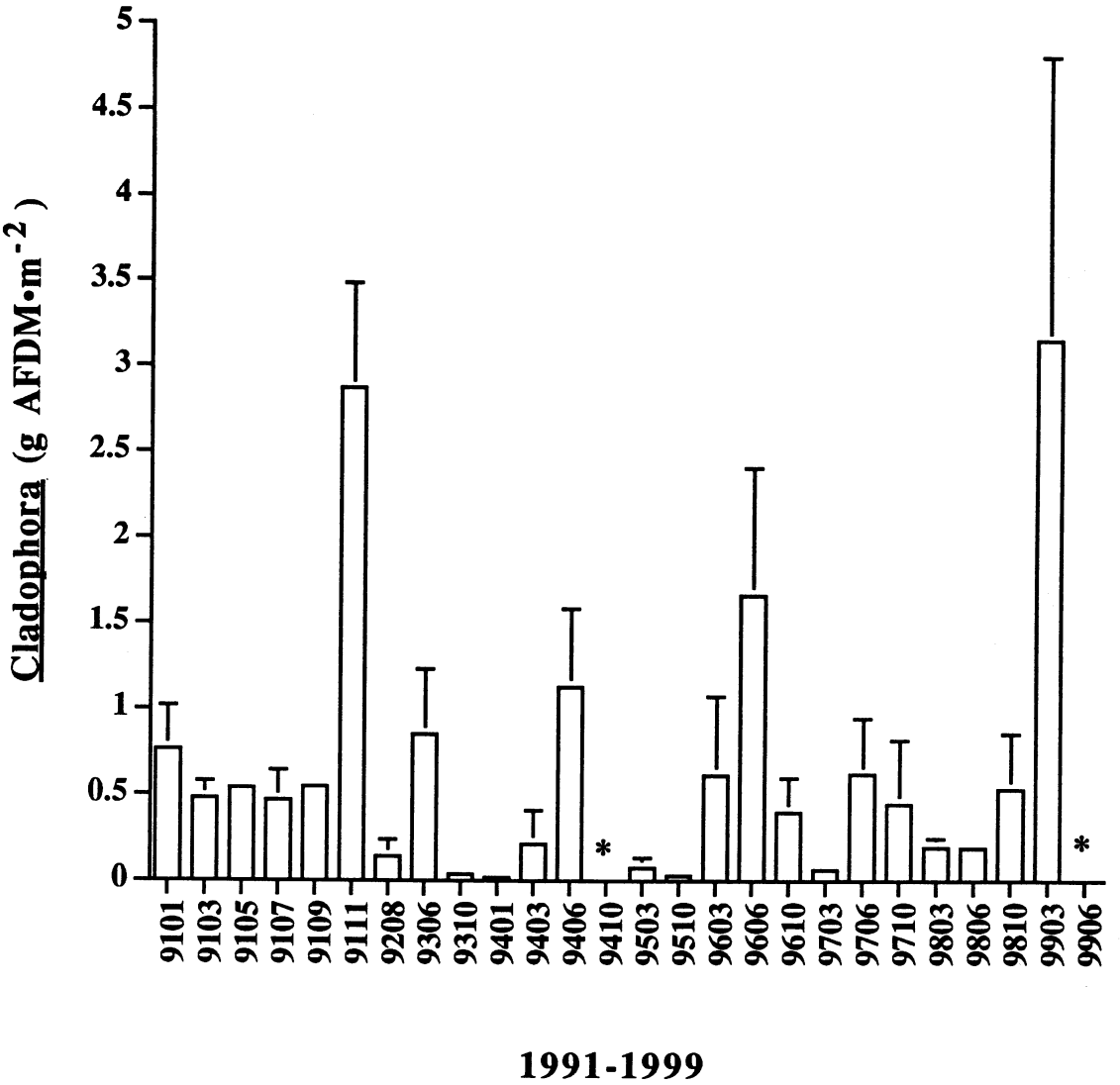

Figure 118. Cladophora biomass estimates (g AFDM•m^{-2}) at 205 Mile rapid Rkm 328.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) at 9410 represents 8 g AFDM•m^{-2} (± 4 SE) and at 9906 represents 8 g AFDM•m^{-2} (± 2 SE).

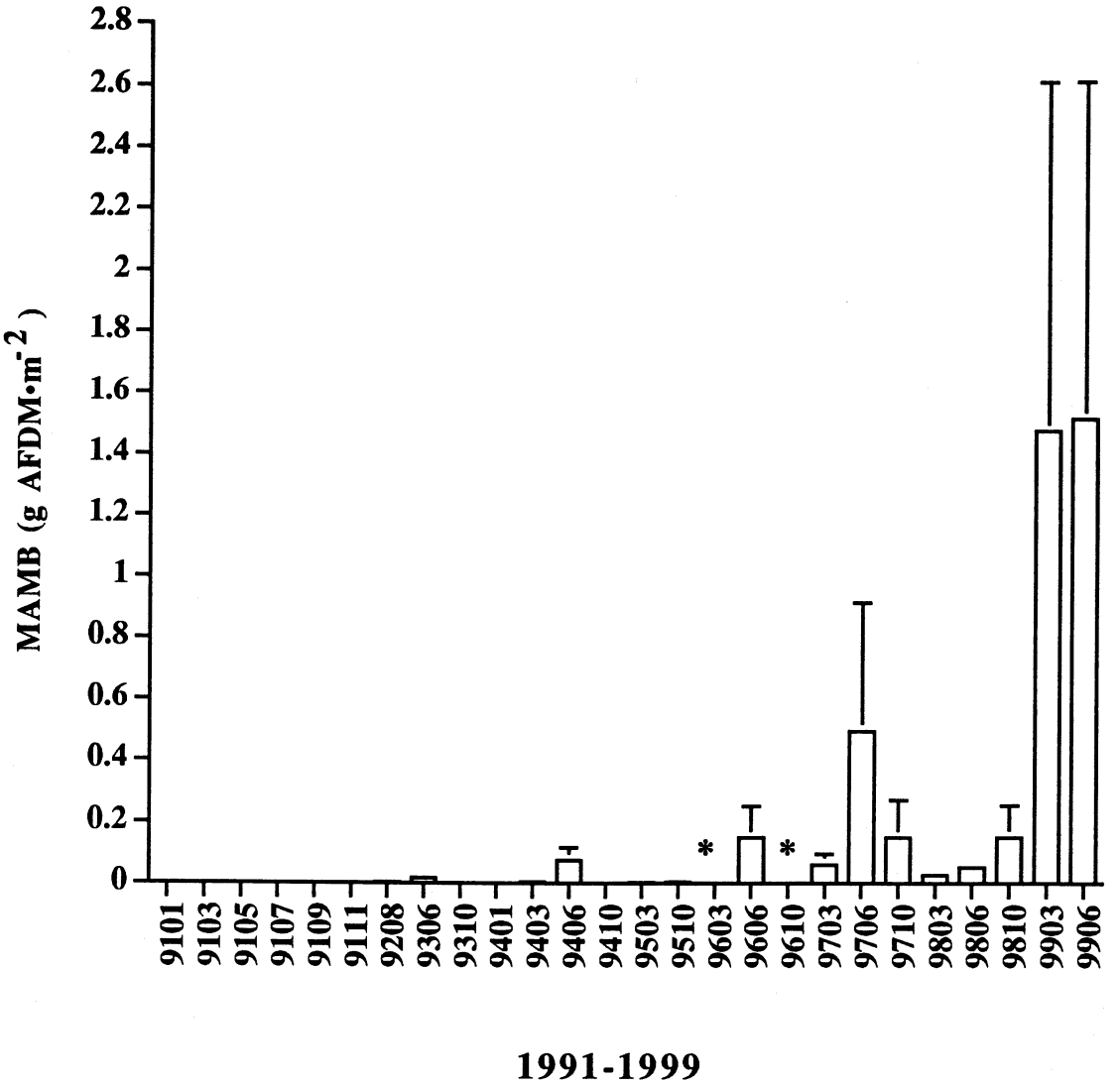

Figure 119. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at 205 Mile rapid Rkm 328.8 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=6). Asterisk (*) at 9603 represents 8 g AFDM•m^{-2} (± 7 SE) and at 9610 represents 4 g AFDM•m^{-2} (± 2 SE).

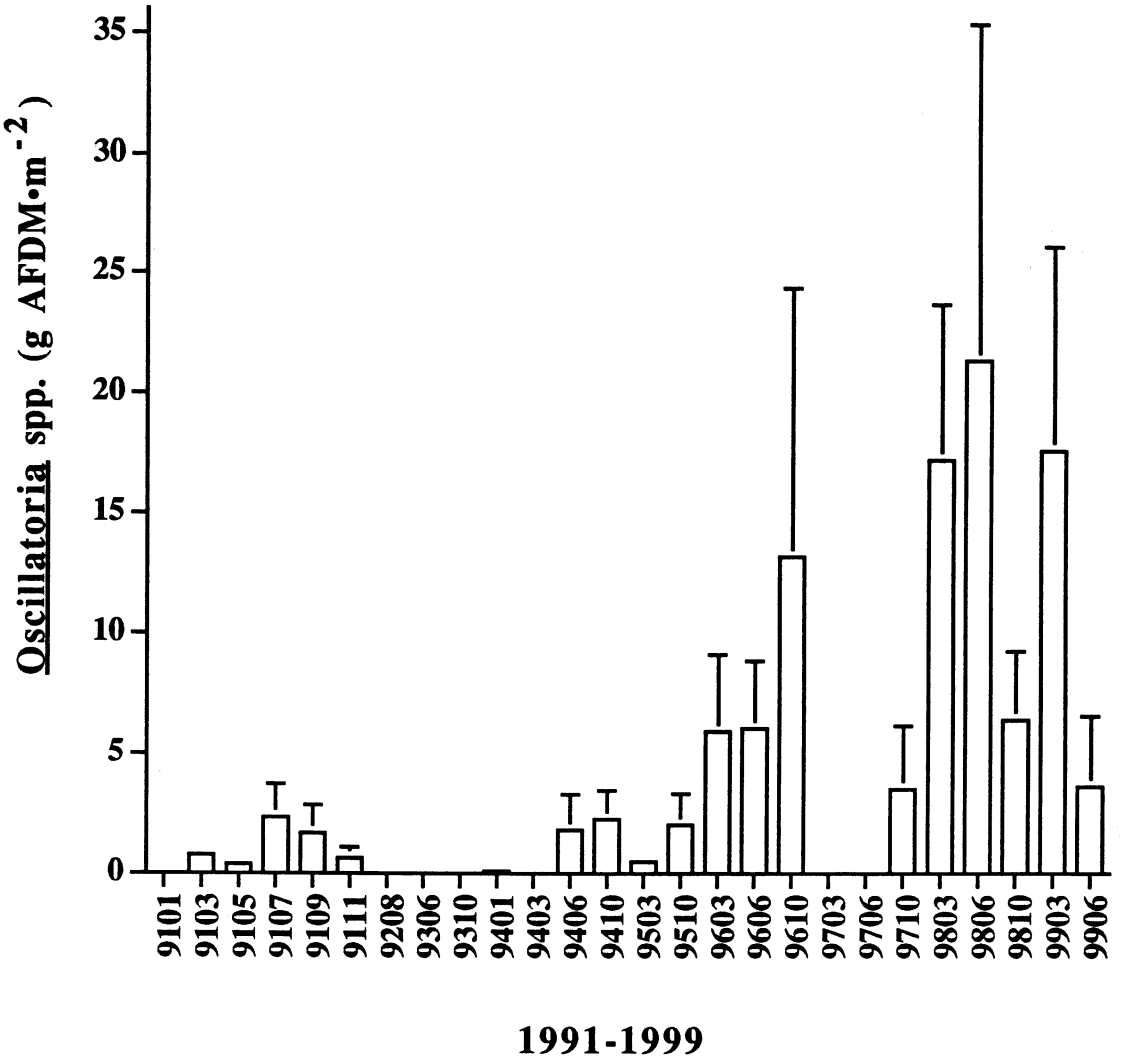

Figure 120. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at 205 Mile rapid Rkm 328.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

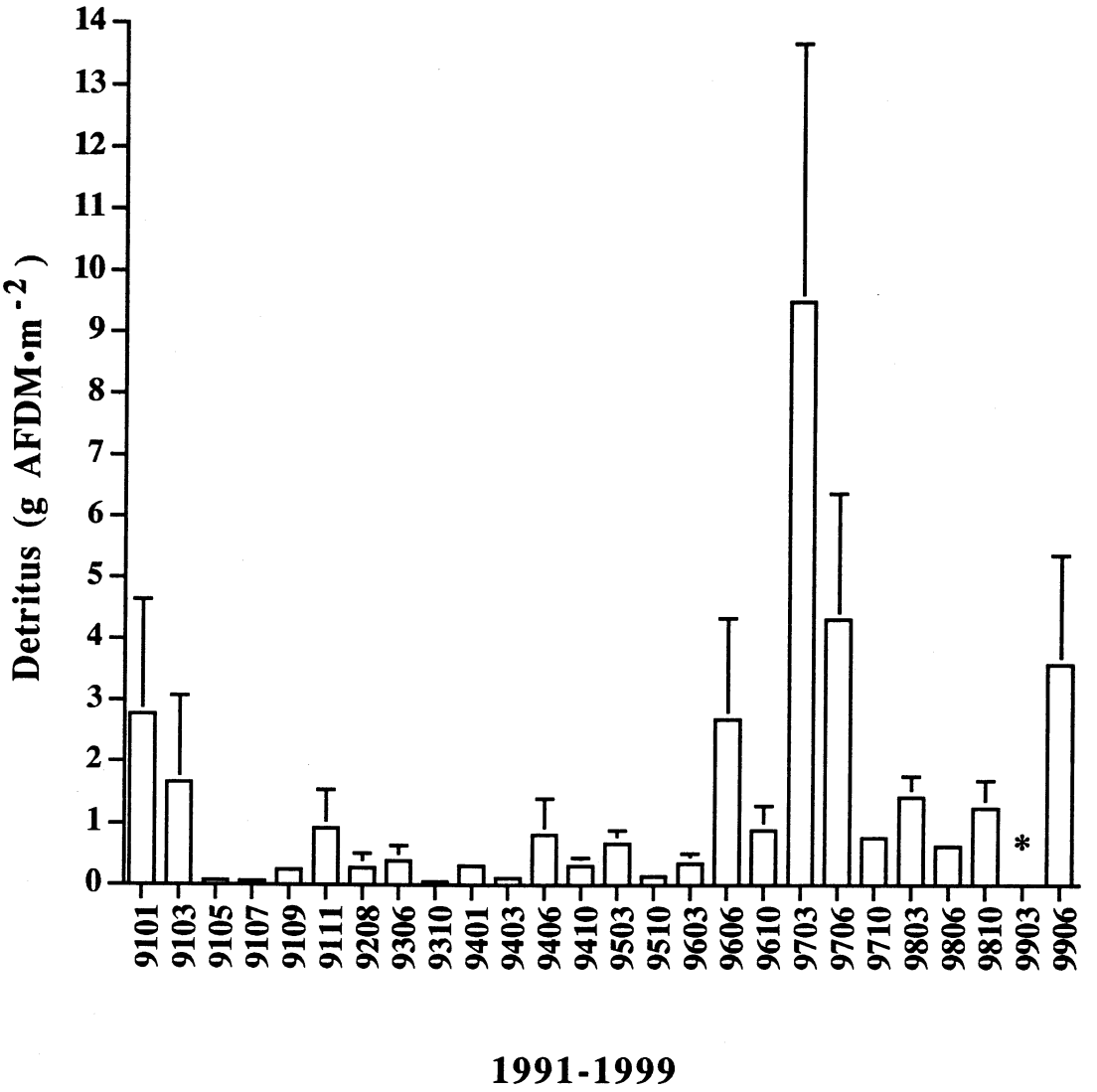

Figure 121. Detritus biomass estimates (g AFDM•m^{-2}) at 205 Mile rapid Rkm 328.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk(*) represents 13 g AFDM•m^{-2} (± 12 SE).

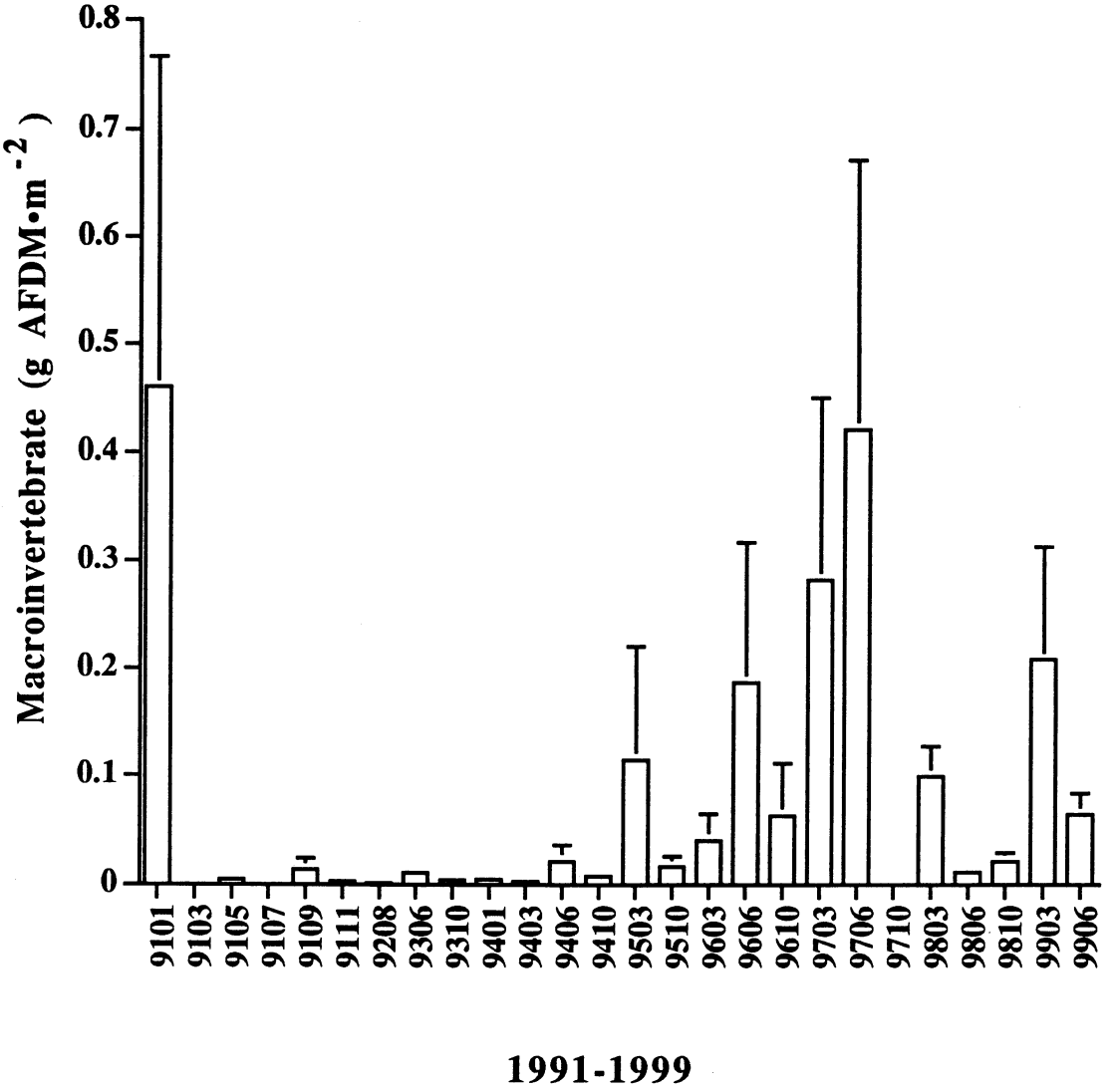

Figure 122. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at 205 Mile rapid Rkm 328.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6).

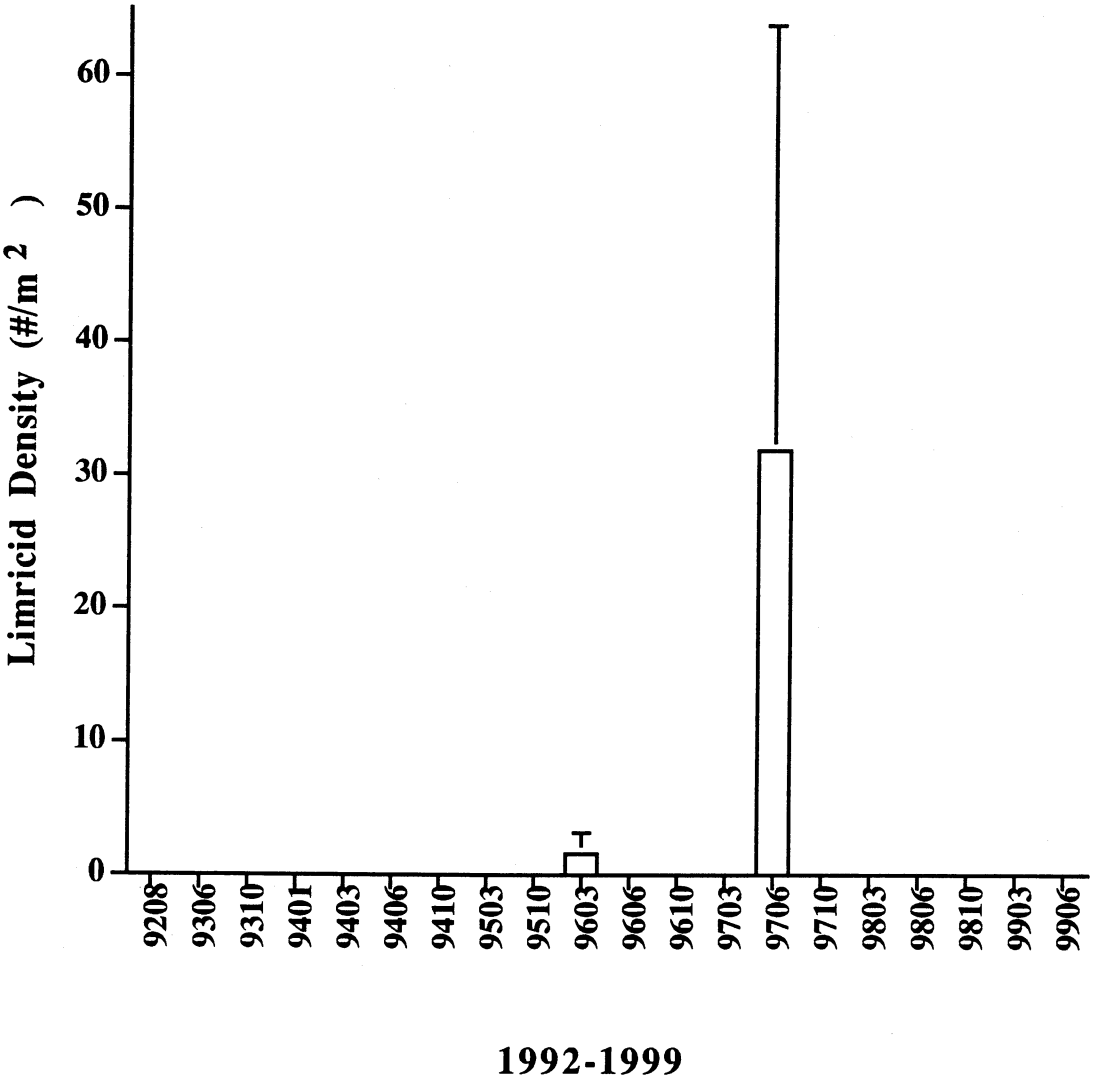

Figure 123. Limbricid densities (#/m ^{2}) collected at 205 Mile Rapid cobble Rkm 202.9 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). .

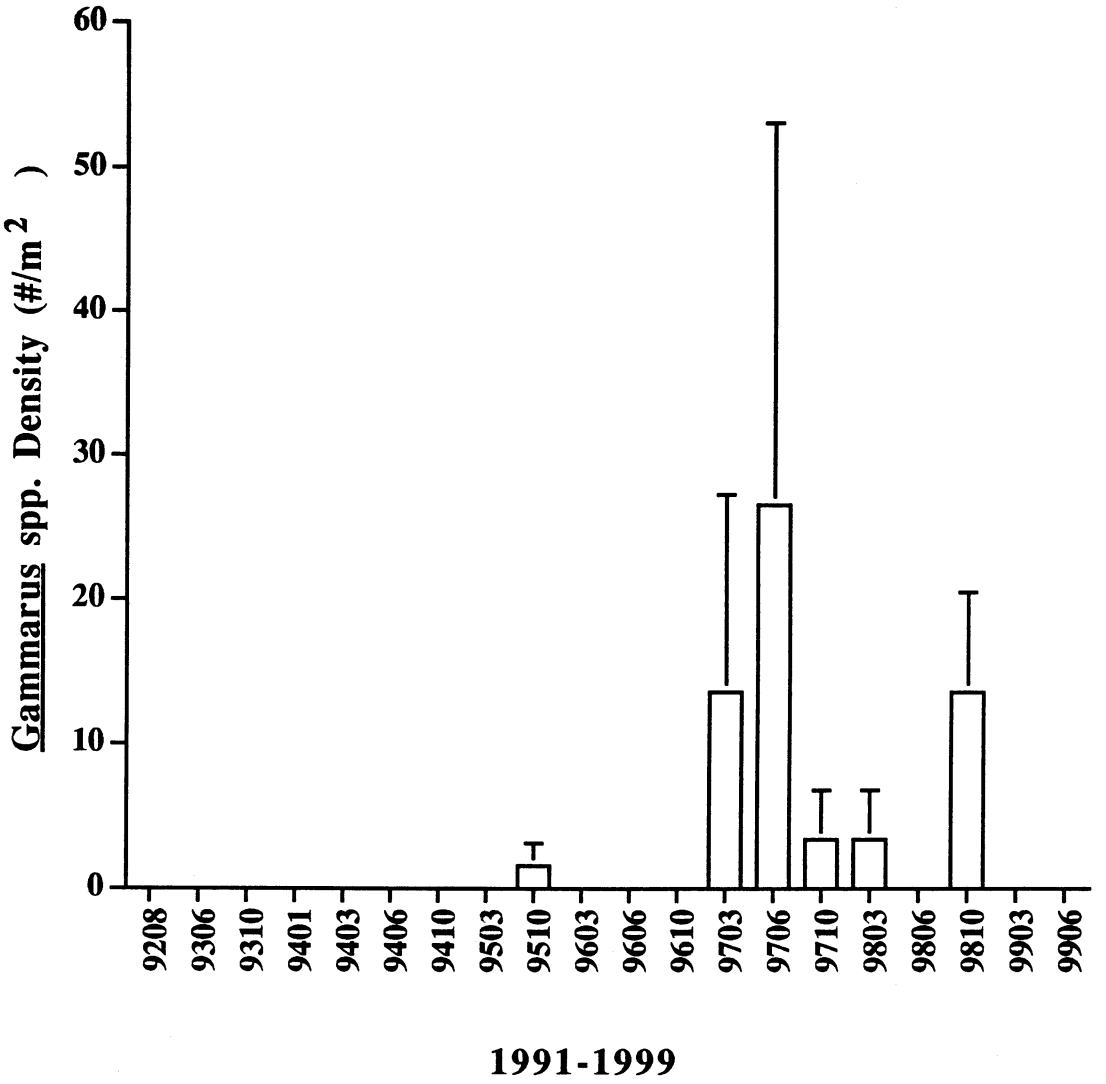

Figure 124. Gammarus spp. densities (#/m^2) collected at 205 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (+ 1 SE, n=6). .

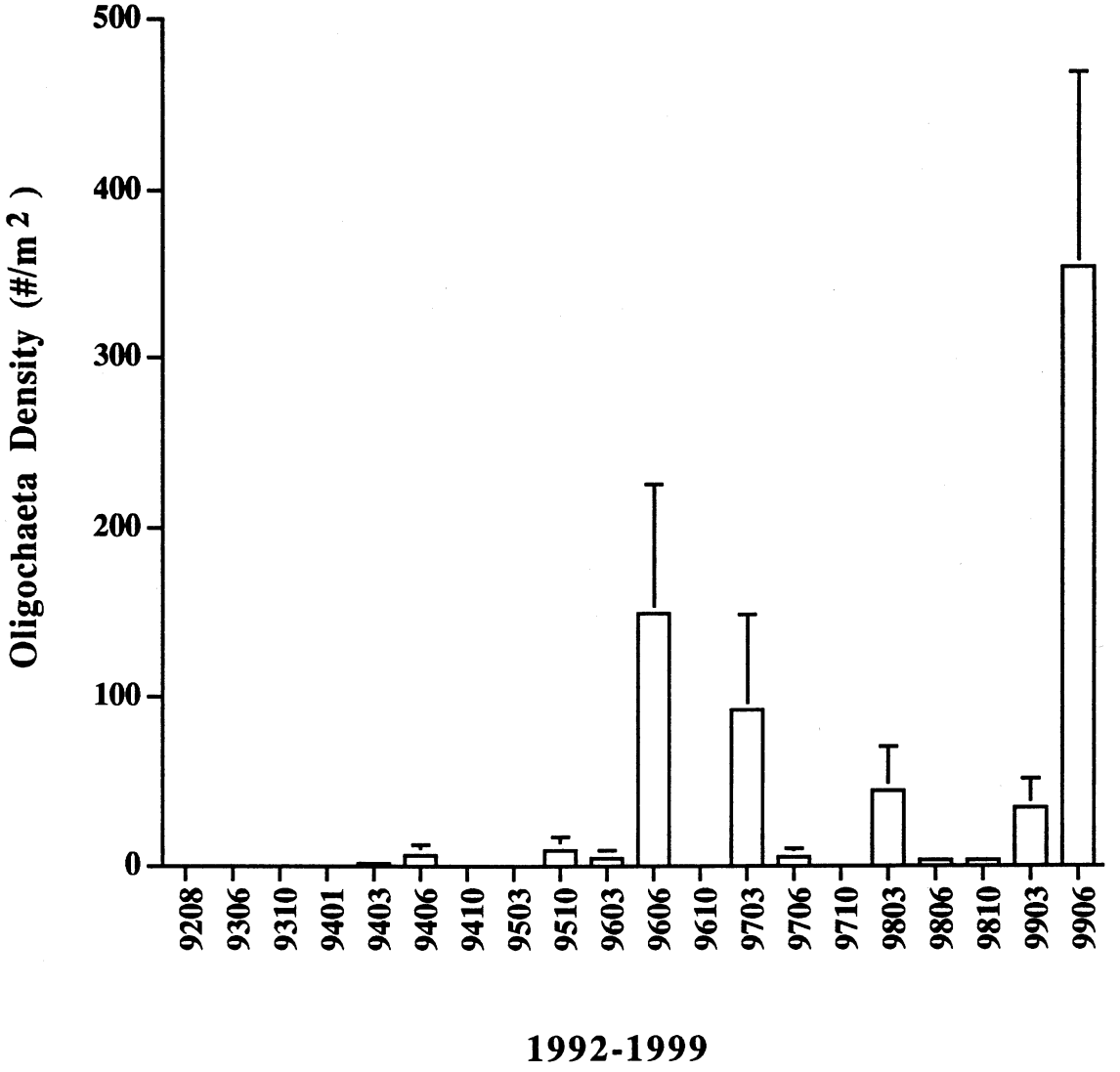

Figure 125. Oligochaeta densities (#/m^2) collected at 205 Mile Rapid cobble Rkm 202.9 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). .

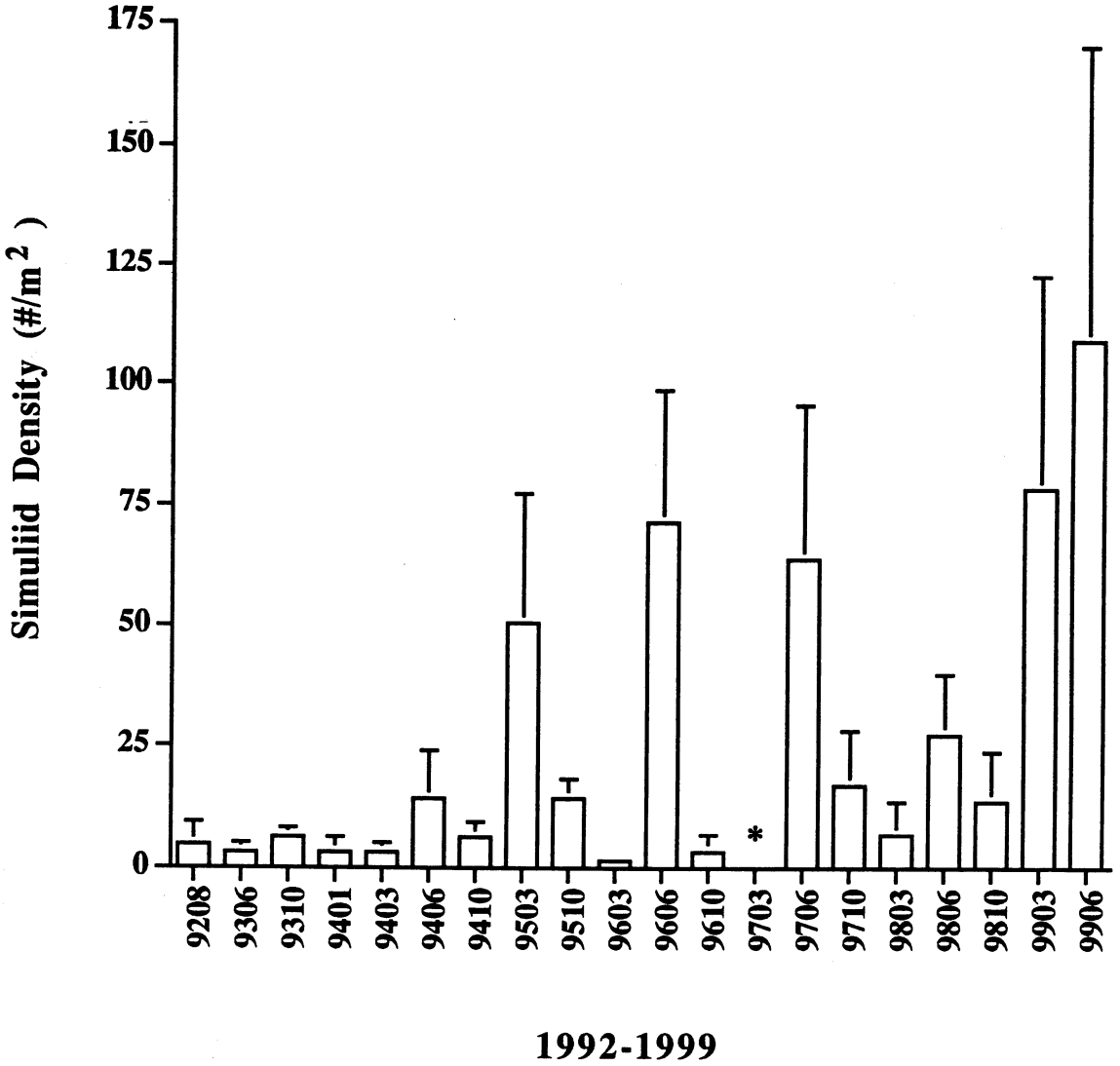

Figure 126. Simuliid densities (#/m^2) collected at 205 Mile Rapid cobble Rkm 202.9 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 350/m^2 (± 225 SE).

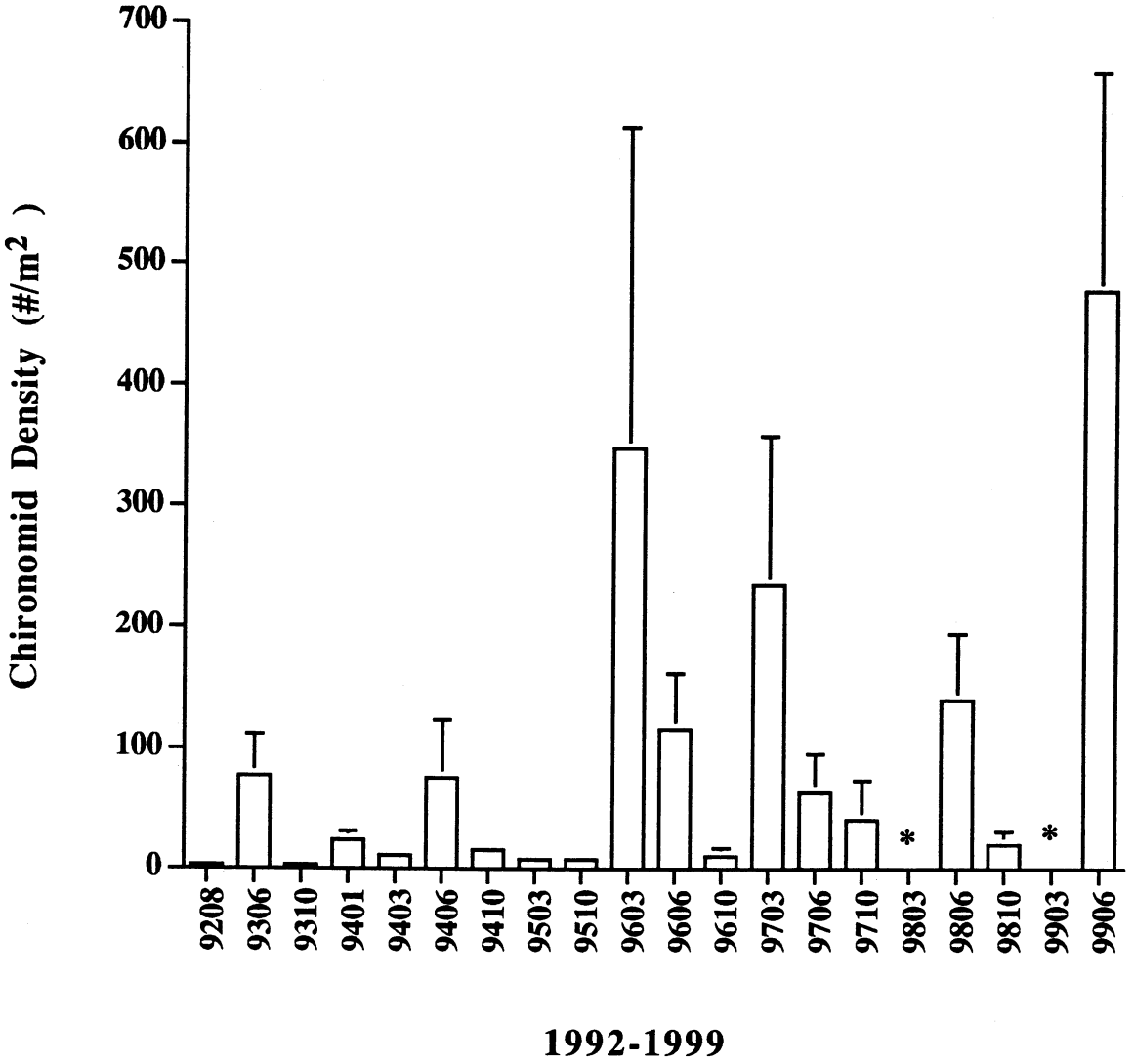

Figure 127. Chiron mid densities (#/m^2) collected at 205 Mile Rapid cobble Rkm 202.9 from August 1992 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) at 9803 represents 15989/m^2 (± 855 SE) and at 9903 represents 1098/m^2 (± 360 SE).

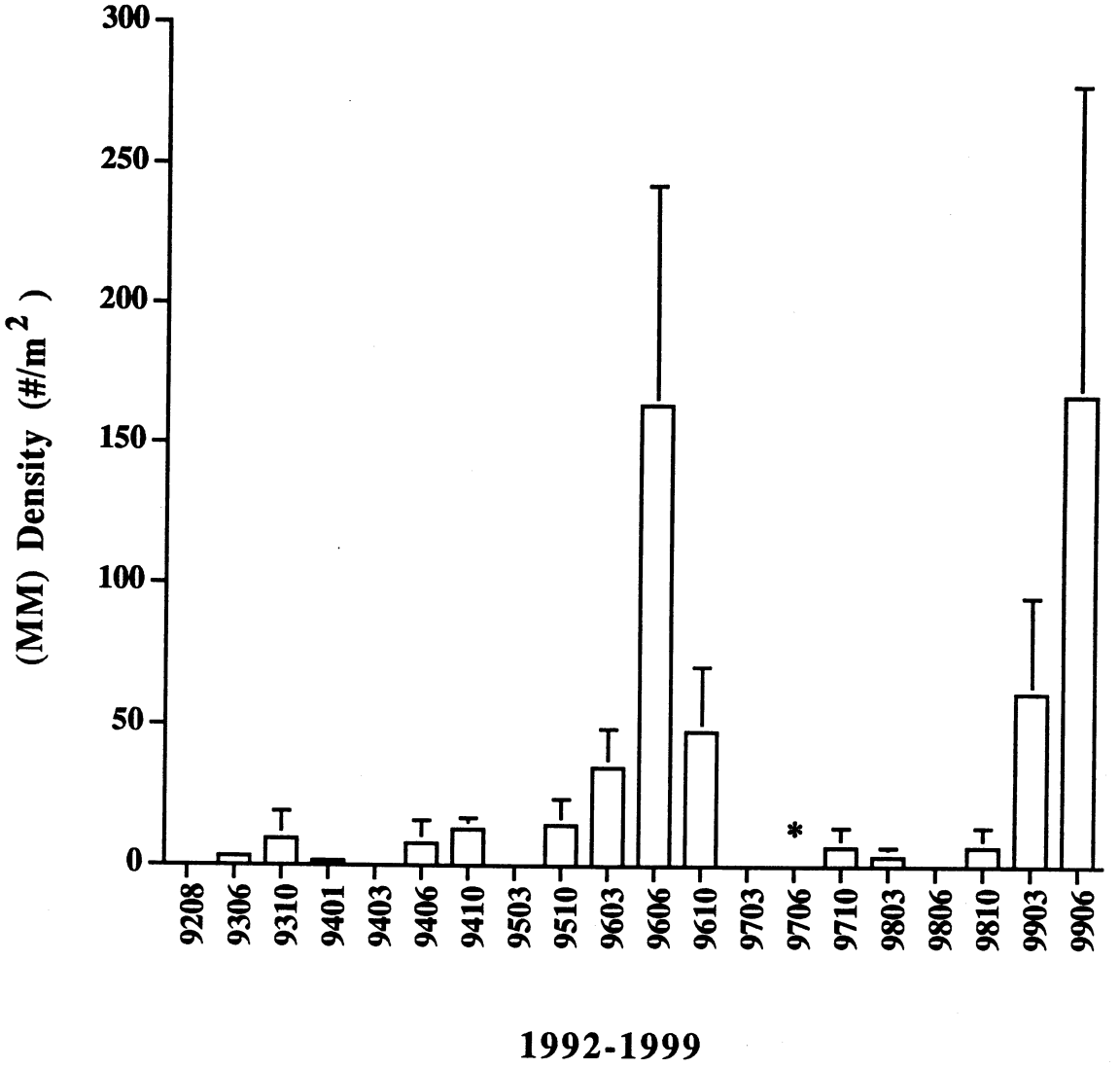

Figure 128. Miscellaneous macroinvertebrate (MM) densities (#/m^2) collected at 205 Mile Rapid cobble Rkm 202.9 from October 1997 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 588/m^2 (± 335 SE).

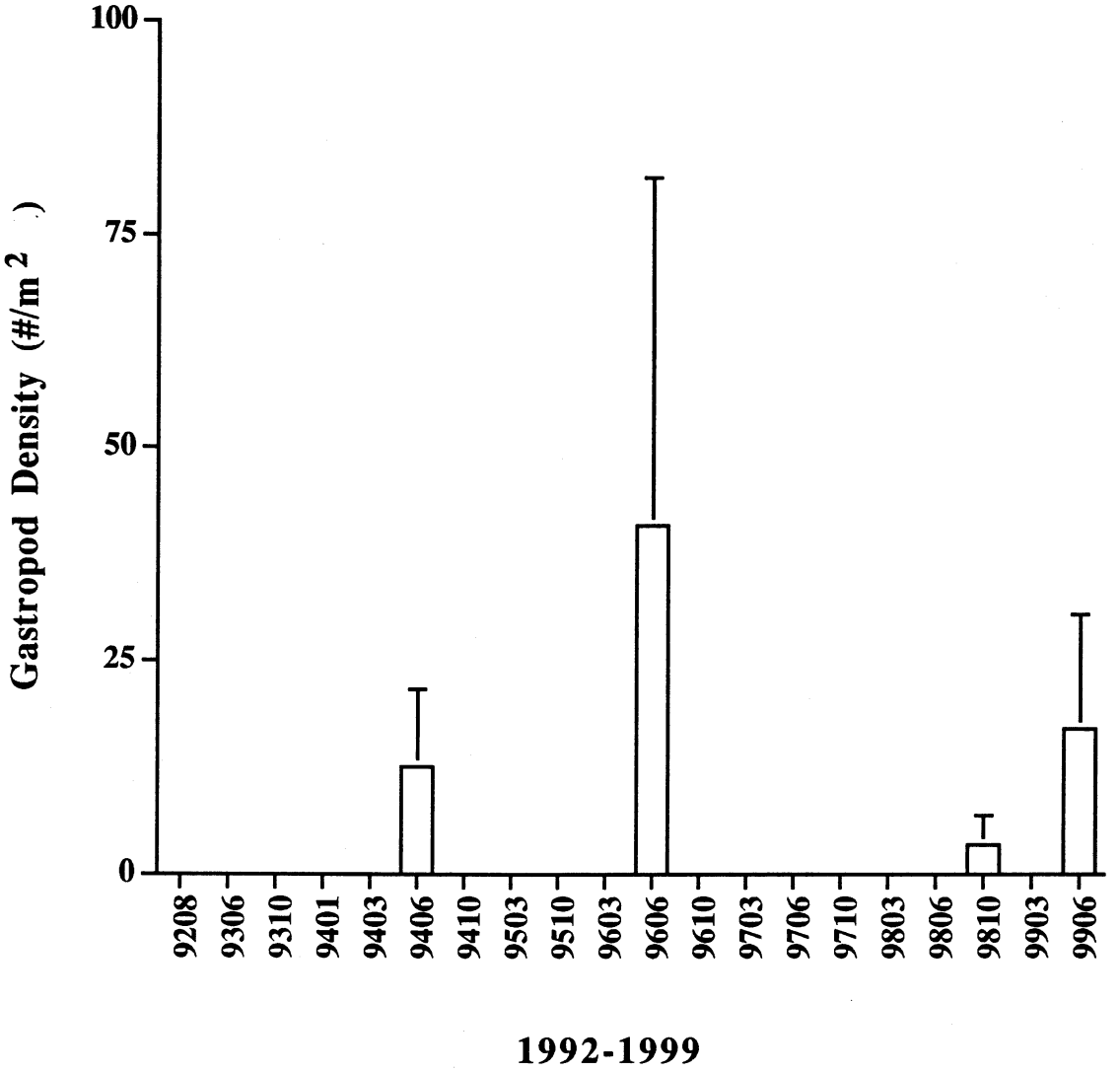

Figure 129. Gastropod densities (#/m^2) collected at 205 Mile Rapid cobble Rkm 202.9 from August 1992 to June 1999. Error bars represent (+ 1 SE, n=6). .

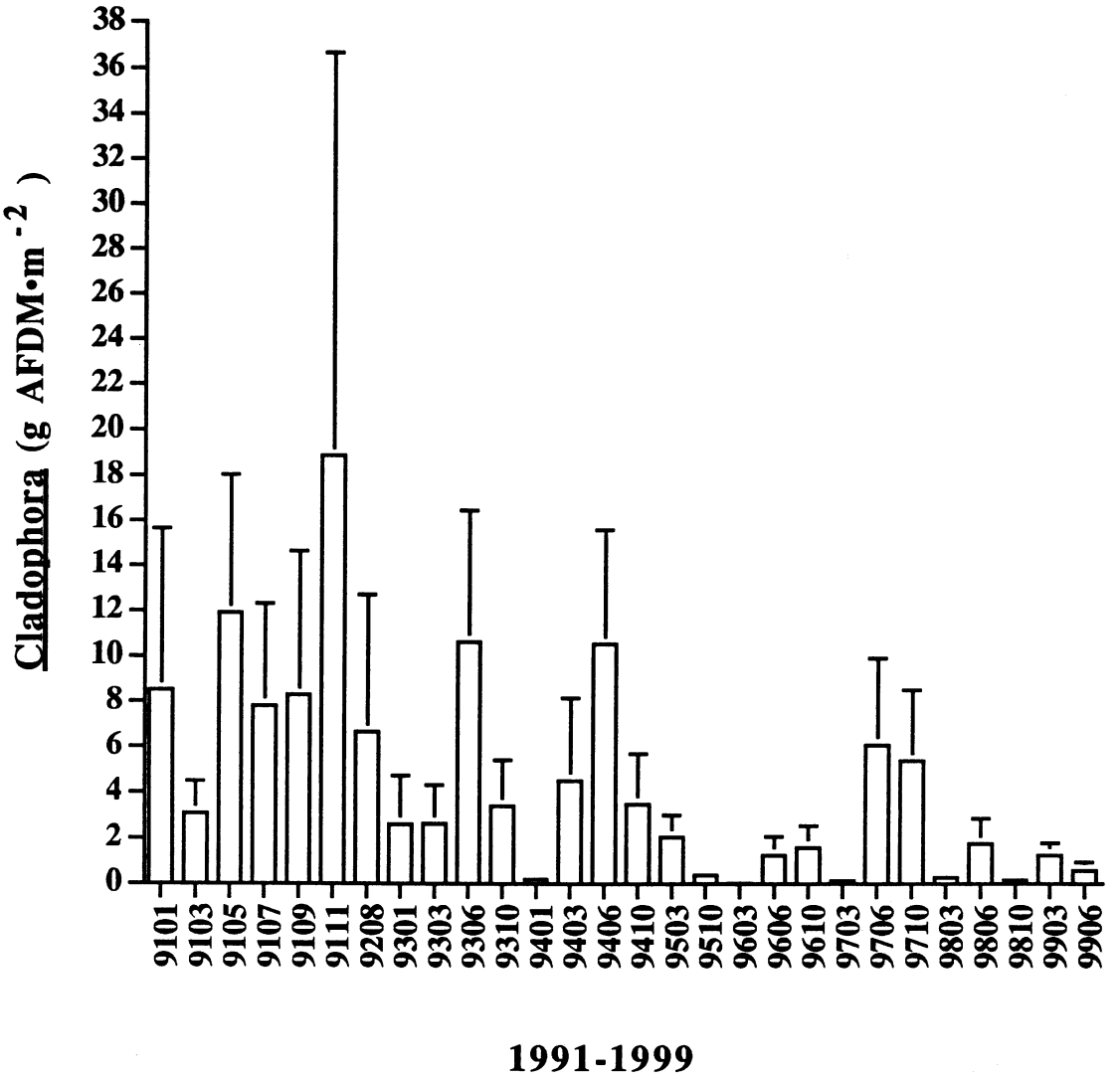

Figure 130. Cladophora biomass estimates (g AFDM•m^{-2}) at Lees Ferry pool Rkm 0.0 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

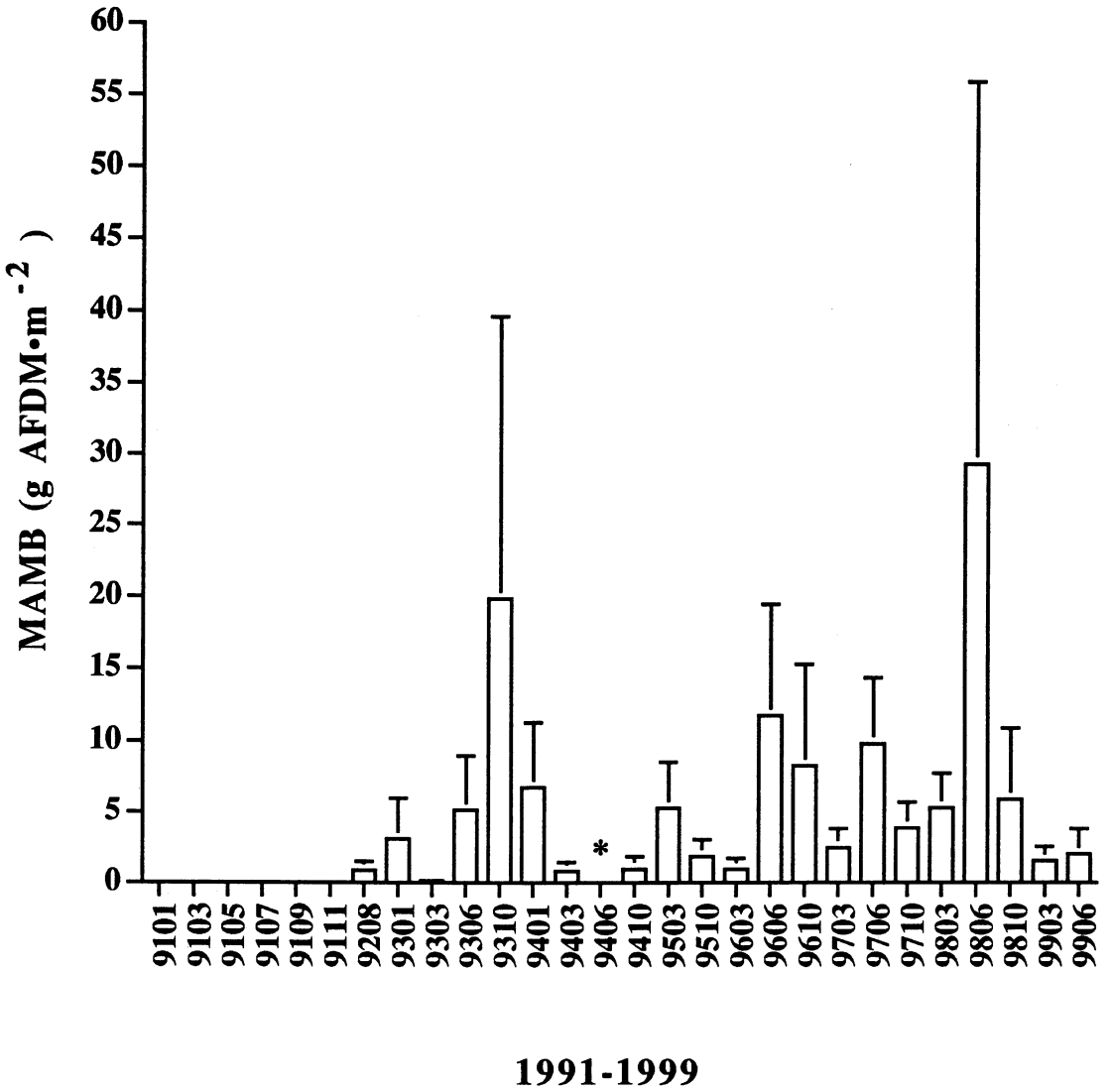

Figure 131. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at Lees Ferry pool Rkm 0.0 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 50 g AFDM•m^{-2} (± 39 SE).

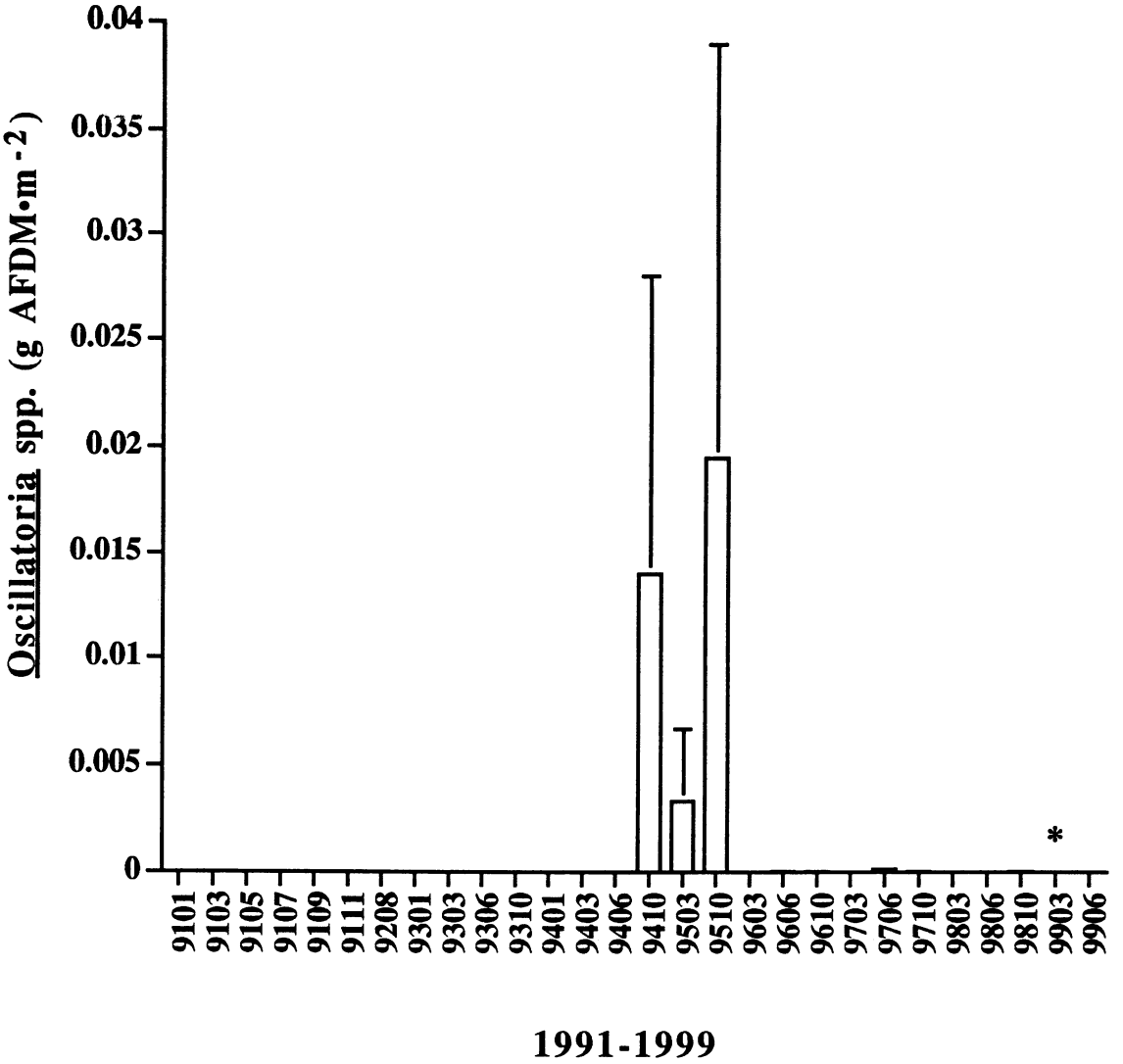

Figure 132. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at Lees Ferry pool Rkm 0.0 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 0.73 g AFDM•m (± 0.73 SE).

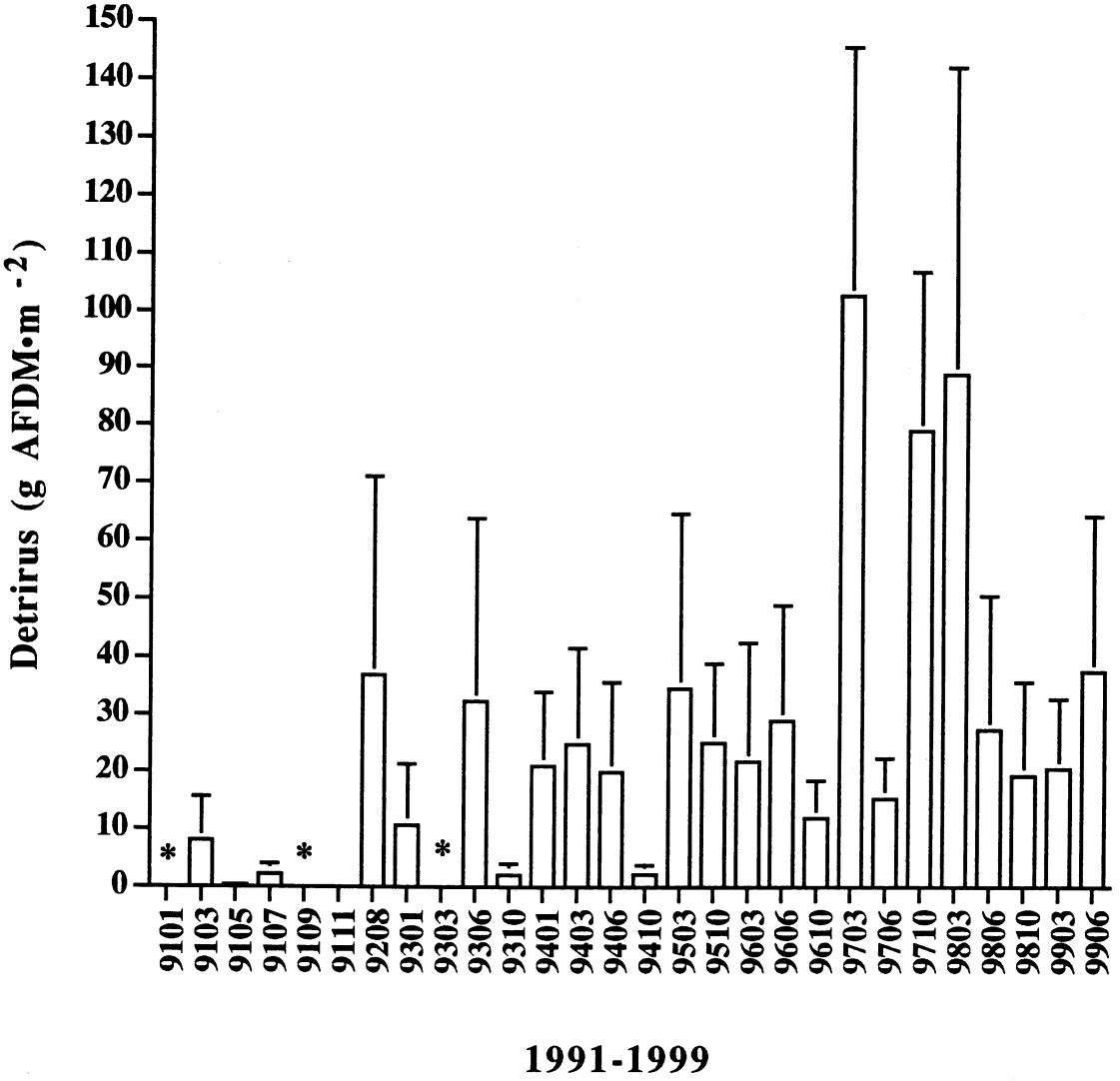

Figure 133. Detritus biomass estimates (g AFDM•m^{-2}) at Lees Ferry pool Rkm 0.0 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) at 9101 represents 1143 g AFDM•m^{-2} (± 1143 SE), at 9109 represents 523 g AFDM•m^{-2} (± 521 SE) and at 9303 represents 213 g AFDM•m^{-2} (± 175 SE).

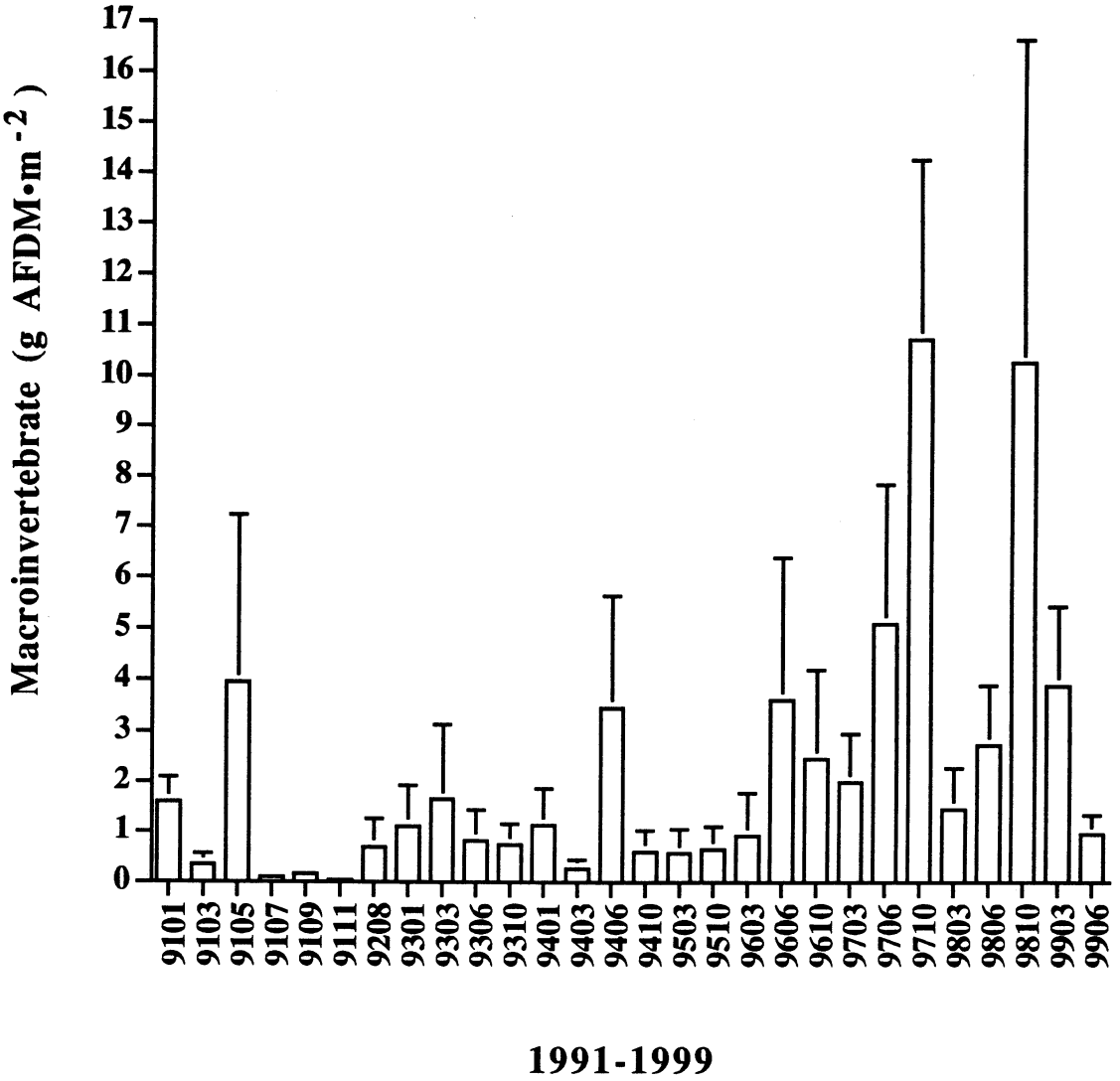

Figure 134. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at Lees Ferry pool Rkm 0.0 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

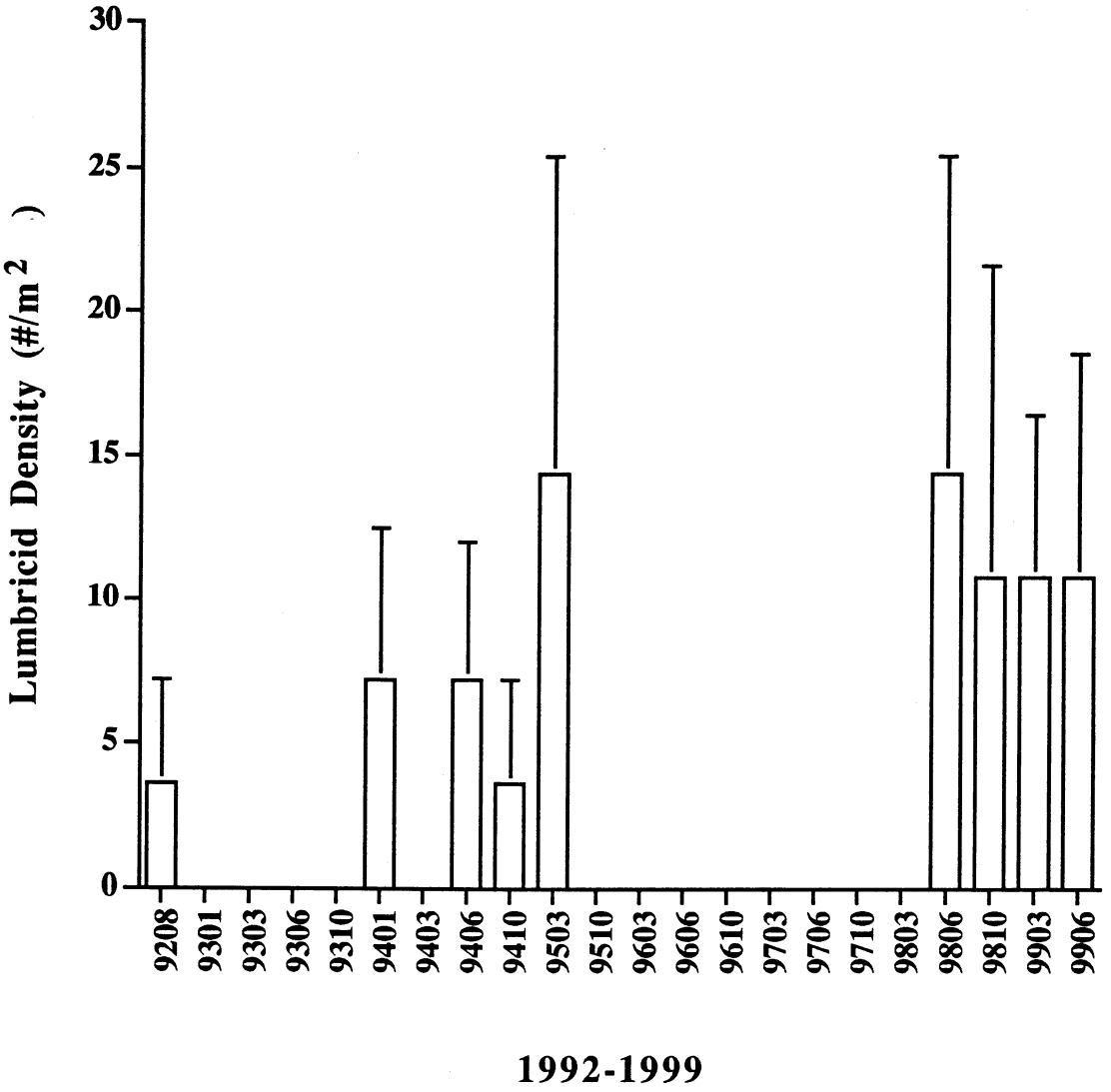

Figure 135. Lumbricid densities (#/m^2) collected at Lees Ferry pool Rkm 0.0 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

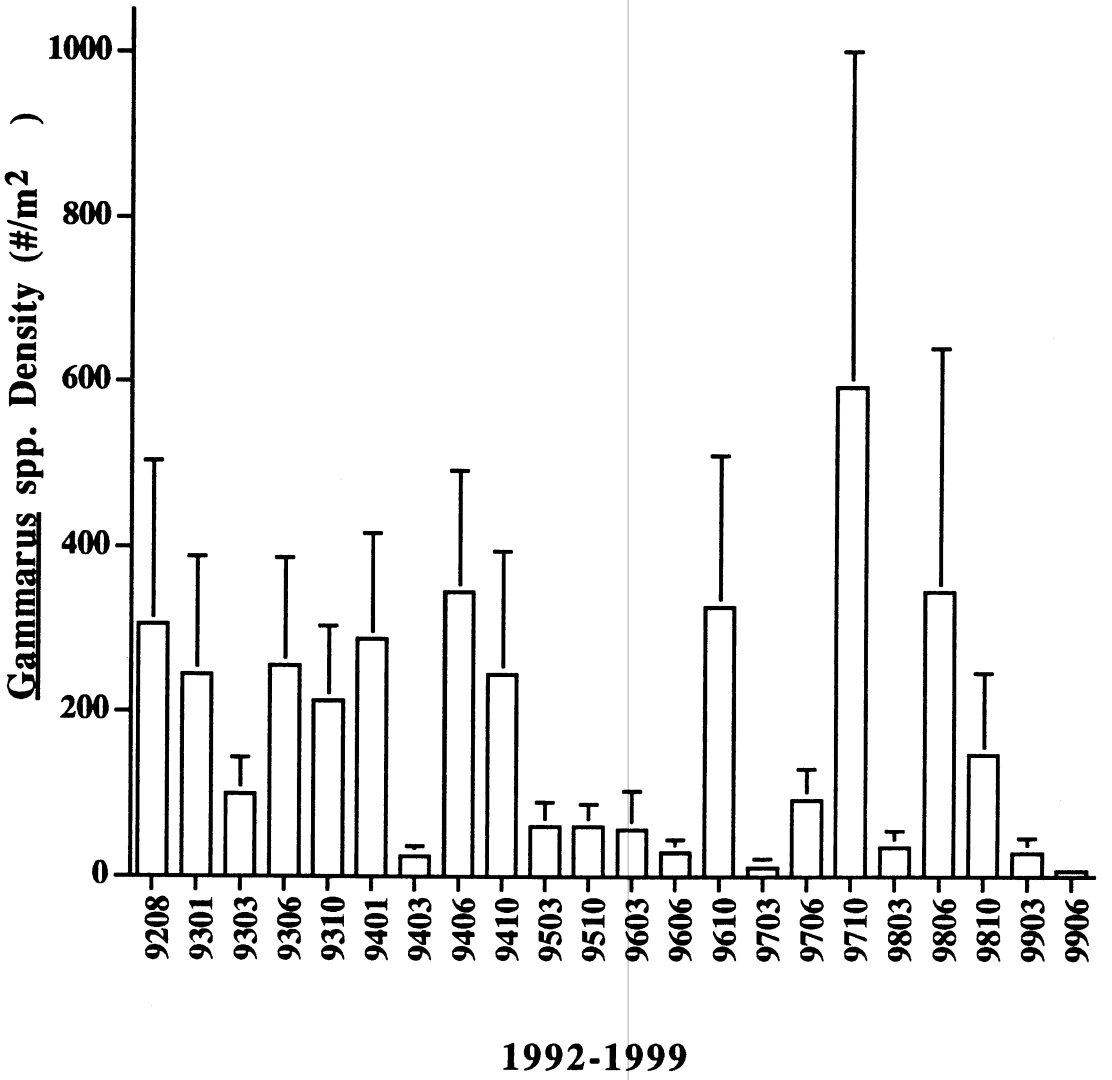

Figure 136. Gammarus spp. densities (#/m^2) collected at Lees Ferry pool Rkm 0.0 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

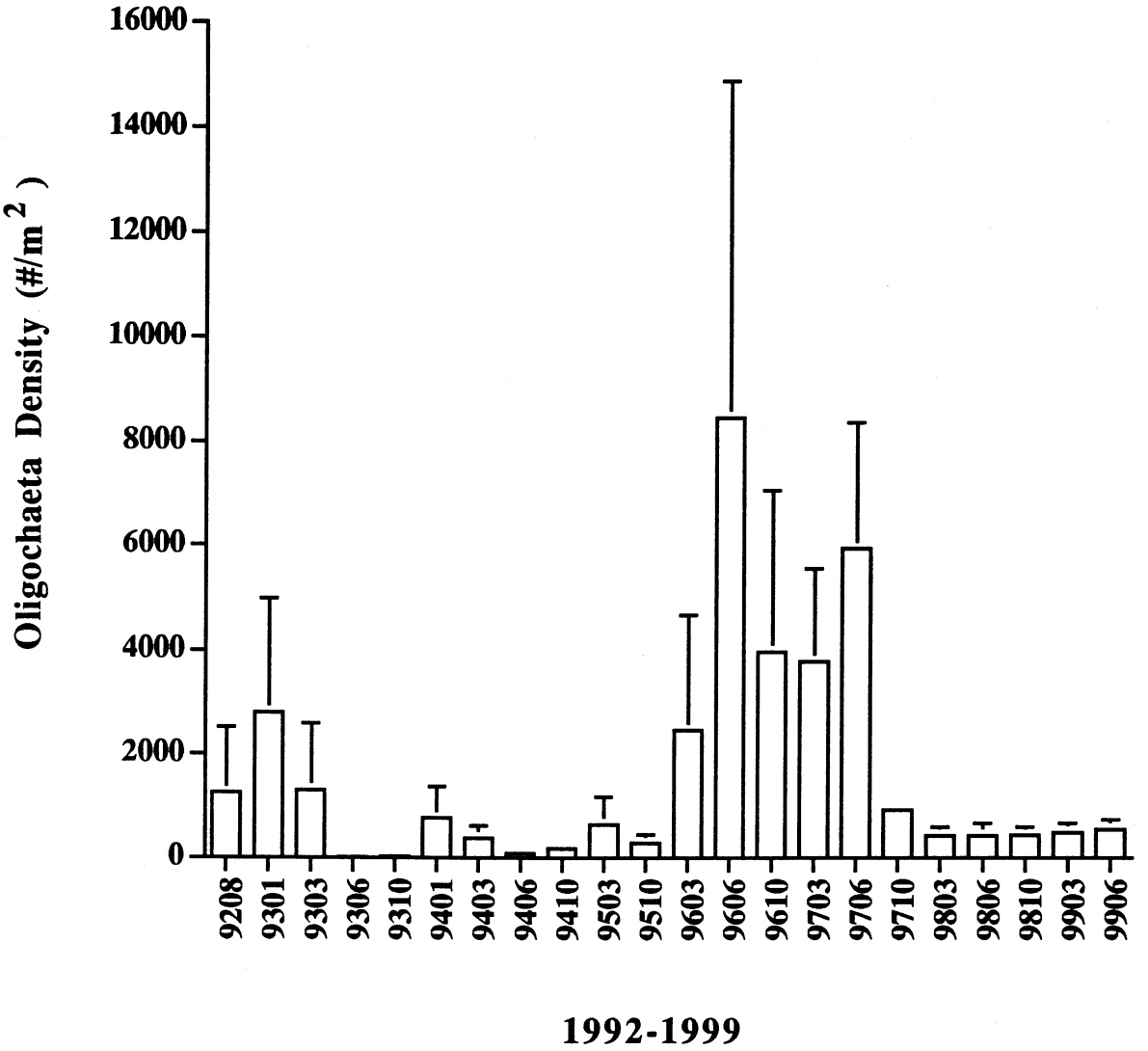

Figure 137. Oligochaeta densities (#/m^2) collected at Lees Ferry pool Rkm 0.0 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

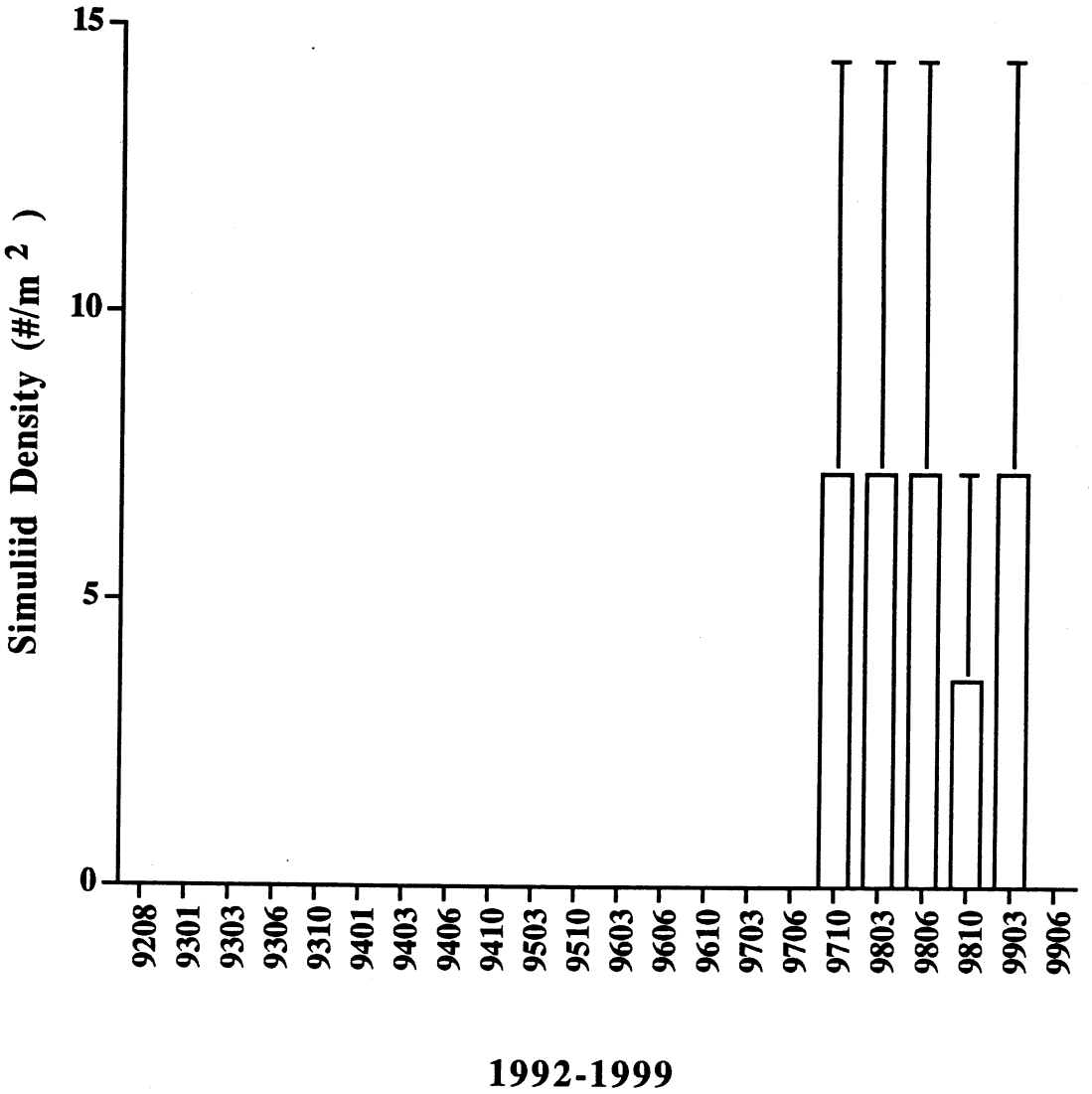

Figure 138. Simuliid densities (#/m^2) collected at Lees Ferry pool Rkm 0.0 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

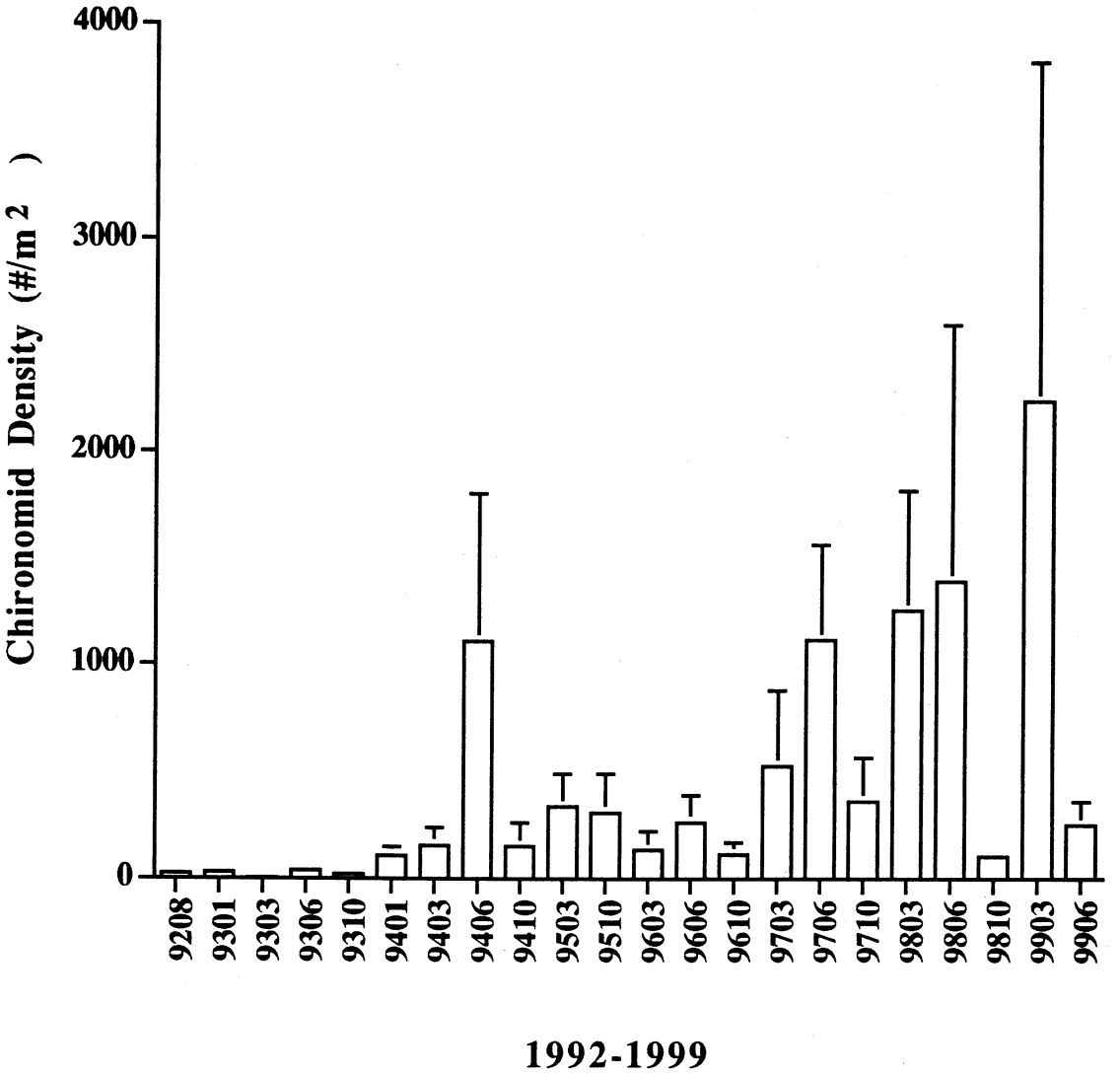

Figure 139. Chironomid densities (#/m ^{2}) collected at Lees Ferry pool Rkm 0.0 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

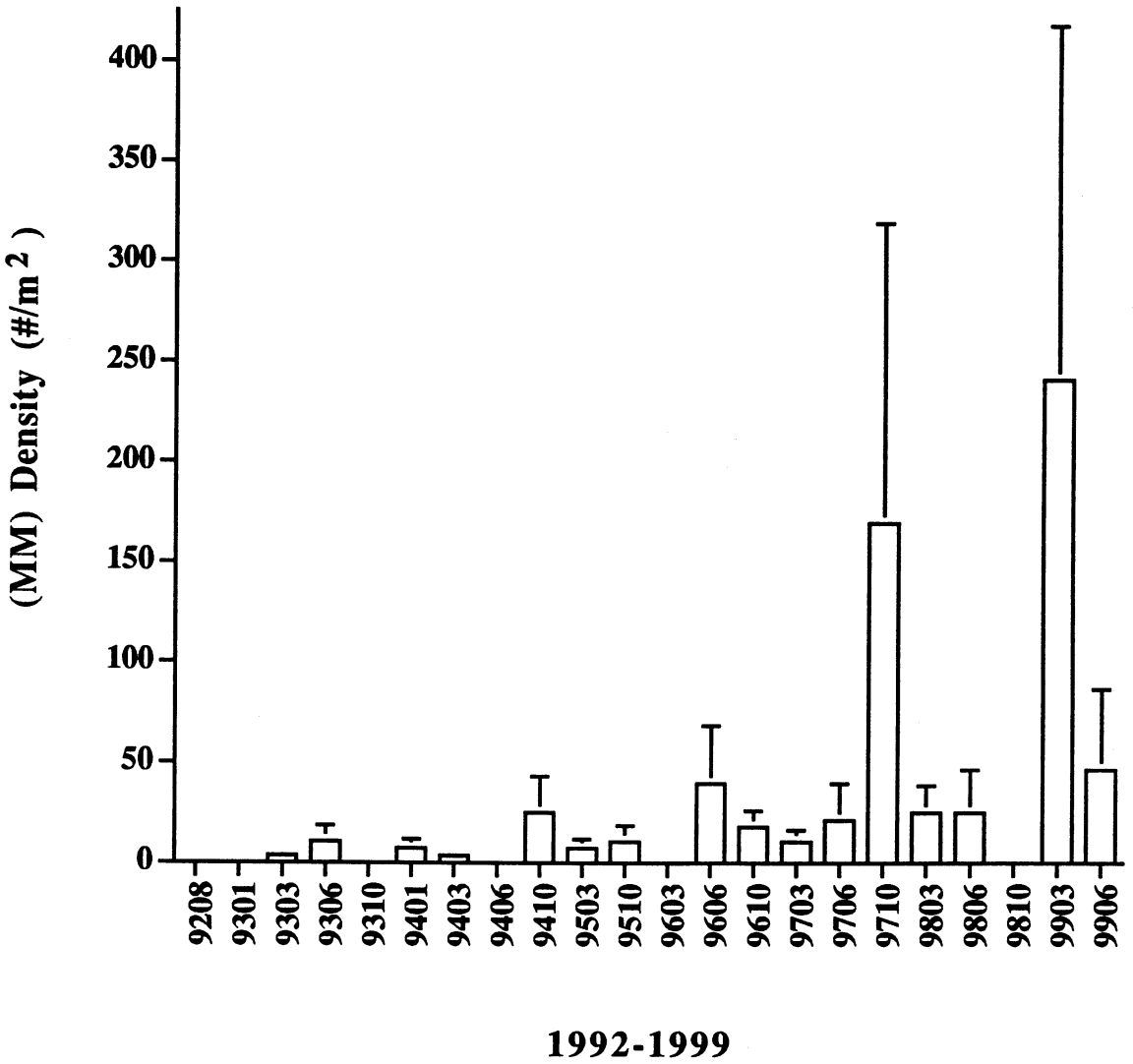

Figure 140. Miscellaneous macroinvertebrate (MM) densities (#/m^2) collected at Lees Ferry pool Rkm 0.0 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 581/m^2 (± 574 SE).

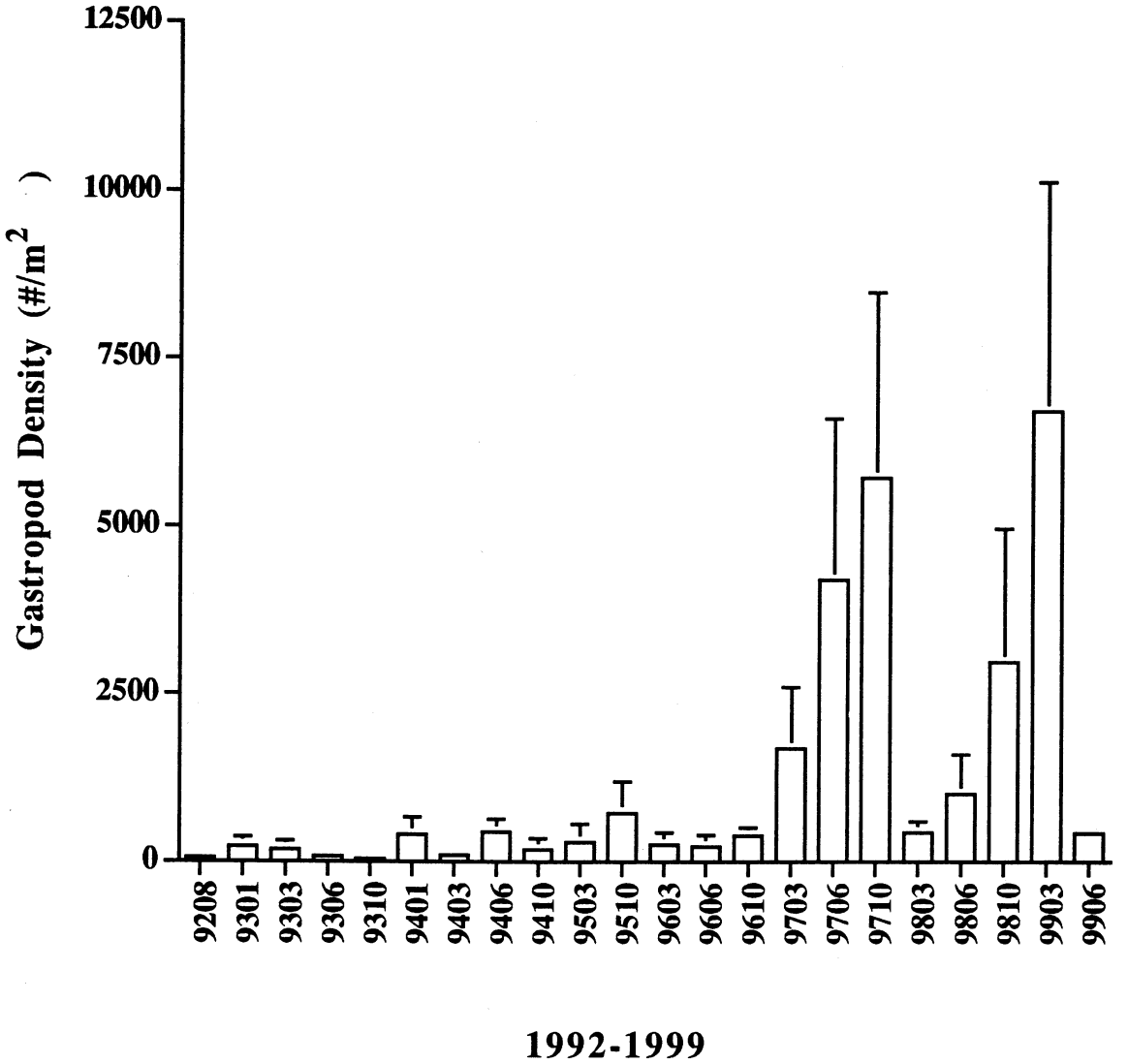

Figure 141. Gastropod densities (#/m^2) collected at Lees Ferry pool Rkm 0.0 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

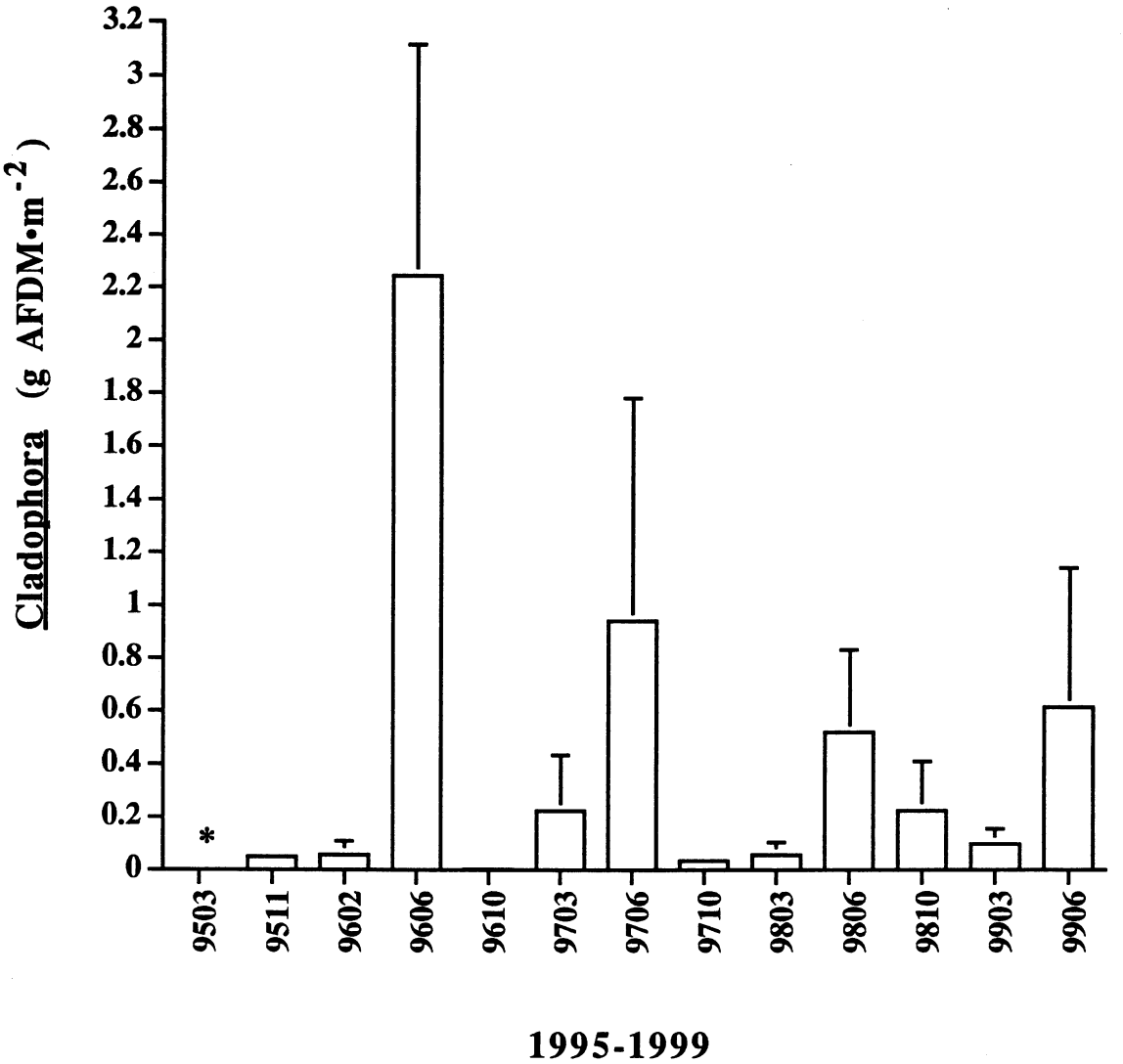

Figure 142. Cladophora biomass estimates (g AFDM•m^{-2}) at Two-Mile pool Rkm 3.1 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 22 g AFDM•m^{-2} (± 22 SE).

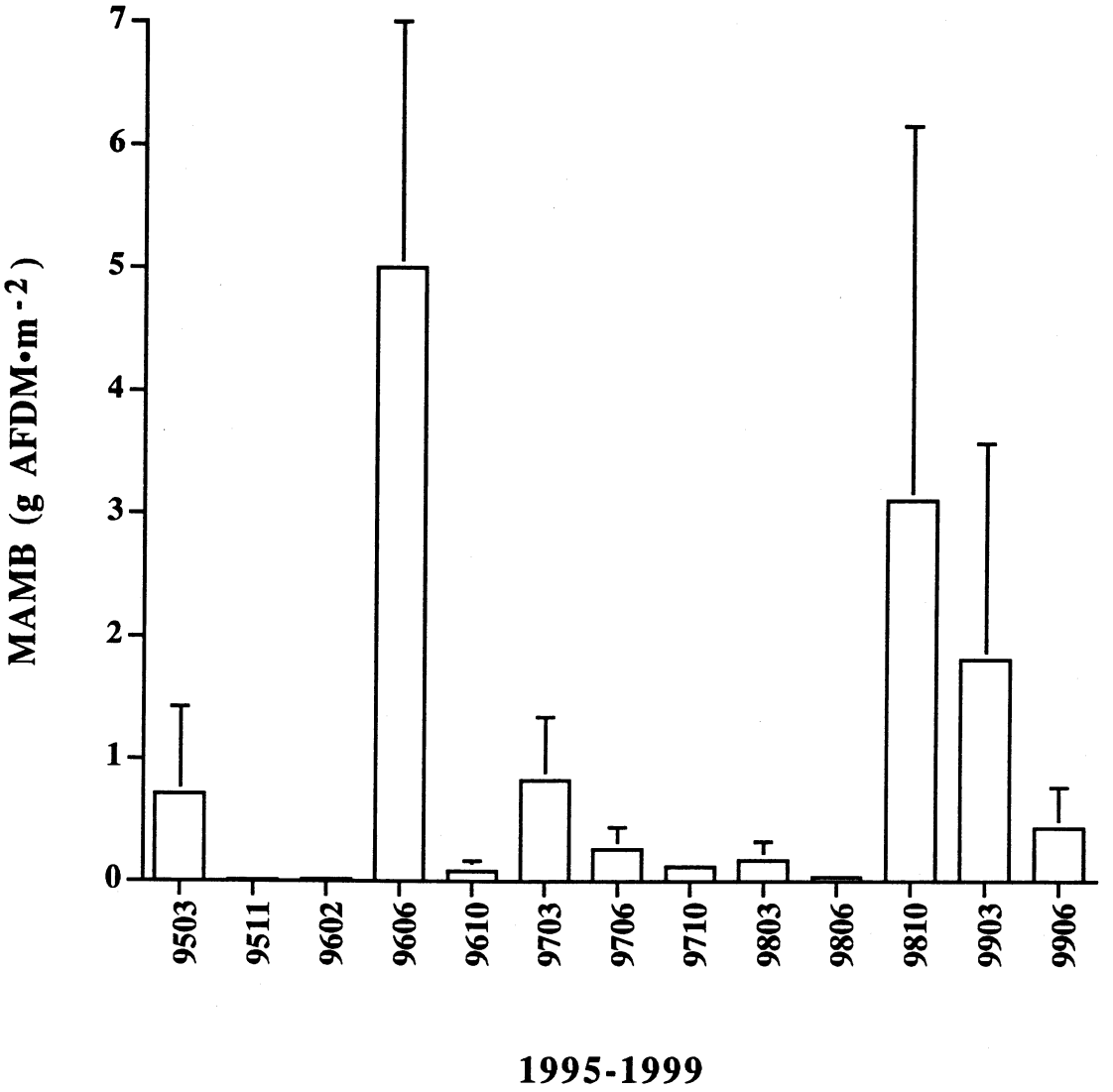

Figure 143. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at Two-Mile pool Rkm 3.1 from March 1995 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=12).

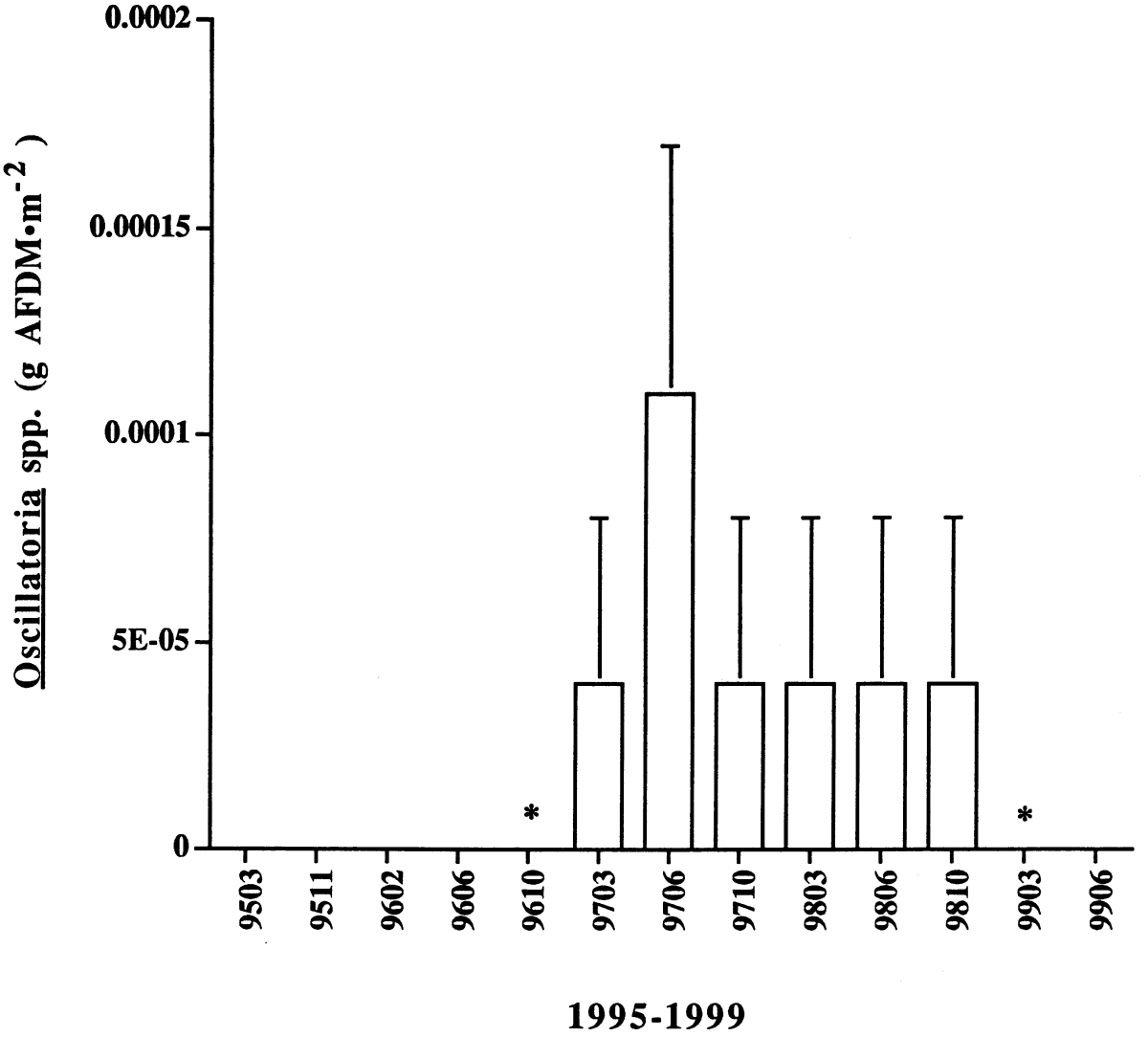

Figure 144. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at Two-Mile pool Rkm 3.1 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) at 9610 represents 13 g AFDM•m^{-2} (± 11.5 SE) and at 9903 represents 0.65 g AFDM•m^{-2}(± 0.65 SE).

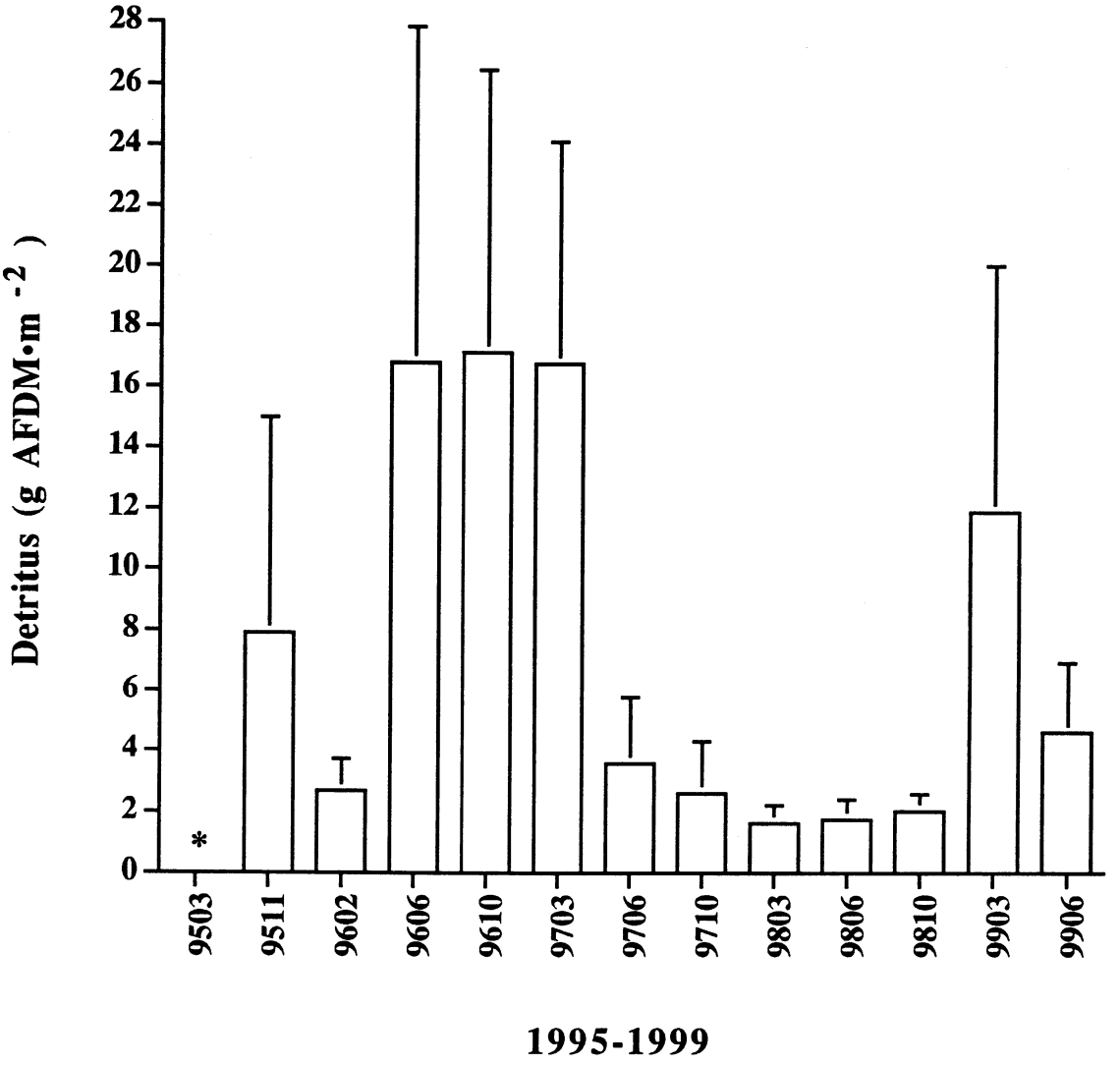

Figure 145. Detritus biomass estimates (g AFDM•m^{-2}) at Two-Mile pool Rkm 3.1 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 822 g AFDM•m^{-2} (± 821 SE).

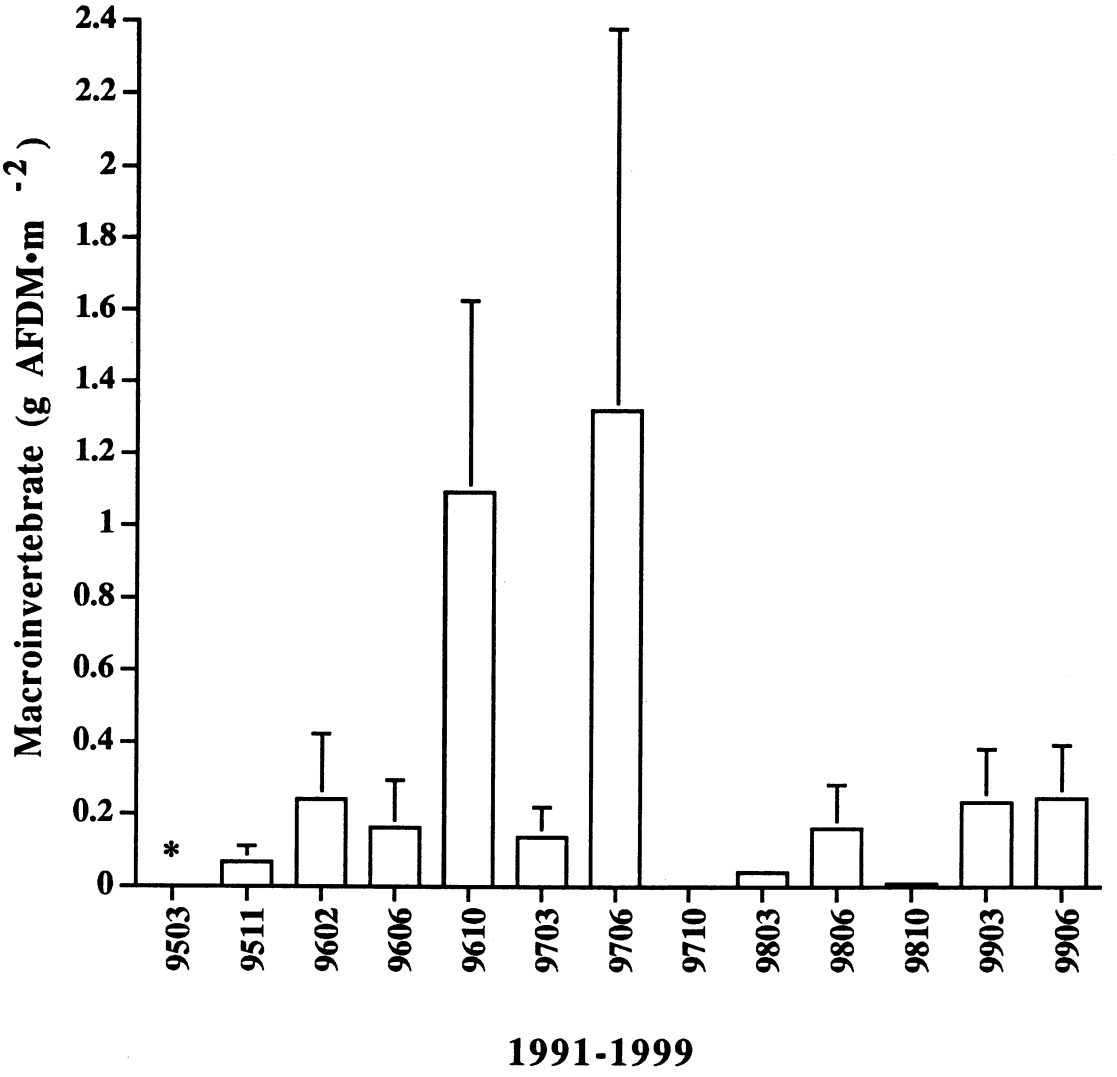

Figure 146. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at Two-Mile pool Rkm 3.1 from January 1991 to June 1999. Error bars represent (± 1 SE, n=6). Asterisk (*) represents 2 g AFDM•m^{-2} (± 2 SE).

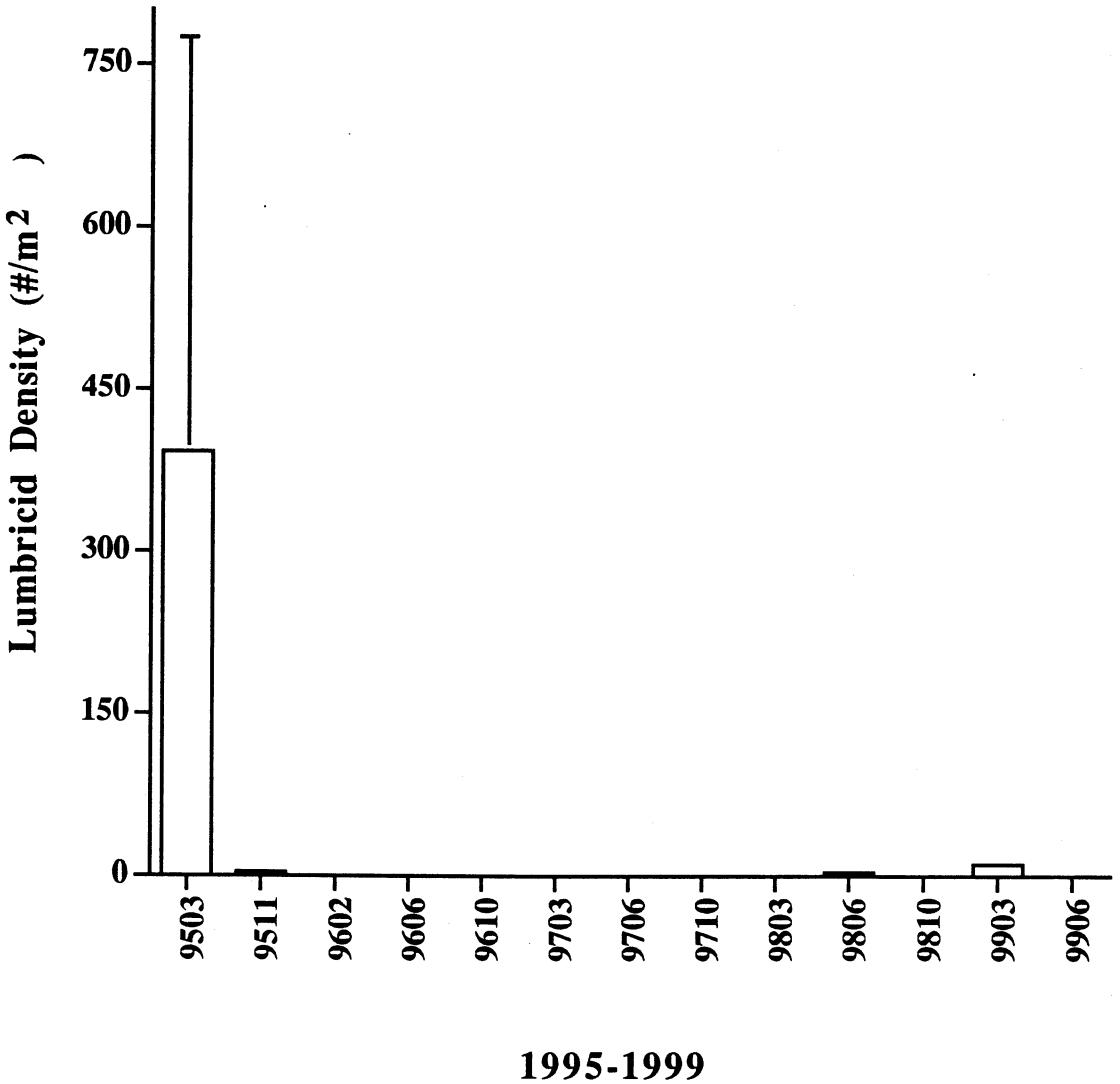

Figure 147. Lumbricid densities (#/m^{2}) collected at Two-Mile pool Rkm 3.1 pool from March 1995 to June 1999. Error bars represent (± 1 SE, n=12).

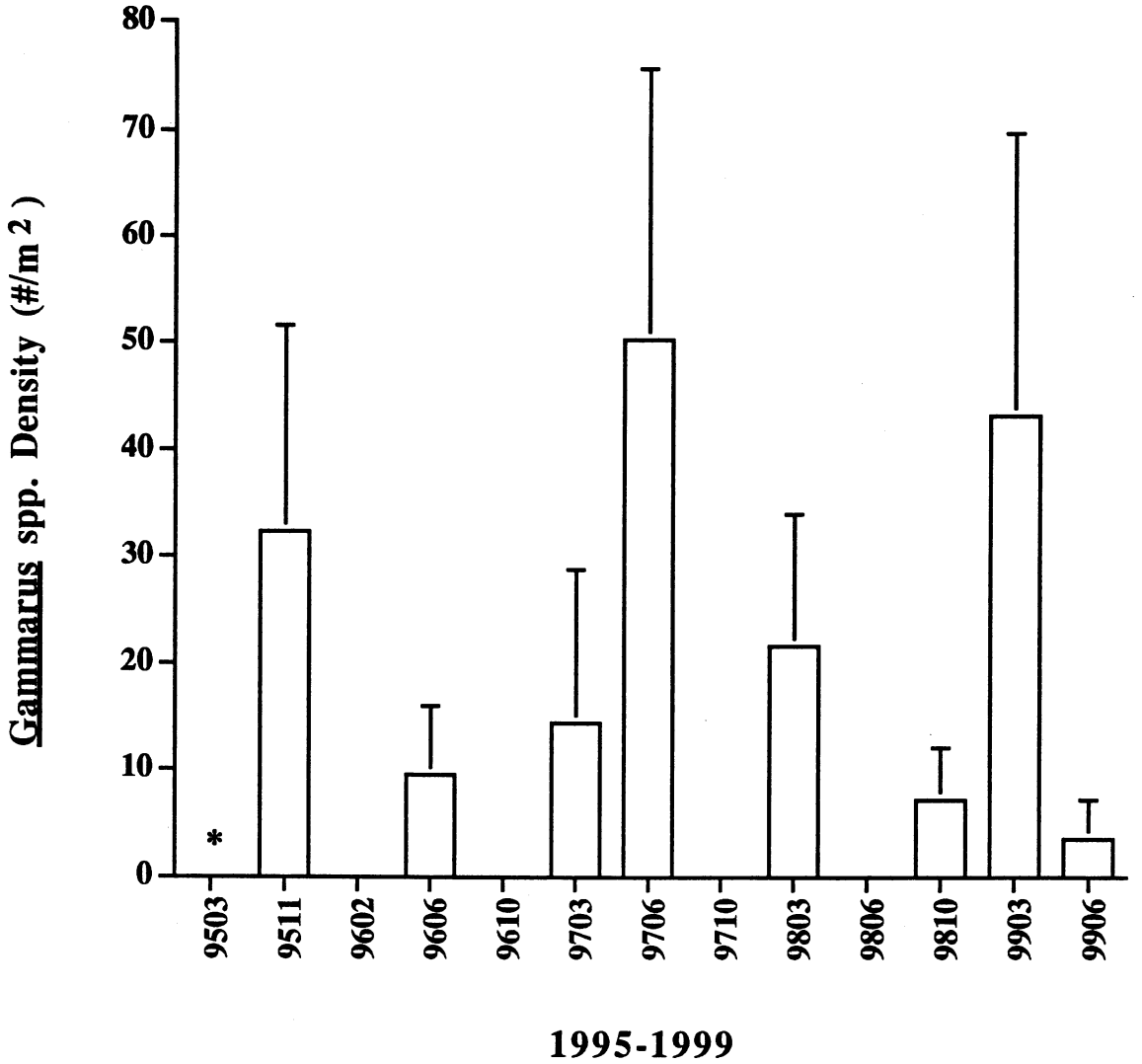

Figure 148. Gammarus spp. densities (#/m^2) collected at Two-Mile pool Rkm 3.1 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 1041/m^2 (± 1041 SE).

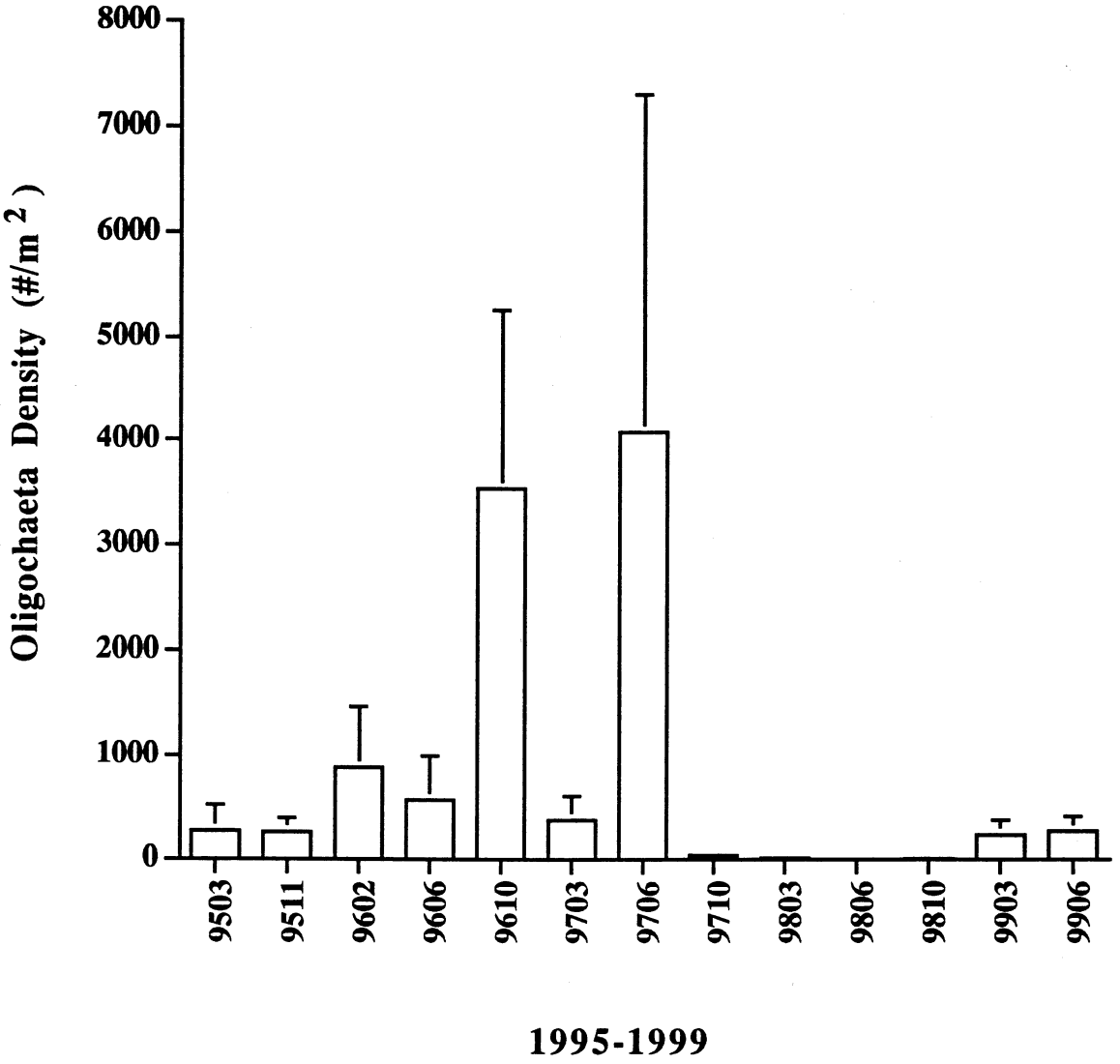

Figure 149. Oligochaeta densities (#/m^2) collected at Two-Mile pool Rkm 3.1 pool Rkm 0.0 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12).

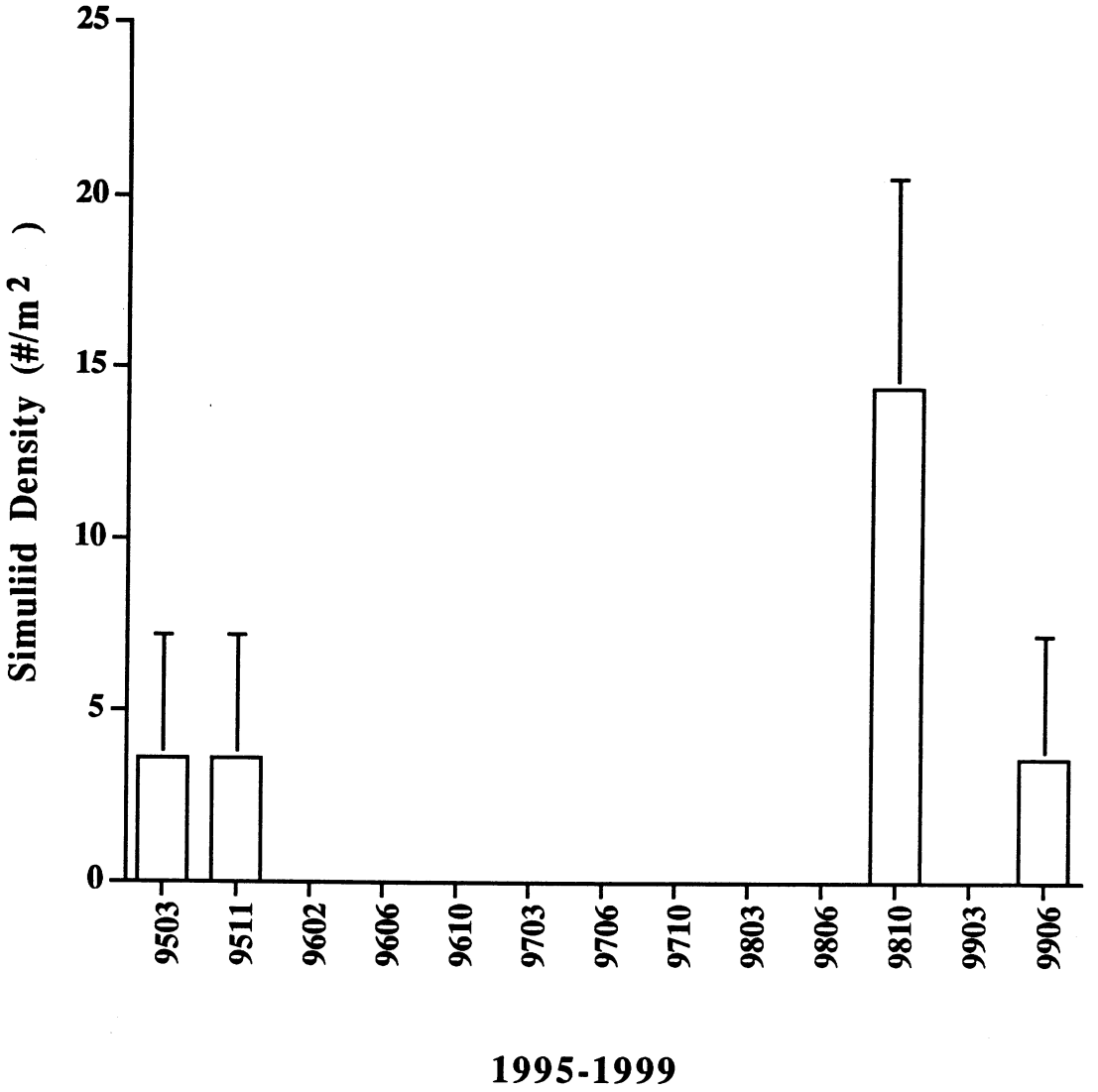

Figure 150. Simuliid densities (#/m^2) collected at Two-Mile pool Rkm 3.1 pool from March 1995 to June 1999. Error bars represent (± 1 SE, n=12).

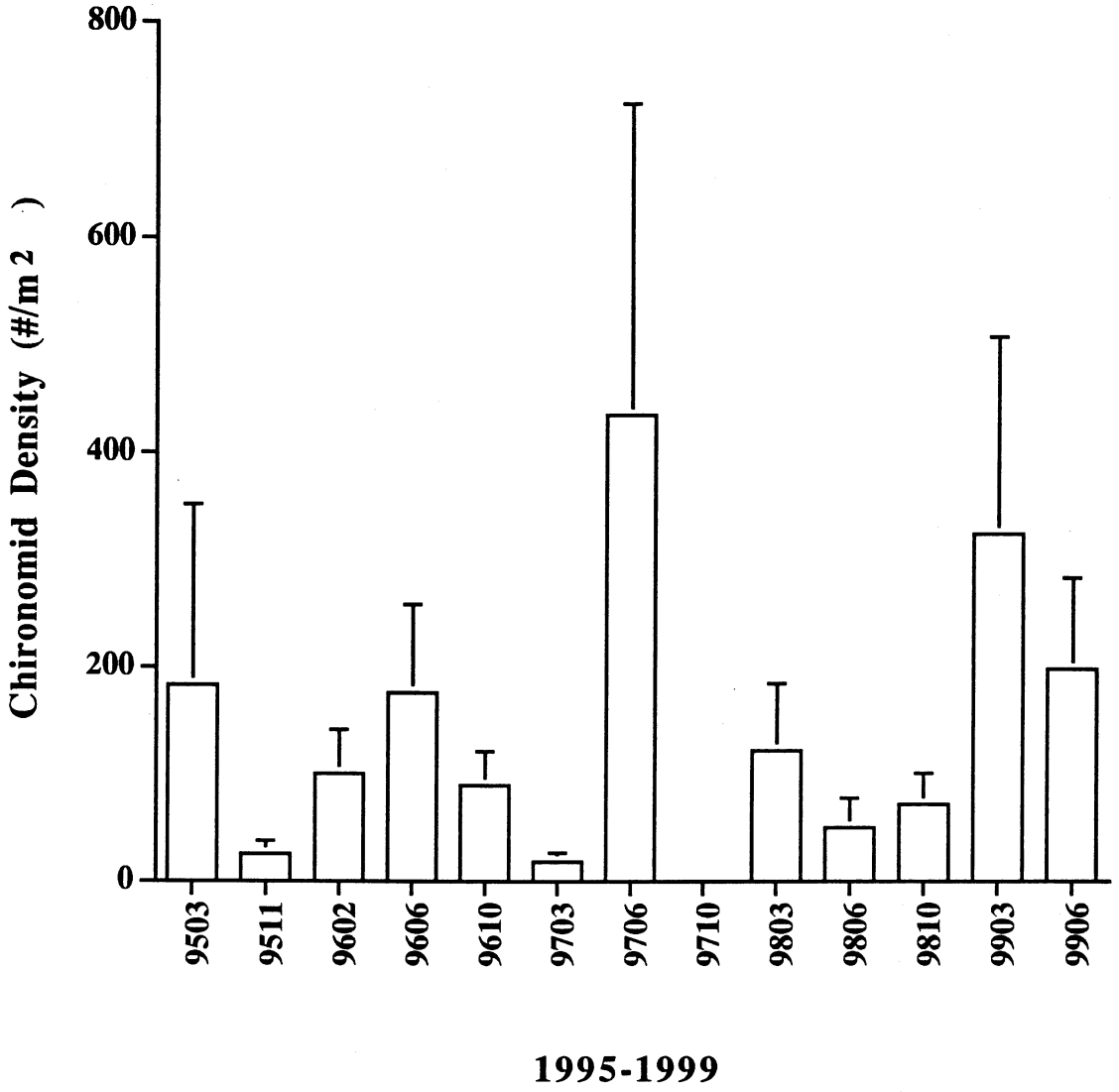

Figure 151. Simuliid densities (#/m^2) collected at Two-Mile pool Rkm 3.1 pool from March 1995 to June 1999. Error bars represent (± 1 SE, n=12).

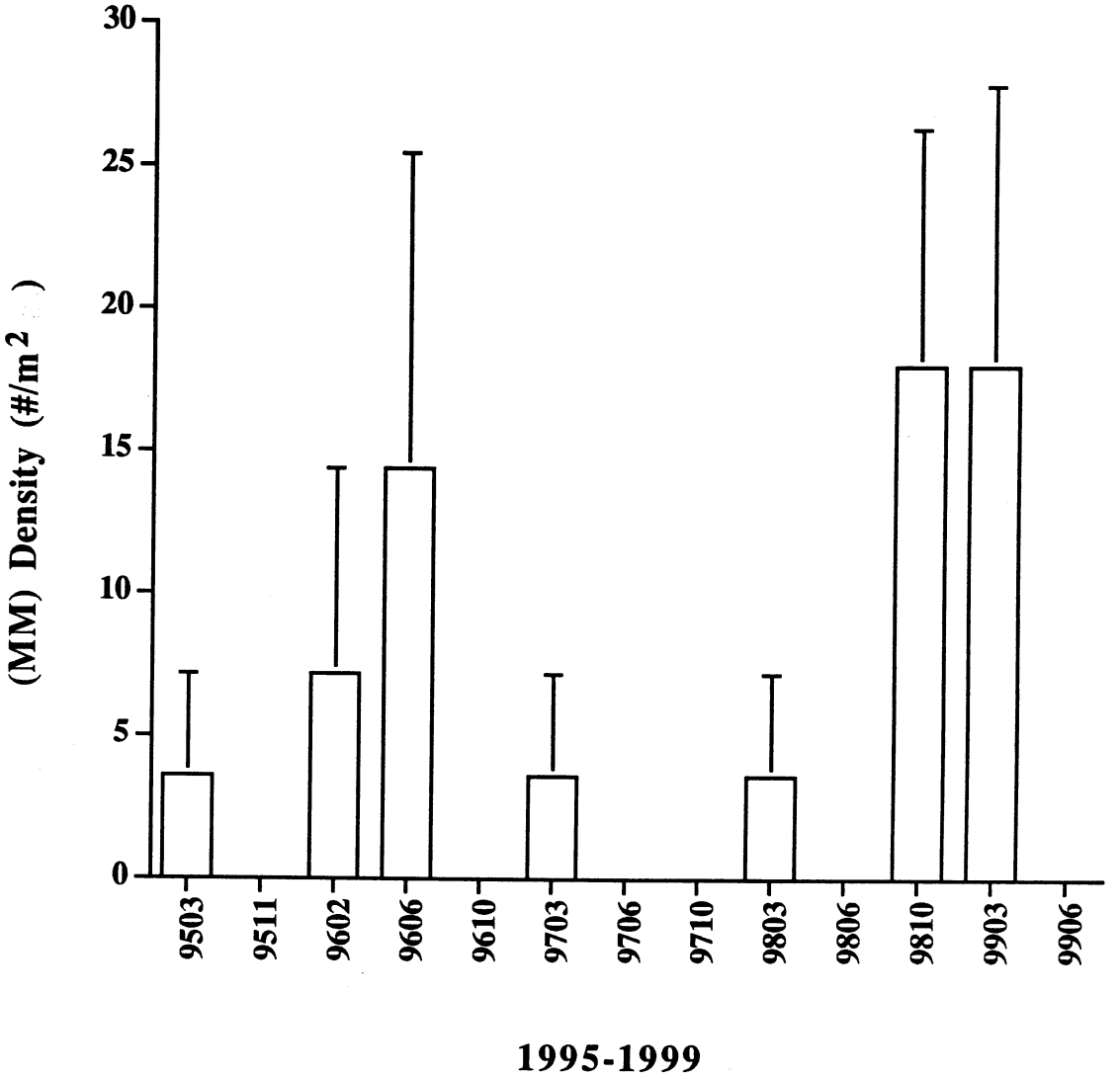

Figure 152. Miscellaneous invertebrate (MM) densities (#/m^2) collected at Two-Mile pool Rkm 3.1 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12).

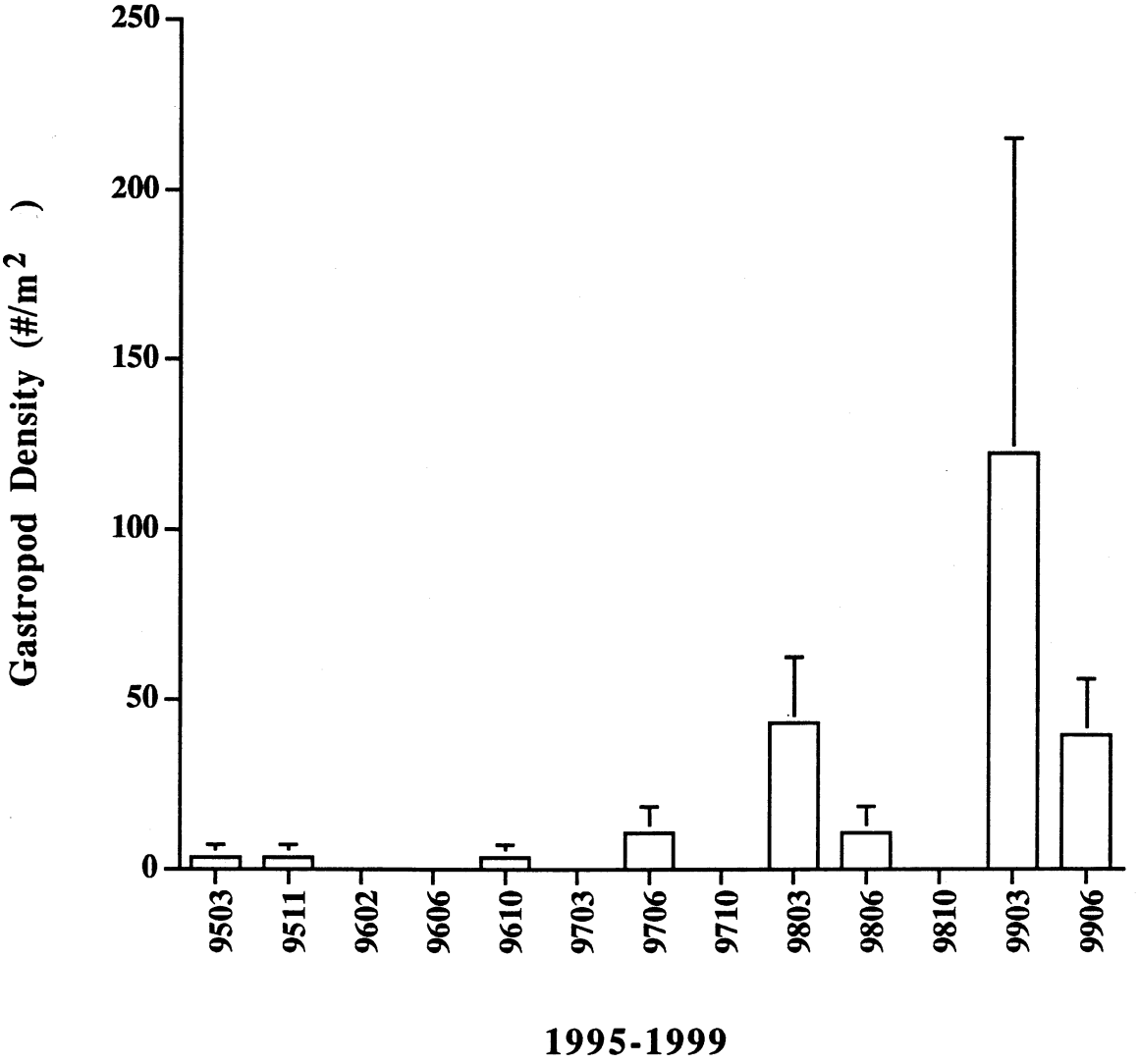

Figure 153. Gastropod densities (#/m^2) collected at Two-Mile pool Rkm 3.1 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12).

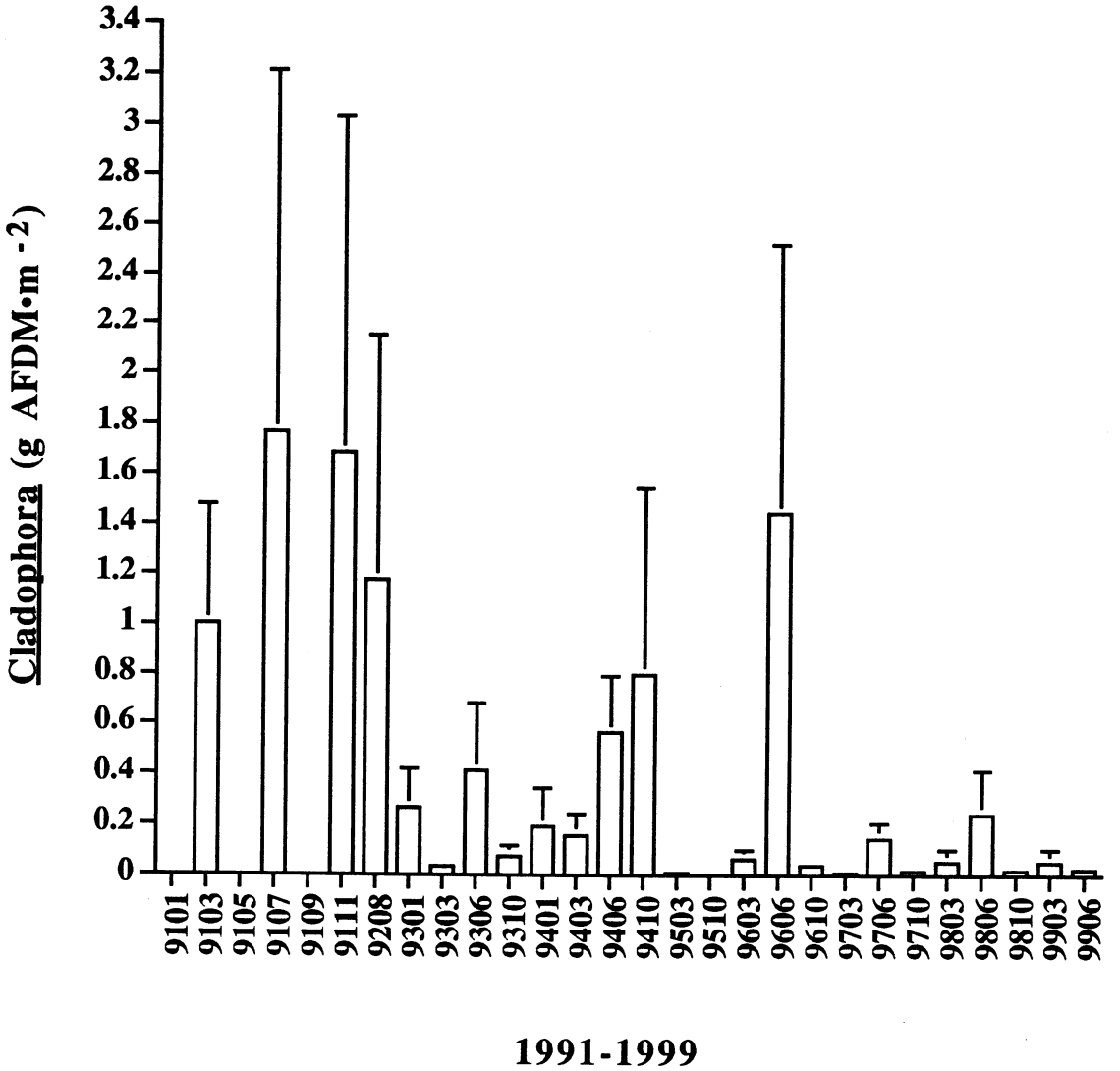

Figure 154. Cladophora biomass estimates (g AFDM•m^{2}) at 60 Mile rapid pool Rkm 95.7 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

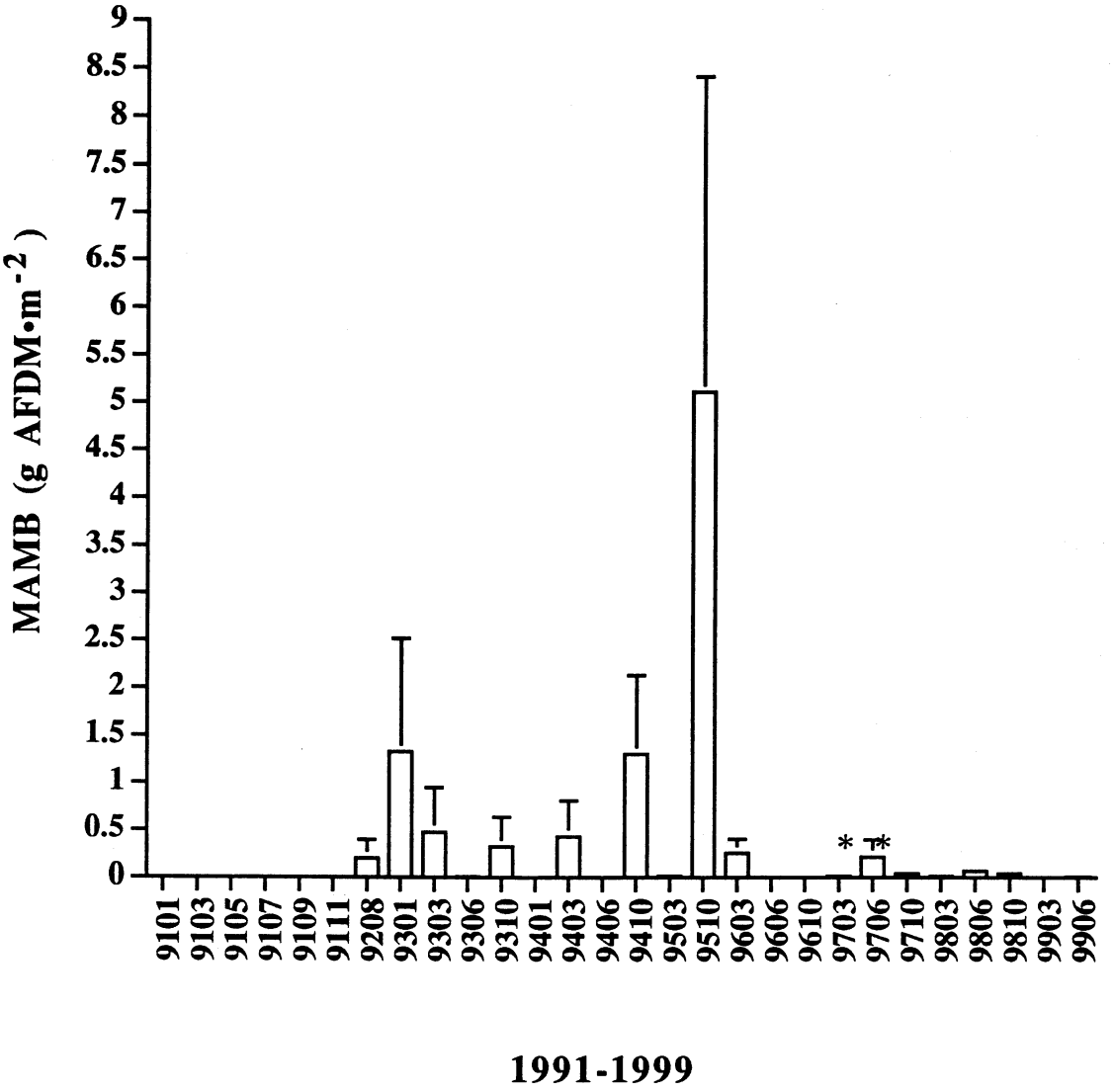

Figure 155. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at 60 Mile rapid pool Rkm 95.7 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=12). Asterisk (*) at 9606 represents 12 g AFDM•m^{-2} (± 10 SE) and at 9610 represents 9 g AFDM•m^{-2} (± 6 SE).

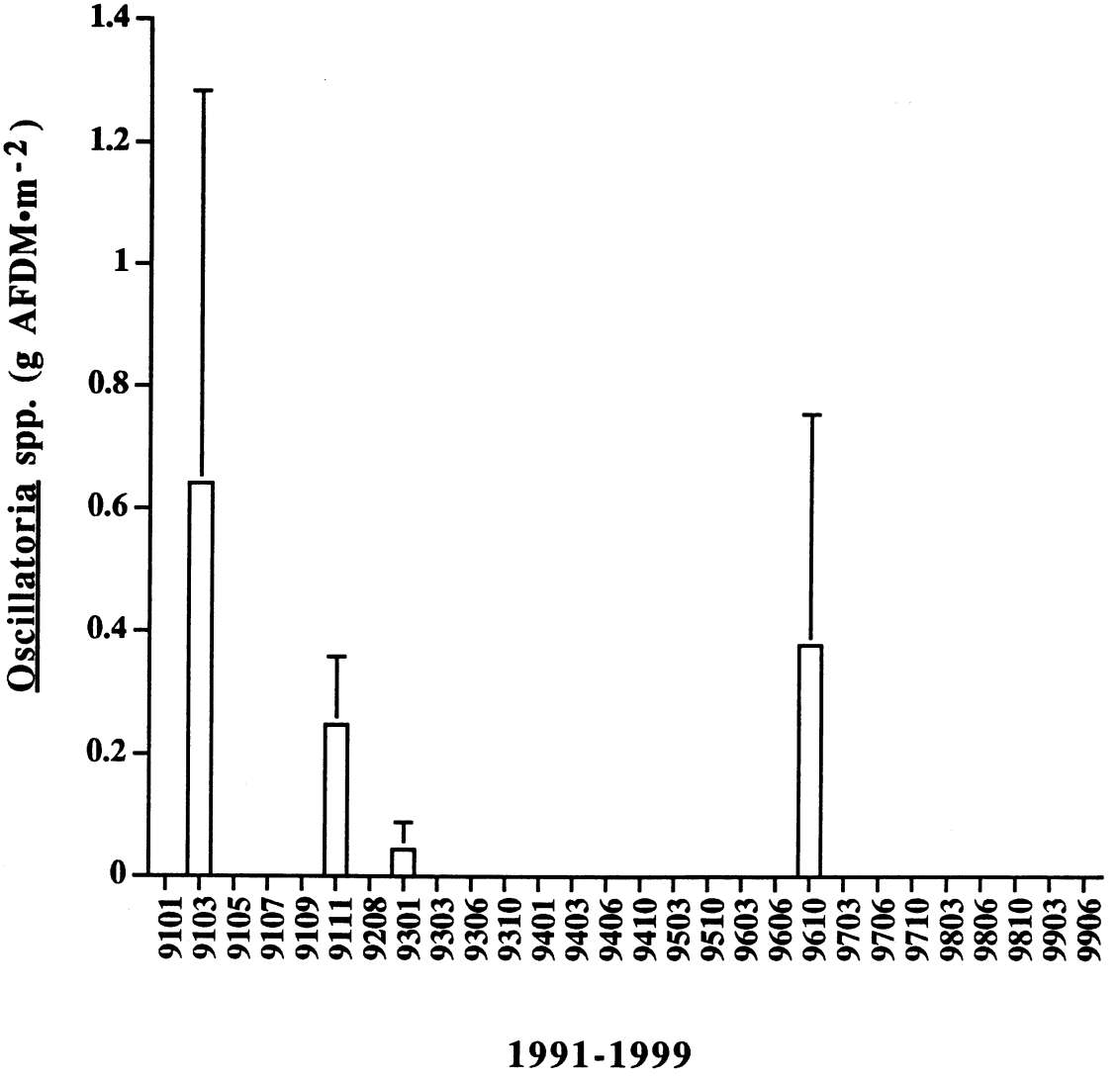

Figure 156. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at 60 Mile rapid pool Rkm 95.7 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

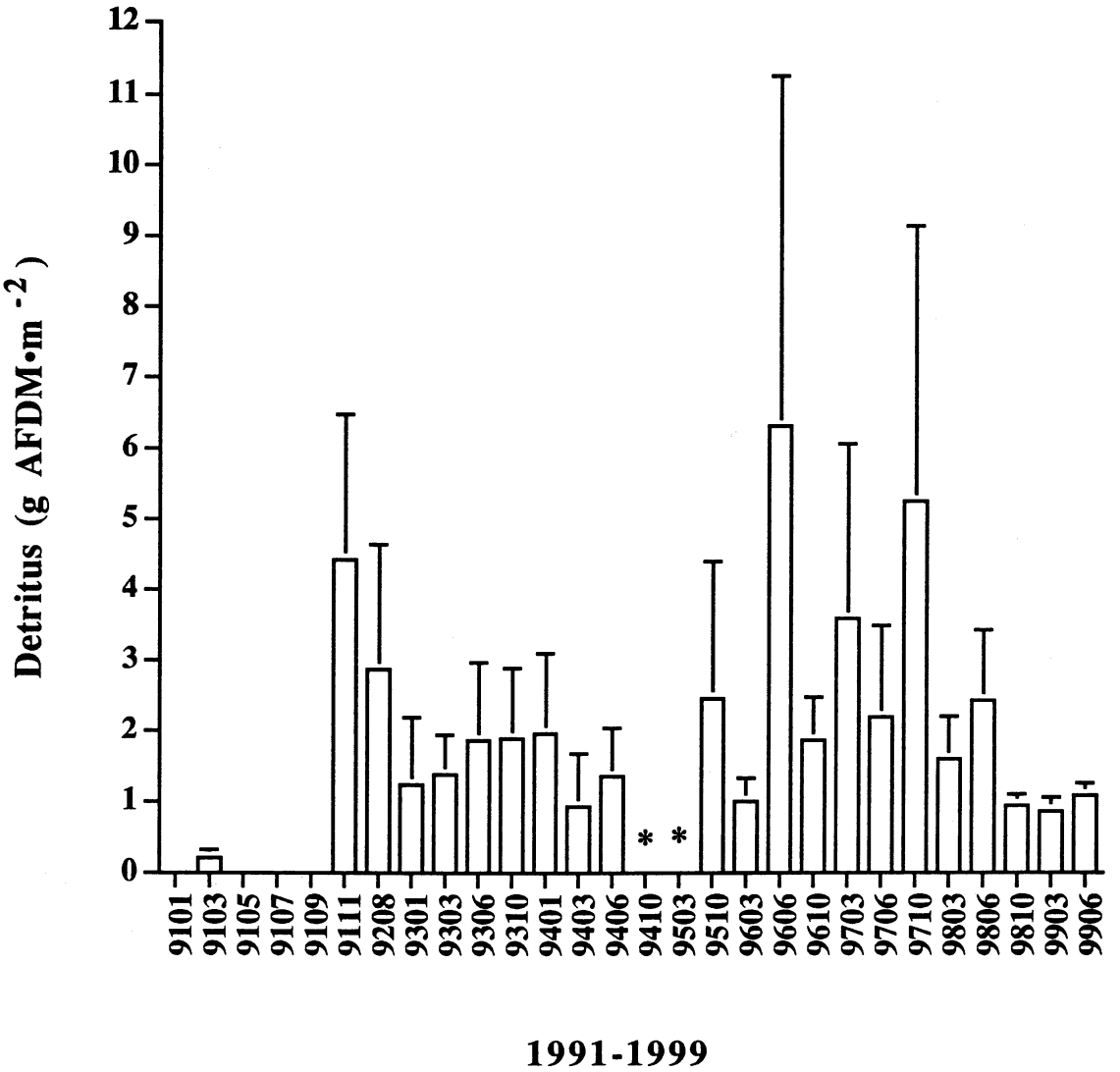

Figure 157. Detritus biomass estimates (g AFDM•m^{-2}) at 60 Mile rapid pool Rkm 95.7 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) at 9410 represents 19 g AFDM•m^{-2} (± 14 SE) and at 9503 represents 49 g AFDM•m^{-2} (± 41 SE).

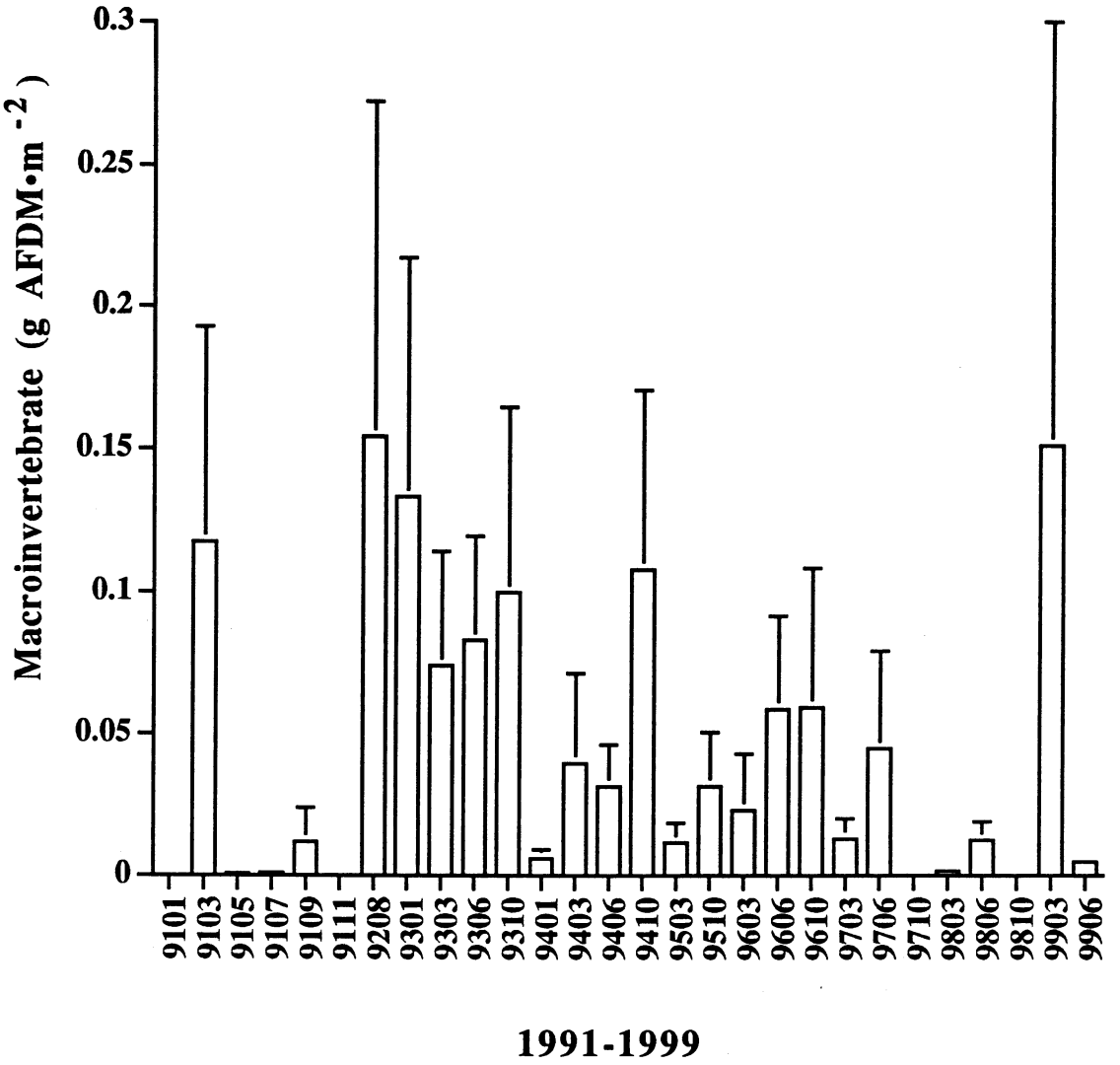

Figure 158. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at 60 Mile rapid pool Rkm 95.7 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

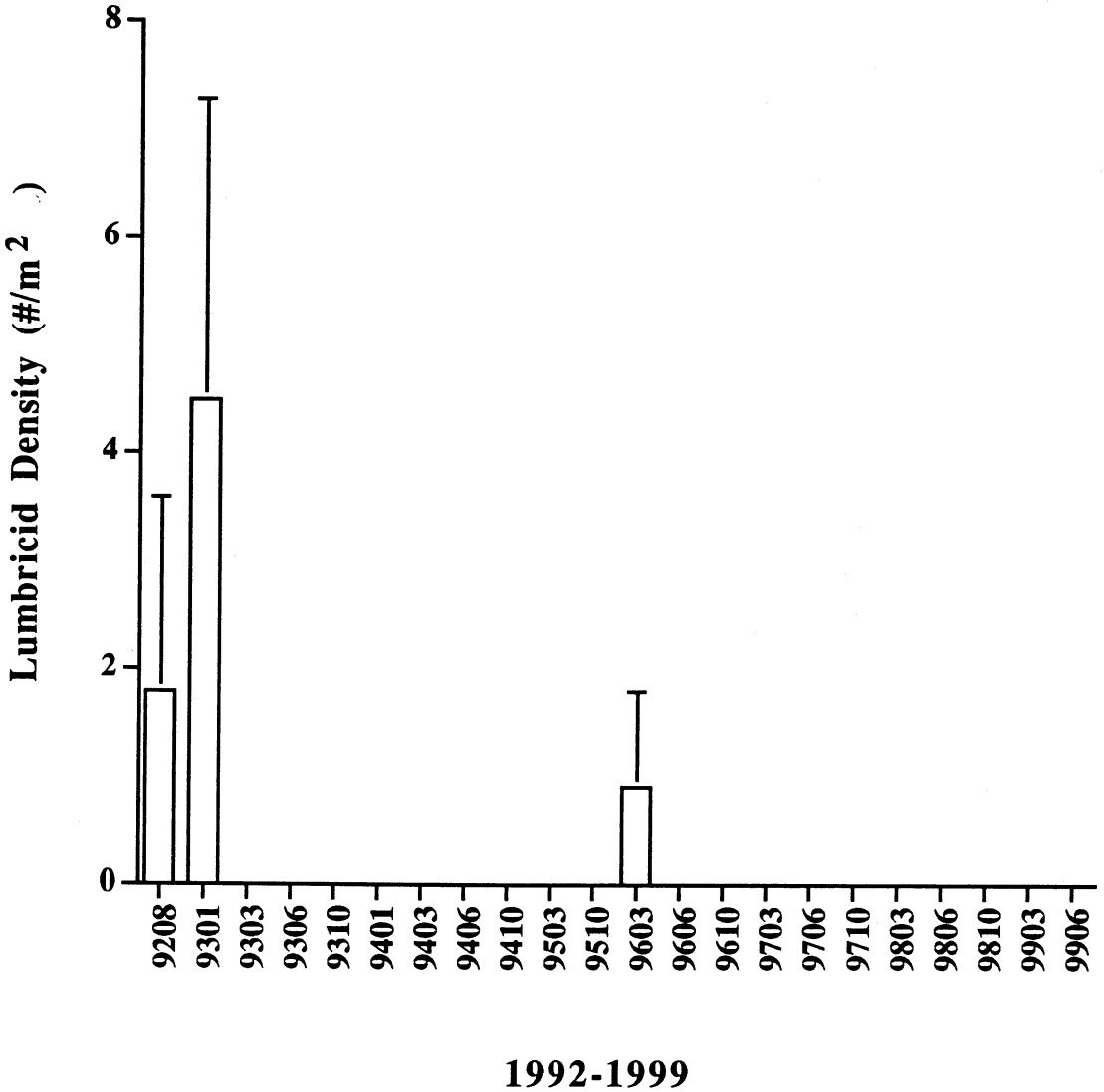

Figure 159. Lumbricid densities (#/m^2) collected at 60 Mile rapid Rkm 95.7 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

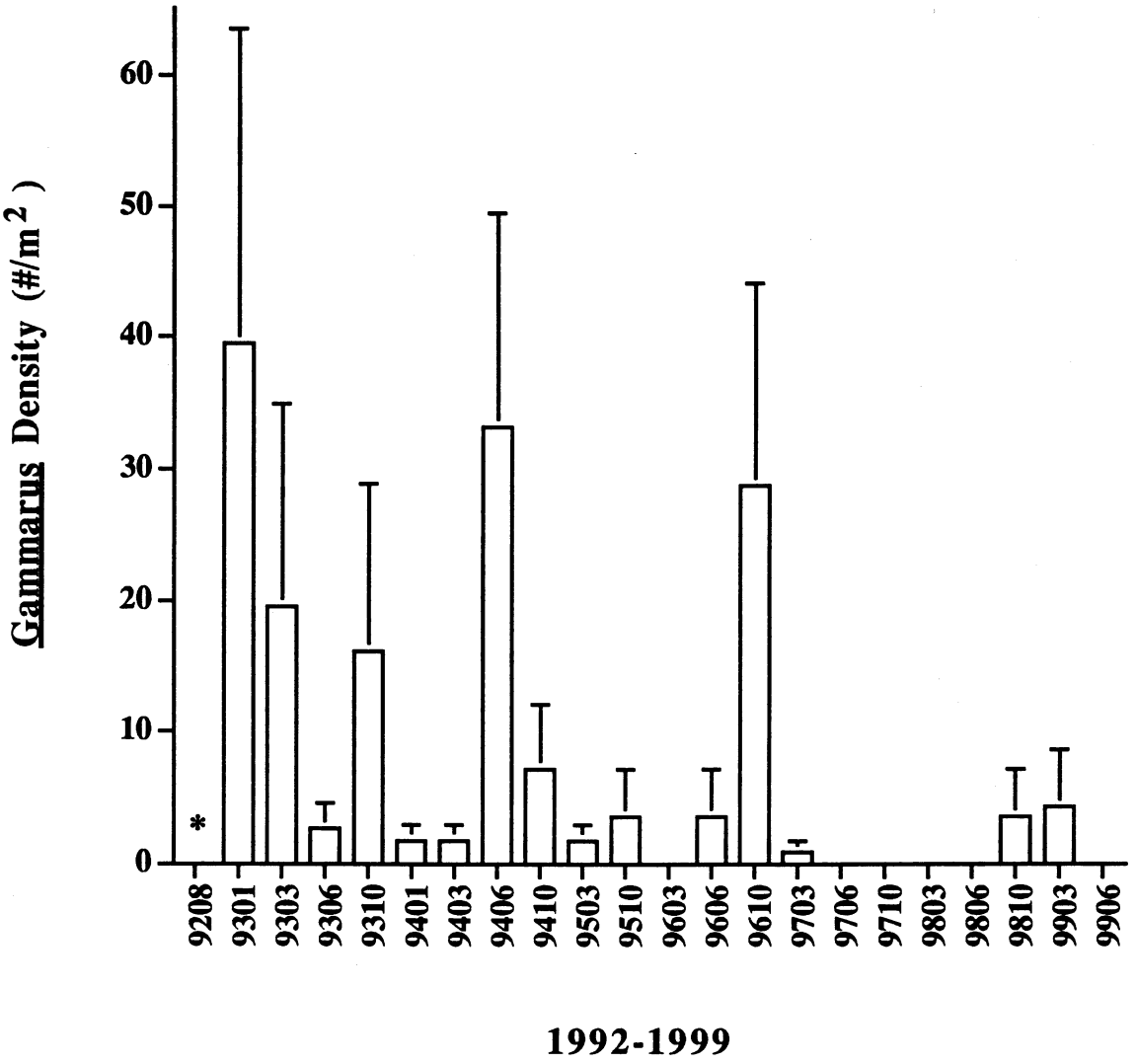

Figure 160. Gammarus spp. densities (#/m^2) collected at 60 Mile rapid Rkm 95.7 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 219/m^2 (± 189 SE).

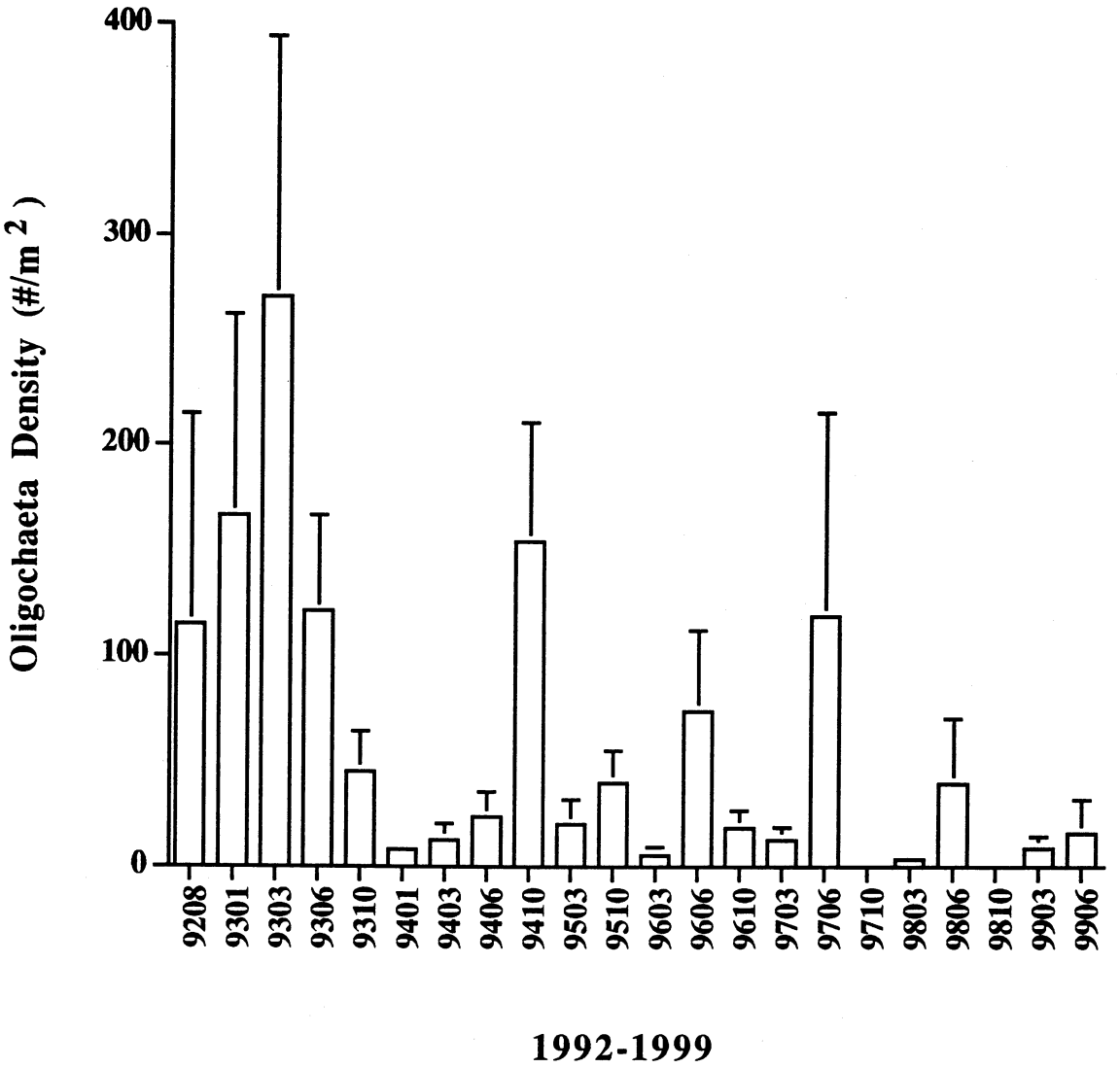

Figure 161. Oligochaeta densities (#/m^2) collected at 60 Mile rapid Rkm 95.7 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

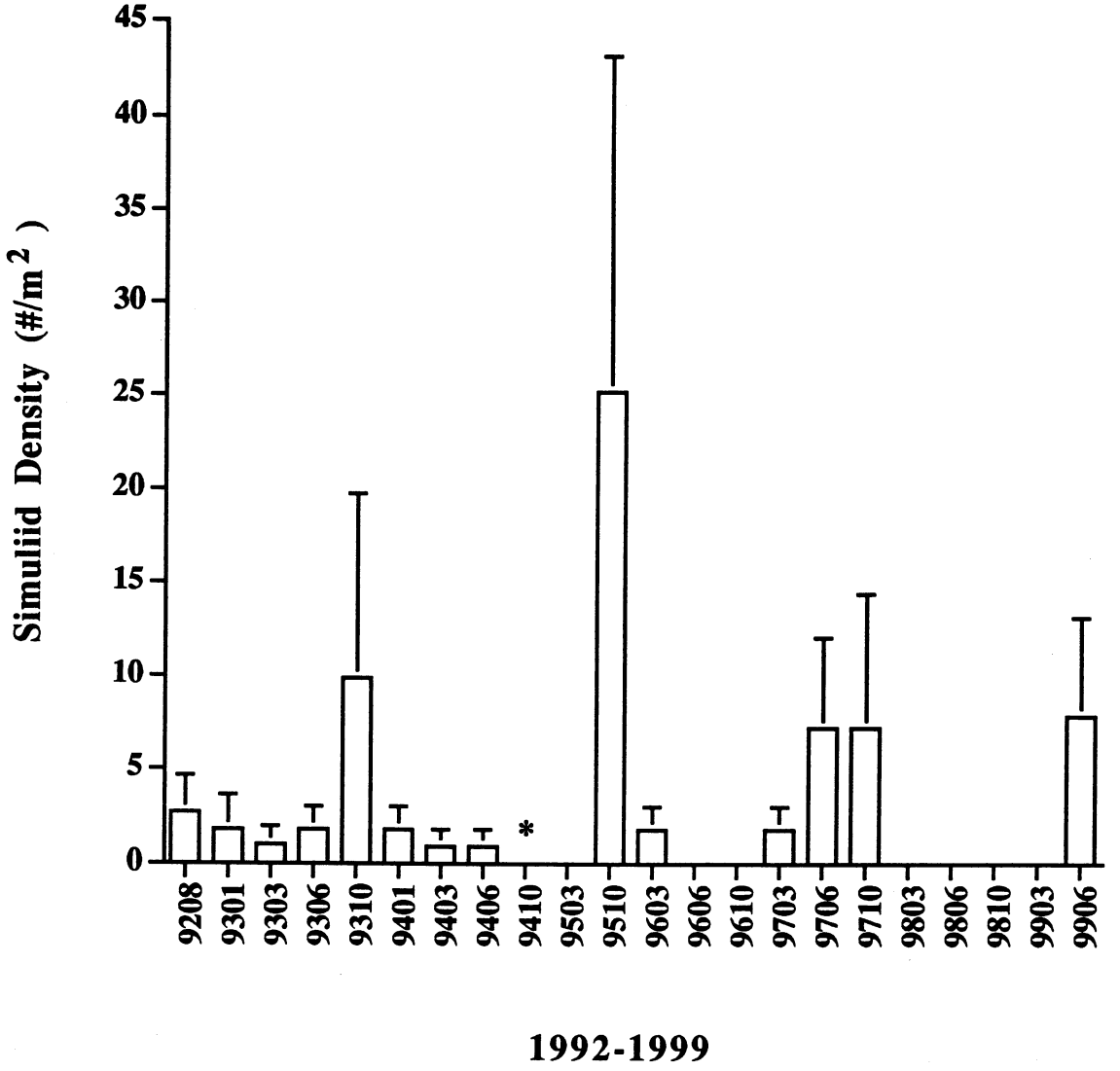

Figure 162. Simuliid densities (#/m^2) collected at 60 Mile rapid Rkm 95.7 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 64/m^2 (± 50 SE).

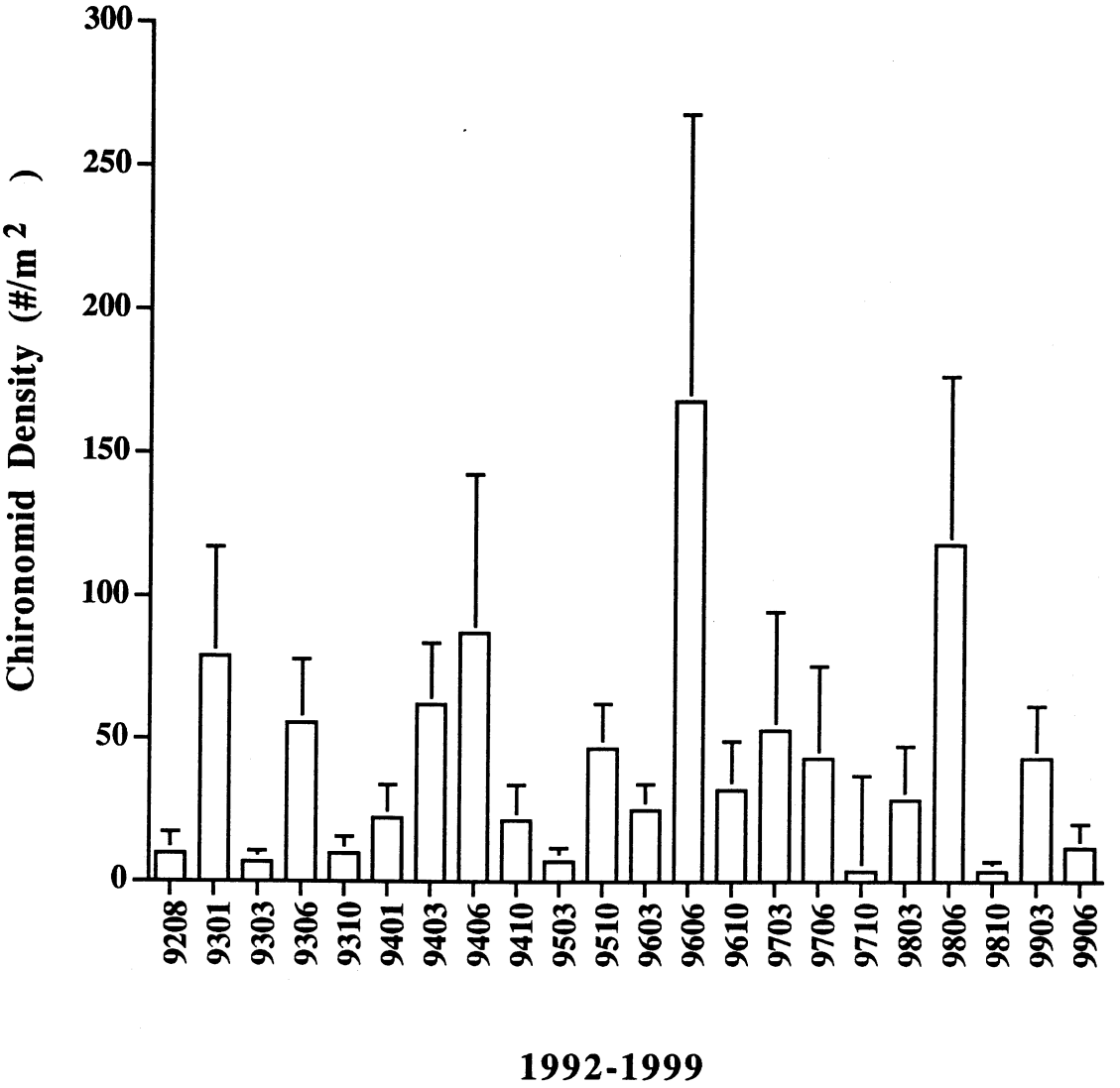

Figure 163. Chironomid densities (#/m^2) collected at 60 Mile rapid Rkm 95.7 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

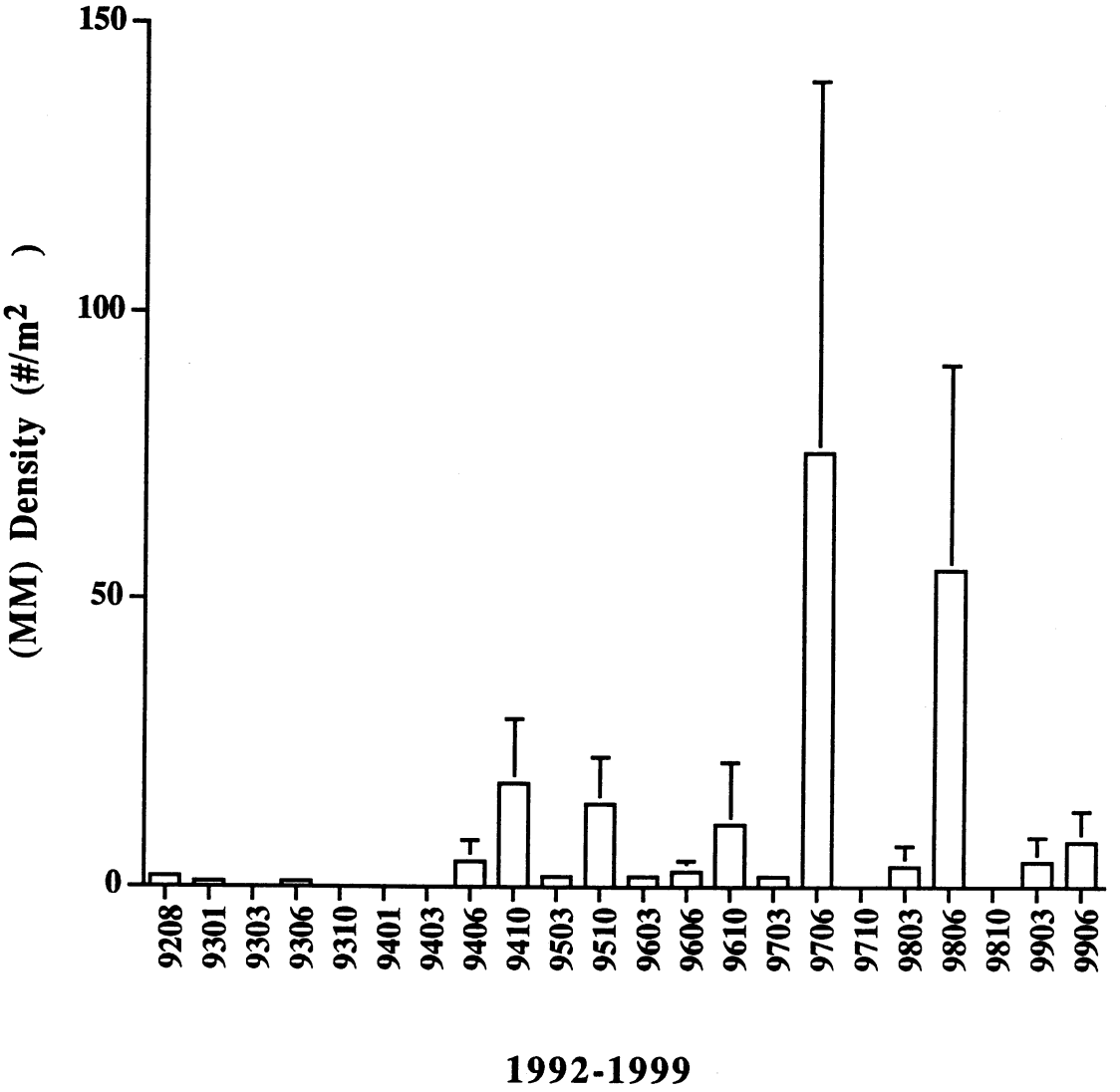

Figure 164. Miscellaneous invertebrate (MM) densities (#/m^2)collected at 60 Mile rapid Rkm 95.7 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

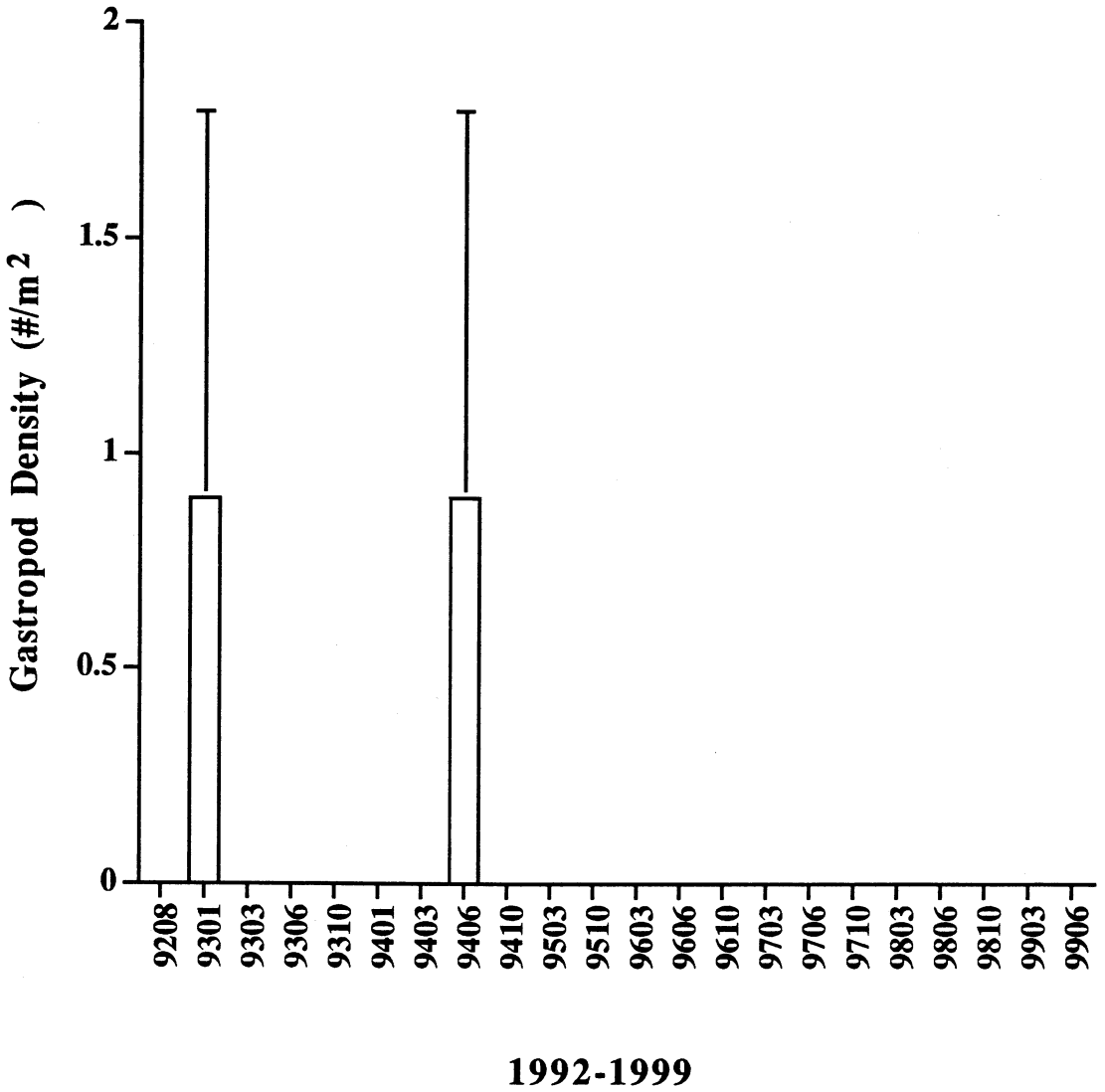

Figure 165. Gastropod densities (#/m^2) collected at 60 Mile rapid Rkm 95.7 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12).

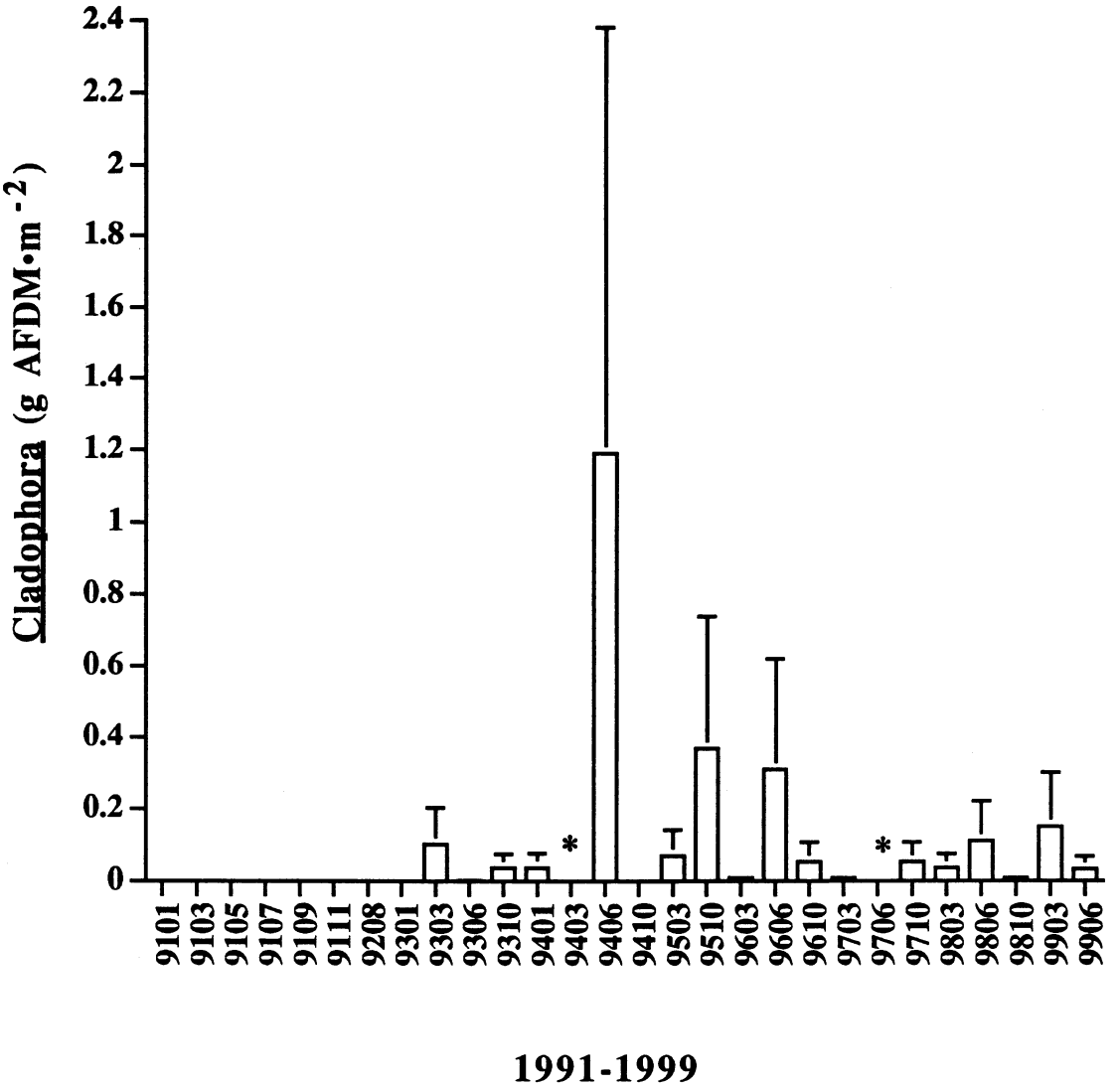

Figure 166. Cladophora biomass estimates (g AFDM•m^{-2}) at Tanner Canyon pool Rkm 108.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) at 9403 represents 5.8 g AFDM•m^{-2} (± 5.8 SE) and at 9706 represents 2 g AFDM•m^{-2} (± 2 SE).

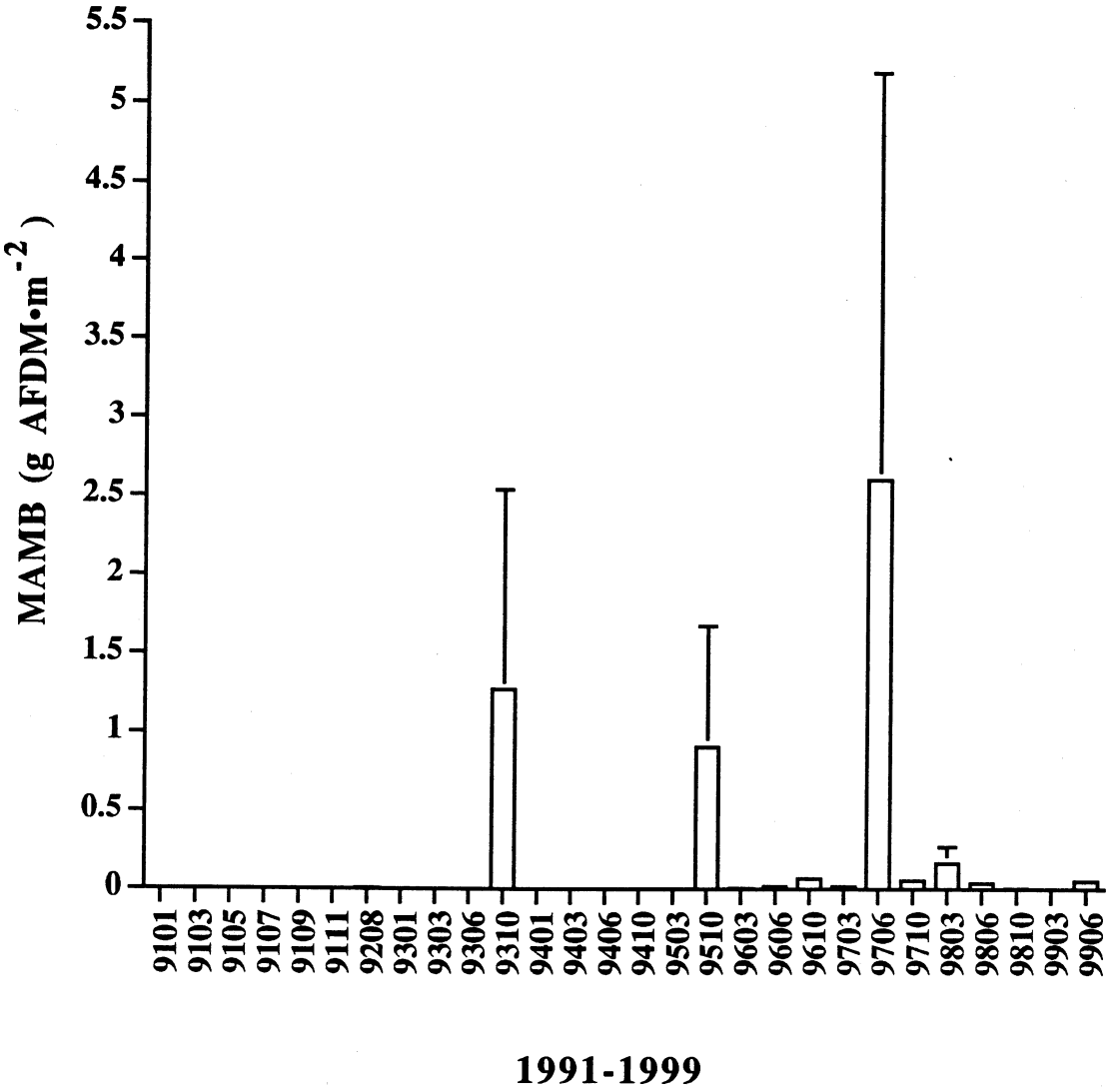

Figure 167. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at Tanner Canyon pool Rkm 108.8 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=12).

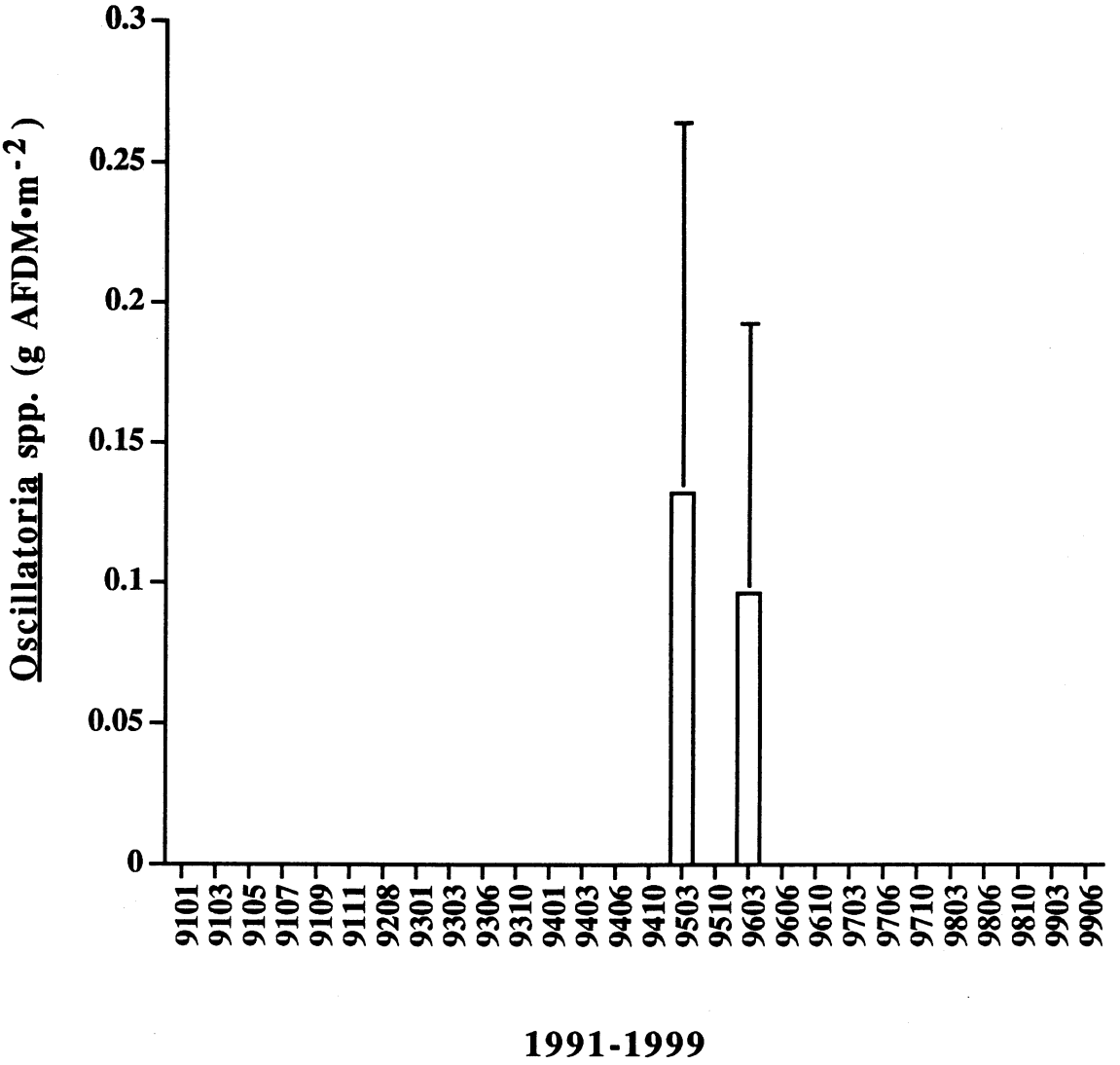

Figure 168. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at Tanner Canyon pool Rkm 108.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

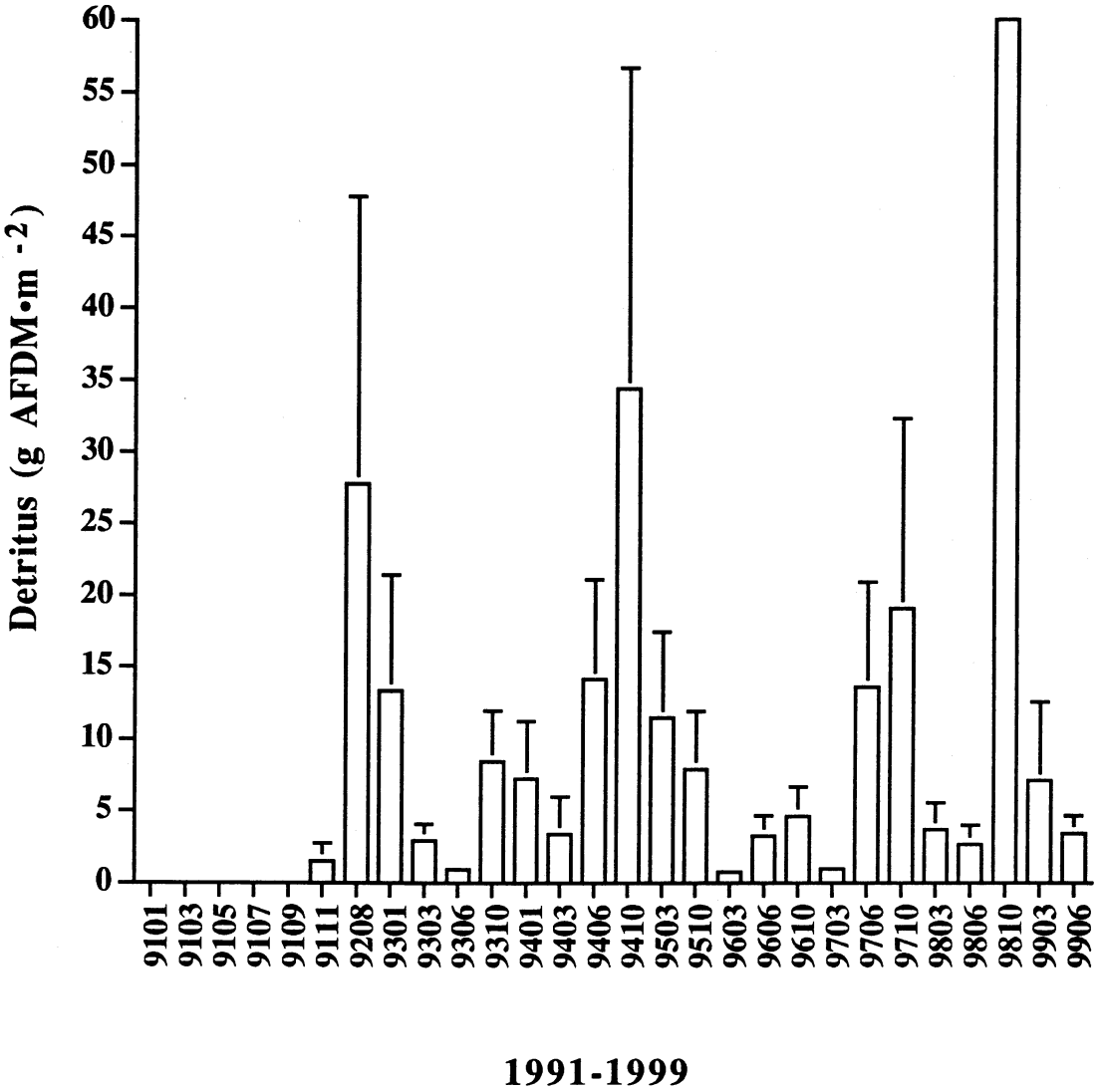

Figure 169. Detritus biomass estimates (g AFDM•m^{-2}) at Tanner Canyon pool Rkm 108.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

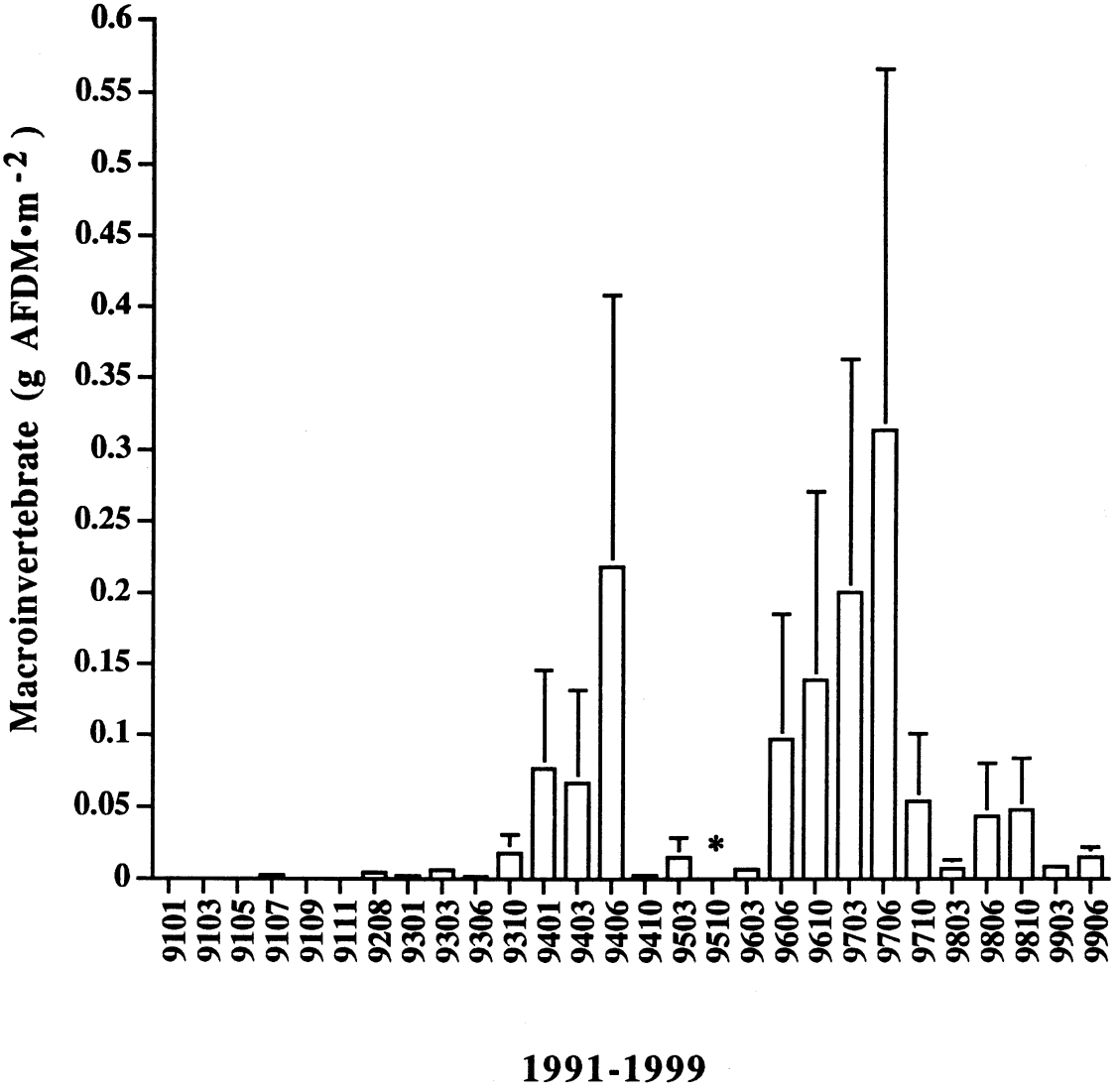

Figure 170. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at Tanner Canyon pool Rkm 108.8 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 0.5 g AFDM•m^{-2} (± 0.5 SE).

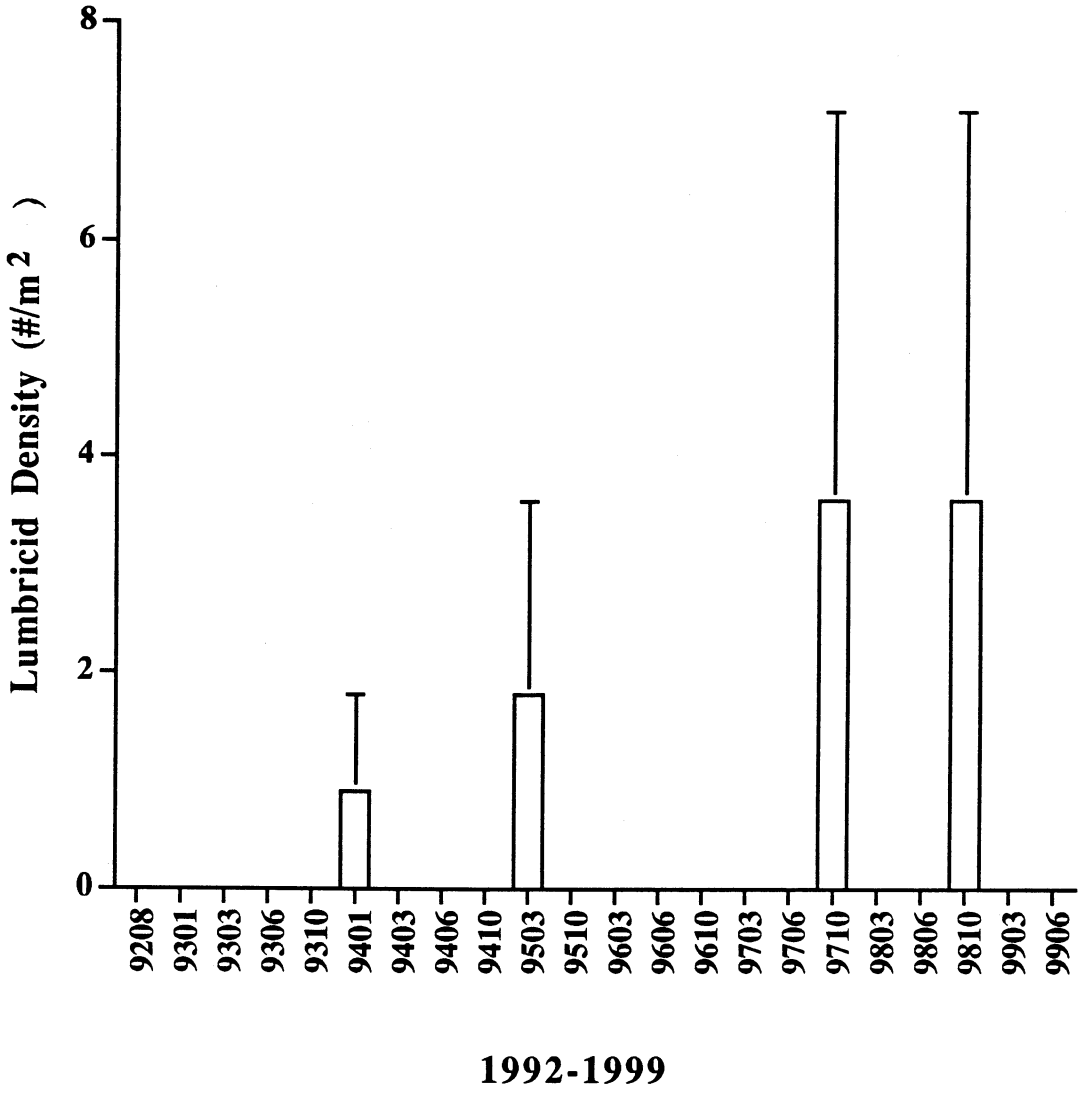

Figure 171. Lumbricid densities (#/m^2) collected at Tanner Canyon pool Rkm 108.8 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

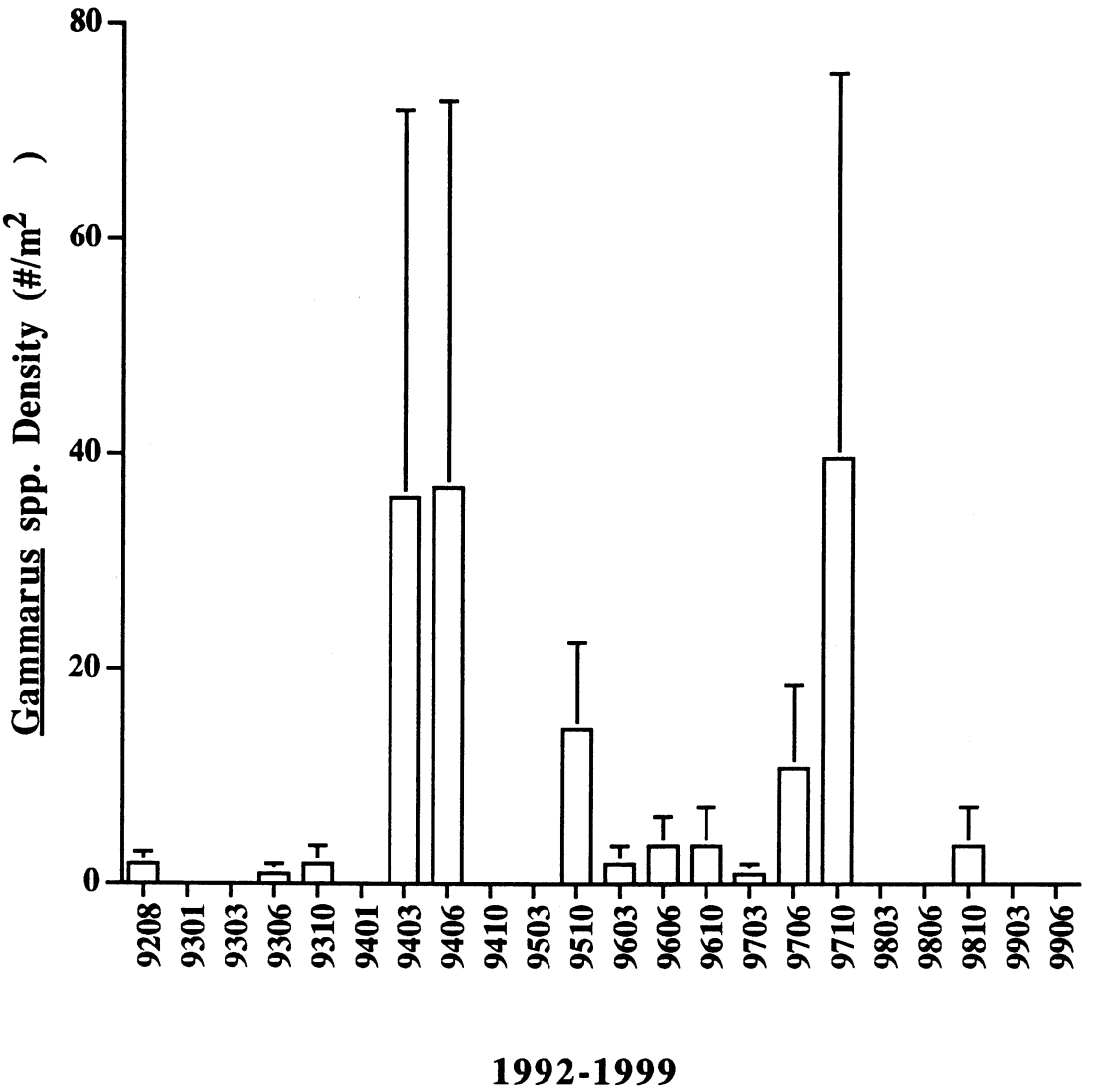

Figure 172. Gammarus spp. densities (#/m^2) collected at Tanner Canyon pool Rkm 108.8 from March 1995 to June 1999. Error bars represent (± 1 SE, n=12).

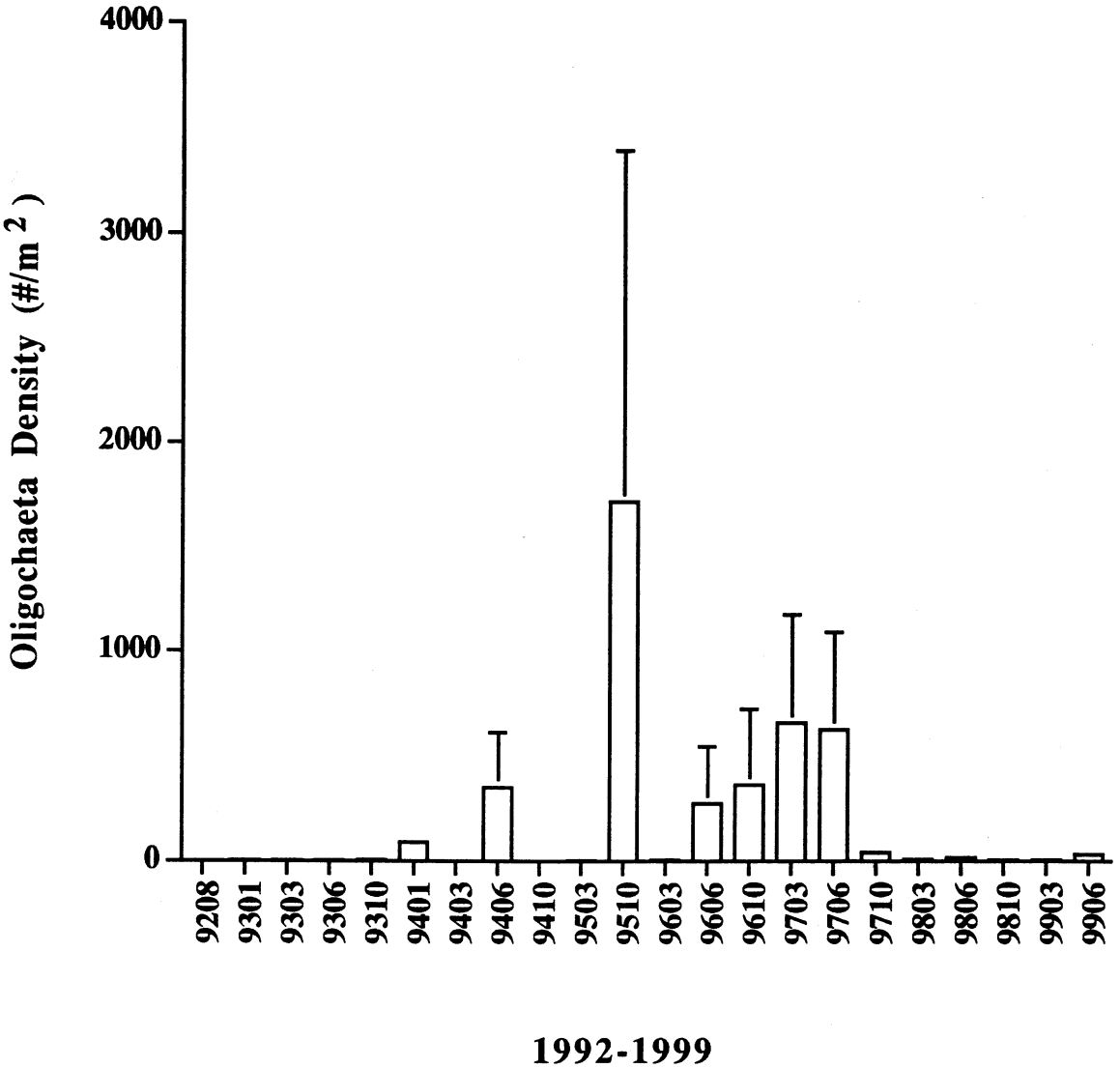

Figure 173. Oligochaeta densities (#/m^2) collected at Tanner Canyon pool Rkm 108.8 from August 1992 to June 1999. Error bars represent ($\pm$ 1 SE, n=12).

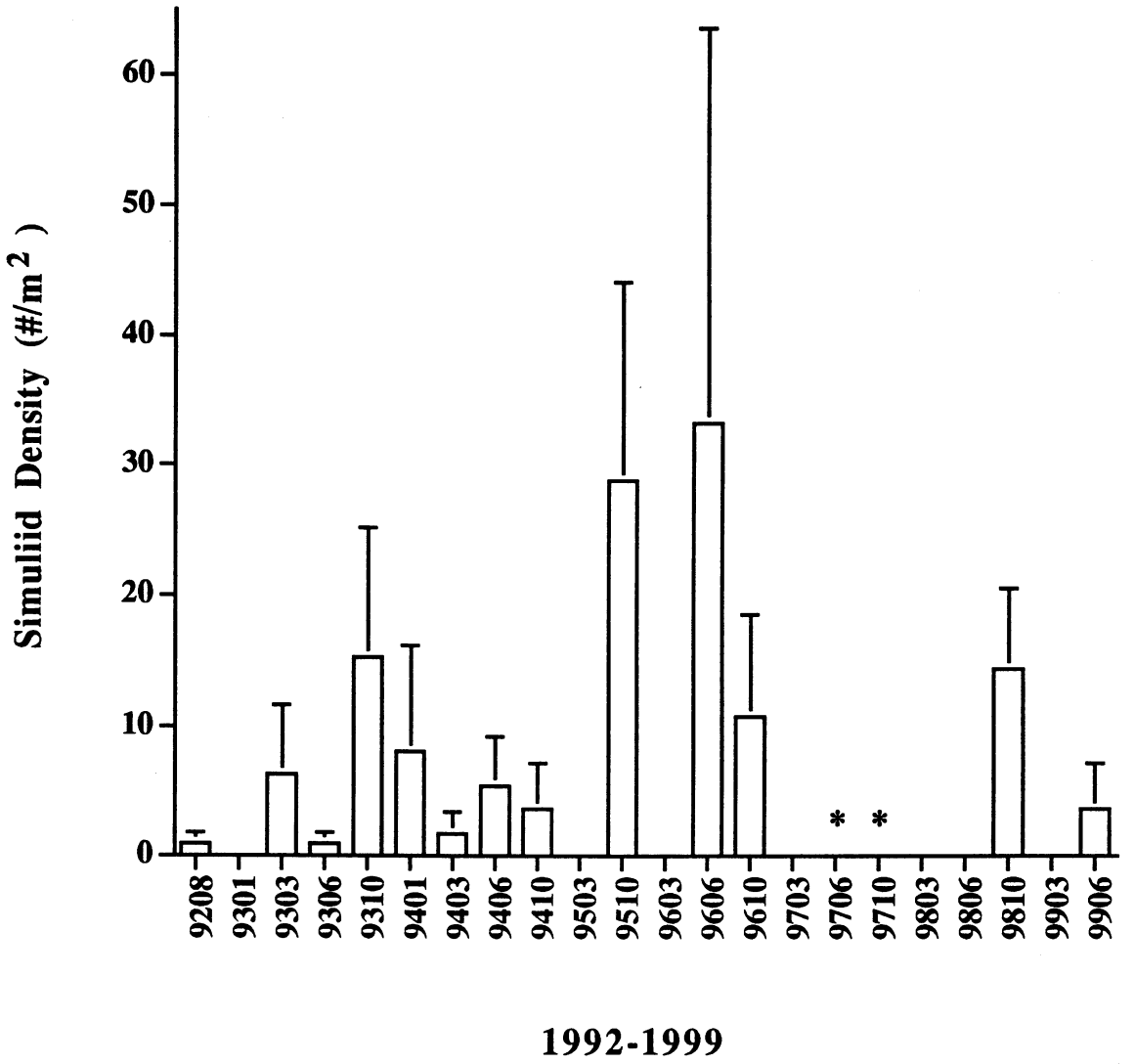

Figure 174. Simuliid densities (#/m^2) collected at Tanner Canyon pool Rkm 108.8 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) at 9706 represents 226/m^2 (± 203 SE) and at 9710 represents 129/m^2 (± 117 SE).

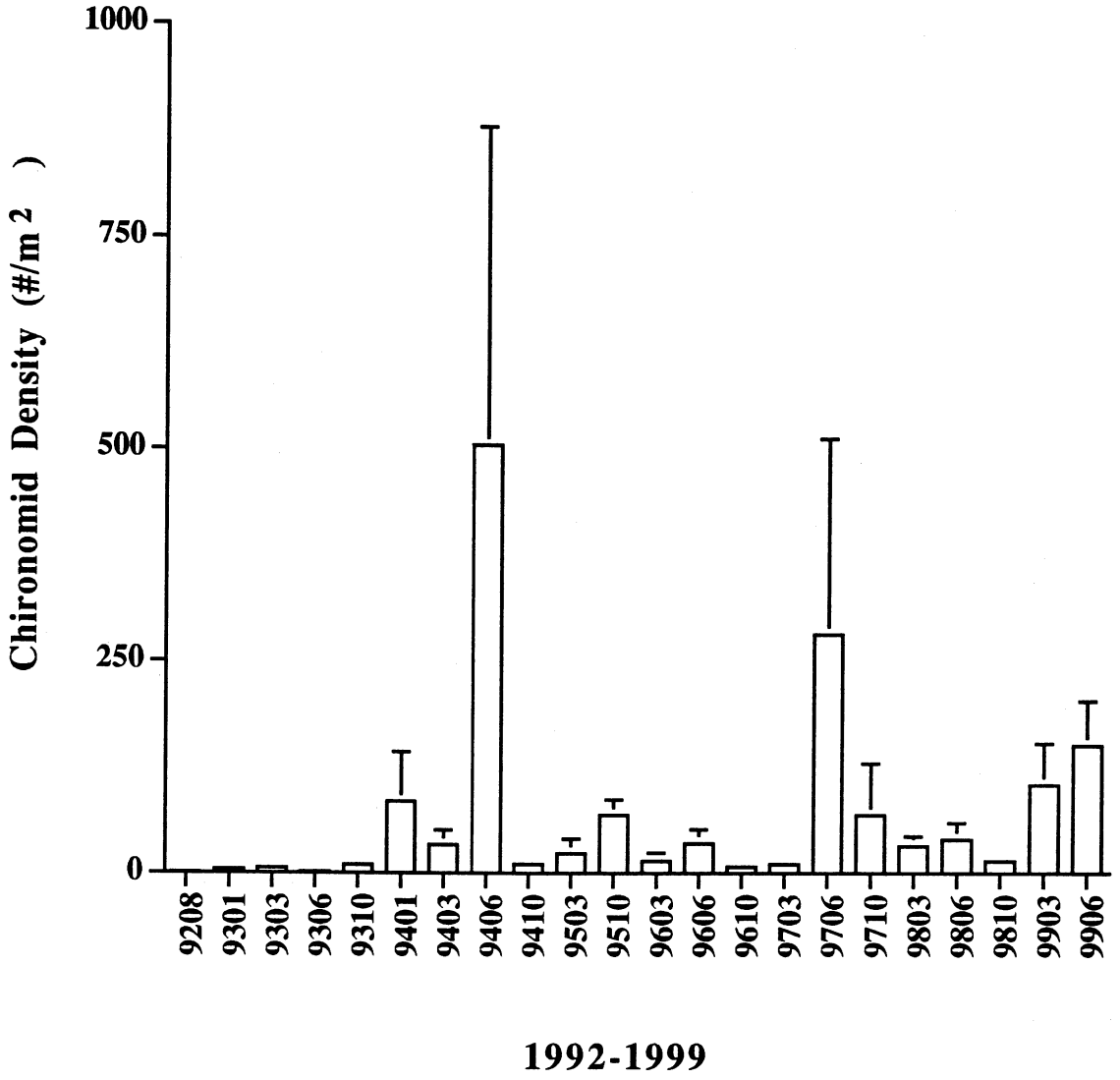

Figure 175. Chironomid densities (#/m^2) collected at Tanner Canyon pool Rkm 108.8 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

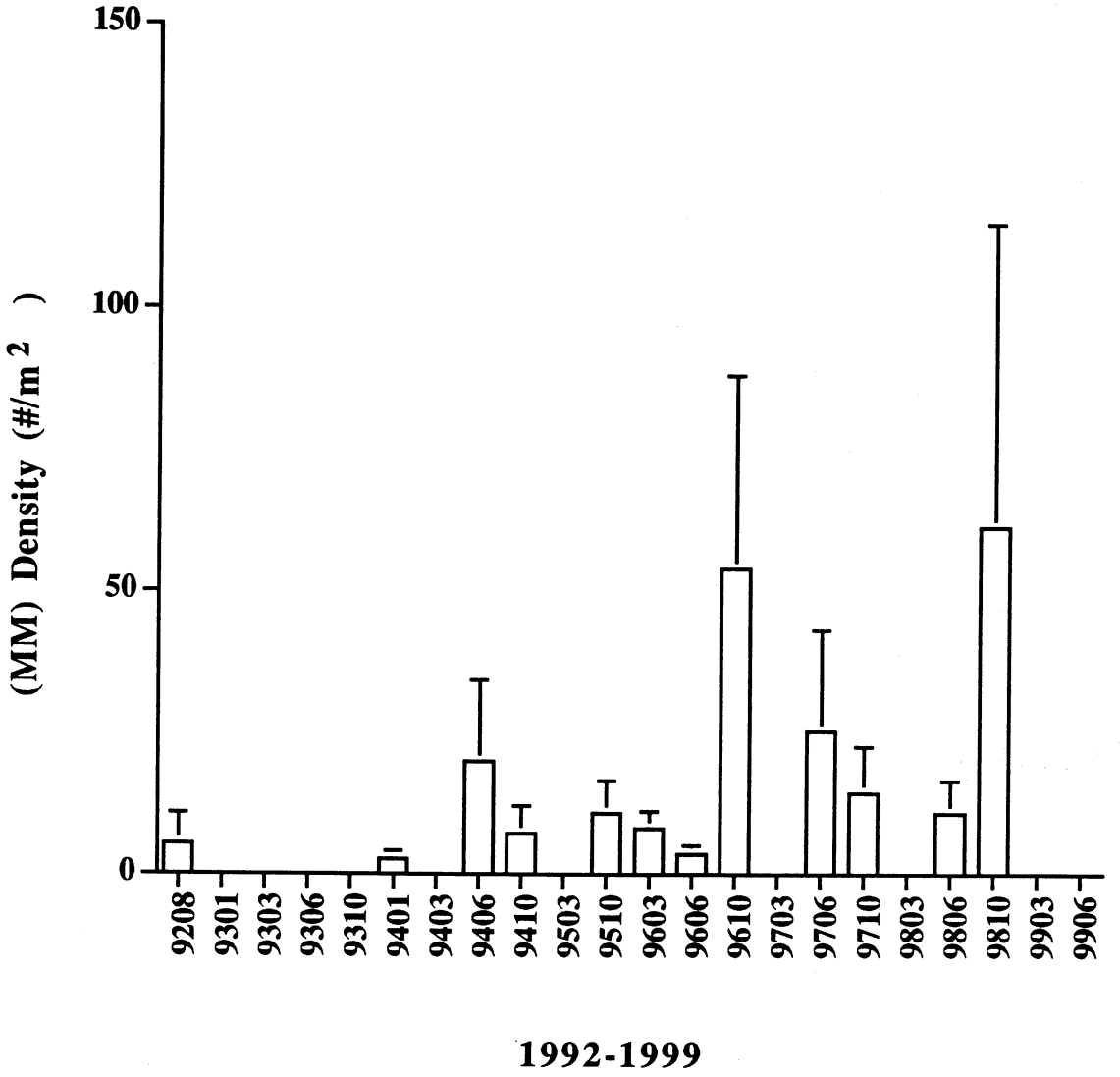

Figure 176. Miscellaneous invertebrate (MM) densities (#/m^2) collected at Tanner Canyon pool Rkm 108.8 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

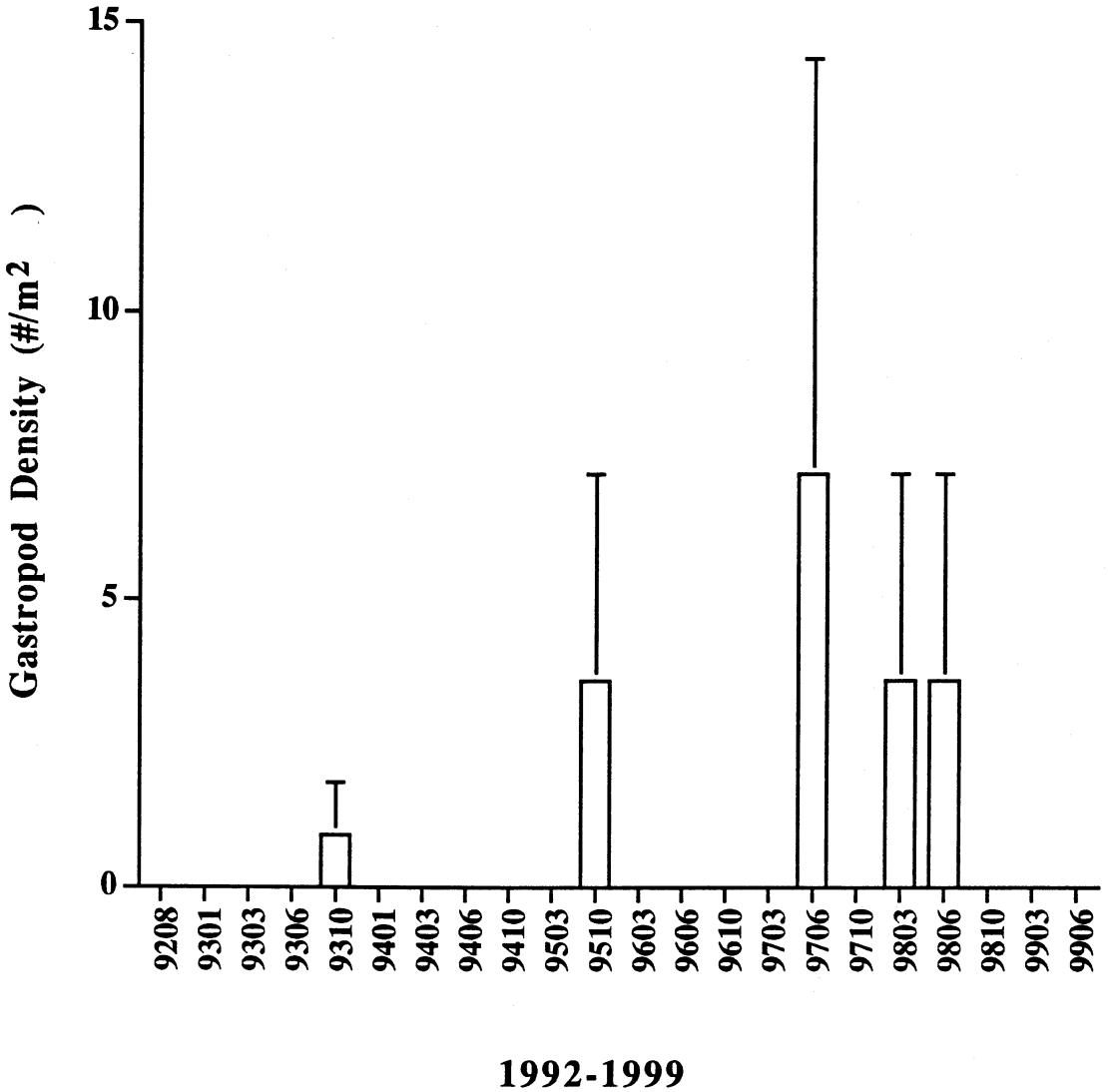

Figure 177. Gastropod densities (#/m^2) collected at Tanner Canyon pool Rkm 108.8 from August 1992 to June 1999. Error bars represent ($\pm$ 1 SE, n=12).

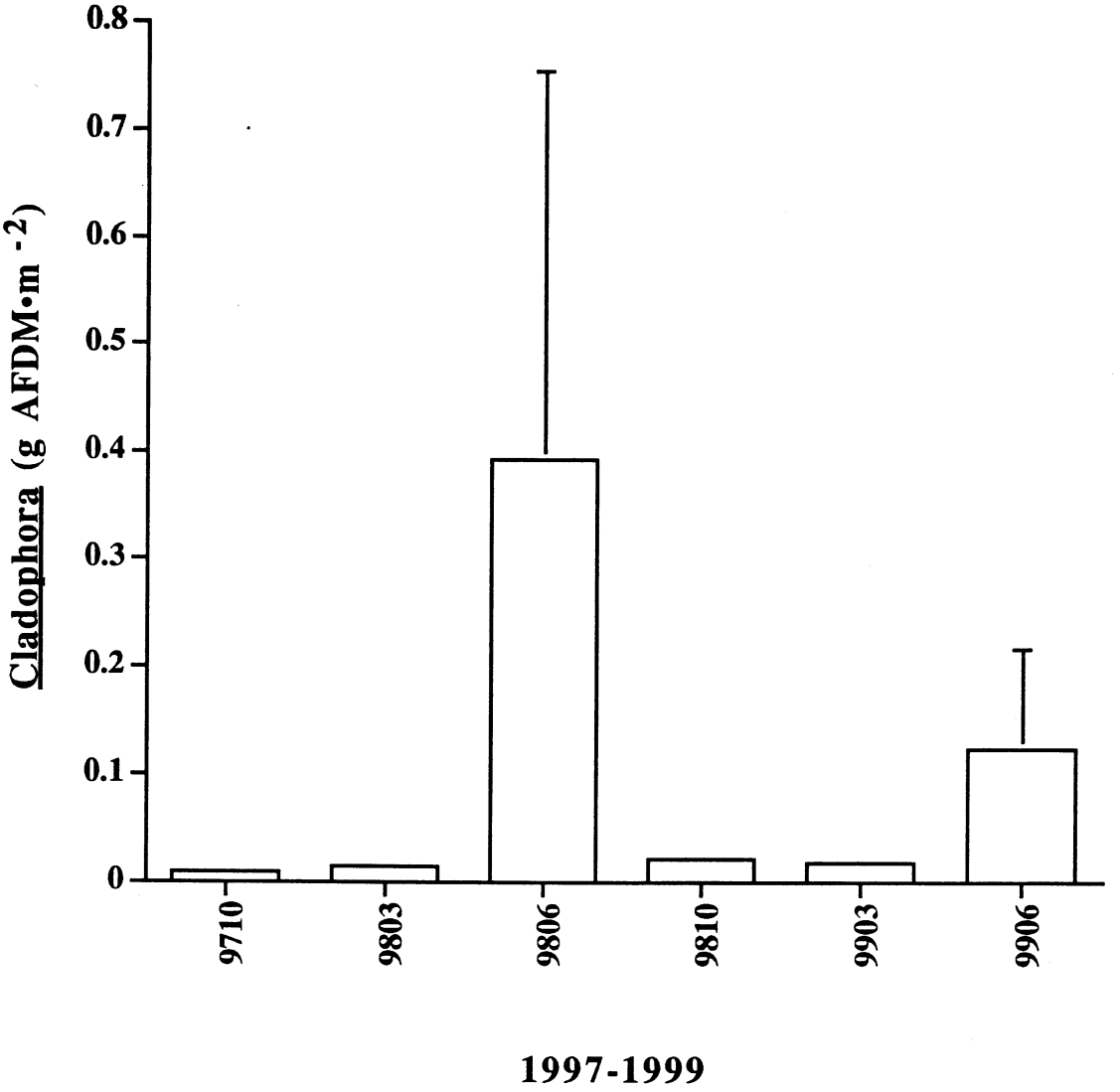

Figure 178. Cladophora biomass estimates (g AFDM•m^{-2}) at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

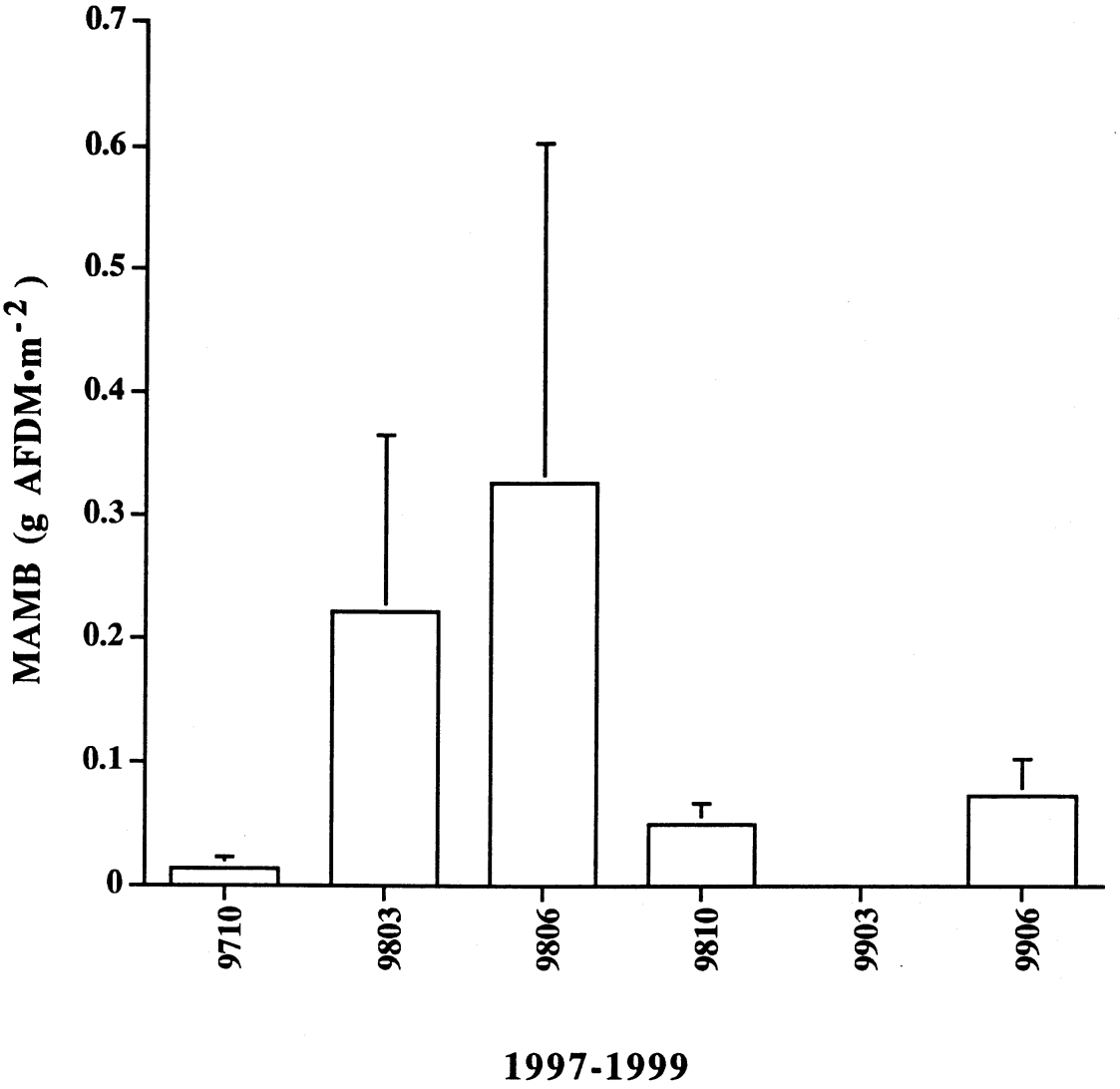

Figure 179. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

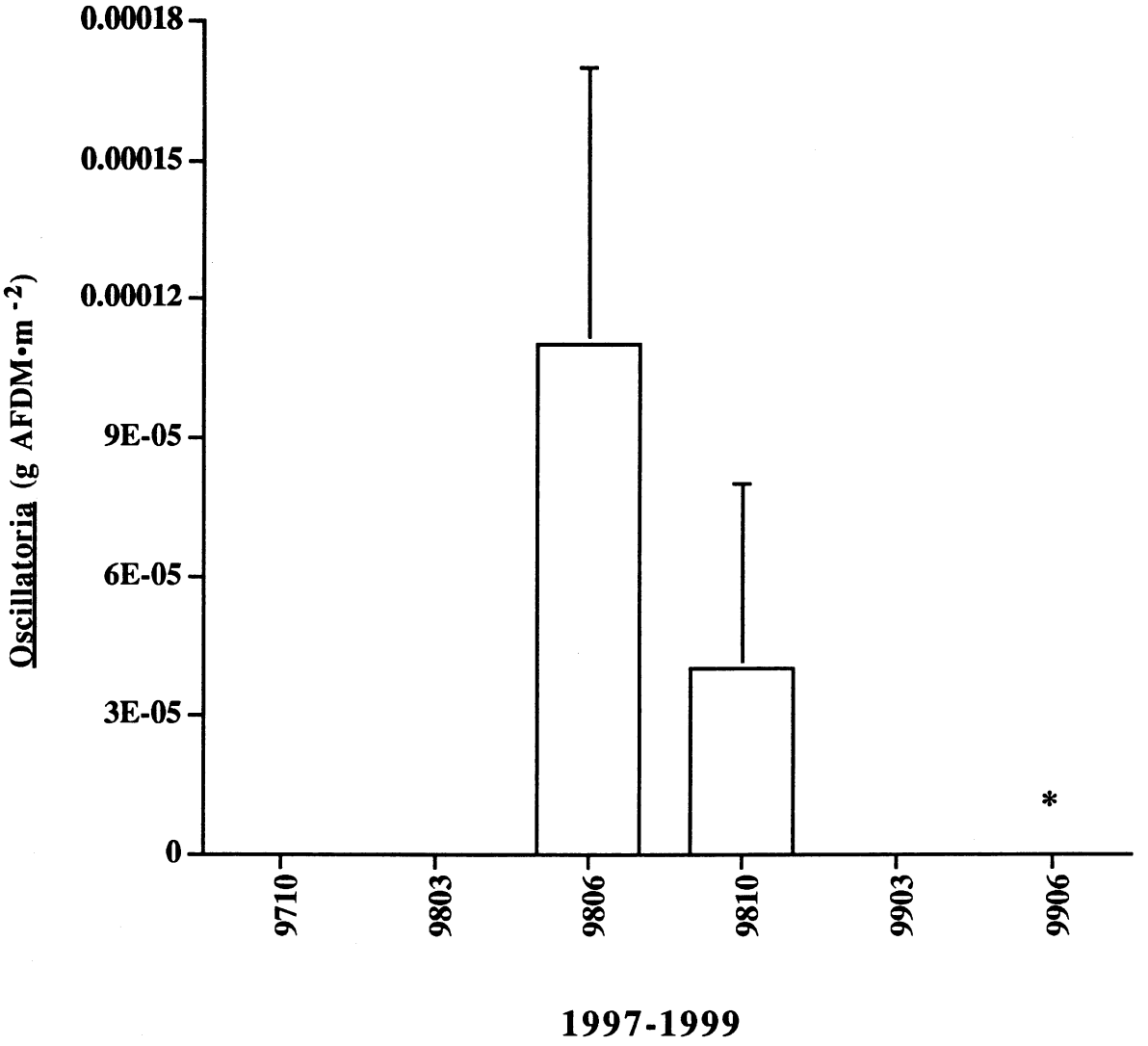

Figure 180. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

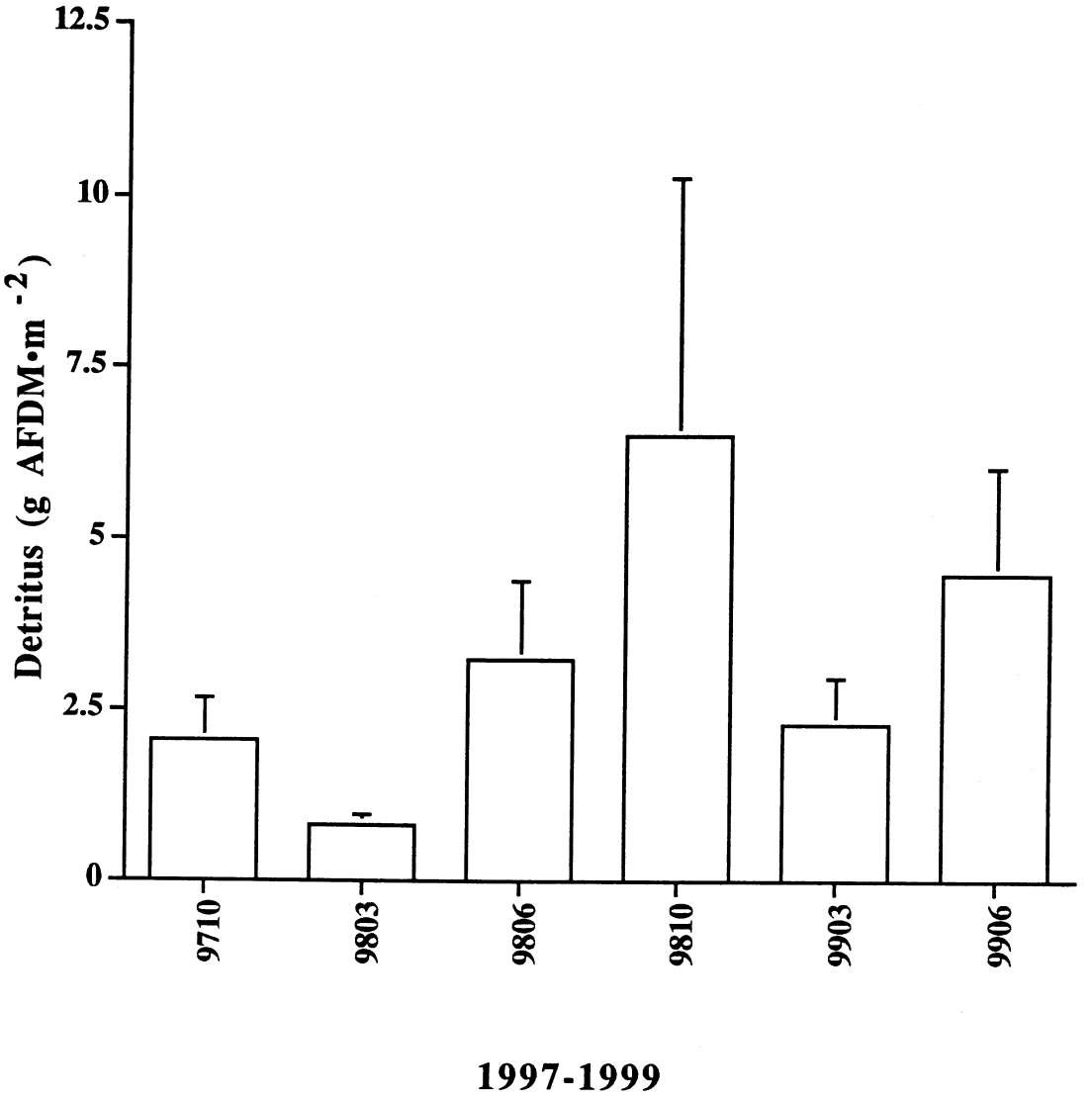

Figure 181. Detritus biomass estimates (g AFDM•m^{-2}) at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

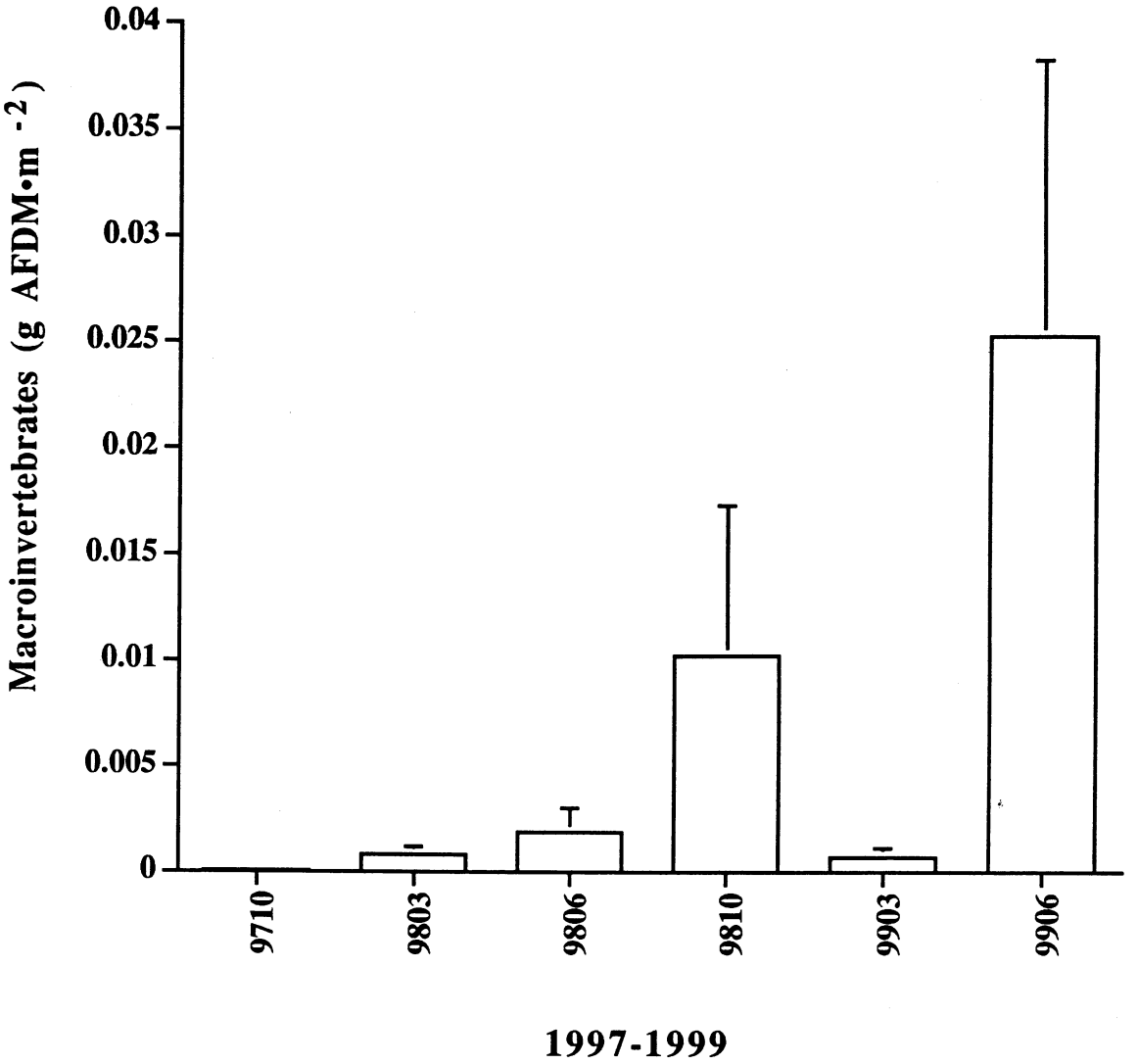

Figure 182. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

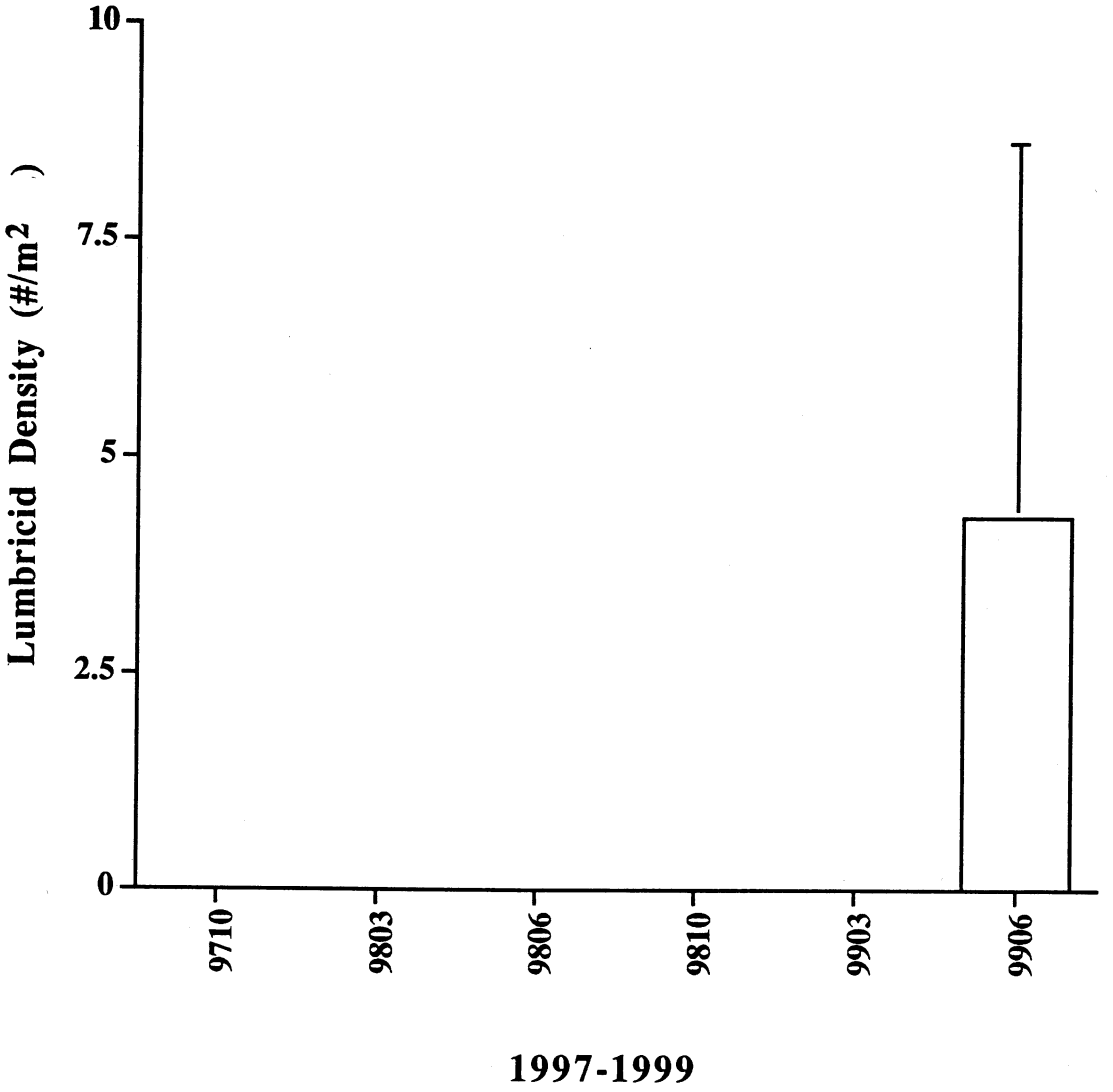

Figure 183. Lumbricid densities (#/m^2) collected at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

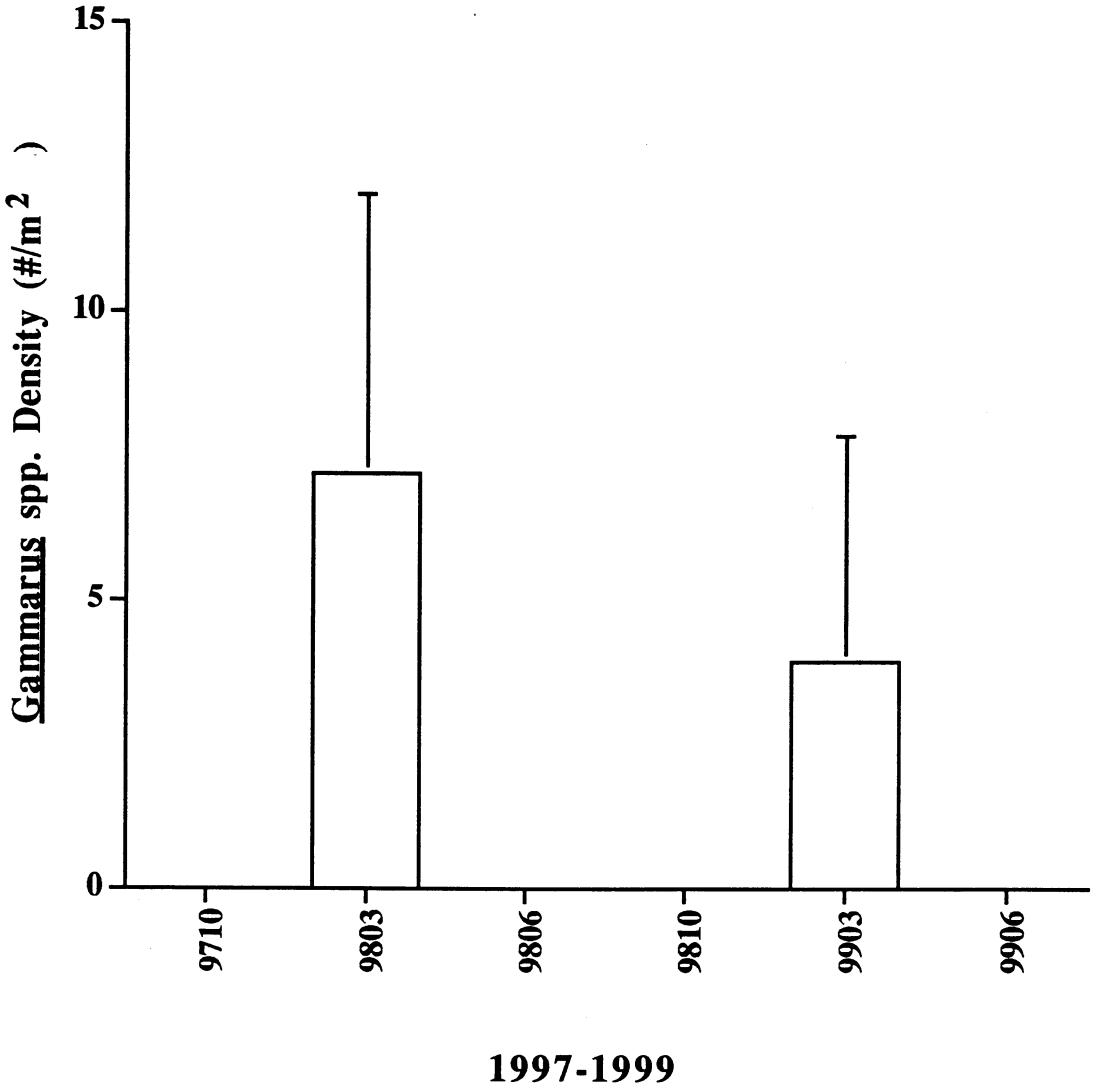

Figure 184. Gammarus spp. densities (#/m^2) collected at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

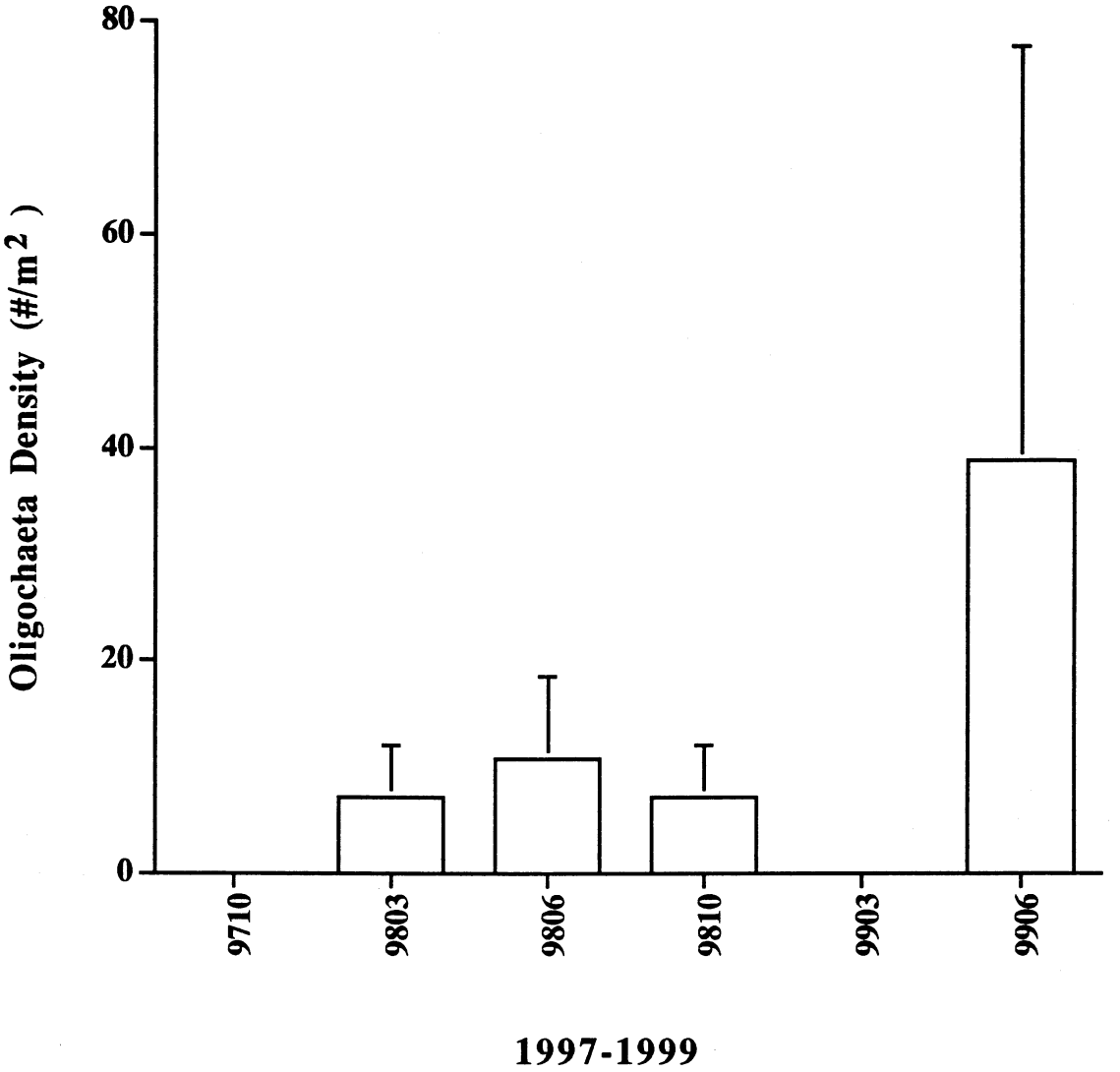

Figure 185. Oligochaeta densities (#/m ^{2}) collected at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

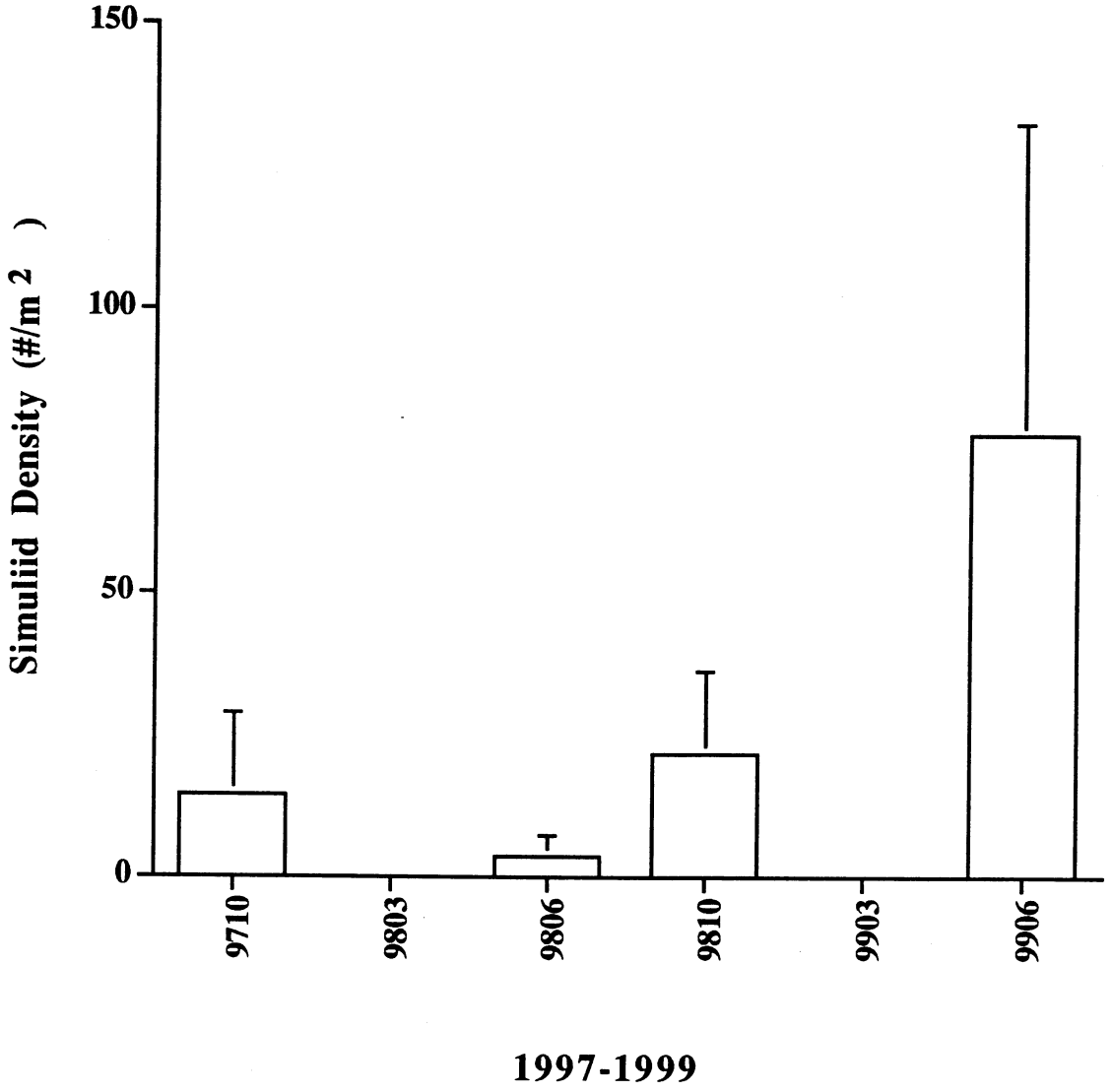

Figure 186. Simuliid densities (#/m^2) collected at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

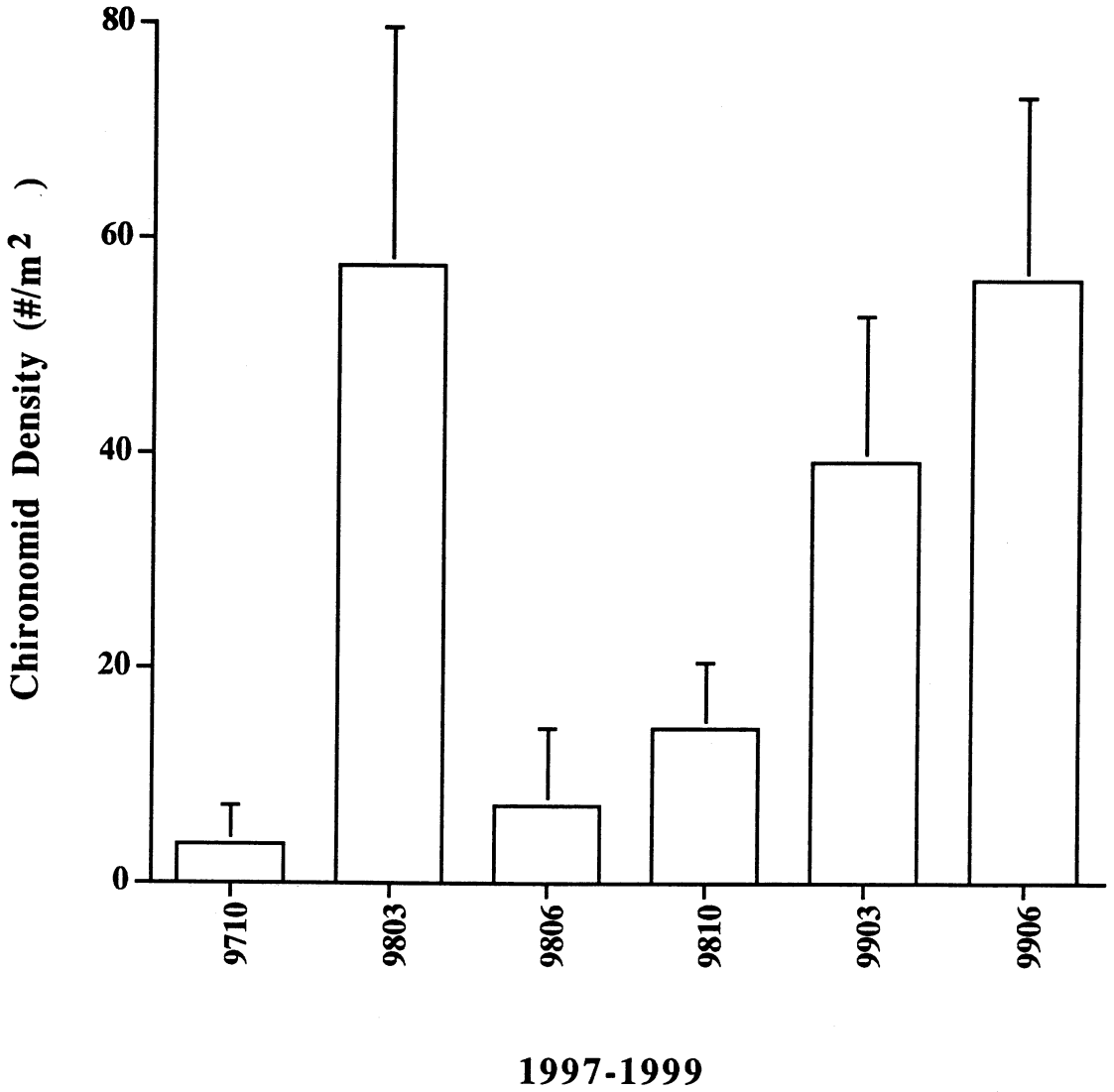

Figure 187. Chironomid densities (#/m^2) collected at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

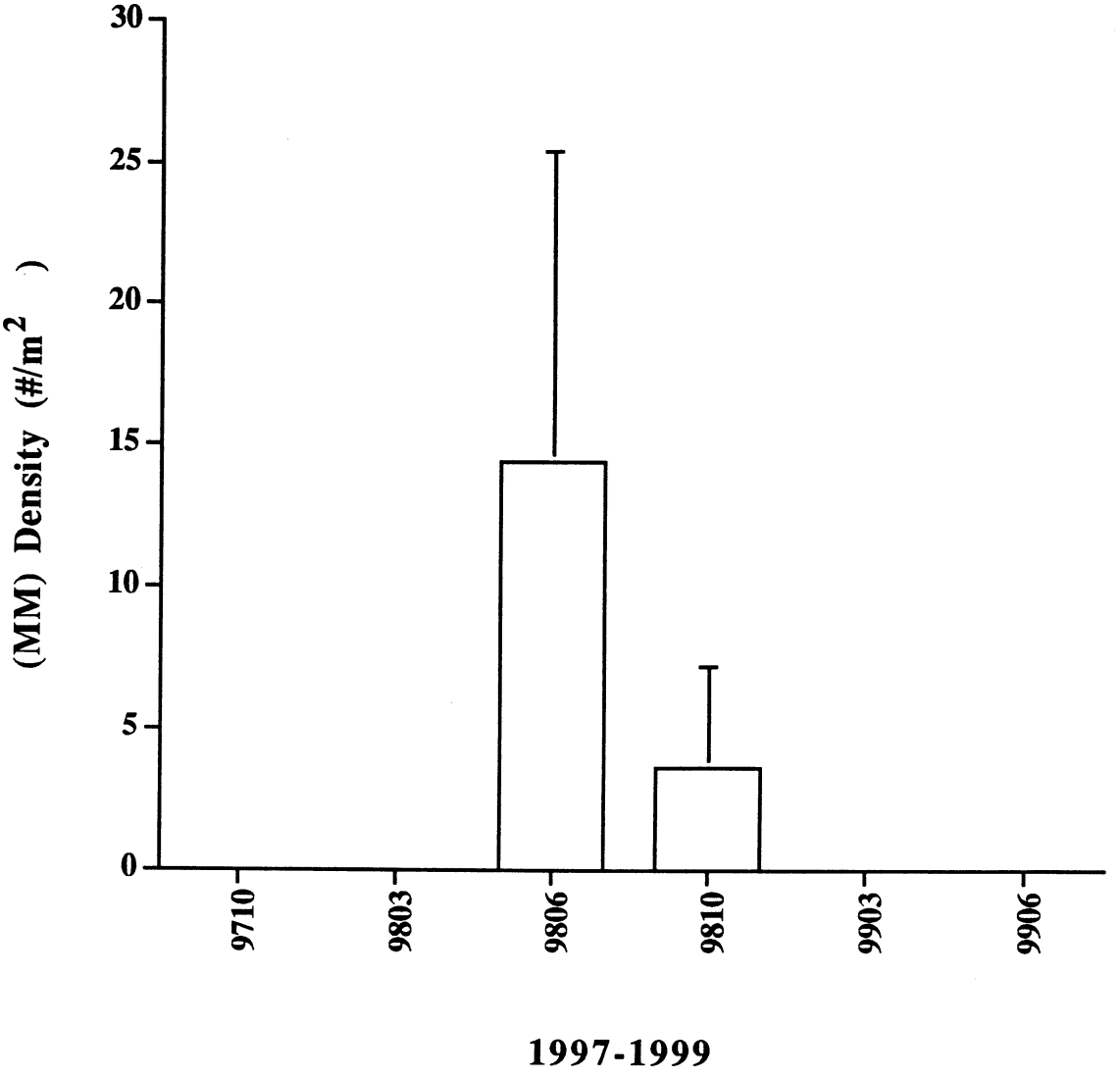

Figure 188. Miscellaneous invertebrate (MM) densities (#/m^2) collected at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. Error bars represent (± 1 SE, n=12).

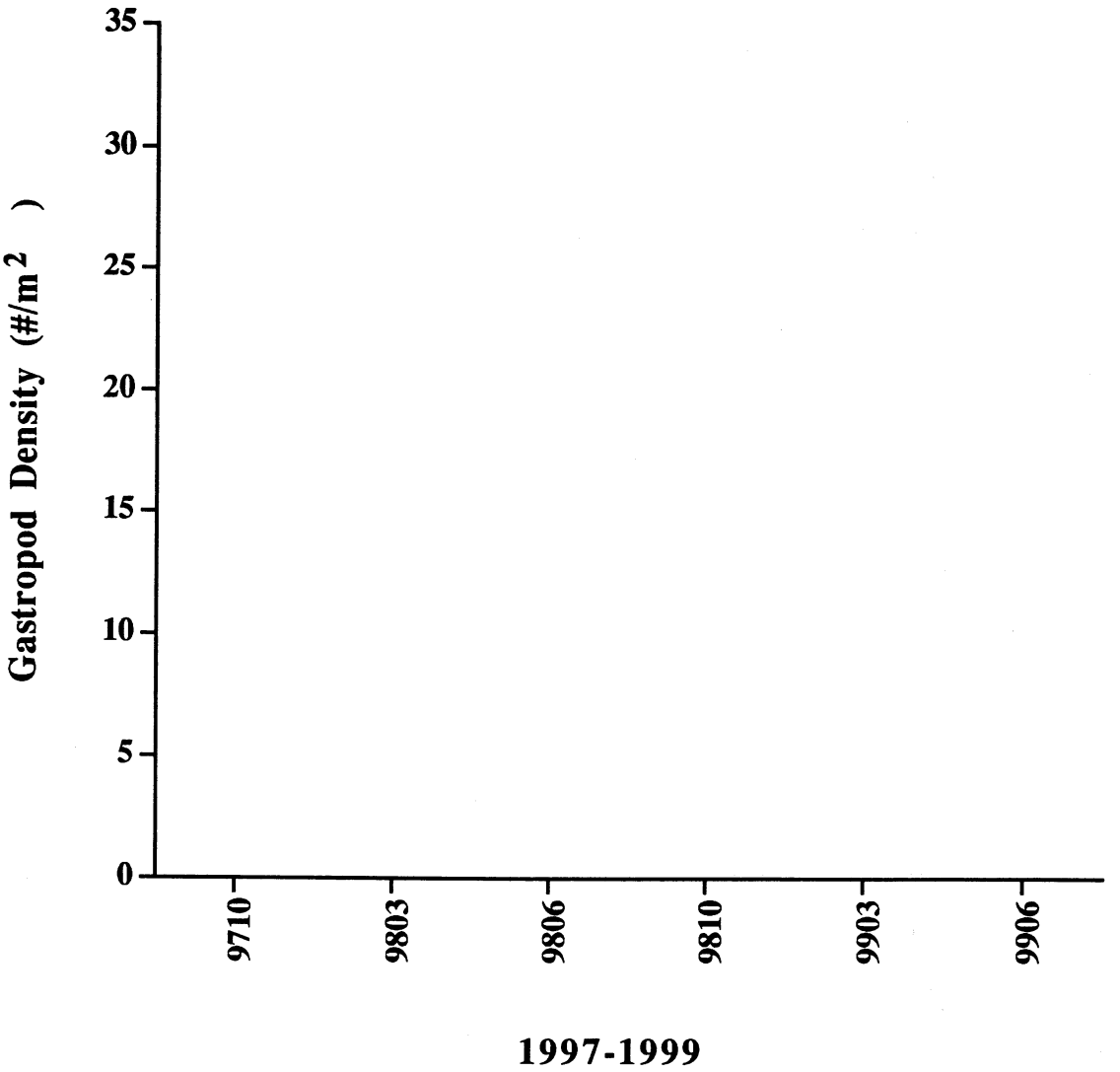

Figure 189. Gastropod densities (#/m^2) collected at Middle Granite Gorge pool Rkm 203.2 from October 1997 to June 1999. No abundances of Gastropods were present during these collection dates.

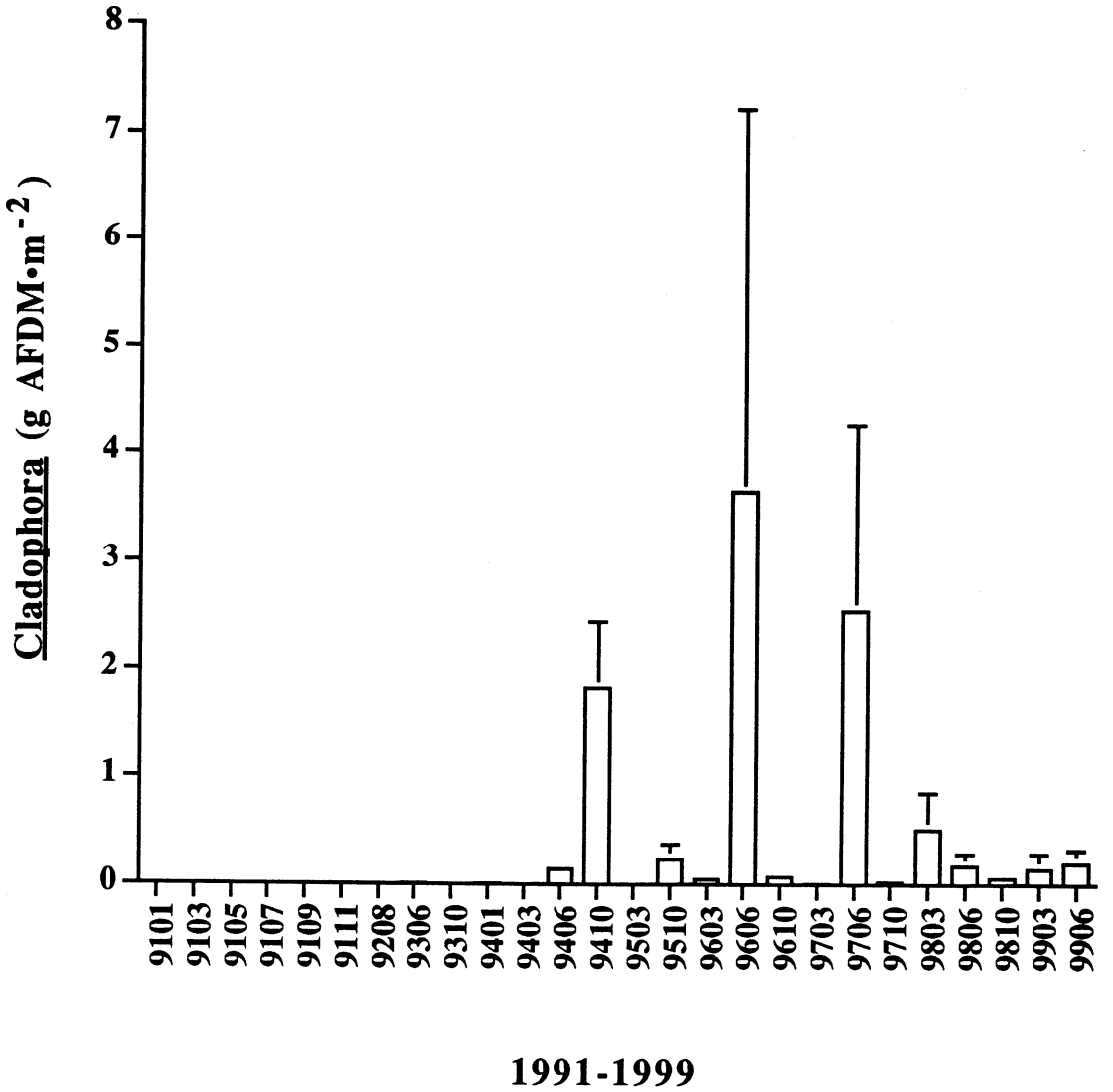

Figure 190. Cladophora biomass estimates (g AFDM•m^{-2}) at Spring Canyon pool Rkm 326.4 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

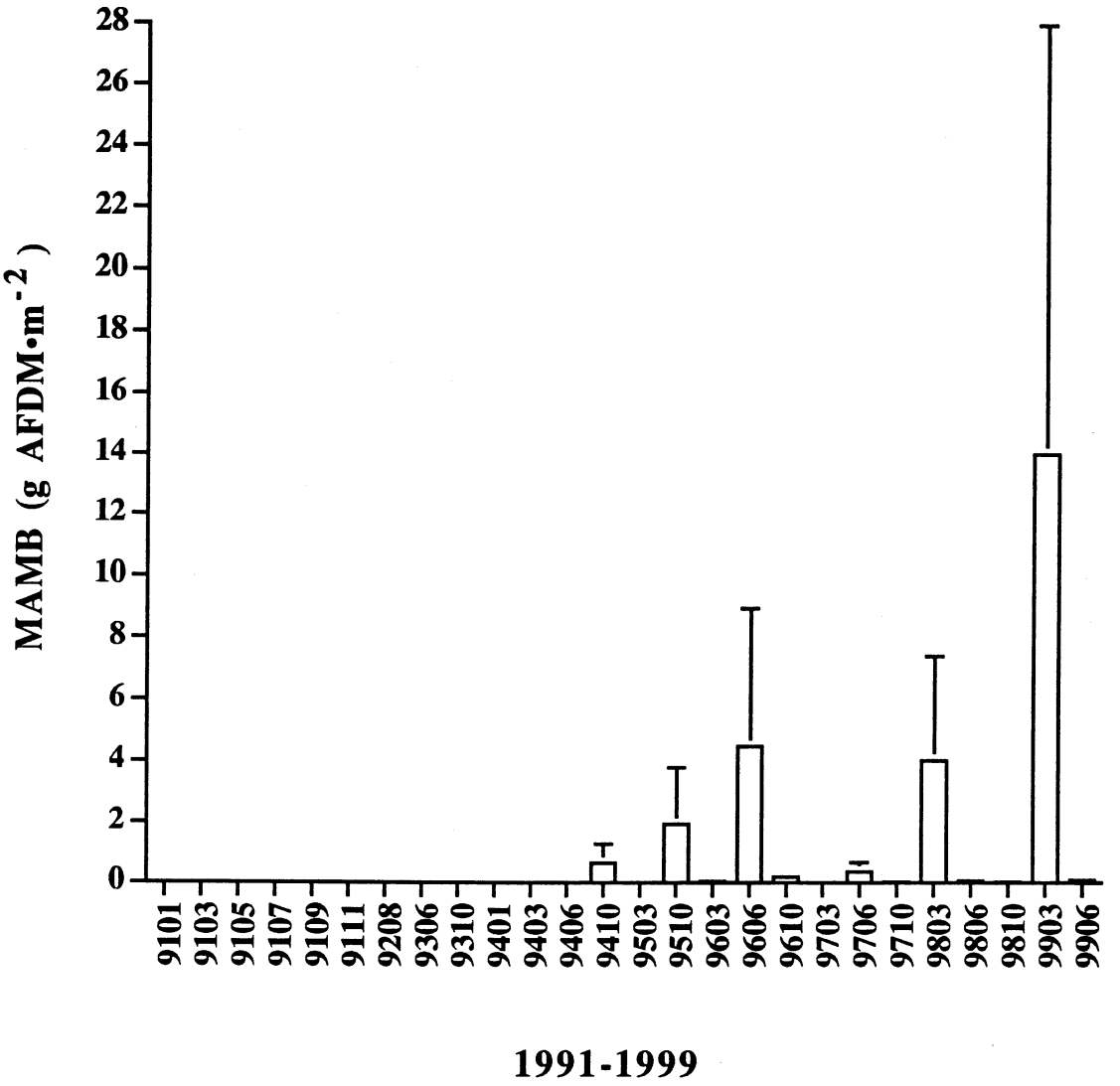

Figure 191. Miscellaneous algae, macrophytes and bryophytes (MAMB) biomass estimates (g AFDM•m^{-2}) at Spring Canyon pool Rkm 326.4 from January 1991 to June 1999. MAMB was not collected prior to August 1992. Error bars represent (± 1 SE, n=12).

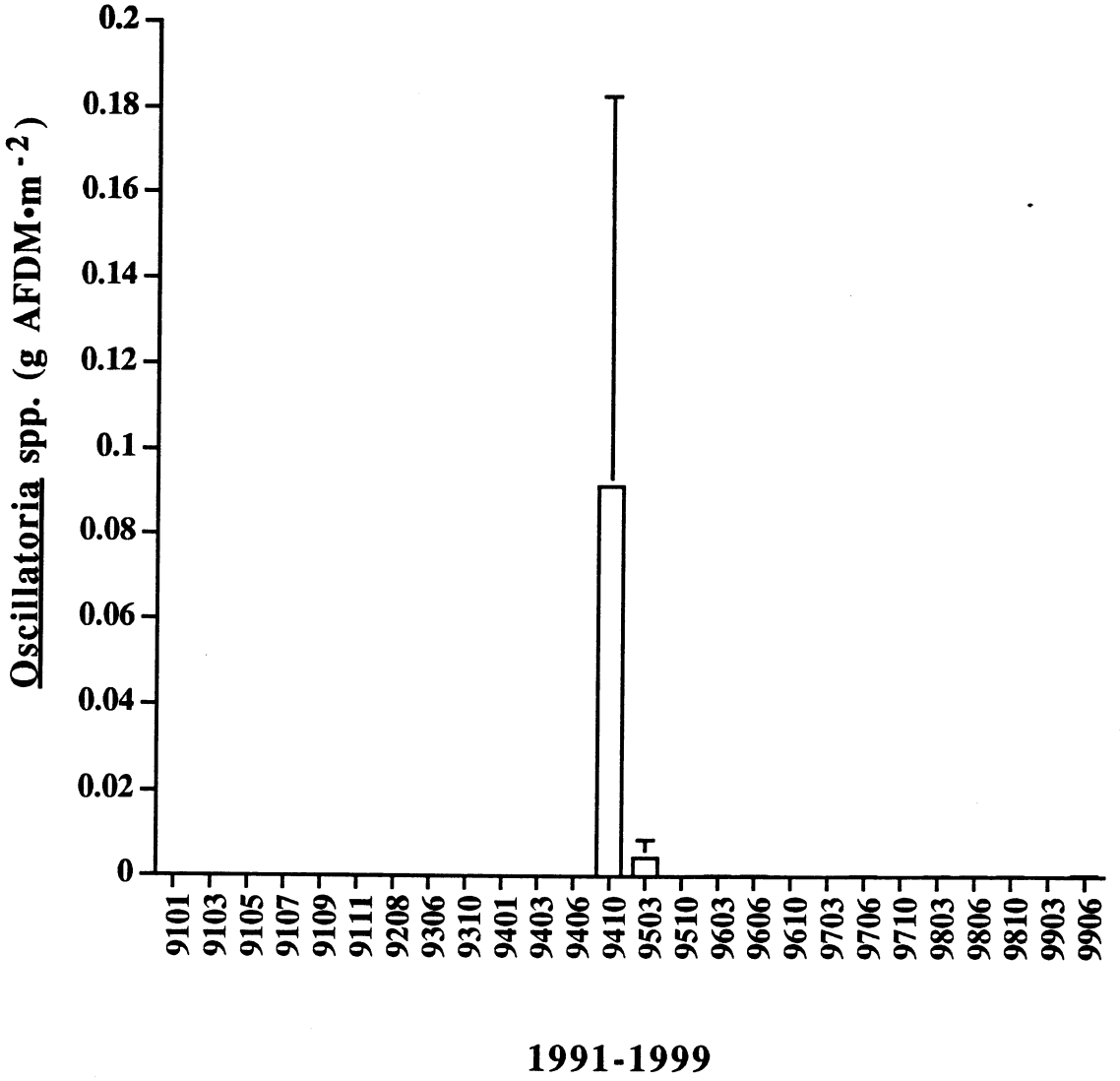

Figure 192. Oscillatoria spp. biomass estimates (g AFDM•m^{-2}) at Spring Canyon pool Rkm 326.4 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

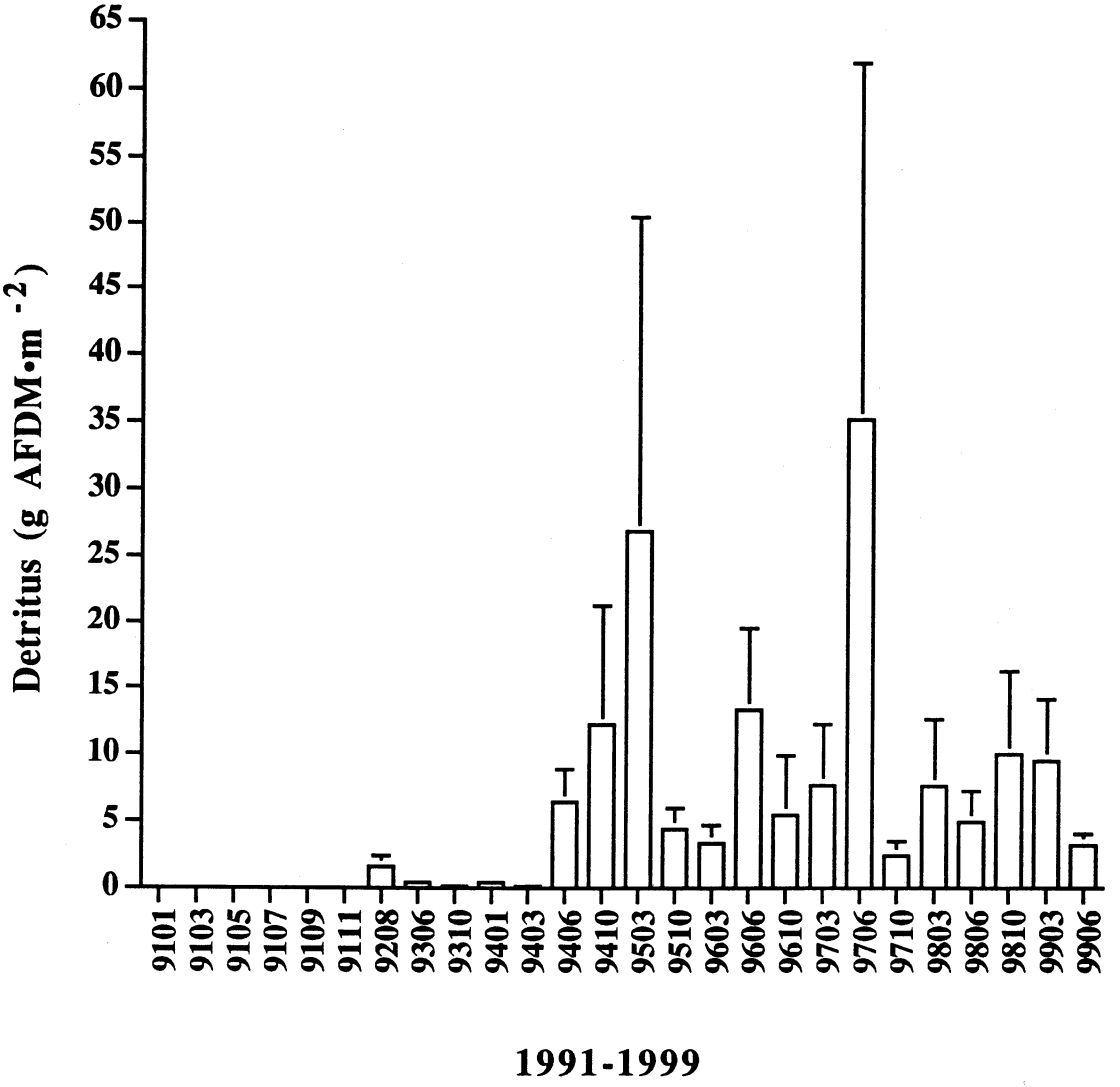

Figure 193. Detritus biomass estimates (g AFDM•m^{-2}) at Spring Canyon pool Rkm 326.4 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

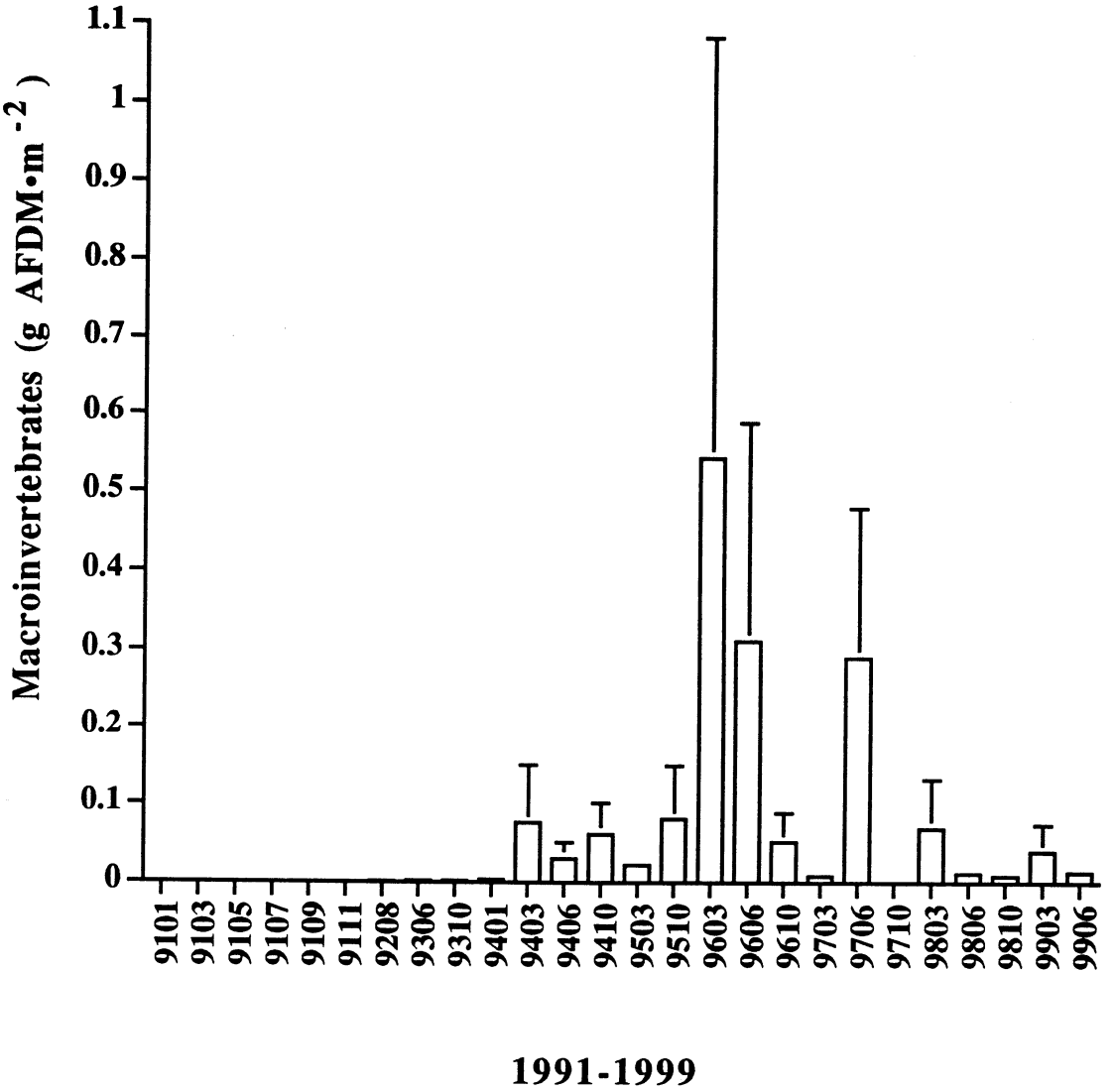

Figure 194. Macroinvertebrate biomass estimates (g AFDM•m^{-2}) at Spring Canyon pool Rkm 326.4 from January 1991 to June 1999. Error bars represent (± 1 SE, n=12).

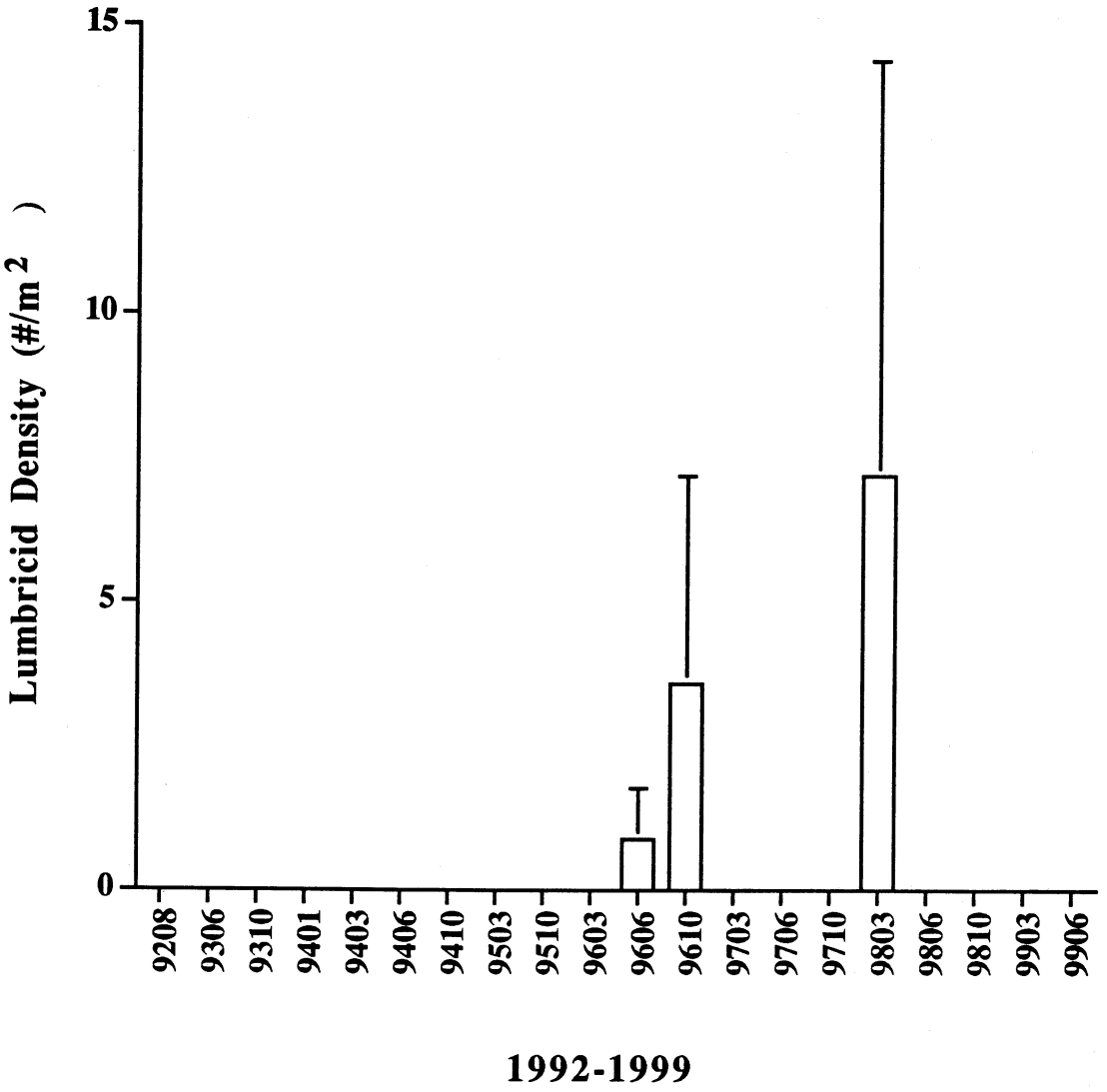

Figure 195. Lumbricid densities (#/m^2) collected at Spring Canyon pool Rkm 326.4 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

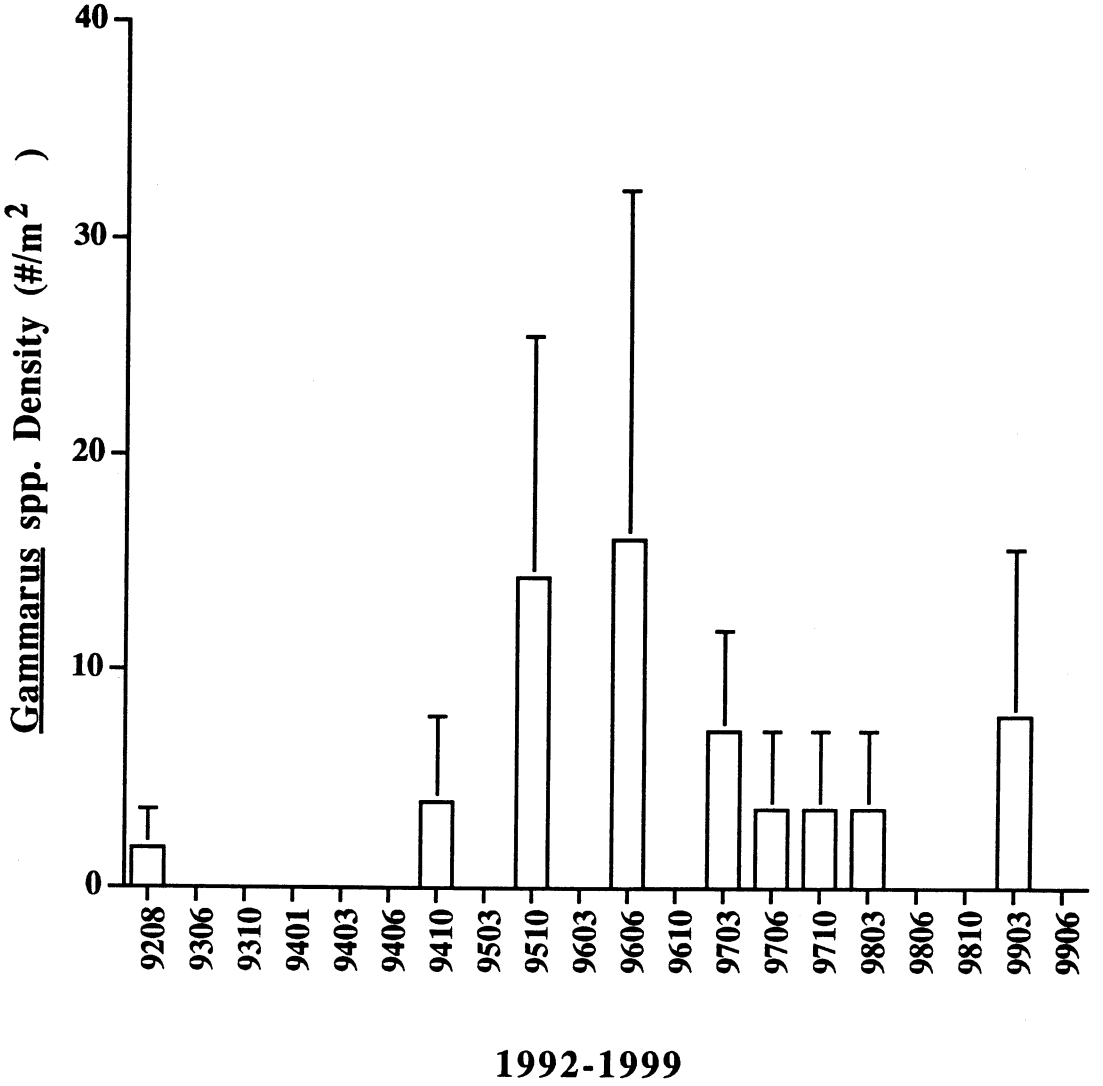

Figure 196. Gammarus spp. densities (#/m^2) collected at Spring Canyon pool Rkm 326.4 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

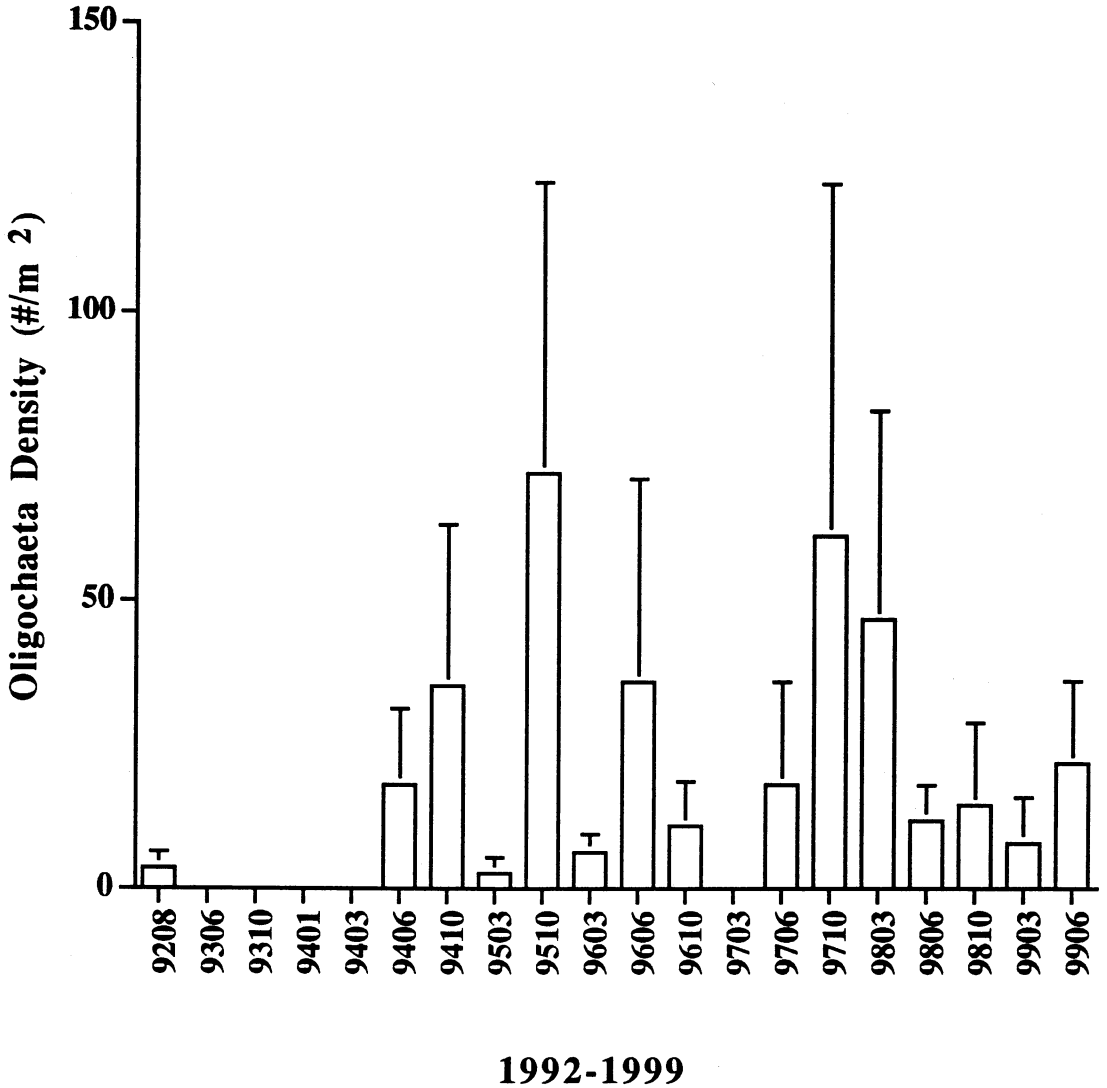

Figure 197. Oligochaeta densities (#/m^2) collected at Spring Canyon pool Rkm 326.4 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

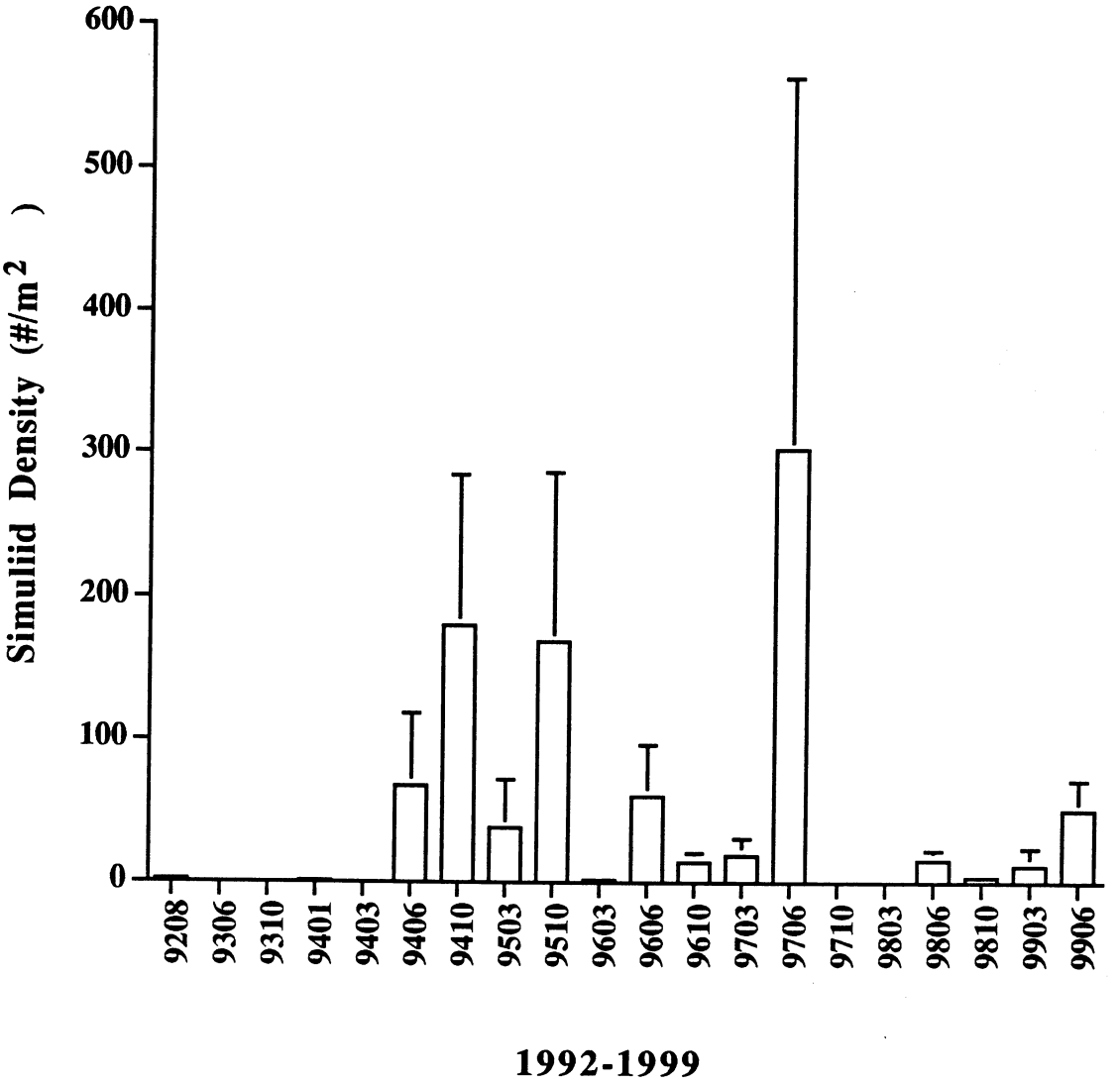

Figure 198. Simuliid densities (#/m^2) collected at Spring Canyon pool Rkm 326.4 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

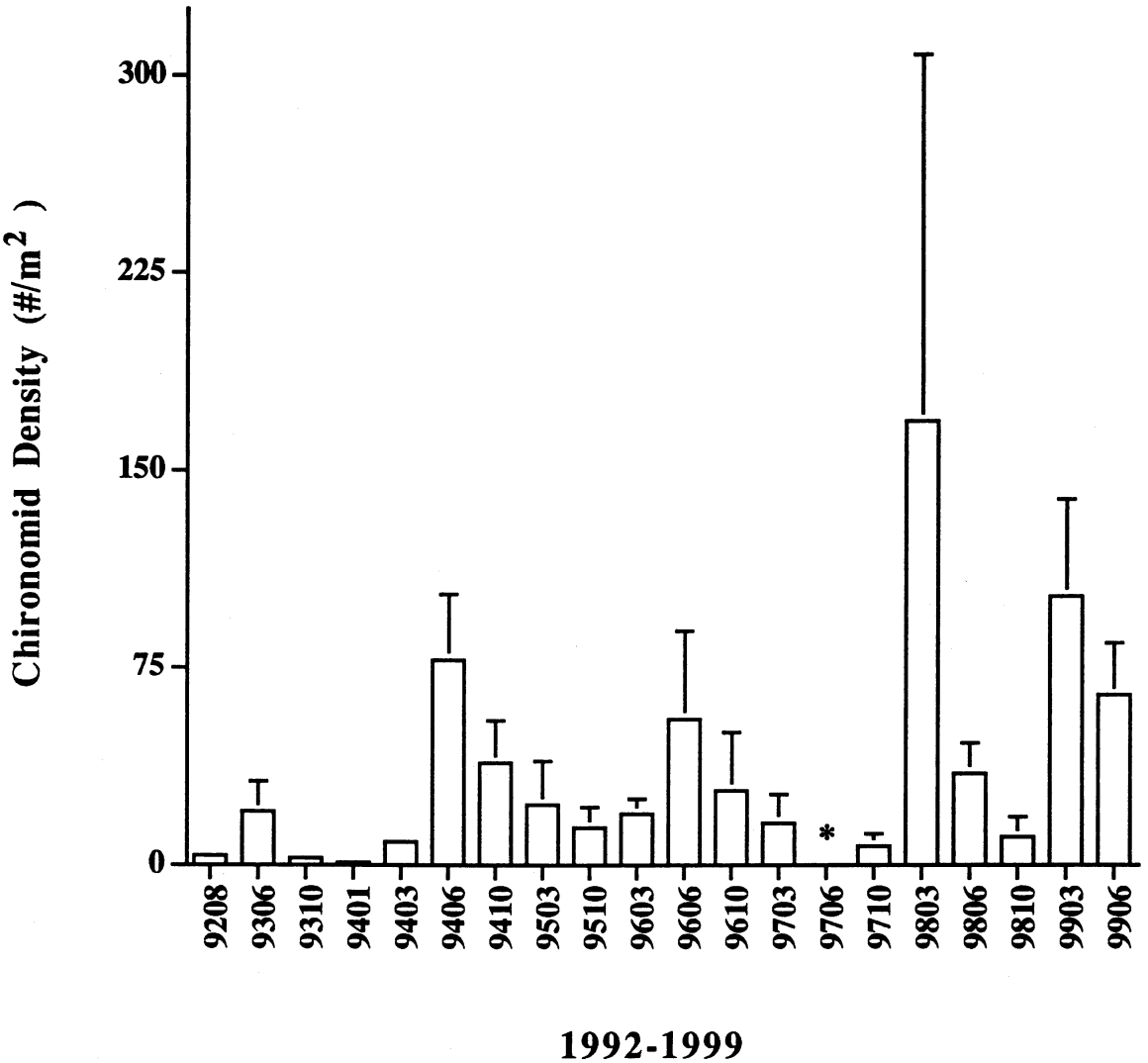

Figure 199. Chironomid densities (#/m^2) collected at Spring Canyon pool Rkm 326.4 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12). Asterisk (*) represents 563/m^2 (± 318 SE).

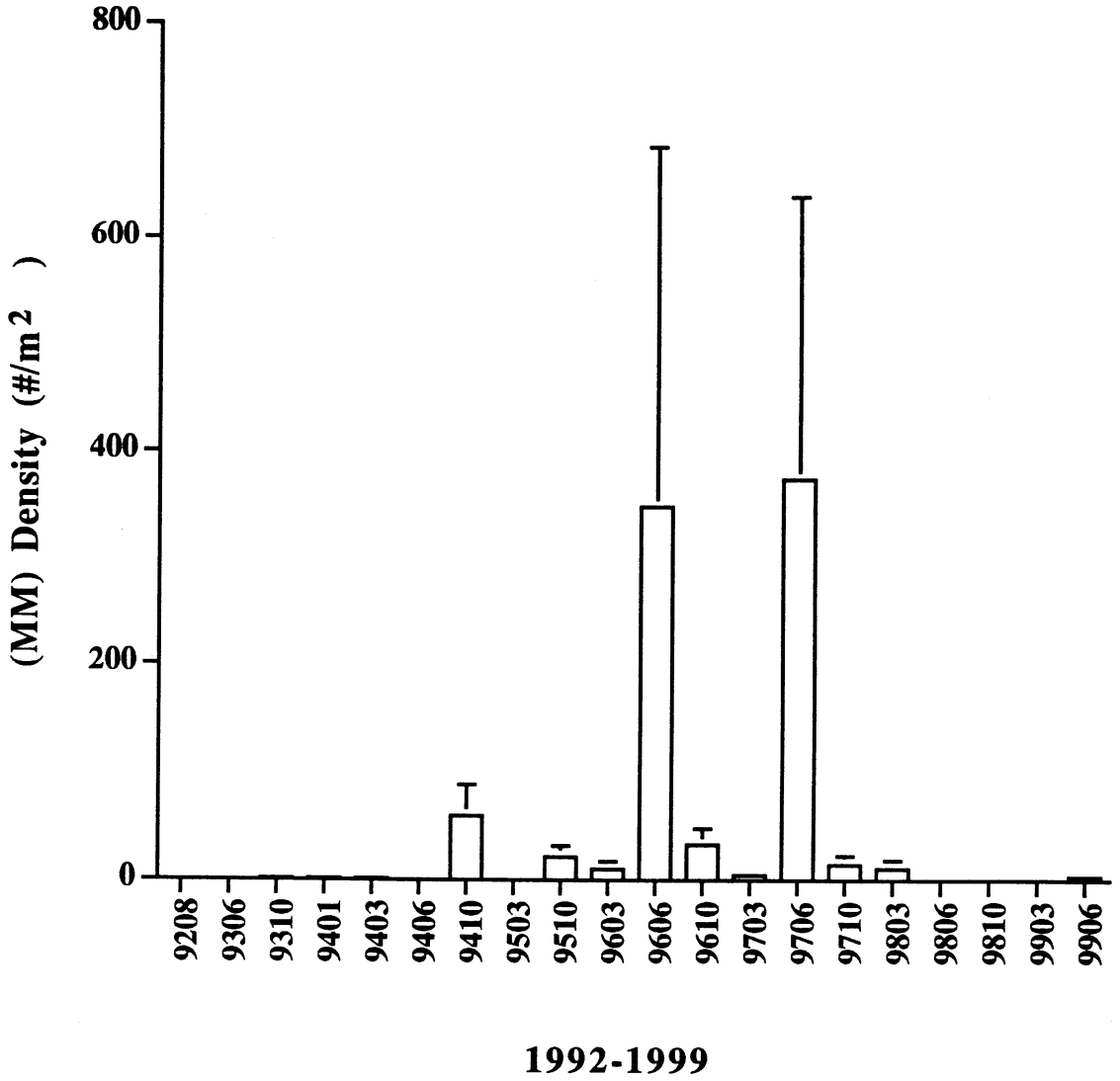

Figure 200. Miscellaneous invertebrate (MM) densities (#/m^2) collected at Spring Canyon pool Rkm 326.4 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

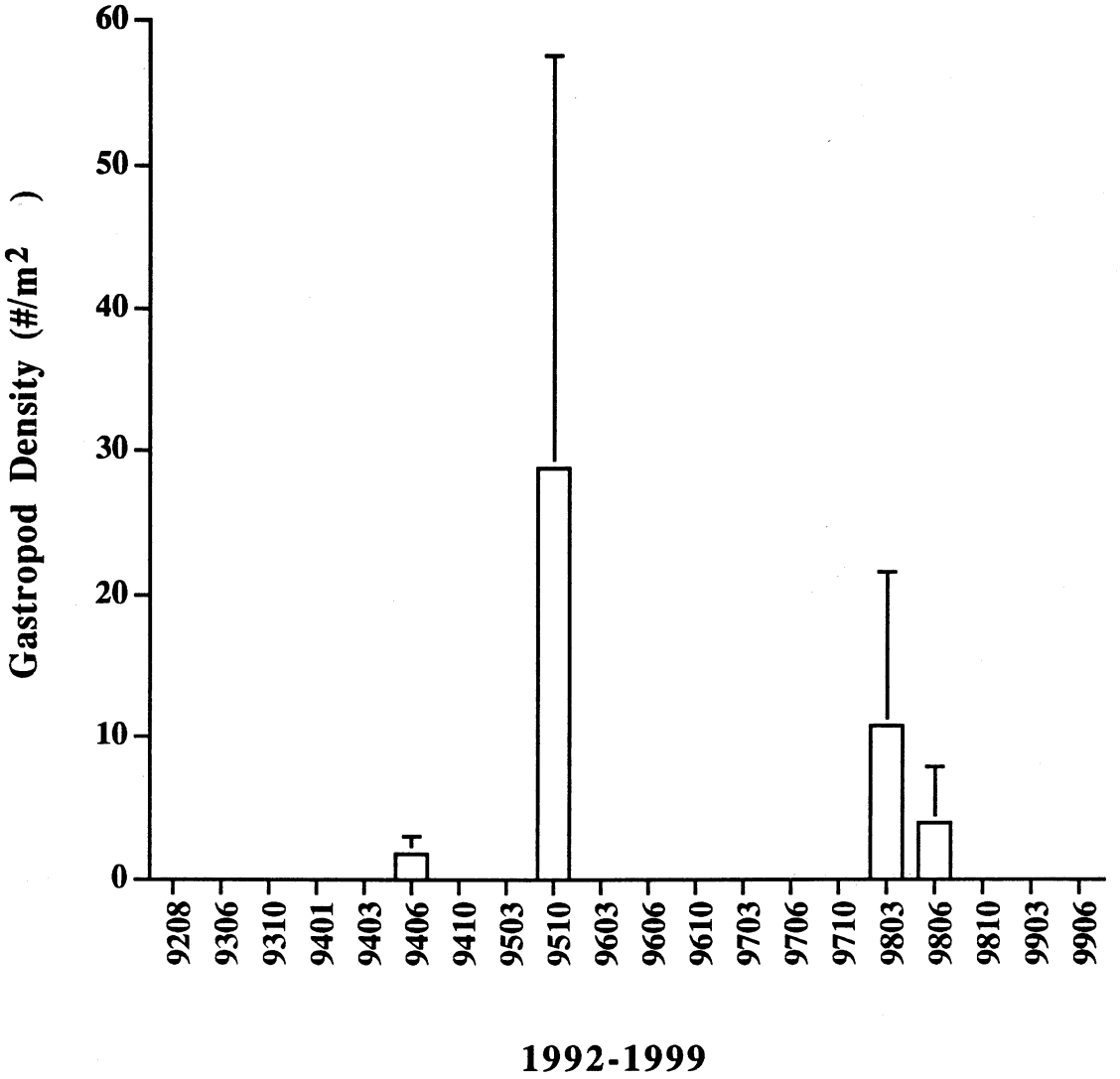

Figure 201. Gastropod densities (#/m^2) collected at Spring Canyon pool Rkm 326.4 from August 1992 to June 1999. Error bars represent (± 1 SE, n=12).

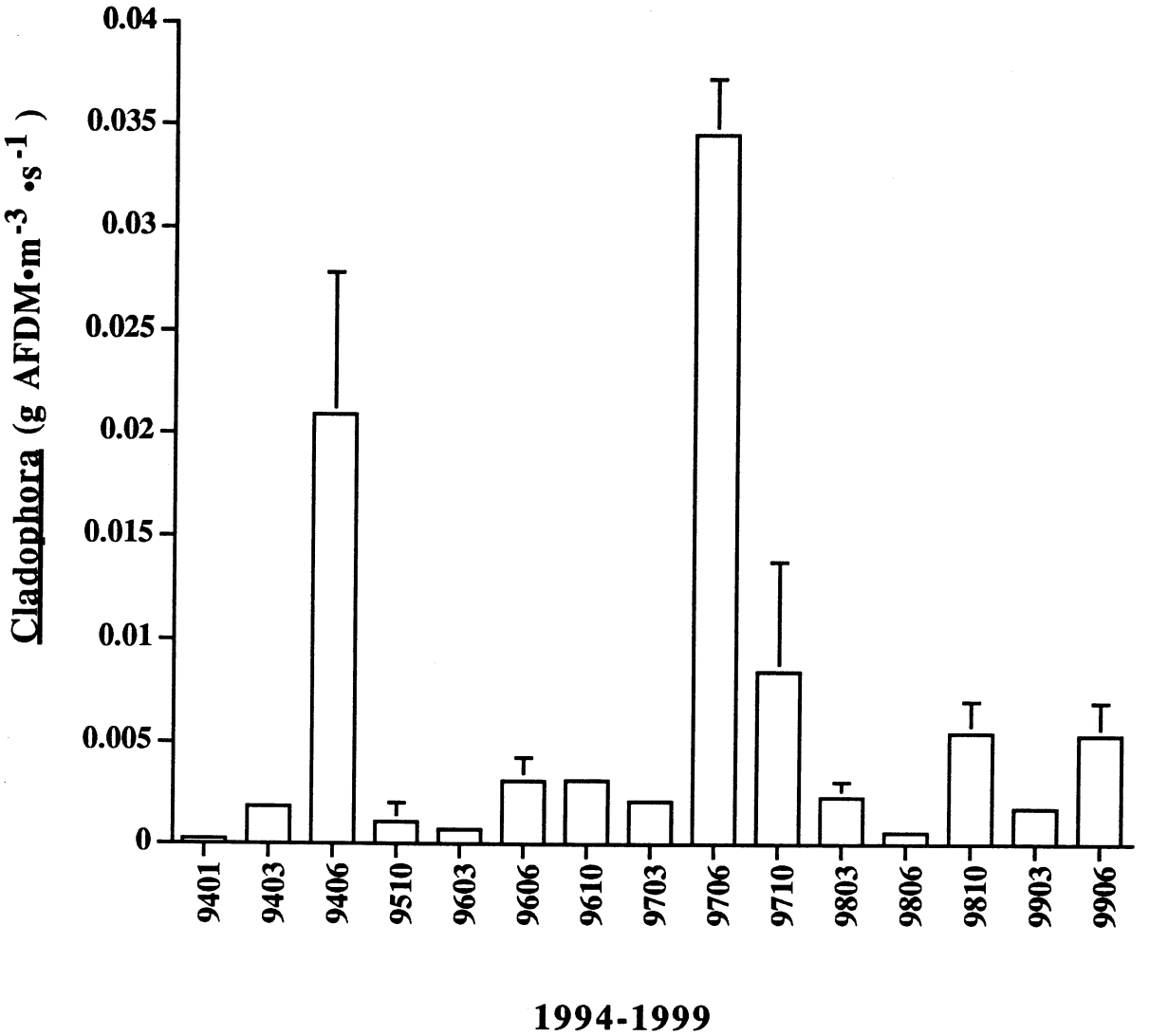

Figure 202. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) of Cladophora collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

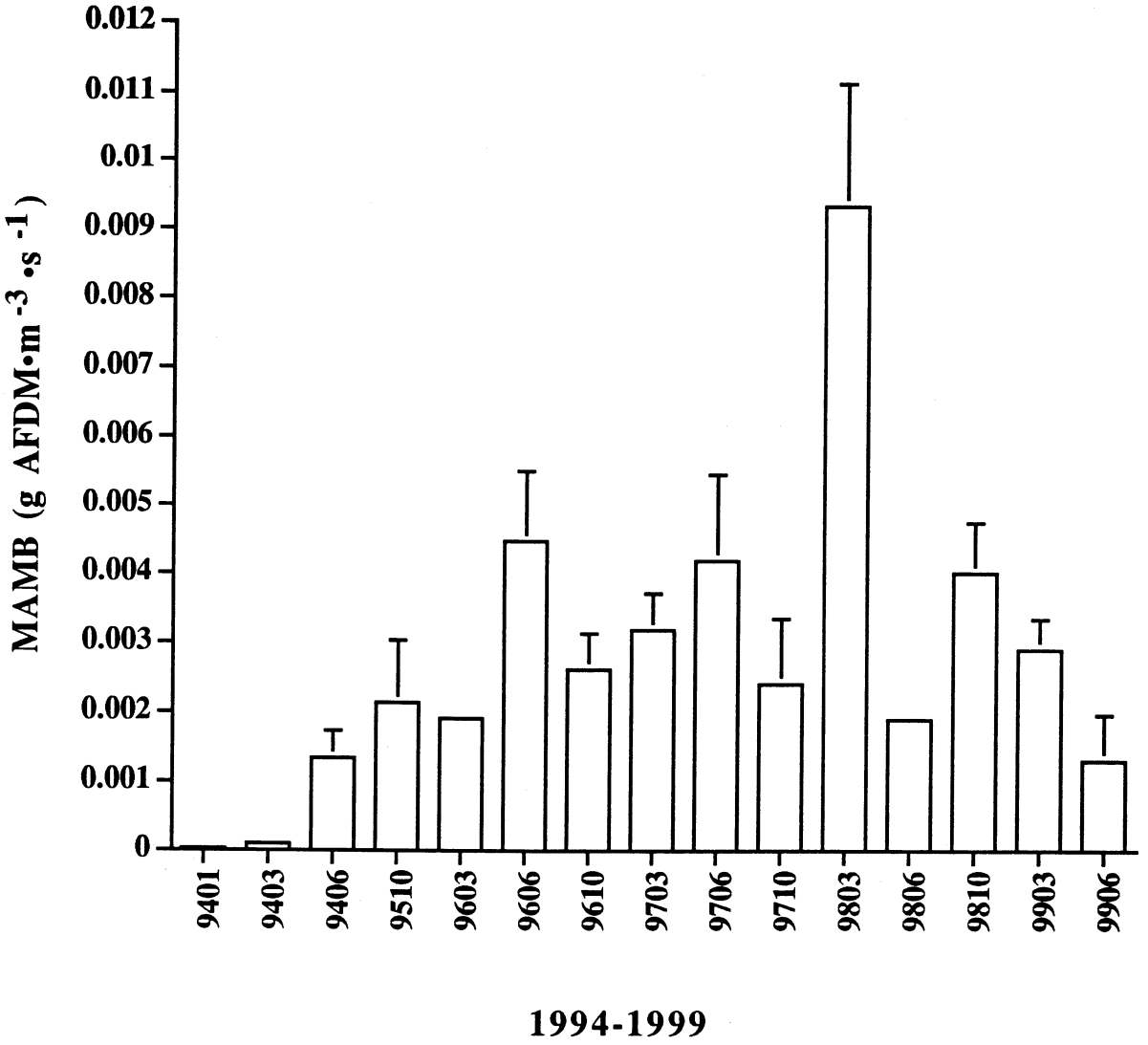

Figure 203. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) of miscellaneous algae, macrophytes, and bryophytes (MAMB) collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

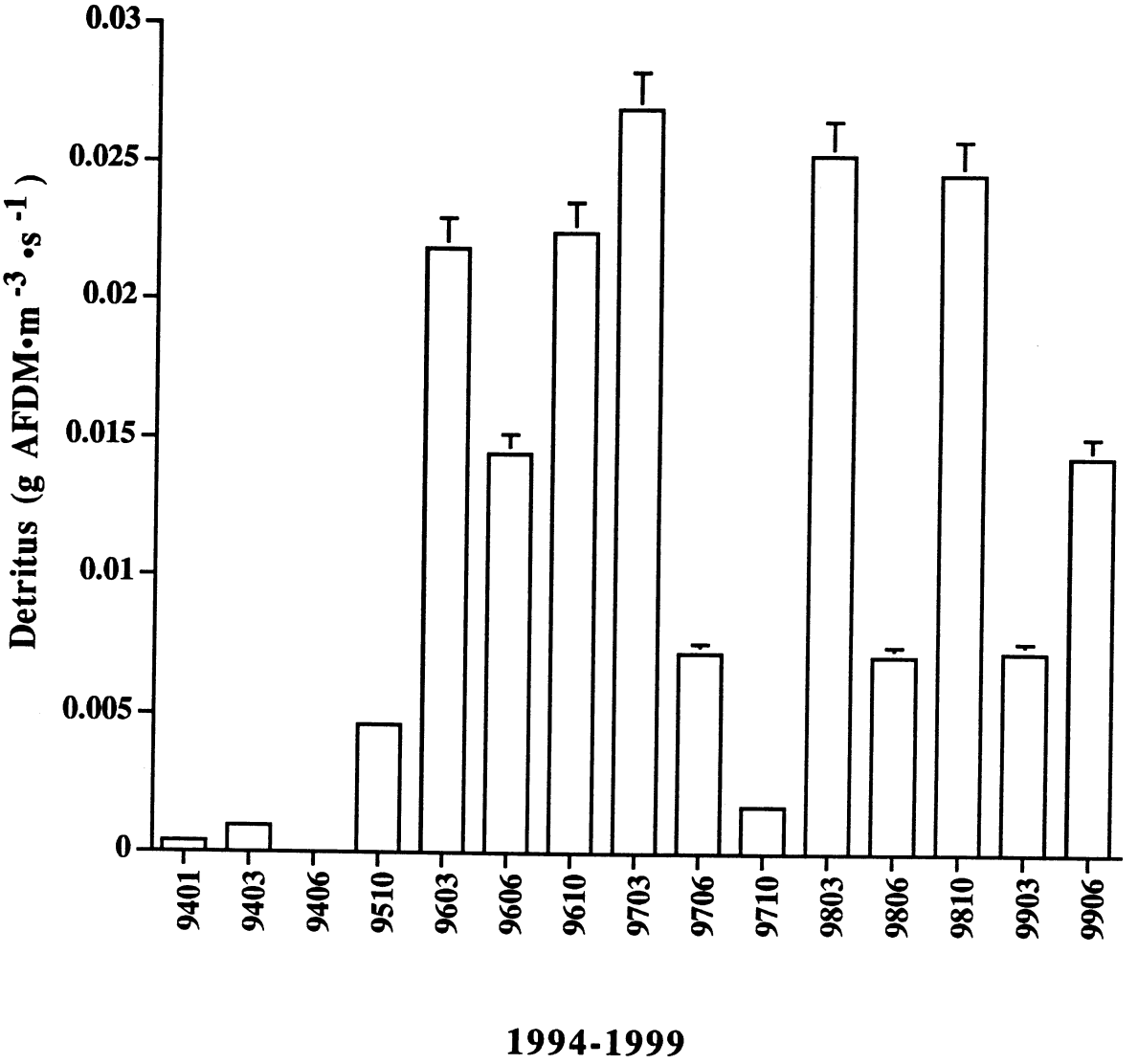

Figure 204. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for detritus collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

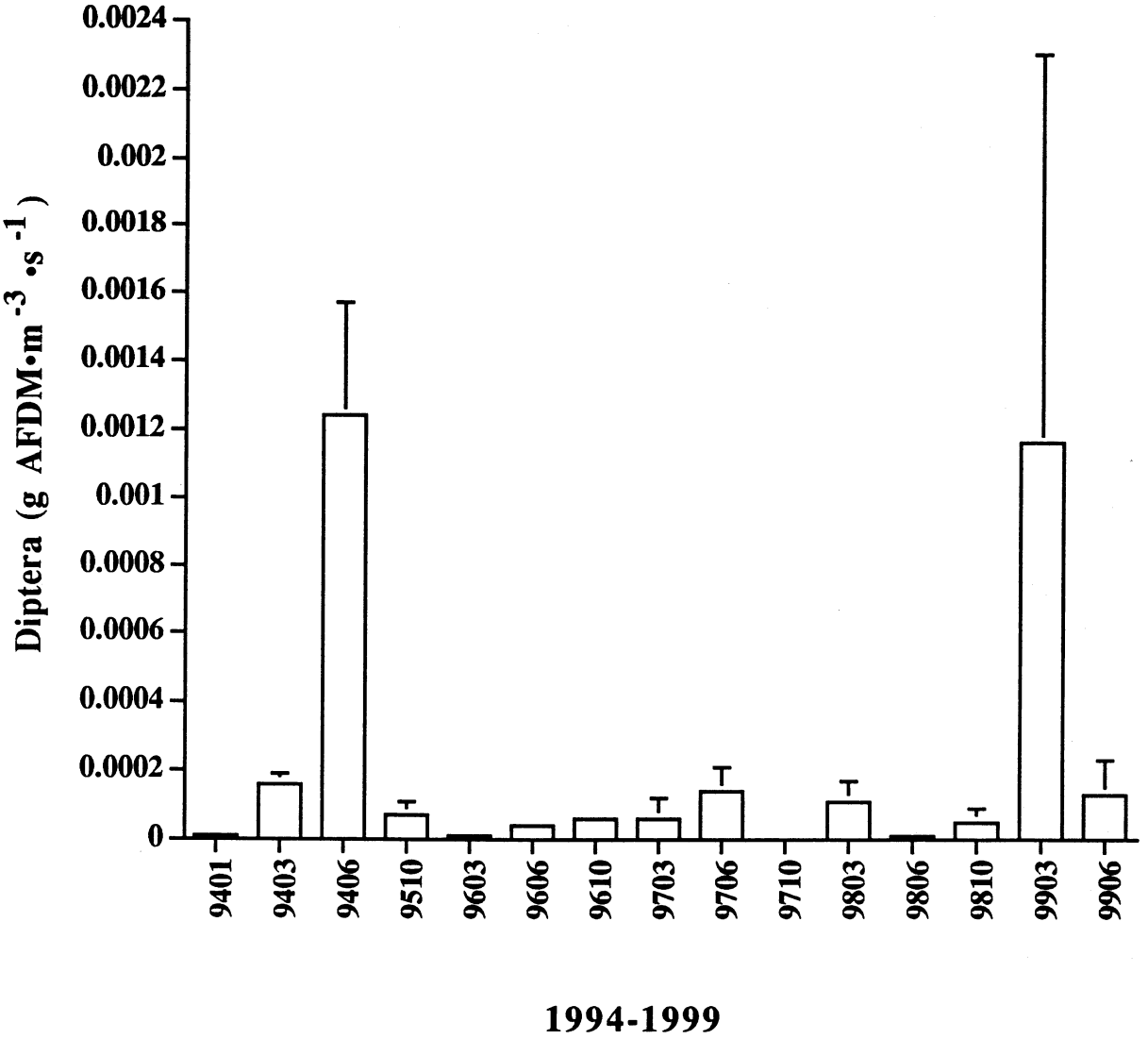

Figure 205. Average CPOM drift mass (g AFDM•m $^{-3}$•s $^{-1}$) for aquatic diptera collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

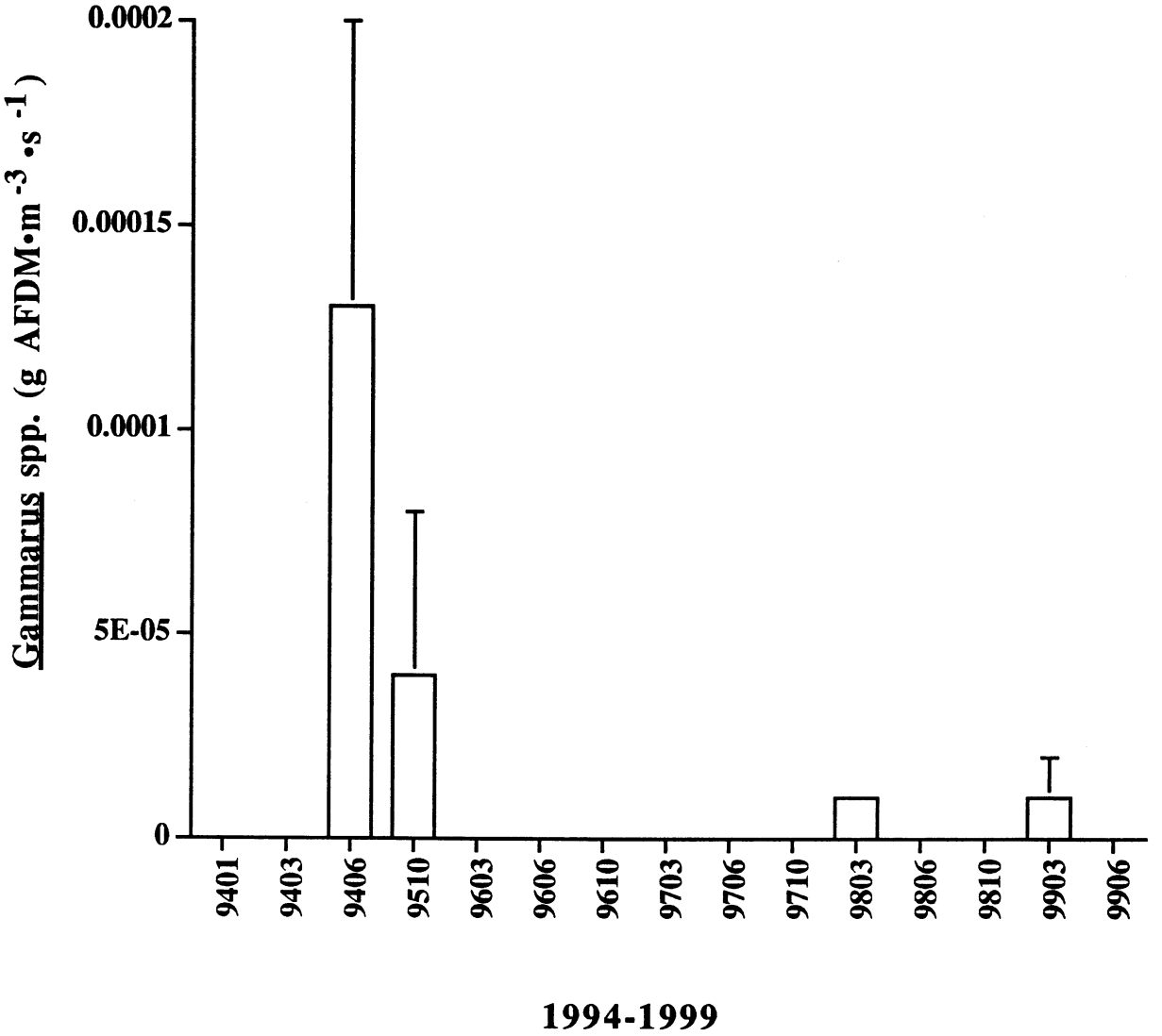

Figure 206. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for Gammarus spp. collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

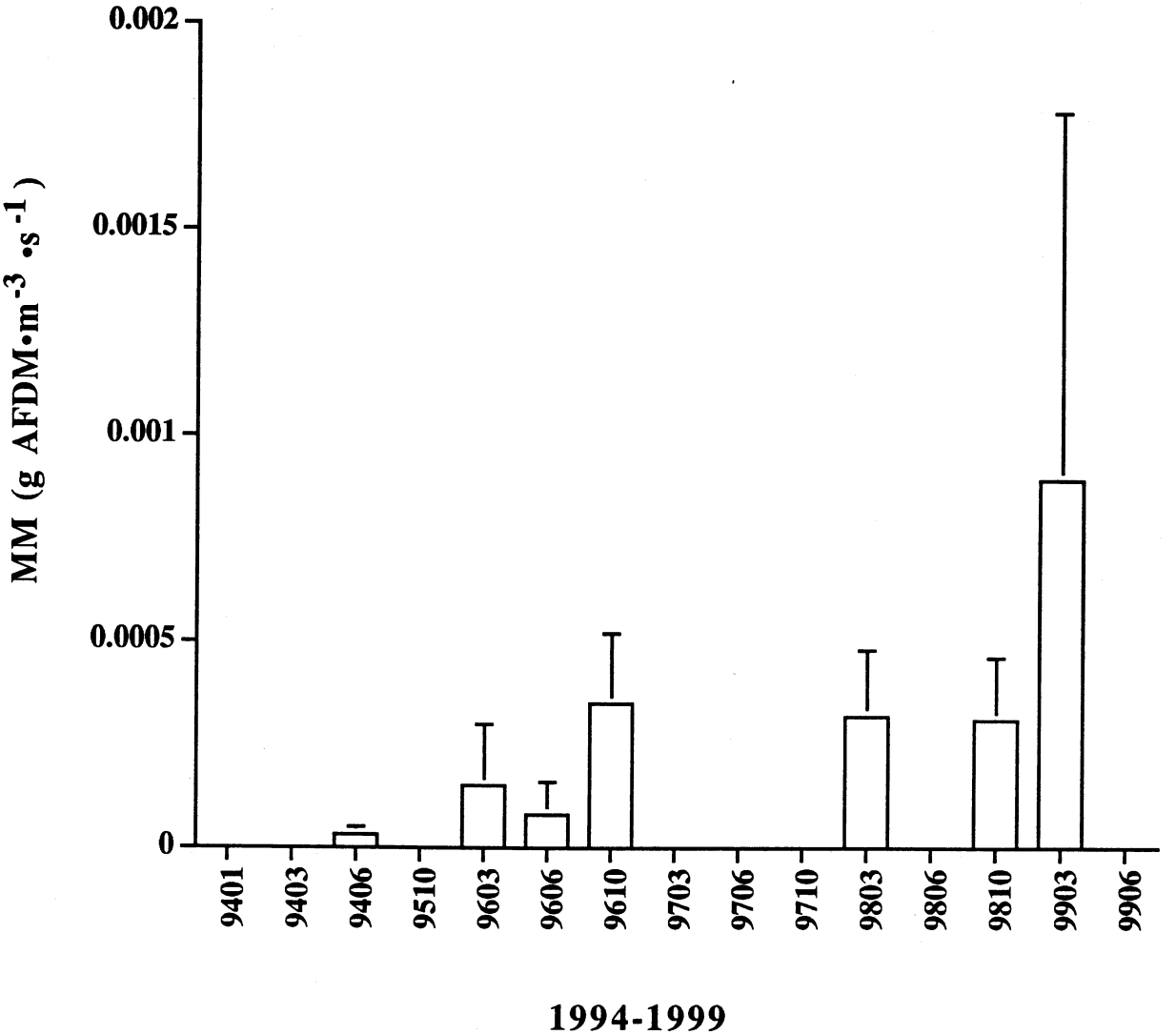

Figure 207. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for miscellaneous macroinvertebrates (MM) collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

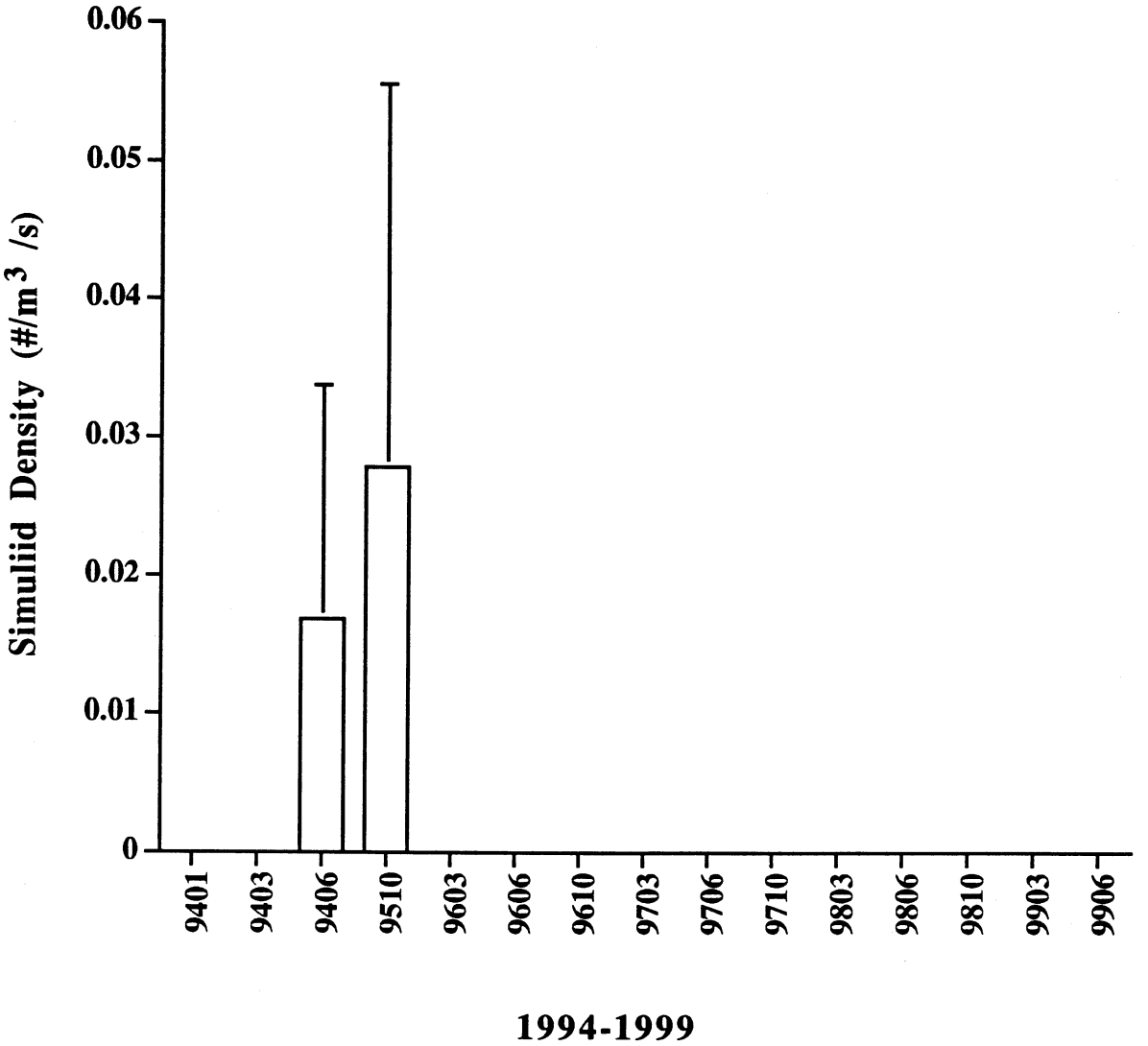

Figure 208. Average CPOM drift densities (#/m^3/s) for Simuliids collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent ($\pm$ 1 SE).

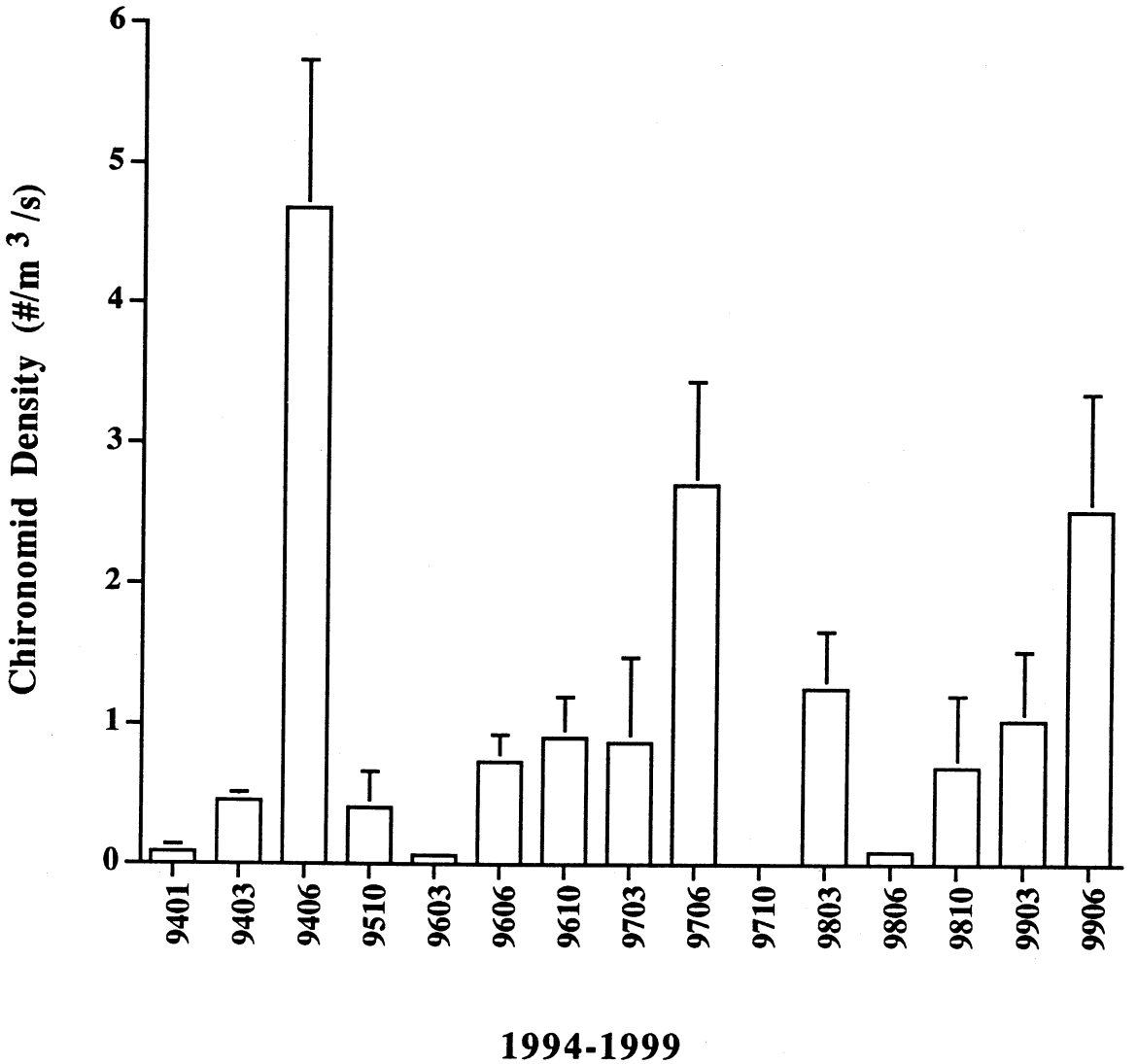

Figure 209. Average CPOM drift densities (#/m^3 /s) for Chironomids collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

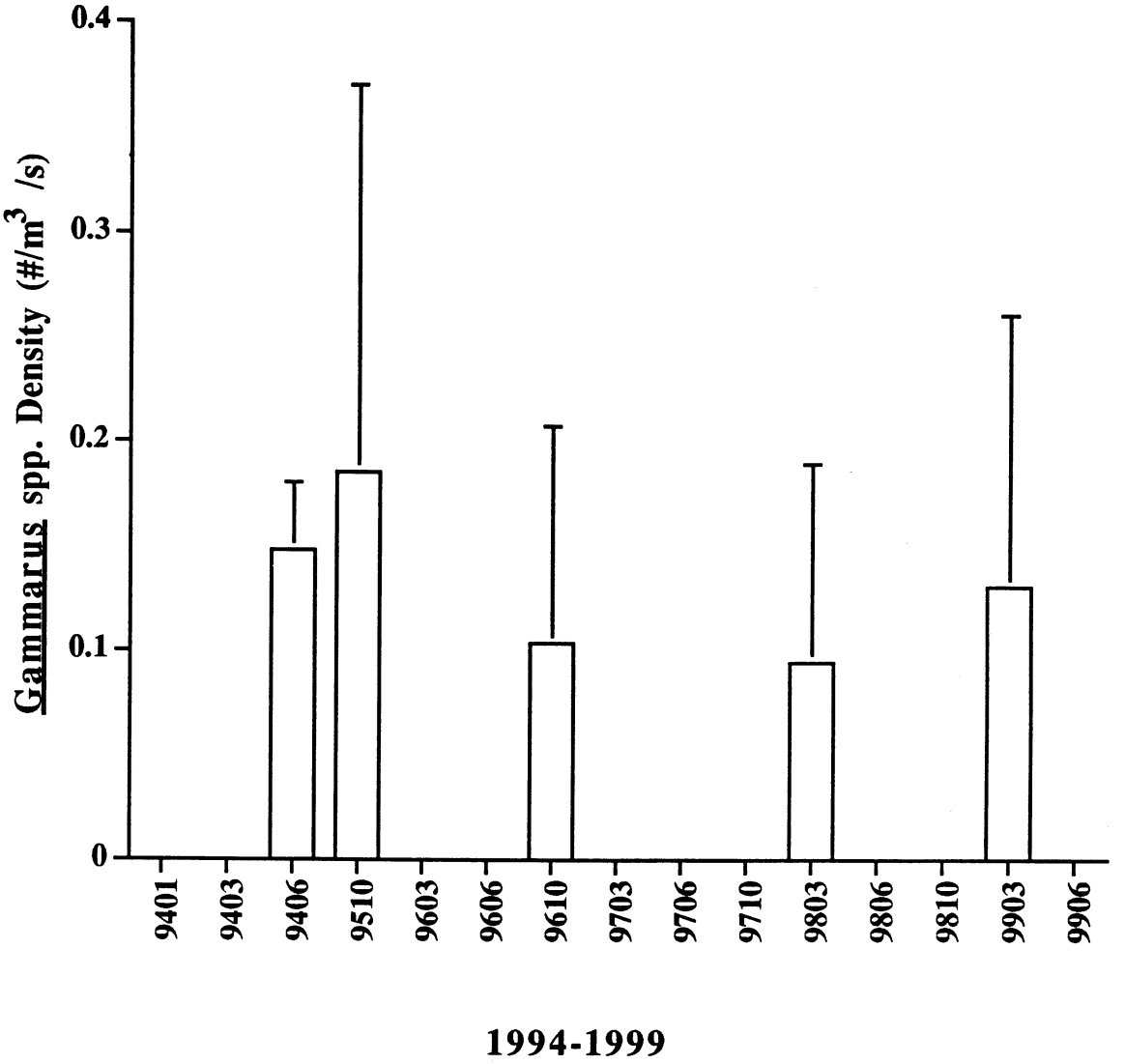

Figure 210. Average CPOM drift densities (#/m^3 /s) for Gammarus spp. collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

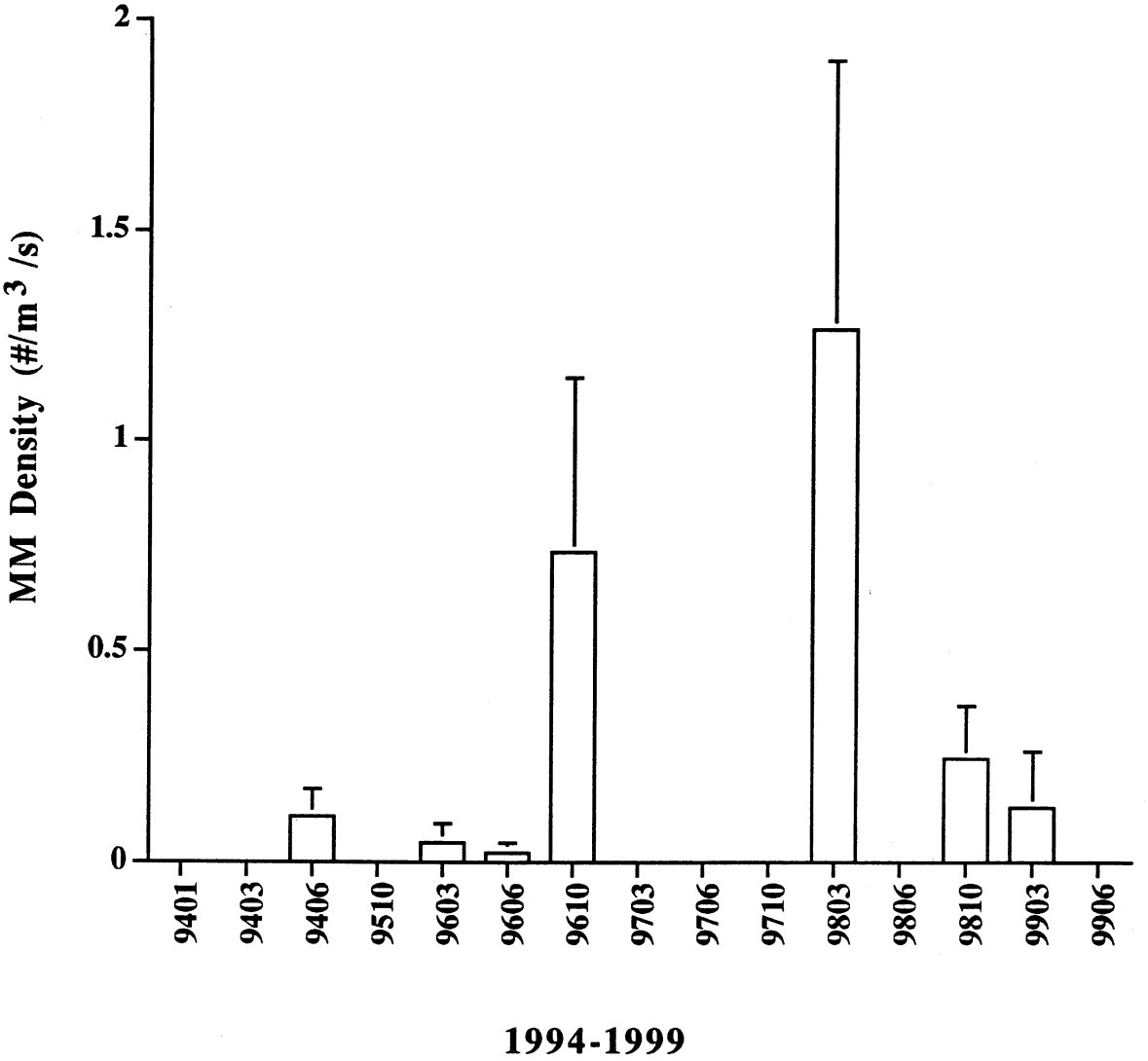

Figure 211. Average CPOM drift densities (#/m^3/s) for miscellaneous macroinvertebrates (MM) collected at Glen Canyon Gauge Rkm -23.2 from January 1994 to June 1999. Error Bars represent (± 1 SE).

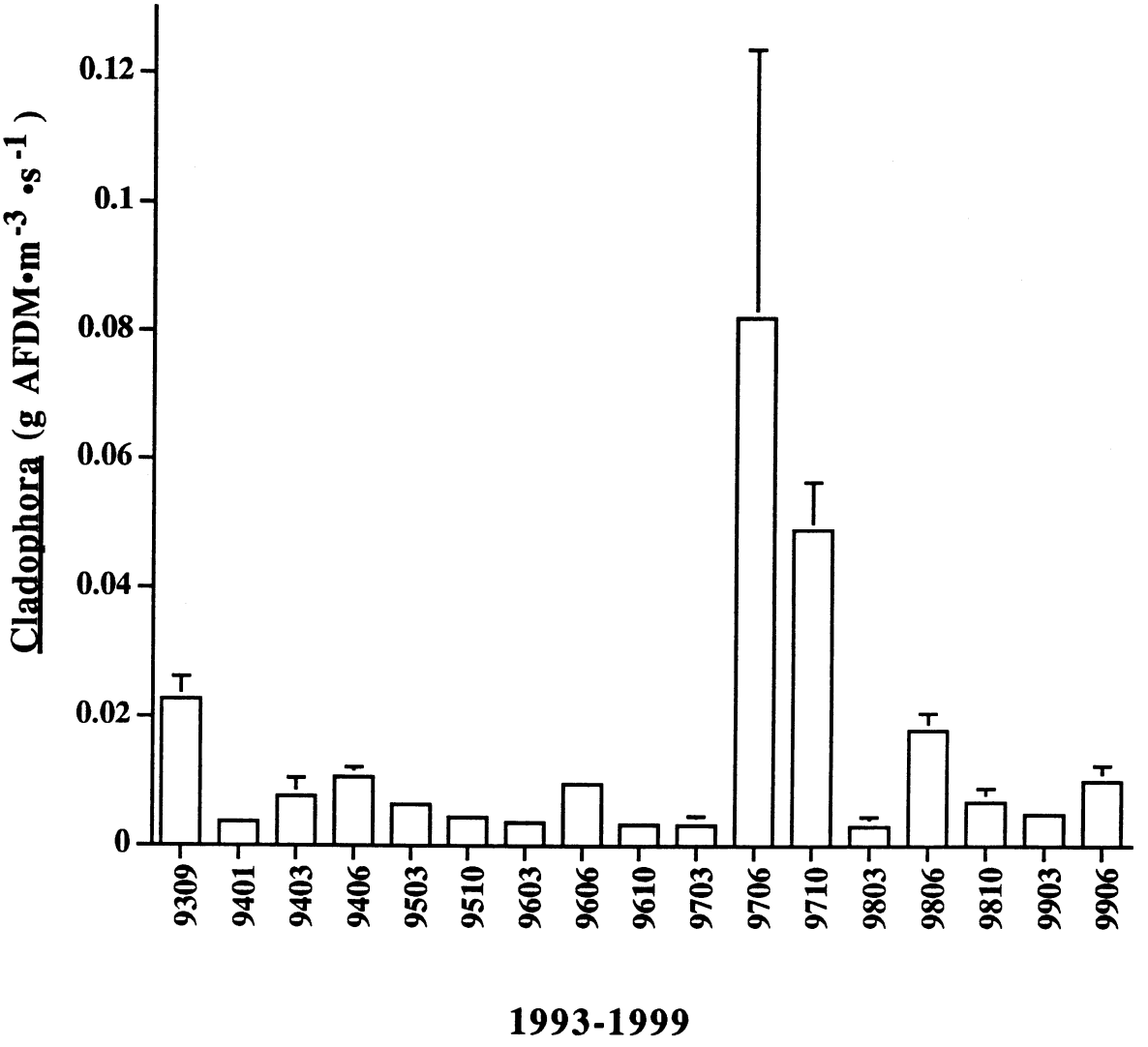

Figure 212. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for Cladophora collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

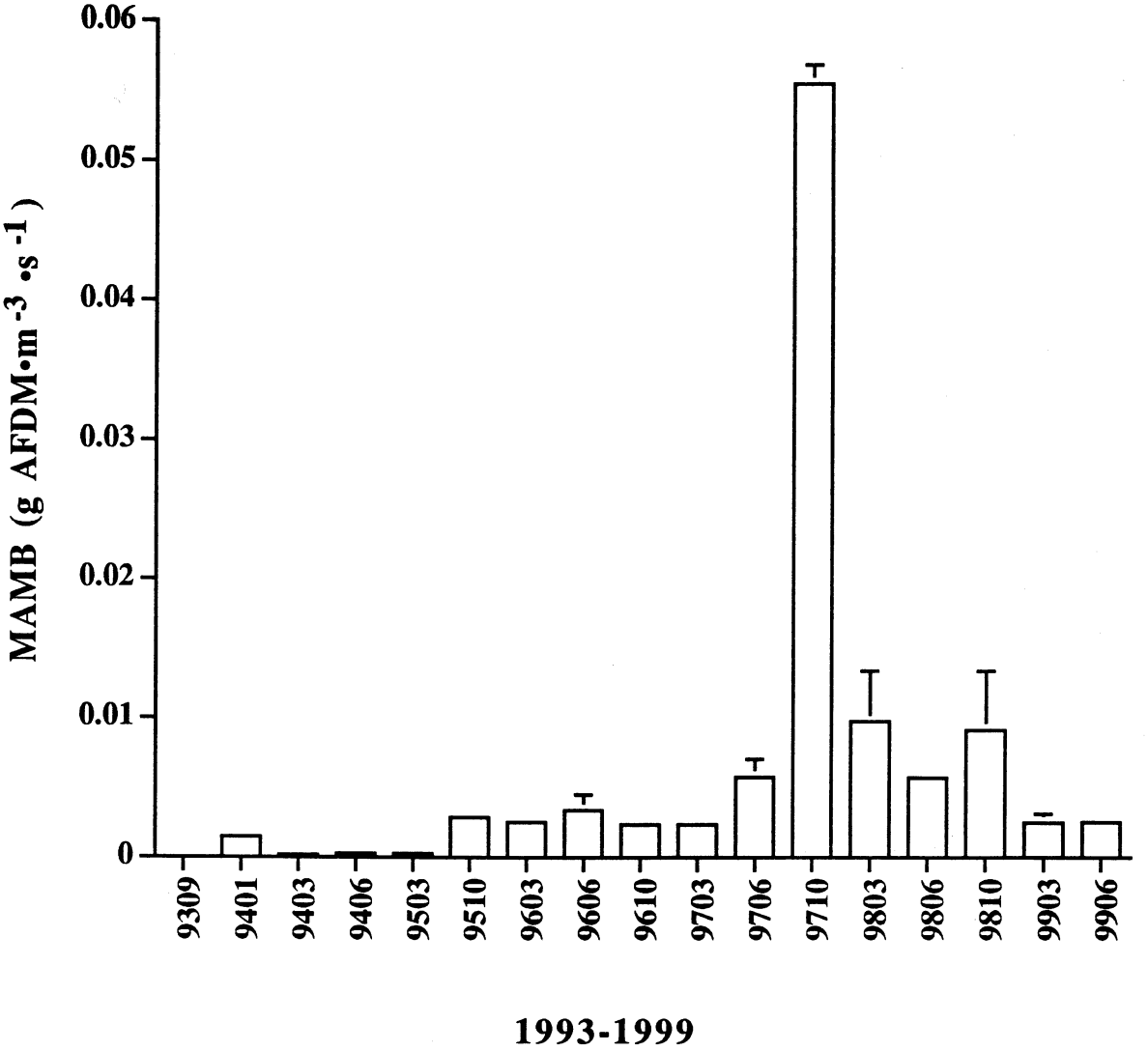

Figure 213. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for miscellaneous algae, macrophytes and bryophytes (MAMB) collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

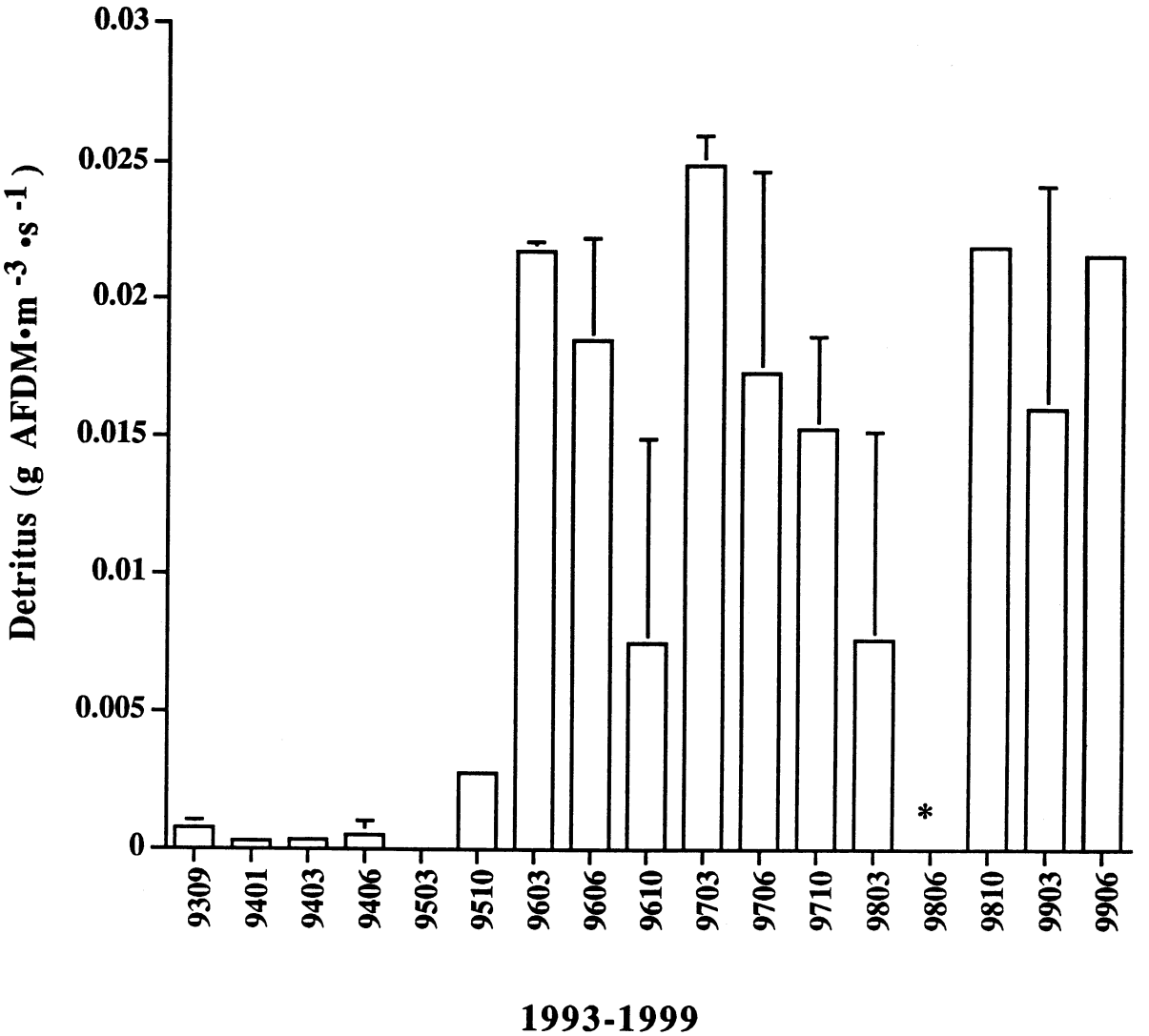

Figure 214. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for detritus collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE). Asterisk (*) represents 0.15 g AFDM•m^{-3}•m^{-1} •s (± 0.12 SE). High values of detritus are due to beaver cuttings.

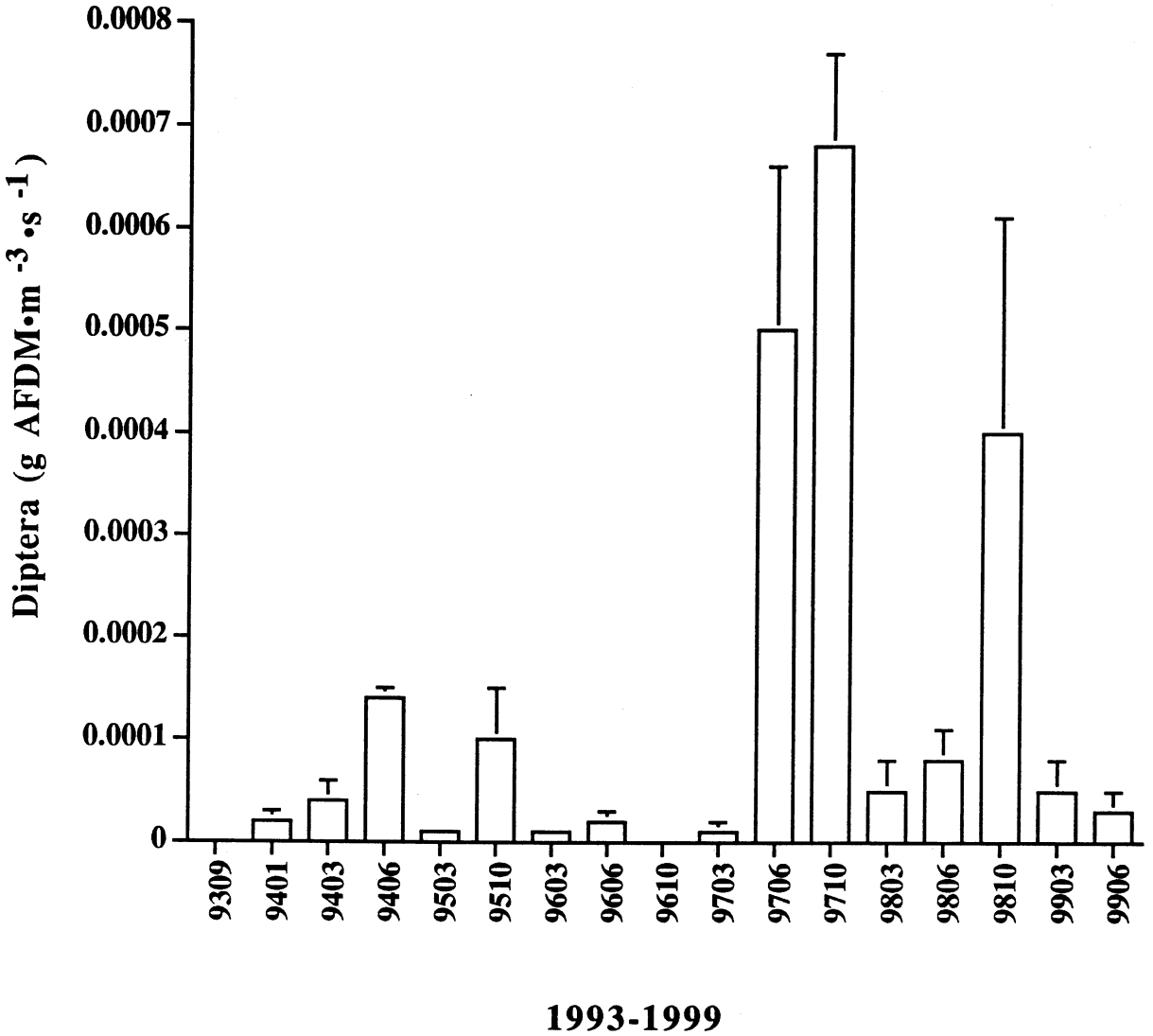

Figure 215. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for aquatic diptera collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

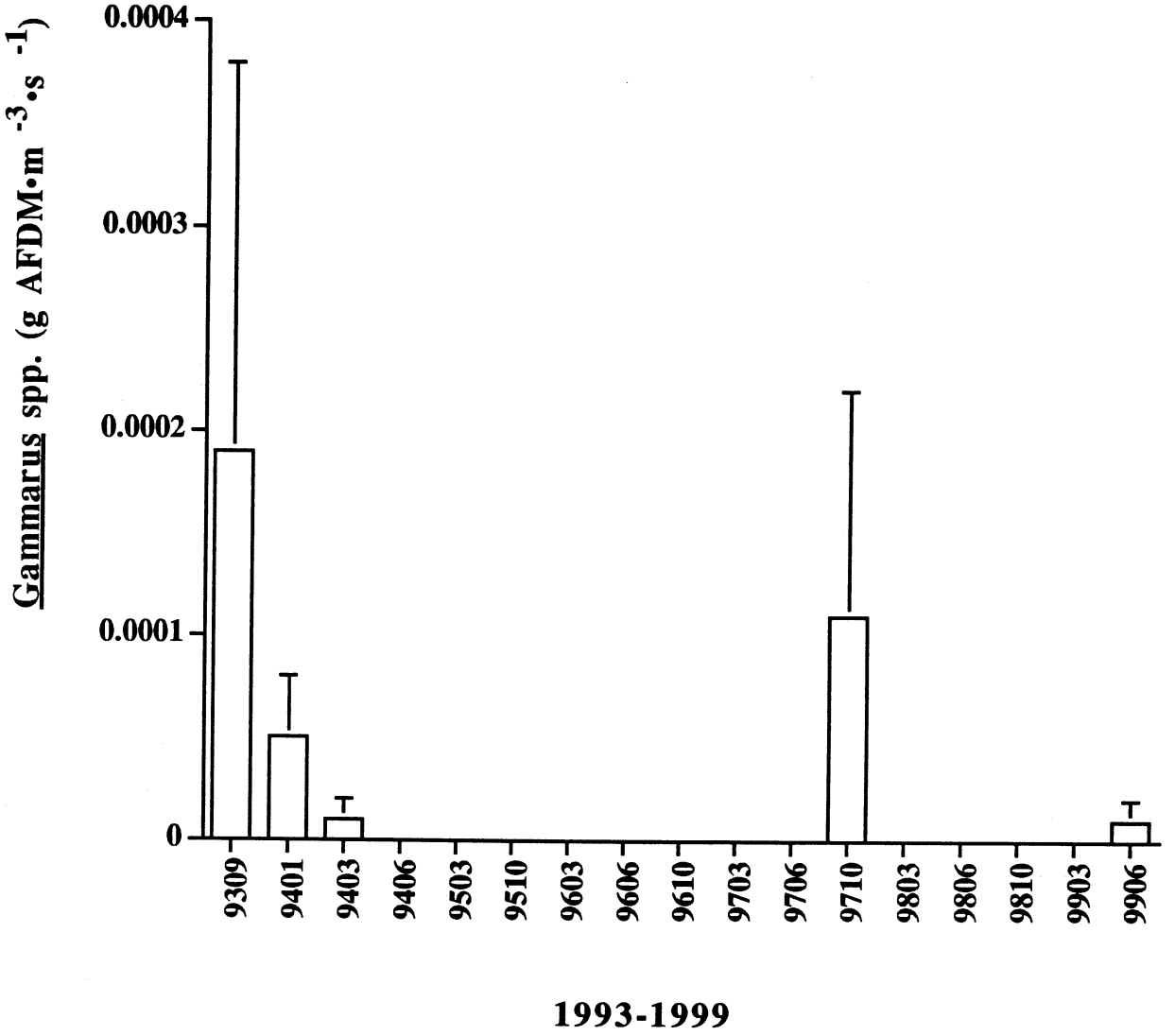

Figure 216. Average CPOM drift mass (g AFDM•m $^{-3}$•s $^{-1}$) for Gammarus spp. collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

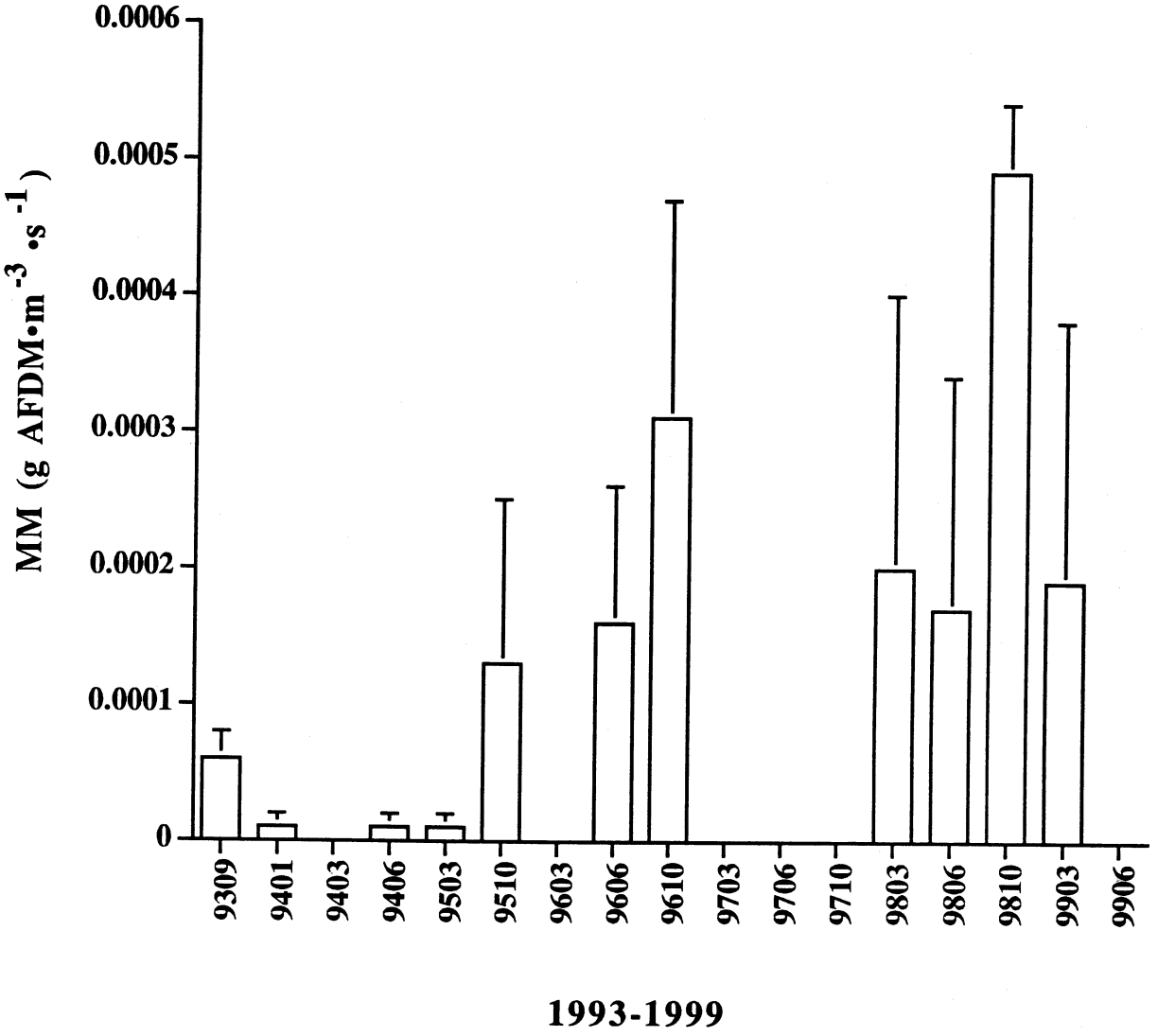

Figure 217. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous macroinvertebrates (MM) collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

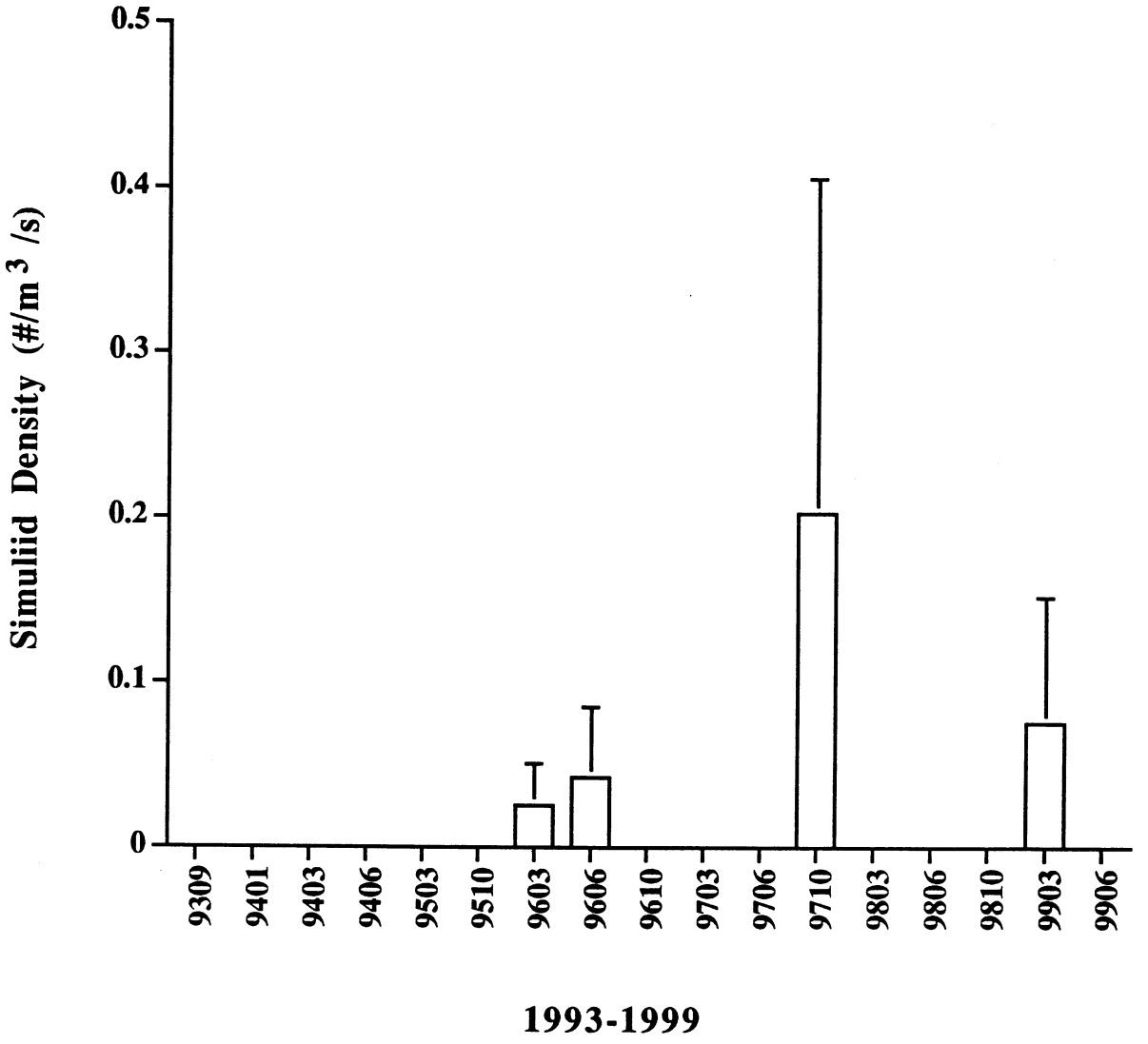

Figure 218. Average CPOM drift densities (#/m^3/s) for Simuliids collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

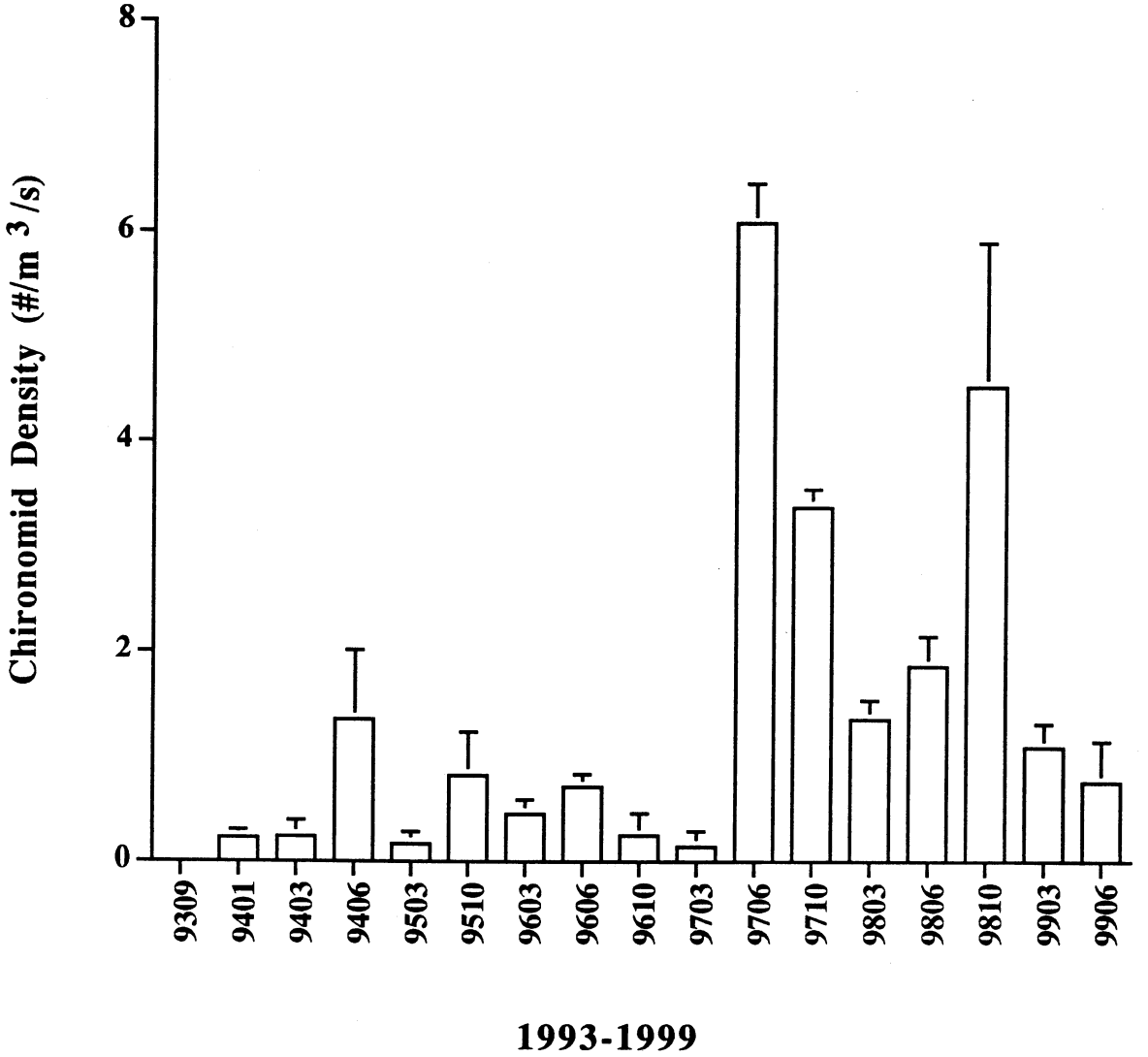

Figure 219. Average CPOM drift densities (#/m^3/s) for Chironomids collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

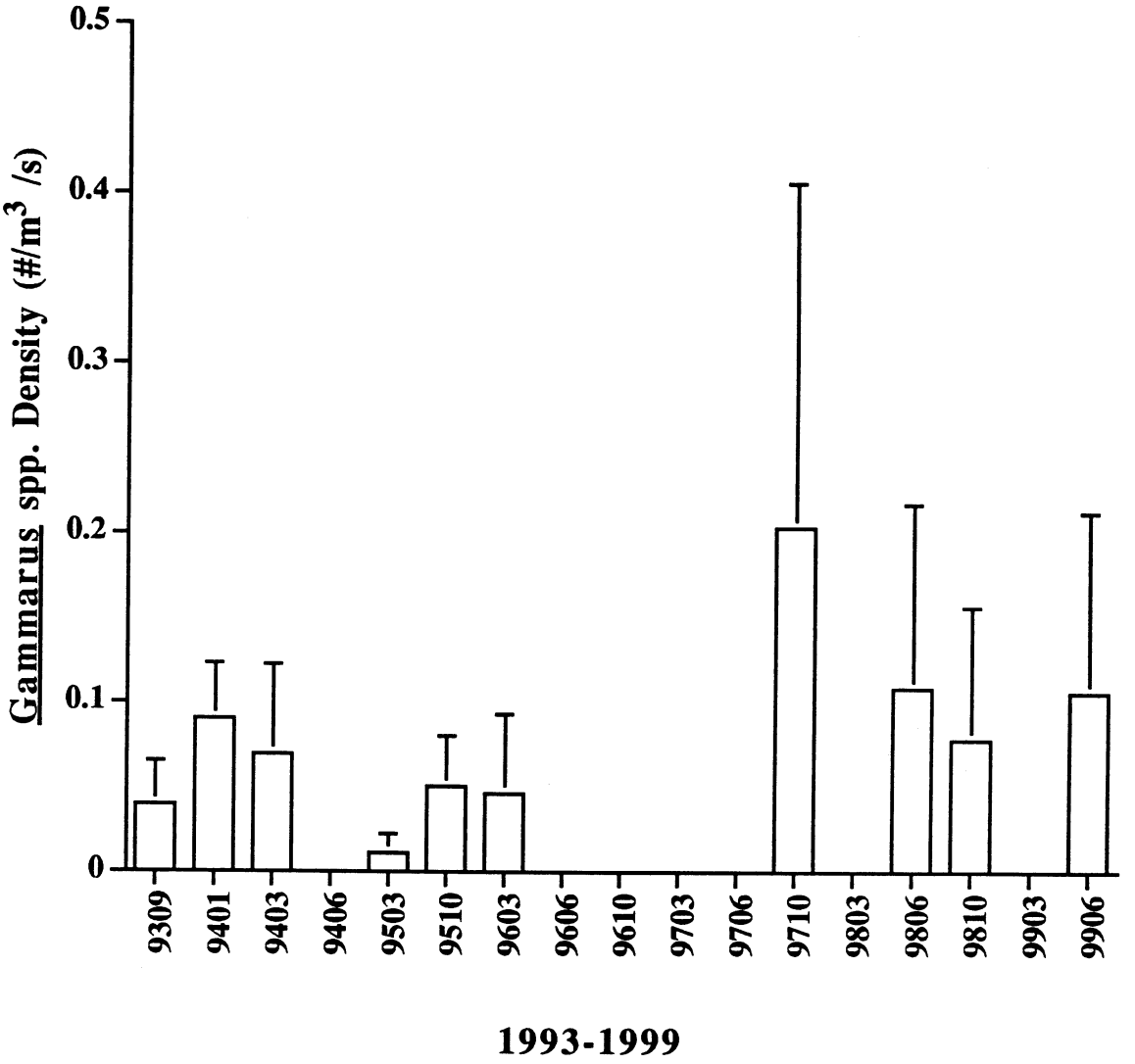

Figure 220. Average CPOM drift densities (#/m^3/s) for Gammarus spp. collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

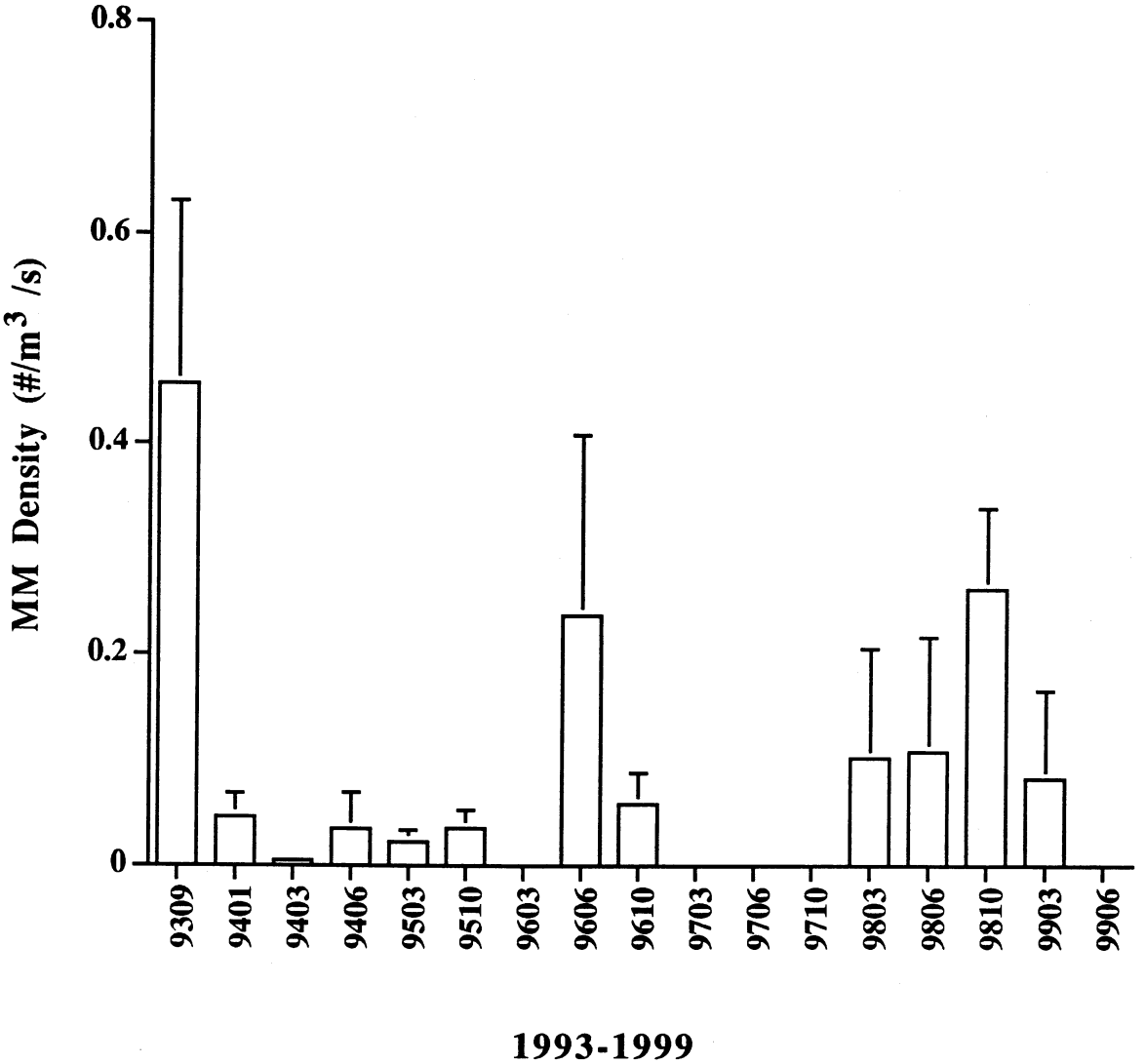

Figure 221. Average CPOM drift densities (#/m^3 /s) for miscellaneous macroinvertebrate (MM) collected at Lees Ferry Rkm 0.0 from September 1993 to June 1999. Error Bars represent (± 1 SE).

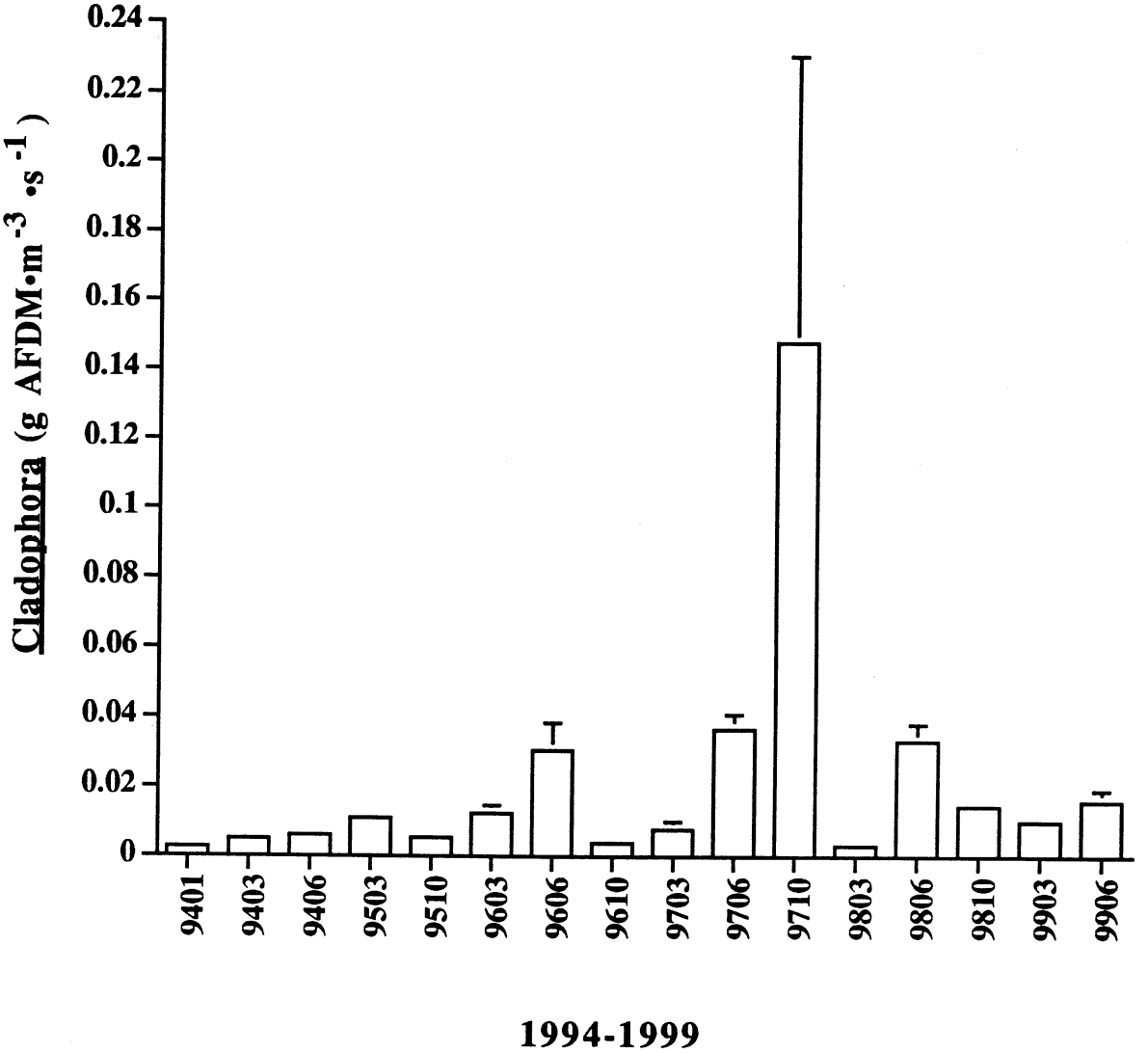

Figure 222. Average CPOM drift mass (g AFDM•m $^{-3}$•s $^{-1}$) for Cladophora collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

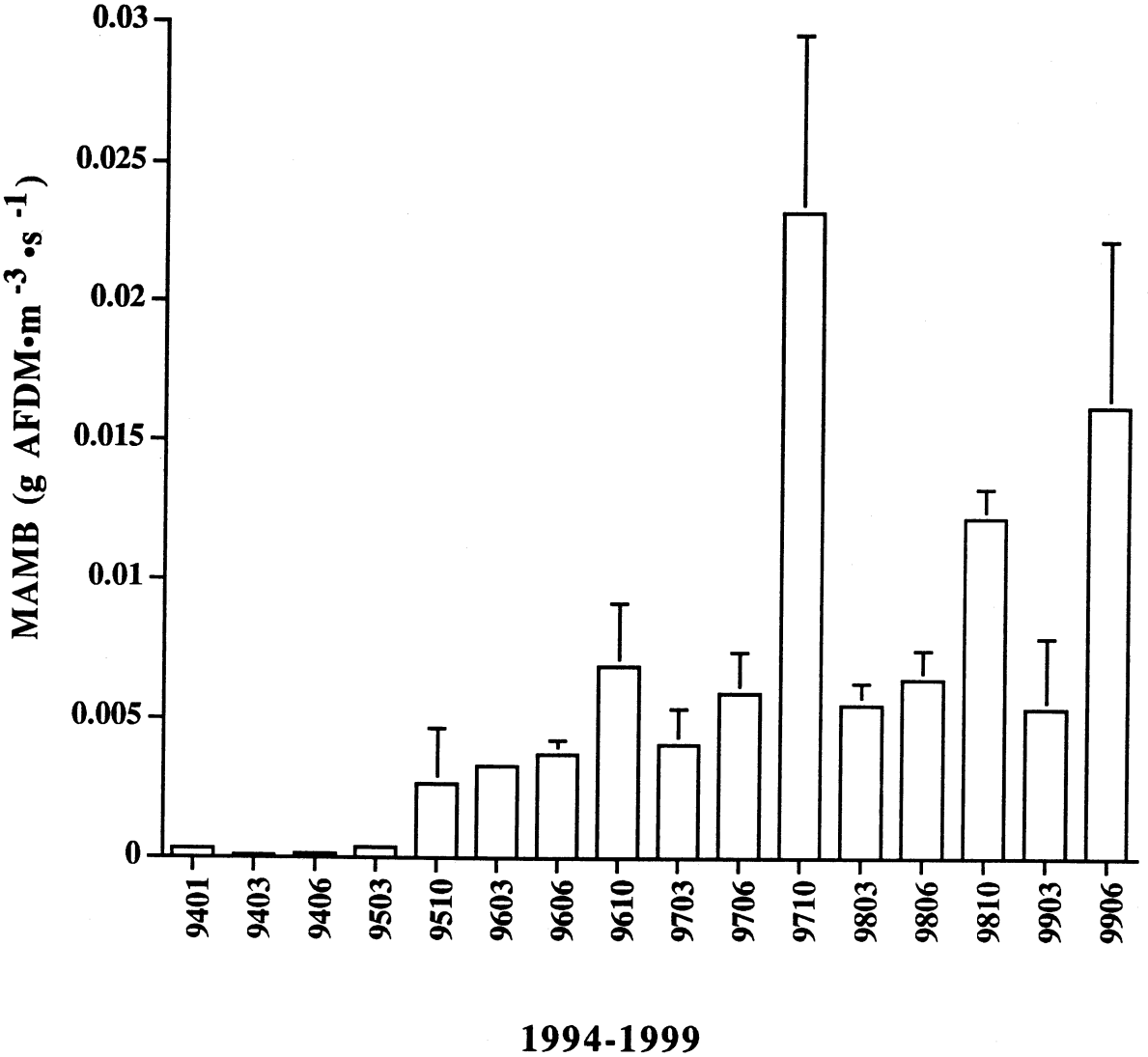

Figure 223. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous algae, macrophytes and bryophytes (MAMB) collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

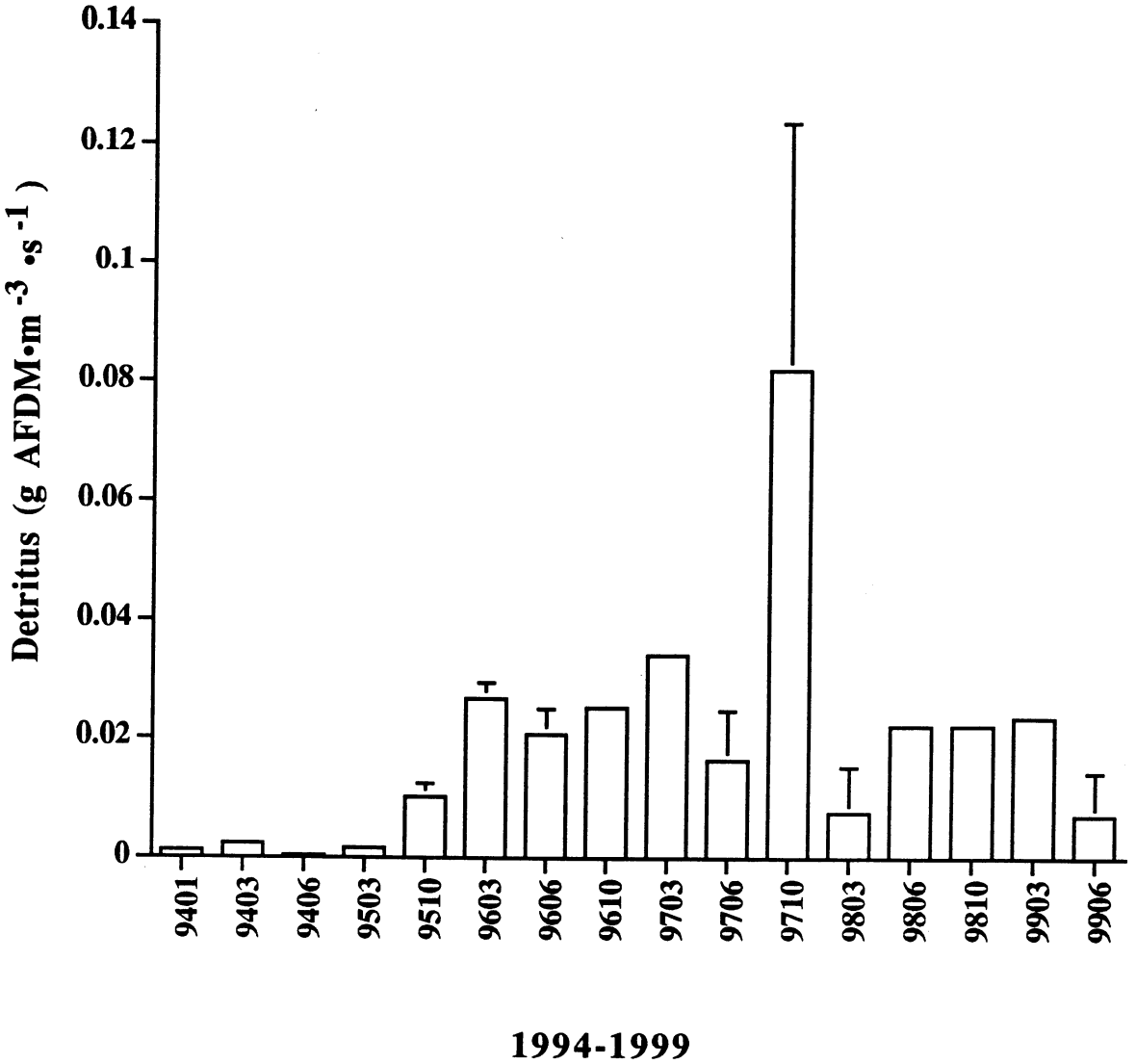

Figure 224. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for detritus collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

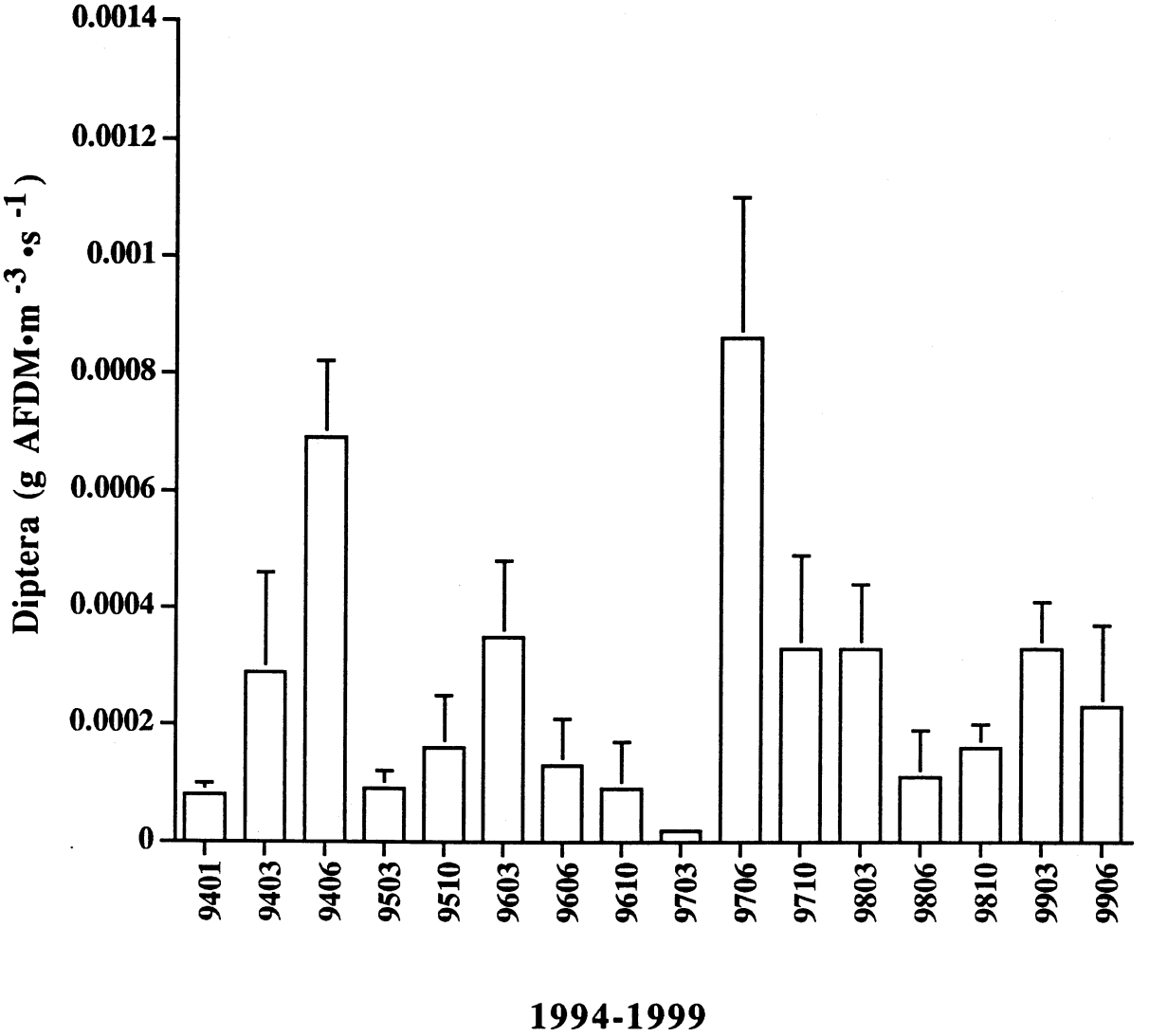

Figure 225. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for aquatic diptera collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

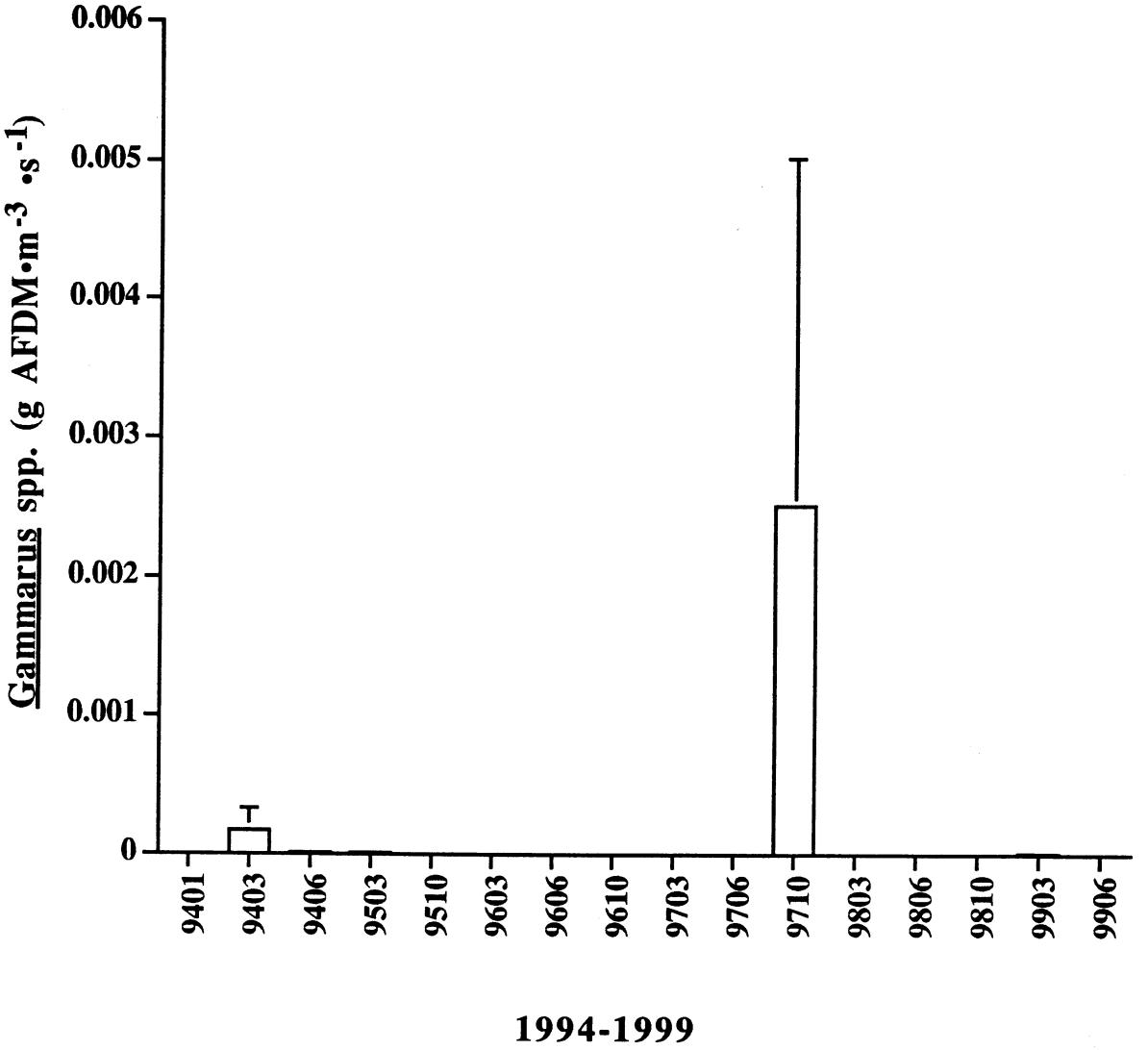

Figure 226. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for Gammarus spp. collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

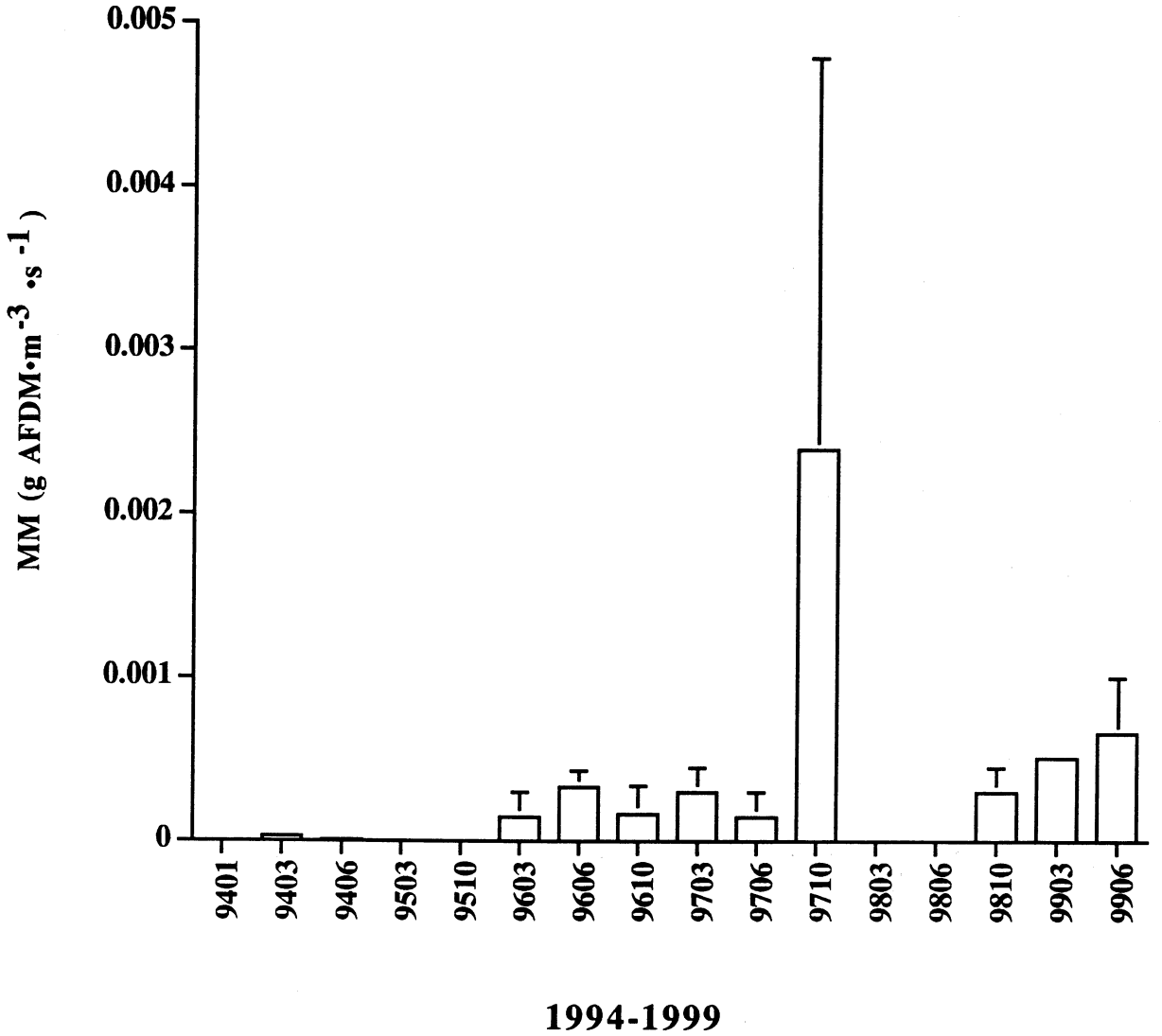

Figure 227. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous macroinvertebrates (MM) collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

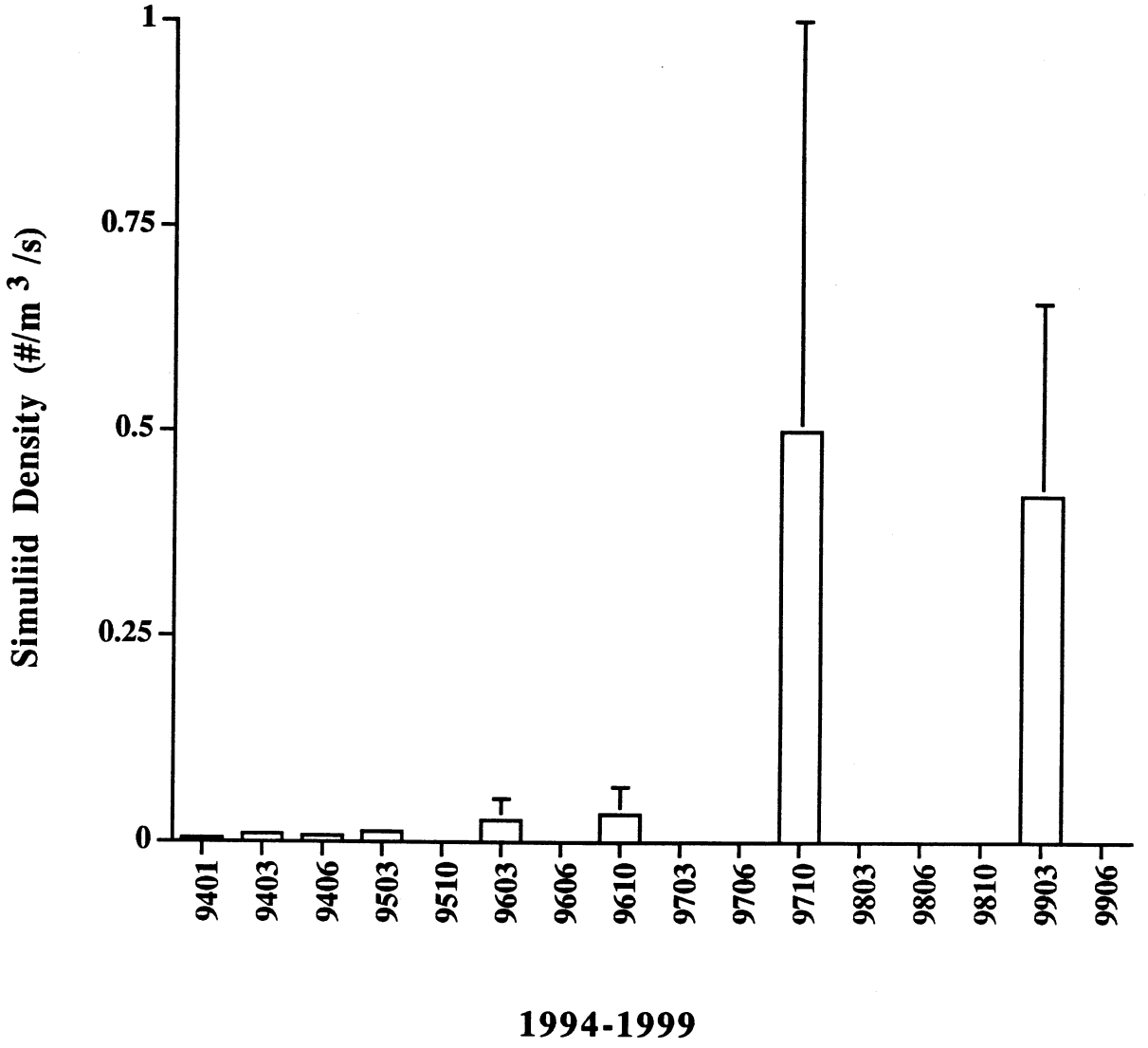

Figure 228. Average CPOM drift densities (#/m^3 /s) for Simuliids collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

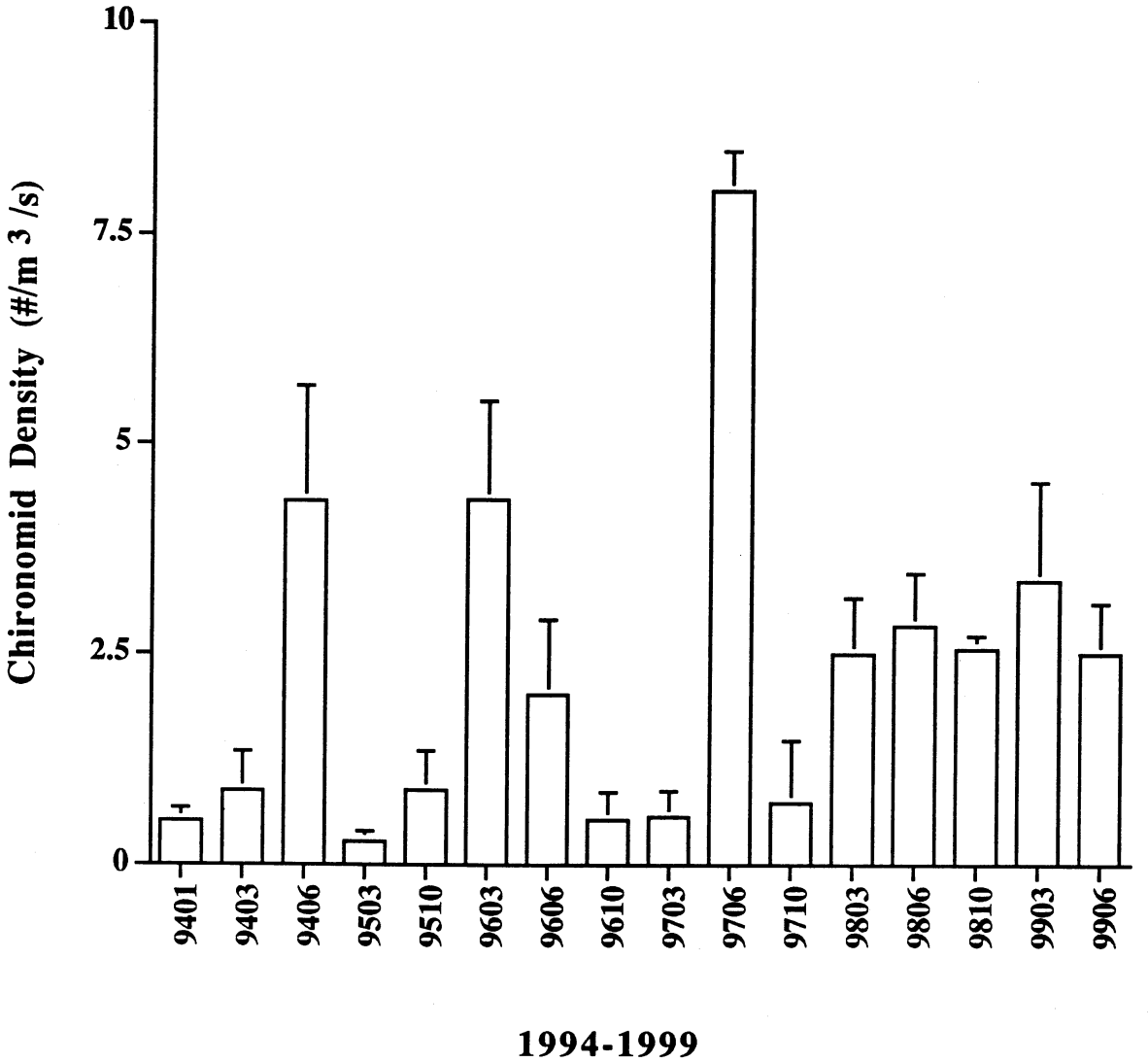

Figure 229. Average CPOM drift densities (#/m^3/s) for Chironomids collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

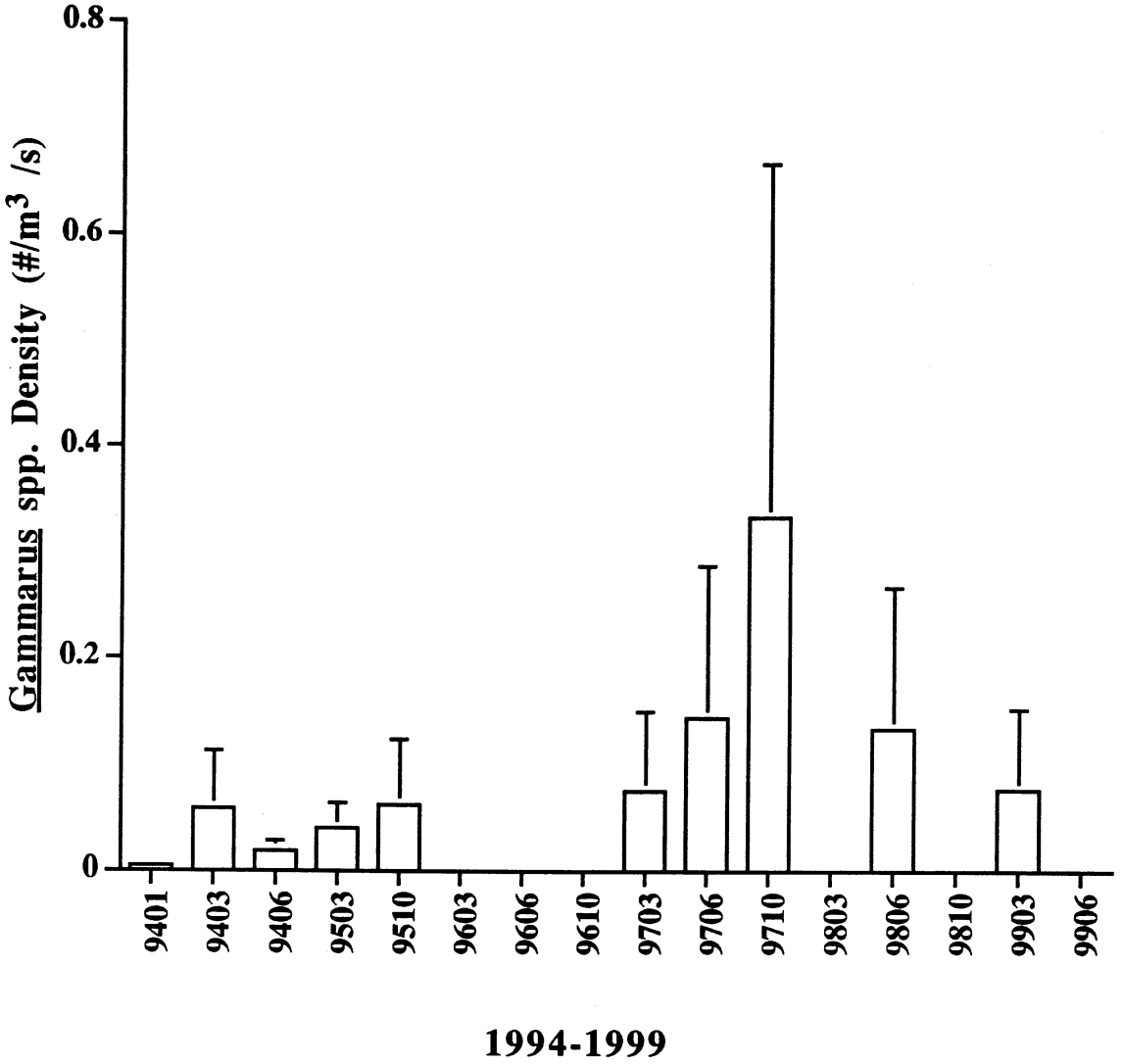

Figure 230. Average CPOM drift densities (#/m^3/s) for Gammarus spp. collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

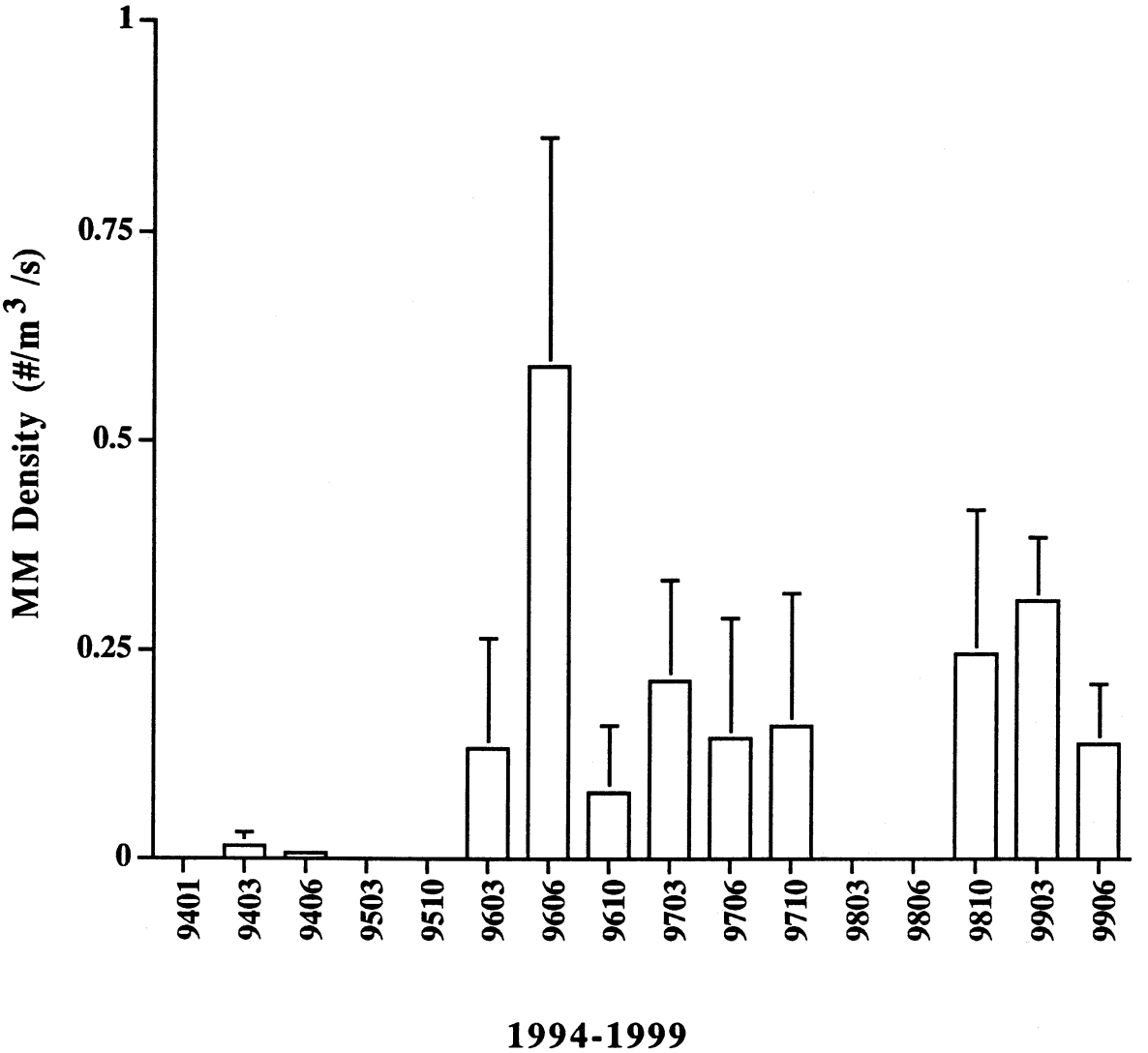

Figure 231. Average CPOM drift densities (#/m^3 /s) for miscellaneous macroinvertebrates (MM) collected at Two-Mile Wash Rkm 2.9 from January 1994 to June 1999. Error Bars represent (± 1 SE).

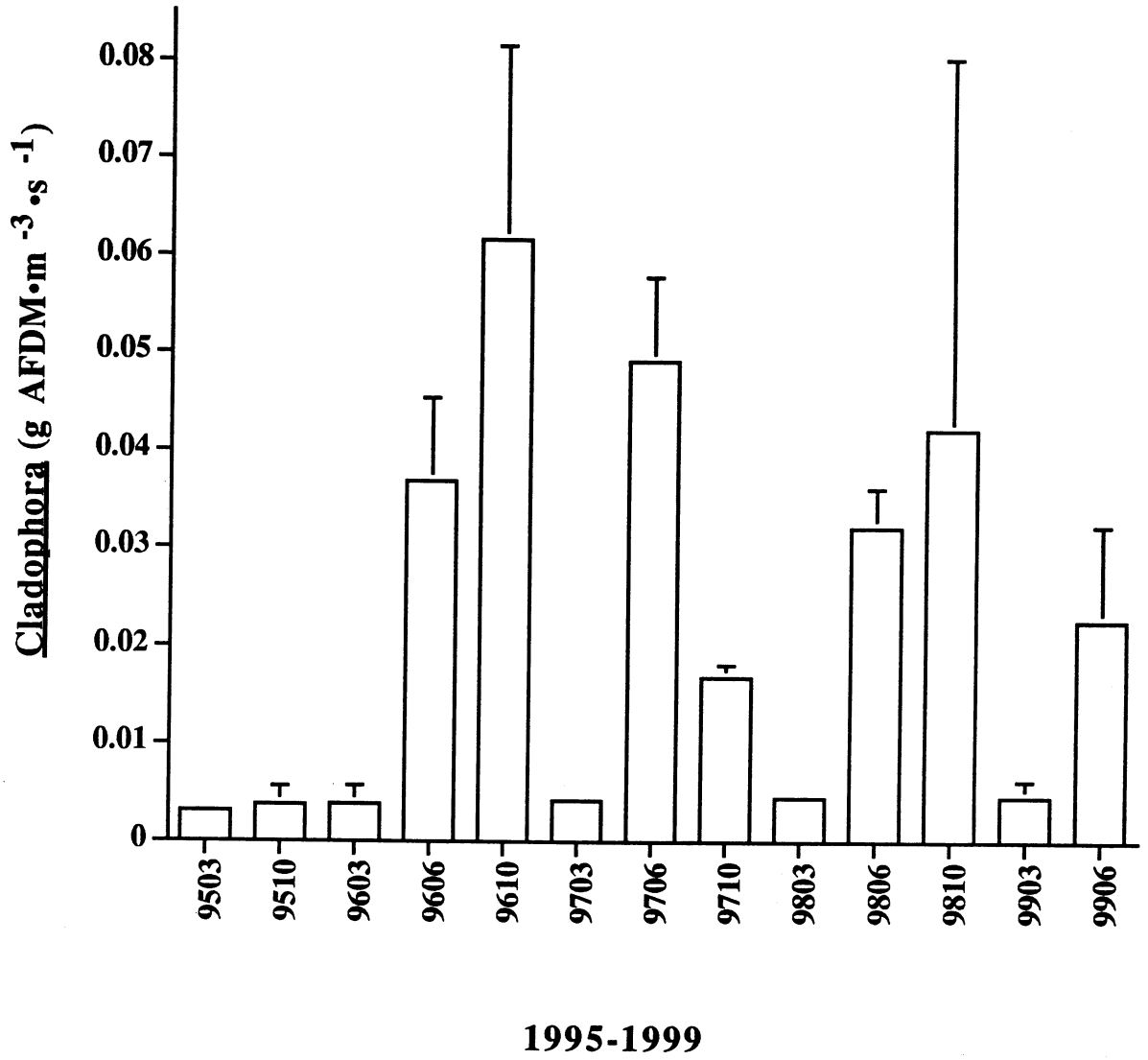

Figure 232. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for Cladophora collected at the Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

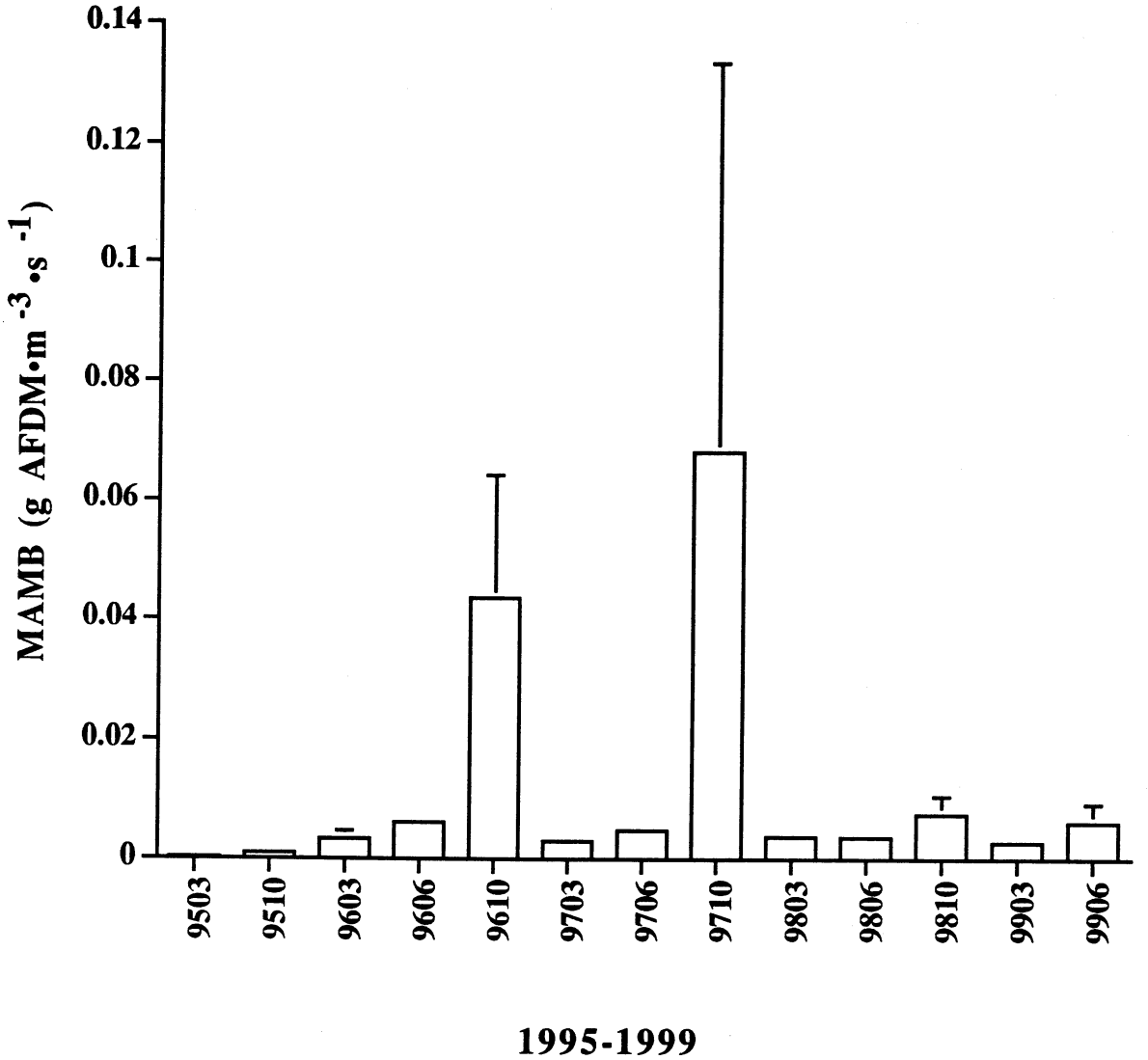

Figure 233. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous algae, macrophytes and bryophytes (MAMB) collected at Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

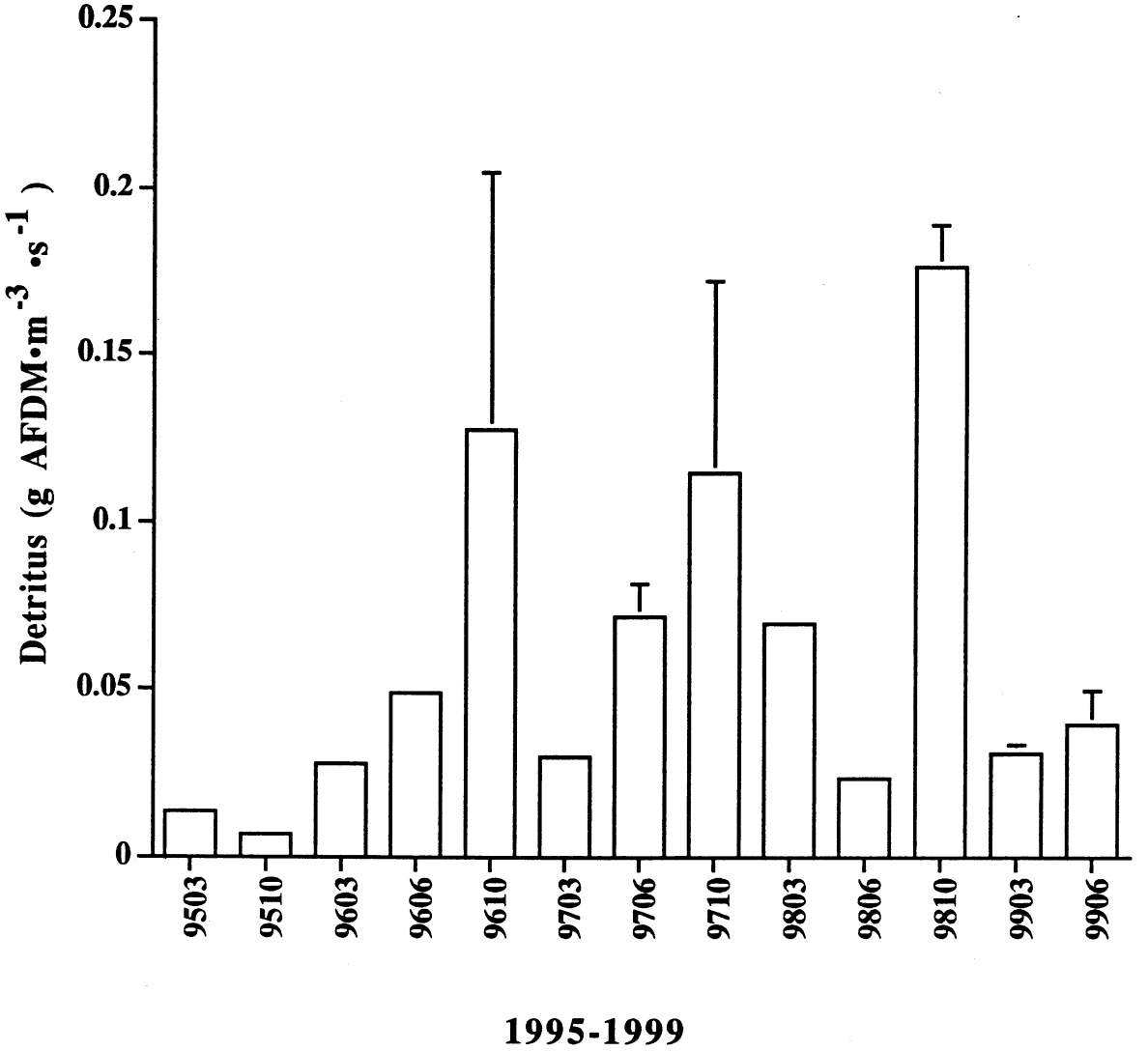

Figure 234. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for detritus collected at the Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

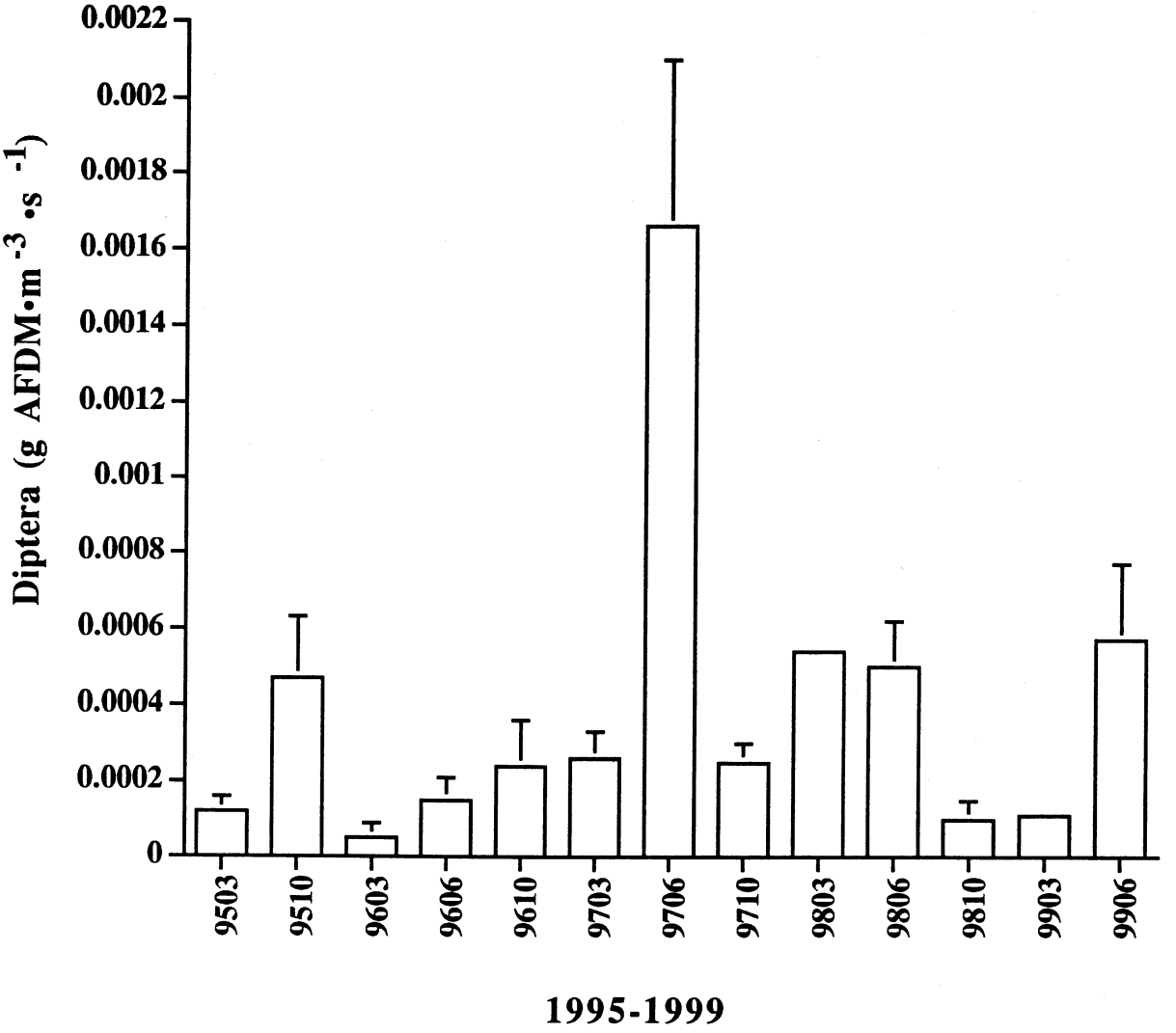

Figure 235. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for aquatic diptera collected at the Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

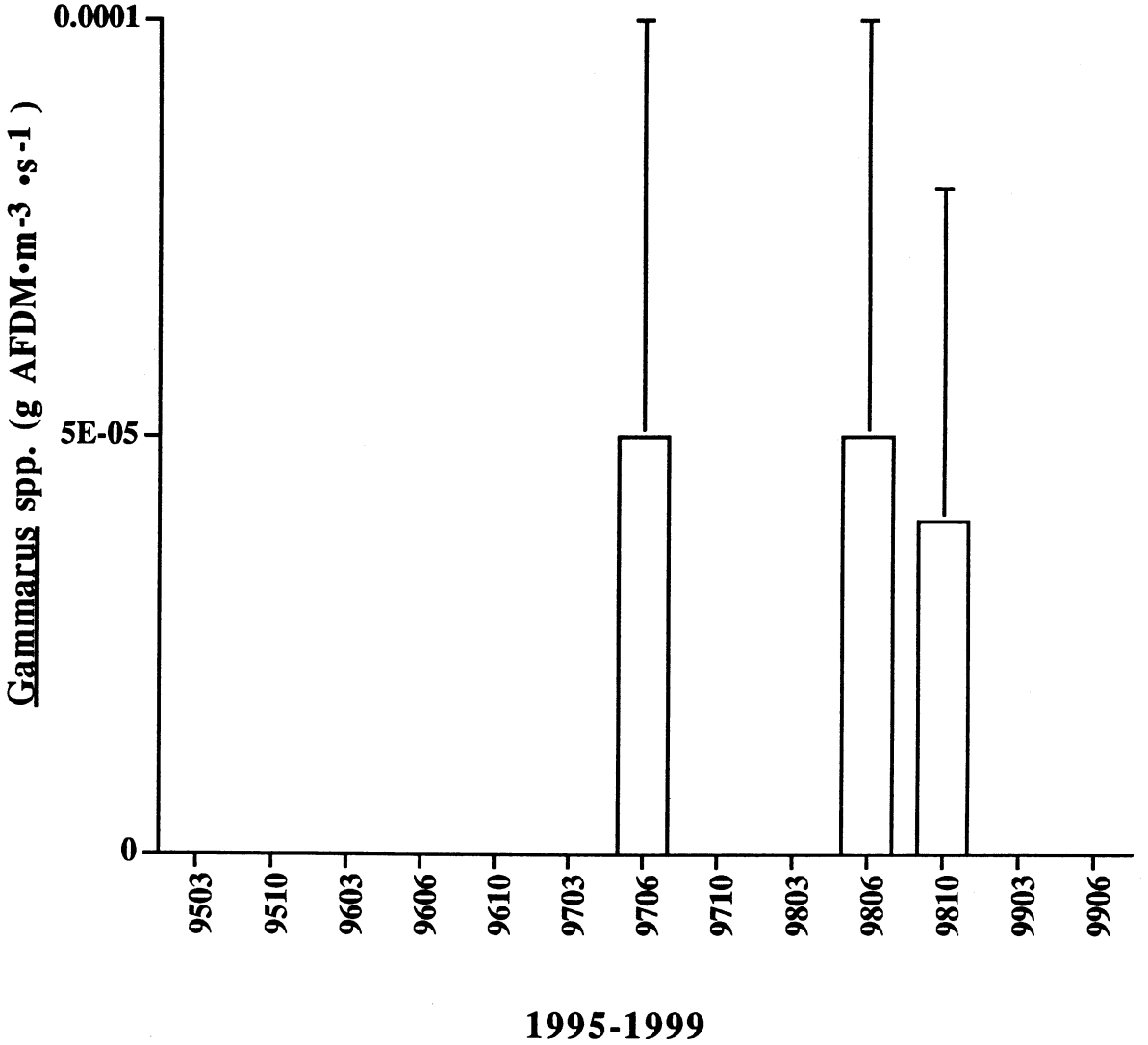

Figure 236. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for Gammarus spp. collected at the Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

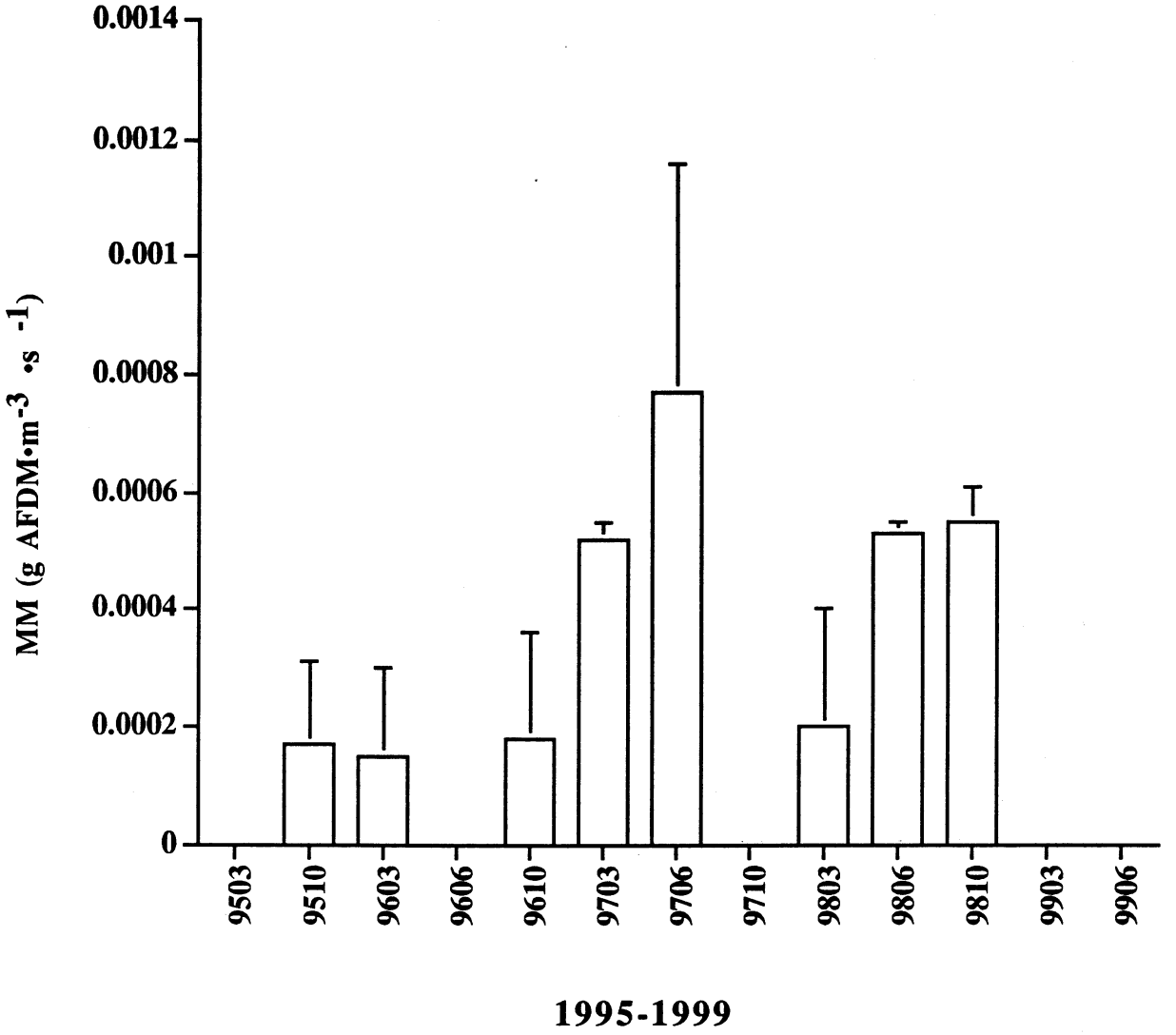

Figure 237. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for miscellaneous macroinvertebrates (MM) collected at the Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

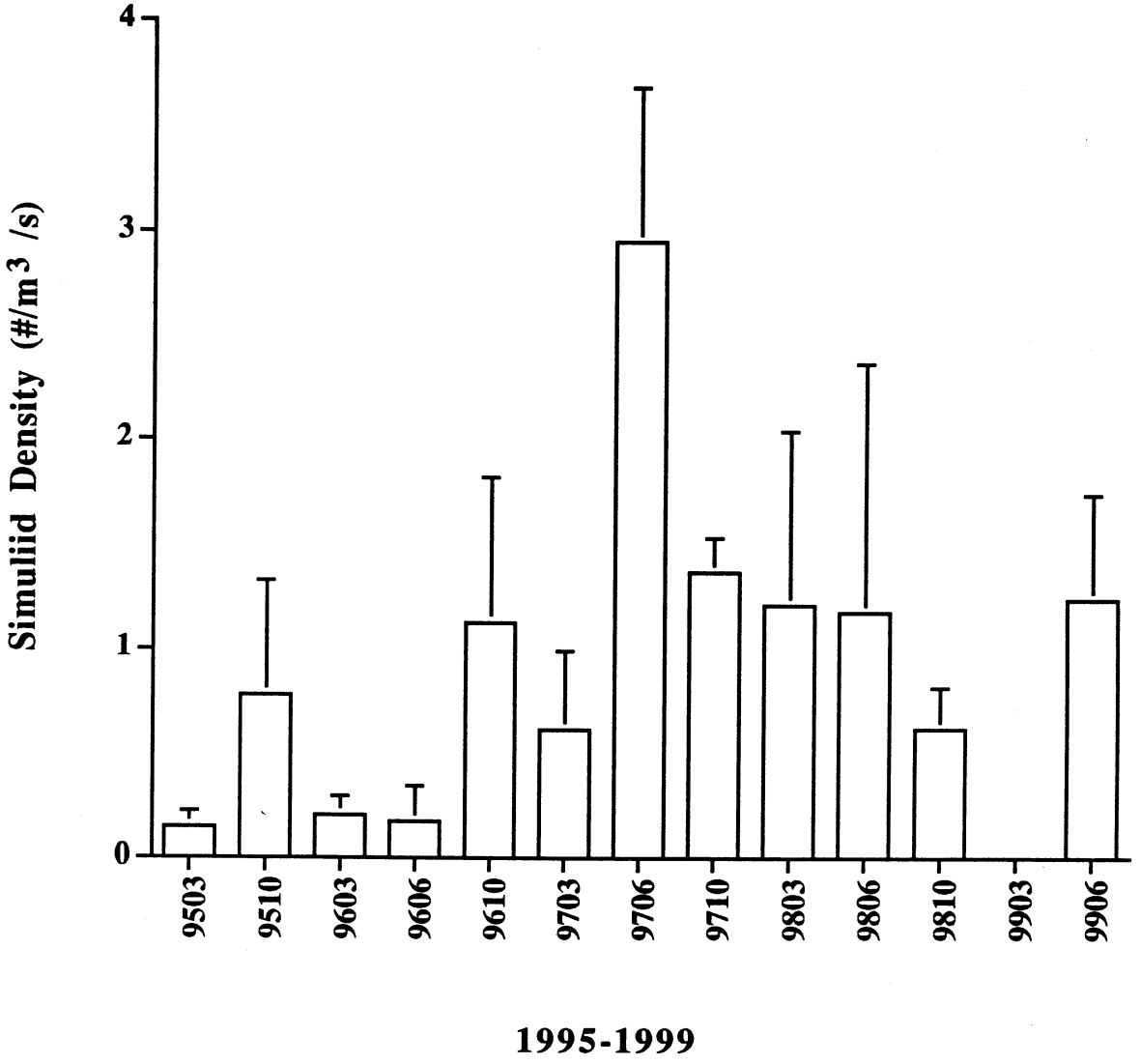

Figure 238. Average CPOM drift densities (#/m^3 /s) for Simuliids collected at Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

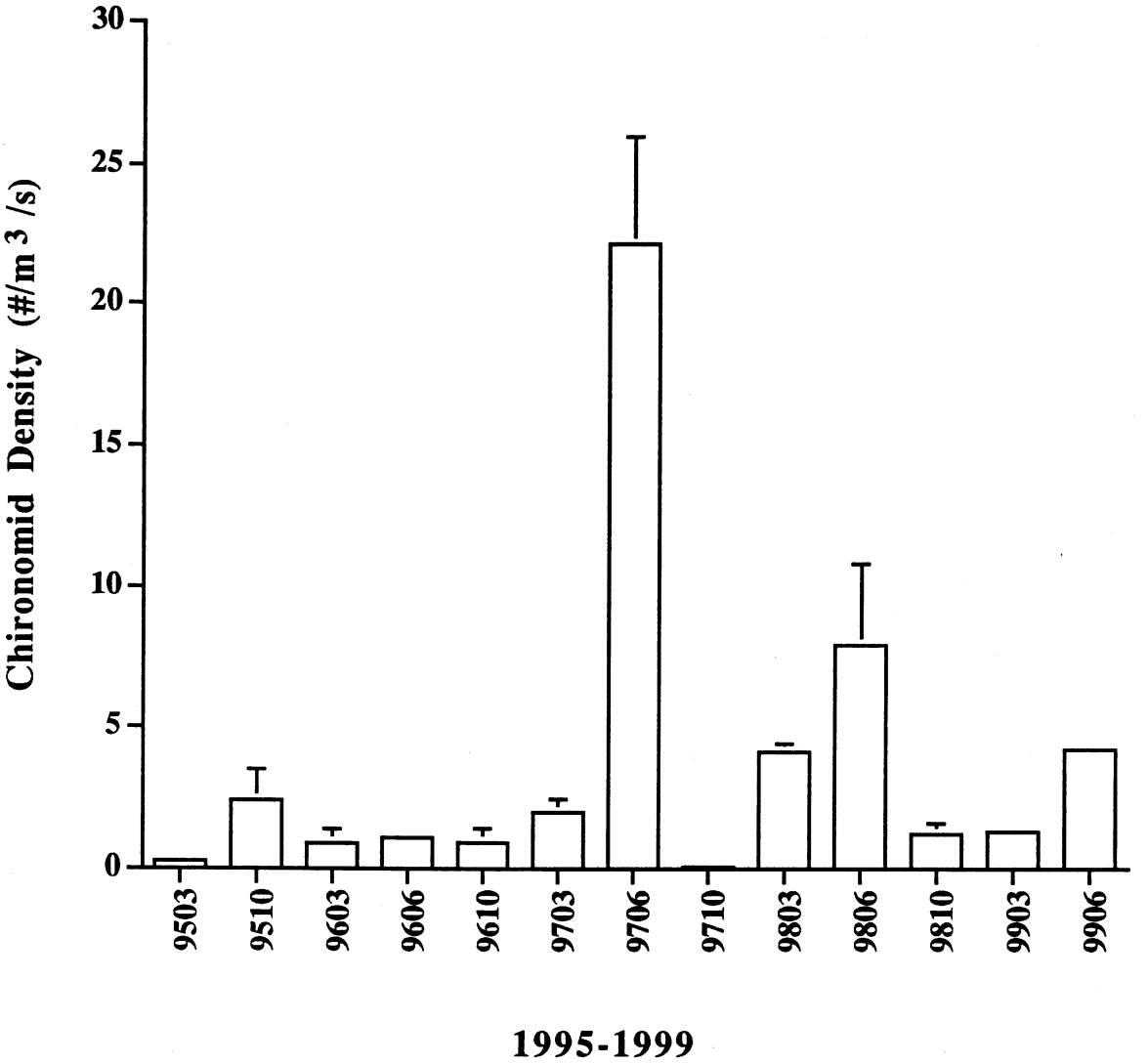

Figure 239. Average CPOM drift densities (#/m^3/s) for Chironomids collected at Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

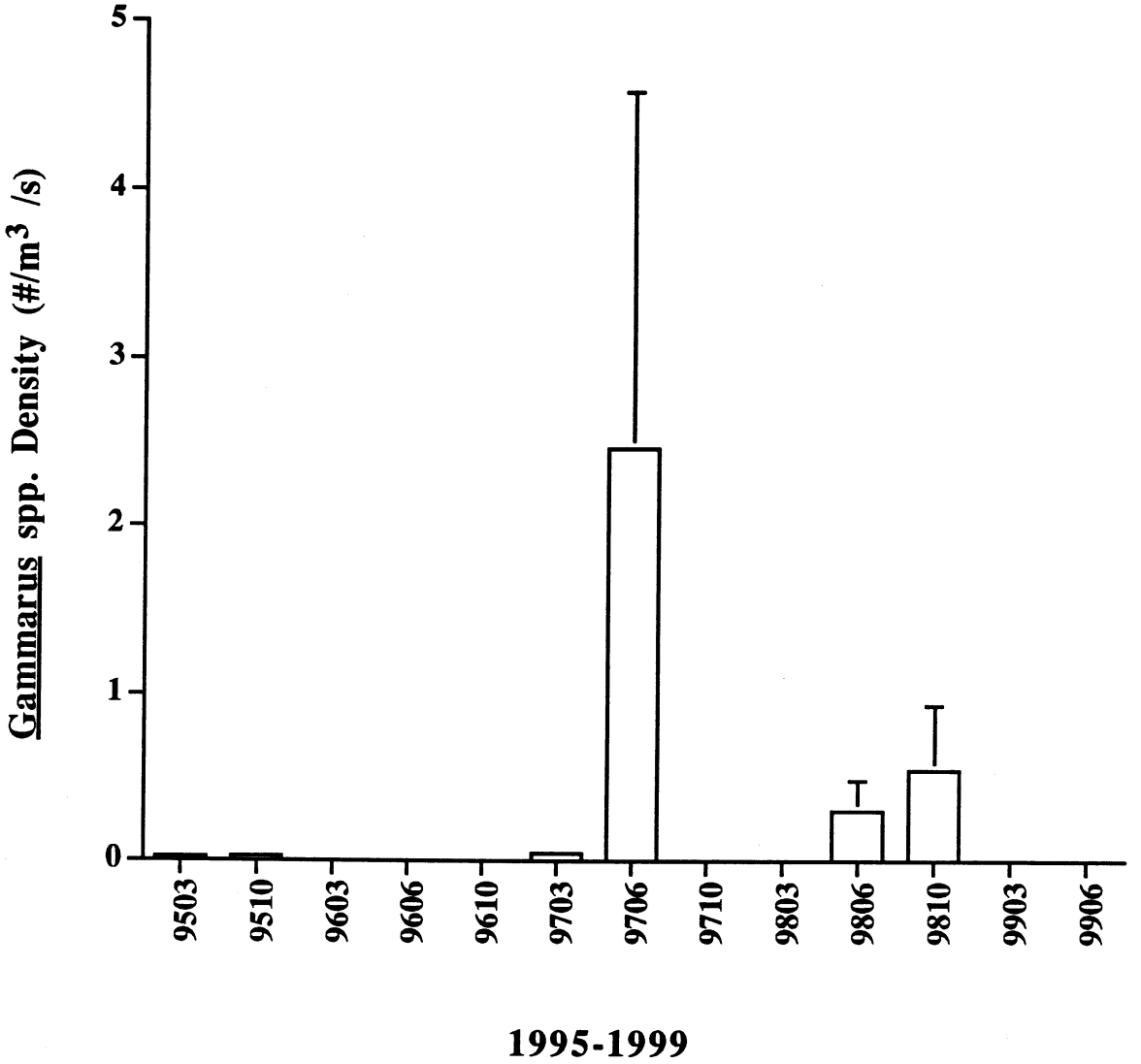

Figure 240. Average CPOM drift densities (#/m^3 /s) for Gammarus spp. collected at Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

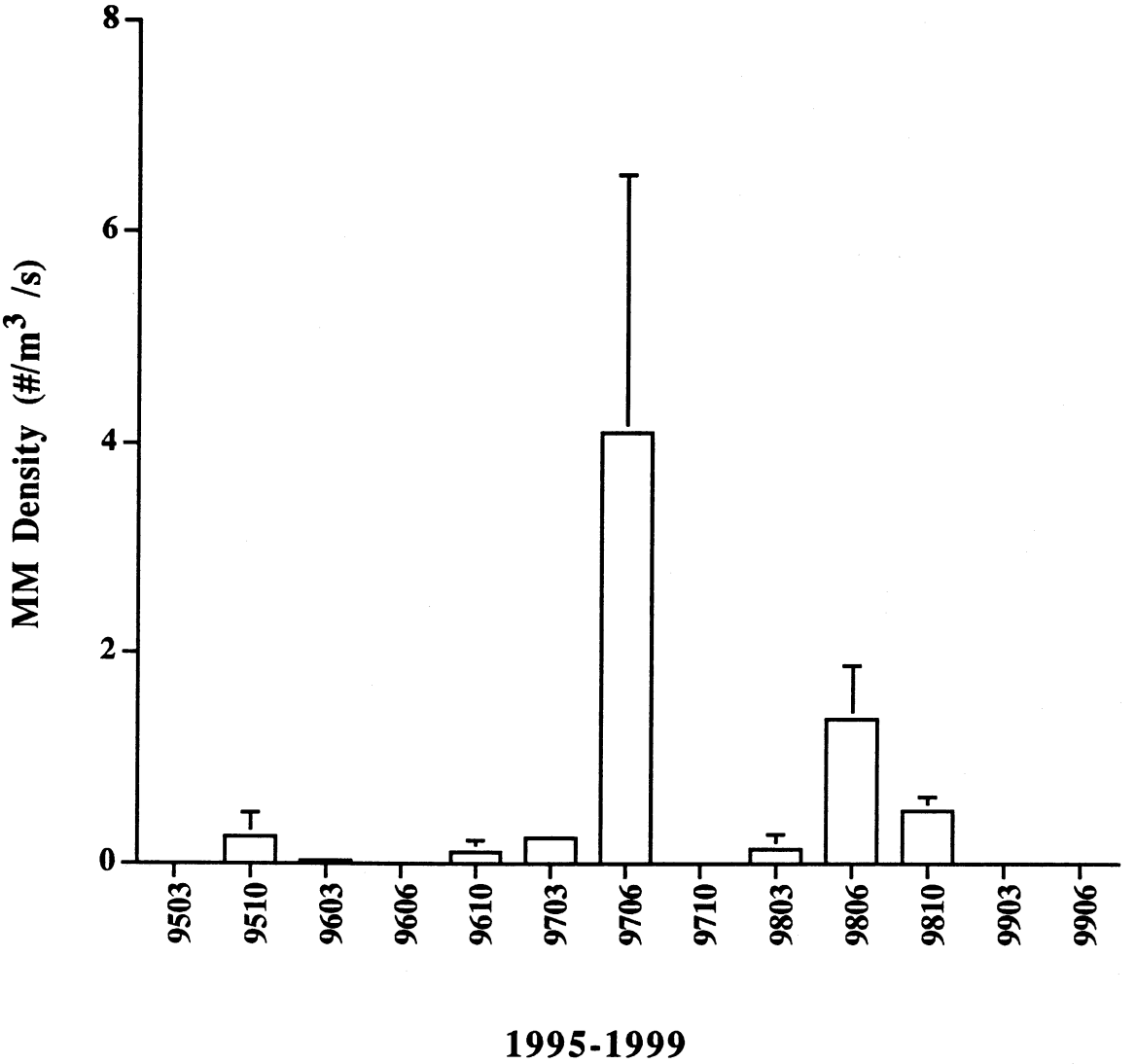

Figure 241. Average CPOM drift densities (#/m^3/s) for miscellaneous macroinvertebrates (MM) collected at Gauge above LCR Rkm 98.4 from March 1995 to June 1999. Error Bars represent (± 1 SE).

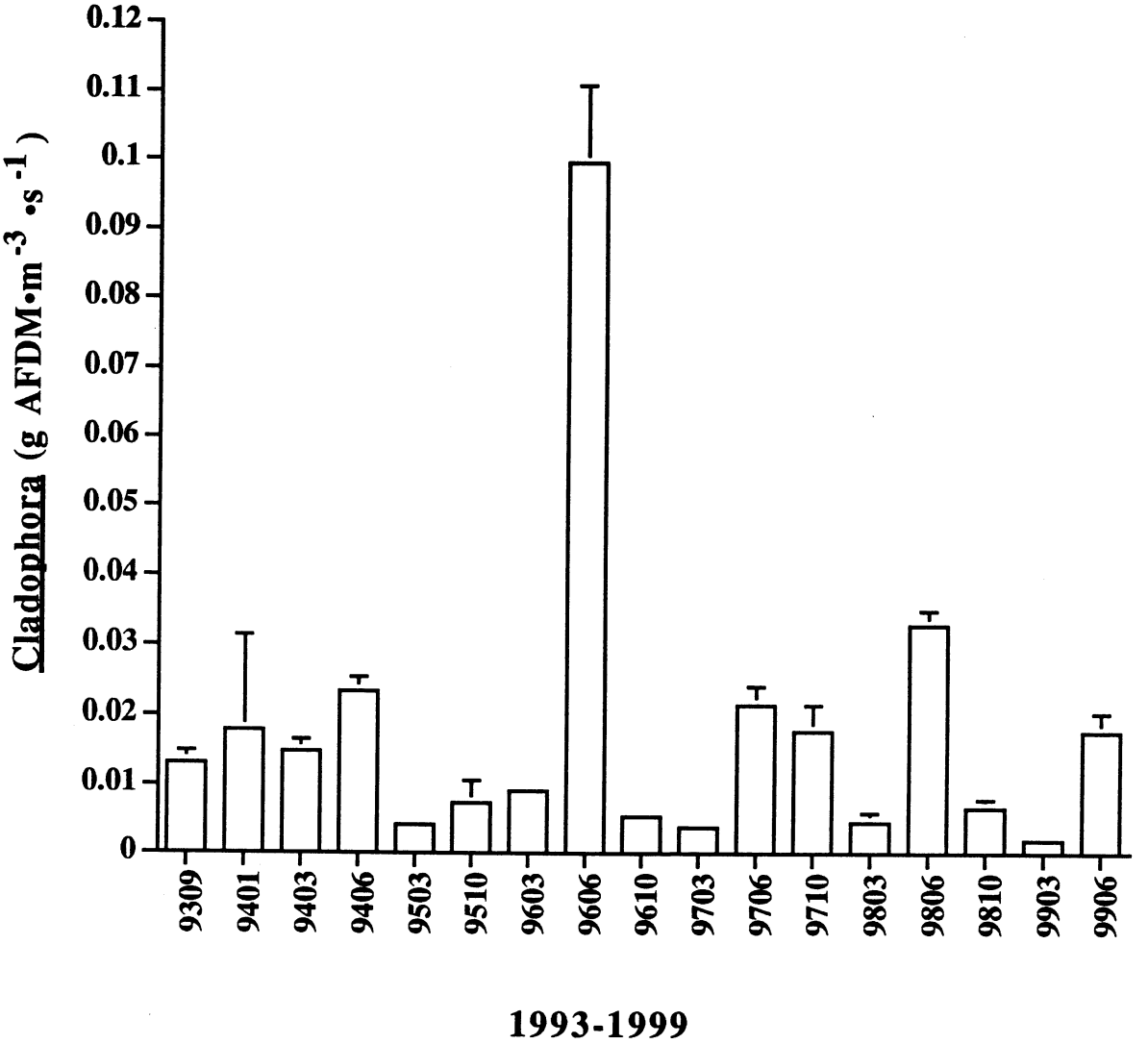

Figure 242. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for Cladophora collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

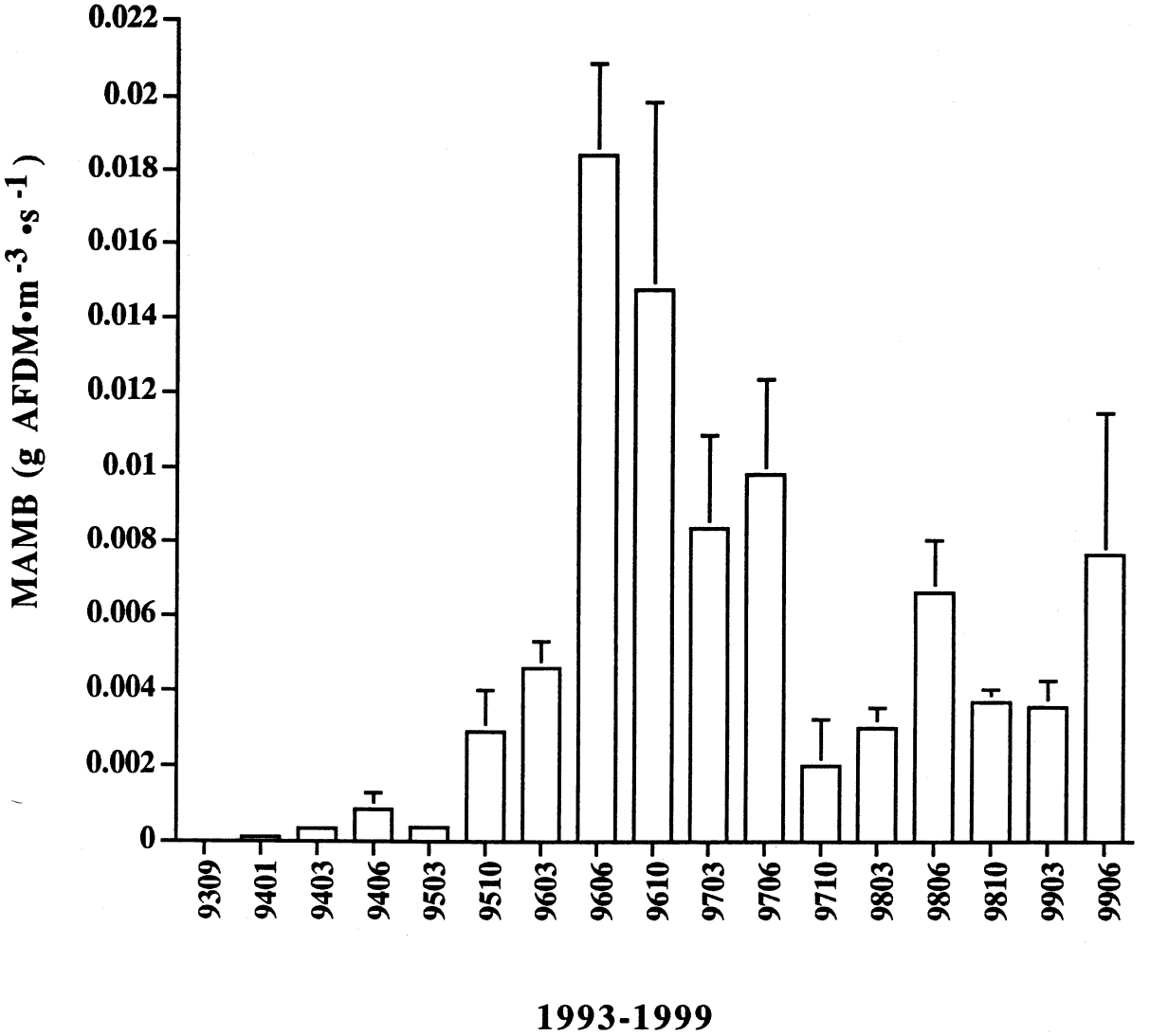

Figure 243. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous algae, macrophytes and bryophytes (MAMB) collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

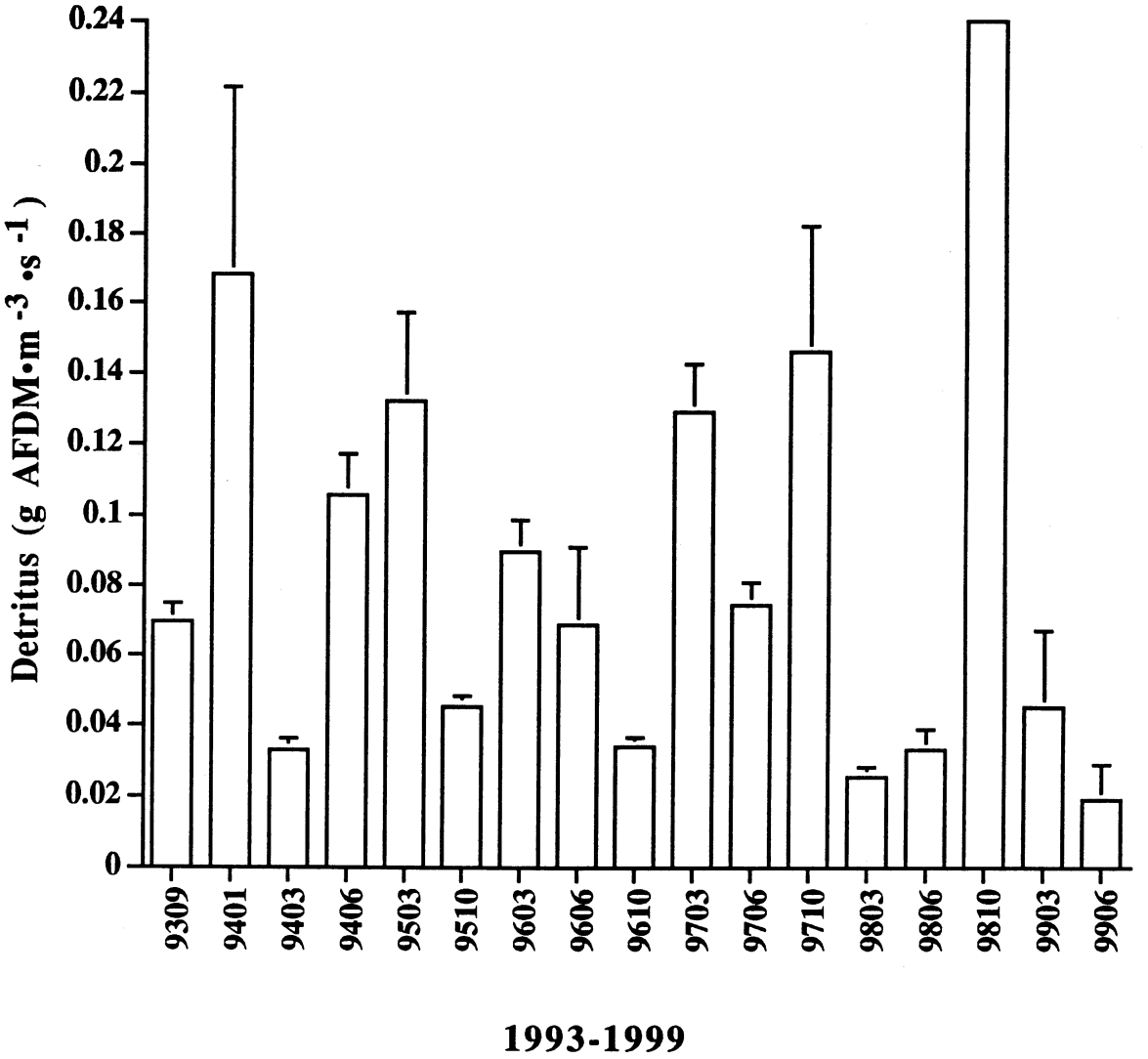

Figure 244. Average CPOM drift mass (g AFDM•m $^{-3}$•s $^{-1}$) for detritus collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

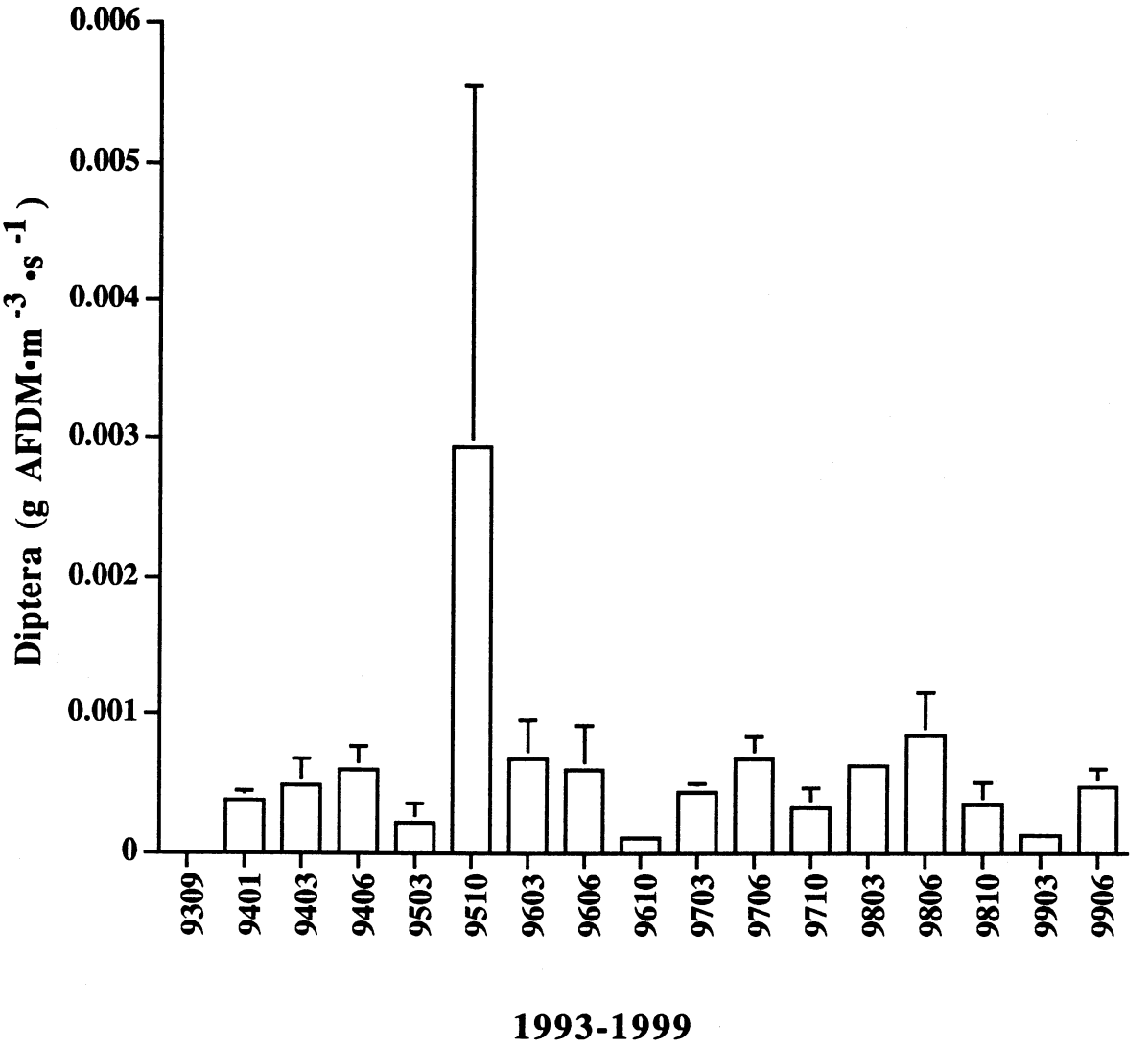

Figure 245. Average CPOM drift mass (g AFDM•m $^{-3}$•s $^{-1}$) for aquatic diptera collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

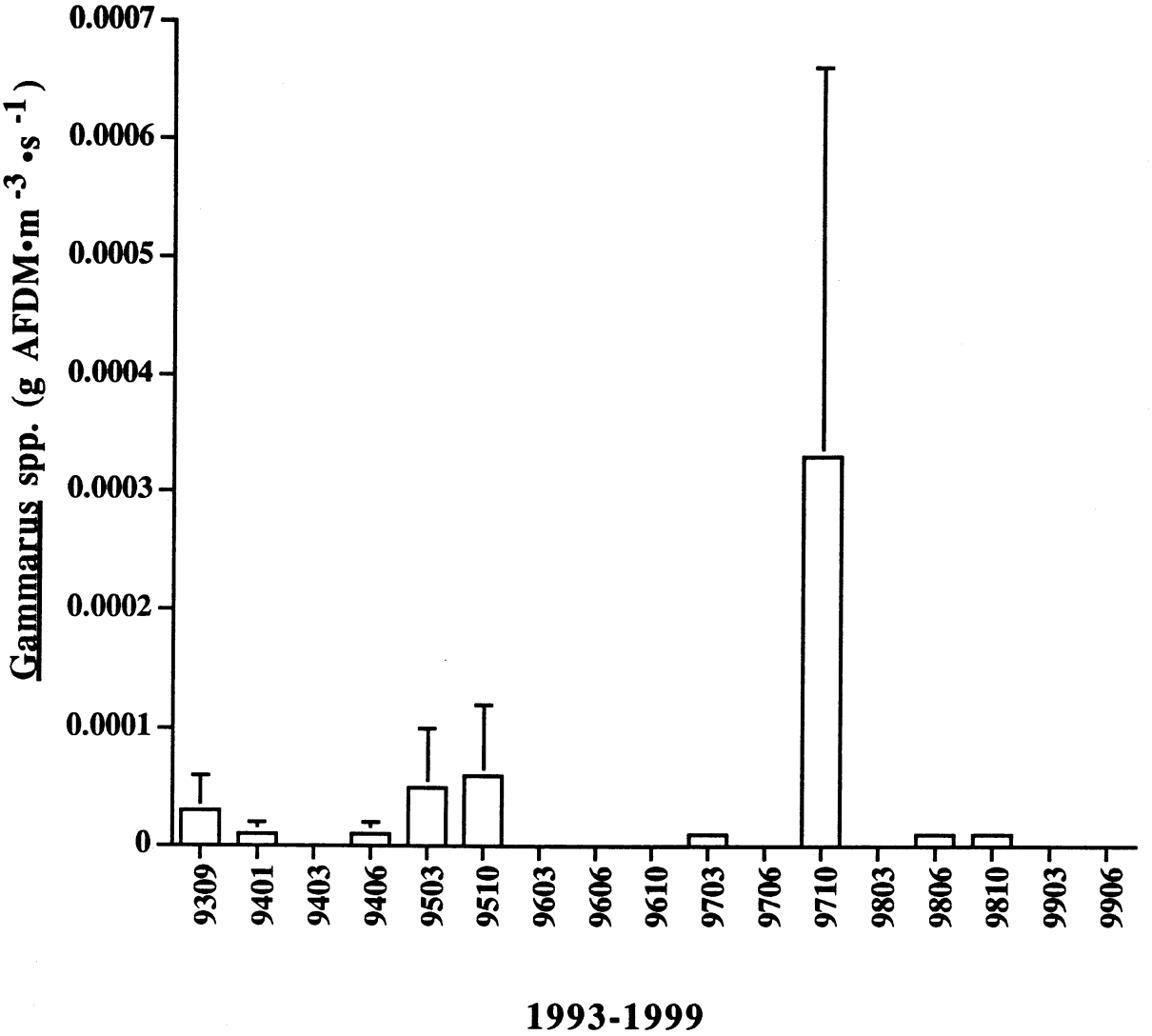

Figure 246. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for Gammarus spp. collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

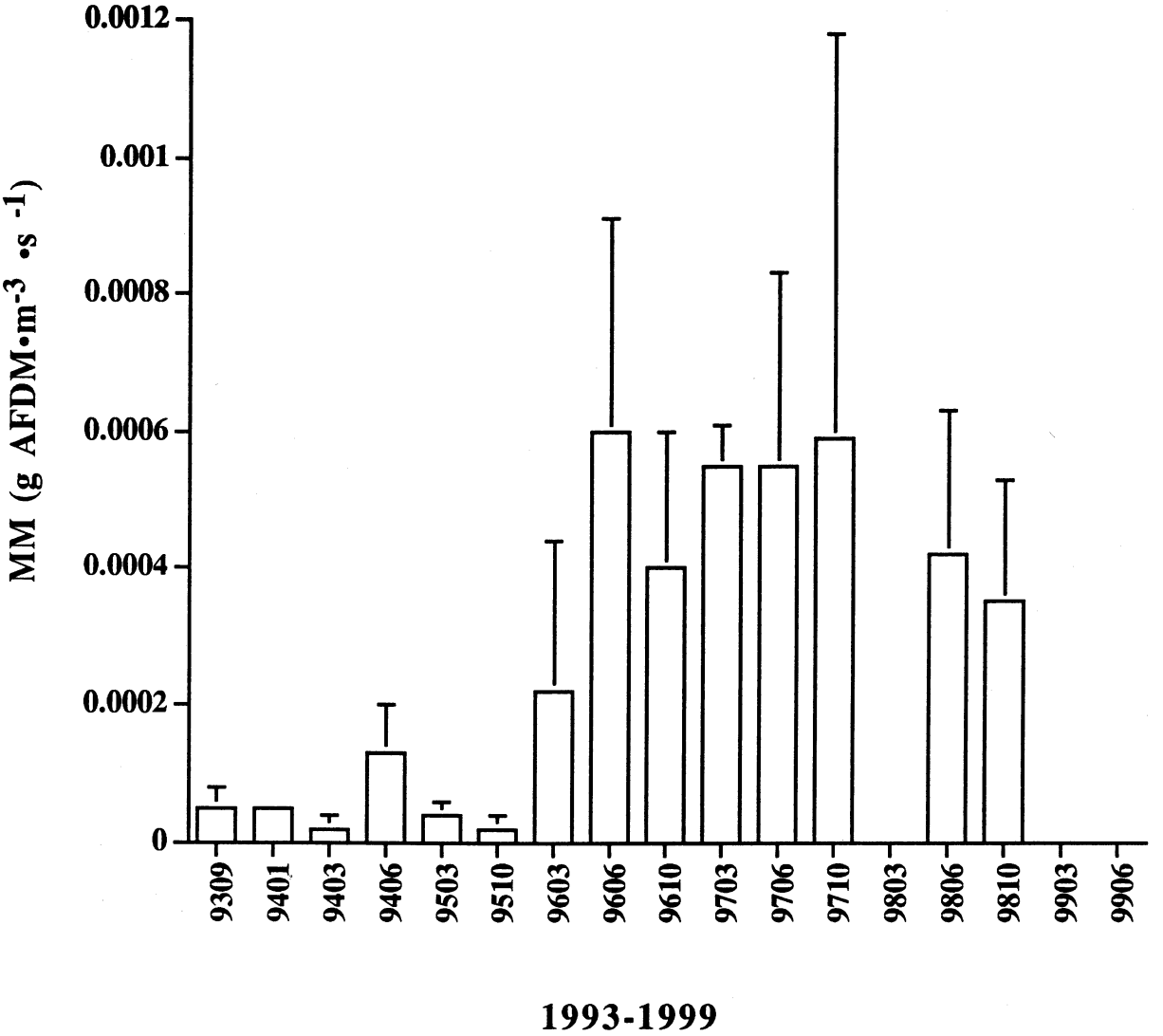

Figure 247. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous macroinvertebrates (MM) collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

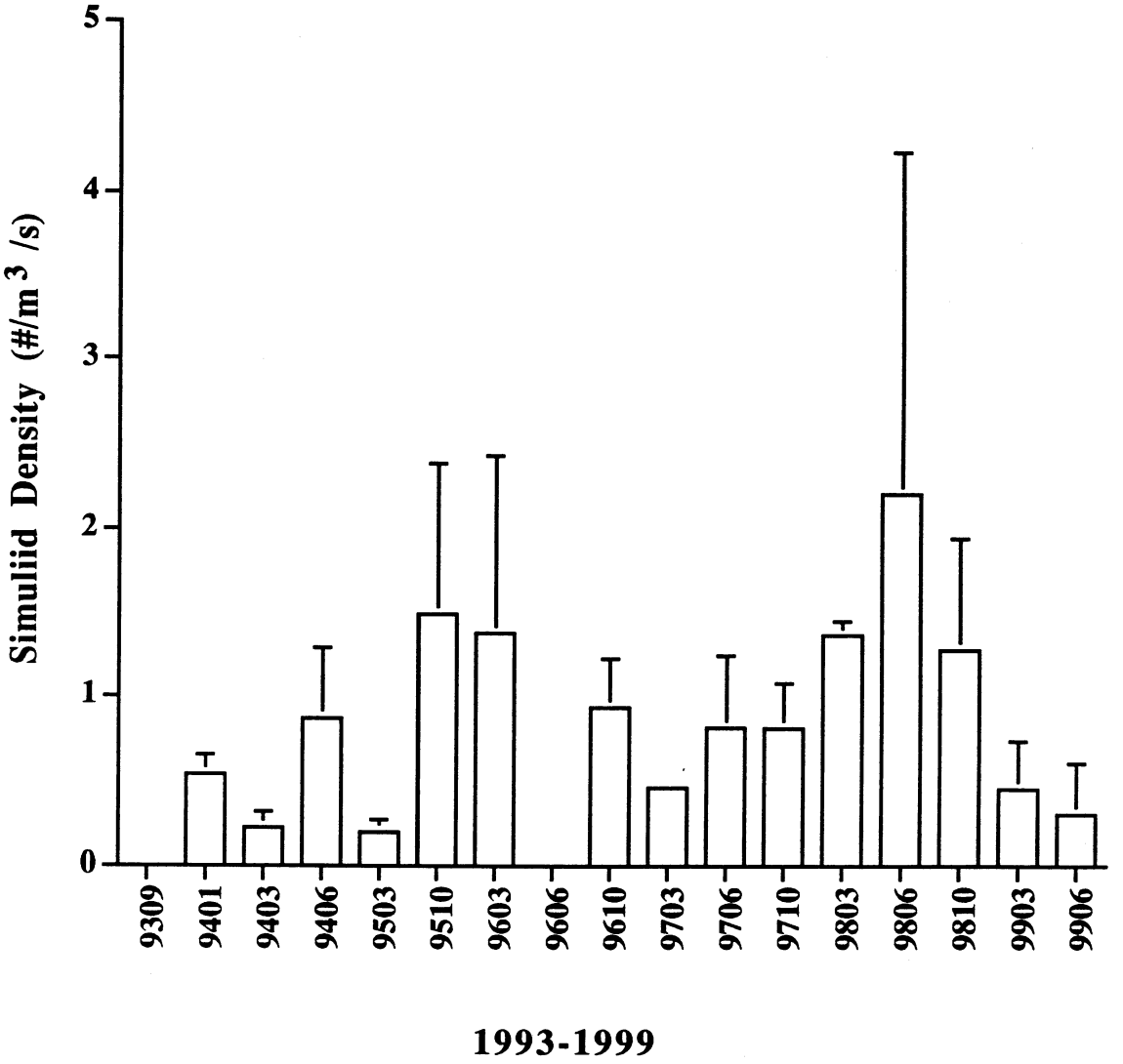

Figure 248. Average CPOM drift densities (#/m^3/s) for Simuliids collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

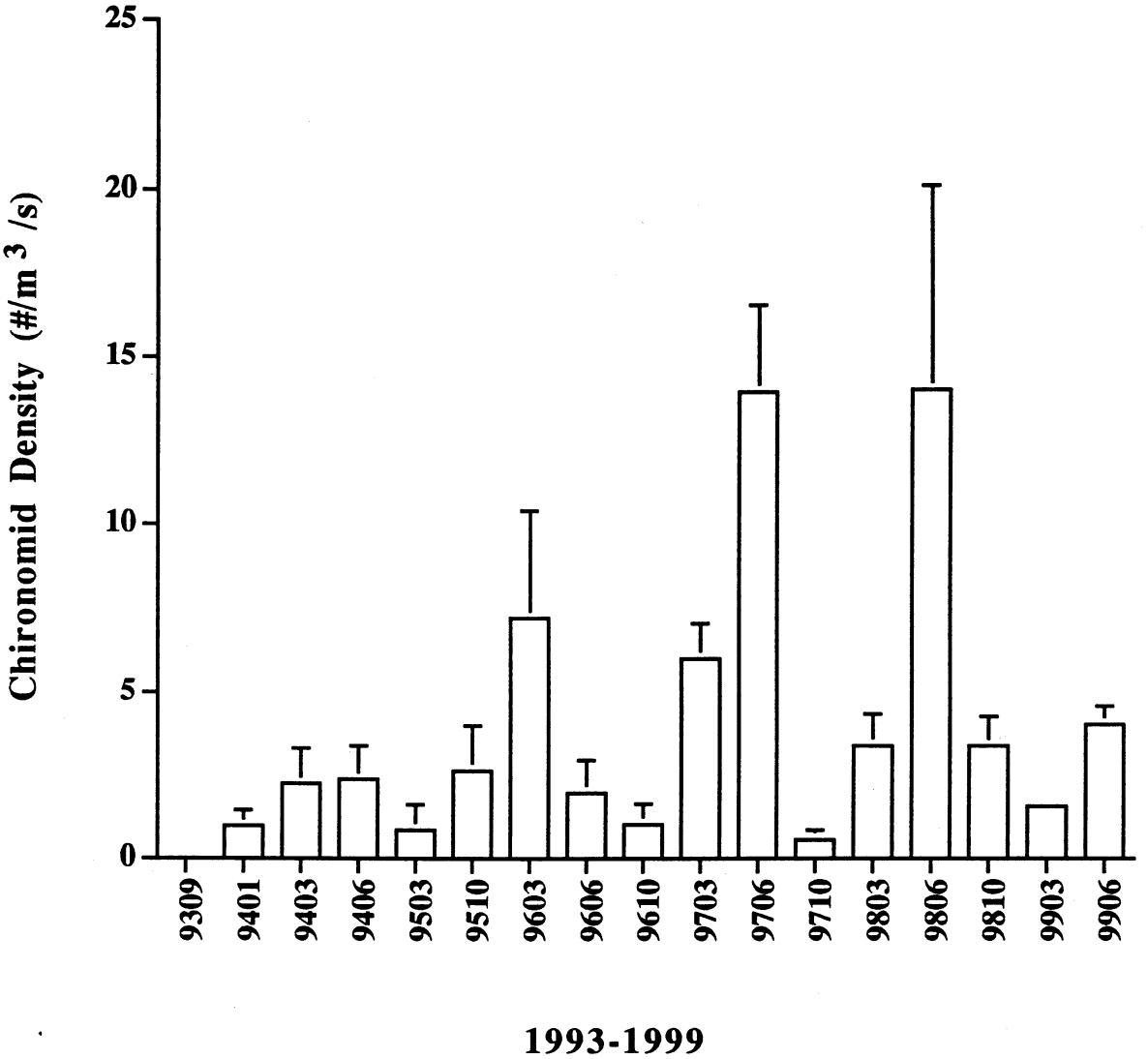

Figure 249. Average CPOM drift densities (#/m^3/s) for Chironomids collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

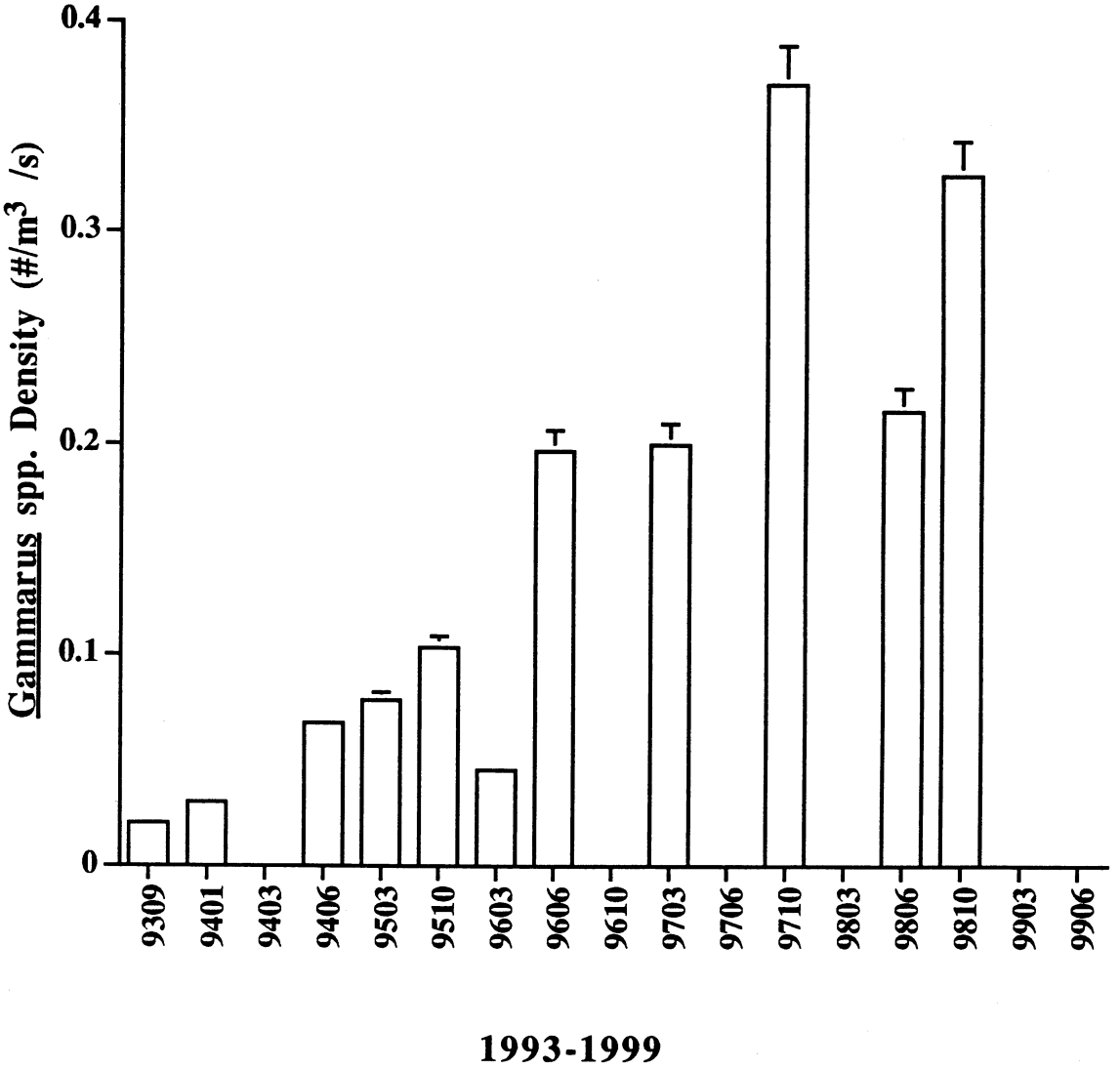

Figure 250. Average CPOM drift densities (#/m^3 /s) for Gammarus spp. collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

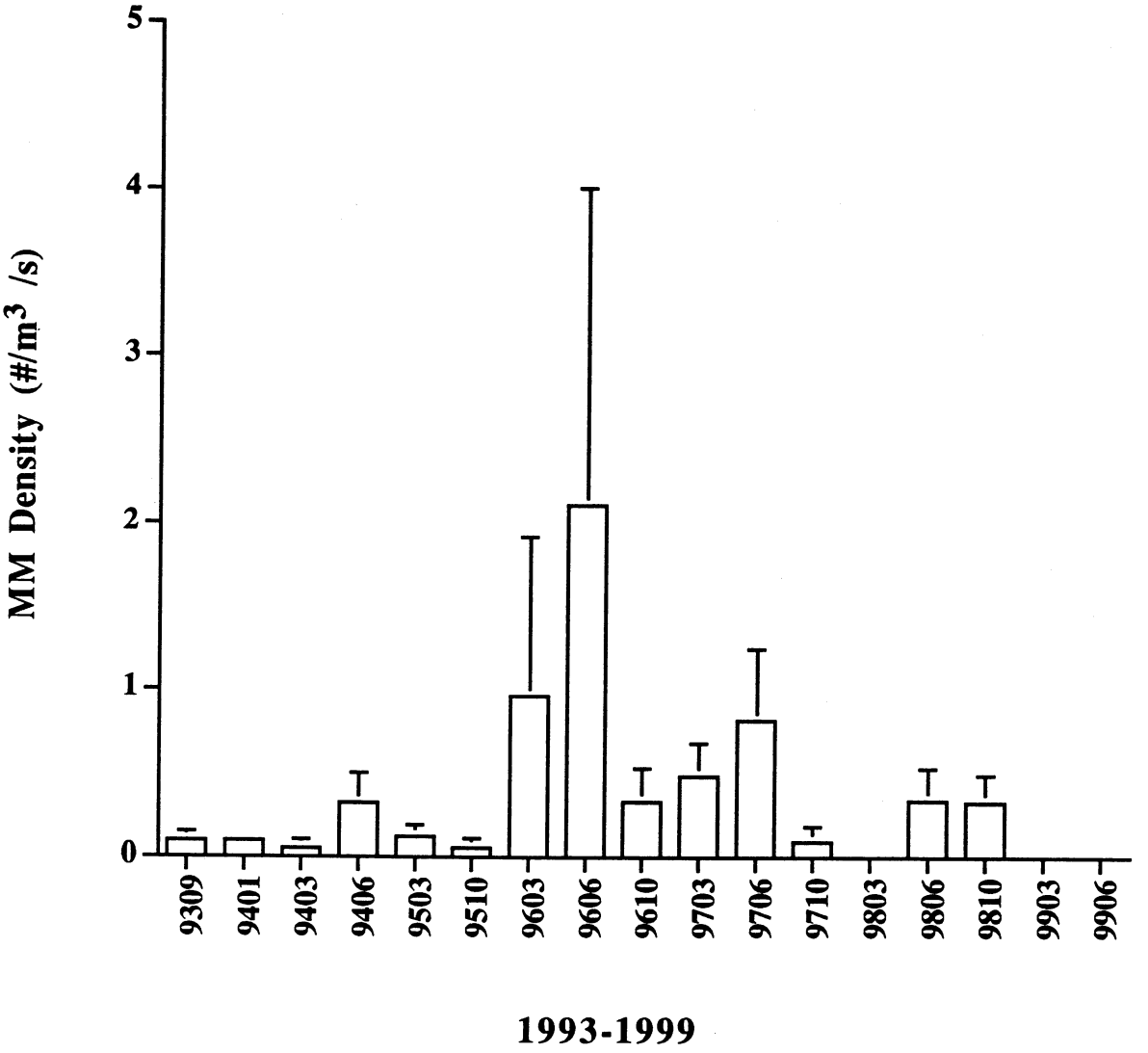

Figure 251. Average CPOM drift densities (#/m^3/s) for miscellaneous macroinvertebrates (MM) collected at Tanner cobble Rkm 109.6 from September 1993 to June 1999. Error Bars represent (± 1 SE).

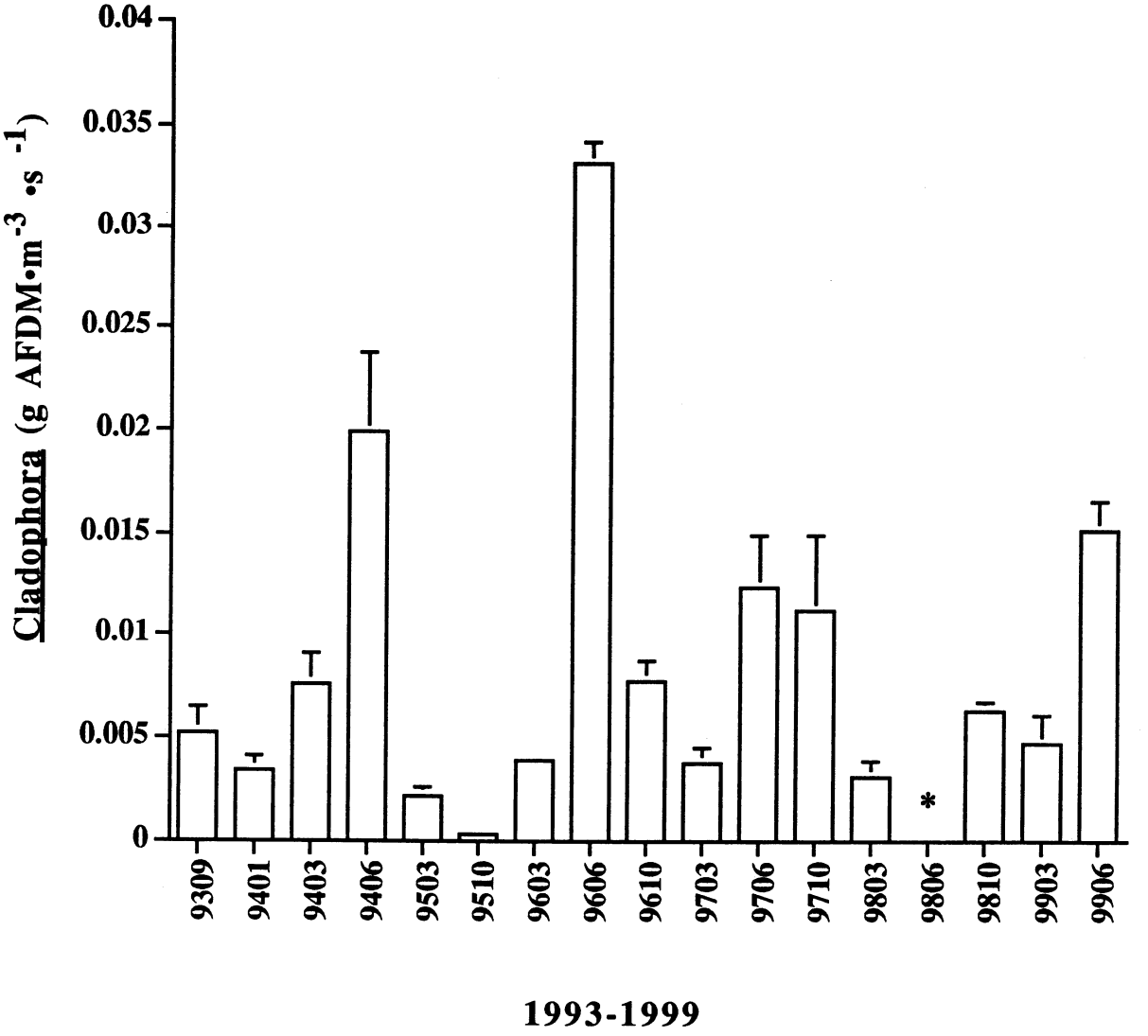

Figure 252. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for Cladophora collected at 127 Mile rapid Rkm 202.9 from September 1993 to June 1999. Error Bars represent (+ 1 SE). Asterisk (*) represents 0.05 g AFDM•m^{-3}•s^{-1} (+ 0.02 SE).

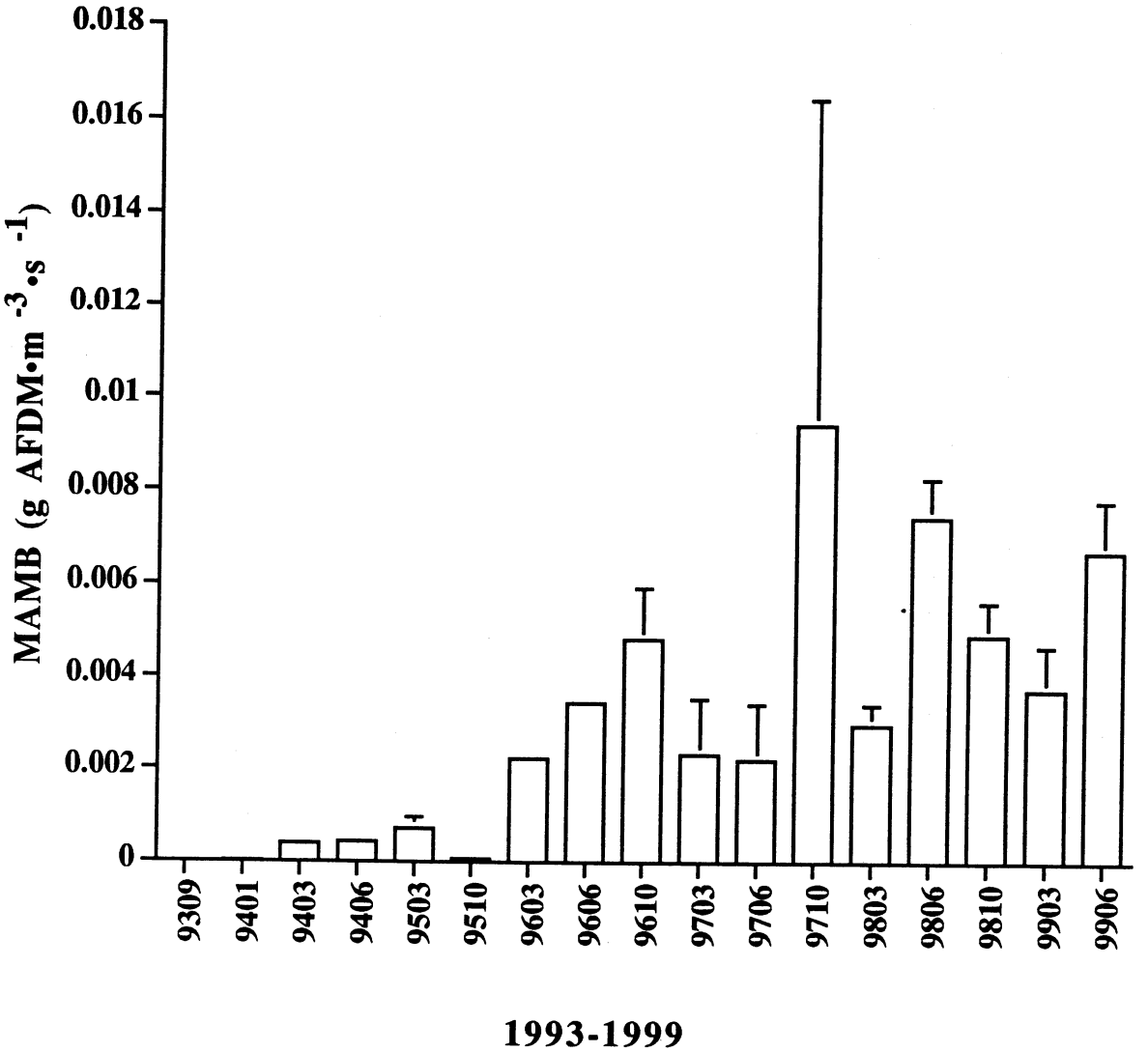

Figure 253. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous algae, macrophytes and bryophytes (MAMB) collected at 127 Mile rapid Rkm 202.9 from September 1993 to June 1999. Error Bars represent (± 1 SE).

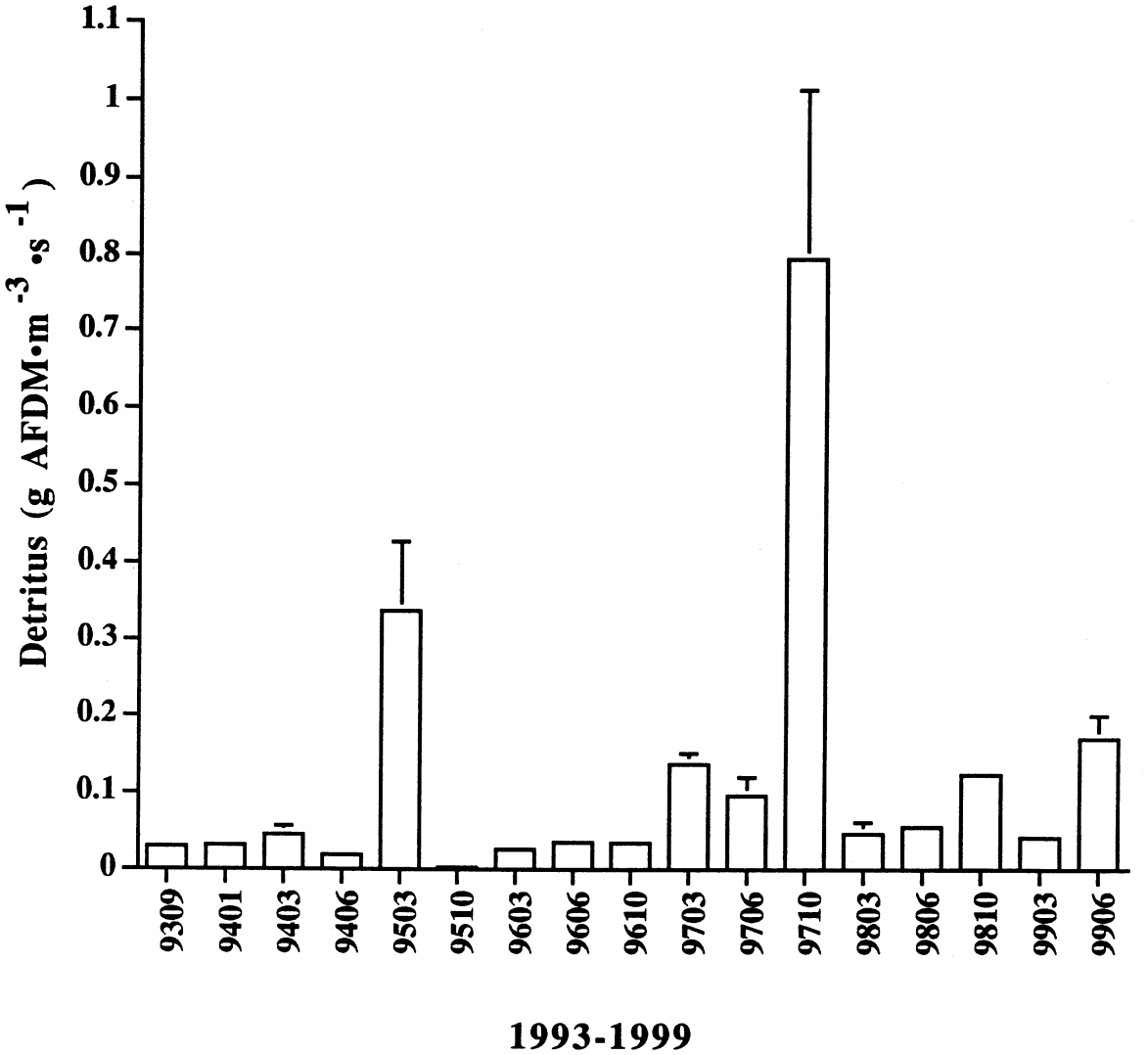

Figure 254. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for detritus collected at 127 Mile rapid Rkm 202.9 from September 1993 to June 1999. Error Bars represent (± 1 SE).

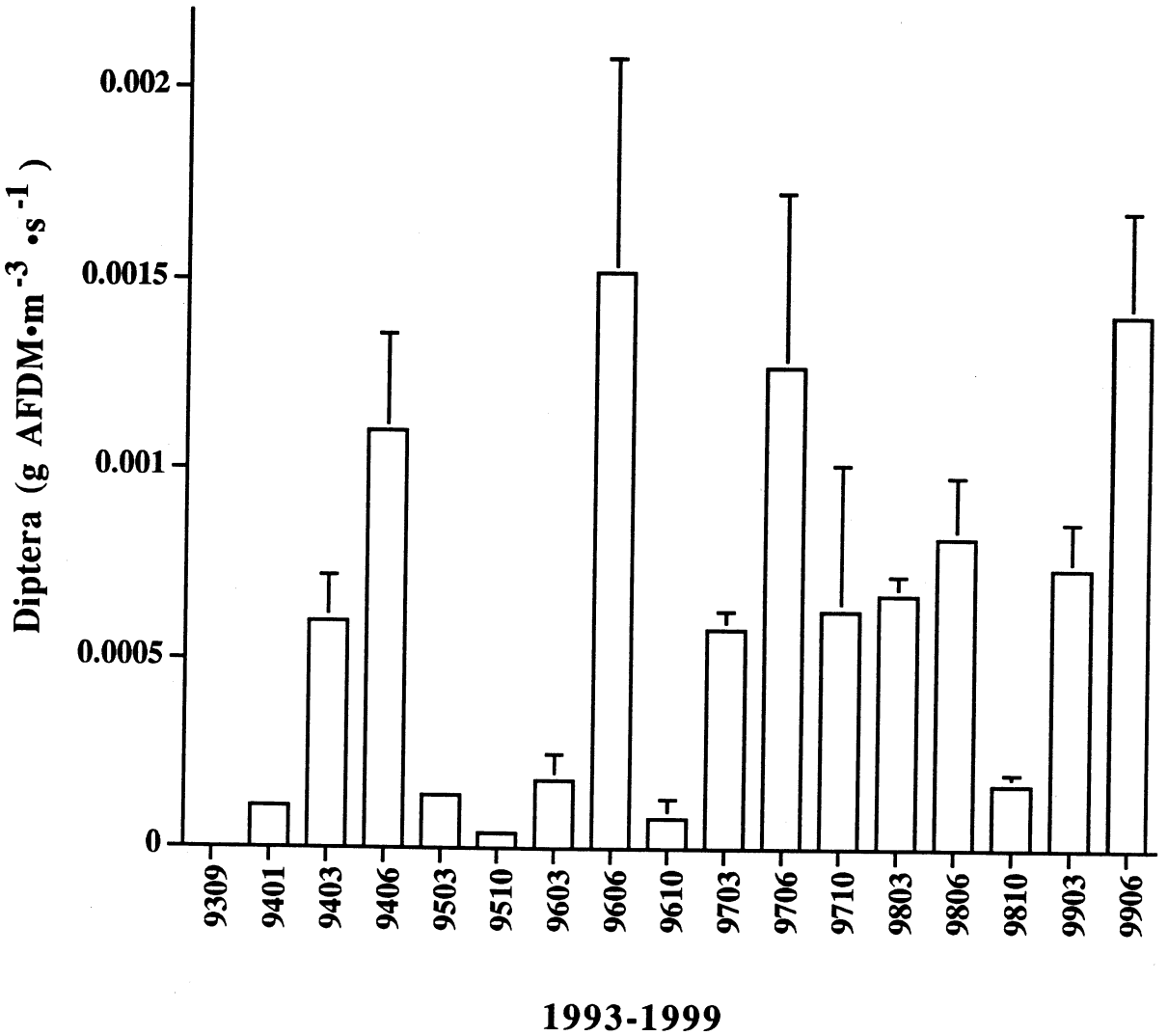

Figure 255. Average CPOM drift mass (g AFDM•m $^{-3}$•s $^{-1}$) for aquatic diptera collected at 127 Mile rapid Rkm 202.9 from September 1993 to June 1999. Error Bars represent (± 1 SE).

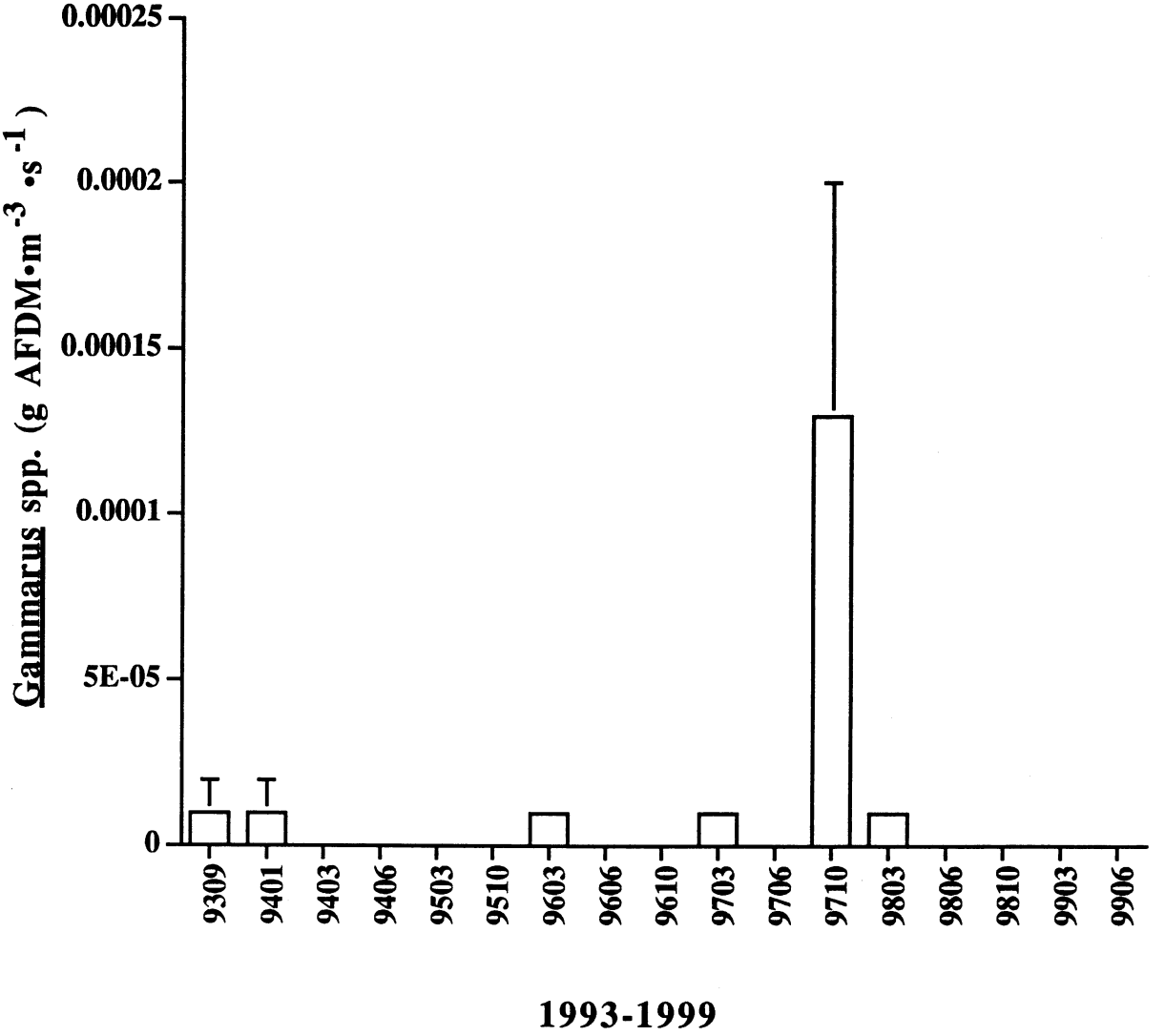

Figure 256. Average CPOM drift mass (g AFDM•m^{-3} •s^{-1}) for Gammarus spp. collected at 127 Mile rapid Rkm 202.9 from September 1993 to June 1999. Error Bars represent (± 1 SE).

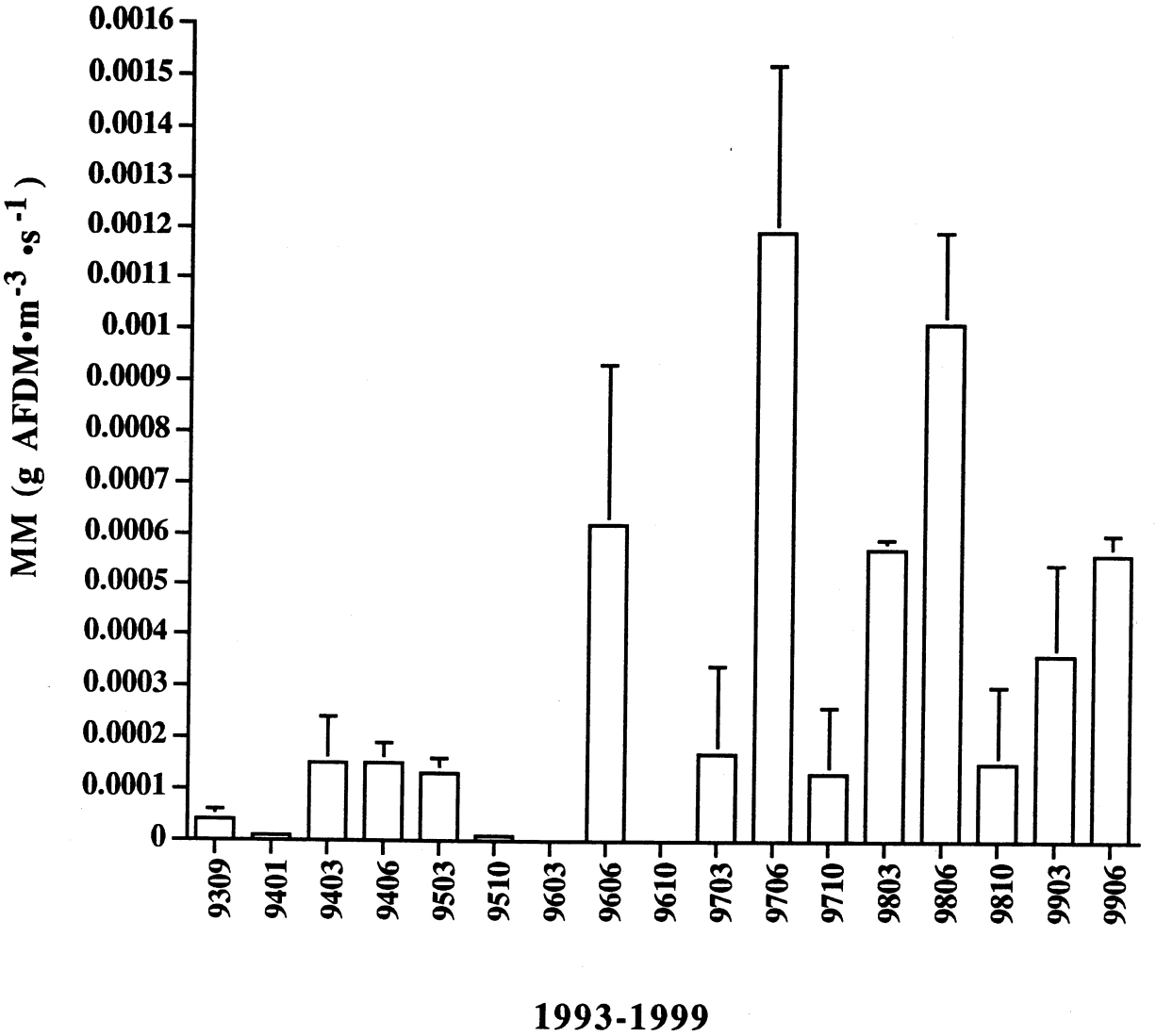

Figure 257. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous macroinvertebrates (MM) collected at 127 Mile rapid Rkm 202.9 from September 1993 to June 1999. Error Bars represent (± 1 SE).

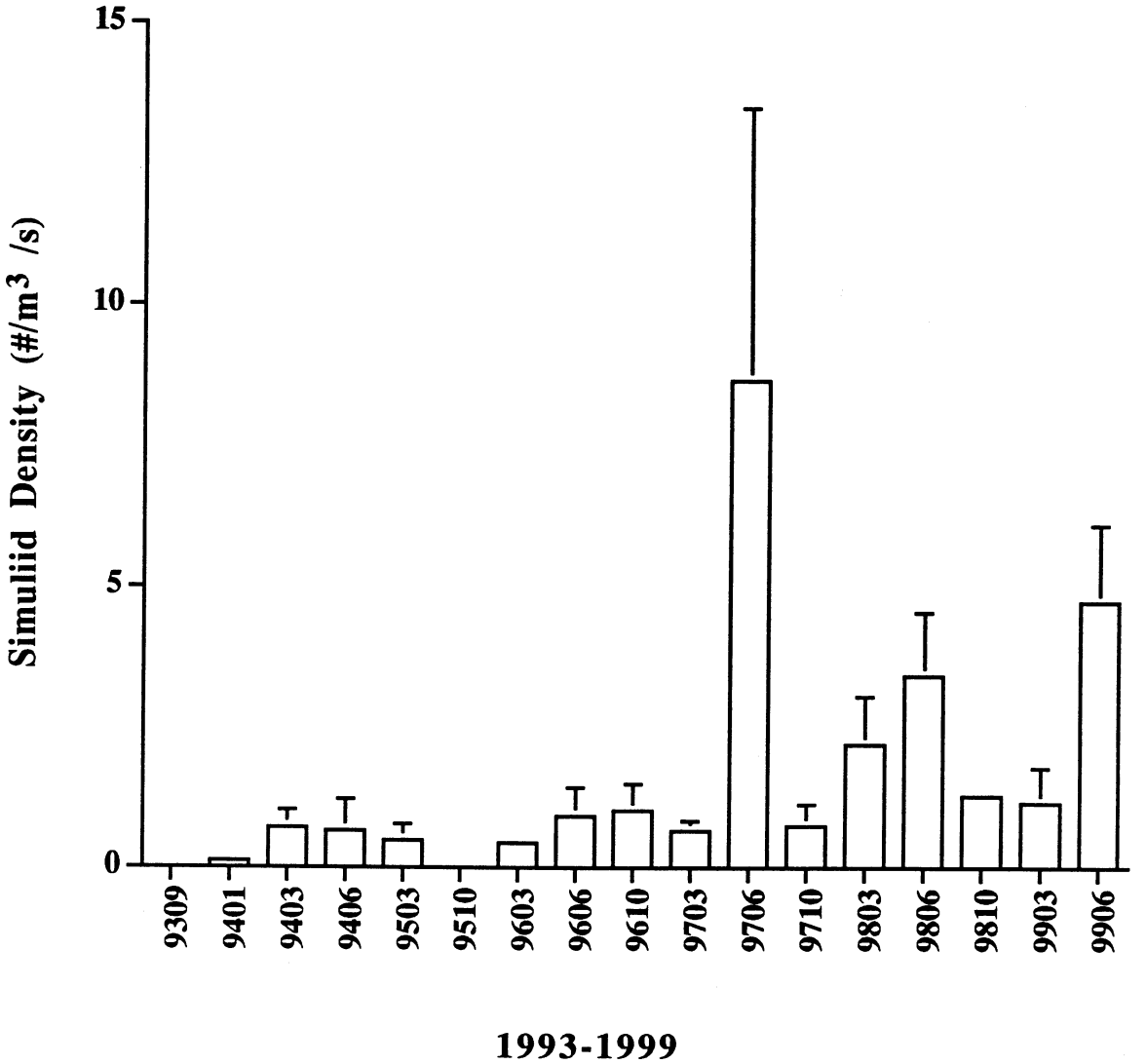

Figure 258. Average CPOM drift densities (#/m^3/s) for Simuliids collected at 127 Mile rapid Rkm 202.9 from September 1993 to June 1999. Error Bars represent (± 1 SE).

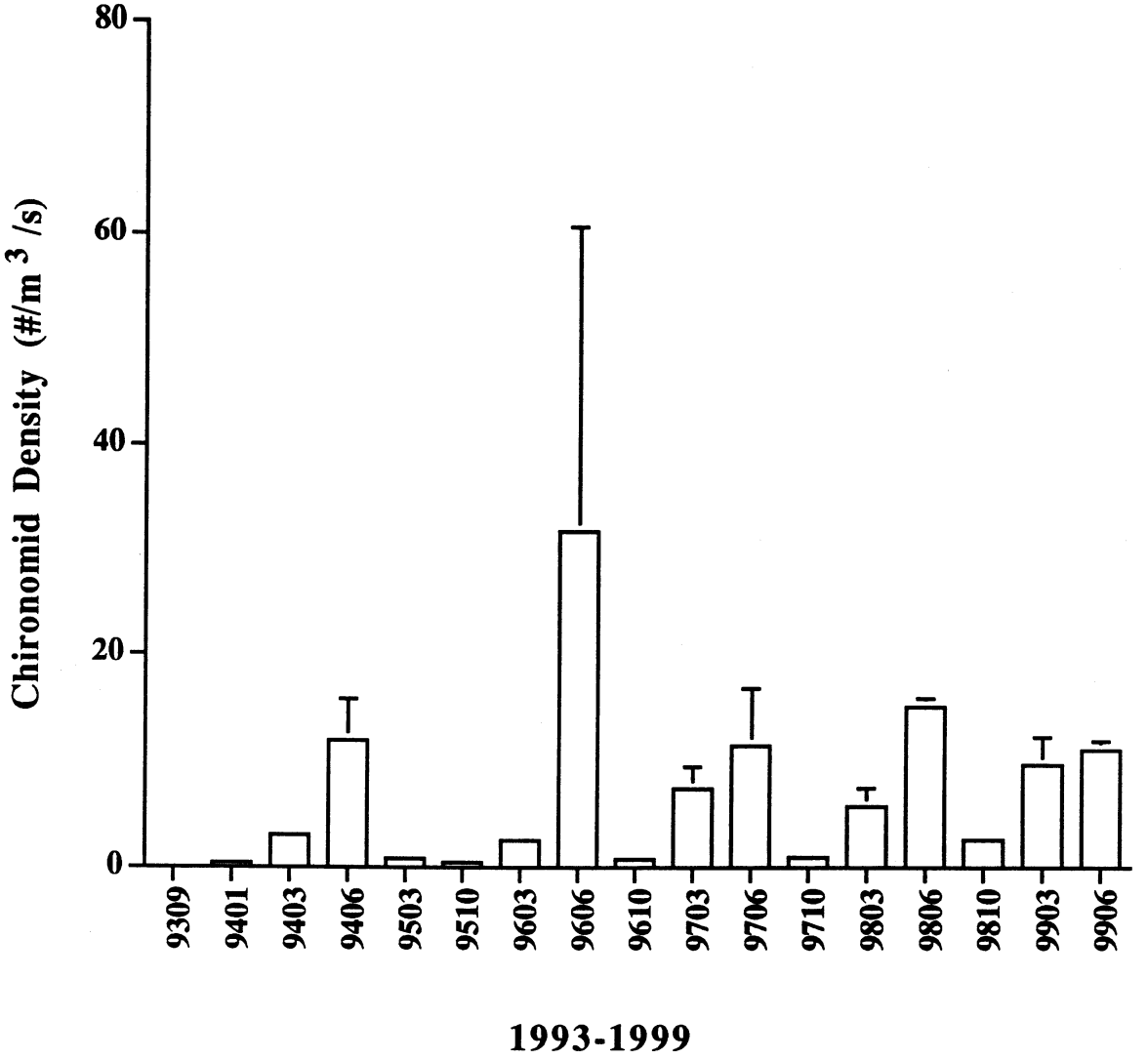

Figure 259. Average CPOM drift densities (#/m^3 /s) for Chironomids collected at 127 Mile Rkm 202.9 rapid from September 1993 to June 1999. Error Bars represent (± 1 SE).

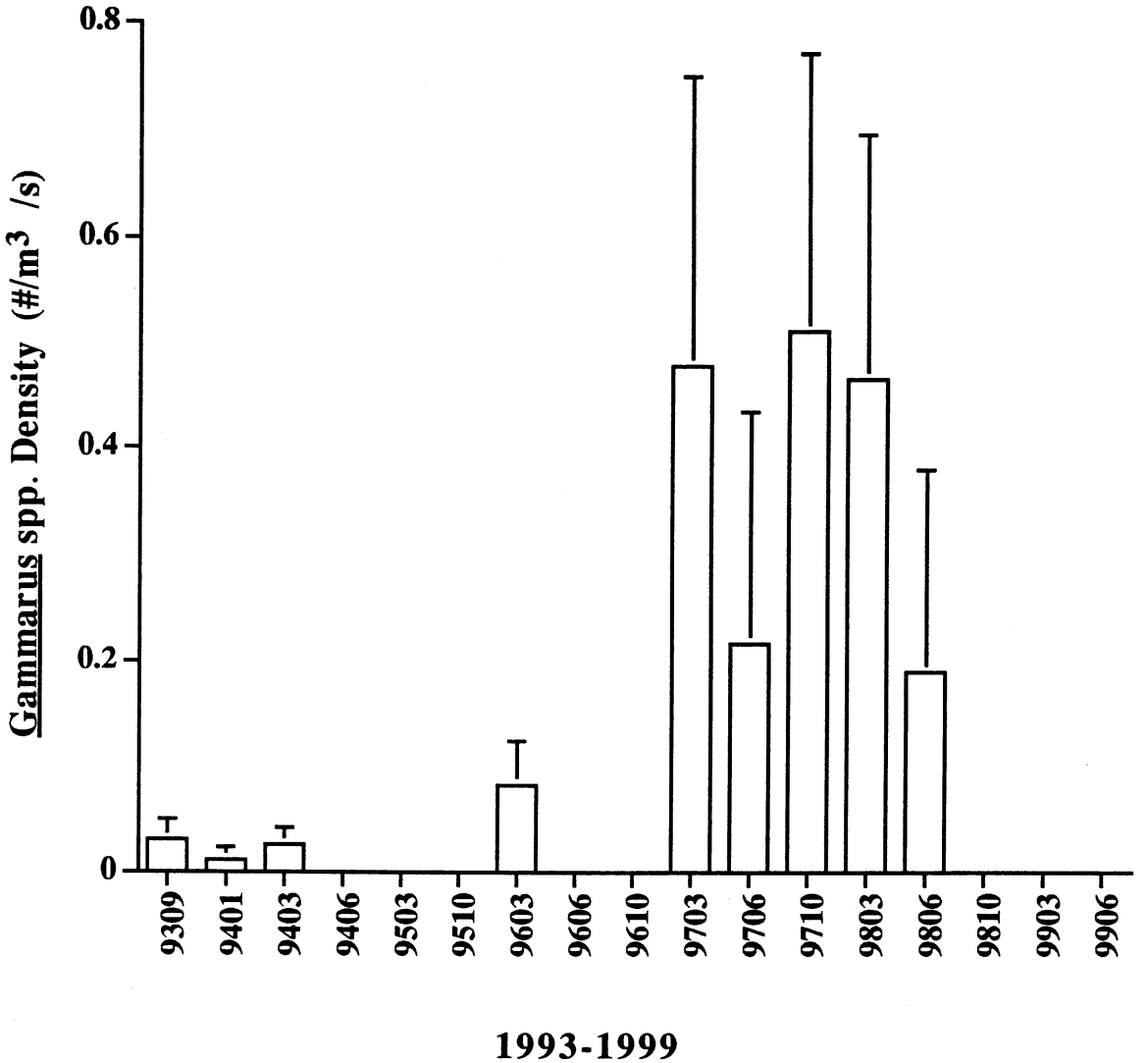

Figure 260. Average CPOM drift densities (#/m^3 /s) for Gammarus spp. collected at 127 Mile Rkm 202.9 rapid from September 1993 to June 1999. Error Bars represent (± 1 SE).

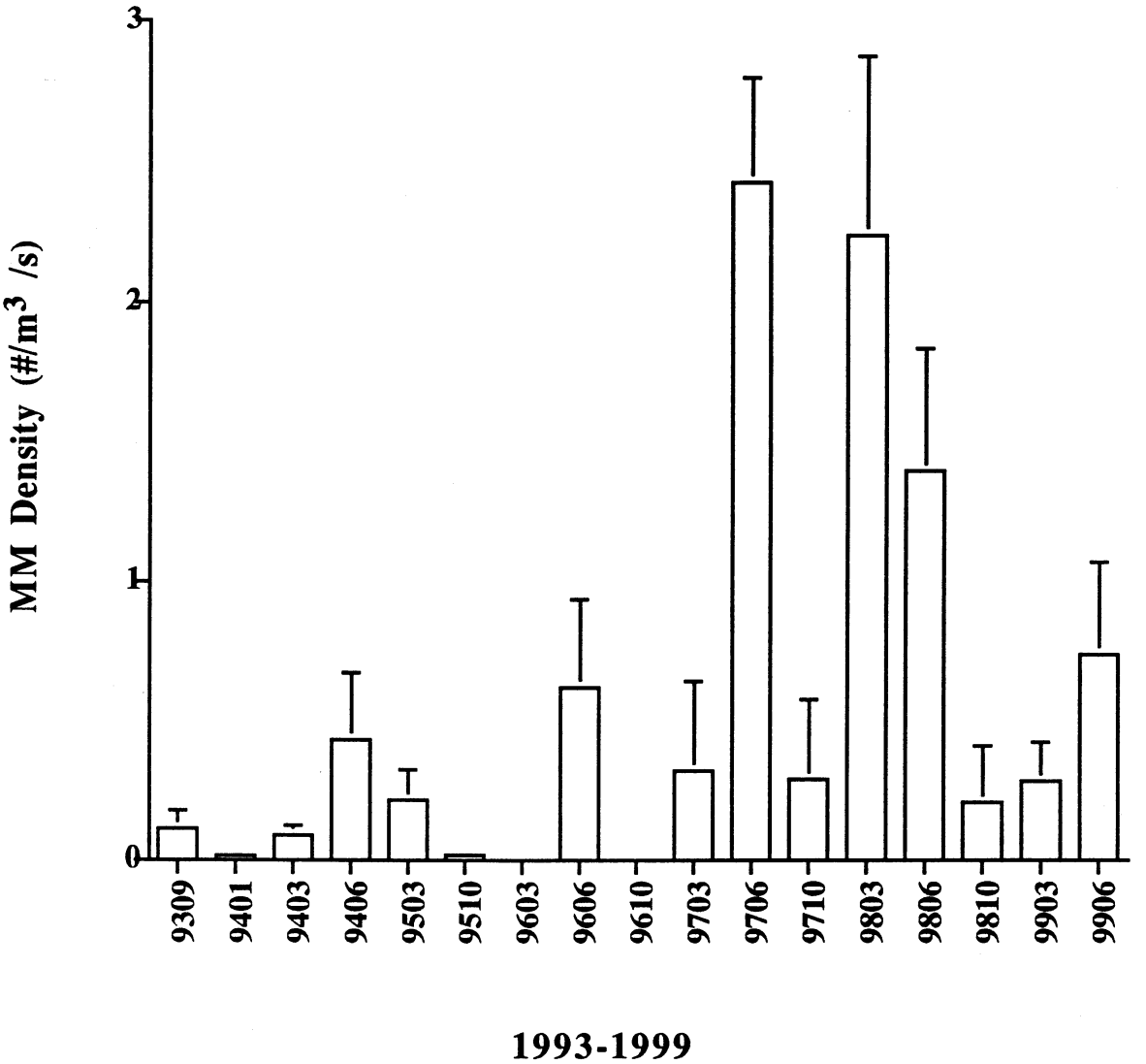

Figure 261. Average CPOM drift densities (#/m^3 /s) for miscellaneous macroinvertebrates (MM) collected at 127 Mile rapid Rkm 202.9 from September 1993 to June 1999. Error Bars represent (± 1 SE).

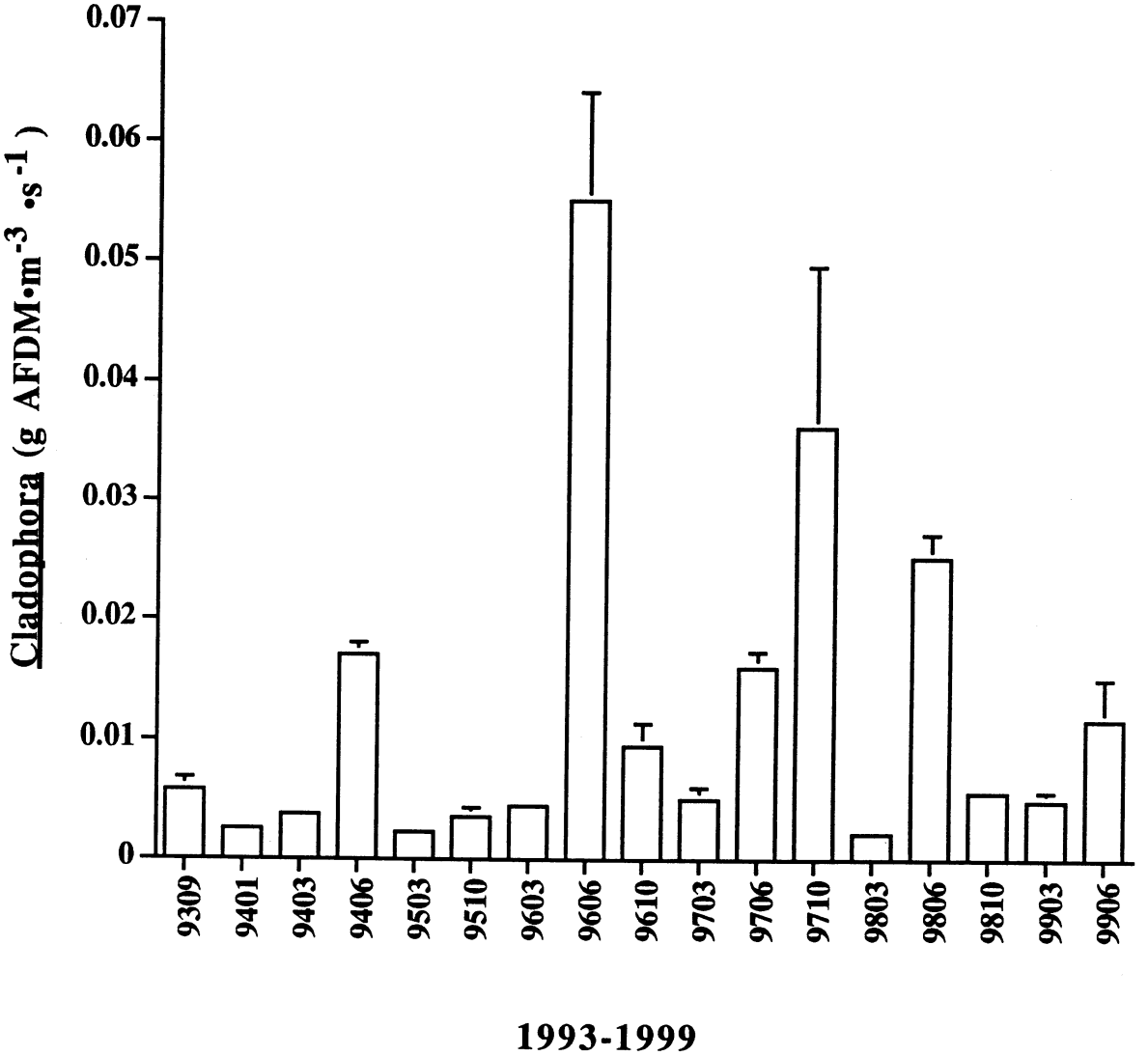

Figure 262. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for Cladophora collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE).

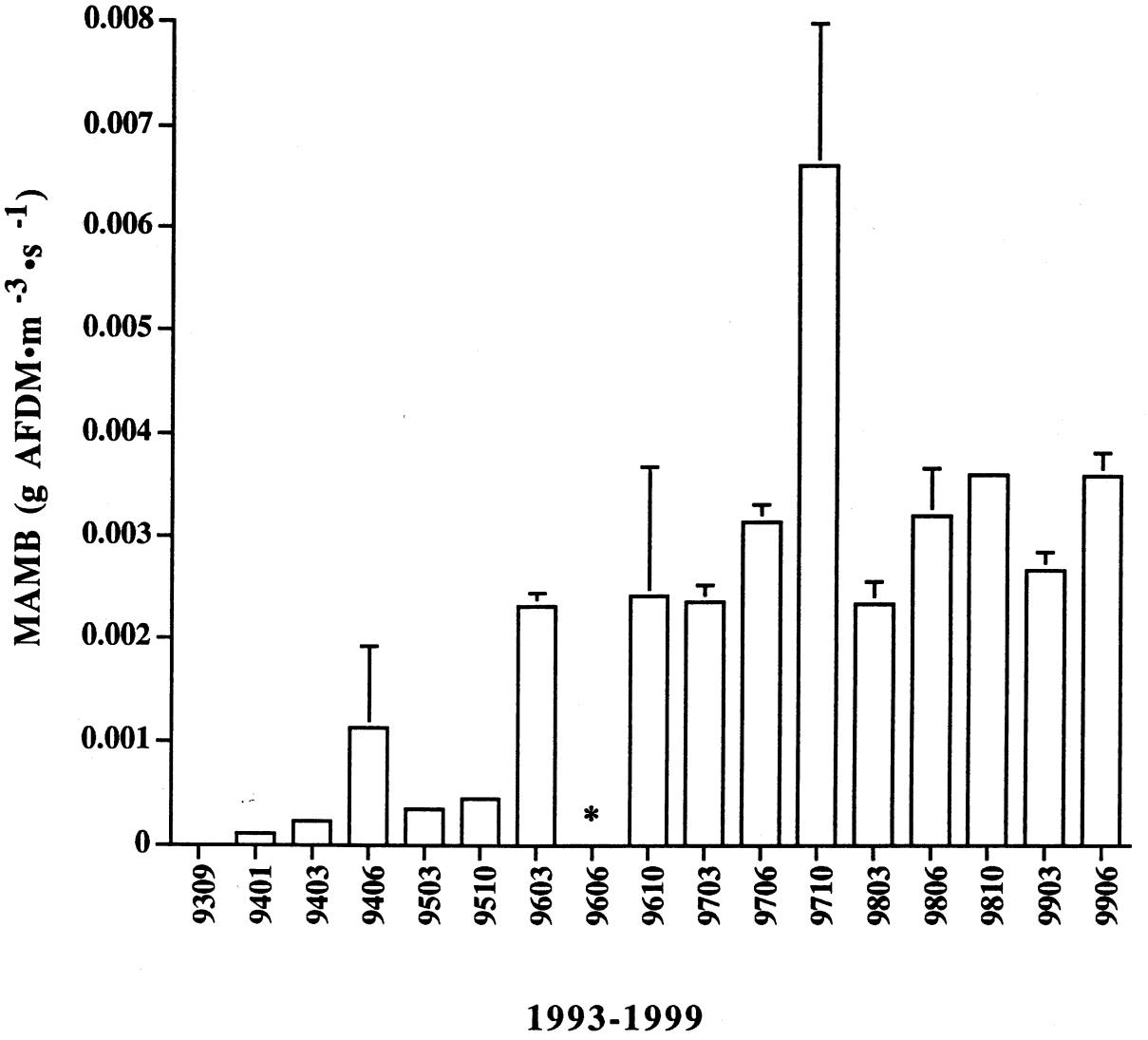

Figure 263. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous algae, macrophytes and bryophytes (MAMB) collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE). Asterisk (*) represents 0.018 g AFDM•m^{-3}•s^{-1} (± 0.011 SE).

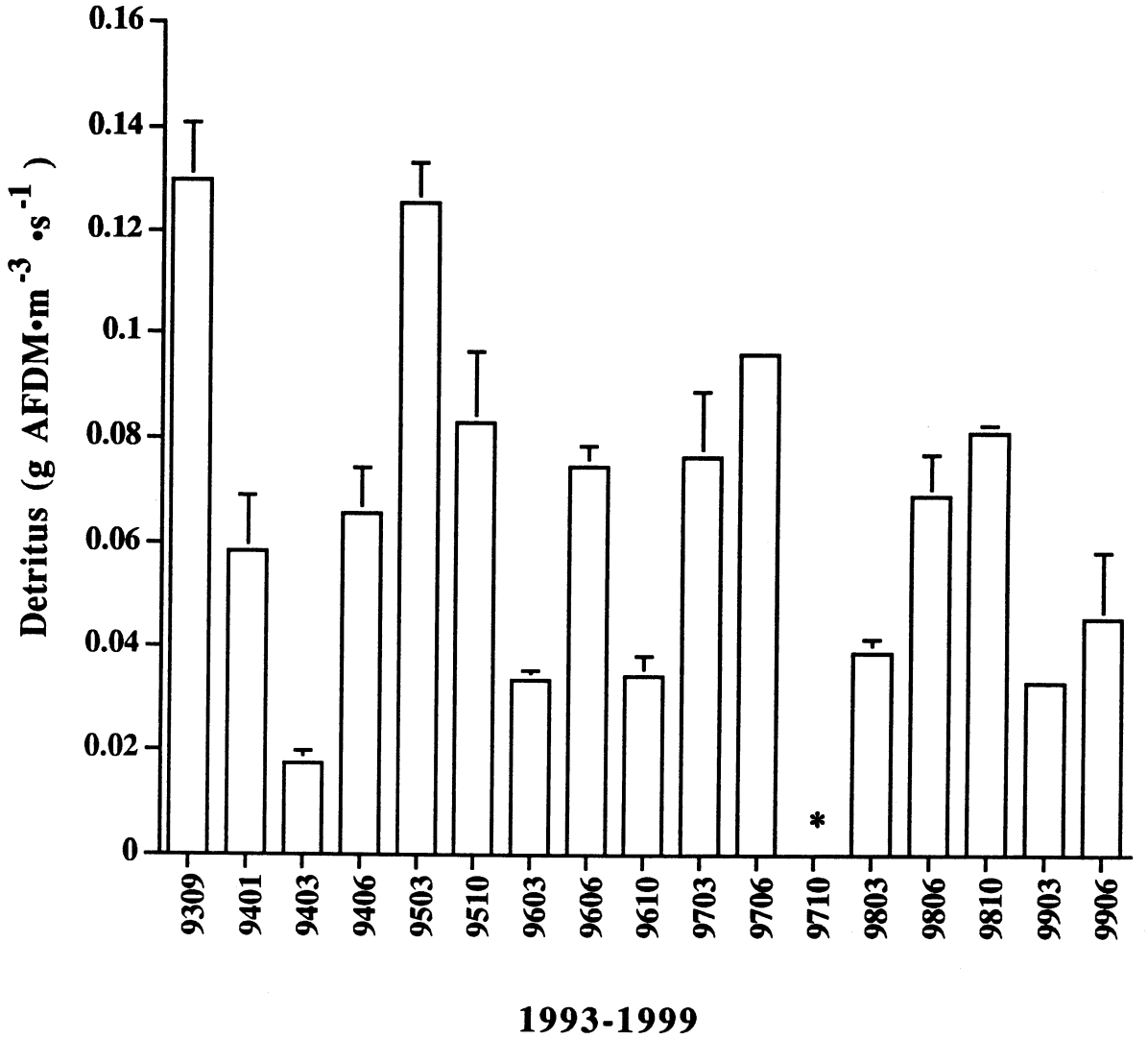

Figure 264. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for detritus collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE). Asterisk (*) represents 0.5 g AFDM•m^{-3}•s^{-1}(± 0.2 SE).

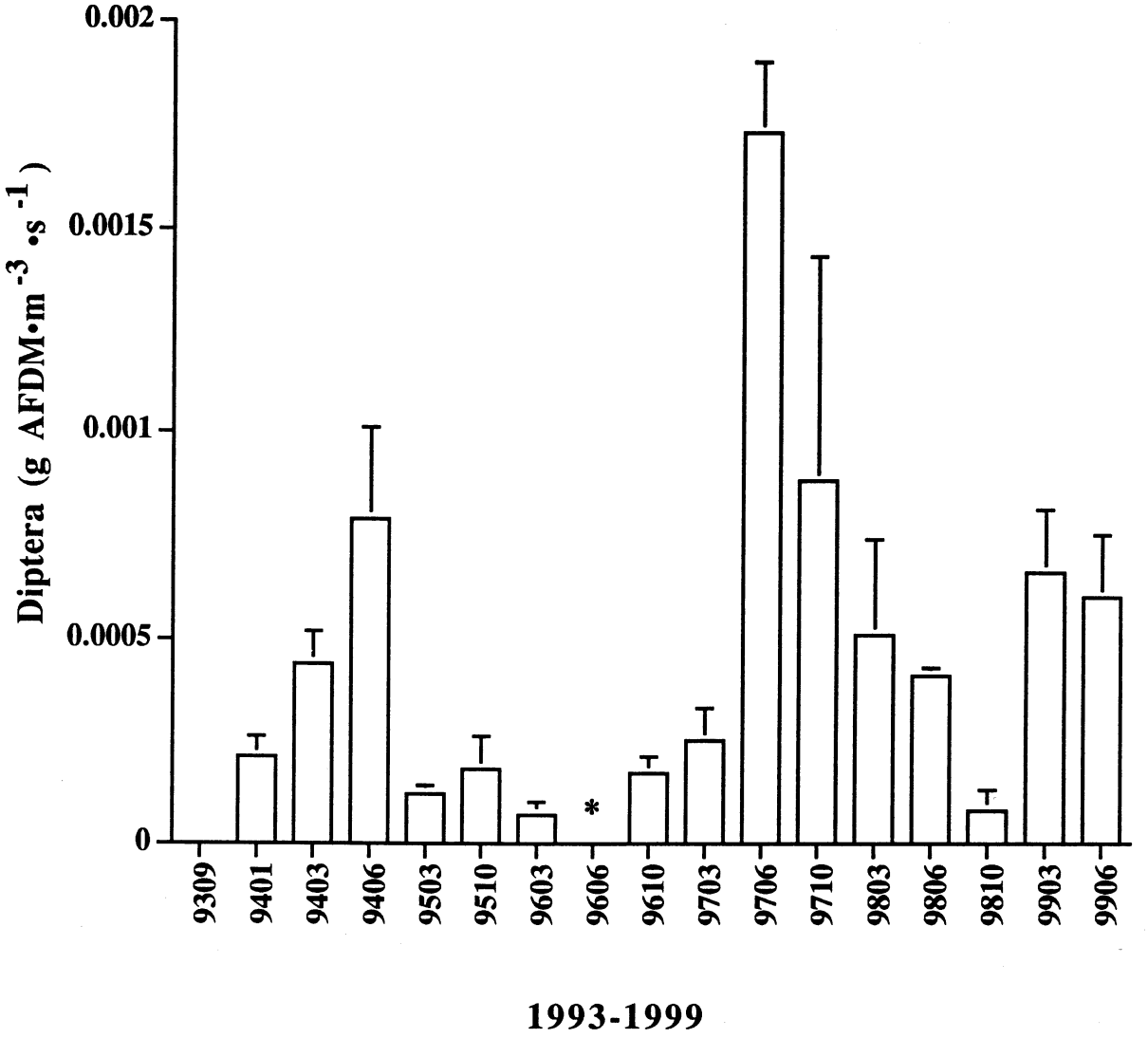

Figure 265. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for aquatic diptera collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE). Asterisk (*) represents 0.005 g AFDM•m^{-3}•s^{-1} (± 0.004 SE).

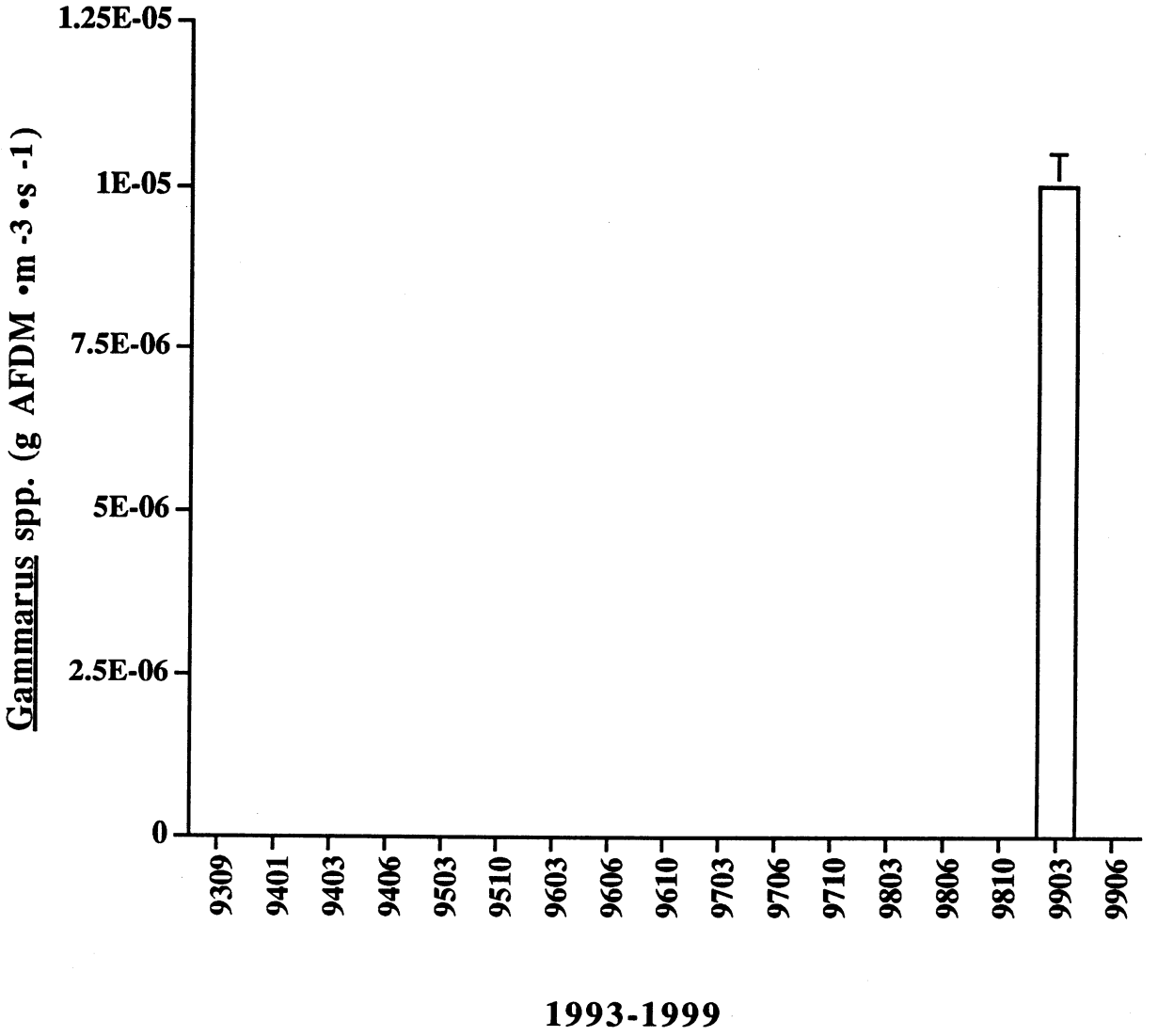

Figure 266. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for Gammarus spp. collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE).

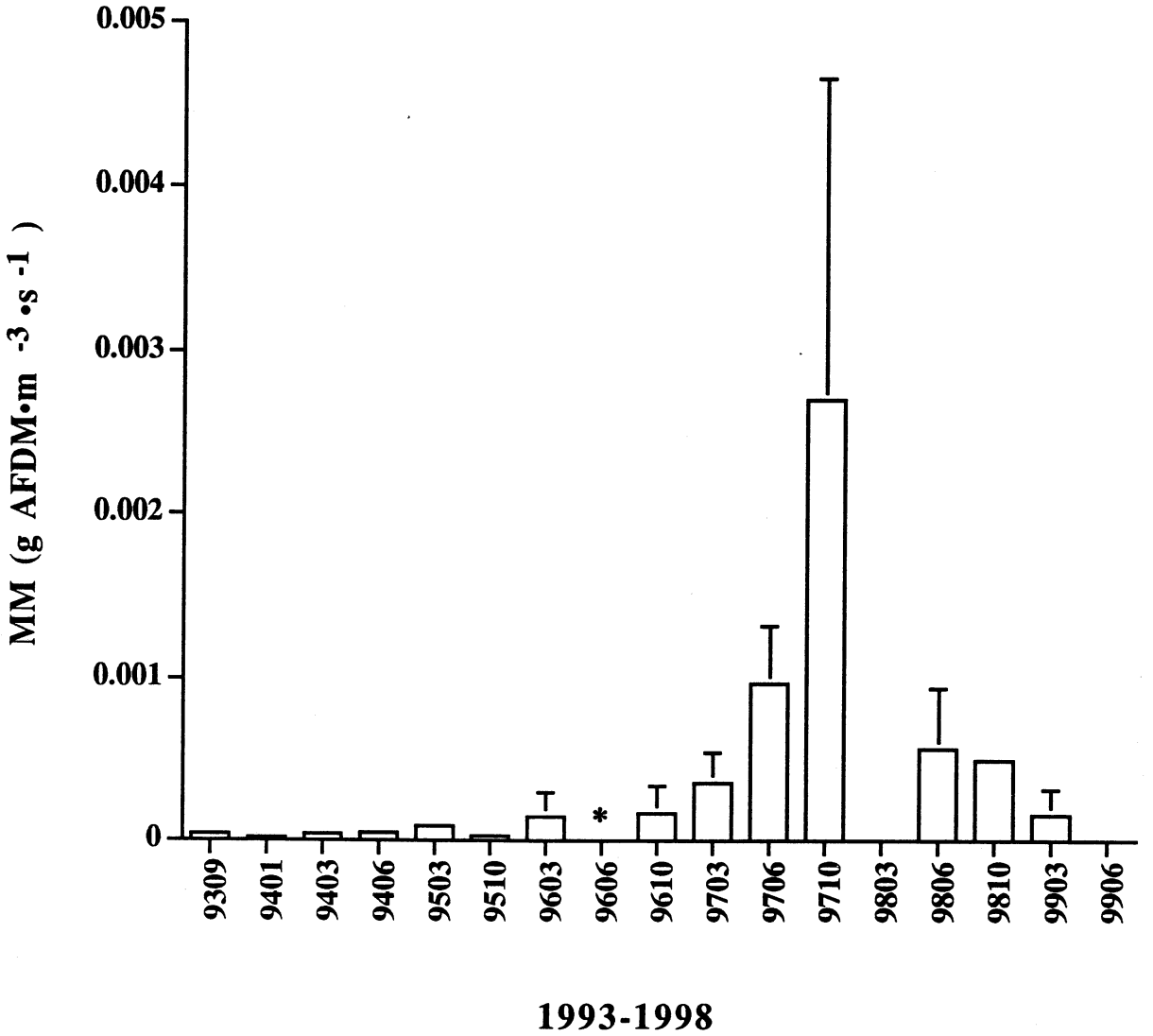

Figure 267. Average CPOM drift mass (g AFDM•m^{-3}•s^{-1}) for miscellaneous macroinvertebrates (MM) collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1998. Error Bars represent (± 1 SE). Asterisk (*) represents 0.014 g AFDM•m^{-3}•s^{-1} (± 0.007).

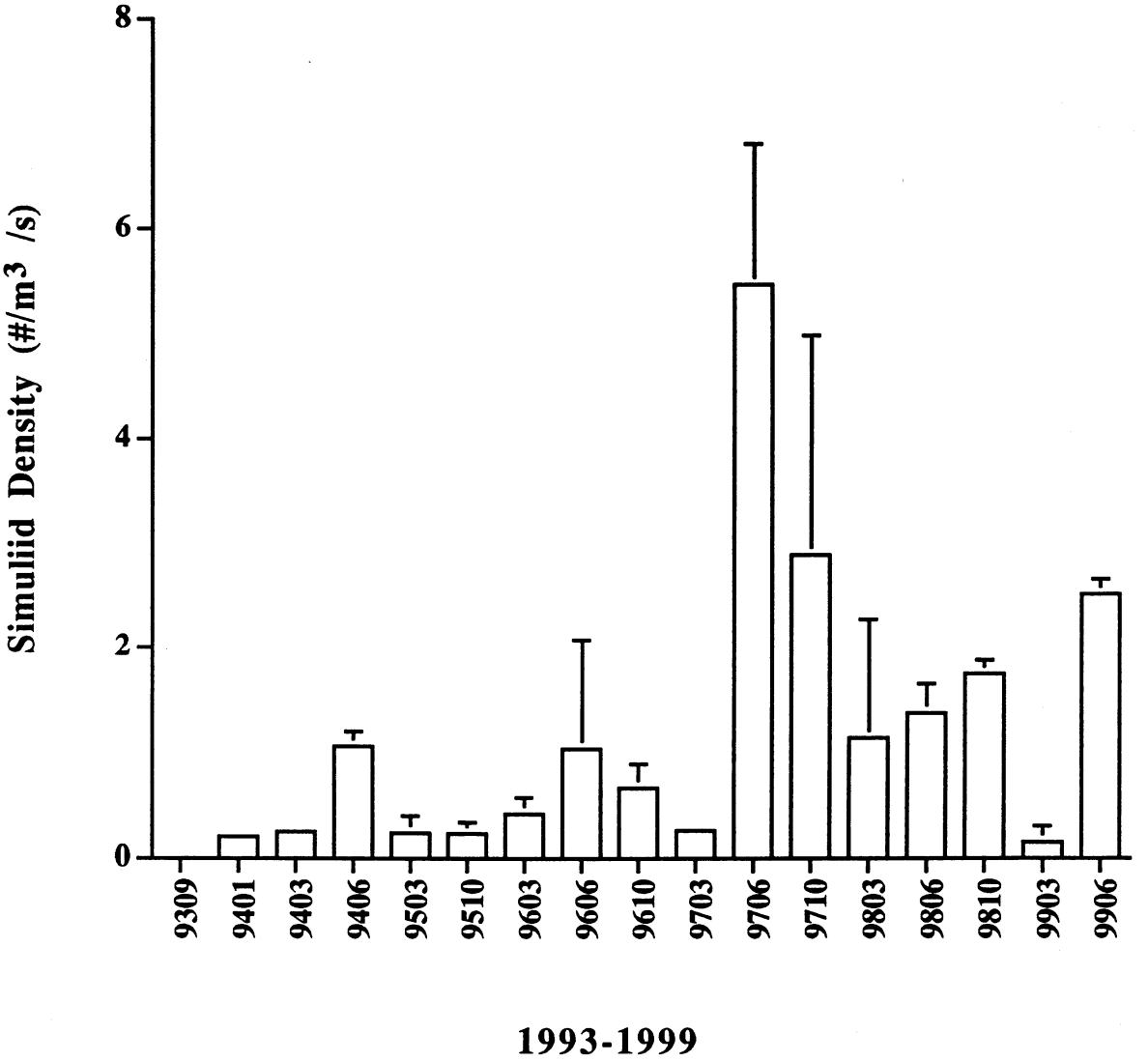

Figure 268. Average CPOM drift densities (#/m^3 /s) for Simuliids collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE).

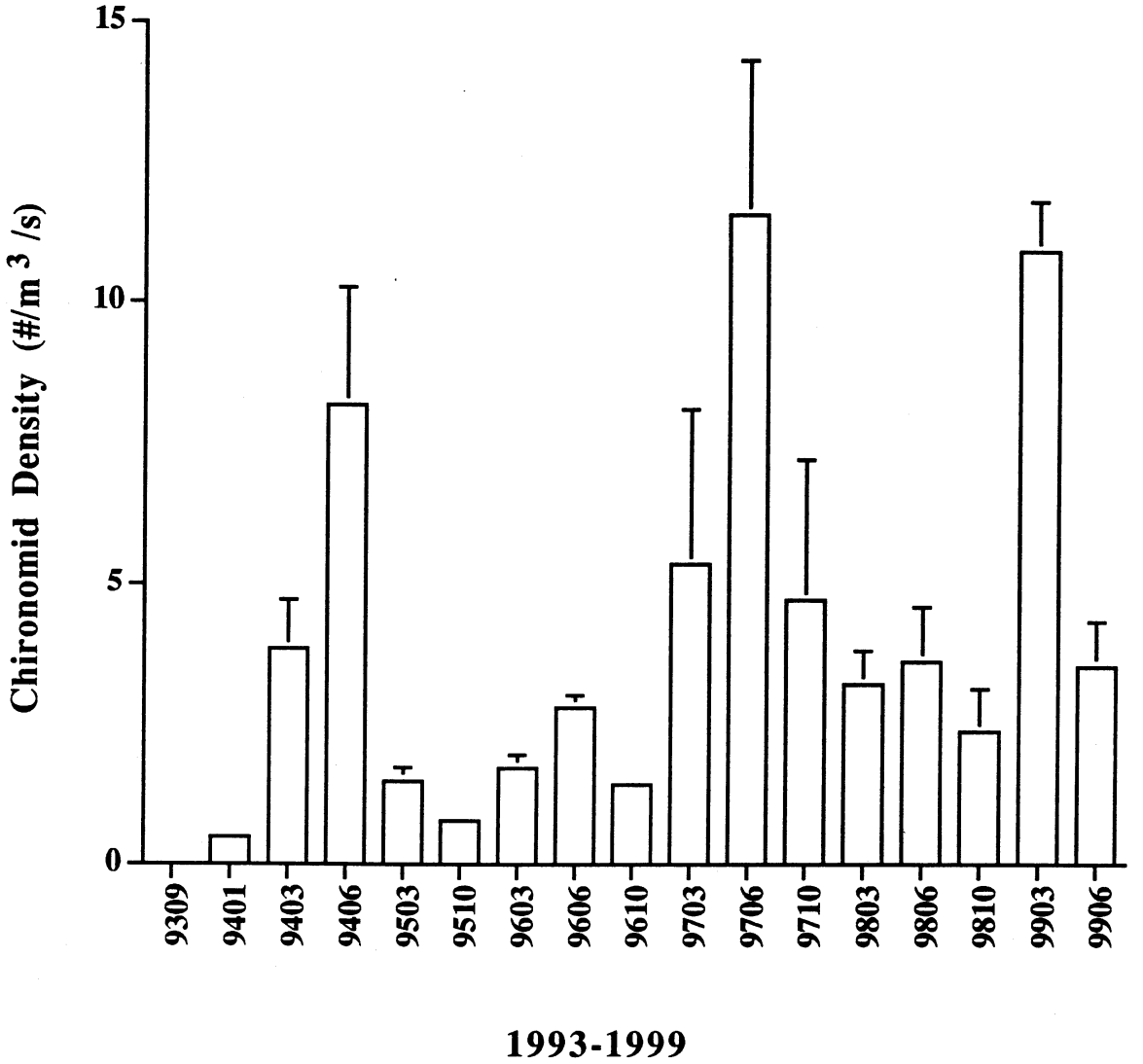

Figure 269. Average CPOM drift densities (#/m^3 /s) for Chironomids collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE).

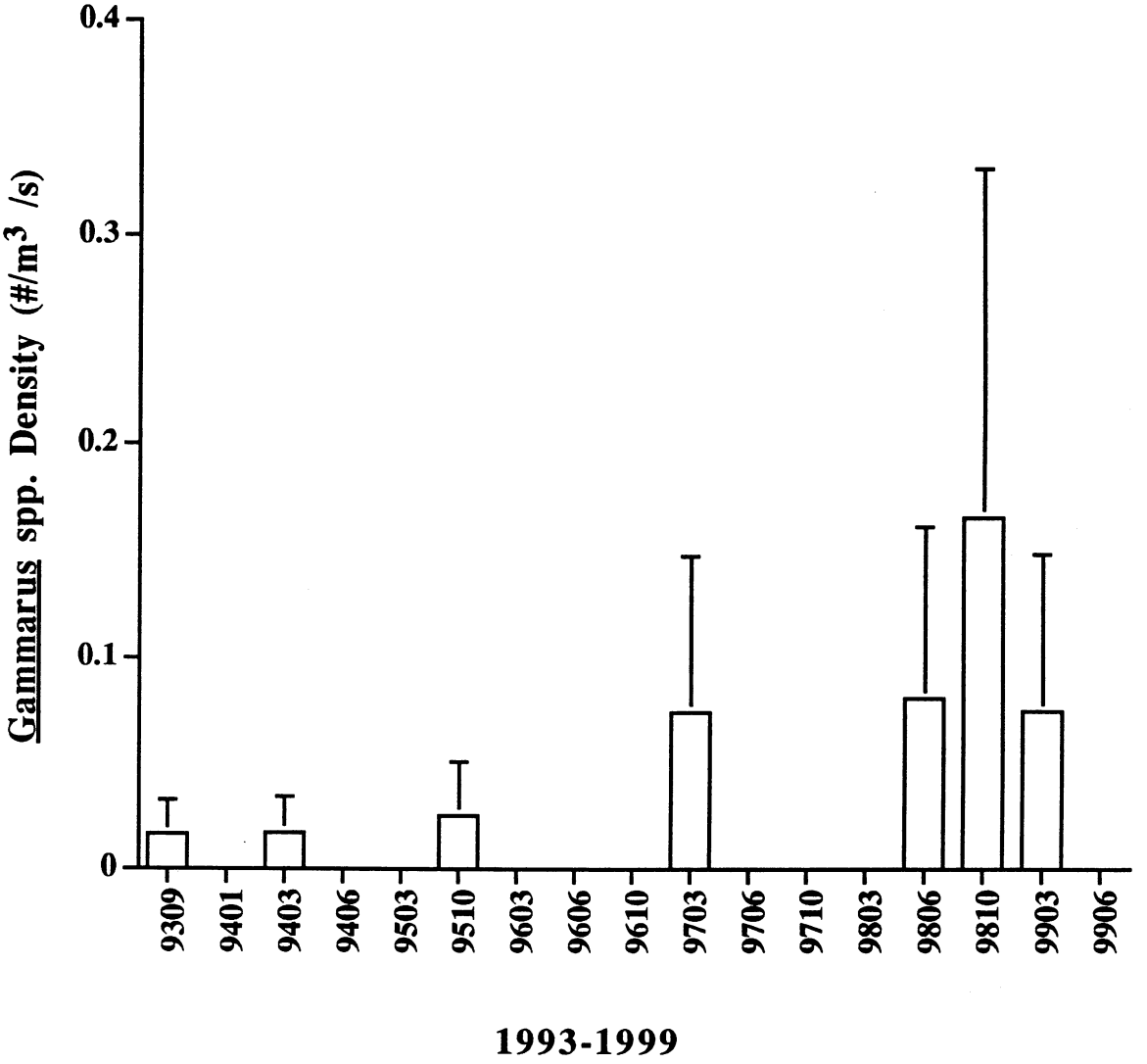

Figure 270. Average CPOM drift densities (#/m^3 /s) for Gammarus spp. collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE).

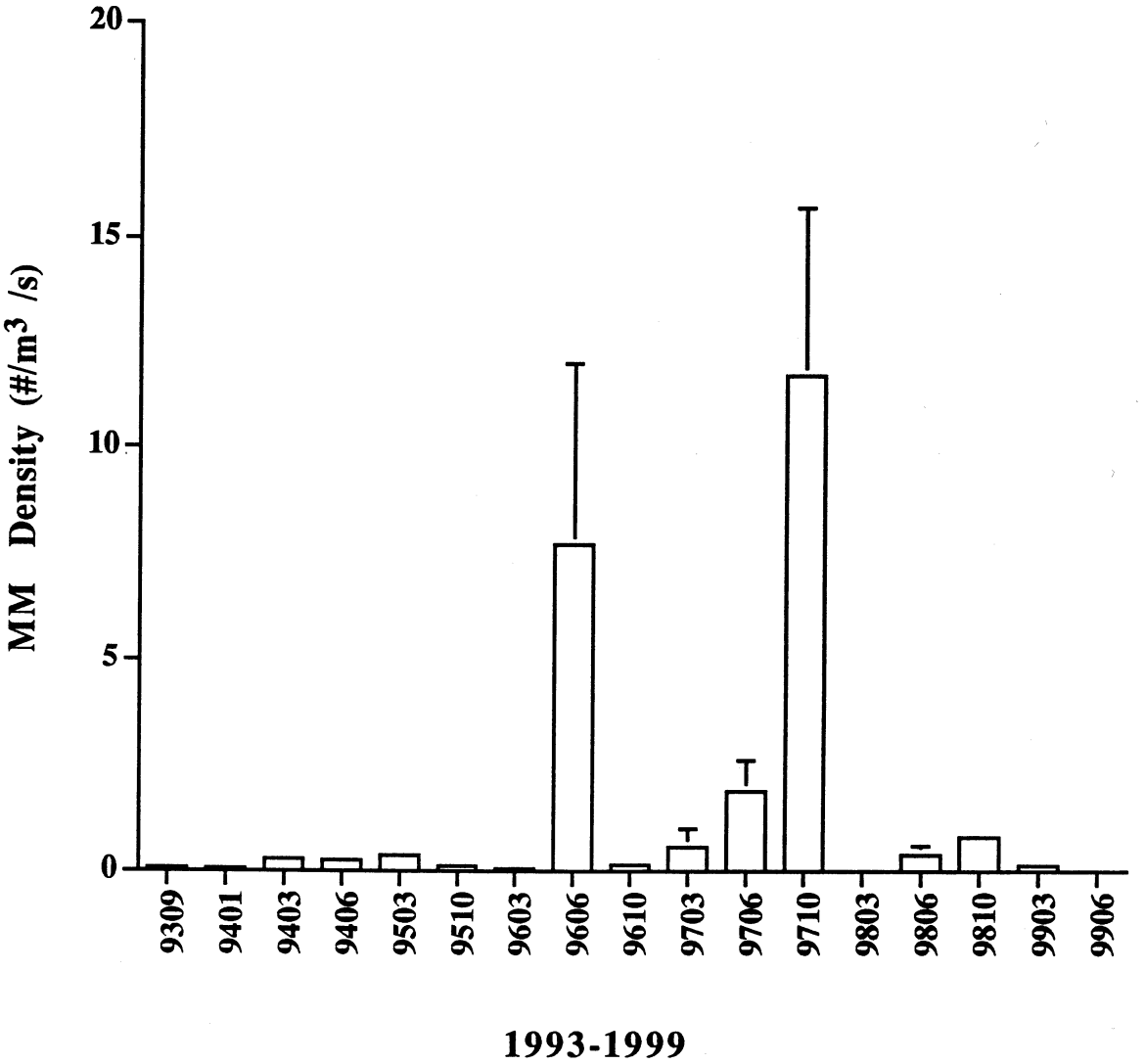

Figure 271. Average CPOM drift densities (#/m^3 /s) for miscellaneous macroinvertebrates (MM) collected at 205 Mile rapid Rkm 328.8 from September 1993 to June 1999. Error Bars represent (± 1 SE).

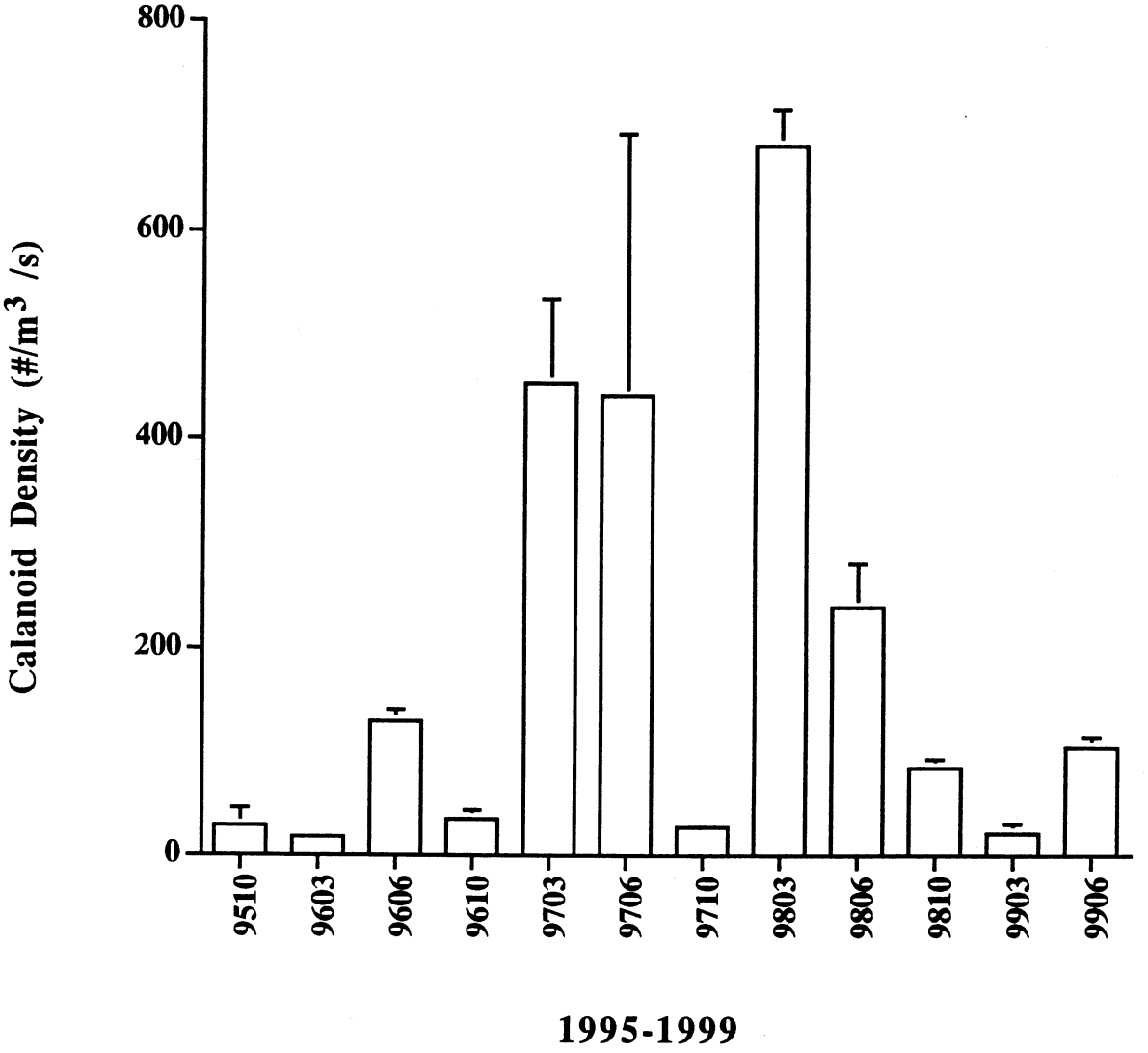

Figure 272. Average FPOM drift densities (#/m^3 /s) of Calanoids collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.Error bars represent (±1 SE).

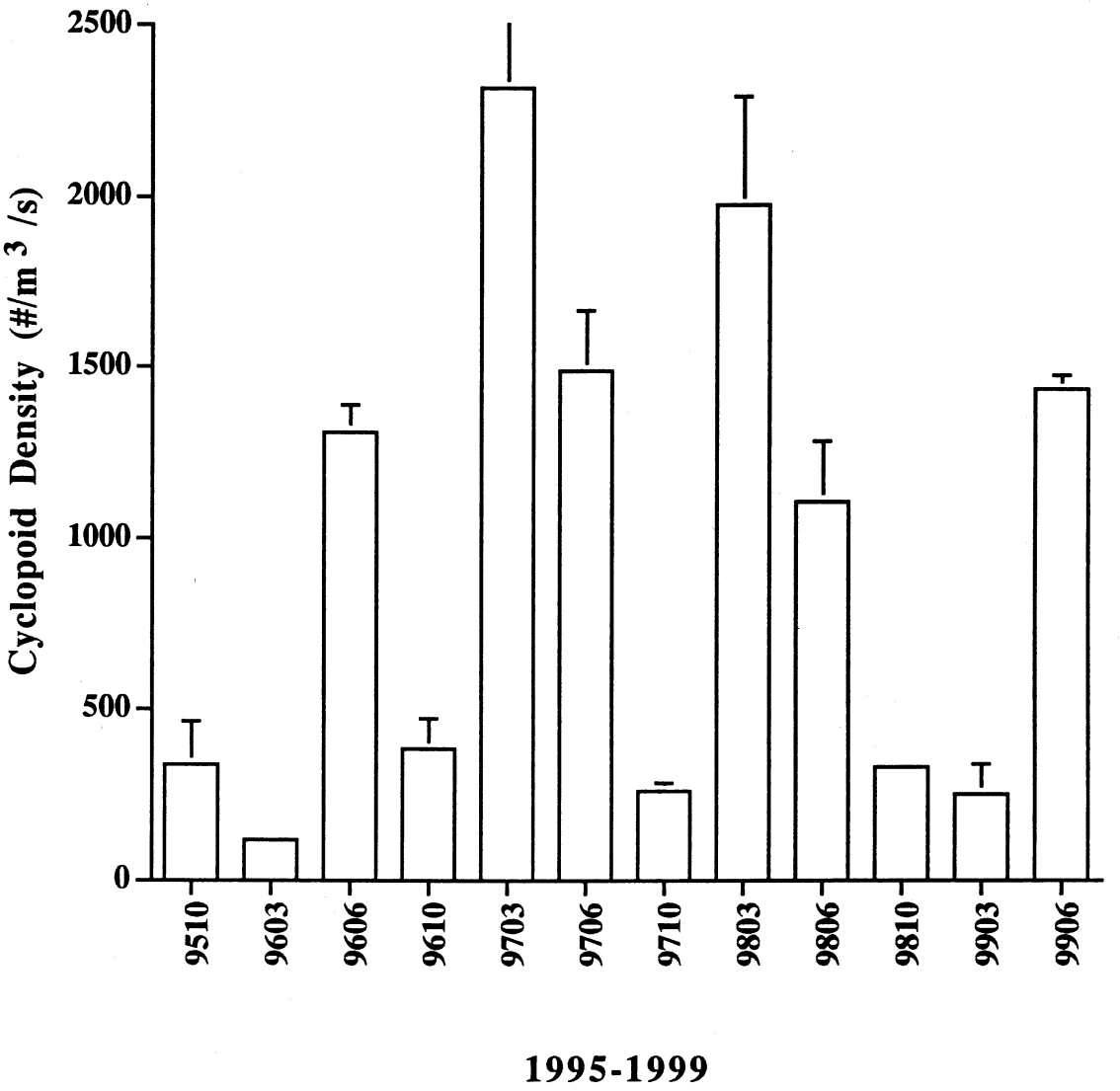

Figure 273. Average FPOM drift densities (#/m^3/s) of Cyclopoids collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999. Error bars represent (± 1 SE).

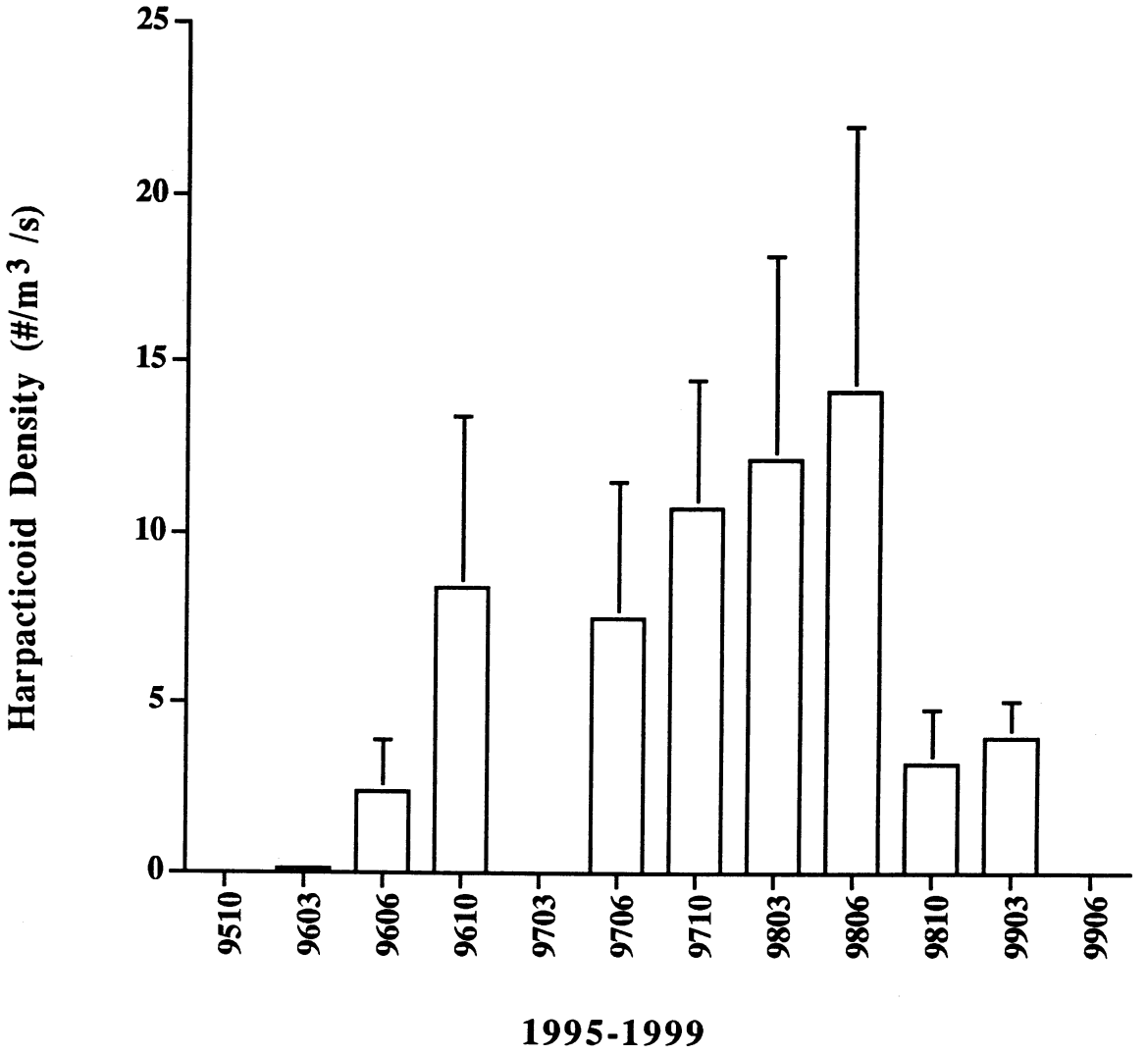

Figure 274. Average FPOM drift densities (#/m^3/s) of Harpacticoids collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

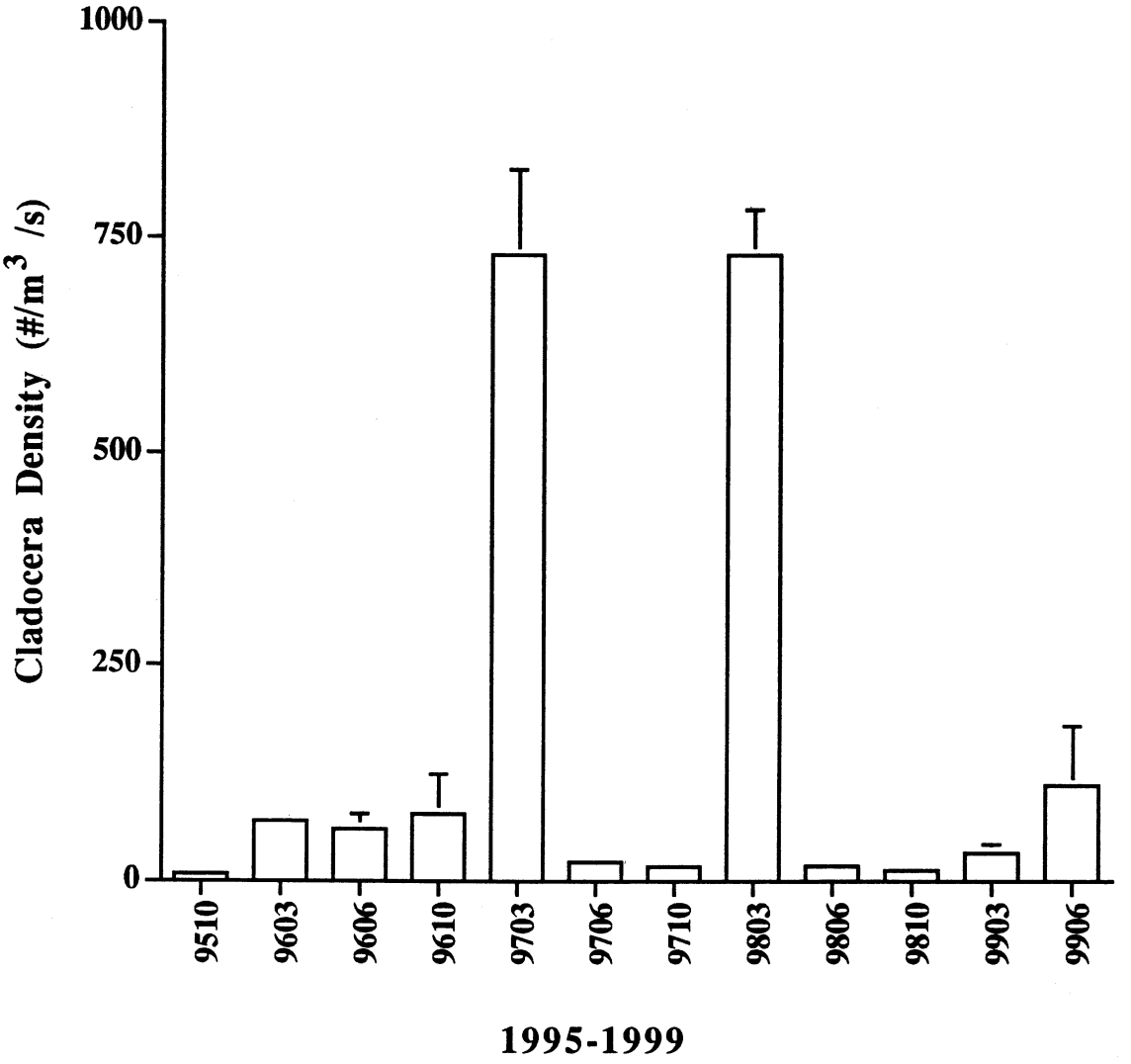

Figure 275. Average FPOM drift densities (#/m^3 /s) of Cladocera collected at Glen Canyon Rkm -23.2 from October 1995 to June 1999.

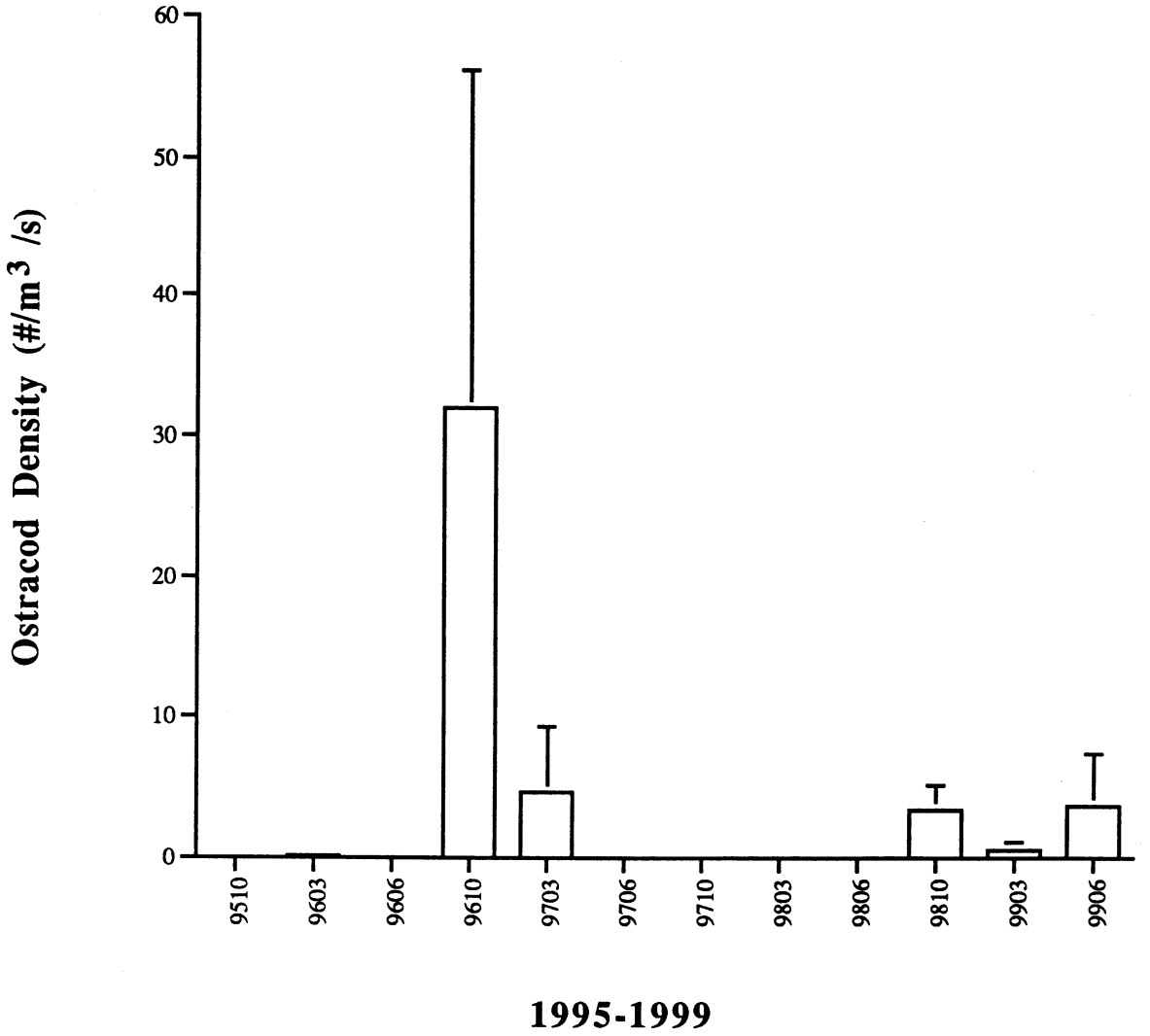

Figure 276. Average FPOM drift densities (#/m^3/s) of Ostracods collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

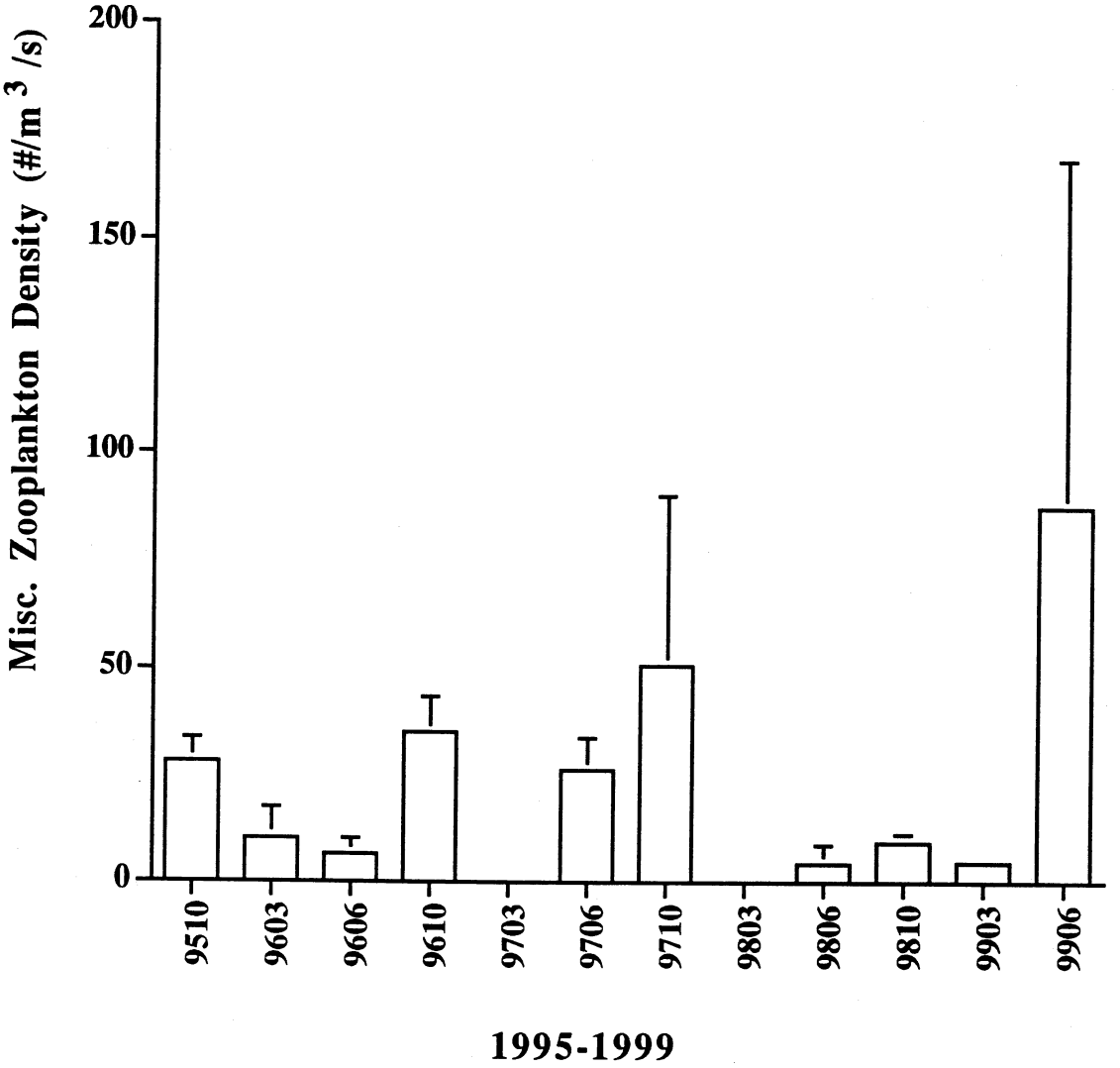

Figure 277. Average FPOM drift densities (#/m^3/s) of miscellaneous zooplankton (benthic origin) collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

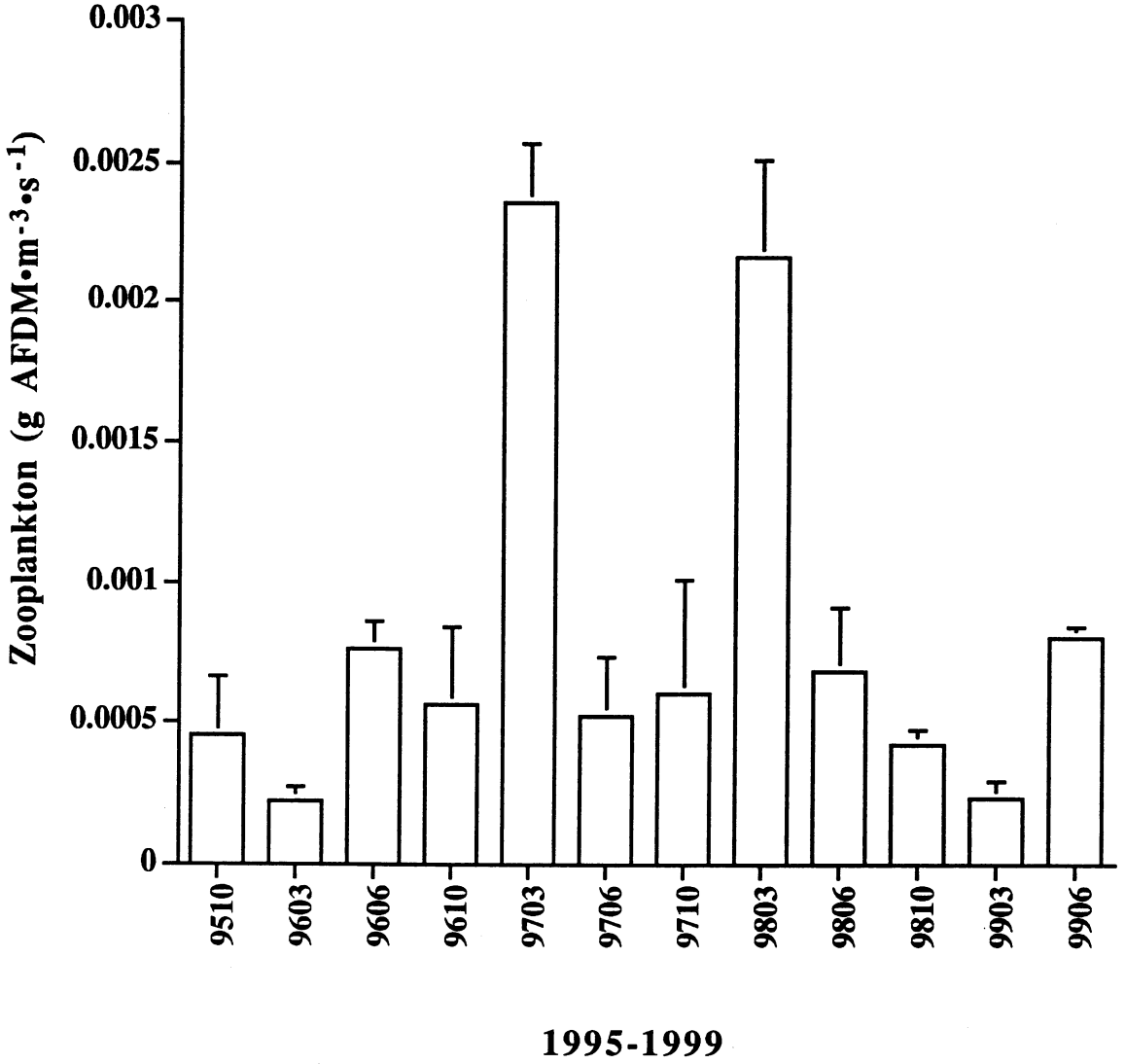

Figure 278. Average zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of lentic origin for Calanoida, Cyclopoida, Cladocera and Ostracoda collected at Glen Canyon Rkm -23.2 from October 1995 to June 1999.

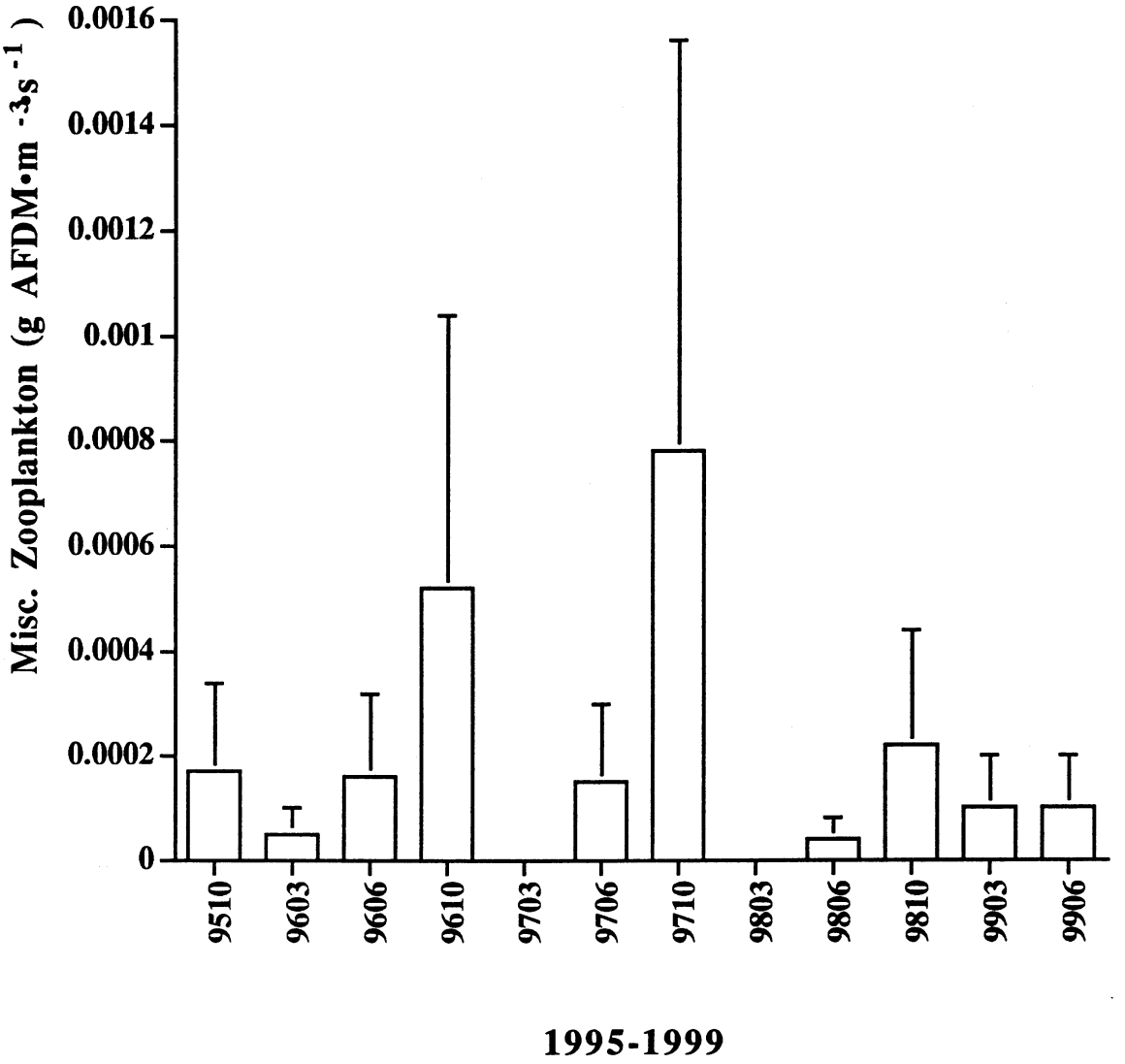

Figure 279. Average miscellaneous zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of benthic origin collected at Glen Canyon Gauge Rkm -23.2 from October 1995 to June 1999.

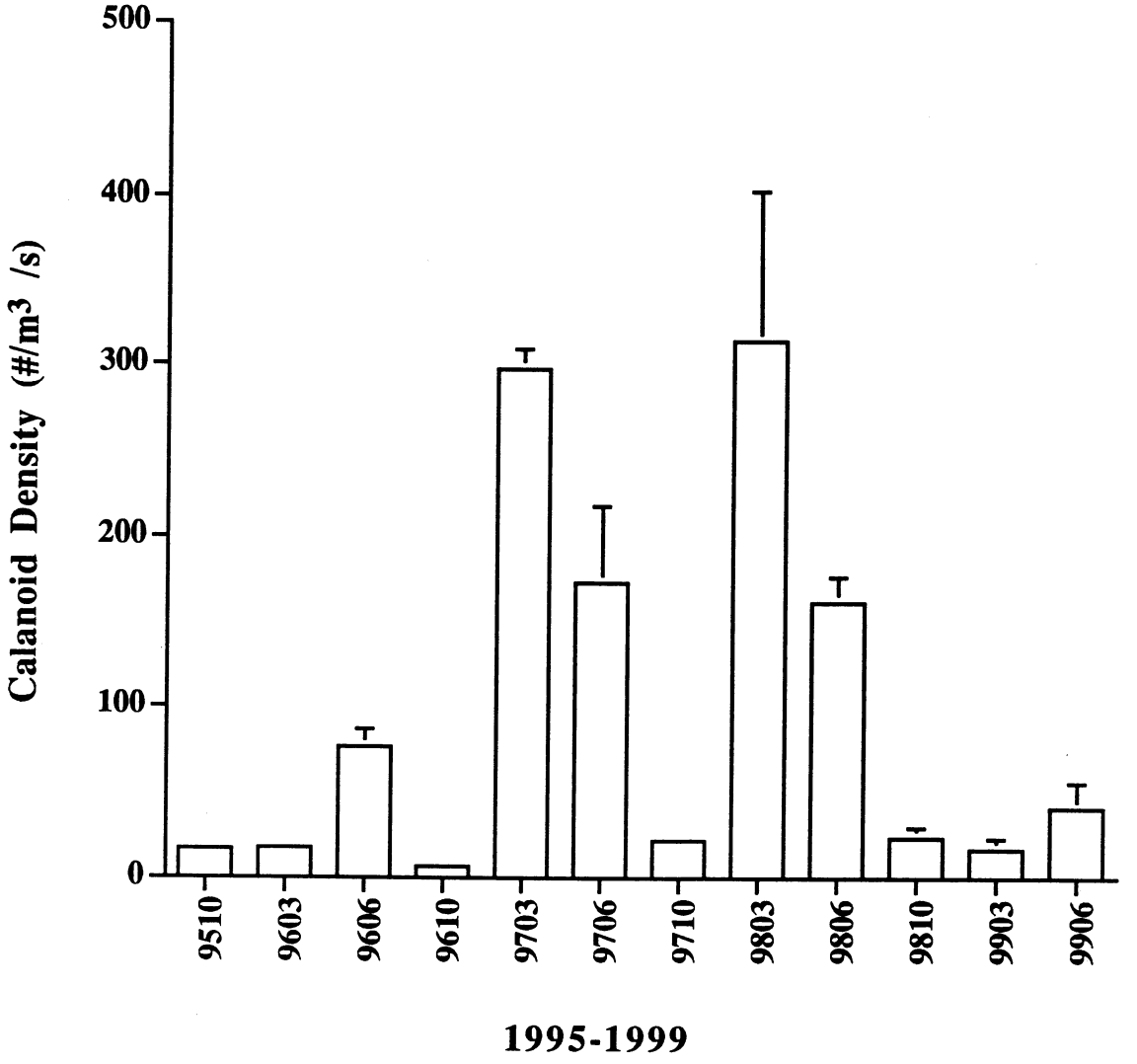

Figure 280. Average FPOM drift densities (#/m^3/s) of Calanoids collected at Lees Ferry Rkm 0.0 from October 1995 to June 1999.

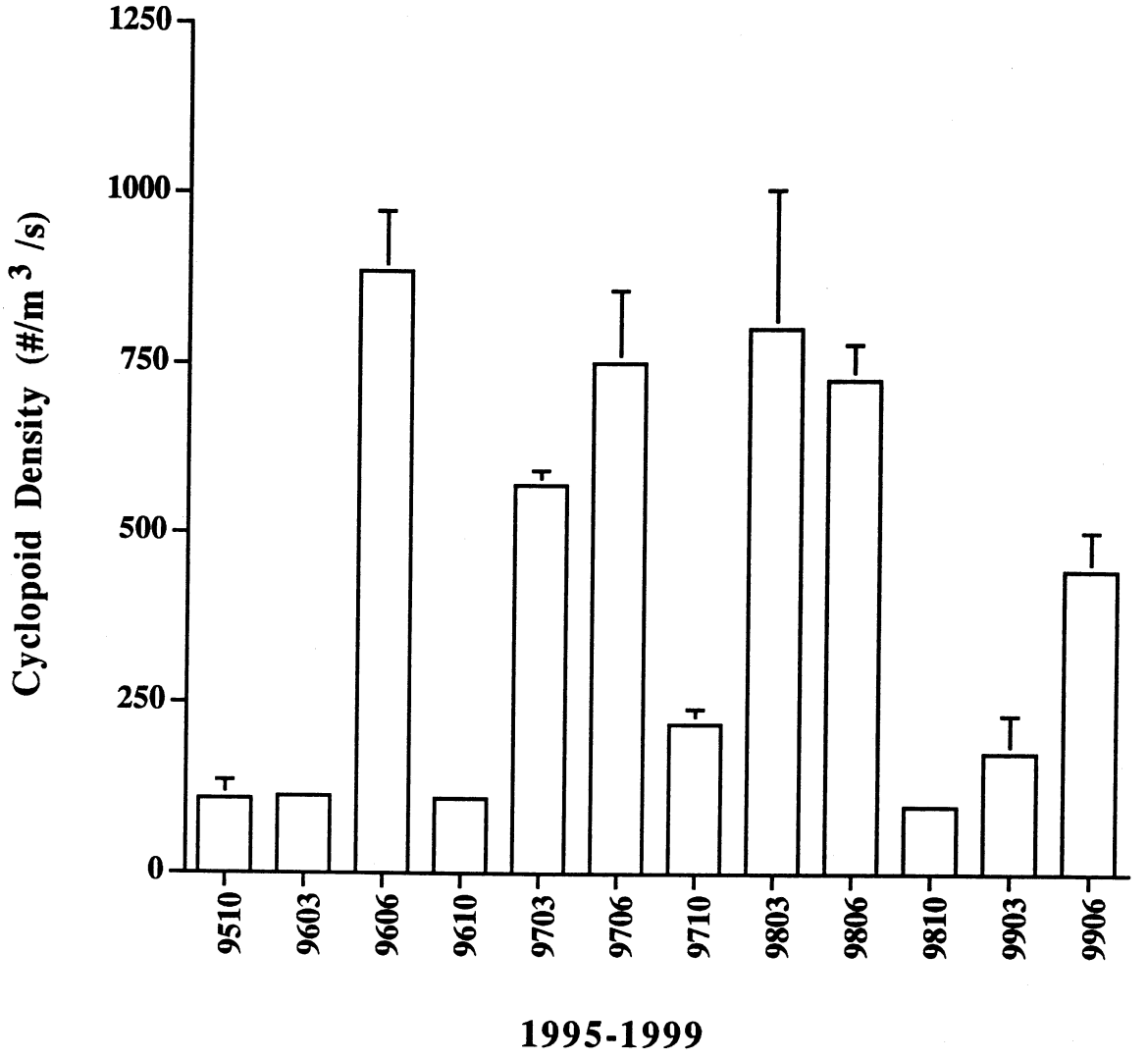

Figure 281. Average FPOM drift densities (#/m^3/s) of Cyclopoids collected at Lees Ferry Rkm 0.0 from October 1995 to June 1999.

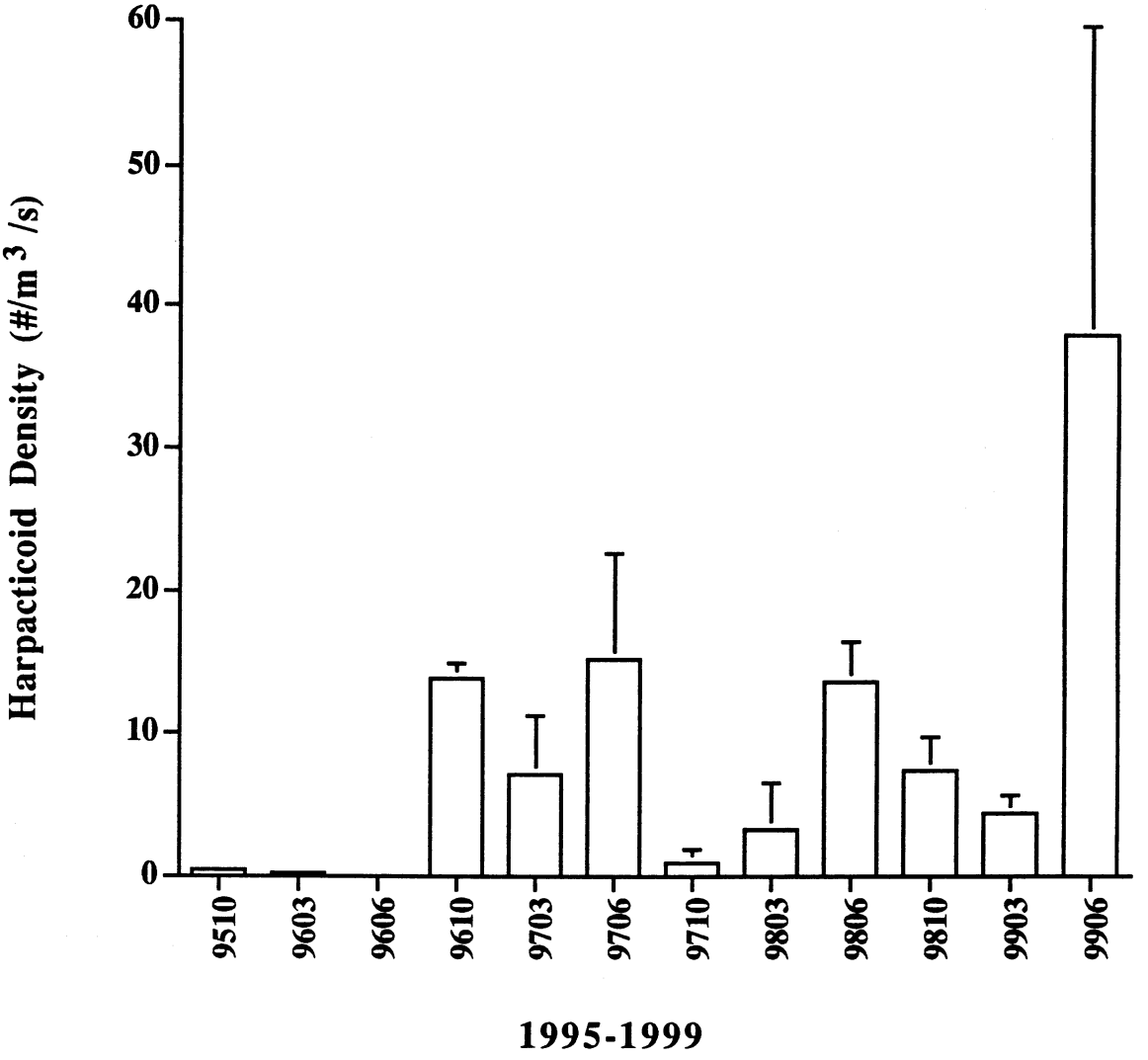

Figure 282. Average FPOM drift densities (#/m^3/s) of Harpacticoids collected at Lees Ferry Rkm 0.0 from October 1995 to June 1999.

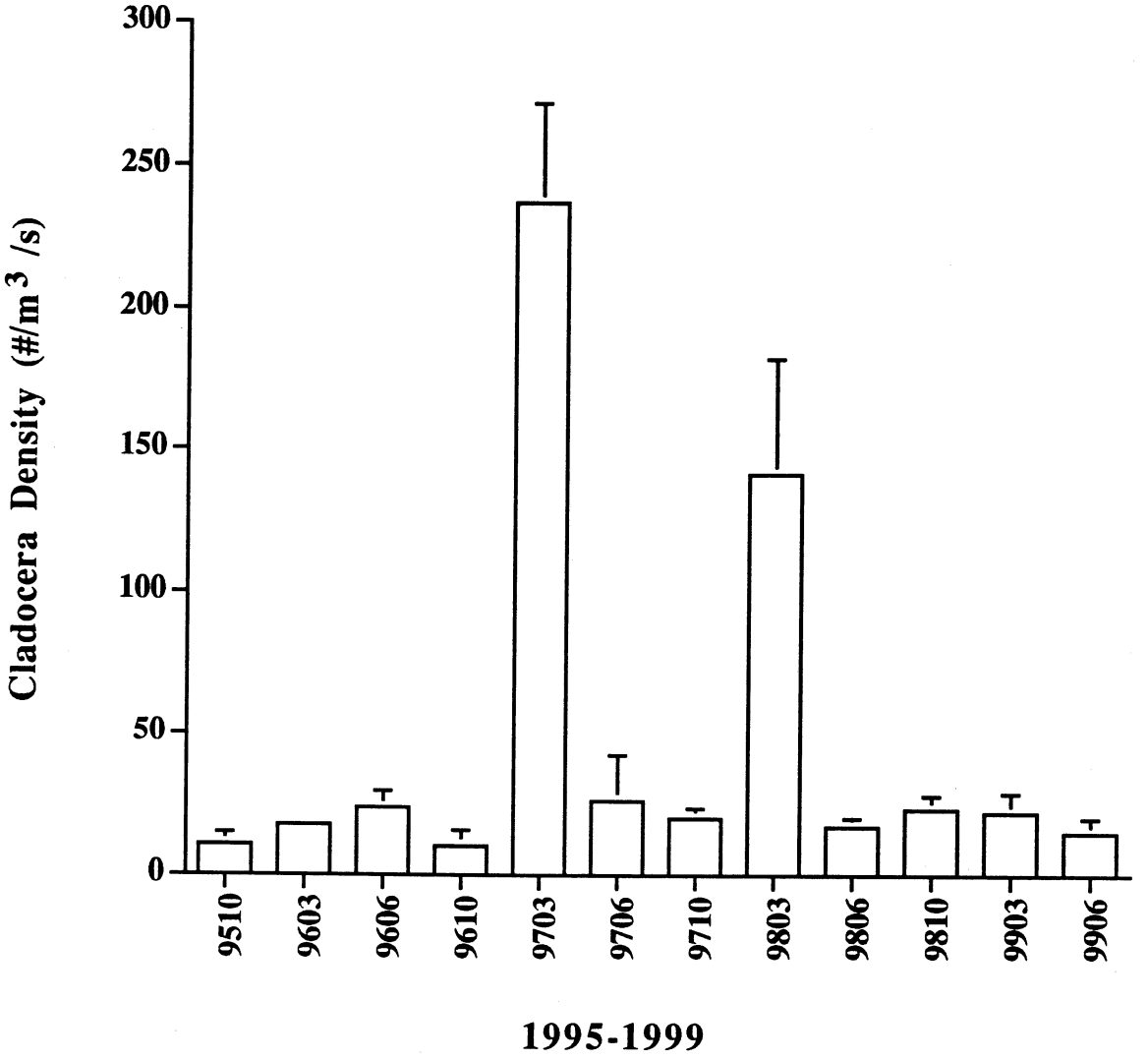

Figure 283. Average FPOM drift densities (#/m^3/s) of Cladocera collected at Lees Ferry Rkm 0.0 from October 1995 to June 1999.

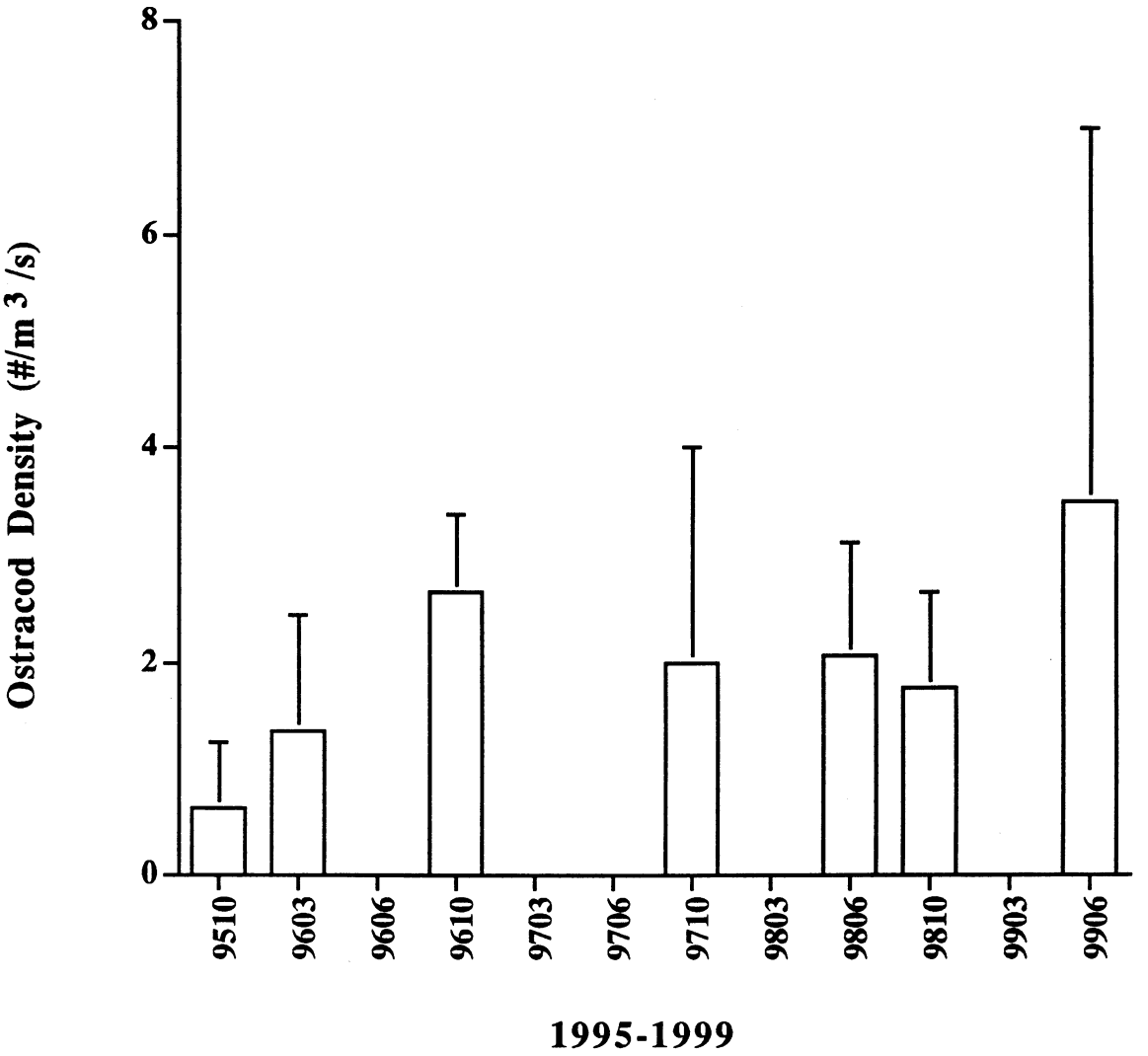

Figure 284. Average FPOM drift densities (#/m^3/s) of Ostracods collected at Lees Ferry Rkm 0.0 from October 1995 to June 1999.

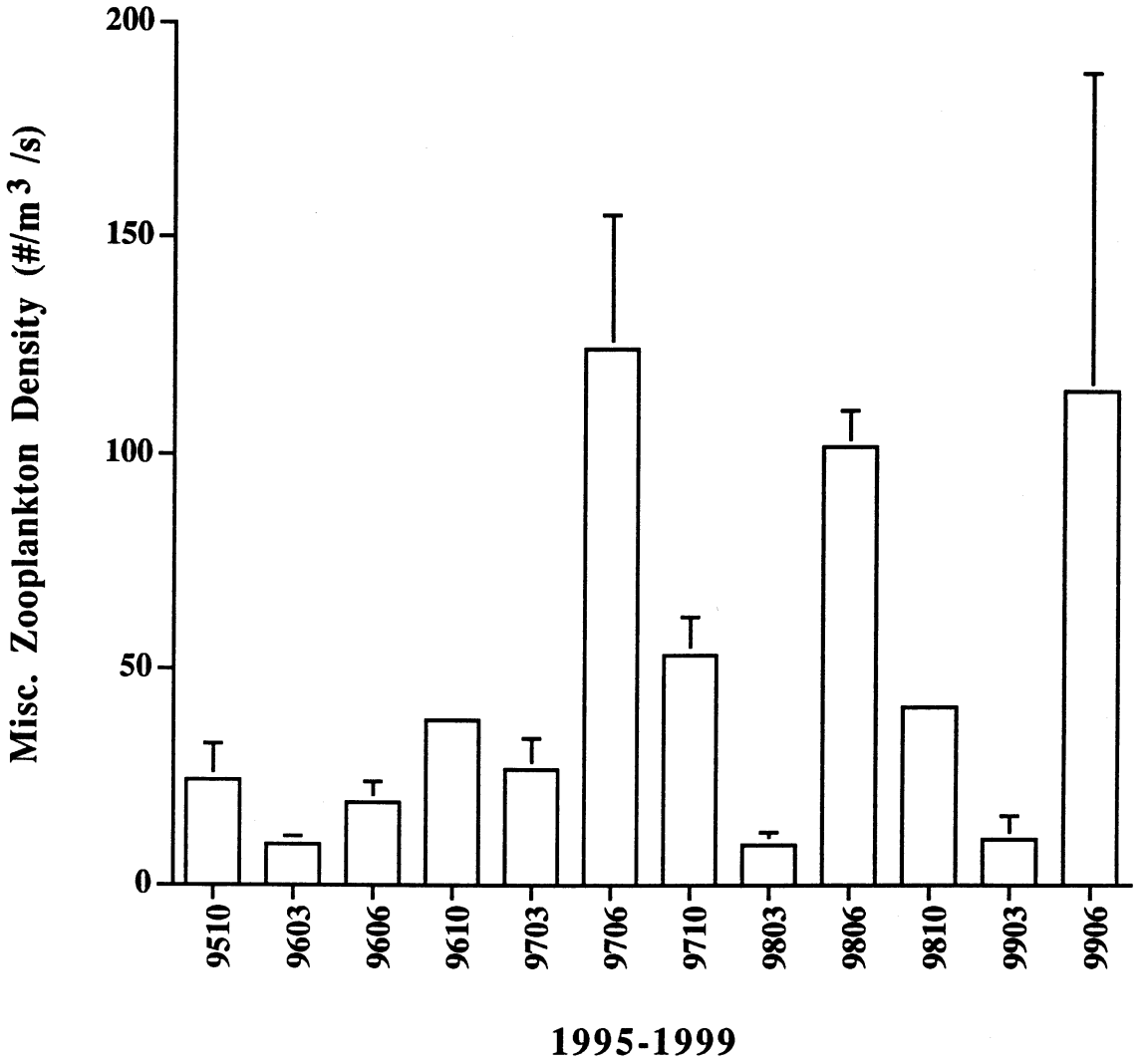

Figure 285. Average FPOM drift densities (#/m^3/s) of miscellaneous zooplankton (benthic origin) collected at Lees Ferry Rkm 0.0 from October 1995 to June 1999.

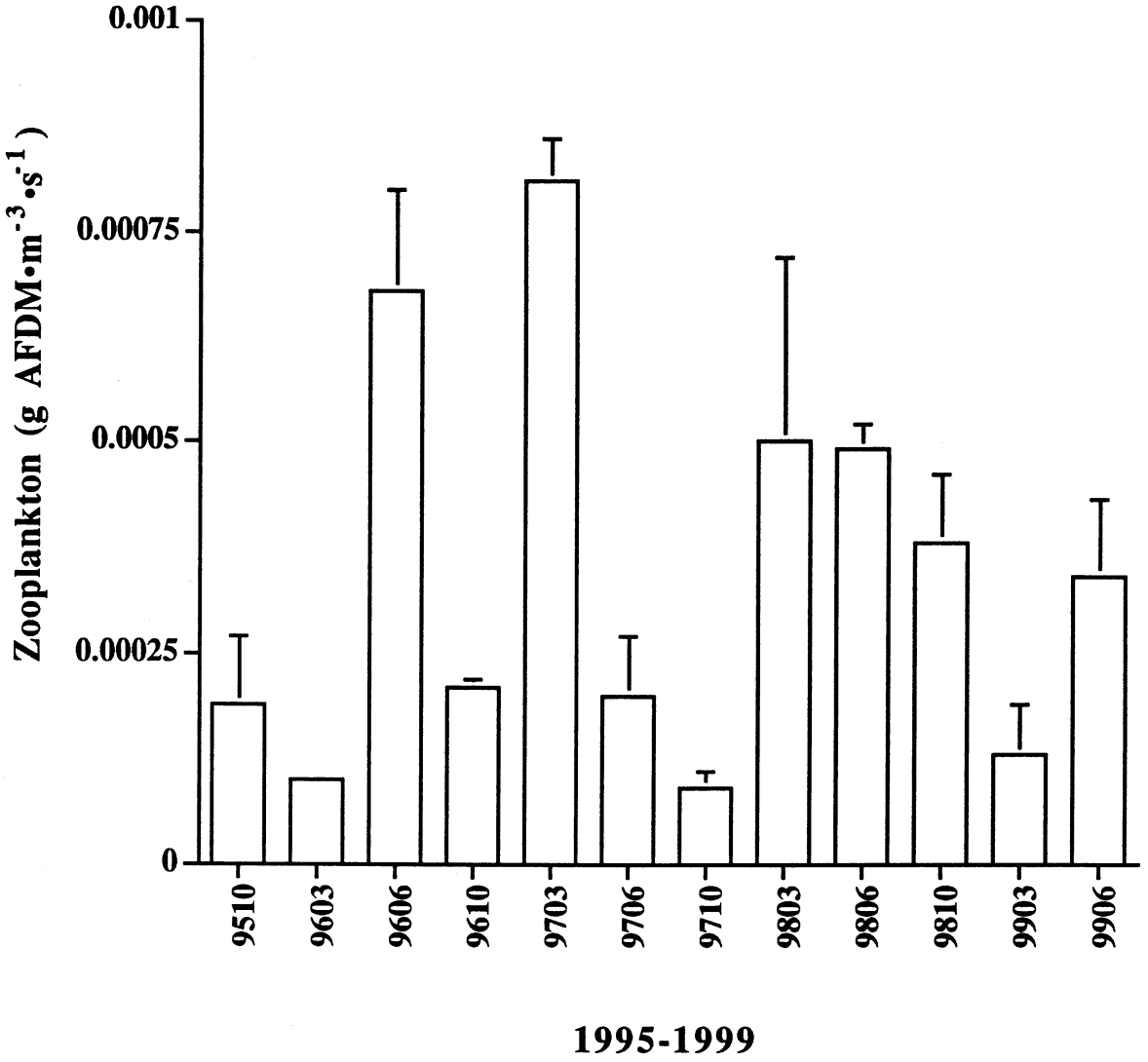

Figure 286. Average zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of lentic origin for Calanoida, Cyclopoida, Harpactacoida, Cladocera and Ostracoda collected at Lees Ferry Rkm 0.0 from October 1995 to June 1999.

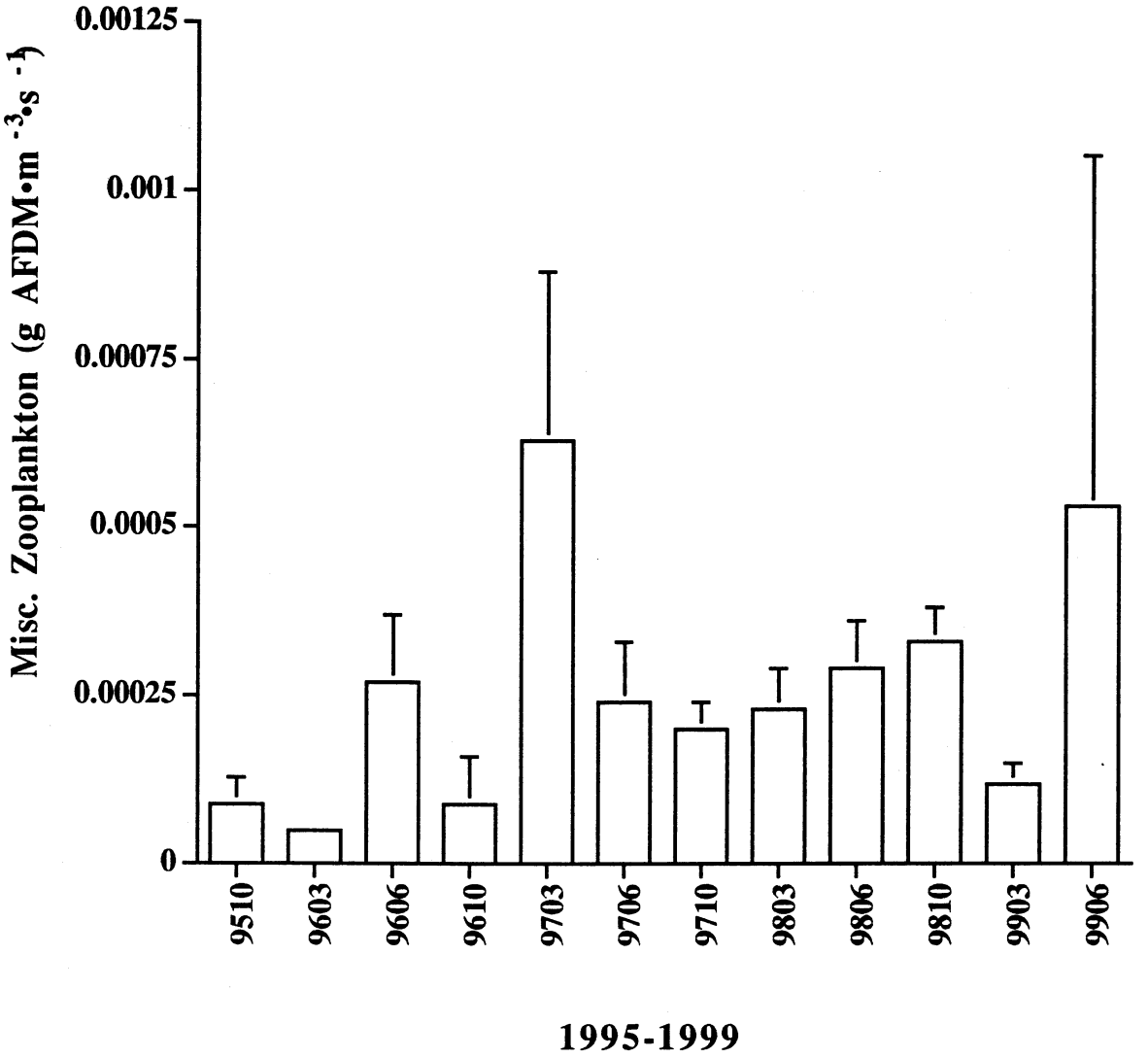

Figure 287. Average miscellaneous zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of benthic origin collected at Lees Ferry Rkm 0.0 from October 1995 to June 1999.

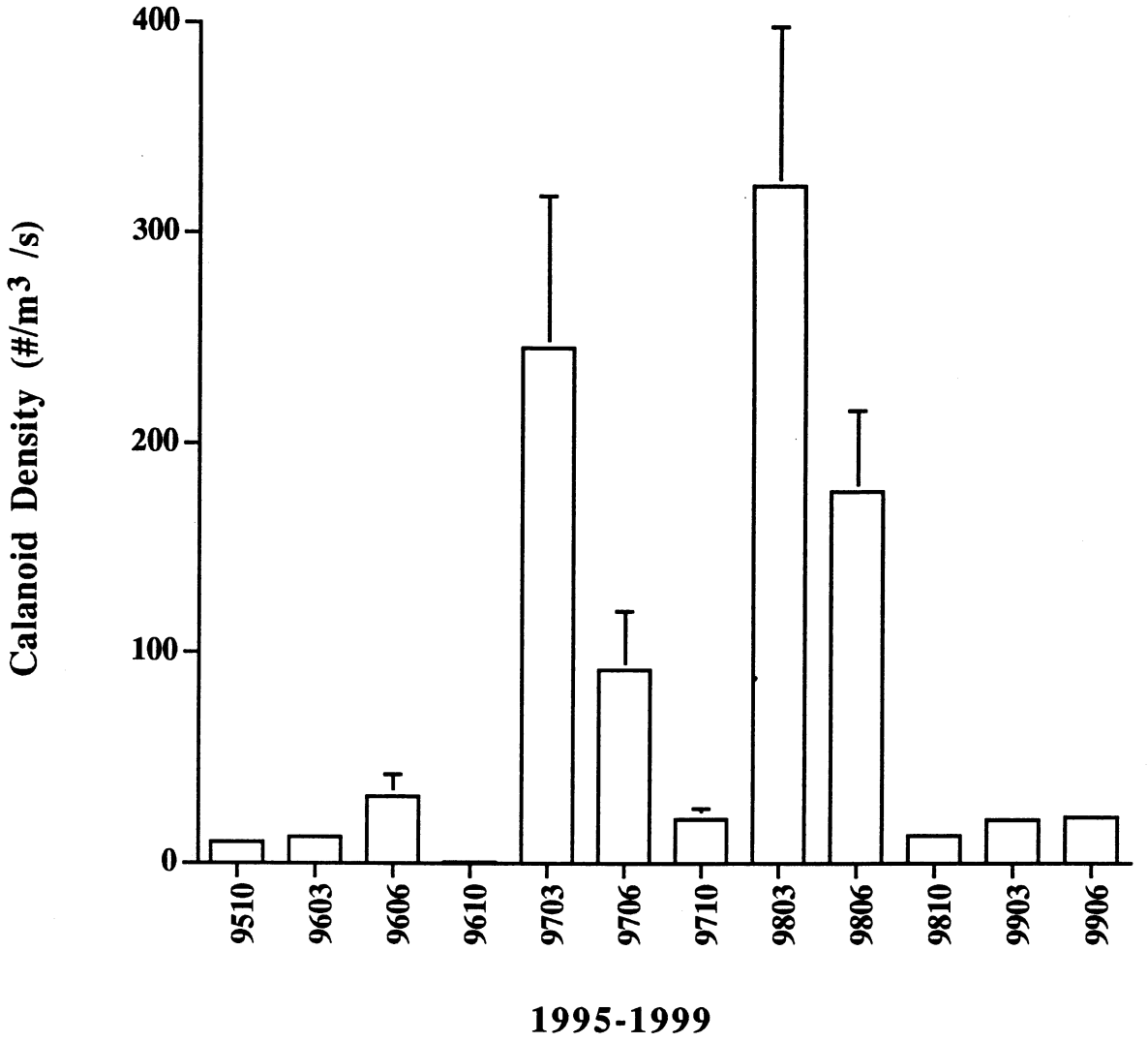

Figure 288. Average FPOM drift densities (#/m^3/s) of Calanoids collected at Two-Mile Wash Rkm 2.9 from October 1995 to June 1999.

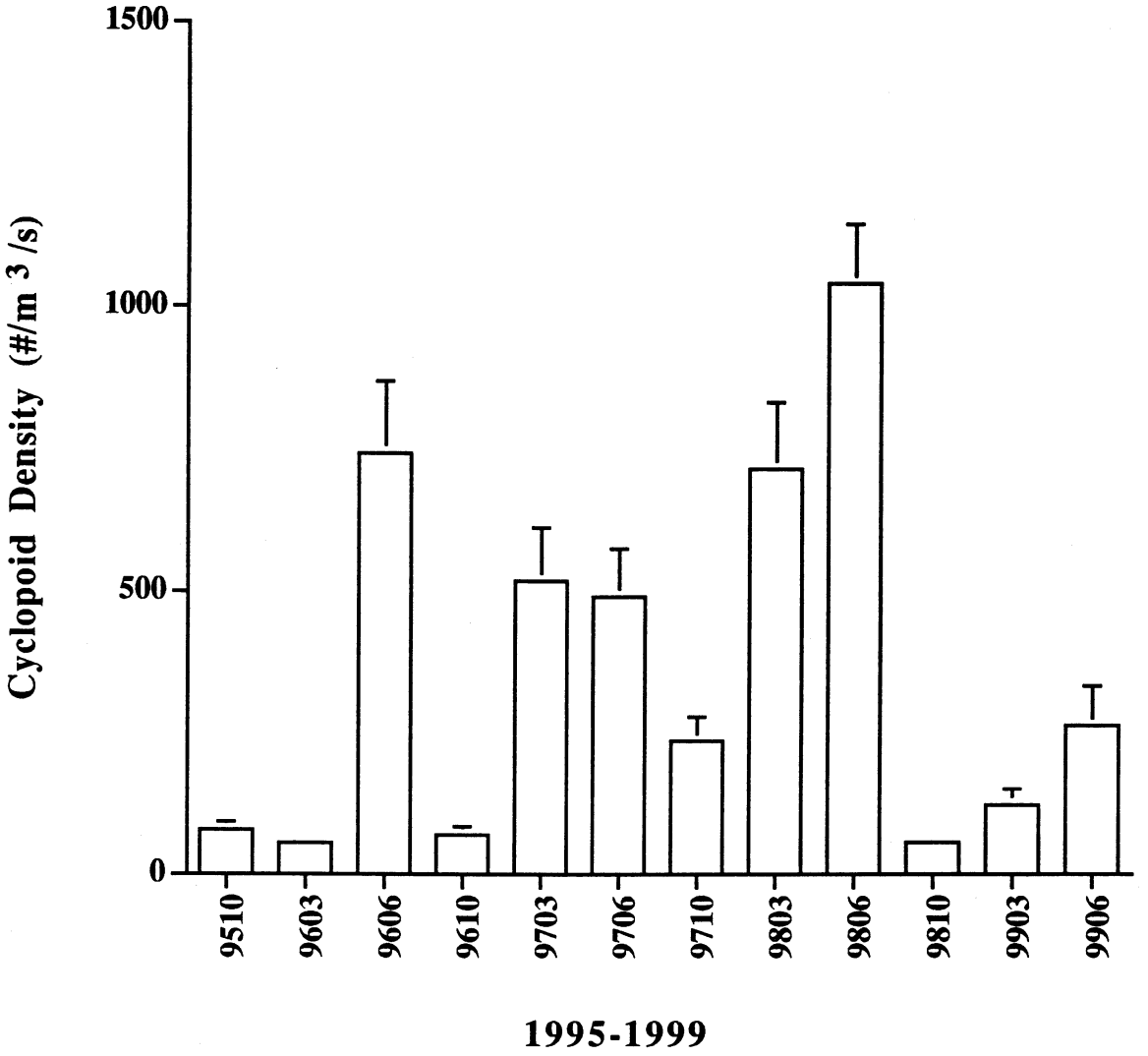

Figure 289. Average FPOM drift densities (#/m^3/s) of Cyclopoids collected at Two-Mile Wash Rkm 2.9 from October 1995 to June 1999.

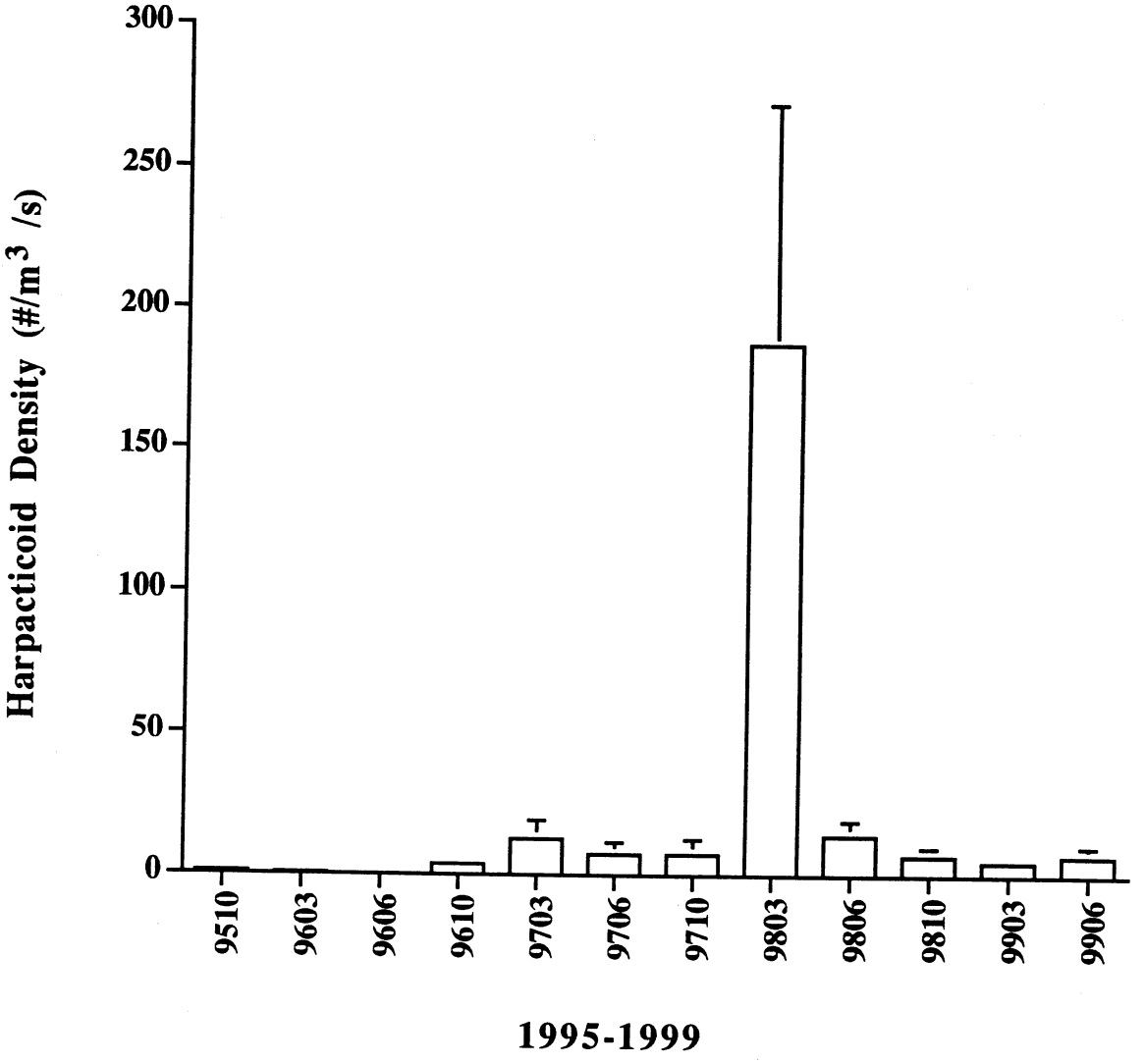

Figure 290. Average FPOM drift densities (#/m^3/s) of Harpacticoids collected at Two-Mile Wash Rkm 2.9 from October 1995 to June 1999.

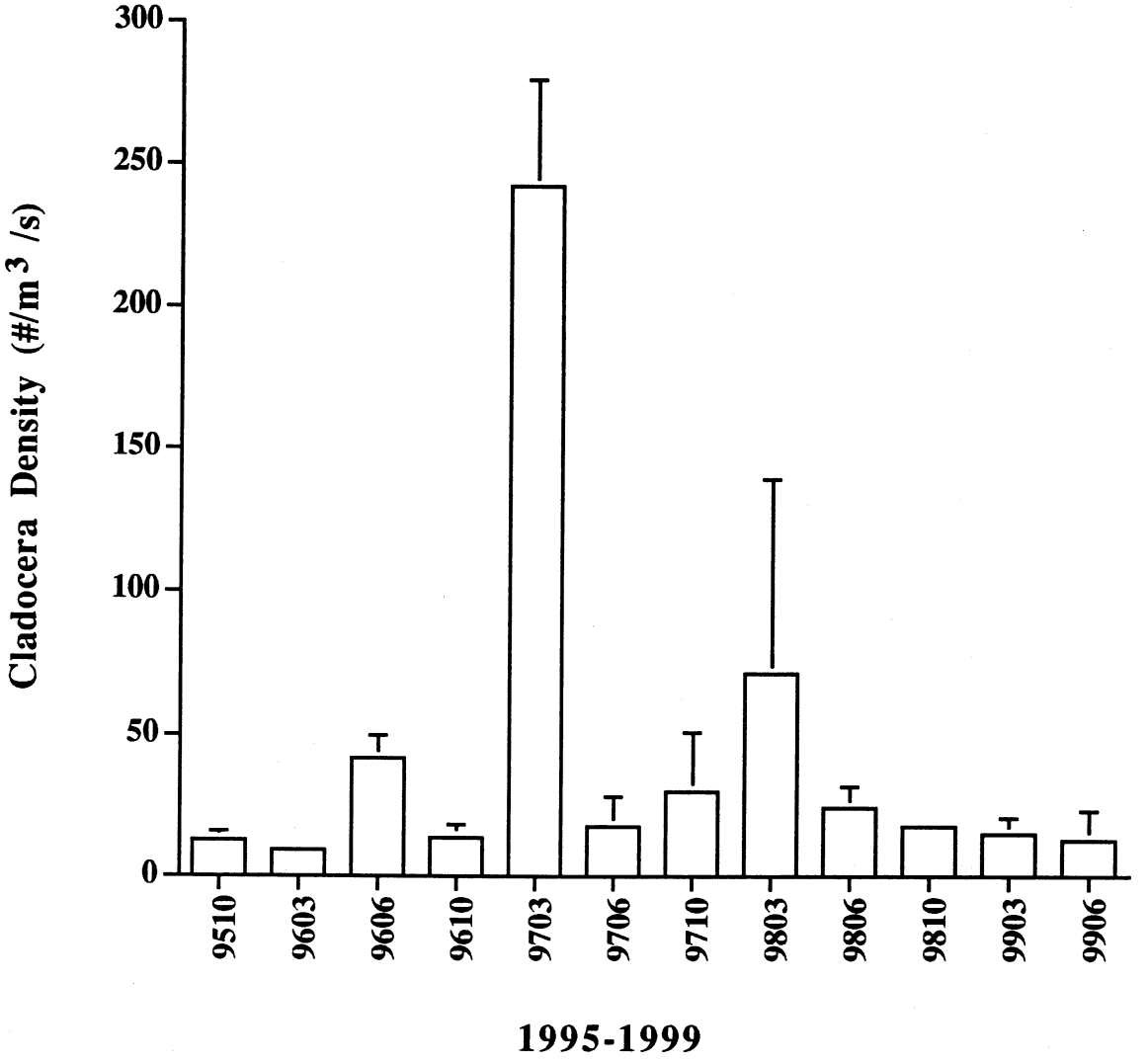

Figure 291. Average FPOM drift densities (#/m^3 /s) of Cladocera collected at Two-Mile Wash Rkm 2.9 from October 1995 to June 1999.

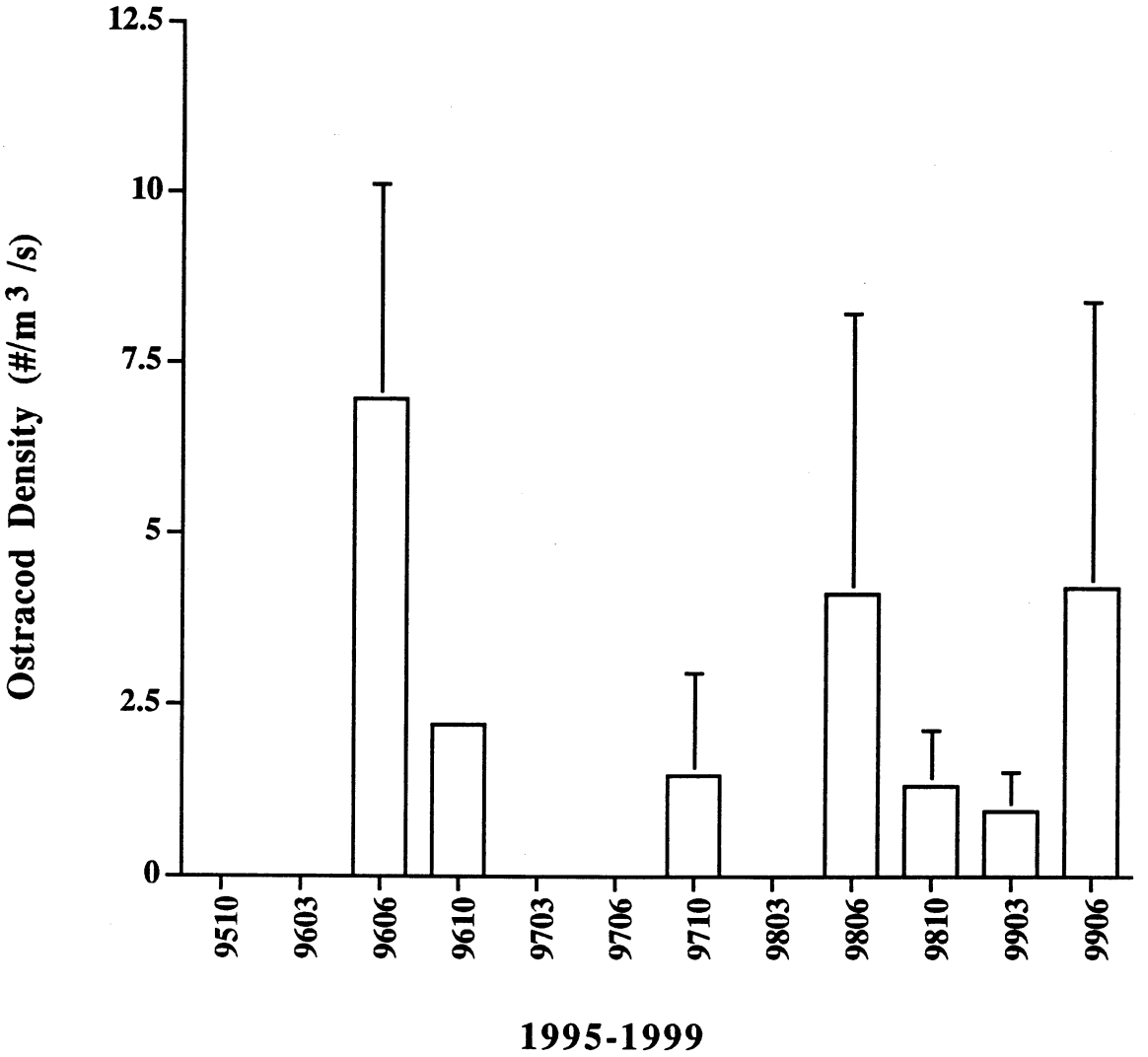

Figure 292. Average FPOM drift densities (#/m^3/s) of Ostracods collected at Two-Mile Wash Rkm 2.9 from October 1995 to June 1999.

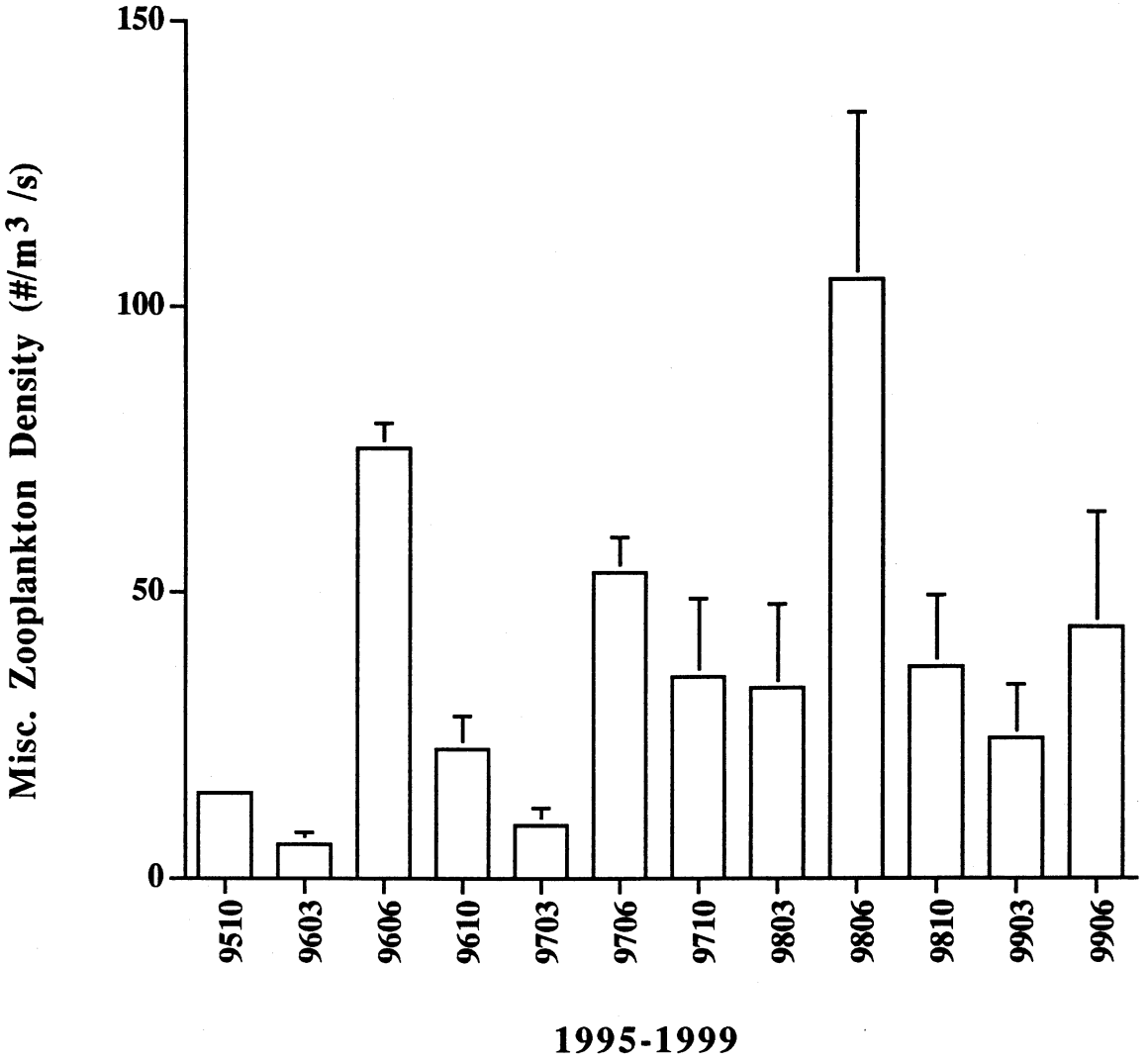

Figure 293. Average FPOM drift densities (#/m^3/s) of miscellaneous zooplankton (benthic origin) collected at Two-Mile Wash Rkm 2.9 from October 1995 to June 1999.

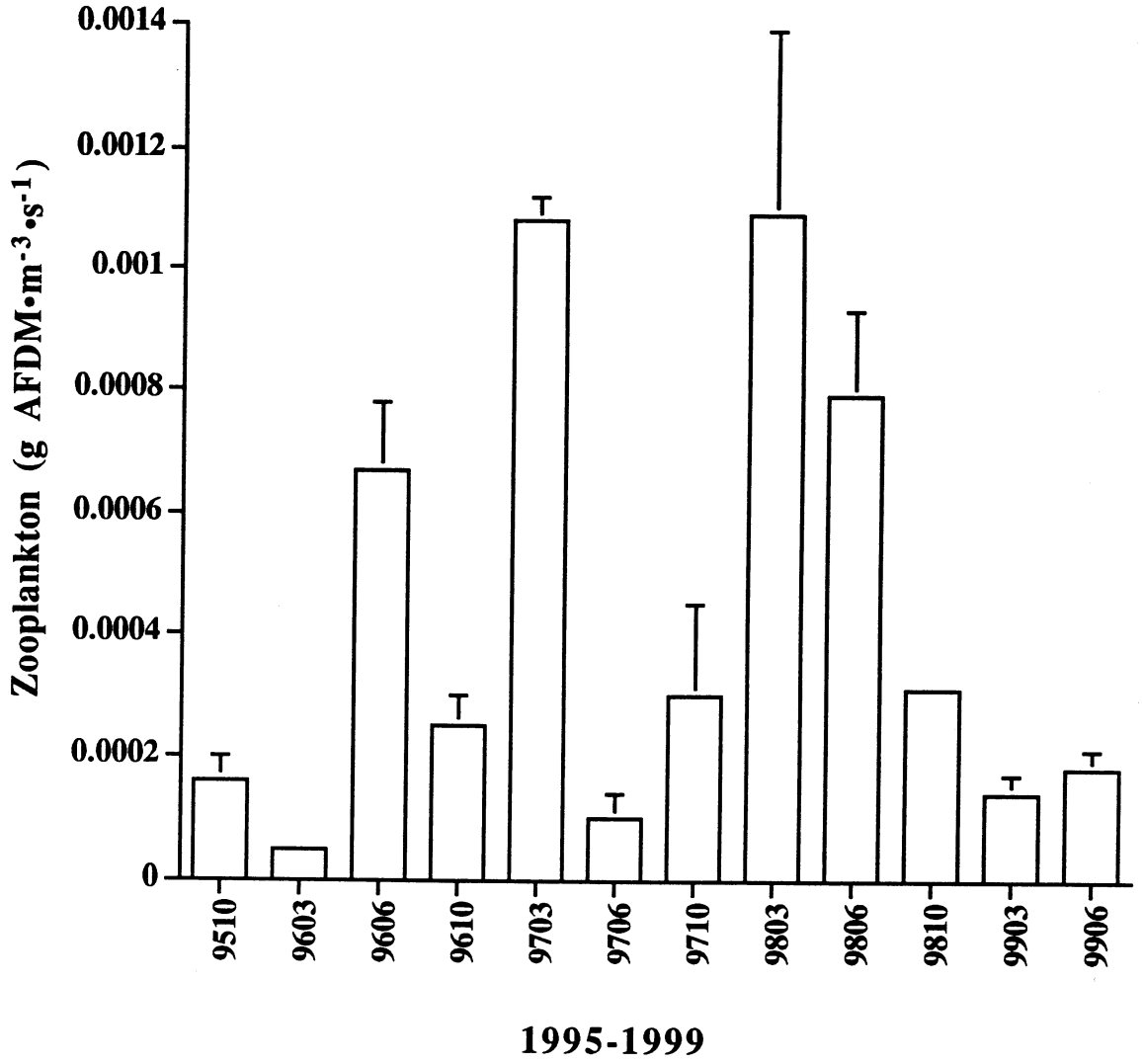

Figure 294. Average zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of lentic origin for Calanoida, Cyclopoida, Harpactacoida, Cladocera and Ostracoda collected at Two-Mile Wash Rkm 2.9 from October 1995 to June 1999.

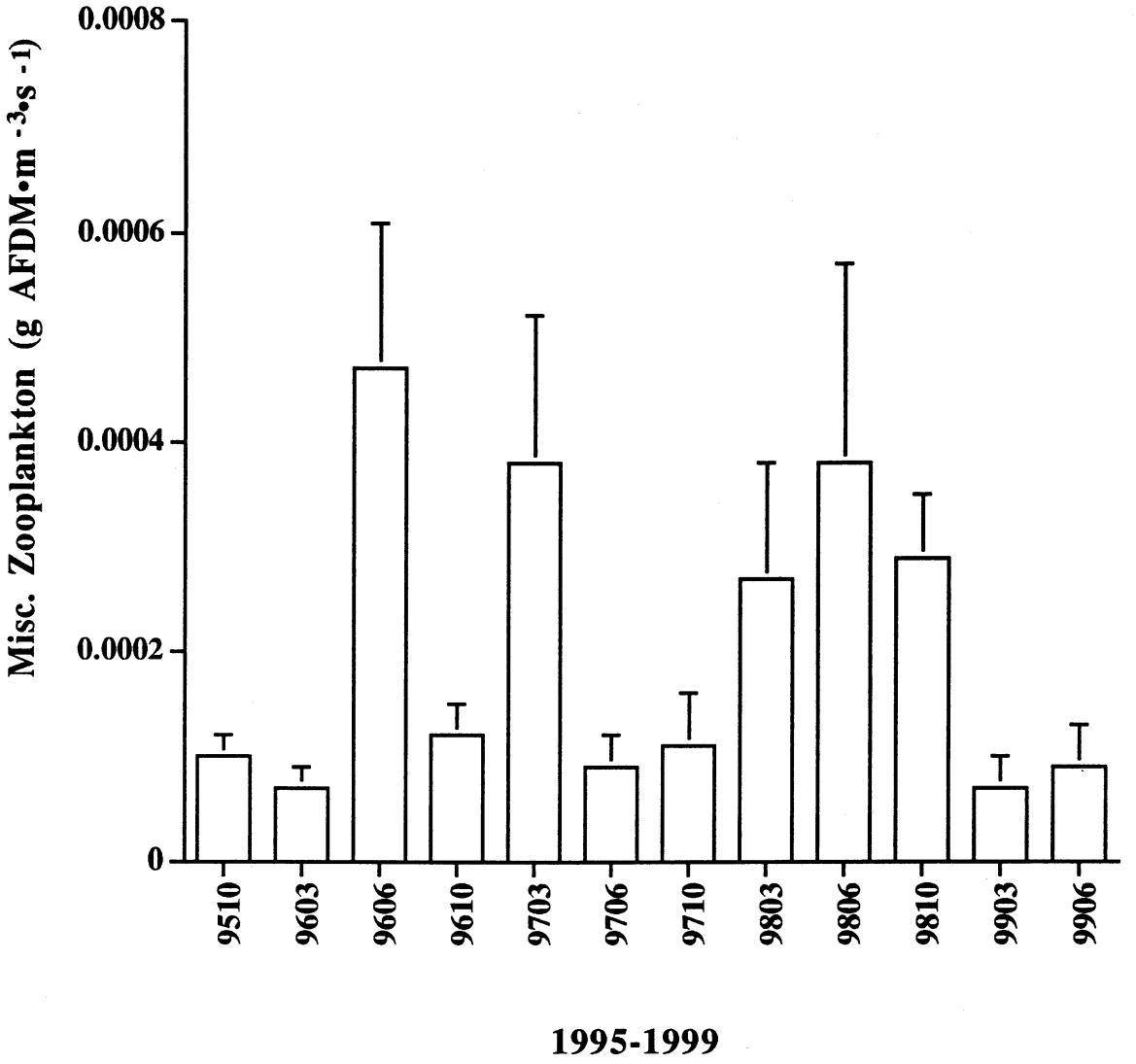

Figure 295. Average miscellaneous zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of benthic origin collected at Two-Mile Wash Rkm 2.9 from October 1995 to June 1999.

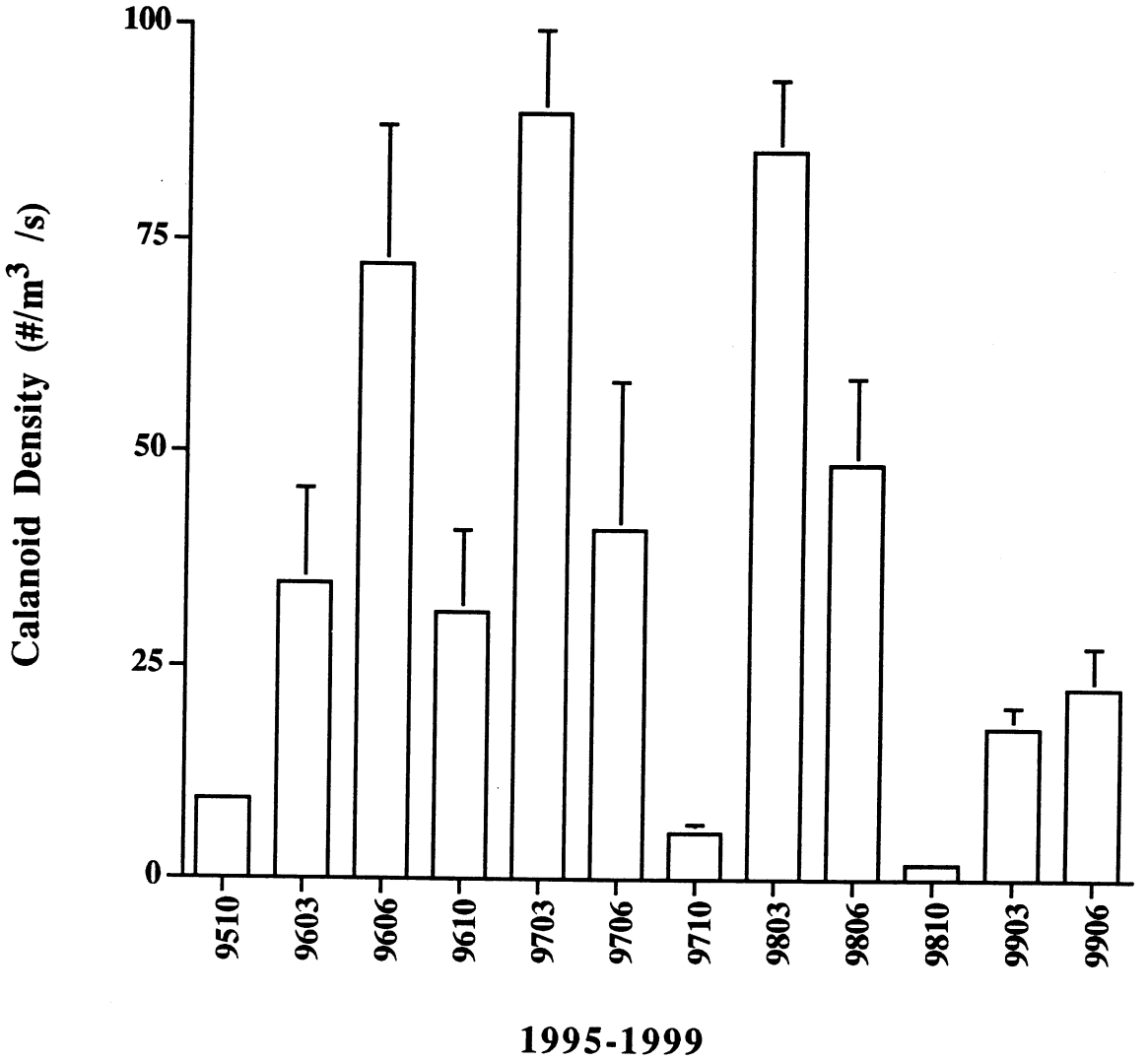

Figure 296. Average FPOM drift densities (#/m^3/s) of Calanoids collected at Guage Above LCR Rkm 98.4 from October 1995 to June 1999.

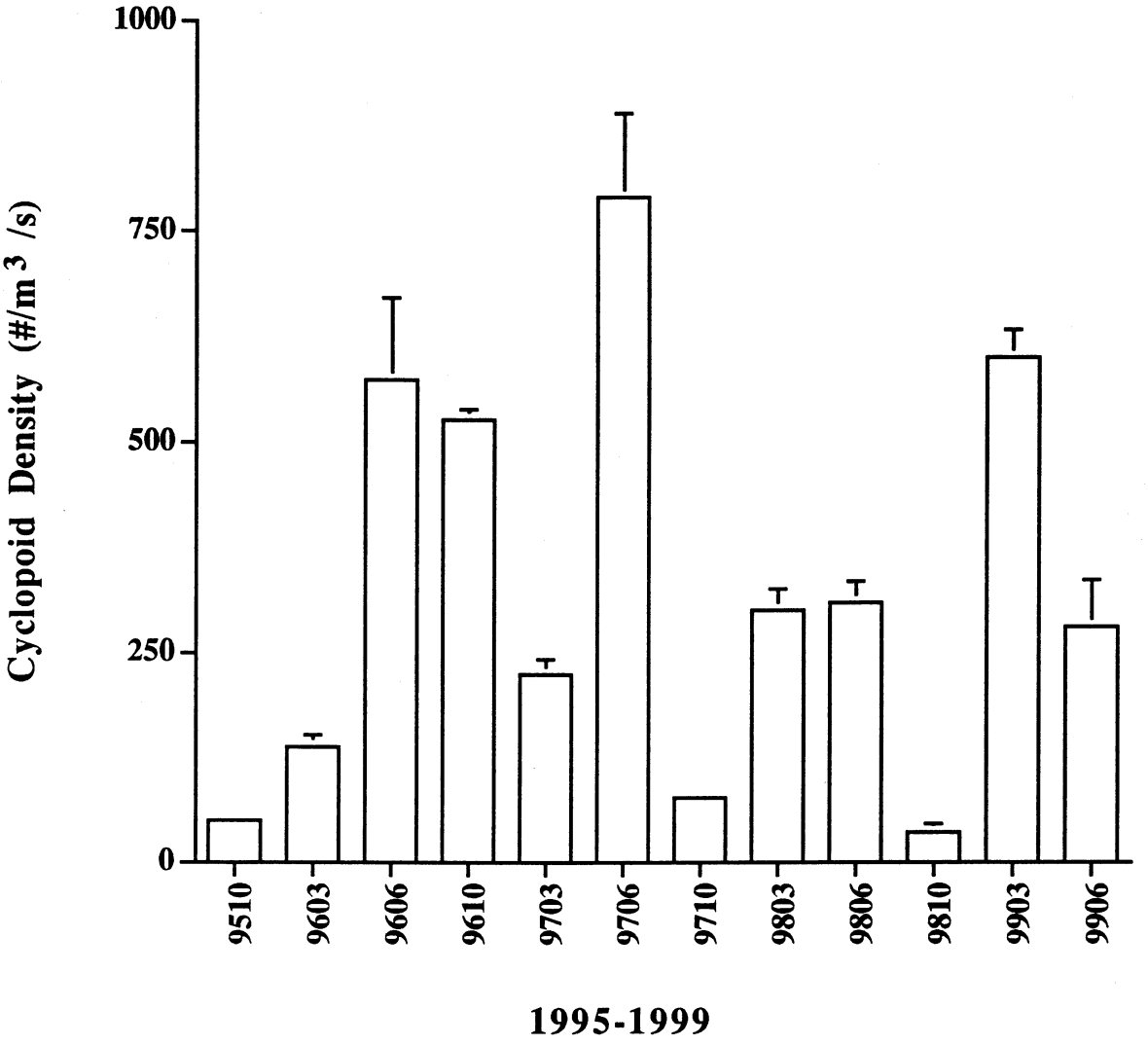

Figure 297. Average FPOM drift densities (#/m^3/s) of Cyclopoids collected at Guage Above LCR Rkm 98.4 from October 1995 to June 1999.

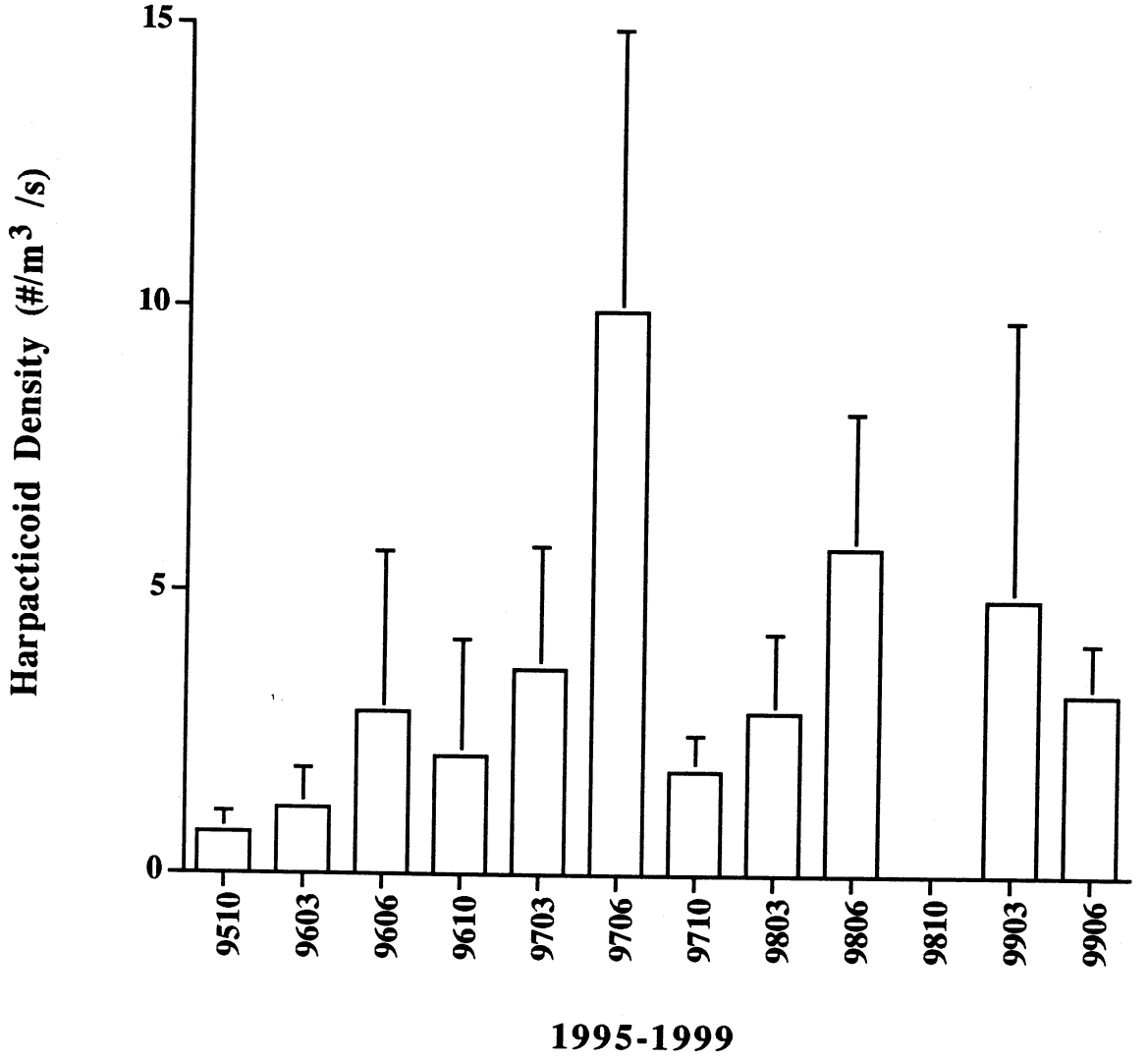

Figure 298. Average FPOM drift densities (#/m ^{3}/s) of Harpacticoids collected at Guage Above LCR Rkm 98.4 from October 1995 to June 1999.

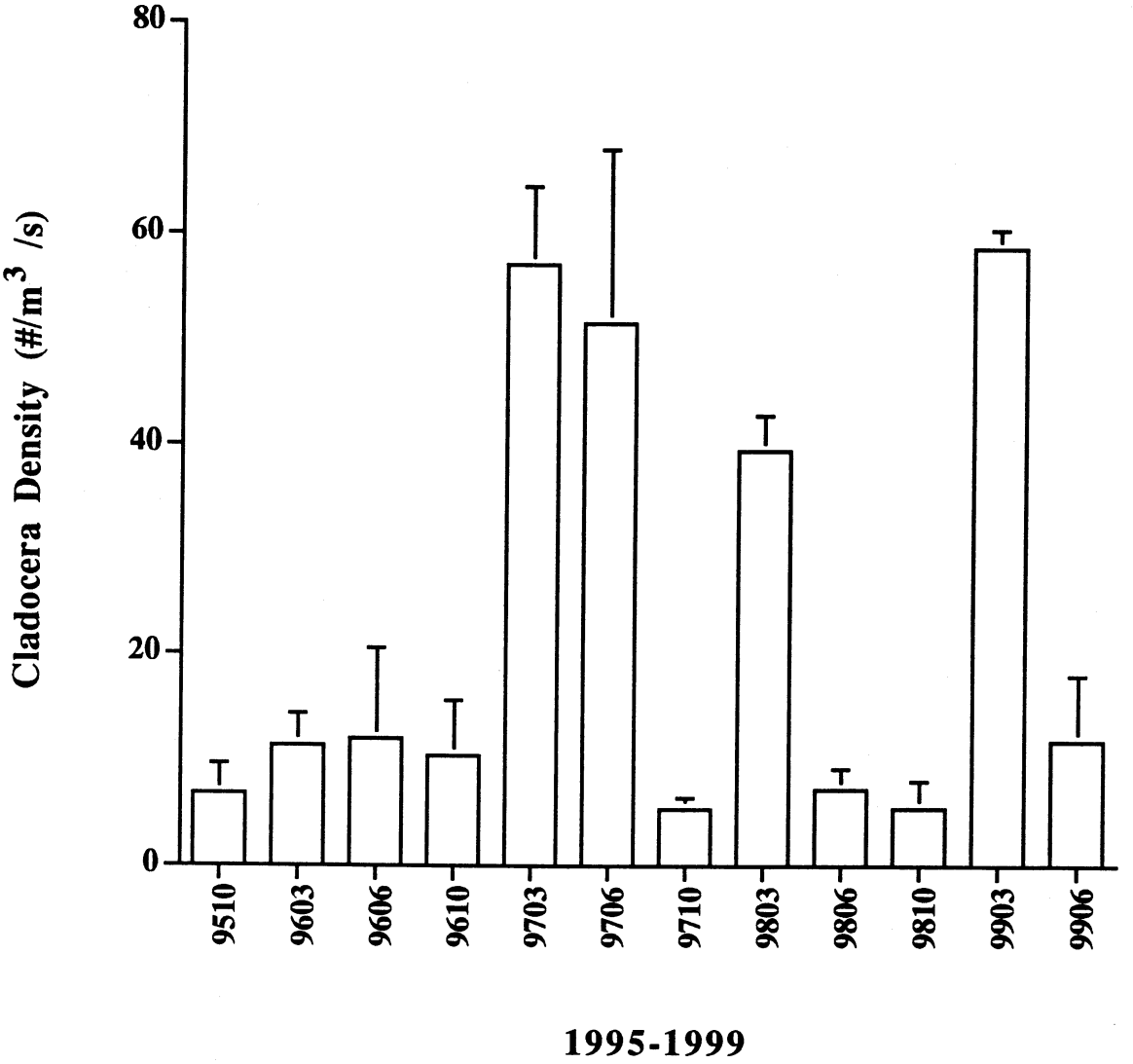

Figure 297. Average FPOM drift densities (#/m^3/s) of Calanoids collected at Guage Above LCR Rkm 98.4 from October 1995 to June 1999.

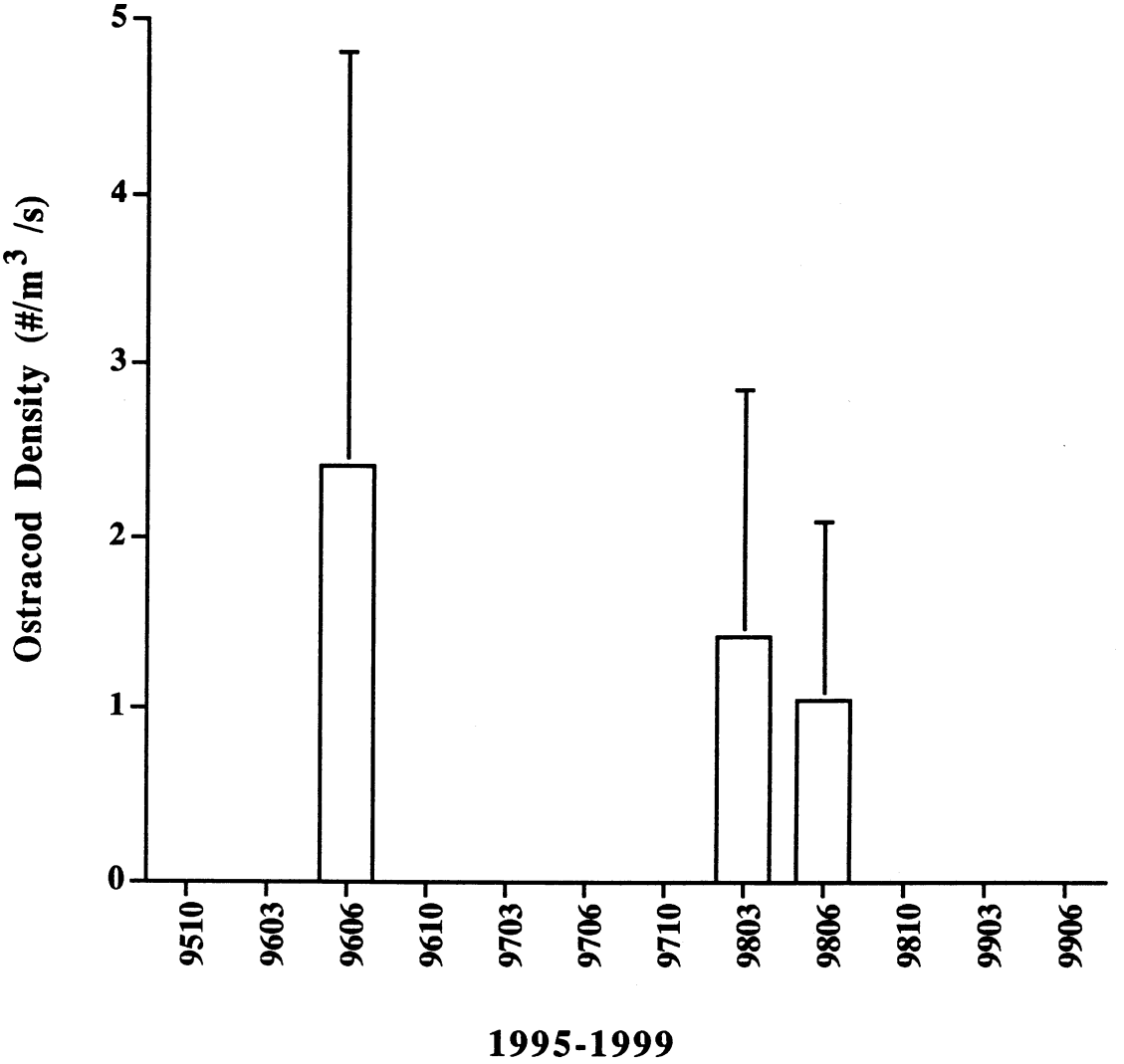

Figure 300. Average FPOM drift densities (#/m^3 /s) of Ostracods collected at Guage Above LCR Rkm 98.4 from October 1995 to June 1999.

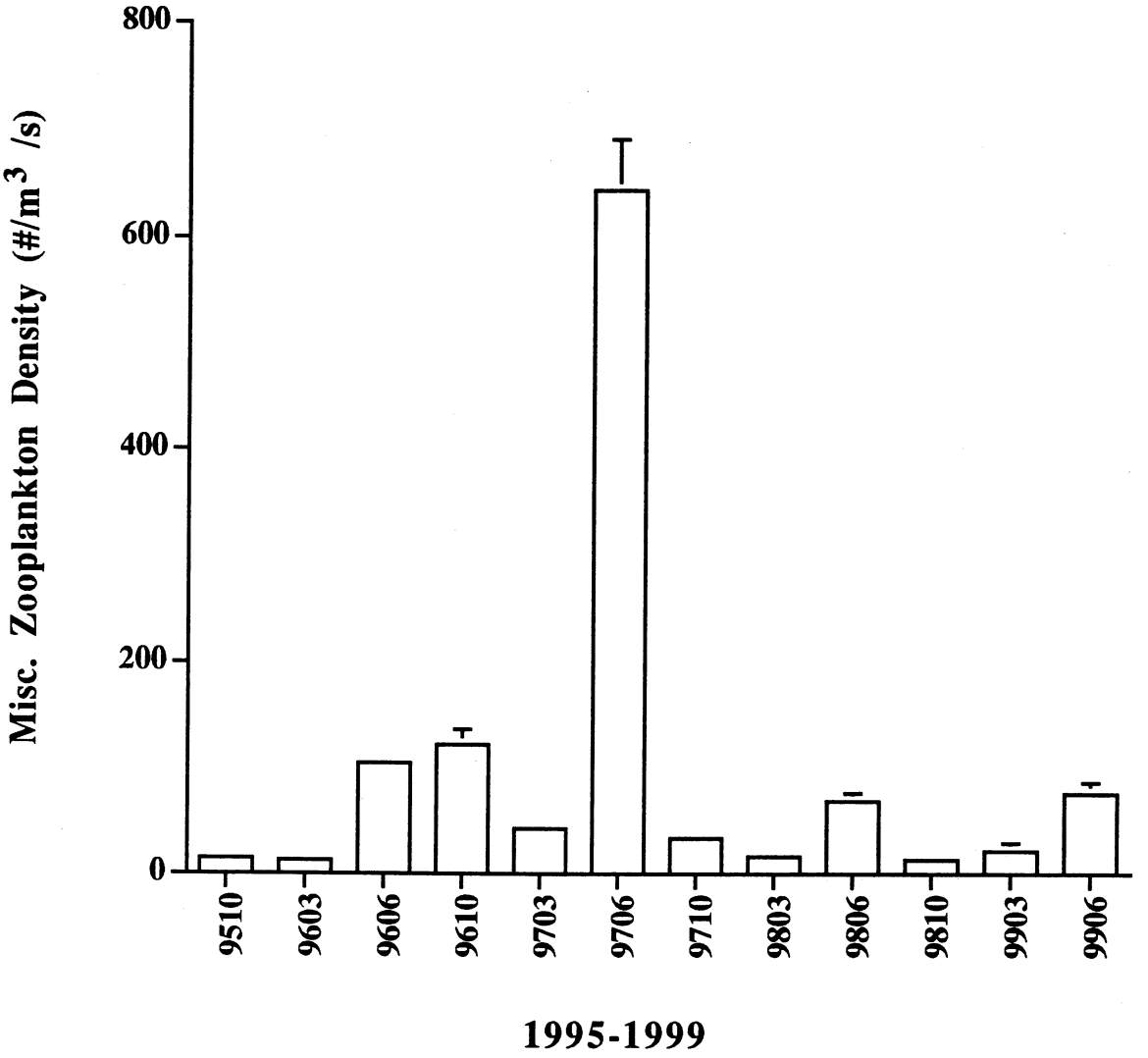

Figure 301. Average FPOM drift densities (#/m^3/s) of miscellaneous zooplankton (benthic origin) collected at Guage Above LCR Rkm 98.4 from October 1995 to June 1999.

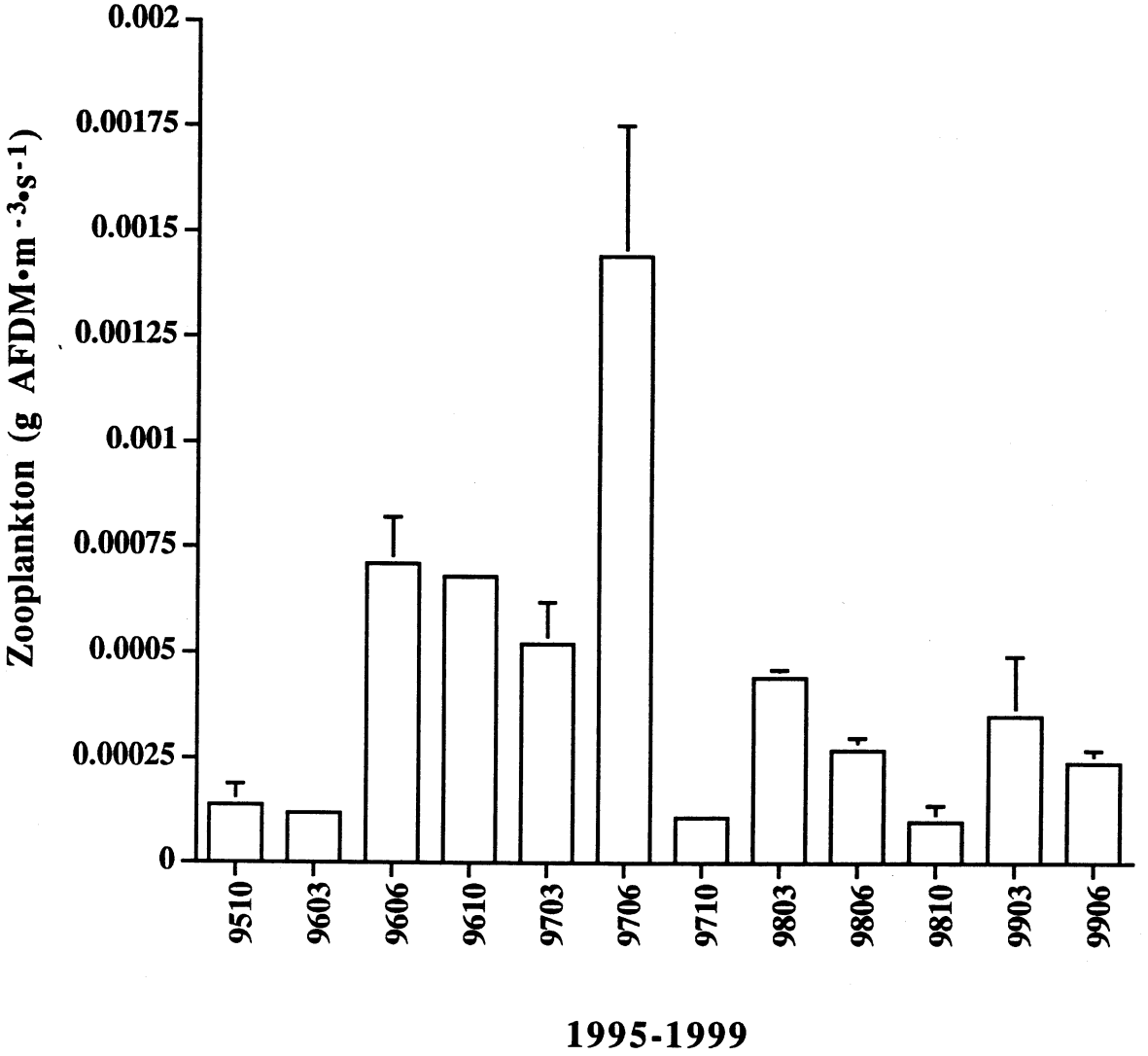

Figure 302. Average zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of lentic origin for Calanoida, Cyclopoida, Cladocera and Ostracoda collected at Gauge Above LCR Rkm 98.4 from October 1995 to June 1999.

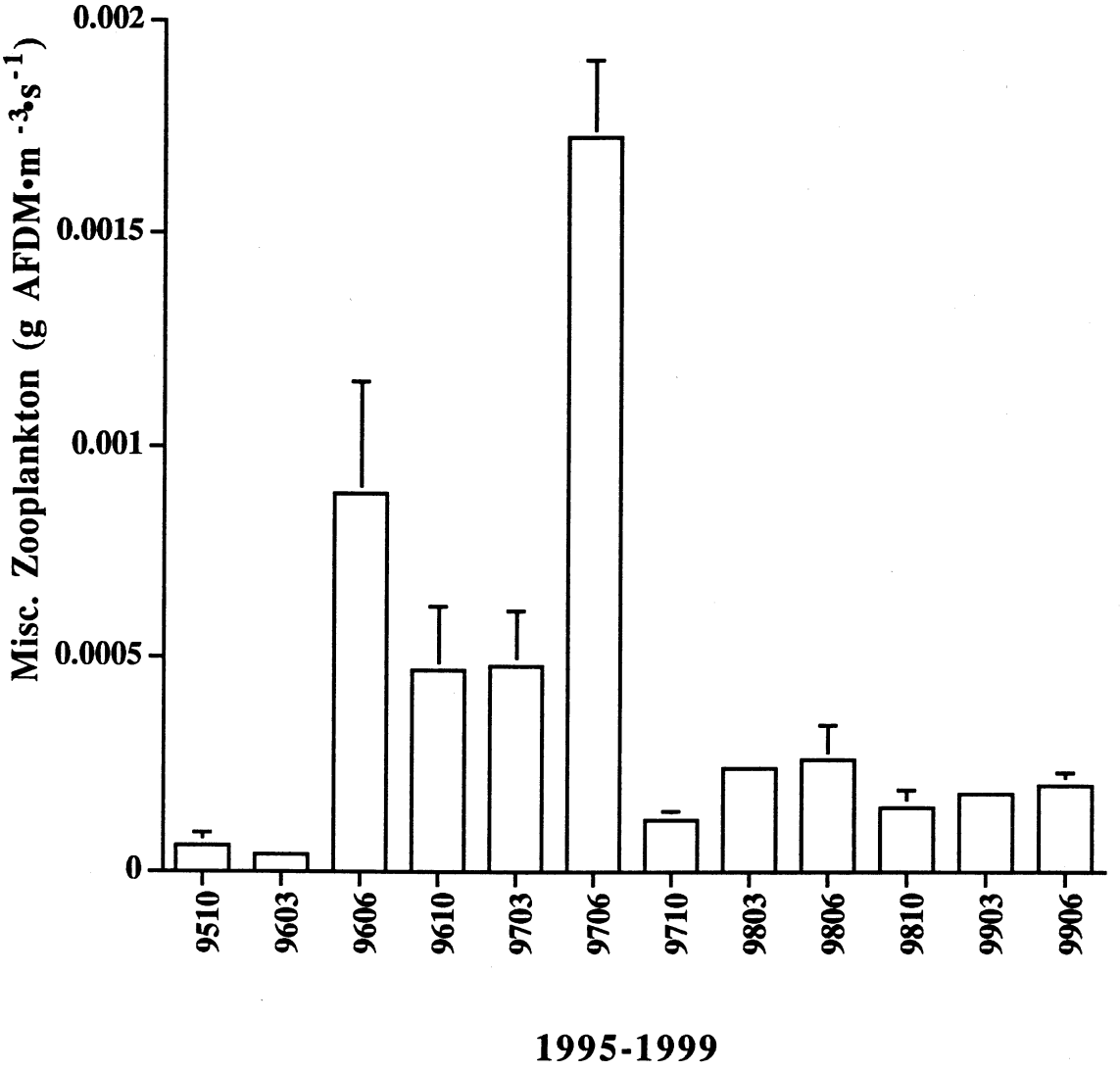

Figure 303. Average miscellaneous zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of benthic origin collected at Gauge Above LCR Rkm 98.4 from October 1995 to June 1999.

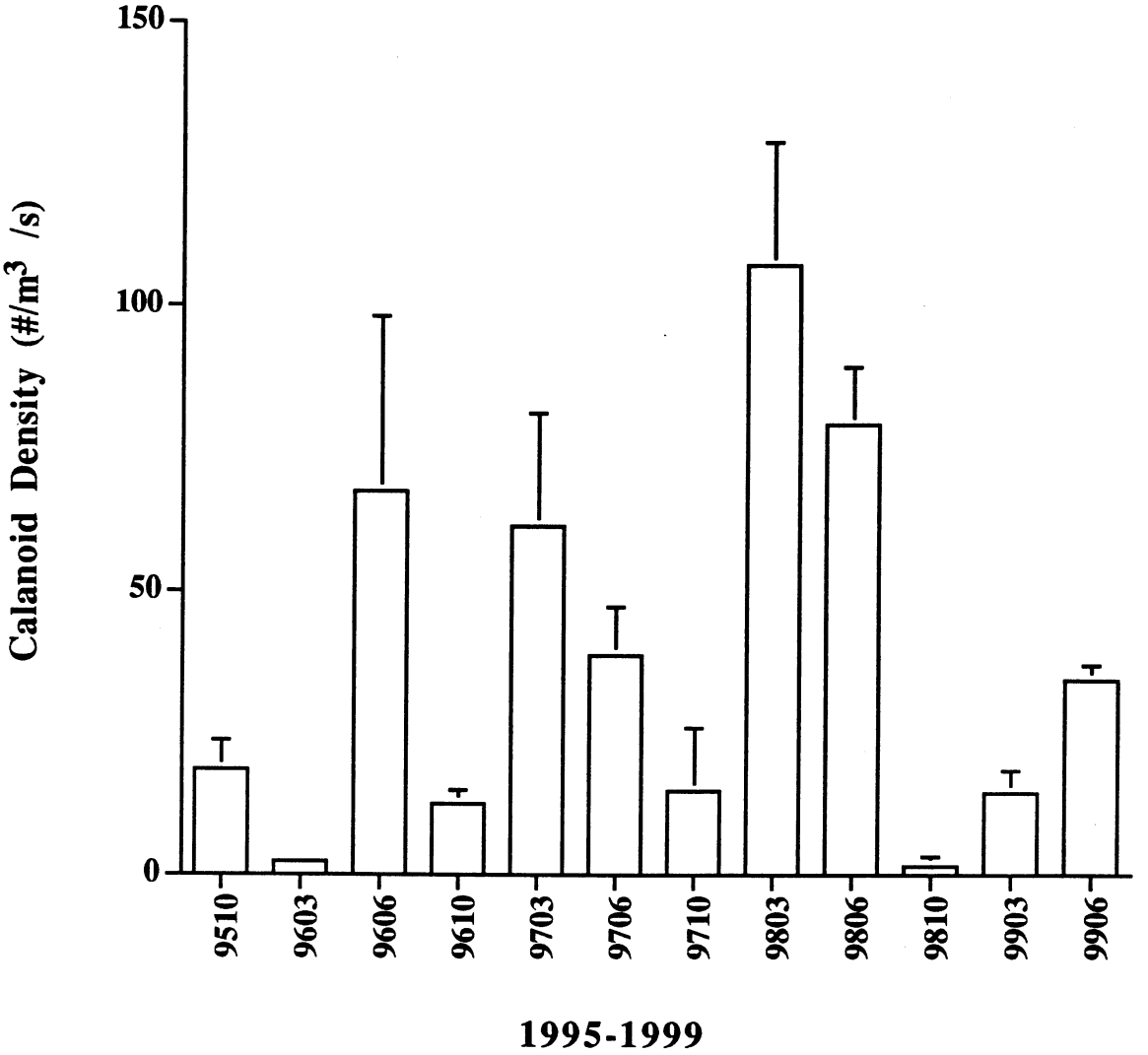

Figure 304. Average FPOM drift densities (#/m^3 /s) of Calanoids collected at Tanner Cobble Rkm 109.6 from October 1995 to June 1999.

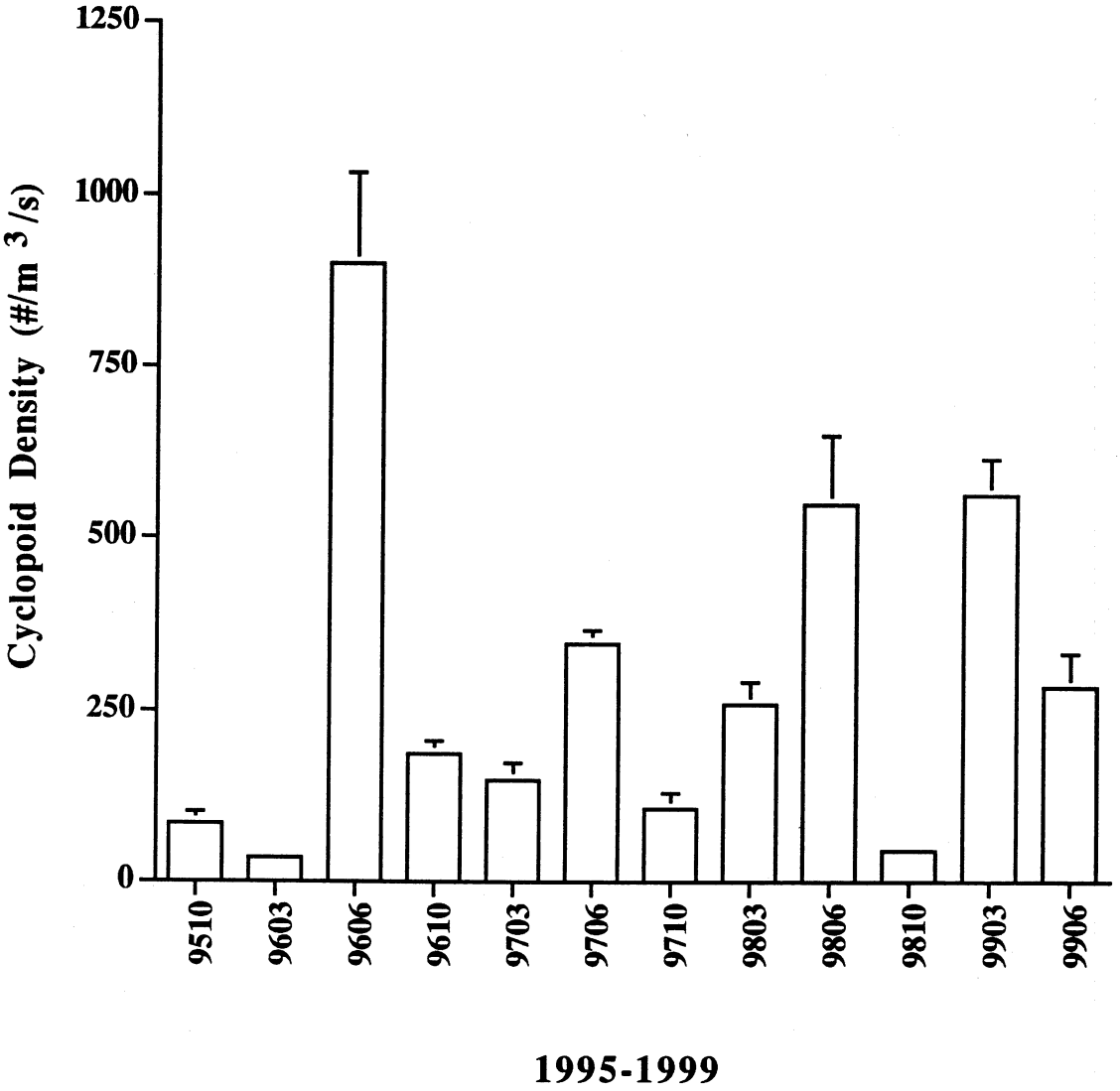

Figure 305. Average FPOM drift densities (#/m^3/s) of Cyclopoids collected at Tanner Cobble Rkm 109.6 from October 1995 to June 1999.

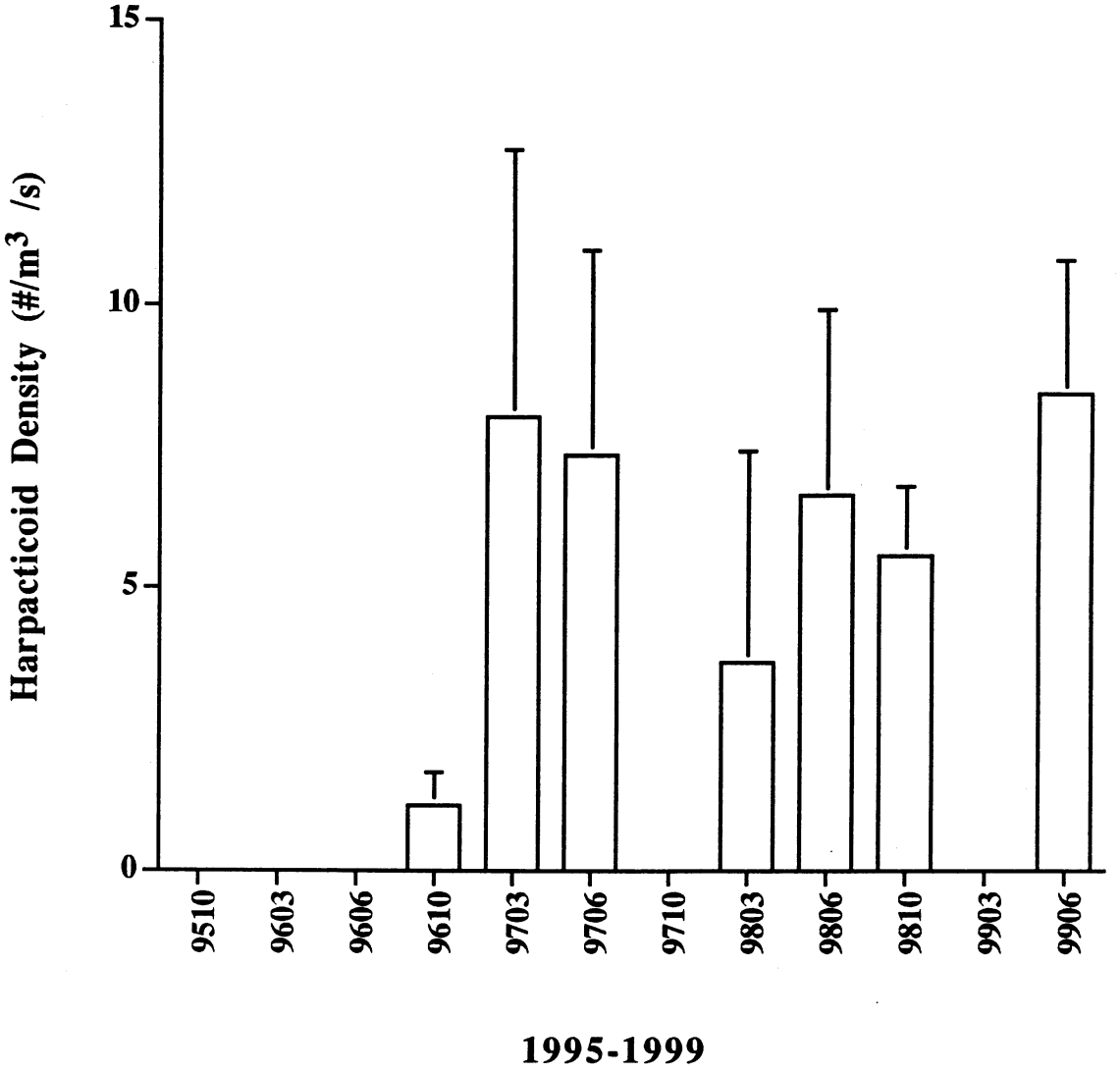

Figure 306. Average FPOM drift densities (#/m^3/s) of Harpacticoids collected at Tanner Cobble Rkm 109.6 from October 1995 to June 1999.

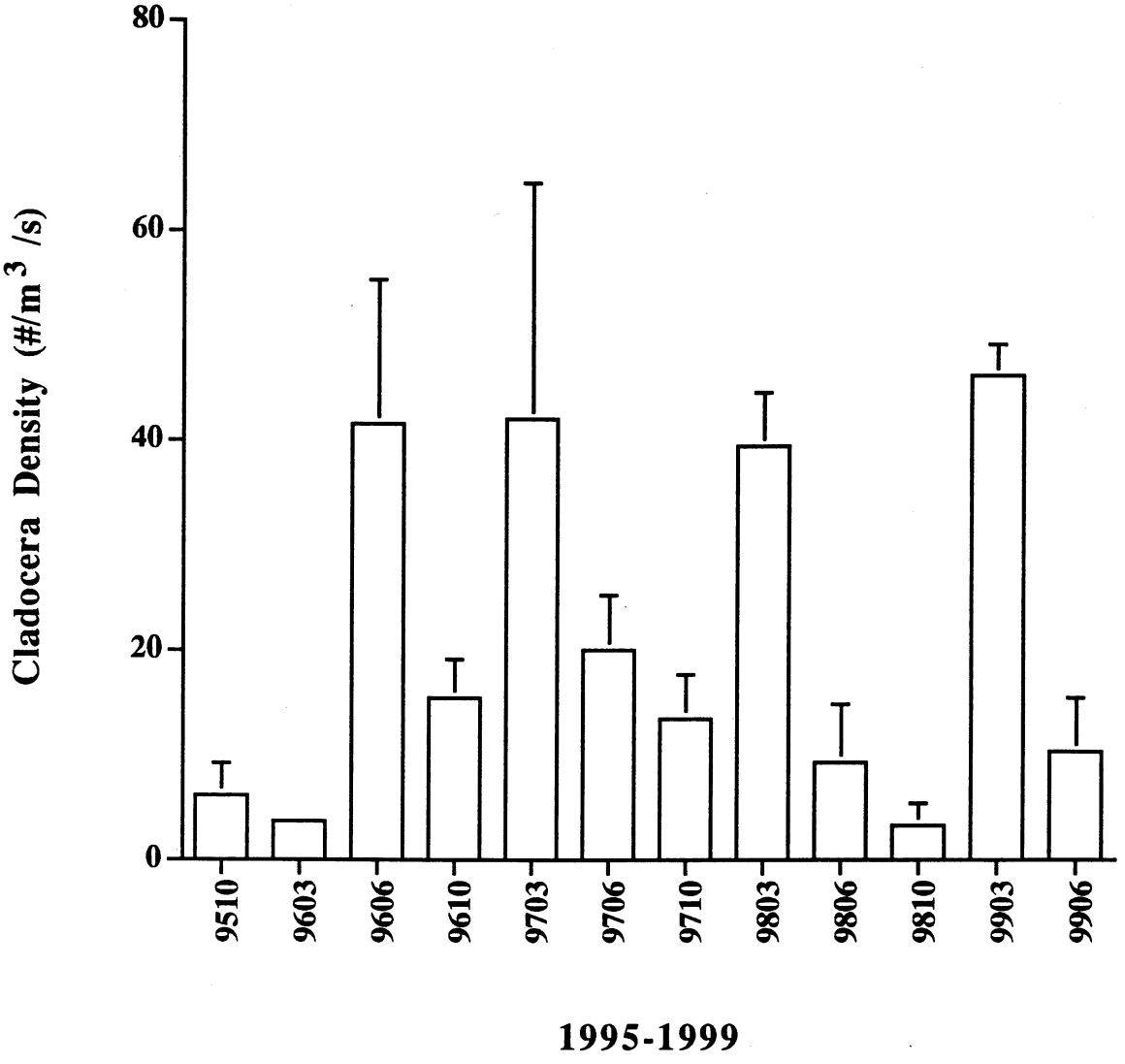

Figure 307. Average FPOM drift densities (#/m^3 /s) of Cladocera collected at Tanner Cobble Rkm 109.6 from October 1995 to June 1999.

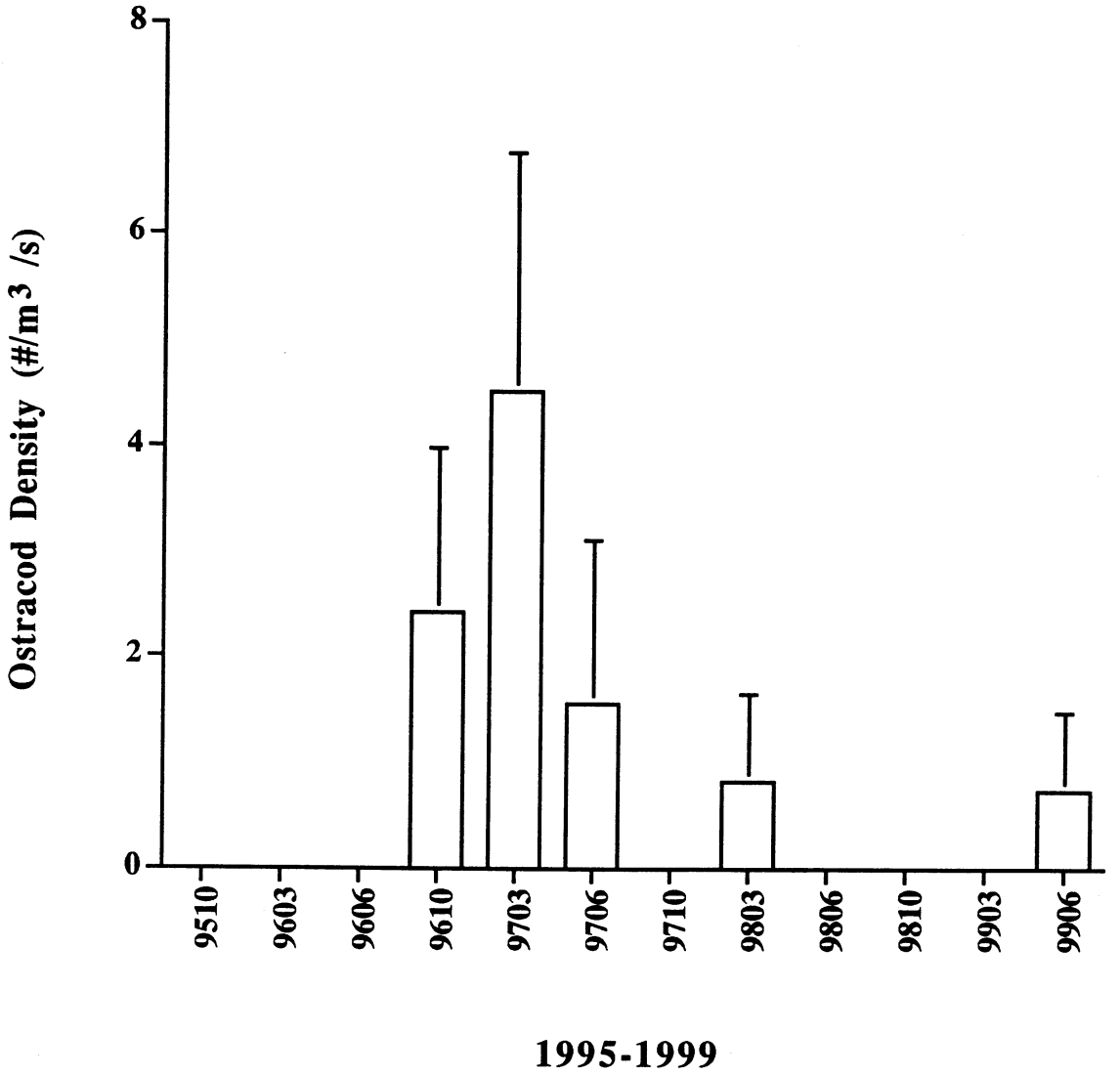

Figure 308. Average FPOM drift densities (#/m^3 /s) of Ostracods collected at Tanner Cobble Rkm 109.6 from October 1995 to June 1999.

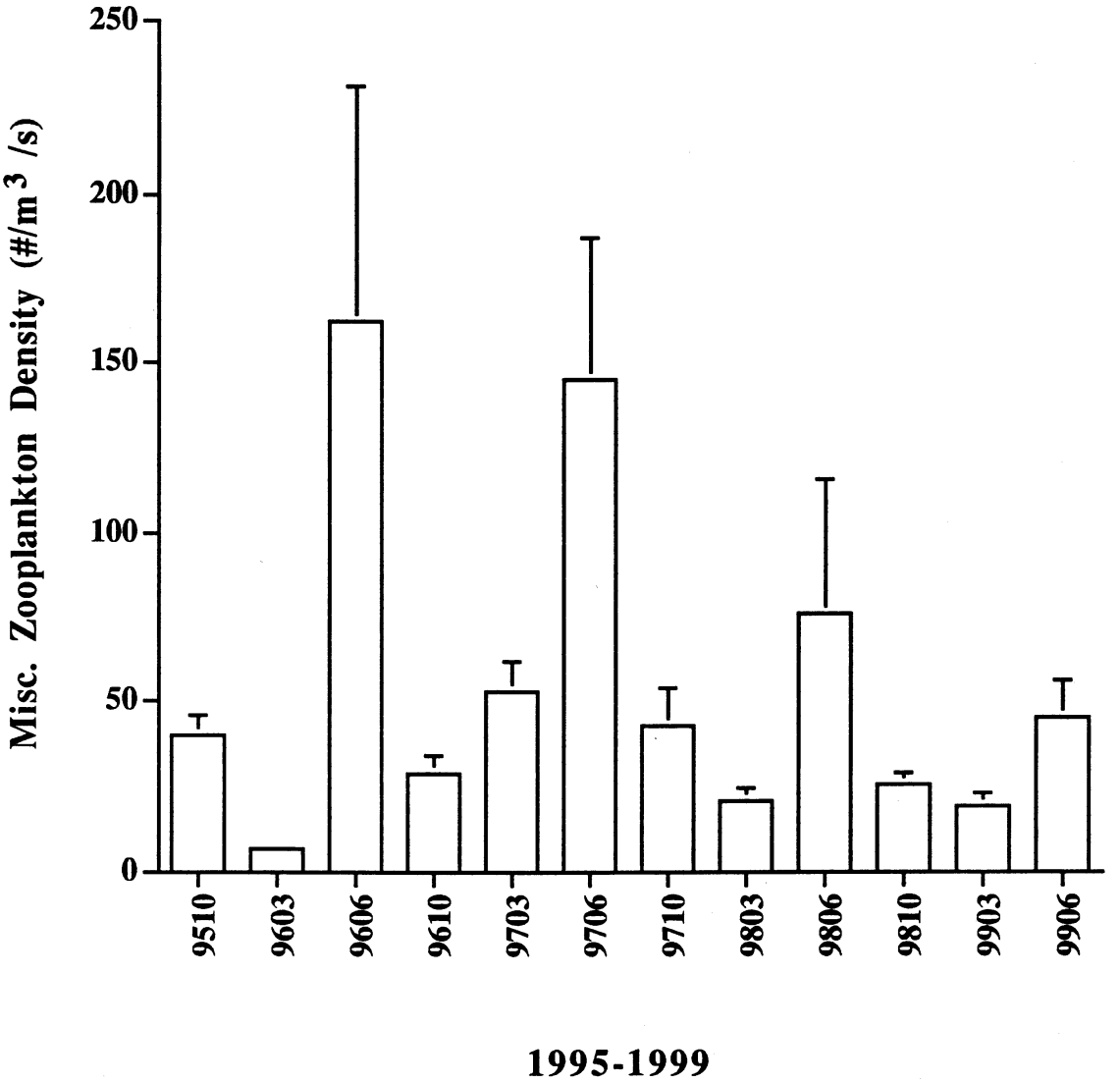

Figure 309. Average FPOM drift densities (#/m^3/s) of miscellaneous zooplankton (benthic origin) collected at Tanner Cobble Rkm 109.6 from October 1995 to June 1999.

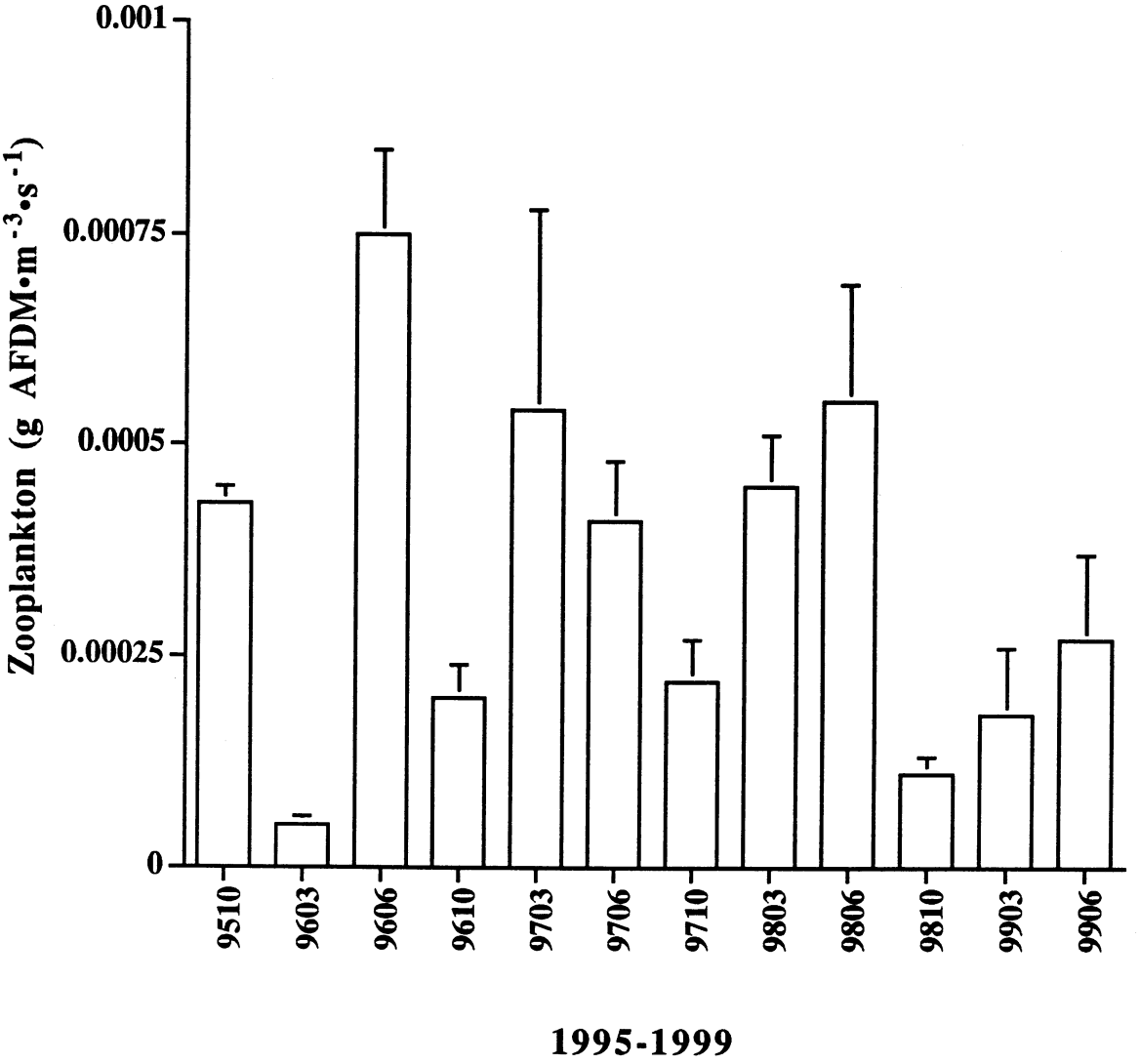

Figure 310. Average zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of lentic origin for Calanoida, Cyclopoida, Cladocera and Ostracoda collected at Tanner Cobble Rkm 109.6 from October 1995 to June 1999.

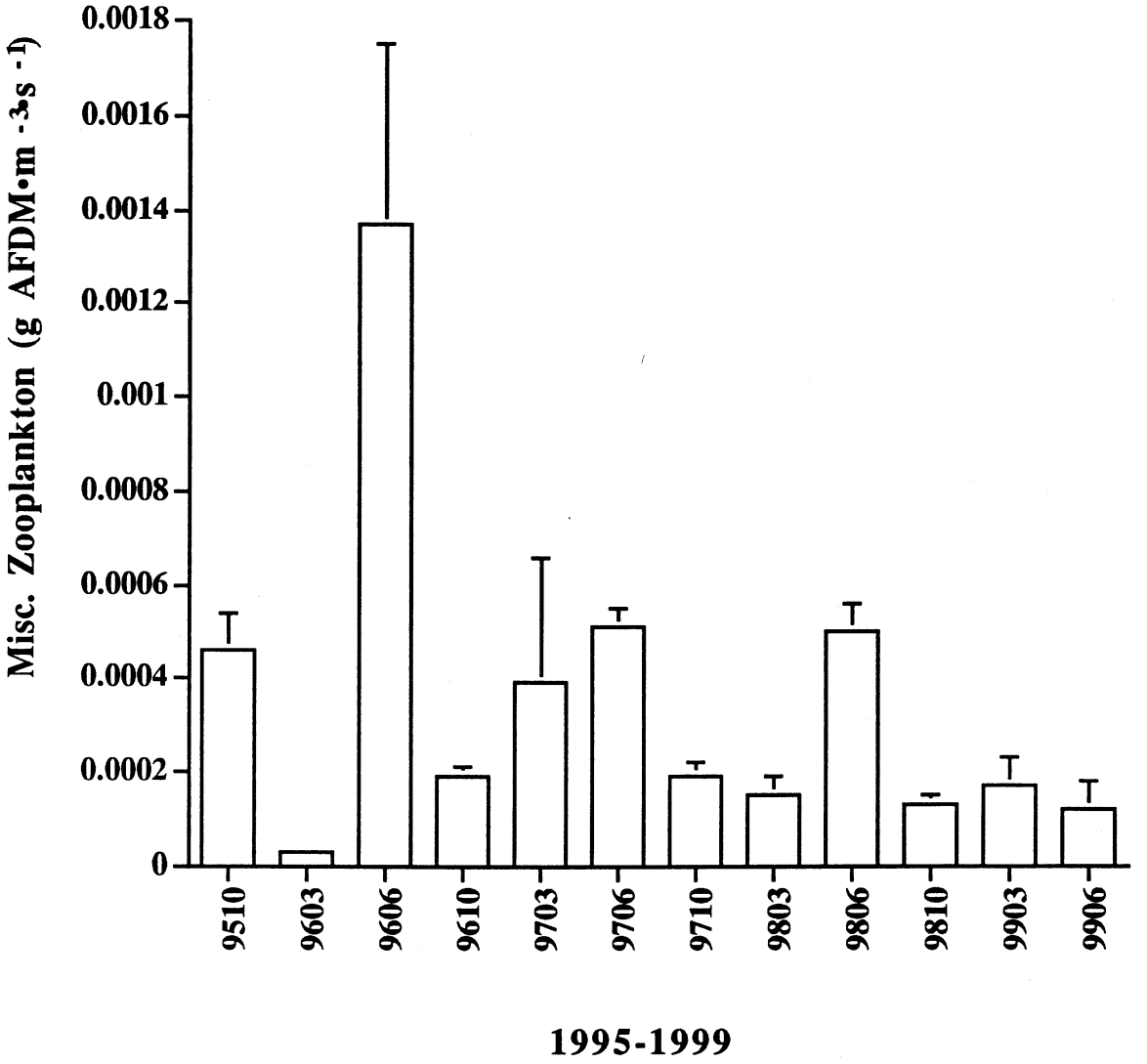

Figure 311. Average miscellaneous zooplankton biomass of benthic origin (g AFDM•m^{-3}•s^{-1}) collected at Tanner Cobble Rkm 109.6 from October 1995 to June 1999.

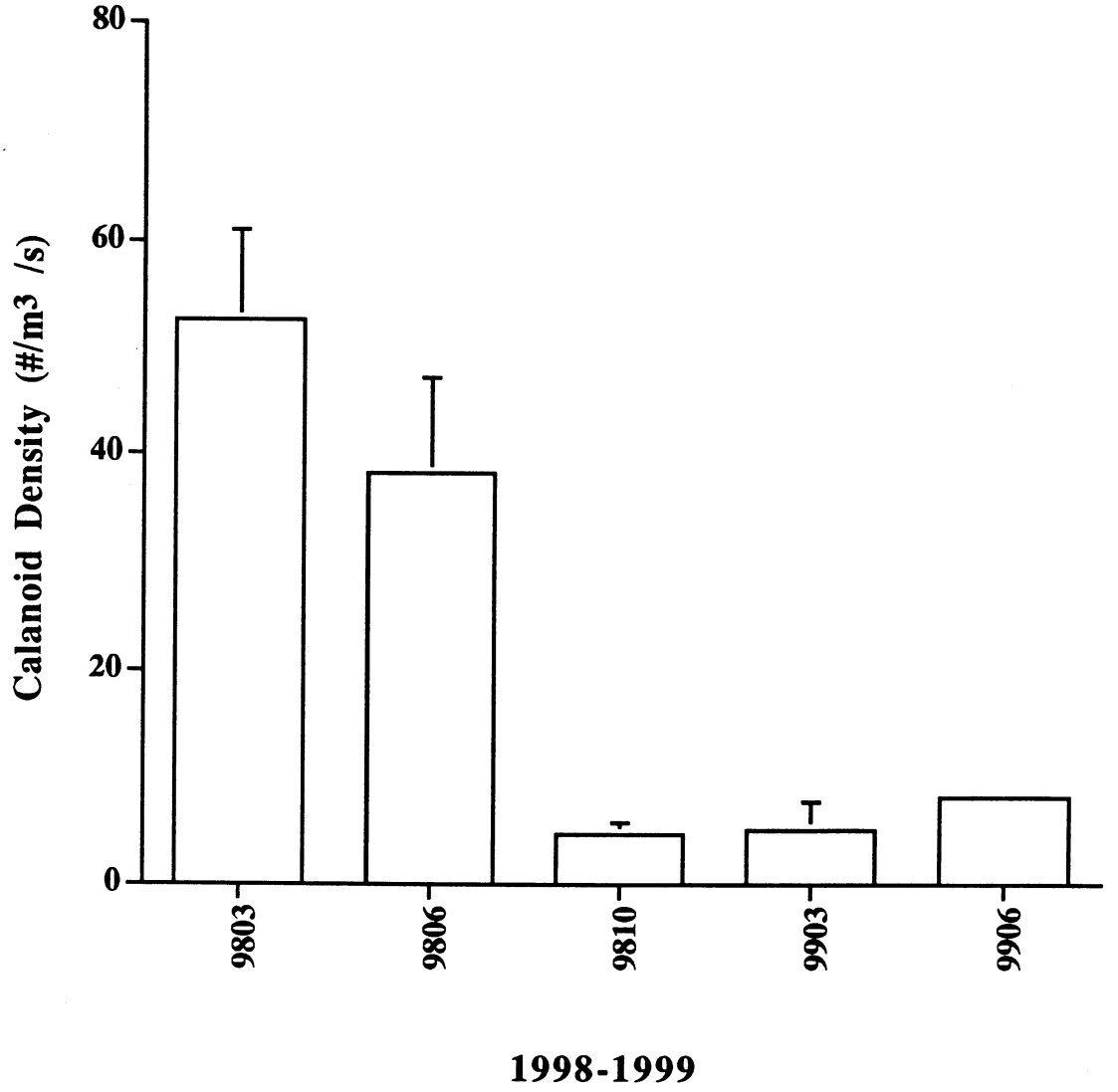

Figure 312. Average FPOM drift densities (#/m^3 /s) of Calanoids collected at 127 Mile Rapid Rkm 202.9 from March 1998 to June 1999.

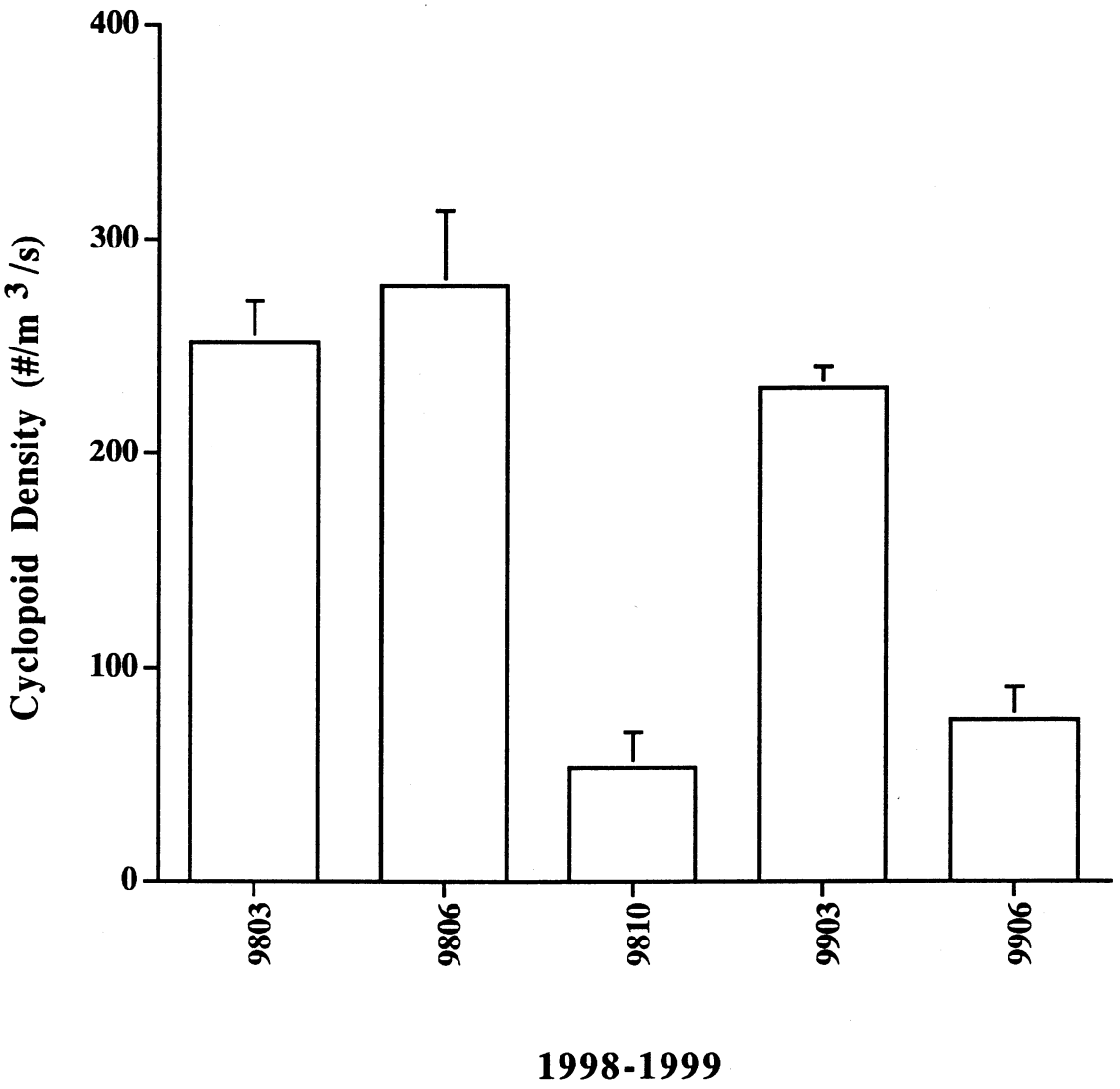

Figure 313. Average FPOM drift densities (#/m^3 /s) of Cyclopoids collected at 127 Mile Rapid Rkm 202.9 from March 1998 to June 1999.

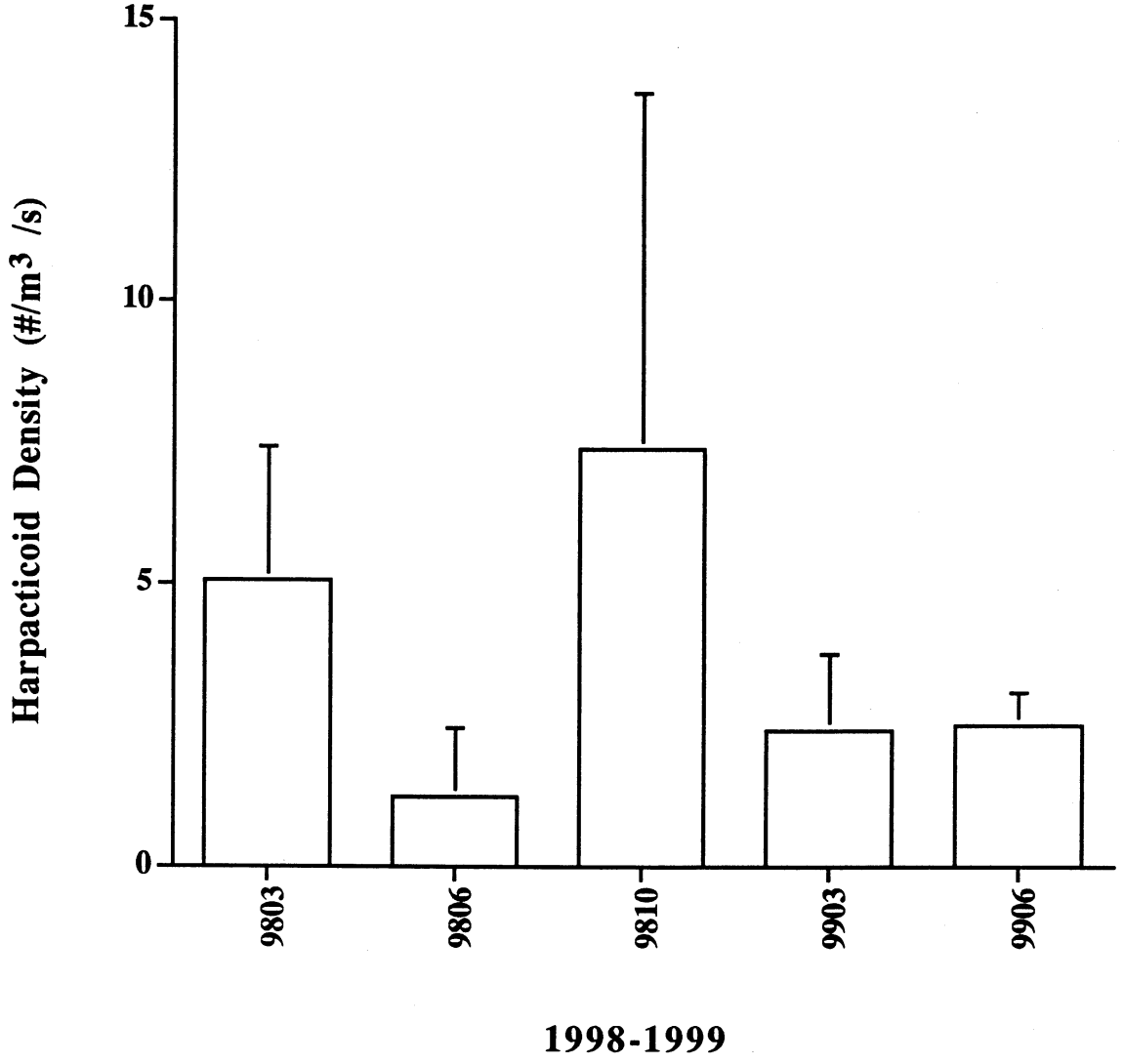

Figure 314. Average FPOM drift densities (#/m^3/s) of Harpacticoids collected at 127 Mile Rapid Rkm 202.9 from March 1998 to June 1999.

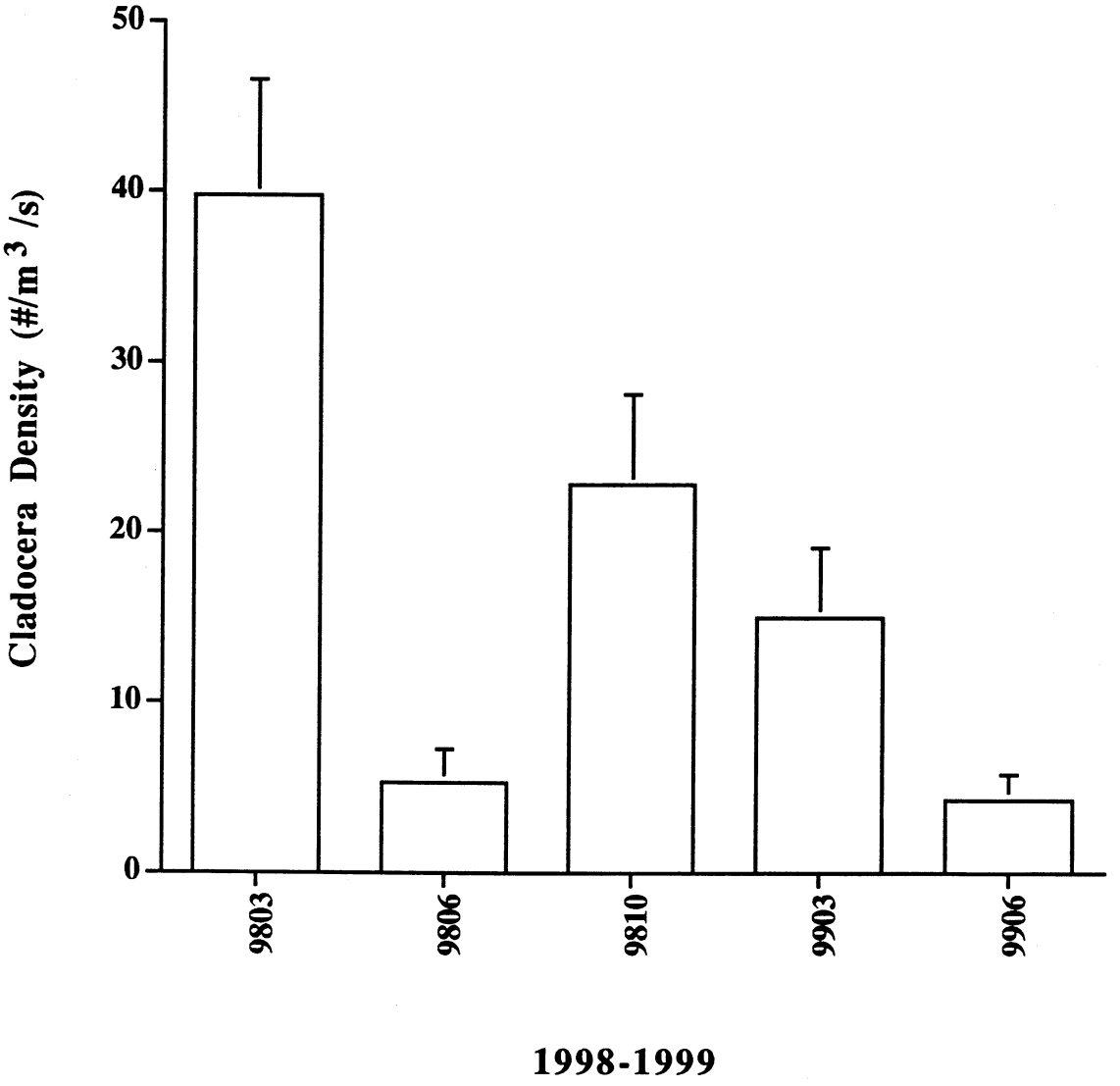

Figure 315. Average FPOM drift densities (#/m^3/s) of Cladocera collected at 127 Mile Rapid Rkm 202.9 from March 1998 to June 1999.

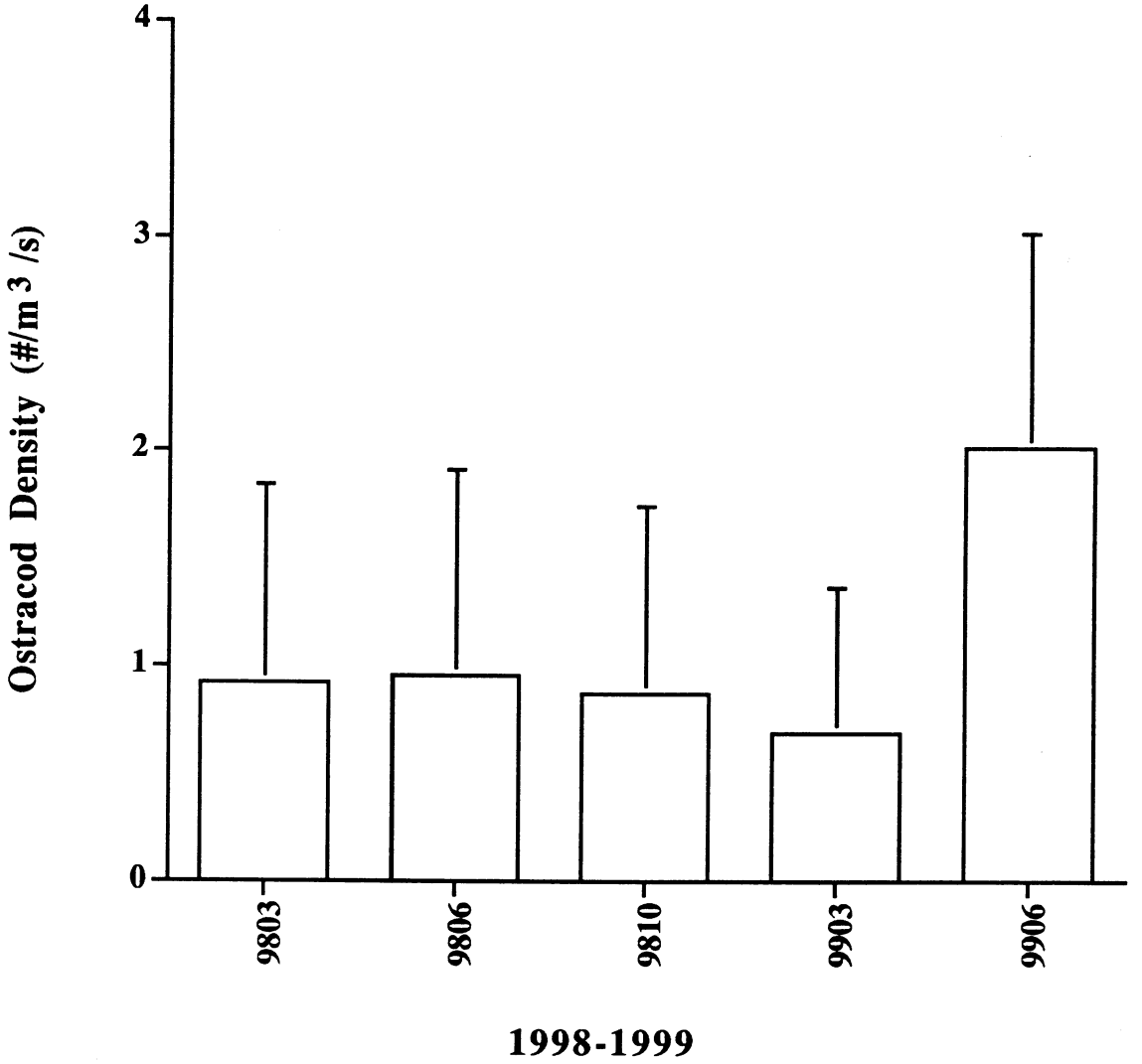

Figure 316. Average FPOM drift densities (#/m^3/s) of Ostracods collected at 127 Mile Rapid Rkm 202.9 from March 1998 to June 1999.

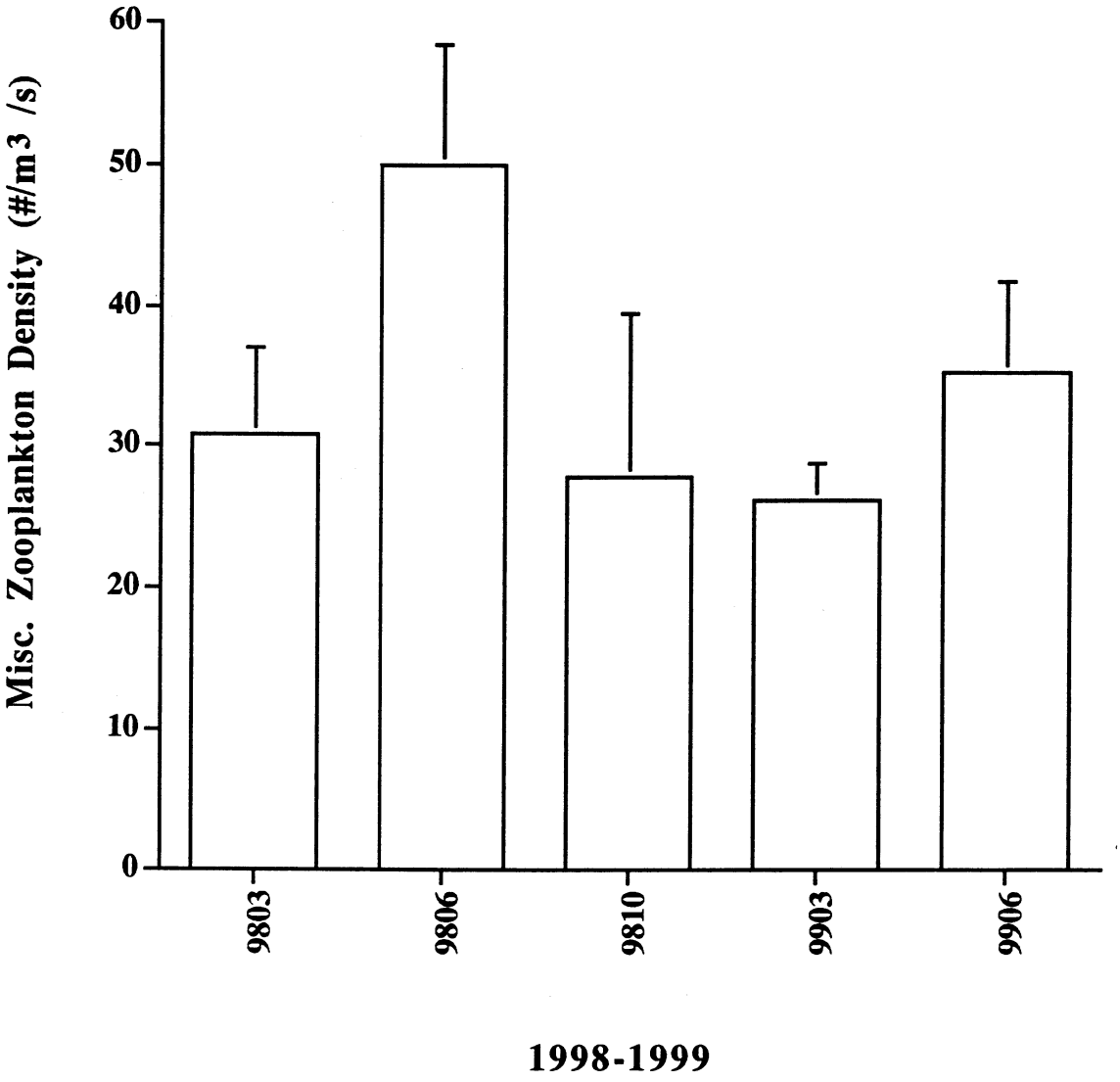

Figure 317. Average FPOM drift densities (#/m ^{3}/s) of miscellaneous zooplankton (benthic origin) collected at 127 Mile Rapid Rkm 202.9 from March 1998 to June 1999.

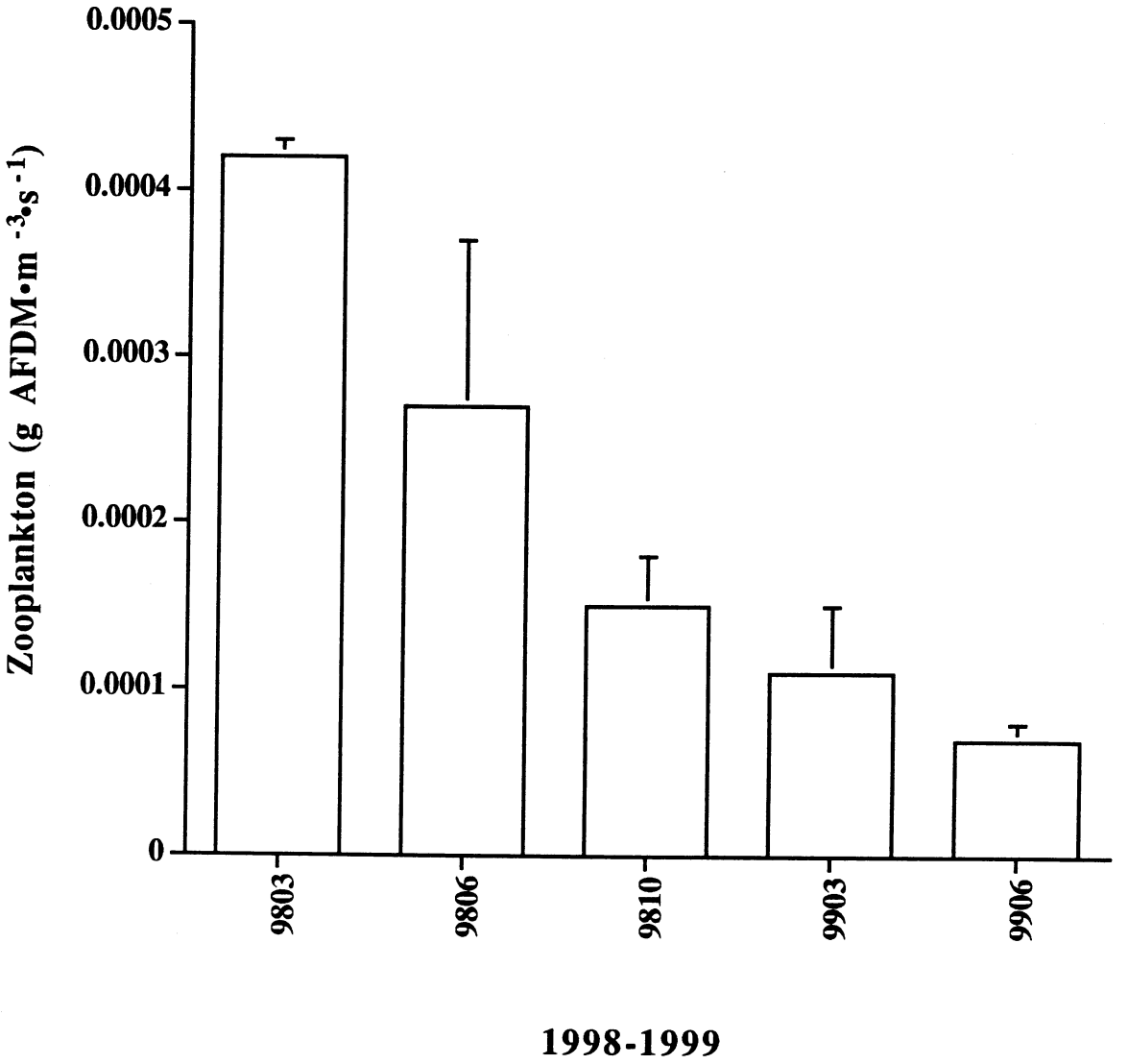

Figure 318. Average zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of lentic origin for Calanoida, Cyclopoida, Cladocera and Ostracoda collected at 127 Mile Rapid from March 1998 to June 1999.

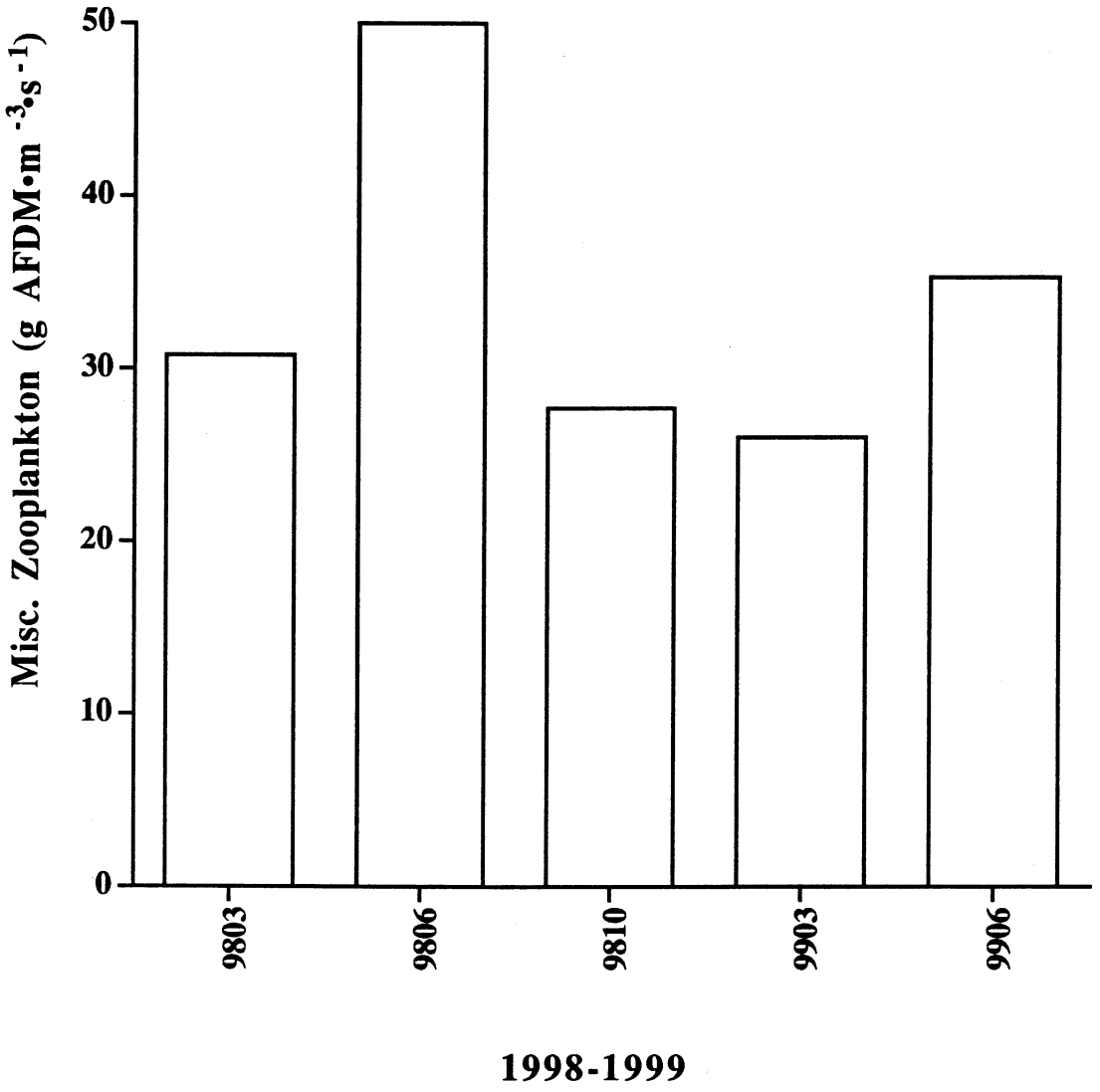

Figure 319. Average miscellaneous zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of benthic origin collected at 127 Mile Rapid from March 1998 to June 1999.

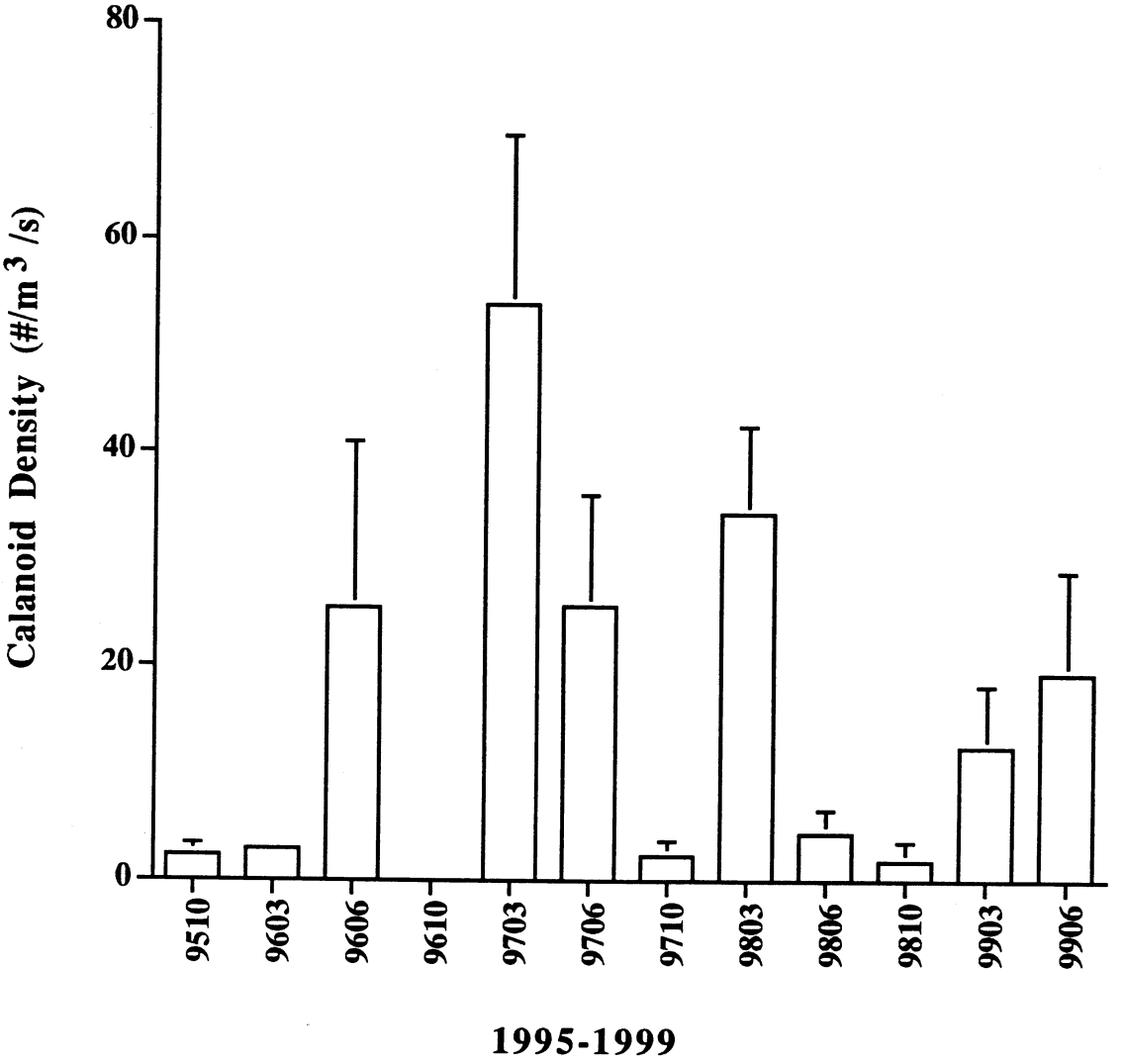

Figure 320. Average FPOM drift densities (#/m^3/s) of Calanoids at 205 Mile Rapid Rkm 328.8 from October 1995 to June 1999.

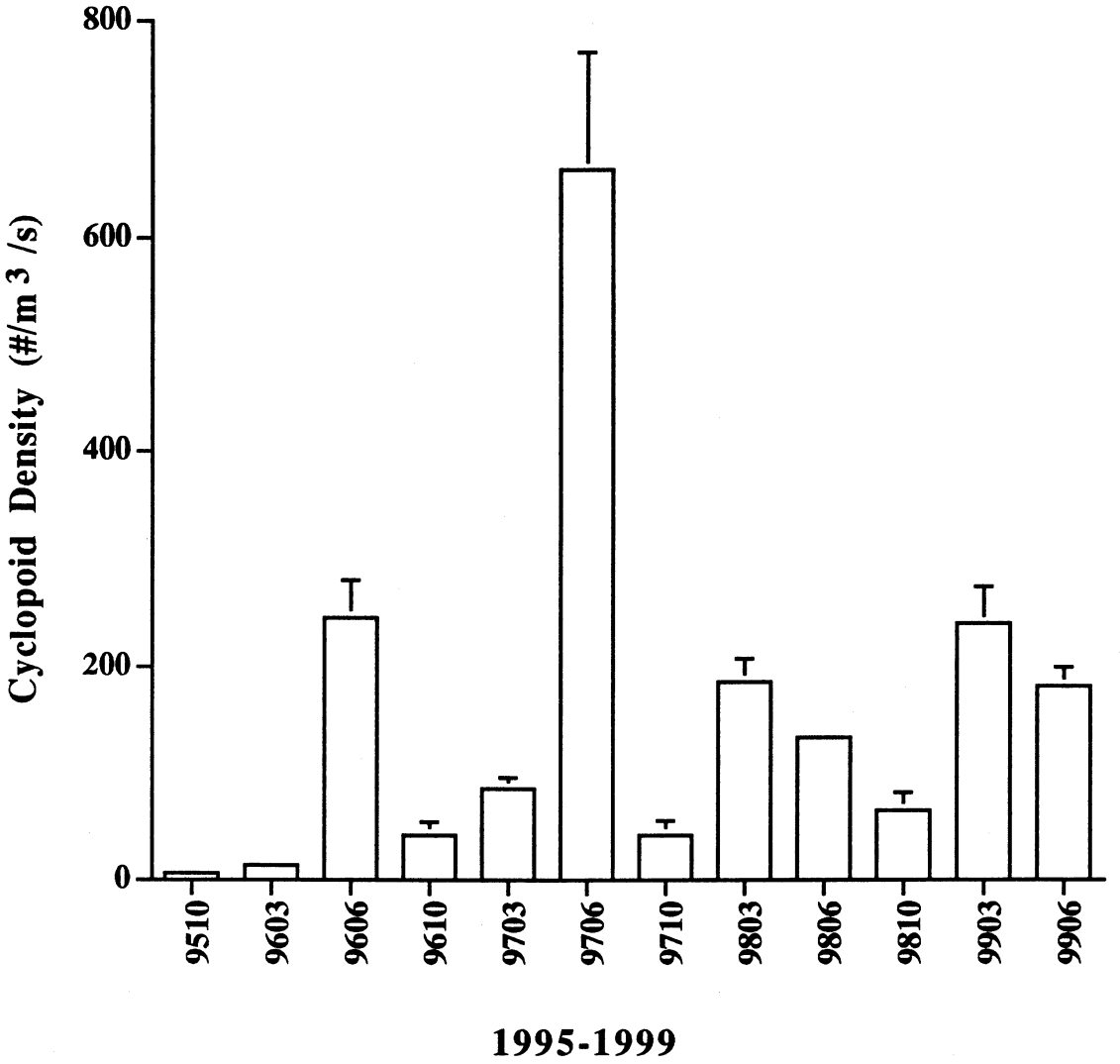

Figure 321. Average FPOM drift densities (#/m ^{3}/s) of Cyclopoids at 205 Mile Rapid Rkm 328.8 from October 1995 to June 1999.

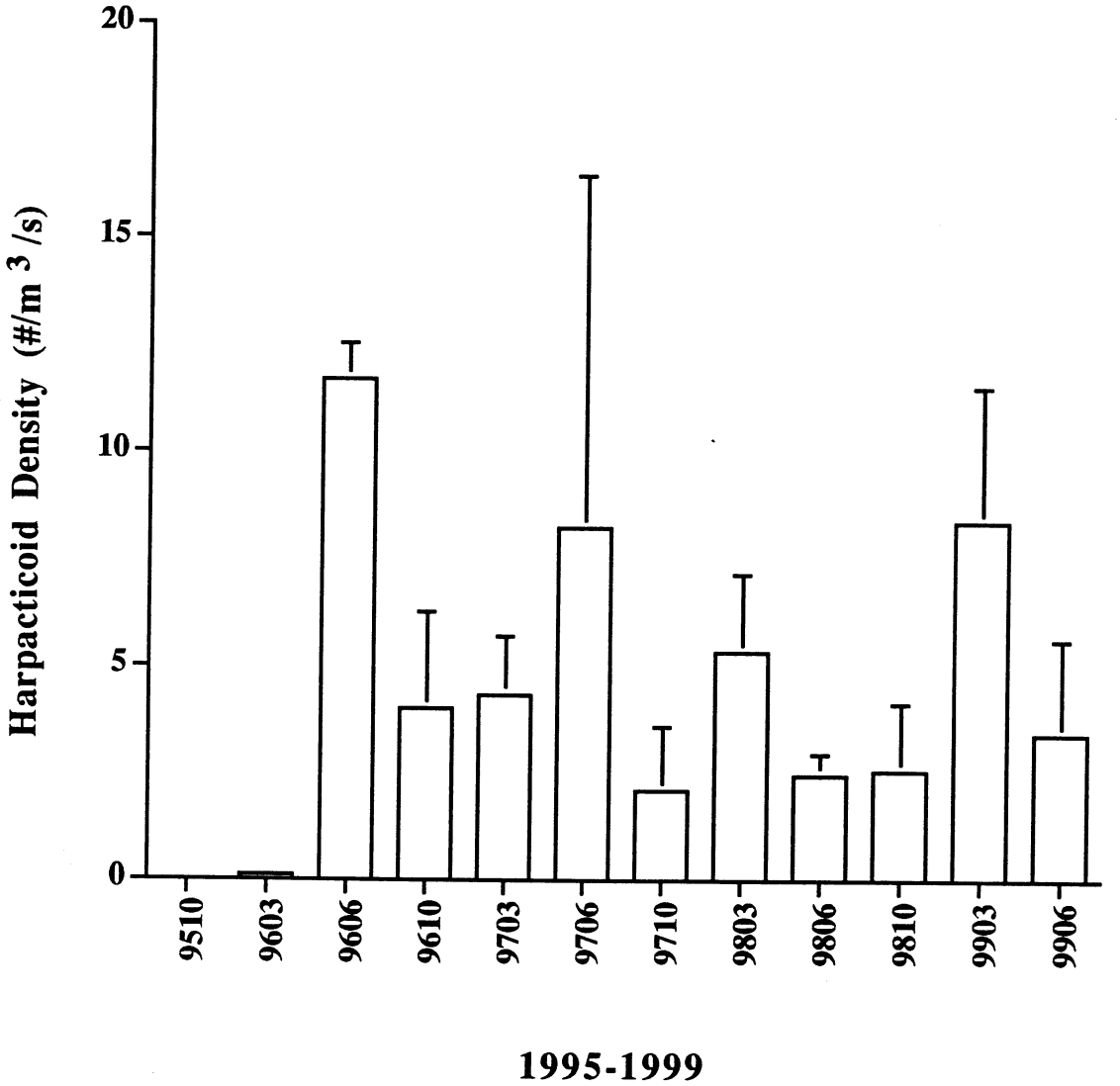

Figure 322. Average FPOM drift densities (#/m^3/s) of Harpacticoids at 205 Mile Rapid Rkm 328.8 from October 1995 to June 1999.

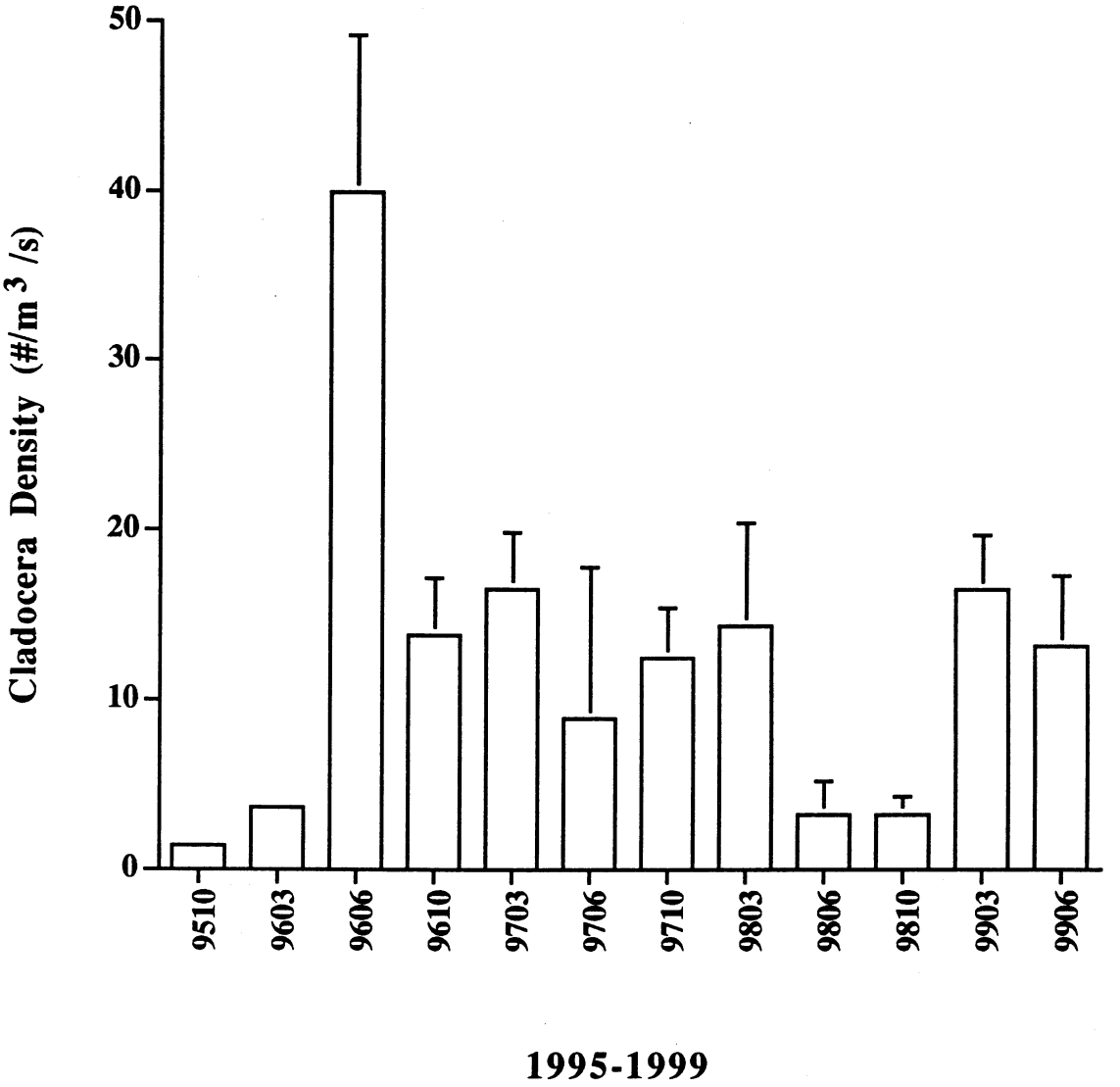

Figure 323. Average FPOM drift densities (#/m^3/s) of Cladocera at 205 Mile Rapid Rkm 328.8 from October 1995 to June 1999.

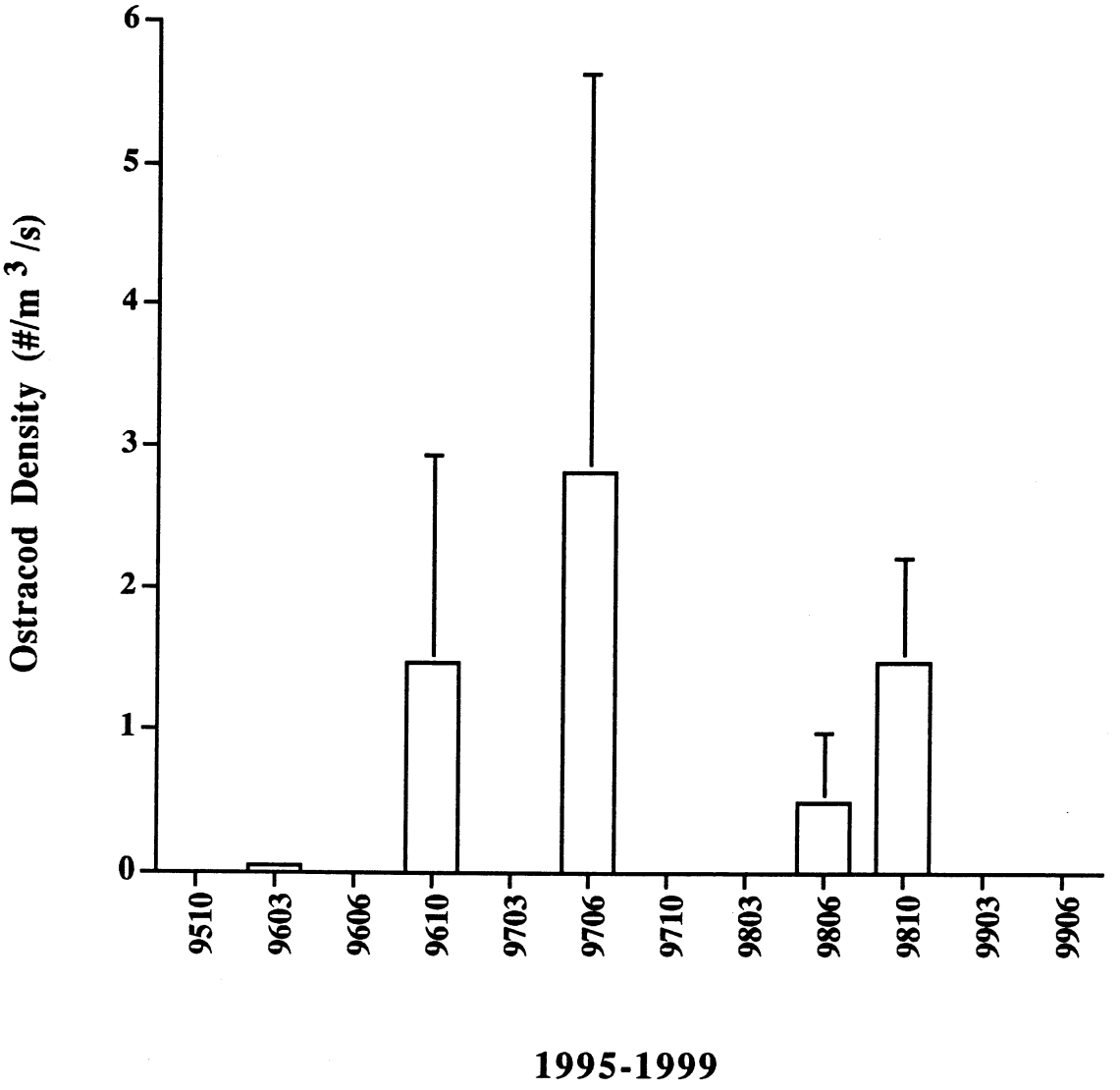

Figure 324. Average FPOM drift densities (#/m ^{3}/s) of Ostracods at 205 Mile Rapid Rkm 328.8 from October 1995 to June 1999.

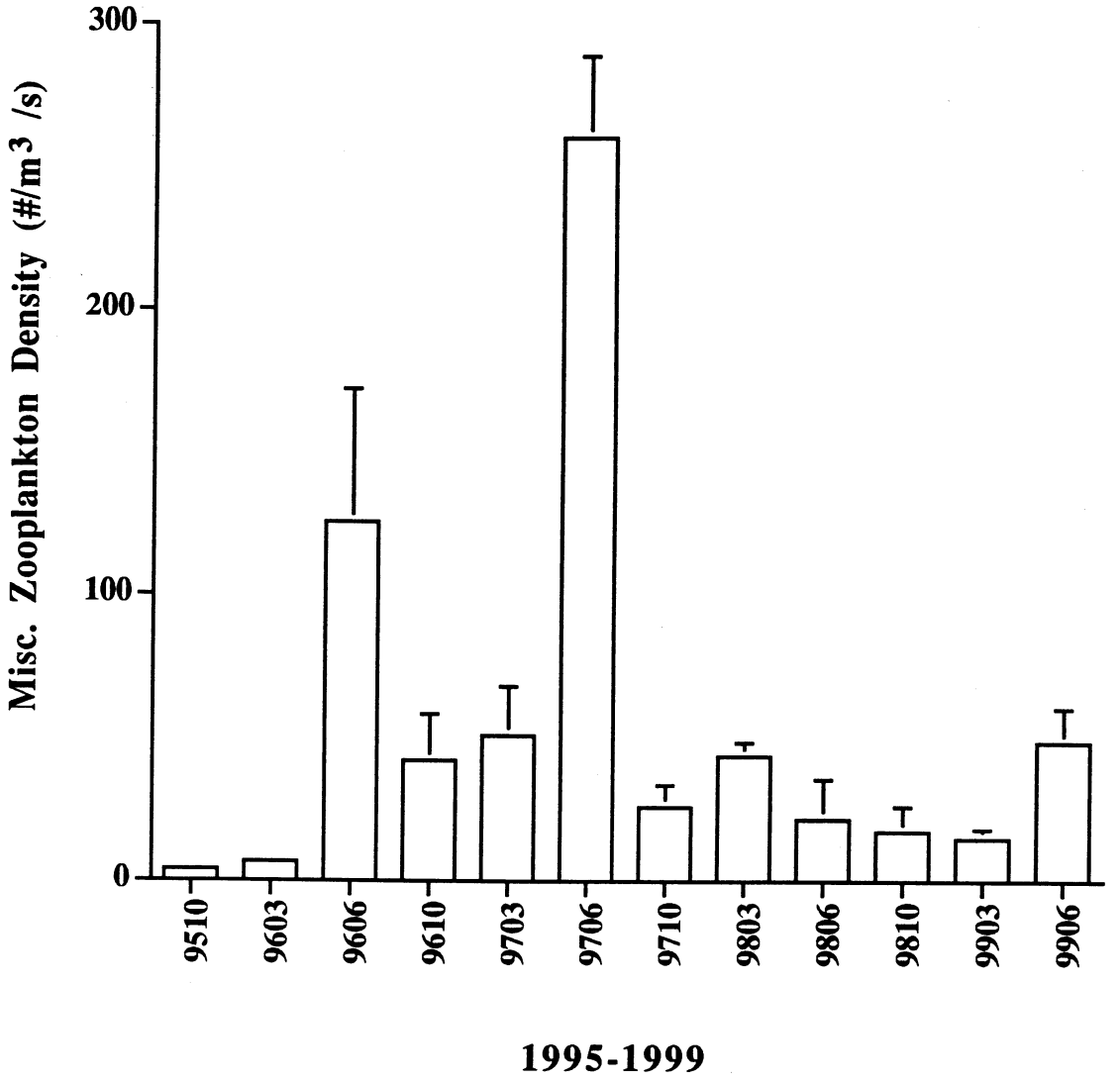

Figure 325. Average FPOM drift densities (#/m^3/s) of miscellaneous zooplankton (benthic origin) at 205 Mile Rapid Rkm 328.8 from October 1995 to June 1999.

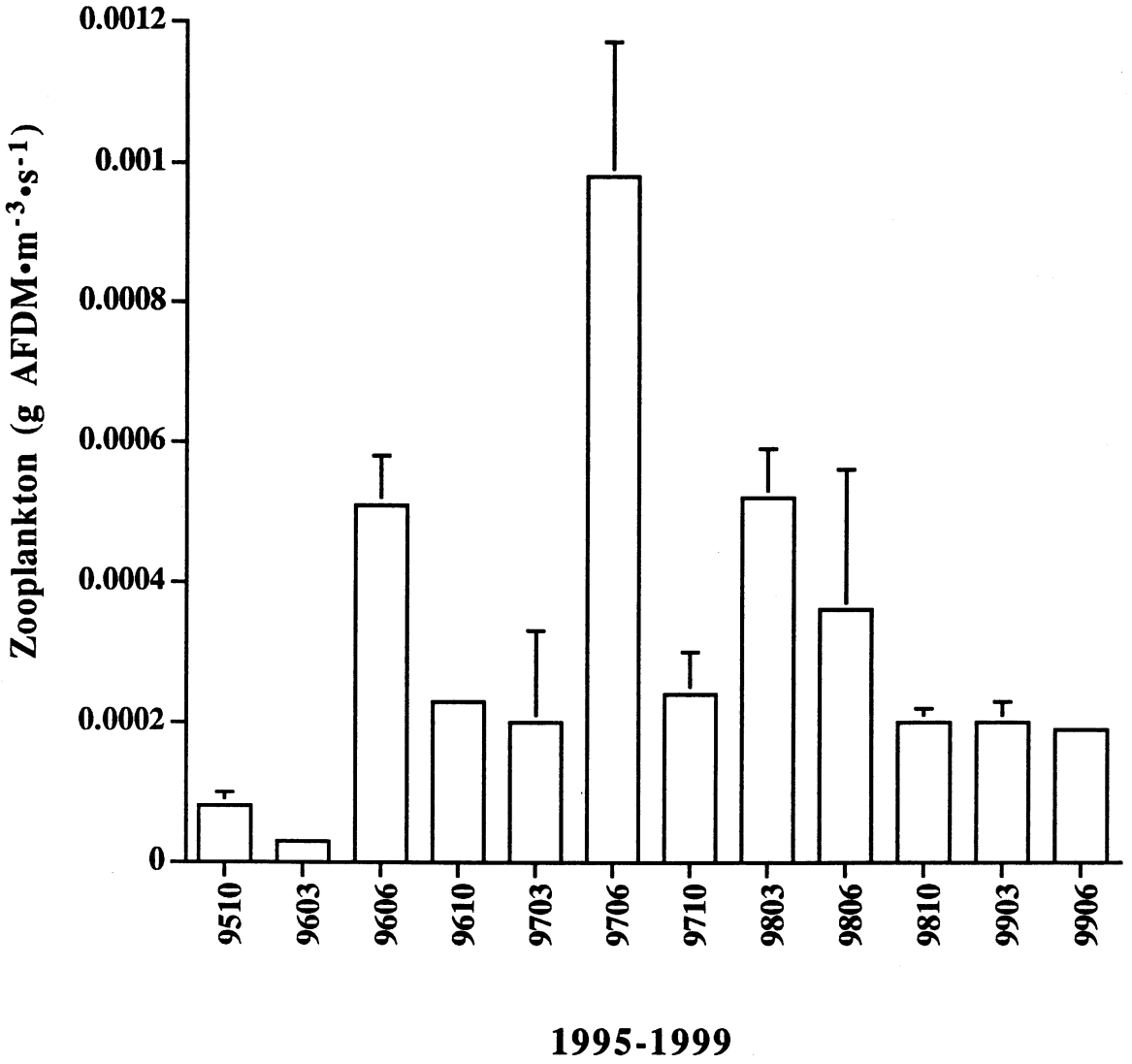

Figure 326. Average zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of lentic origin for Calanoida, Cyclopoida, Cladocera and Ostracoda collected at 205 Mile Rapid Rkm 328.8 from October 1995 to June 1999.

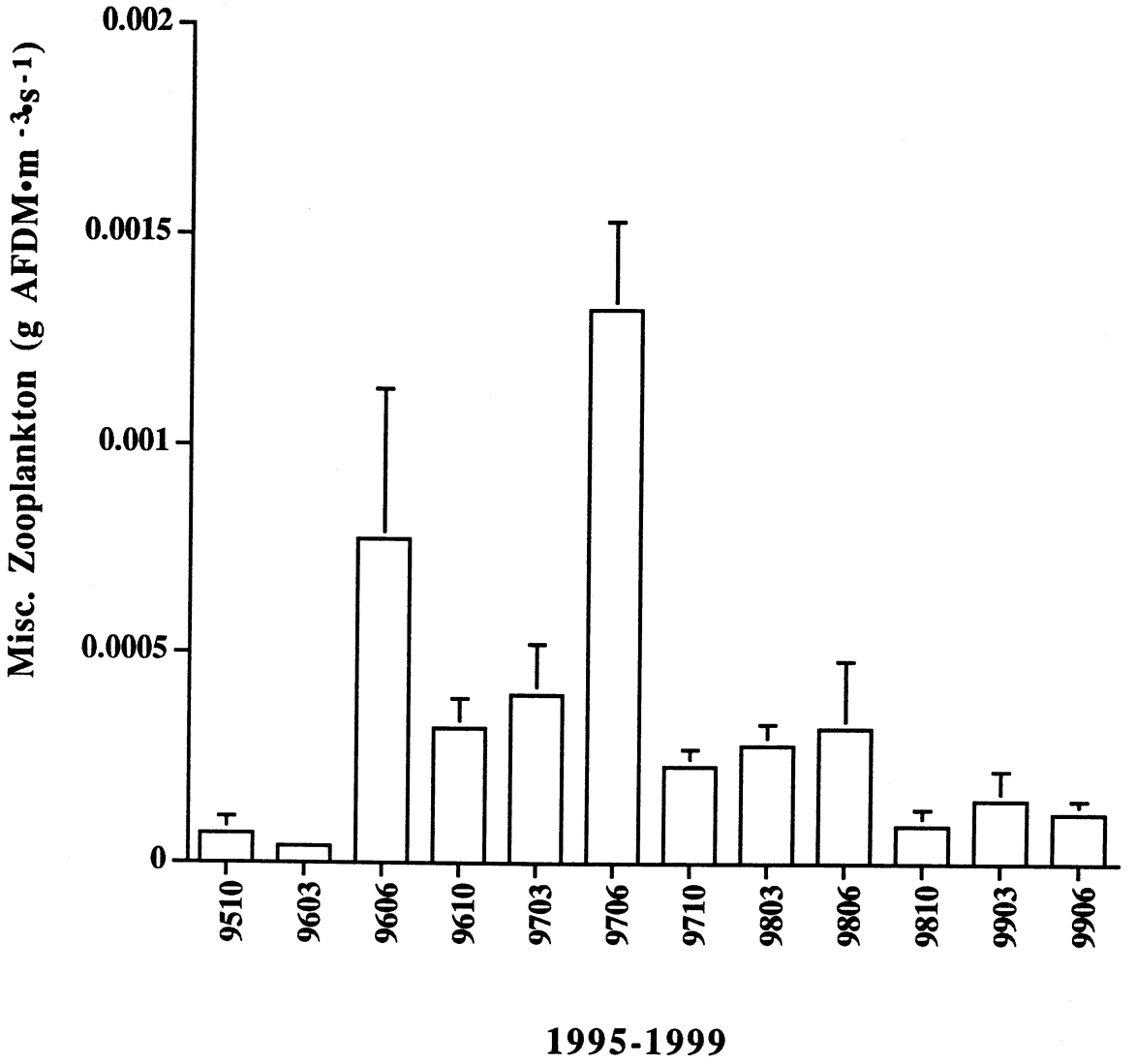

Figure 327. Average miscellaneous zooplankton biomass (g AFDM•m^{-3}•s^{-1}) of benthic origin collected at 205 Mile Rapid Rkm 328.8 from October 1995 to June 1999.