

EFFECTS OF A STREAM LAB ON CARBON LEVELS IN MACROINVERTEBRATES IN THE MAPLE RIVER

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ABSTRACT

To test the hypothesis that discharge from the stream lab affects the amounts of organic material found in organisms within the secondary production level of the Maple River, I set up an experiment with four sampling sites according to location relative to the University of Michigan Biological Station Stream Lab in Pellston, Michigan. An upstream site was located before the intake pipes, a midstream site was in the Maple River adjacent to the stream lab, a downstream site was placed after the stream lab water is expelled, and a site was placed within the stream lab. After sampling over a period of 17 days and using ash-free dry mass, I found that the upstream site had a significantly higher average ash-free dry mass, as well as higher average weight of organisms, while the other sites showed weights that were considerably less. There was more of a change in carbon levels between the upstream and midstream sites, than levels between the midstream and downstream sites. This suggests that the effect of reduced macroinvertebrate growth on the Maple River was caused by material being removed from the stream by the stream lab, rather than by material from the lab being added into the water downstream of the lab.

INTRODUCTION

There have been extensive studies on the role of carbon cycling through river systems (Neves 1979). By observing and assessing different levels of carbon found in a particular environment, many things can be concluded about that area. For many years, researchers have been using carbon levels to assess the impact of human disturbance on stream environments.

Human impacts, including dams and channel modifications, on river systems are becoming an increasing problem, affecting biota, flow, temperature, and sediment regimes (Cushing and Allan). Research is continuing to better understand the carbon cycling and limitations in river ecosystems that are being disturbed by human interference. Research facilities, such as stream labs, where researchers are able to manipulate river water to study universal river principles, are beginning to expand to become better resources for studies.

The University of Michigan Biological Station in Pellston, Michigan is an example of one such research facility that pulls water from the East Branch of the Maple River to aid in stream research. Little is known about the effects of stream labs, like this one, on the very streams that supply its water. While also being used to study overall river systems in order to better conserve them in the future, the presence of the stream lab itself causes a disturbance and forces change and adaptation within its surrounding environment. It is known that the effects of disturbance in some aquatic ecosystems are related to the nature of the disturbance regime (magnitude, frequency, timing, etc.) (Gurtz and Wallace 1984). Physical disturbances that result in changes to population structure or resource availability are common in many streams (Power et al. 1988), and are thought to have strong, possibly overriding influences on community structure in rivers and streams (Lake and Barnuta 1986, Resh et al. 1988).

Macroinvertebrates can be very important indicators of how human impact has changed a river community and how carbon is cycled through a system such as this. Macroinvertebrates have served as valuable indicators of degradation of streams, and as increasing demands are placed on our water resources, their value in assessments of these impacts will increase (Wallace and Webster 1996). The accurate measurement of invertebrate secondary production in both benthic and planktonic populations is critical to understanding biotic energy flow through aquatic ecosystems (Benke 1984). When habitats and flows are altered, native species are disadvantaged (Cushing and Allan 2001). The amount of organic material in macroinvertebrates can aid in evaluating the impact of stream labs on surrounding ecosystems so we can better understand the effects of these disturbances on the native community.

The objective of this study is to assess the effects of the stream lab on organic material found in organisms within the secondary production level of the Maple River using ash-free dry mass.

METHODS

The study was conducted for a period of 17 days between July 22 and August 8, 2003, at the University of Michigan Biological Station Stream Lab on the East Branch of the 1st-order Maple River in Cheboygan County, Michigan.

The University of Michigan Biological Station Stream Lab is a research facility that takes approximately 0.070 cubic meters per second from the Maple River through a series of pipes and pumps. The water is manipulated within the lab according to experiments being performed within the establishment, such as effects of different nitrogen and phosphorous levels on river water, and invertebrate and algal communities. When the water initially reaches the stream lab pad, the water is fed through a simple nylon mesh filter to clear larger organisms, debris, and substrate. Well water is also carried into the facility and is combined with the river water before being expelled back into the river downstream of the intake.

Four study sites were selected to test the hypothesis that the stream lab has an effect on the carbon levels found in macroinvertebrates. These sites were designated according to their locations relative to the stream lab and were chosen to resemble one another with similar flow, substrate, light penetration, and depth from the surface of the water. The flow rate at the midstream site was 0.08 m/s and the rates at the other three sites were 0.17 m/s. The temperatures of these sites ranged from 18-22 degrees Celsius and the substrate along the bottom of the gutters was sand. Vegetation cover was about

5% and gutters were placed in the same longitudinal direction in the river to equalize the amount of sunlight that hit these gutters throughout the day.

The upstream site was placed in the river immediately before the water intake where the river water is brought to the lab by a series of pipes and pumps. It was located at a small bend in the river and was in more shallow water than the other sites. The midstream site was placed in the Maple River adjacent to the stream lab. The downstream site was positioned about 20 feet downstream from the pipes that reintroduced the water from the lab into the river. The stream lab site was located within a man-made concrete trough located about half the distance from point where river water enters the lab and the point at which it is expelled. The trough channels the used water from the lab to pipes that pump the water back into the Maple River.

An inverted plastic gutter 2.44 m long was situated at each site so that the flow of the river ran parallel to the length of the gutter. To each gutter were glued 35 bleached 5.08 cm square ceramic tiles and numbered consecutively. There were five sample days during the experimental period with each sample day being 3-4 days apart. Using a random number generator, five randomly selected tiles were taken from each gutter for analysis each sampling day. The macroinvertebrates were then removed from the tiles using a dissecting scope and tweezers, and placed in glass vials of ethanol for storage.

Ash-free dry mass as described by Hauer and Lamberti (1996) was performed on each replicate. Macroinvertebrates collected from each tile were stored in separate vials according to tile number. Each replicate was placed in aluminum tins and dried in a drying oven set at 100 degrees Celsius overnight. They were then weighed and placed in a muffle oven that was set at 520 degrees Celsius for one hour. The oxidized samples

were then weighed again and the loss of weight upon oxidation is referred to as ash-free dry mass.

The dry weight and ash-free dry mass of the organisms were averaged for each sampling day for analysis. Standard error was calculated and graphs were produced using Excel.

RESULTS

During the 17-day study, the upstream site showed a steady increase in the average ash-free dry mass (AFDM) of the macroinvertebrates as time went on, immediately starting with a higher average weight than that of the other sites, increasing from 0.00086 g to 0.00308 g (Fig. 1). With the exception of one sampling day, the average organism weight also increased over time from 0.00162 g to 0.00526 g (Fig. 1). At the stream lab site, the average organism weight ranged from 0 g to 0.00248 g (Fig. 3) and the average AFDM ranged from 0 g to 0.00132 g (Fig. 3).

The midstream and downstream sites, with the exception of one plot, showed similar results in, both, average AFDM and average organism weight over time. The midstream site had organism weight averages ranging from 0.00054 g to 0.00185 g (Fig. 2) and average AFDM between 0.00008 g and 0.00068 g (Fig. 2). The downstream site had average organism weights ranging from 0.00074 g to 0.005325 g (Fig. 4) and average AFDM between 0.0001 g and 0.000925 g (Fig. 4).

The stream lab site was not similar to the other sites, but the average AFDM and the average organism weight did correlate with each other within that location. When the average organism weight increased, the average AFDM also increased and so on. This

was seen overall in all four sites, though with varying differences in values for each sample.

At the upstream site, the average AFDM increased when the average dry weight of the organisms increased, with the exception of the 2nd sampling day. At the midstream site, the average AFDM and average dry weight followed each other's trend until the last sampling day. The average AFDM and average dry weights at the downstream site also followed the same trend with the exception of the first sampling day. The stream lab site was the only location where, both the AFDM and average organism weights from each sampling day followed the same trend for the entirety of the research period.

When comparing average organism weight and average ash-free dry mass between the sites, it can be seen that the midstream and downstream sites show similar results (Fig. 5, Fig. 6).

The average organism weight and ash-free dry mass at the upstream site was significantly higher than that of the other three sites (Fig. 7). The average AFDM at each site is about half the average weights of the organisms found at those sites (Fig. 7).

DISCUSSION

As expected, it appears that the stream lab does have an effect on the carbon levels found within the macroinvertebrates of the Maple River. It was originally thought that the cause would be due to manipulation of the water by the stream lab and the major differences would be seen after the water from the stream lab was reintroduced into the river, between the midstream and downstream sites. The results actually show a larger impact between the upstream and midstream sites, suggesting that it is not the reentering water that is changing the ecology of the river, but rather the fact that the stream lab is

removing important things from the river, affecting the ecology of the reaches downstream of the intake.

With these results, we can assume that the effect on the carbon within the stream macroinvertebrates is not occurring within the stream lab. Because something is happening between the upstream and midstream sites, it is possible that the lab is taking away from the stream something that is needed for the high level of secondary production seen in the upstream site. The large differences in the upstream site compared to the mid- and downstream sites could be due to the fact that the upstream site became increasingly different than the other sites as time went on. Sand built up or the water level decreased, bringing the gutter closer to the surface. The gutter was also placed in a small bend of the river, unlike the other sites placed within a straight reach and caused a difference in flow along the gutter that became more apparent over time.

The data from the stream lab was expected to be very different from the other sites because the water had to go through hundreds of feet of pipes and pumps to be spilled onto a concrete pad with an entirely different ecosystem than that of the river, and as expected, the stream lab results were not similar to any of the other sites. Another interesting finding is that the stream lab sampling site was located before the well water was added and, because there was not much of an effect seen downstream, the well water may not be affecting the river as much as previously thought.

There were many observations and mistakes that seemed to have affected the results and should be taken with more care in the future. For example, it should be noted that the gutter at the upstream site was placed at a small bend in the river where the flow was altered as it made its way around the wide corner. As time went on, the sand at the

upstream site built up or the depth of the water decreased at that particular part of the river because the depth of the water over the gutter had significantly decreased by the end of the research period. This affected the light penetration and flow velocity where the tiles were located. For future purposes, it should also be noted to place the gutter in a straight reach so that the flow is consistent with that of the other sites. This may explain the fact that there were many more invertebrates found at the upstream site than at any other site.

Ash-Free Dry Mass (AFDM) may not be the best method of measuring organic matter in macroinvertebrates alone because there may be a large amount of vertebrate organic matter in the sample. AFDM does not allow the investigator to distinguish the different types of organic matter in the sample. The physiological state of the organic material is also unaccounted for. Drying by heat may volatilize certain organic compounds and carbonates, leading to an underestimation of true AFDM (Hauer and Lamberti 1996).

When doing AFDM, the individual types and sizes of macroinvertebrates were not taken into account in my experiment. This means that, if there happened to be a large macroinvertebrate on one of the random tiles, its weight would cause a major difference in overall weight compared to the other tiles. By evaluating the different organisms and feeding groups found on the tiles, in addition to the AFDM, results that address, more specifically, how carbon flow through this system can be evaluated. Also, if there was more time to sample, there most likely would have been larger or more invertebrates on the samples to take into account.

There were mistakes that should have been avoided when sampling, taking measurements, and analyzing. There were two scales used to weigh out the macroinvertebrates. One scale was used after the AFDM was taken and the other to weigh out the tins that contained the samples before they were placed in the drying oven. The other measurements were inconsistently taken between the scales. These results were skewed because the two scales may have been calibrated differently.

Each day, one person from our research group was assigned to observe the different sites and make sure the gutters were clear of any new sand or sediment that may have settled on them overnight. The lab was not checked everyday as planned, which altered the results because of the inconsistency of clearing the gutters of silt and sand.

Before I could analyze my samples, there were two other group members who needed the same tiles and macroinvertebrates for their own analysis before I could start because I had to volatilize my samples. Organic material could have been lost with the additional handling and time it took before I could begin my analysis. In addition, the ethanol used to preserve the macroinvertebrates from the time they were removed from the tiles to the time of analysis most likely broke down some of the organic weight, affecting the data. Organic matter and whole organisms could have also been destroyed during collection beyond recognition. When removed, the tiles were placed in whirlpacks, which were then stacked on top of one another. This most likely killed or destroyed some of the needed invertebrates to the point that they are unrecognizable and unaccounted for because they were not picked off of the tile for analysis.

Along this line, the accuracy in recognizing and removing the macroinvertebrates may have altered the results if there were organisms that were not collected for analysis.

If the group members somehow missed some organisms, that would alter the results. Even though standard error was calculated, failing to remove a few organisms could greatly change results. Also, if they were placed in the vial along with sediment or other unnecessary debris, it most likely altered weight measurements if they were weighed in addition to the invertebrates.

There were a few weights that did not make sense after being calculated. There was a remarkable amount of these differences on the second sampling day and just a few on the 1st, 3rd, and 4th days. Two possibilities can be explained: 1) the humidity levels on some of the days when data was being weighed and analyzed was very high, which could quickly add minute amounts of weight onto the sample, altering the data. 2) the fact that two different scales were used at random times could produce the questionable numbers. The numbers that were being analyzed are so small, that the slightest calibration difference could make the data appear false.

In order to gather more information, additional measurements should have been taken regularly throughout the sampling period. These measurements could be helpful during analysis and bring to light other explanations for my findings.

In addition to these mistakes, there was also an unfortunate event that we could not control. Before the last sampling day, the gutter that was placed at the stream lab site was found to be flipped over and could have been that way for up to two full days. This altered the findings because it disrupted the environment and there was no access to the top of the tiles for the organisms that would have otherwise inhabited the area.

There is much more to learn about the effects of research facilities like the stream lab on river ecosystems. Though there were many things that could have been performed

and evaluated differently, the conclusion of this study is that the stream lab does have an effect on the carbon found in macroinvertebrates of the Maple River. This effect is caused by factors being removed from the river rather than other factors being introduced into the river by the stream lab. There was a difference in the types of invertebrates found on the tiles between sites, but this study concentrated on the effects on total amount(s) of carbon being utilized within the stream due to the stream lab. This study also does not take into account what is exactly being taken away from the stream at the intake and could be the basis for further study. With these further studies, more can be learned and improved upon, so that research facilities can be better equipped to conserve the very streams and rivers they are learning about.

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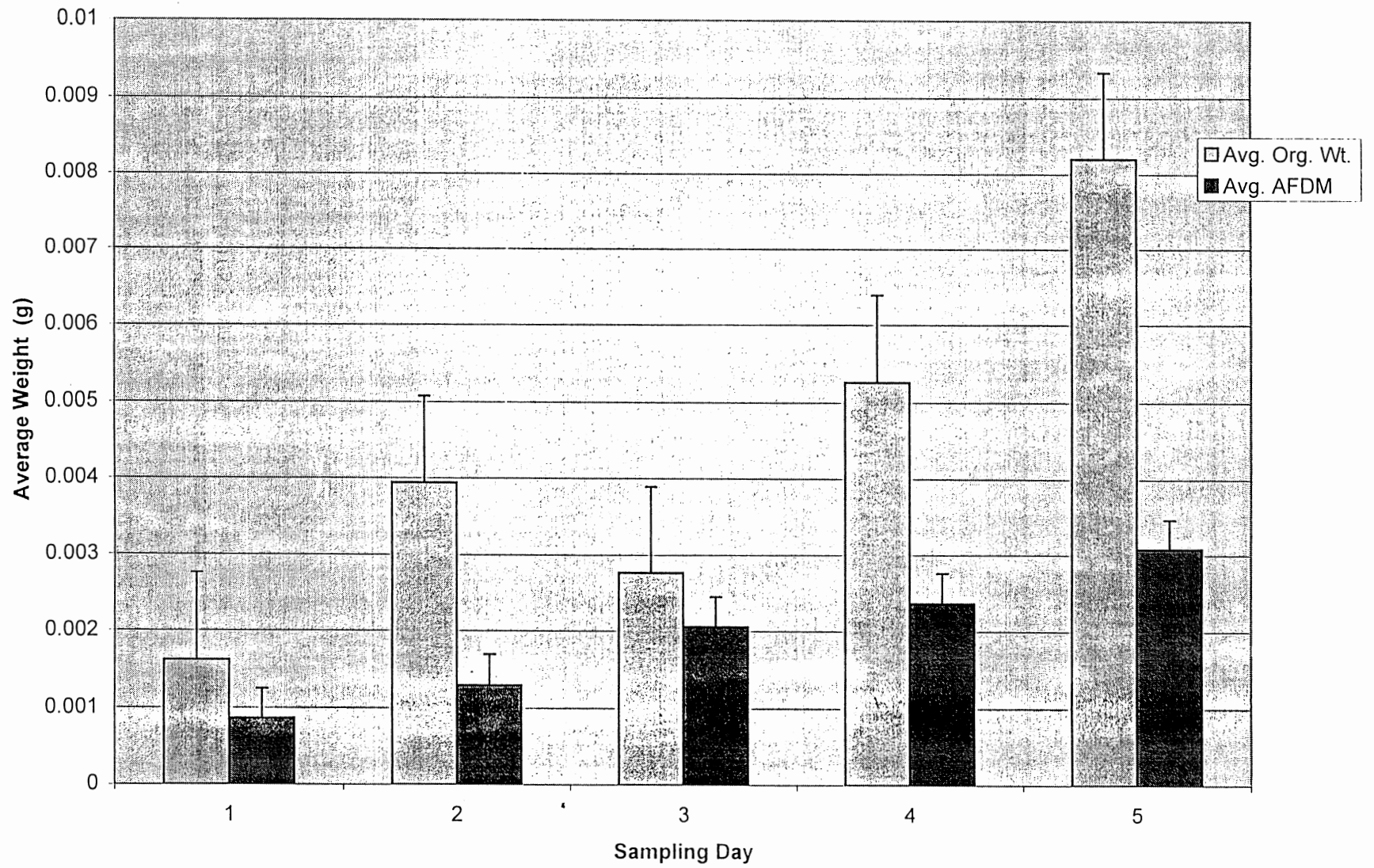


Fig. 1 Relationship between average weight of organism and average AFDM found at the upstream site over five sampling days

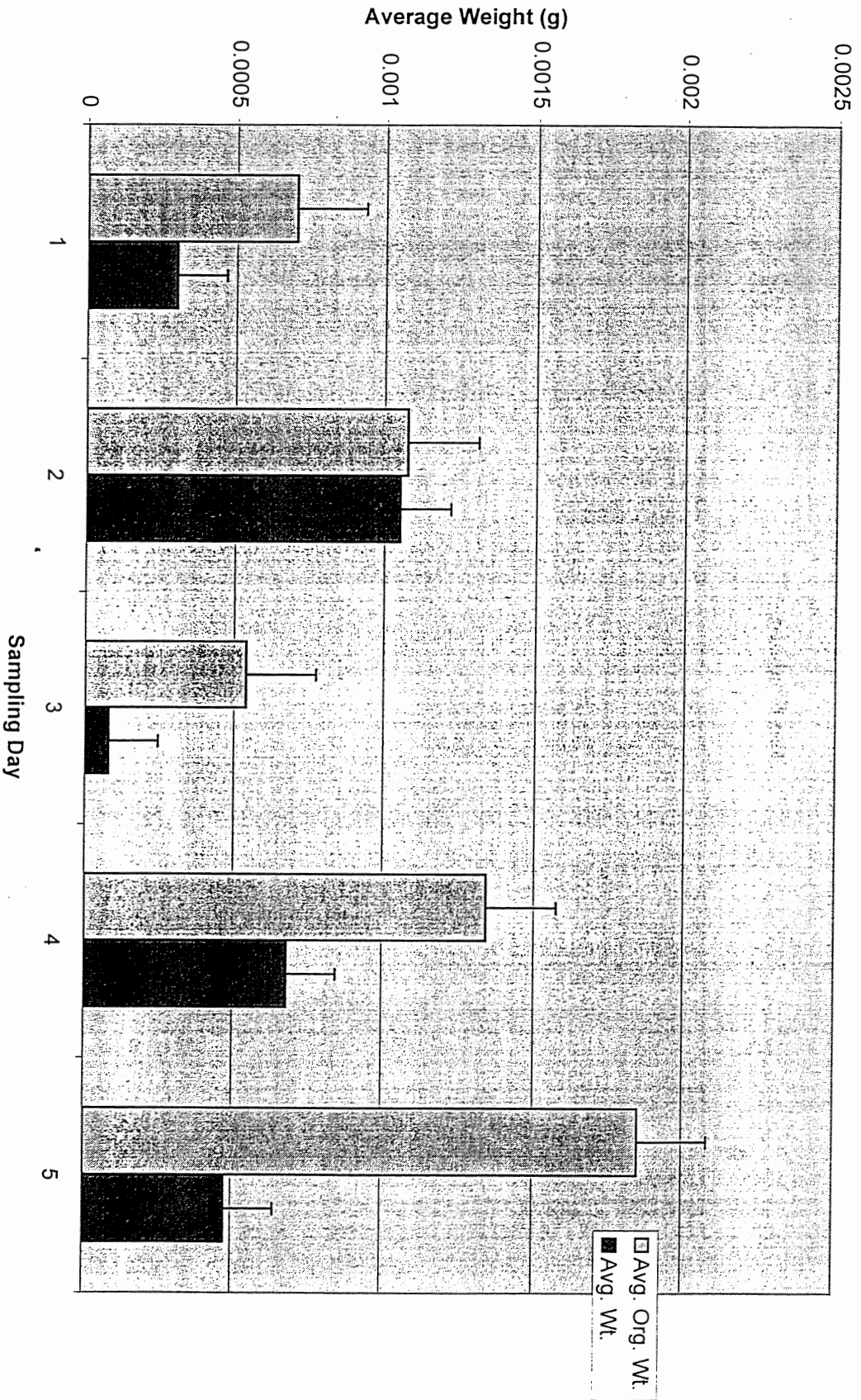


Fig. 2 Relationship between average weight of organism and average AFDM found at the midstream site over five sampling days

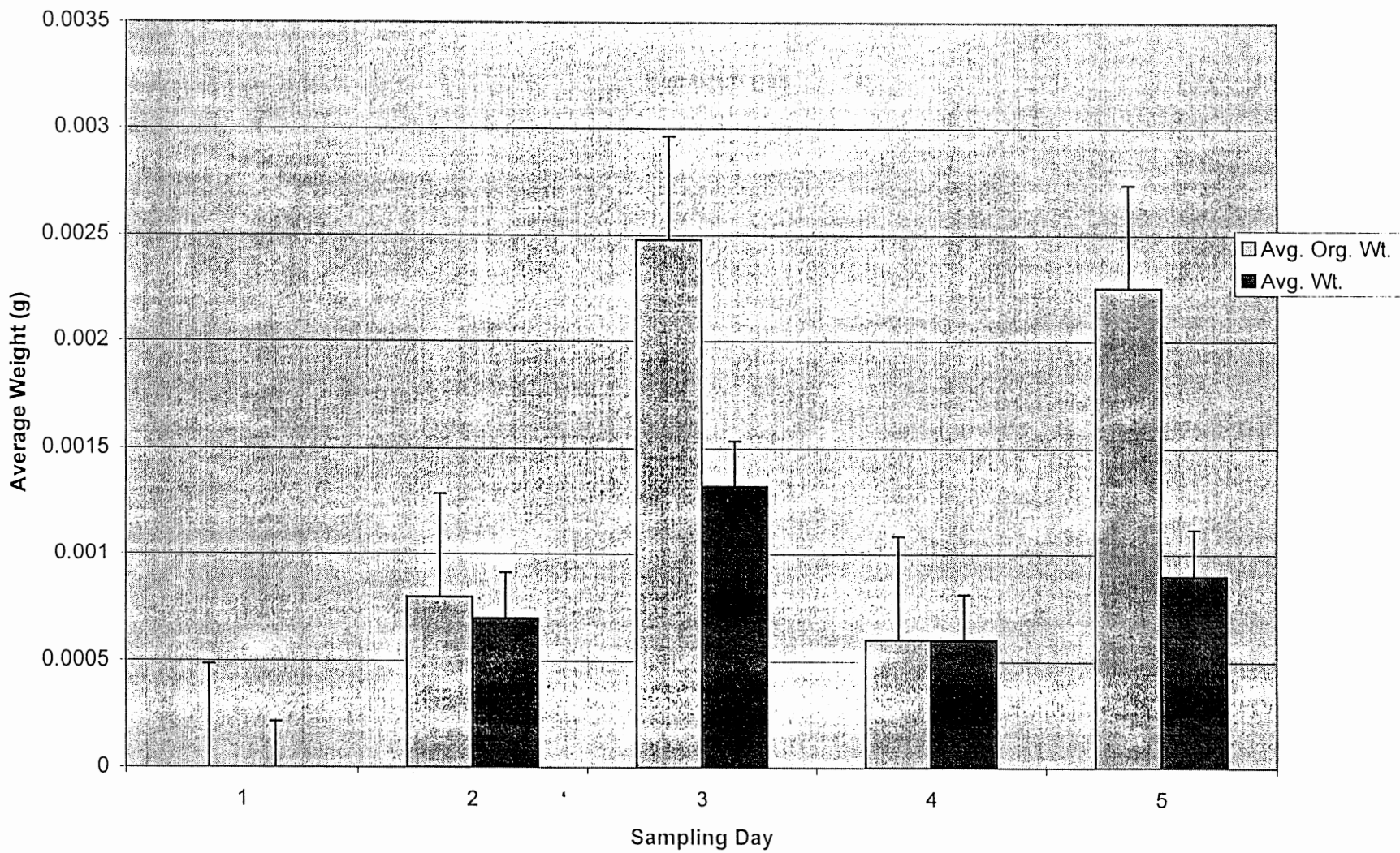


Fig. 3 Relationship between average weight of organism and average AFDM found at the stream lab site over five sampling days

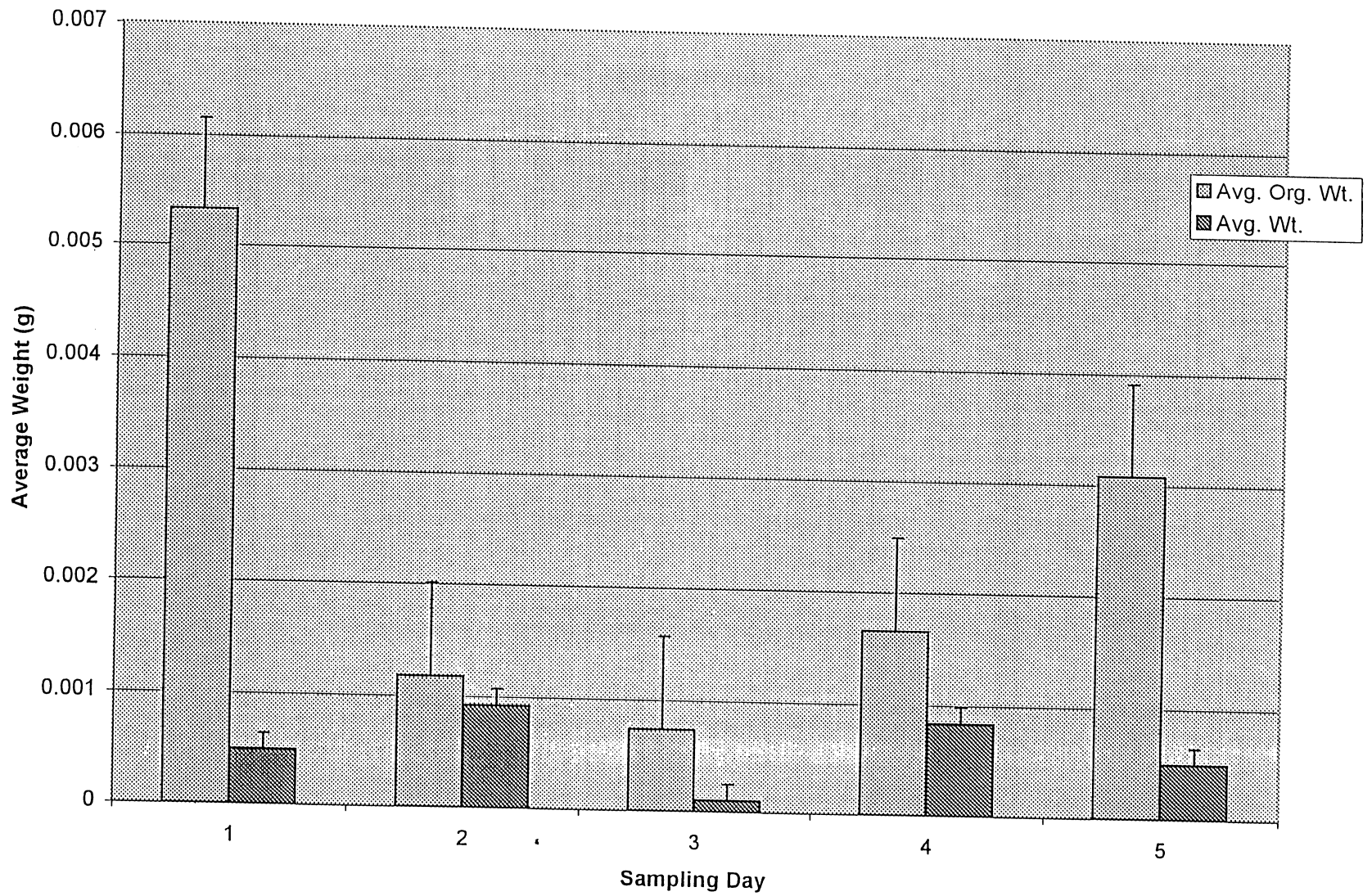


Fig. 4 Relationship between average weight of organism and average AFDM found at the downstream site over five sampling days

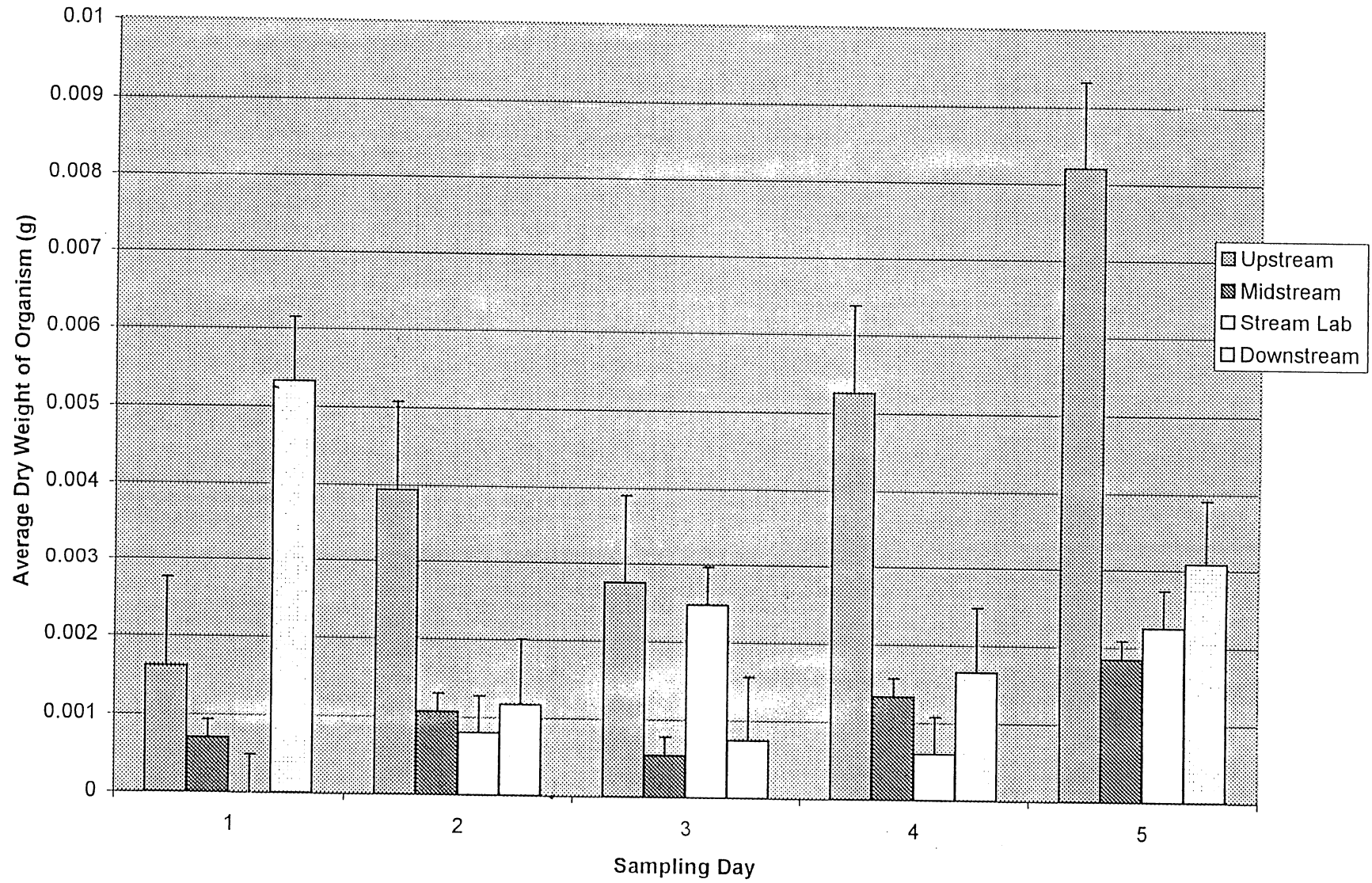


Fig. 5 Relationships between average dry weights of organisms at each site over time

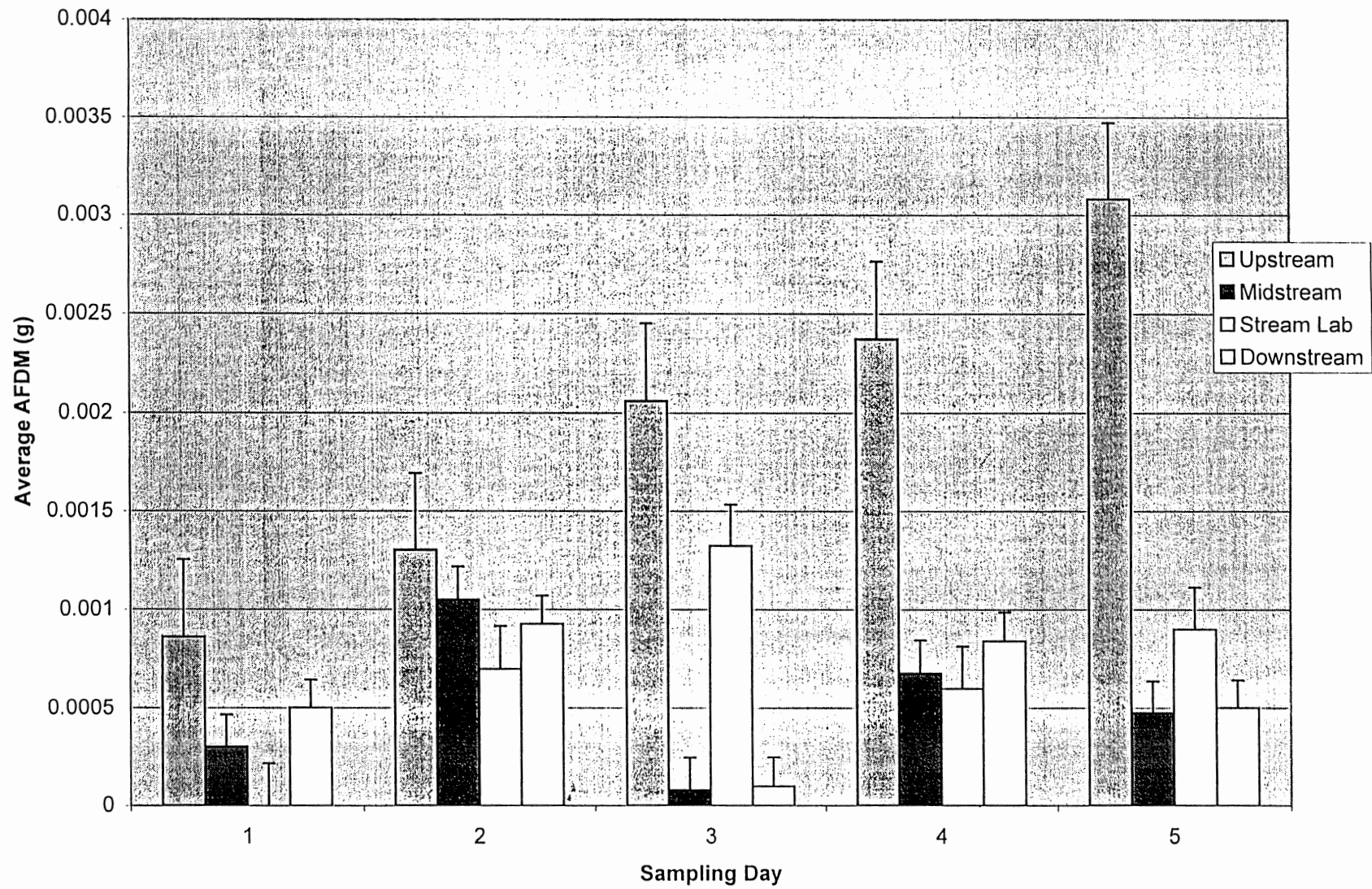


Fig. 6 Relationships between average ash-free dry mass at each site over time

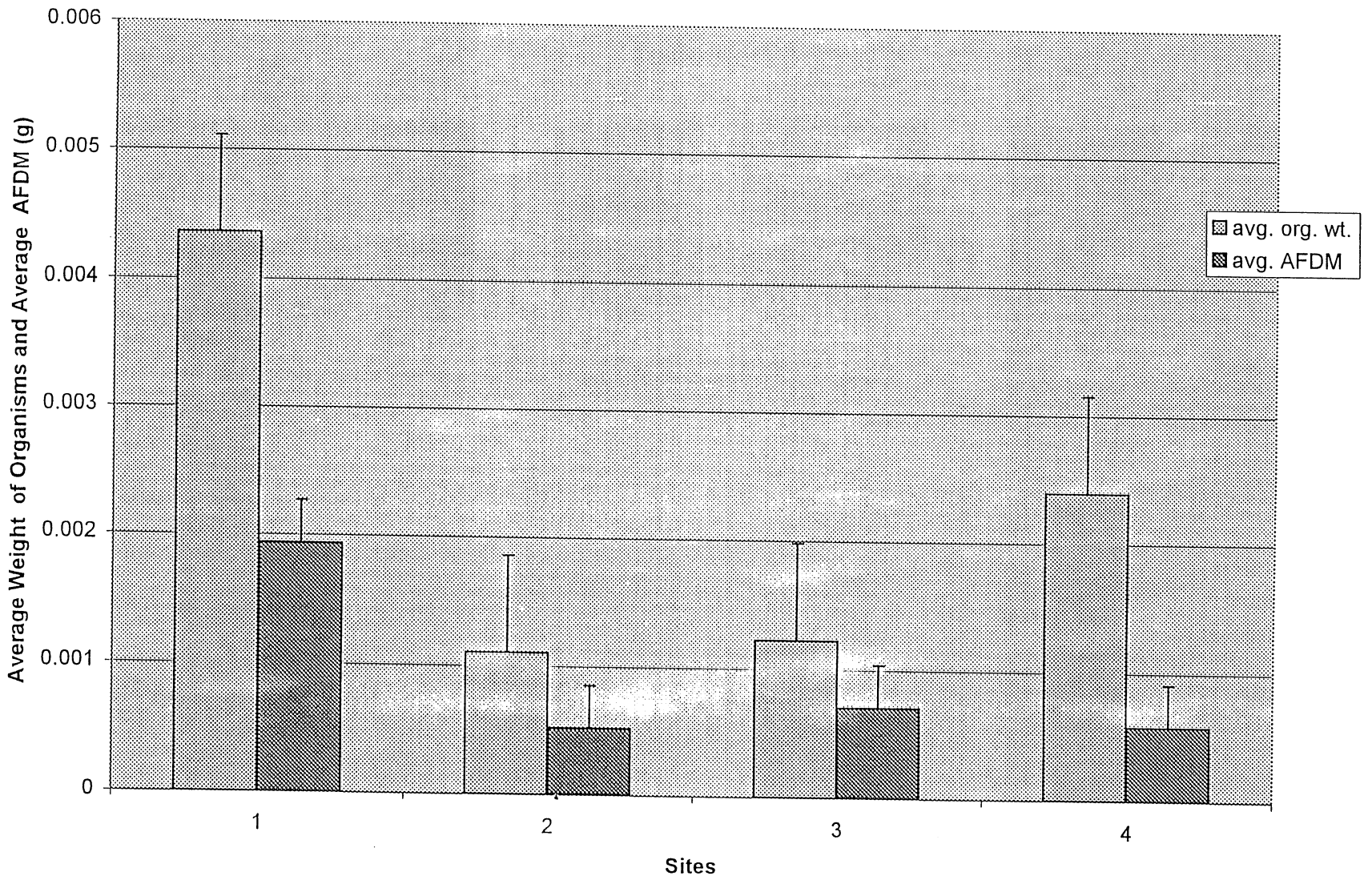


Fig. 7 Relationships between total average weights of organisms and average AFDM (ash-free dry mass) at each site. 1 - Upstream site, 2 - Midstream site, 3 - Stream Lab site, 4 - Downstream site