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Bioaccumulation of P-32 in Bluegill and Catfish

Prepared by B. Kahn, K. S. Turgeon, D. K. Martini, S. J. Dunkerly, R. M. K. El-Shinawy, M. D. Wilson, R. A. Hammond, R. Uribe, A. A. Mizner

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U.S. Nuclear Regulatory Commission

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Abstract

Bluegill and catfish were fed P-32 at a constant feeding rate per body weight to determine the bioaccumulation factor (BF_r) for P-32 in muscle relative to water. The fish were maintained in flow-through tanks at two feeding levels. The bluegill accumulated P-32 for 51 days, followed by depuration for 28 days. The catfish study had to be terminated after 11 days. Fish were analyzed in triplicate for P-32 and phosphorus at intervals of 1 - 8 days. Additional aquaria experiments were performed to determine the effects of water temperature, feeding rate, and type of food (worms vs. pellets) on P-32 uptake, and to observe P-32 uptake from water by unfed fish (including fish with blocked esophagus).

A simple calculational model was used to determine the phosphorus turnover constant from the specific activity in tissue relative to food. This ratio at steady state approaches the BF_r/BF ratio (where BF is the phosphorus bioaccumulation factor) if P-32 transfers rapidly from water to food.

The bluegill showed a weight gain of 0.2 %/d, a phosphorus turnover constant in muscle of 0.43 %/d, and a BF_r/BF ratio of 0.081 at the higher feeding rate, and 0.05 %/d, 0.34 %/d, and 0.064 at the lower feeding rate. Hence, respective P-32 BF_r values are 6,000 and 4,000 at a phosphorus BF of 70,000. The BF_r values for catfish were approximately twice as high. The aquarium experiments suggest that the higher factors are due to a much higher phosphorus intake, higher water temperature, higher retention from pellets than from worms, and possible higher retention by catfish than bluegill under the same conditions.

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Acknowledgments

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1. Introduction

The elemental bioaccumulation factor (BF) is widely used to compute public radiation doses due to a radionuclide discharged at nuclear facilities. The bioaccumulation factor for a specific radioisotope (BF_r) is obtained from stable element concentrations in a medium and in its precursor in the transfer pathway; from environmental monitoring data for the radionuclide in these two media; from field or laboratory tracer studies; or, if none of these sources of information is available, from data for homologous elements. Values for P-32 in edible tissue of freshwater fish are available from all of these direct data sources, but they range from below 100 to above 100,000. This laboratory tracer study was undertaken to recommend a reliable BF_r for P-32 in freshwater fish flesh.

A survey of the BF for all elements in edible aquatic organisms (Th72) recommended the value of 100,000 for freshwater fish, based on the ratio of the typical phosphorus concentration in muscle to that in water. A BF derived from stable element concentrations is recognized as being conservative because it represents the upper limit for the BF_r unless multiple pathways or physico-chemical forms complicate the situation (Th72). A more recent review of reported values for P-32 (Ka80) utilized earlier discussions of the bioaccumulation factor (Fo59, Po66, Pe71, Lo71, Th72, Va75) to identify the main reasons for the wide range:

(1) some higher BF_r values are based on P-32 concentrations in whole fish, for which the phosphorus concentration is more than twice as high as in muscle;
(2) the BF value is much higher than the BF_r value because the 14.3-day half life of P-32 prevents the fish from accumulating radioactive atoms to the same extent as stable ones;
(3) phosphorus concentrations in fish are homeostatically controlled, hence the BF is not constant but varies with the phosphorus concentration in water; and
(4) uptake of phosphorus in fish is mainly by food consumption rather than direct intake from water, hence the BF_r depends on the availability of P-32 in food and the food consumption rate by fish.

Considering only edible fish tissue, average BF_r values based on pond studies range from 800 to 12,000 (Wa57, Da58, Fo62, Il61) and those based on monitoring range from 600 to 1,600 (Ra74, Ka80).

Recalculation of the BF with more recently reported phosphorus concentrations in fish muscle and in larger U.S. streams suggested a generic value of 70,000 on the basis of a mean phosphorus concentration in fish muscle of 2 mg/g and in water of 0.03 mg/L (Ka80). Because concentrations between the first and ninety-ninth percentiles of reported values range by approximately a factor of two from the mean for tissue and by a factor of ten for water, the BF for a specific fish, location, and time can be considerably different than the generic value.

The BF_r for P-32 was calculated to be 3,000 on the basis of the BF of 70,000 and an estimated biological turnover constant of 0.002 per day for phosphorus in fish muscle (Ka80). This BF_r is now being used by the US NRC (Br82). The turnover constant was derived from such diverse sources, however, that experimental determinations of this constant and the associated ratio of BF_r to BF were recommended (Ka80).

In the main experiment described here, the pattern of P-32 accumulation and depuration was obtained to determine the biological turnover constant, and the pattern was observed at two feeding levels to determine the influence of intake. Bluegill (Lepomis macrochirus) in a flow-through system, divided into a high-feed and a low-feed group, were subjected to P-32 accumulation for 51 days and to depuration for the following 28 days. Each group was fed a constant amount of worms per average body weight. During accumulation, P-32 was maintained at a nearly uniform specific activity in the worms. Sets of three fish were sacrificed, dissected, and analyzed for phosphorus and P-32 at intervals of 1 to 8 days. A parallel experiment with pellet-fed catfish (Ictalurus punctatus) had to be terminated after accumulation for 11 days.

Ancillary experiments were performed in aquaria for 9-day periods to examine the influence of species (bluegill vs. catfish), foods (worms vs. pellets), and water temperatures. A separate 4-day aquarium experiment with unfed fish -- some with blocked esophagus -- examined the extent of P-32 uptake directly from water. On some occasions, fish from the flow-through system were placed in aquaria for one day before sampling to measure excreted P-32 in water.

The data are reported in terms of specific activity (P-32 count/minute per mg phosphorus) for food, muscle, and other fish sections. The specific activity in tissue relative to that in food was used to determine the biological turnover constant and the ratio of BF_r to BF at steady state in terms of a simple 1-compartment model per tissue. The results are considered to be applicable to fish in the environment on the basis of observed growth rates, and the test fish were sufficiently large to represent fish caught for consumption.

2. Procedure

Laboratory Studies. the P-32 accumulation and depuration experiment was performed in two 2,000-Liter tanks, separated into halves by framed plastic netting. Tap water from the Atlanta municipal system flowed into each tank at 10 - 20 L/min after chlorine removal in two 0.2-m^3 columns of activated charcoal and gravel (Bruner Manuf. Co.). Air was bubbled into each tank from 5 lines to maintain adequate oxygen concentration.

The oxygen content and temperature of the water were measured daily; chlorine, pH, nitrite and ammonia were measured daily at the beginning of the experiment and then occasionally. The oxygen was generally near saturation (8 - 10 mg/L) during the bluegill study and at lesser concentrations (4 - 8 mg/L) for the catfish study. The catfish were in the tank from August 15 to 26, 1982, at water temperatures of 24° - 26° C; the bluegill were in the tank from September 26 to December 15, 1982, while the water temperature gradually decreased from 22° to 16° C. Chlorine was below detection levels (less than 0.003 mg/L). The pH was near 6.0. The nitrite concentration was less than 0.3 mg/L and ammonia was between 0 and 2.5 mg/L.

On six occasions, excreted P-32 was measured. For this purpose, sets of three bluegill were transferred on the day before they were sacrificed from the flow-through system to an aquarium. The fish were moved, fed, and then maintained in 24 L water without further feeding. After the fish were removed for sampling, solids were collected from the aquarium bottom by siphoning and separated from water by filtering with a 75-micron filter; a sample of the filtered water was also retained for analysis.

These aquaria, and the ones used in the experiments described below, were 75-L glass containers, filled with dechlorinated water into which air was bubbled. Three fish were maintained per aquarium.

The effects of species, food and water temperature on bioaccumulation were observed on January 18 - 27 and February 8 - 17, 1983. Water was changed daily by replacing 55 L of a total 70-L volume. Attempts were made to maintain the water at temperatures of 15°, 20° or 25° C but some measured averages deviated from these values. Some bluegill were isolated with screens when more dominant fish were seen to prevent them from feeding.

Uptake of P-32 by six unfed bluegill was studied on December 6 - 10, and by six unfed catfish, on December 13 - 17, 1982. Each aquarium held three fish in 48 L water. To obtain the relatively high phosphorus concentration of 5 mg/L, equimolar in di- and monohydrogen phosphate, 9.66 mg NaH_2PO_4 and 11.43 mg Na_2HPO_4 were added per liter. This is the approximate distribution of phosphate at neutral pH. Tracer P-32 was added to the water with the phosp salts. The water temperature was 17 - 18° C. After two days, each set of fish was transferred to a second aquarium that contained a fresh batch of the same solution.

Two of the unfed bluegill and three catfish were prevented from swallowing by a water-filled 30-cc balloon inserted in the esophagus. Each fish was anesthetized before a modified Foley catheter (20 French with 30-cc balloon) was inserted. The balloon then was partially filled with water, the inflation channel to the balloon was blocked with a microstopper, and the channel was cut off at the mouth of the fish. After initial difficulties with two test fish, the fish lived through the 4-day period with the blocking device in place. Each group of three included fish with blocked and unblocked esophagus.

In the accumulation-depuration experiment, sets of three fish were sacrificed at weekly intervals, with additional samples on the first, second, and third days of accumulation and on the third day of depuration. The bluegill experiment began with 55 fish on the East (E) side and 51 fish on the West (W) side. The average weight was 122 g (range, 78 - 160 g) on the E side and 121 g (86 - 164 g) on the W side. The catfish experiment began with 69 fish in each half of the tank. The average weight was 170 g (68 - 284 g) on the E side and 167 g (67 - 267 g) on the W side.

In the aquarium experiments for examining the effects of feed and temperature on P-32 bioaccumulation, 24 bluegill and 24 catfish were used. The respective average initial weights were 115 g (73 - 167 g) and 166 g (122 - 271 g). The uptake of P-32 by unfed fish was studied with 6 bluegill and 6 catfish. Their respective average initial weights were 166 g (44 - 256 g) and 155 g (122 - 218 g).

Fish Maintenance. Approximately 200 bluegill were obtained from the Errol Brown Fish Farm, Fayetteville, GA, and Patrick's Fish Farm, Tifton, GA, on August 3 and 25, 1982. Approximately the same number of channel catfish were obtained from the Whitehall Laboratory of the University of Georgia on June 22 and from Mac's Fish Farm, Opelika, AL, on July 28. The fish had been spawned in the spring of 1981.

After initial problems in fish maintenance due to disease diagnosed as Ich (Ichthophthirius multiphilis - protozoan), fish were treated at monthly intervals by adding malachite green-formalin solution to the flow-through tank to minimize parasites and fungus. After fish were handled, they were treated in reduced water volume with furanace as an antibiotic. Both treatments were performed by stopping water flow, increasing aeration, and maintaining the fish in the appropriate solution for 1 hour or less (malachite-formalin) and 2 hours (furanace). The furanace concentration was 3 mg/L. The concentrations of zinc-free malachite and formalin were 0.03 and 0.05 mg/L, respectively. The tank walls were scrubbed during the latter treatment to expose all surfaces. The treatments were spaced to minimize shock to the fish.

The fish were kept in one flow-through tank until placed in the second tank or the aquaria for the experiments. Fish were acclimated for 14 days in the flow-through tanks and 7 days in the aquaria before beginning P-32 addition to food or water.

For identification by 3-digit number, catfish were branded on their left flanks with a copper marker dipped in liquid nitrogen, and bluegill had a nylon dart tag inserted behind the high point of the back arch, penetrating the dorsal fin rays. Both techniques were used for all fish, but brands tended to fade in bluegill while most catfish dislodged their tags.

The fish were weighed before the experiment, at approximately monthly intervals during accumulation-depuration, and after death. The live fish were anesthetized with tricaine methanesulfonate 2-2-2, weighed on a pan balance to the nearest 0.1 g, measured for length to the nearest 0.1 cm, identified by brand or tag, and quickly returned to water.

Feeding. In the accumulation-depuration experiment, bluegills were fed worms that had assimilated P-32 from labelled worm feed and catfish were fed pellets mixed with P-32. The low-feed and high-feed groups of a species were maintained in the separated halves of the tank. Efforts were made to keep the feed at a constant P-32 level per gram throughout the experiment, and the food intake at a uniform rate per weight of fish. Hence, (1) the aliquot of P-32 added to each daily portion was increased from day to day to adjust for radioactive decay, and (2) the total amount of food was adjusted from day to day to compensate for estimated fish growth and removal of fish for sampling. The high-feed portion had the same phosphorus concentration and P-32 specific activity as the low-feed portion, but provided higher daily intakes of phosphorus and P-32.

The initial plan was to expose each group of fish to daily doses of P-32 tracer for 60 days and then to observe depuration for another 60 days while feeding the same amount of nonradioactive food. Because of program changes requested by the US NRC, the study period for bluegill was shortened to accumulation for 51 days and depuration for 28 days. A plan to determine the P-32 balance in feed, fish, and water was also modified to collecting and analyzing water on a few occasions during the accumulation-depuration and aquarium studies. An accidental interruption in the flow of water during the night caused a fish kill that terminated the catfish accumulation study after 11 days, and the experiment could not be restarted because of the above-cited program changes.

Radioactive P-32 tracer was obtained in 2- or 4-mCi amounts on three occasions from New England Nuclear. The radionuclide was in the form of K_2HPO_4 in water, at a specific activity greater than 50 mCi/mmol phosphorus. This corresponded to a specific activity greater than $1x10^9$ count/min per mg phosphorus. Two stock solutions were prepared: the tracer diluted to 100 ml in deionized water and a further 1/10 dilution. More dilute solutions of these P-32 stock solutions were prepared to measure the P-32 activity, which in every case was consistent with the amount reported by the supplier.

Aliquots of the two stock solutions were combined with daily feed portions to provide a constant level of P-32 per gram feed for the entire period of a particular experiment. Daily feeding levels were selected to be below 0.4 µCi ($3x10^5$ count/min) per fish for the high-feed group, and one-half as much for the low-feed group. For the indicated flow rates with as many as 140 fish per tank, these daily amounts of P-32 permitted precise measurements of P-32 in tissue while keeping well below the maximum permissible concentration of 2×10^{-5} µCi/ml for P-32 in water discharged to the sewer.

The pellet feed was Purina trout chow. The amount prepared as a daily portion was calculated on the basis of the total initial weight of fish in the half tank, estimated weight gain and removal of fish for sampling, plus an additional 2 g for analyzing the P-32 and phosphorus content. Each portion of feed for the accumulation-depuration experiment was 2 g/d (dry weight) per 100-g catfish (wet weight) on the high-feed (East) side of the tank and one-half as much on the West side. The trout chow was ground to a powder and moistened with water until plastic in consistency. The P-32 tracer was added and mixed with the feed. The feed was then extruded with a meat grinder, cut into small (approx. 1 - 2 cm) pellets, dried, weighed again, and sealed in plastic bags until fed to the fish.

The weight of worms to be fed to the fish each day was calculated as indicated above for pellets, each portion constituting 3 g/d (moist weight) per 100 g bluegill on the high-feed (West) side and one-half as much on the East side. To introduce P-32 into worms, Carnation worm feed was moistened, P-32 tracer was added, and the worm feed was dried. For each weighed portion of red wiggler worms (0.2 - 0.5 g per worm, moist weight) in peat moss, 3 g worm feed with P-32 was added per 100 g worms (moist weight). On the following day, the worms were taken from the peat moss and placed on a dry surface, where worms separate themselves from the remaining pieces of peat moss by curling into balls to prevent desiccation. These worms were fed to the fish.

The bluegill were fed once daily (6 PM) and the catfish, twice daily (7 AM and 7 PM). The pellets or worms were scattered on the surface of the water a few at a time, to assure that all of the food would be consumed immediately by the fish. When the fish stopped feeding, any unconsumed food was weighed and this amount was subtracted from the nominal daily food portion. Small amounts of uneaten pellets were often observed on the tank bottom, but apparently all the worms were consumed.

Analysis. Bluegill were dissected into seven sections: muscle, tail fin, gill filaments, skin plus scales, viscera, skeleton (including dorsal and anal fins), and head (including gill arches, pectoral and pelvic fins, and girdles). After the first six sets of analyses in the accumulation-depuration experiment, the tail fin was included with the skeleton to reduce the analytical load. Catfish were dissected into eight sections: muscle, gills, skin, skeleton, head, viscera, fins, and fin spines. Internal organs were in the viscera and head portions. For the unfed fish, bluegill tail fins and catfish fin spines were combined with the skeleton, and catfish fins were combined with the head.

The sections were immediately weighed, dried at 110° C, and reweighed. The sections were ashed, first in crucibles over an open flame and then at 550° C in a furnace for 2 - 4 days to obtain a white ash. The ash was weighed, dissolved in 6 N HCl, and diluted with distilled water to 100 ml for analysis. In a few instances, samples were divided into separate portions for replicate analyses or were diluted to larger volumes. Samples of pellets, worms and other solids were processed in the same way.

Aliquots of water from aquaria or the tap were usually taken in 4-L volumes, concentrated to 100 ml by evaporation, acidified with 10 ml conc. HNO_3 and 2 ml conc. H_2SO_4, and boiled until further concentrated to 10 ml. Acid addition and boiling were repeated as necessary to obtain a colorless solution. The solution was then diluted to 50 ml for analysis. If insoluble material was observed, the solution was filtered and saved for analysis. The filters were ashed and dissolved in HCl, and the solution was diluted to 50 ml for analysis.

The P-32 activity in all samples was measured in a liquid scintillation counter (Beckman LS 233) with an automatic sample changer. Each sample consisted of 20 ml solution that filled a conventional glass vial. The Cherenkov radiation emitted by energetic P-32 beta particles passing through water was detected. A channel setting of 0 - 2.6 (full scale: 10.0) was used to collect essentially all counts. The counting efficiency determined with a comparison P-32 source was 32 ± 4 percent under these conditions, but results were recorded in counts/minute because all data analysis was based on comparative measurements. The radiation background, measured for each set of analyses, ranged from 24 to 27 counts/min.

Duplicate aliquots were measured for each sample. Counting periods were 10 minutes for count rates above 200 count/min and 50 minutes for lesser count rates. The minimum detectable level under these conditions was approximately 2 counts/min. per 20 ml. In almost all instances, duplicate analyses agreed within twice the standard deviation of the count; if not, additional aliquots were counted. The count rate in the sample was calculated by adjusting for radioactive decay of P-32 since sample collection and for sample concentration.

The phosphorus concentration in all samples was measured with the vanadomolybdophosphoric acid colorimetric method (AP 80). Aliquots of the sample solutions ranging from 0.1 ml to 10 ml, depending on their phosphorus concentrations, were combined with the vanodomolybdate indicator in 50-ml volumetric flasks. If water samples larger than 1 ml were used, sufficient NaOH was added to neutralize the acid to pH 3. A Beckman DB-GT spectrophotometer was used to measure light transmission at 470 or 440 nm. Measured values were compared to a standard solution prepared from KH_2PO_4 salt (Fisher, Certified) which was dried at 40° C, weighed, dissolved and made to volume (0.2195 g/L) with 25 ml 7 N H_2SO_4. The phosphorus concentration in this solution is 50.0 mg/L.

Most phosphorus analyses were performed by direct measurement, but samples from each type of tissue were also analyzed by the standard addition technique. Samples for which results deviated considerably from the normal range for that tissue were also reanalyzed with standard addition. Replicate analyses showed a standard deviation of 2 percent by both techniques. The two techniques yielded results within 10 percent of each other and there was no consistent trend of one relative to the other.

The P-32 and phosphorus concentrations were calculated relative to wet weight of fish and feed sample or volume of water. The specific activity was obtained by dividing the P-32 concentration by the phosphorus concentration. Most observations were calculated in terms of a nondimensional relative value, the specific activity in fish tissue divided by the specific activity in the feed. These values were averaged for triplicate tissue analyses and for daily feed analyses. The reported plus/minus value is the standard deviation of the mean. For measurements in triplicate, standard deviations of the mean were estimated (NC78) to be 0.591 times the range, divided by the square root of 3.

Field Study. A field study at the Sequoyah Nuclear Plant near Chattanooga on the Tennessee R. (Chicamauga Lake) had been planned with TVA (the plant operator), US NRC, and US EPA staff. Aquatic samples were collected by plant personnel in a preliminary study and analyzed at the Eastern Environmental Radiation Facility, Montgomery, AL, of the Office of Radiation Programs, US EPA. The project then was discontinued by the plant operator because of the relatively low radiation dose for maximum exposed persons offsite attributed to P-32 releases (Ma83).

3. Results

All P-32 and phosphorus analytical data are compiled in the Appendices. Results for the accumulation-depuration experiment are in Appendix A. This appendix includes data for tissue (A.1), food (A.2), and water (A.3). Weight gain data for fish are in Appendix A.4 and comparisons of tissue weights with whole fish weight are in Appendix A.5. The corresponding information for experiments concerning the effects of water temperature and feed on P-32 accumulation are in Appendix B. Appendix C contains the data for unfed fish. Some additional information concerning the phosphorus levels in feed and water is in Appendix D.

Relatively large samples of catfish muscle and head that were divided into two or even three portions to fit into crucibles for ashing provide some replication of analytical results (see Appendix A.1-2). The average standard deviation of these 15 muscle and 4 head replicates was 0.09 mg/g (4 percent) for phosphorus in muscle and 4 mg/g (16 percent) for phosphorus in the head. The larger variability in the head reflects gross sectioning of this large body portion without effort to achieve homogeneity. Standard deviations of the P-32 count rate per gram were more variable. On the average, the standard deviation was 10 percent, five times the value due to counting error alone. The latter was computed from the count rate, length of counting period, radioactive decay factor, and amount of sample in the counted aliquot. Hence, sample preparation and sample nonuniformity appeared to be greater sources of variability than counting error.

Values of wet, dried, and ash weights relative to each other were used to check data reliability for the more than 800 tissue samples that were analyzed. In a few instances, clearly erroneous values were found. The results marked by footnotes in Appendices A.1, B.1, and C.1 did not change after reanalysis, suggesting problems due to sample preparation or identification. Values of P-32 specific activity and phosphorus concentration affected by these errors were not included in the calculations.

A change in dissecting instrument from fine scalpel to filet knife after the catfish skeleton samples listed in Apendix A.1-2 had been prepared resulted in lower phosphorus concentrations (compare Appendices B.1-2 and C.1). The change was made to reduce the time needed for dissecting these many samples, but appears to have left considerable soft tissue on skeletal samples. The summarized phosphorus concentration values are for initial higher values.

The concentrations of phosphorus and specific activity of P-32 were determined in each daily portion of worms for both the accumulation-depuration and the feed/temperature-effects experiments. The average phosphorus concentration was 1.2 mg/g wet weight, based on averages of 1.23 $\pm$ 0.03 (standard deviation of the mean) mg/g in

Appendix A.2-1 and 1.15 ± 0.03 mg/g in Appendix B.2-1. The specific activity in the worms was 6,020 ± 370 c/min.mg for the accumulation-depuration experiment, and 16,500 ± 1,300 c/min.mg for the feed and temperature study. The large standard deviation reflects variability in P-32 uptake by the worms. Values for the worms used in the accumulation-depuration experiment in the period Sept. 27 - Oct. 5 were not included in these averages because these samples were apparently contaminated with the peat moss in which the worms were kept.

The concentration of phosphorus in the pellets was 13.7 mg/g dry weight based on an average of 13.6 ± 0.4 mg/g for the period August 15 - 27 in Appendix A.2-2 and 13.7 ± 0.2 mg/g in Appendix B.2-2. The phosphorus concentration reported by the supplier (Appendix D.1) is 11 mg/g dried weight. The specific activity for the accumulation-depuration experiment was 7,000 ± 340 c/min.mg, and for the feed/temperature study, 21,900 ± 400 c/min.mg.

The average phosphorus concentration measured by Atlanta Water Bureau staff (Appendix D.2) in tap water was 0.4 mg/L; values ranged from 0.07 to 1.6 mg/L throughout the period. The phosphorus concentration in Chattahoochee River water at the water plant intake is relatively low (approx. 0.04 mg/L), but zinc metaphosphate is added at the water plant to a phosphorus level of 1 mg/L to reduce pipe corrosion. Concentrations of phosphorus in tap water measured for this study were 0.39 and 0.76 mg/L (Appendix A.3-1) and 0.26 mg/L (Appendix B.3-2). Concentrations of phosphorus in aquarium water in the course of studies ranged from 0.24 to 0.99 mg/L (Appendices A.3-1, B.3-1, and B.3-2). Some of this phosphorus was from unconsumed food or excretion by fish, as indicated by P-32 in water.

The initial phosphorus concentrations measured in water for determining uptake by unfed fish were 5.44 and 5.40 mg/L. These values are consistent with the average phosphorus content in tap water of 0.4 mg/L and the 5.0 mg/L added in the form of NaH_2PO_4 and Na_2HPO_4. The specific activities in the two sets of aquaria were 63,800 and 67,000 c/min.mg.

4. Calculations

The elemental bioaccumulation factor, BF, for phosphorus in edible fish tissue is defined as

$$BF = \frac{c_t}{c_w} \qquad (1)$$

where c is the concentration of phosphorus in mg/g and the subscripts t and w refer to moist edible tissue and water, respectively. For consistency, muscle has been used to represent edible fish tissue, and total dissolved phosphorus data were used to obtain c_w (Ka80). It should be noted that tissue phosphorus is in various inorganic, lipid, protein, sugar and nucleotide forms that are not necessarily uniform throughout fish muscle; and that some reported phosphorus concentrations in water include suspended material, while others exclude dissolved phosphorus not readily converted to orthophosphates.

The radioisotope bioaccumulation factor, BF_r, for P-32 in edible fish tissue can be defined analogously as

$$BF_r = \frac{c_t^*}{c_w^*} \qquad (2)$$

where the asterisks refer to radioactivity levels in consistent units, such as disintegrations/min per g. If the specific activity (P-32 relative to phosphorus), a, is expressed in disintegrations/min.mg,

$$\frac{BF_r}{BF} = \frac{a_t}{a_w} \qquad (3)$$

In this report, specific activity values are in count/min.mg because the P-32 activity for all samples was measured identically -- i.e., the ratio of count/min to disintegration/min is identical.

The above relation holds true only if P-32 and the stable isotope, P-31, are in the same physico-chemical forms so that they behave identically. Because phosphorus exists in different forms, both inorganic and organic, and many of these do not readily interchange, it is possible that P-32 discharged into water may not be in the same forms as the nonradioactive phosphorus.

The values of BF reported and utilized for predicting radionuclide transfer are defined as equilibrium or steady-state constants. The corresponding value of BF_r would apply to a fish that has been exposed to a constant P-32 specific activity in water for a sufficiently long time that the specific activity in muscle has reached a constant value.

Intake data for fish suggest that under normal conditions the main source of phosphorus (> 99 percent) is food, not water (Ka80). Hence, the BF describes the indirect transfer of P-32 from water through biota at lower trophic levels to the fish under consideration. Transfer may be through a single organism, a food chain, or an entire food web. If bioaccumulation of phosphorus throughout the food web is very rapid relative to the P-32 radioactive decay constant of 0.0485 per day, then the ratio BF_r/BF is almost unity to the point of food intake by the fish. Rapid bioaccumulation has been found for plankton (Wh61), algae (Wh61) and bacteria (Ri56). Under this circumstance, the ratio BF_r/BF can be measured by comparing a_t with a_f, the specific activity in the food, so that

$$\frac{BF_r}{BF} = \frac{a_t}{a_f} \quad (4)$$

Any slow phosphorus uptake in the food web would result in BF_r/BF less than a_t/a_f.

Concentrations of phosphorus are generally of the same magnitude in the food consumed by the fish and in their muscle. Hence, the large BF is at the lower trophic levels of the food web, for example in algae.

The general case of bioaccumulation in a tissue represented as compartment can be described by

$$\frac{da_t}{dt} = - a_t \sum_{s=1}^{n} \frac{R_{st}}{Q_t} + \sum_{s=1}^{n} \frac{R_{st}}{Q_t} a_s + a_f \frac{R_{ft}}{Q_t} - a_t \frac{R_{ft}}{Q_t} - a_t \lambda_r \quad (5)$$

as defined in Appendix E. If R_{ft}/Q_t is written as the biological uptake or turnover constant for compartment t, λ_b, and R_{st}/Q_t is written as the turnover constant for transfer from any other compartment to compartment t, λ_s, then

$$\frac{da_t}{dt} = - a_t \sum_{s=1}^{n} \lambda_s + \sum_{s=1}^{n} \lambda_s a_s + a_f \lambda_b - a_t \lambda_b - a_t \lambda_r \quad (6)$$

If $\Sigma\lambda_s$ is combined as λ_u, the transfer constant into compartment t from all other compartments, the change of specific activity in compartment with time can be written as:

$$\frac{da_t}{dt} = - a_t (\lambda_b + \lambda_u + \lambda_r) + a_f \lambda_b + \sum_{s=1}^{n} \lambda_s a_s \quad (6a)$$

If $a_s = a_t$ or $\lambda_u = 0$, then the one-compartment equation can be solved:

$$\frac{a_t}{a_f} = \frac{\lambda_b}{\lambda_b + \lambda_r} (1 - e^{-(\lambda_b + \lambda_r)t_1})e^{-(\lambda_b + \lambda_r)t_2} \quad (7)$$

where t_1 is the time during P-32 accumulation and t_2 is the time during depuration from the end of accumulation. The value of t_2 is zero during accumulation; during depuration, t_1 is the preceeding period of accumulation and a_f is the specific activity of the feed during accumulation.

If $a_s = 0$, a solution is:

$$\frac{a_t}{a_f} = \frac{\lambda_b}{\lambda_b + \lambda_u + \lambda_r} (1 - e^{-(\lambda_b + \lambda_u + \lambda_r)t_1})e^{-(\lambda_b + \lambda_u + \lambda_r)t_2} \quad (8)$$

If a_s is not almost a_t or zero, then the equations can be solved numerically with measured values of a_s.

Further simplification in obtaining λ_b is possible by examining the specific activity ratio during selected periods of the study. In the very early period of accumulation,

$$\lambda_b t_1 = \frac{a_t}{a_f} \quad (7a)$$

During steady state accumulation,

$$\frac{\lambda_b}{\lambda_b + \lambda_r} = \frac{a_t}{a_f} \quad (7b)$$

During depuration,

$$\lambda_b + \lambda_r = \frac{1}{t_2} \ln \left(\frac{a_{t_1}}{a_{t_2}}\right) \quad (7c)$$

In these P-32 experiments, however, too few measurements applied to the region of equation (7a); the value obtained for λ_b with equation (7c) is not reliable when λ_b is much smaller than λ_r; and equation (7b) pertains only to the one-compartment system.

All a_t/a_f values from the bluegill experiment were used in a Marquardt nonlinear estimate to obtain λ_b in equation (7). Where it was apparent that equation (8) was better applicable, the sum $(\lambda_b + \lambda_u + \lambda_r)$ and the best value for a_t/a_f at $t_2 = 0$ were obtained by linear regression analysis of depuration data, and λ_b was obtained at $t_2 = 0$ from

$$\lambda_b = \frac{(\lambda_b + \lambda_u + \lambda_r)(\frac{a_t}{a_f})}{1 - e^{-(\lambda_b + \lambda_u + \lambda_r)t_1}} \qquad (8a)$$

The value of λ_b for catfish was obtained as an average for 4 or 5 values of a_t/a_f measured during early accumulation by

$$\lambda_b = \frac{\lambda_r}{\frac{a_f}{a_t}(1 - e^{-(\lambda_b + \lambda_r)t_1}) - 1} \qquad (7d)$$

For the unfed fish, λ_b was calculated with equation (7d) from the ratio a_t/a_f measured after four days of exposure. The value of $\lambda_b + \lambda_r$ in the exponent was obtained by trial and error, which is simple when λ_b is much smaller than λ_r.

The average concentration of phosphorus in the whole fish was calculated by averaging the phosphorus concentration, c_t, in the dissected portions and averaging the ratios of portion weight per summed weights, r_t, then multiplying these two averages, $\bar{c}_t \bar{r}_t$, for each portion and adding the results for the entire fish. The average turnover rate of phosphorus in each of the tissues from food, $\bar{R}_{ft}$, is

$$\bar{R}_{ft} = \lambda_b \bar{c}_t \bar{r}_t \qquad (9)$$

Values of $\bar{R}_{ft}$, in units of mg/day per 100-g fish, were summed for the whole fish to obtain the phosphorus turnover rate for the entire fish. This value was divided by the average phosphorus concentration to compute the average biological turnover constant for the whole fish. The phosphorus turnover rate was also compared to the phosphorus feeding rate to determine the fraction of ingested phosphorus that was utilized, and to the phosphorus concentration in water for unfed fish for determining the daily amount of water utilized by the fish.

Endogenous excretion of P-32 was calculated for comparison with the results of 1-day collections in Appendices A.3-1 and A.3-2 on the basis of viscera turnover rates and P-32 concentrations. The average P-32 content in the viscera of the three bluegill maintained in aquaria during the day before analysis (see Appendix A.1-1) on five occasions during depuration was multiplied by the viscera turnover constant (minus a small fraction for fish growth). Excretion of unabsorbed or rapidly turning over P-32 was also calculated for the one set of fish segregated in aquaria during accumulation on the basis of the P-32 feeding rate per fish on 11/08 and the estimated fraction of rapidly excreted phosphorus from this food.

5. Discussion

5.1 Feeding rate and growth

The uptake of P-32 by freshwater fish was studied primarily by incorporating P-32 tracer in food rather than water because an estimated phosphorus balance for fish indicated that the main intake pathway was through food (Ka80). Reported dissolved phosphorus concentrations in the larger U.S. streams averaged 0.03 mg/L and 99 percent of the concentrations were less than 0.4 mg/L. At the reported food-phosphorus intake of several mg/day per 100-g fish and water intake of several ml/day per 100-g fish, only a minute fraction could be contributed by water.

Relatively few observations of food intake rates over extended periods were available to guide fish feeding for this experiment, although selection of appropriate feeding rates is crucial for assuring that observed phosphorus turnover rates are pertinent for fish in the environment. Food consumption varied considerably in the few reported studies, as would be expected for different species, fish size, foods, and water temperatures. In five intake studies for freshwater fish, average food intake ranged from 2 to 6 g/day per 100-g fish and increased with water temperature in the range 5 to 30° C (Ka80). The corresponding average phosphorus intakes were from 1 to 30 mg/day per 100-g fish. In four balance studies where fish fed ad lib., (St74, Ma71, Ki75, Ko79) three of which utilized very small bluegill sunfish, the typical phosphorus intake rate was 4 mg/day per 100-g fish (0.3 percent per day phosphorus intake) in the 17 - 25° C temperature range and much lower intakes at 1 - 12° C. Growth rates for these fish averaged 0.3 percent per day.

Brown (Br57) calculated the maintenance food requirement of 1.5 g/day per 100-g fish for small (50 g) brook trout, and the food requirement of 4.5 g for 1 percent growth. If the food is meat with a phosphorus content of 1.5 mg/g wet weight, then the phosphorus requirements are 2.2 mg/d per 100-g fish for maintenance and an additional 0.7 mg/day for each 0.1 percent/d growth.

In view of the above information, the rate at which bluegill were fed worms with a phosphorus content of 1.2 mg/g wet weight was planned at levels of 1.5 and 3.0 g/d per 100-g fish. In practice, the average feed consumption ranged from 0 to 2.0 and from 0 to 4.3 g/d per 100-g fish at the two respective levels during P-32 accumulation (see App. A.2-1). The average daily food intakes were 1.5 and 2.6 g/d per 100-g fish, corresponding to phosphorus intake rates of 1.8 and 3.1 mg/d per 100-g fish.

The feeding rates for catfish were planned at pellet dry weights of 1.0 and 2.0 g/d per 100-g fish. These pellets had the high phosphorus content of 13.7 mg/g. Actual consumption rates averaged 0.8 (range 0.2 - 1.5) and 1.1 (0.4 - 2.0) g/d per 100-g fish (see App. A.2-2), corresponding to phosphorus intake rates of 11 and 15 mg/d per 100-g fish.

Average growth constants were used as indicators of the applicability of these feeding regimes to normal environmental conditions, although various other factors can also affect phosphorus turnover in tissue. The average measured growth constants for bluegill were 0.05 and 0.19 percent/d at the lower and higher feeding rates, based on the data in Appendix A.4. For the catfish, growth constants were 0.2 and 0.4 percent/d at the much higher phosphorus intakes than for bluegill. The data for catfish are much more uncertain because of the relatively brief period of observation. Measurements of bluegill, black crappie, and bass in an East Tennessee lake (Kr56) showed growth rates of 0.10, 0.06, and 0.35 percent/d (Ka80), respectively, in the 60 - 600 g weight range.

Unfed fish in water at the uncommonly high phosphorus concentration of 5.4 mg/L had an average weight loss of 0.7 percent/d in a 4-day period (Appendix C.3). Fish maintained in the same aquaria but fed worms or pellets also tended to lose weight during their 9-day study period (Appendix B.4).

5.2 Phosphorus concentrations in fish

The mean phosphorus concentrations in bluegill were 2.4 and 15.4 mg/g in muscle and whole fish, respectively, as shown in Table 1a; in catfish, they were 2.2 and 8.8 mg/g (Table 1b). Geometric means were obtained because phosphorus concentrations in fish had been described better by a logarithmic distribution than a linear one (Ka80). As indicated in the footnotes to Tables 1a and 1b, the phosphorus concentration values in whole fish are subject to a nonrandom error due to losses during dissection that averaged 6 percent of the fish weight for bluegill and 7 percent for catfish.

Compared to whole-body concentrations between 2.2 and 11.4 mg/g reported earlier (Ka80) for various species, the average for catfish measured here is among the higher values and the bluegill average is the highest observed. Most of the phosphorus in these two species is in bone material and in bluegill scales. Muscle contains only a small fraction of the body phosphorus -- 4 percent in bluegill and 11 percent in catfish. The amount of phosphorus measured in the viscera may include some residual food.

5.3 Accumulation and depuration of P-32

The ratios of the specific activity in bluegill muscle to the food worms, a_t/a_f, near the end of the accumulation period were 0.049 and 0.072 for fish fed 1.5 and 2.6 g/d per 100-g fish, respectively, as shown in Tables 2a and 2b. According to equation (4), this value is also the ratio of the bioaccumulation factor for P-32 relative to phosphorus when P-32 moves rapidly through the food web. The ratios

Table 1a

Geometric Mean Tissue Weight Fraction and Phosphorus Concentration in Bluegill Tissue

Tissue	Tissue weight fraction		P concentration in tissue, mg/g		P concentration rel. to whole fish, mg/g
muscle	0.260	(1.20)	2.41	(1.11)	0.63
skeleton & tail	0.219	(1.09)	18.0	(1.20)	3.94
(skeleton	0.211	(1.13)	17.2	(1.20)	3.63)
(tail	0.0095	(1.18)	33.2	(1.14)	0.32)
head	0.331	(1.10)	19.2	(1.18)	6.36
scales	0.108	(1.20)	39.9	(1.23)	4.31
gills	0.0056	(1.27)	2.27	(1.30)	0.013
viscera	0.065	(1.24)	2.19	(1.21)	0.14
total	0.989				15.39

Notes:
1. Data are from the 92 fish in the experiment using the flow-through system.
2. Values in parentheses are geometric standard deviations.
3. The weight fraction refers to the sum of the dissected tissues; the summed weight averaged 94.5 percent (range 86.1 - 99.5 percent) of the weight before dissection (see Appendix A.5-1).
4. Skeleton and tails were separated initially but combined in later samples.

Table 1b

Geometric Mean Tissue Weight Fraction and Phosphorus Concentration in Catfish Tissue

Tissue	Tissue weight fraction		P concentration in tissue, mg/g		P concentration rel. to whole fish, mg/g
muscle	0.452	(1.07)	2.24	(1.12)	1.01
skeleton	0.088	(1.16)	14.2	(1.16)	1.25
fin	0.027	(1.12)	13.9	(1.15)	0.38
fin spine	0.0032	(1.20)	91.0	(1.19)	0.29
head	0.257	(1.08)	22.0	(1.14)	5.65
skin	0.056	(1.17)	1.39	(1.19)	0.078
gills	0.0081	(1.29)	2.15	(1.36)	0.017
viscera	0.100	(1.29)	1.68	(1.26)	0.17
total	0.991				8.85

Notes:
1. Data are from 30 fish collected 08/16 - 08/26 (see Appendix A.1-2)
2. Values in parentheses are geometric standard deviations.
3. The weight fraction refers to the sum of the dissected tissues; the summed weight averaged 93.1 percent (range, 90.4 - 95.2 percent) of the total weight before dissection (see Appendix A.5-2).

Table 2a
Average Specific Activity in Tissue Relative to Feed for Bluegill during Accumulation and Depuration (Low Feed)

Date, 1982	Interval, days(1)	Muscle	Skeleton	Tail	Head	Scales/ Skin	Gills	Viscera
09/28	1	0.65 ± 0.24 (2, 3)	0.27 ± 0.15	0.5 ± 0.3	0.18 ± 0.12	0.18 ± 0.10	2.5 ± 1.8	7.8 ± 0.8
09/29	2	5.8 ± 1.9	1.5 ± 0.4	1.9 ± 0.4	1.3 ± 0.2	1.1 ± 0.3	29 ± 13	110 ± 40
09/30	3	7.3 ± 3.8	1.5 ± 0.6	2.4 ± 1.0	1.6 ± 0.8	1.1 ± 0.4	38 ± 19	140 ± 80
10/06	9	29 ± 4	3.7 ± 0.5	6.0 ± 1.8	3.5 ± 0.6	3.3 ± 1.3	100 ± 17	270 ± 60
10/12	15	51 ± 13	6.6 ± 2.5	7.0 ± 2.2	4.8 ± 1.4	3.5 ± 1.1	120 ± 35	170 ± 20
10/19	22	50 ± 4	8.0 ± 3.2	9.0 ± 1.8	6.6 ± 2.2	5.1 ± 1.9	120 ± 19	120 ± 30
10/26	29	42 ± 17	6.6 ± 2.7	----	5.5 ± 1.9	5.5 ± 2.0	86 ± 28	170 ± 60
11/03	37	49 ± 8	10.3 ± 2.3	----	8.6 ± 0.8	6.1 ± 0.7	120 ± 14	200 ± 20
11/09	43	42 ± 6	7.6 ± 2.8	----	5.0 ± 1.4	5.1 ± 1.6	120 ± 12	170 ± 30
11/17	51(0)	49 ± 10	9.3 ± 3.0	----	9.8 ± 4.3	6.6 ± 2.3	140 ± 31	190 ± 60
11/20	(3)	65 ± 26	8.1 ± 1.9	----	7.1 ± 0.8	5.8 ± 1.0	101 ± 25	116 ± 11
11/24	(7)	50 ± 6	6.0 ± 0.9	----	5.3 ± 0.6	4.3 ± 0.5	80 ± 6	82 ± 4
11/30	(13)	30 ± 4	3.7 ± 0.7	----	3.0 ± 1.0	2.4 ± 0.5	48 ± 9	39 ± 4
12/07	(20)	16 ± 4	3.2 ± 1.5	----	2.8 ± 1.2	1.7 ± 0.7	28 ± 5	22 ± 4
12/15	(28)	15 ± 1	1.7 ± 0.3	----	1.3 ± 0.3	1.2 ± 0.1	20 ± 3	10.6 ± 1.2

Notes: (1) Days in parentheses refer to depuration period. (2) Divide all values of c/min.g tissue ÷ c/min.g feed by 1,000. (3) value is estimated standard deviation of mean for 3 fish tissue values [0.59 x range/$(3)^{0.5}$] combined with standard deviation of mean for 41 bluegill feed values (370 c/min.g) or for 5 catfish feed values (300 c/min.g). (4) Specific activity ratios in parentheses were not utilized because of large weight losses (>0.006 per day) by fish.

Table 2b
Average Specific Activity in Tissue Relative to Feed for Bluegill during Accumulation and Depuration (High Feed)

Date, 1982	Interval, days(1)	Muscle	Skeleton	Tail	Head	Scales/ Skin	Gills	Viscera
09/28	1	5.6 ± 1.1	1.2 ± 0.3	1.5 ± 0.4	1.2 ± 0.2	0.6 ± 0.2	34 ± 14	210 ± 70
09/29	2	13.3 ± 1.0	3.1 ± 0.2	2.6 ± 0.3	2.6 ± 0.2	1.9 ± 0.3	60 ± 5	190 ± 20
09/30	3	11.0 ± 0.8	2.1 ± 0.3	2.3 ± 0.3	2.4 ± 0.3	1.5 ± 0.1	56 ± 10	350 ± 30
10/06	9	32 ± 4	8.5 ± 0.8	10.6 ± 0.9	9.8 ± 1.6	7.6 ± 1.5	120 ± 15	340 ± 40
10/12	15	47 ± 17	8.6 ± 3.0	10.3 ± 2.5	8.3 ± 3.4	6.5 ± 2.0	103 ± 16	260 ± 20
10/19	22	69 ± 12	14 ± 2	11.8 ± 3.2	11.1 ± 1.6	7.8 ± 1.5	190 ± 25	200 ± 10
10/26	29	76 ± 16	10.0 ± 0.8	----	6.8 ± 0.5	5.3 ± 0.7	140 ± 25	210 ± 20
11/03	37	50 ± 13	8.3 ± 3.0	----	6.1 ± 1.9	5.0 ± 1.6	120 ± 28	200 ± 20
11/09	43	70 ± 17	8.0 ± 2.4	----	6.0 ± 1.5	5.6 ± 1.4	130 ± 13	180 ± 40
11/17	51(0)	72 ± 13	13 ± 3	----	10.6 ± 1.3	7.0 ± 1.5	170 ± 22	210 ± 20
11/20	(3)	54 ± 9	11 ± 2	----	6.8 ± 0.7	6.5 ± 0.7	130 ± 11	120 ± 20
11/24	(7)	56 ± 11	7.1 ± 1.5	----	5.8 ± 1.0	5.0 ± 0.7	100 ± 10	94 ± 7
11/30	(13)	48 ± 8	11 ± 3	----	8.6 ± 3.2	5.8 ± 1.7	60 ± 6	53 ± 4
12/07	(20)	25 ± 2	5.6 ± 1.7	----	4.3 ± 1.2	3.3 ± 1.1	33 ± 6	29 ± 2
12/15	(28)	18 ± 4	3.7 ± 0.4	----	3.0 ± 0.5	2.4 ± 0.3	17 ± 2	14 ± 1

Table 2c

Average Specific Activity in Tissue Relative to Feed for Catfish during Accumulution (High Feed)

Date, 1982	Interval, days	Muscle	Skeleton	Fins	Fin Spines	Head	Skin	Gills	Viscera
08/16	1	16 ± 10	3.7 ± 1.7	5.4 ± 2.7	2.5 ± 0.8	3.0 ± 1.3	28 ± 14	23 ± 5	150 ± 80
08/17	2	9 ± 5	1.9 ± 0.8	3.8 ± 1.2	1.0 ± 0.3	1.7 ± 0.7	14 ± 5	19 ± 8	48 ± 14
08/18	3	21 ± 7	6.1 ± 1.2	8.6 ± 0.8	3.1 ± 0.6	5.2 ± 1.3	36 ± 9	52 ± 5	190 ± 70
08/24	9	83 ± 38	25 ± 10	19. ± 10.	17. ± 11.	19. ± 8	108 ± 38	170 ± 81	340 ± 130
08/26	11	77 ± 18	24 ± 6	27 ± 7	9.9 ± 2.3	17 ± 4	130 ± 10	160 ± 27	320 ± 20

Table 2d

Average Specific Activity in Tissue Relative to Feed for Catfish during Accumulation (Low Feed)

Date, 1982	Interval, days	Muscle	Skeleton	Fins	Fin Spines	Head	Skin	Gills	Viscera
08/16	1	(0.25± 0.06) (4)	(0.05± 0.03)	(<0.09)	(<0.2)	(0.06± 0.03)	(<3)	(1.4± 0.8)	(<0.3)
08/17	2	3.7 ± 2.3	1.3 ± 1.1	1.6± 0.5	0.4 ±0.2	0.6 ± 0.3	7.5 ± 4.	10 ± 6	20 ± 16
08/18	3	10.3 ± 3.1	2.8 ± 0.8	4.1± 0.9	1.4 ±0.4	2.7 ± 0.8	15. ± 4	27 ± 5	56 ± 18
08/24	9	57 ±33	12.0 ± 6.0	16 ± 8	8.5 ±6.2	8.0 ± 4.0	97 ± 49	120 ±57	320 ± 100
08/26	11	77 ±36	15.0 ± 7.0	17 ± 8	5.9 ±2.1	13. ± 6	130 ± 63	120 ±44	250 ± 100

for the entire experiment are reasonably consistent with equation (7) for a single-compartment system (see Fig. 1a). These curves indicate steady state ratios of 0.064 and 0.081 respectively for the low-feed and high-feed groups. The biological turnover constants for phosphorus uptake by muscle of 0.0033 d^{-1} and 0.0043 d^{-1}, respectively, given in Table 3a, correspond to these curves.

The average specific activity ratios in other bluegill tissues at the various sampling dates are also given in Tables 2a and 2b and in Figs. 1b - 1g. The average biological turnover constants and steady-state bioaccumulation factors for P-32 relative to phosphorus for these tissues are summarized in Table 3a on the basis of the same one-compartment model as for muscle. The following patterns appear:

- The fish fed larger portions had higher turnover constants and bioaccumlation factor ratios in all tissus. The ratio of high-feed to low-feed λ_b averaged 1.30; values for all 6 tissues measured during the entire study period were within 1 standard error value of this average.

- These values were similar in the skeleton, head, tail, and scales, all of them being approximately an order of magnitude below the values for muscle; gills had higher values than muscle, and viscera values were highest.

- Some very high specific activity ratios during the first two weeks of accumulation, particularly in the viscera, do not fit the curve for the single-compartment model.

- The single compartment model provides a reasonable fit for the tissues that turn over more slowly, but depuration measurements show this model to be inappropriate for gills and viscera.

The summed turnover constants and specific activity ratios at the beginning of depuration, determined by regression analysis of the depuration data (see Table 4), were utilized in equation (8a) to calculate the biological turnover constants shown in the last two lines of Table 4. In most cases, the turnover constant for a tissue is similar to the one in Table 3a and even the largest differences are within 50 percent. Utilization of the third turnover constant, to account for dilution of phosphorus in the tissue by phosphorus from other tissues that have almost no P-32, results in the better fit for gills and viscera given by the dotted lines in Figs. 1f and 1g. The complexity introduced by the additional constant was not considered useful for data analysis of the tissues that turn over more slowly.

The three total turnover constants with values from 0.008 to 0.012 d^{-1} below the minimum of 0.0485 d^{-1} for only radioactive decay in Table 4 may indicate the extent of uncertainty for values derived only from depuration. If values of λ_b plus λ_u (the third turnover constant) are

Table 3a

Computed Phosphorus Turnover Constants and Bioaccumulation Factor Ratios for Worm-fed Bluegill

Section	Turnover constant, day^{-1}		BF_r/BF, steady state	
	Low feed	High feed	Low feed	High feed
Muscle	0.0033 ± 0.0002	0.0043 ± 0.0002	0.064	0.081
Skeleton	0.00050 ± 0.00002	0.00068 ± 0.00006	0.0102	0.014
Tail	(0.00075 ± 0.00007)	(0.0012 ± 0.0001)	(0.015)	(0.024)
Head	0.00042 ± 0.00002	0.00053 ± 0.00006	0.0086	0.0108
Scales/skin	0.00034 ± 0.00002	0.00041 ± 0.00004	0.0070	0.0084
Gills	0.0081 ± 0.0006	0.0102 ± 0.0009	0.14	0.17
Viscera	0.013 ± 0.002	0.018 ± 0.005	0.21	0.27

Notes: 1. Turnover constants and standard errors were obtained through Marquardt nonlinear estimation, except that values for Tail were estimated from only 6 accumulation measurements.

2. BF_r/BF at steady state is a_t/a_f and $\lambda_b/(\lambda_b + \lambda_r)$

Table 3b

Estimated Phosphorus Turnover Constants and Bioaccumulation Factor Ratios for Pellet-fed Catfish

Section	Turnover constant, day^{-1}		BF_r/BF, steady state	
	Low feed	High feed	Low feed	High feed
Muscle	0.0058 ± 0.0018	0.0100 ± 0.0023	0.107	0.17
Skeleton	0.0013 ± 0.0003	0.0027 ± 0.0005	0.026	0.053
Fins	0.0016 ± 0.0003	0.0033 ± 0.0006	0.032	0.064
Fin spines	0.0006 ± 0.0002	0.0016 ± 0.0004	0.013	0.032
Head	0.0010 ± 0.0002	0.0021 ± 0.0004	0.020	0.042
Skin	0.010 ± 0.003	0.016 ± 0.004	0.17	0.25
Gills	0.012 ± 0.003	0.020 ± 0.003	0.20	0.29
Viscera	0.030 ± 0.009	0.075 ± 0.024	0.38	0.61

Notes: 1. Turnover constants were obtained by averaging values measured during initial 11 days of accumulation.

2. BF_r/BF at steady state is a_t/a_f and $\lambda_b/(\lambda_b + \lambda_r)$

Table 4

Phosphorus Biological Turnover Constants Based on Depuration for Worm-fed Bluegill

	Feeding Level	Muscle	Skeleton	Head	Scales	Gills	Viscera
Mean total turnover constant, day^{-1}(1)	Low	0.055	0.059	0.067	0.064	0.071	0.101
	High	0.049	0.040	0.037	0.037	0.082	0.092
Correlation coefficient	Low	0.94	0.990	0.98	0.990	0.993	0.996
	High	0.97	0.89	0.86	0.95	0.999	0.996
Specific activity ratio, beginning of depuration (1)	Low	0.062	0.0092	0.0089	0.0065	0.129	0.167
	High	0.072	0.0141	0.0093	0.0073	0.171	0.182
Non-radioactive turnover constant, day^{-1}(2)	Low	0.006	0.011	0.018	0.016	0.022	0.052
	High	0.001	-0.008	-0.012	-0.012	0.034	0.044
Compartment biological turnover constant, day^{-1}(3)	Low	0.0036	0.00057	0.00062	0.00043	0.0094	0.017
	High	0.0038	0.00065	0.00041	0.00032	0.014	0.017

(1) Values were calculated by linear regression analysis of average specific activity ratios for 6 sets of samples collected during depuration.
(2) Non-radioactive turnover constant is mean total turnover constant minus 0.0485 day^{-1}.
(3) Values were calculated with equation (8a).
(4) Feeding level: "Low" is 1.5 g/d per 100-g fish, "High" is 2.6 g/d per 100-g fish.

uncertain at least to that extent, the biological turnover constants in Table 4 are less reliable than in Table 3a, except for gills and viscera. The negative values could also be due to some continued uptake of P-32 from other tissues after the end of accumulation, a possibility ignored by the assumptions for equation (8).

The initially higher specific activity ratios and the subsequent decreases during accumulation, particularly in the viscera, are not consistent with uniform conditions. The most reasonable explanation, in view of some P-32 totals in the high-feed bluegill during the first three days (see Appendix A.2-1) that exceed the intake due to worms alone, suggests contamination of the feed during the first few days by P-32 in peat. Factors that could contribute to this trend are the gradually decreasing water temperature, the gradually increasing fish weight, and fluctuations in daily P-32 intakes.

The average specific activity ratios for catfish muscle relative to pellet feed in Tables 2c and 2d were fitted with the curves shown in Fig. 2a to yield turnover constants of 0.0058 d^{-1} and 0.010 d^{-1} for fish fed 0.8 and 1.1 g/d per 100-g fish, respectively (see Table 3b). The corresponding ratios of the bioaccumulation factors for P-32 relative to phosphorus are 0.11 and 0.17. These values are considerably less certain than for bluegill because they were obtained from only four or five values early in the accumulation period.

Average specific activity ratios for other dissected portions of catfish are given in Tables 2c and 2d and in Figs. 2b to 2h. Curves of equation (7) are shown in these figures, and the turnover constants resulting in the best fits of curve to data are listed in Table 3b, together with associated ratios of the bioaccumulation factors for P-32 relative to phosphorus. The catfish turnover constants and bioaccumulation factor ratios show the same patterns as for bluegill:

- fish fed larger food portions had higher turnover constants and bioaccumulation factor ratios in all tissues;

- lowest values were in skeleton, head, fins, and fin spines; turnover constants for muscle were three to ten times as high, values for skin and gills were even higher, and values for the viscera were highest.

The phosphorus turnover rates in Table 5, calculated from the turnover constants in Tables 3a and 3b and the tissue phosphorus concentrations in Tables 1a and 1b, indicate uptake rates from 1 to 4 mg/d per 100-g fish for the two species at the two feeding levels. At the lower phosphorus feeding rate for bluegill, the daily phosphorus uptake was approximately one-half of the amount fed. Uptake was a higher fraction of the intake at the lower feed rate, as would be expected. In catfish, the uptake was a much lower fraction of the feed intake

Table 5

Phosphorus Turnover Rates for Tissues and Turnover Constants for Whole Bluegill and Catfish

Tissue	P turnover rate, g/d.100-g fish			
	Bluegill		Catfish	
	Low feed	High feed	Low feed	High feed
muscle	0.21	0.27	0.58	1.01
skeleton	0.18	0.24	0.16	0.034
tail	0.024	0.034	----	----
fin	---	---	----	----
fin spine	---	---	0.017	0.046
head	0.27	0.34	0.56	1.19
scales	0.15	0.18	----	----
skin	---	---	0.078	0.12
gills	0.010	0.013	0.021	0.035
viscera	0.18	0.25	0.51	1.28
total turnover rate	1.02	1.32	1.99	4.15
fraction of feed rate	0.57	0.44	0.18	0.28
mean turnover constant, d^{-1}	0.00066	0.00086	0.0022	0.0047

Notes:

1. The phosphorus turnover rate is the product of the tissue turnover constant (Table 3) and the tissue phosphorus concentration (Table 1)

2. The fraction of feed rate is the total turnover rate divided by feeding rates of 1.8, 3.0, 11, and 15 mg/d.100-g fish, respectively.

3. The mean turnover constant for the whole fish is the total phosphorus turnover rate divided by the total phosphorus concentration (Table 1).

and, surprisingly, the fish with larger daily portions took up a somewhat larger fraction of the feed.

The mean turnover constants for phosphorus in the whole fish, also listed in Table 5, were similar to the growth constants in catfish. In bluegill, the phosphorus turnover constant was similar to the growth constant in the low-feed group but only one-half as large in the high-feed group. The turnover constants in whole bluegill were similar to the values in bone material due to the large fraction of body phosphorus in that tissue. In catfish, where bone material does not constitute such a large fraction of body mass, the whole-body phosphorus turnover constants are intermediate to those in bone and other tissues.

The phosphorus excretion measured in water for a day (Appendix A.3-1 and A.3-2) is endogenous excretion from the listed tissues plus excretion of that fraction of the daily phosphorus intake that passes through the fish so rapidly that it is not measured in viscera 24 hours after intake. The endogenous excretion constant in a single-compartment system is the difference between what has here been called the turnover constant (actually, the uptake constant) and the growth constant. The much larger turnover constant in viscera than in muscle suggests that a larger fraction of visceral phosphorus is excreted. At least part of this turnover phosphorus originates in other tissues (as represented by λ_u).

The daily P-32 excretion rate is predicted in Table 6 for bluegill on the basis of the rapidly excreted P-32 intake (in only the first of the six tests) plus the relatively small contributions of endogenous P-32. The rapidly excreted P-32 was taken to be one-half of the feed, as suggested by the averages in Table 5.

In all subsequent tests, the feed contained no P-32. Endogenous excretion was estimated from the viscera specific activity, amount of phosphorus (see Appendix A.1-1), and turnover constant. A value of 0.04 d^{-1} was used for the latter, based on the non-radioactive turnover constants from Table 4 minus a small fraction for phosphorus utilized for growth. These values are compared with P-32 measurements on the indicated dates -- one during accumulation and the other five during depuration.

Predicted P-32 excretion rates ranged widely about the values measured in water and suspended material. The differences are believed to be due to large day-to-day fluctuations about the mean values of turnover and excretion rates. Excretion rates may also have been affectd by stress on the fish from handling them and transferring them to the aquarium.

5.4 Factors that affect the phosphorus turnover constant

Table 6

Excreted P-32 in Aquarium Water from Bluegills during Accumulation and Depuration

Date, 1982	Average viscera P-32/P, c/min.mg	Average P per fish viscera, mg	Average P-32 excretion rate per fish, c/min.d.			
			Calculated		Measured	
			slow	rapid	dissolved	suspended
11/09	E: 1,008	14.4	580	7,200	950	960
	W: 1,095	16.7	730	14,400	7,300	730
11/20	E: 703	20.1	570	0	2,800	240
	W: 736	20.5	600	0	8,200	<140
11/24	E: 496	19.3	380	0	~300	<120
	W: 563	21.0	470	0	1,200	<120
11/30	E: 236	18.6	180	0	250	< 80
	W: 320	28.2	360	0	3,900	< 80
12/07	E: 132	17.3	91	0	<140	< 70
	W: 172	17.3	120	0	370	< 70
12/15	E: 64	30.2	65	0	<120	< 40
	W: 83	23.0	76	0	<120	< 40

Notes: 1. Rapid turnover is 7,200 c/min.g x g feed/fish x rapid fraction; feed was 2 g/fish in E and 4 g/fish in W, and rapid fraction is approximately 0.5.

2. The measured daily values were obtained for a 25-hr period on 11/09, a 24-hr period on 11/30, and 20-hr periods on all other days; the values have not been adjusted for deviations from 24 hrs.

The experiments in the flow-through system yielded higher phosphorus turnover constants for higher feeding rates both in worm-fed bluegill and pellet-fed catfish. The higher turnover constants in catfish than in bluegill are for much higher daily phosphorus intakes. Factors such as the higher water temperatures for the catfish and dissimilar foods, with phosphorus in different forms, can contribute to the difference. Inherent characteristics in phosphorus body content and utilization or better acclimation to the experimental conditions could also cause a higher turnover constant in catfish. Finally, any comparison of phosphorus turnover constants between bluegill and catfish needs to recognize the larger uncertainty due to the early termination of the catfish experiment.

Data in Tables 7a-h from the parallel experiments performed in aquaria for 9 days are considered less reliable than from the flow-through tanks because of poor acclimation by fish as indicated by low pellet consumption, weight loss and large variability in tissue P-32 levels. Furthermore, inadvertent changes in water temperature for some aquaria prevented direct comparisons at the same temperature. The results are consistent among the various tissues, however, and suggest some trends in phosphorus turnover constants.

Water temperature. The accumulation of P-32 in the bluegill and catfish at 11° C was far below that at temperatures between 19 and 27° C. Direct comparison of catfish fed pellets at 0.9 g/d per 100-g fish consistently shows slightly higher P-32 accumulation at 24° than at 20° C. Temperature changes prevented comparisons between 20° and 25° C for bluegill, but increased turnover constants as a function of temperature in the range of 10 - 25° C have been reported for small bluegill (Ki75, Ko79). Increased food intake at higher temperatures over this range is commonly observed (Da30, Pe39, Ni74), and would be expected to cause increased phosphorus turnover.

Aquaria vs. flow-through system. Catfish fed pellets at 0.9 g/d per 100-g fish and 24° C in aquaria accumulated less P-32 in muscle, skin, gills, and viscera but the same in bone material (skeleton, head, fins, and fin spines), than catfish in the flow-through system after 9 days. The latter were at approximately the same water temperature and feeding rate.

Direct comparisons are not available for bluegill, but these fish at slightly lower temperatures in the flow-through system consistently accumulated more P-32 than in the aquaria at worm-feeding rates of both 1.5 and 2.6 g/d per 100-g fish. Although some of these accumulation values in the flow-through system at 9 days are unusually high, as indicated in Figures 1a - g, the consistently lower values in the aquaria suggest poorer acclimation by the fish.

Table 7a

Specific Activity in Tissue Relative to Food in Fish
Maintained 9 Days in Aquaria: Muscle

Feed, per 100 g fish per day			Average temperature, °C		
Worms, g moist	Pellets, g dry	P, mg	11	19 - 20	23 - 27
0.9	---	1.0	0.003 ± 0.002	----	----
1.4 - 1.6	---	1.7 - 1.9	----	(0.029)(3)	0.013 ± 0.010(1) 0.012 ± 0.002 0.027 ± 0.009(2)
2.4 - 2.6	---	2.9 - 3.1	----	(0.032)	0.020 ± 0.003
2.9 - 3.0	---	3.5 - 3.6	----	----	0.018 ± 0.013 0.024 ± 0.013 0.036 ± 0.010
---	0.3 - 0.4	4.7 - 5.6	0.002 ± 0.002	0.030 ± 0.016	0.064 ± 0.025
---	0.5 - 0.6	6.6 - 8.5	----	0.063 ± 0.009 <0.001(1)	----
---	0.8 - 0.9	10.8 - 12.1	----	0.042 ± 0.042 0.024 ± 0.006	0.036 ± 0.009 (0.057)
---	1.1	15.1	----	----	(0.083)

(1) Average fish weight loss exceeded 0.006 day^{-1}.
(2) Values for catfish are underlined
(3) Values in parentheses are measurements in flow-through tanks.
(4) Means of triplicate values are given; ± values are 0.591 $R/3^{0.5}$, where R is the range of triplicate values

Table 7b

Specific Activity in Tissue Relative to Food in Fish
Maintained 9 Days in Aquaria: Skeleton

Feed. per 100 g fish per day			Average temperature, °C		
Worms, g moist	Pellets, g dry	P, mg	11	19 - 20	23 - 27
0.9	---	1.0	0.0013 ± 0.0007	----	----
1.4 - 1.6	---	1.7 - 1.9	----	(0.004)	0.003 ± 0.002(1) 0.003 ± 0.001 0.012 ± 0.004
2.4 - 2.6	---	2.9 - 3.1	----	(0.008)	0.005 ± 0.001
2.9 - 3.0	---	3.5 - 3.6	----	----	0.006 ± 0.003 0.005 ± 0.004 0.018 ± 0.007
---	0.3 - 0.6	4.7 - 5.6	0.0008 ± 0.0008	0.011 ± 0.007	0.030 ± 0.012
---	0.5 - 0.6	6.6 - 8.5	----	0.026 ± 0.001 <0.0001(1)	----
---	0.8 - 0.9	10.8 - 12.1	----	0.010 ± 0.010 0.011 ± 0.002	0.014 ± 0.004 (0.012)
---	1.1	15.1	----	----	(0.025)

Table 7c

Specific Activity in Tissue Relative to Food in Fish
Maintained 9 Days in Aquaria: Head

Feed, per 100 g fish per day			Average temperature, °C		
Worms, g moist	Pellets, g dry	P, mg	11	19 - 20	23 - 27
0.9	---	1.0	0.0015 ± 0.0008	----	----
1.4 - 1.6	---	1.7 - 1.9	----	(0.004)	0.003 ± 0.002(1) 0.004 ± 0.001 0.008 ± 0.002
2.4 - 2.6	---	2.9 - 3.1	----	(0.010)	0.005 ± 0.001
2.9 - 3.0	---	3.5 - 3.6	----	----	0.005 ± 0.003 0.005 ± 0.004 0.012 ± 0.004
---	0.3 - 0.5	4.7 - 5.6	0.005 ± 0.0005	0.011 ± 0.006	0.020 ± 0.008
---	0.5 - 0.6	6.6 - 8.5	----	0.016 ± 0.001 <0.0001(1)	----
---	0.8 - 1.0	10.8 - 12.1	----	0.010 ± 0.010 0.007 ± 0.002	0.009 ± 0.003 (0.008)
---	1.1	15.1	----	----	(0.19)

Table 7d

Specific Activity in Tissue Relative to Food in Fish
Maintained 9 Days in Aquaria: Fins

Feed, per 100 g fish per day			Average temperature, °C		
Worms, g moist	Pellets, g dry	P, mg	11	20	24 - 27
1.4	---	1.7	----	----	0.012 ± 0.004
3.0	---	3.6	----	----	0.016 ± 0.005
---	0.3 - 0.4	4.7 - 5.6	0.0016 ± 0.0016	----	0.026 ± 0.014
---	0.5 - 0.6	6.6 - 8.1	----	0.022 ± 0.001 <0.0001(1)	----
---	0.8 - 0.9	11.0 - 12.1	----	0.009 ± 0.002	0.013 ± 0.005 (0.016)
---	1.1	15.1	----	----	(0.019)

Table 7e

Specific Activity in Tissue Relative to Food in Fish
Maintained 9 Days in Aquaria: Fin Spines

Feed, per 100 g fish per day			Average temperature, °C		
Worms, g moist	Pellets, g dry	P, mg	11	20	24 - 27
1.4	---	1.7	----	----	0.004 ± 0.001
3.0	---	3.6	----	----	0.006 ± 0.001
---	0.3 - 0.4	4.7 - 5.6	0.0003 ± 0.0003	----	0.011 ± 0.006
---	0.5 - 0.6	6.6 - 8.5	----	0.006 ± 0.001 <0.0001(1)	----
---	0.8 - 0.9	11.0 - 12.1	----	0.003 ± 0.001	0.004 ± 0.002 (0.008)
---	2.0	15.1	----	----	(0.017)

Table 7f

Specific Activity in Tissue Relative to Food in Fish
Maintained 9 Days in Aquaria: Skin and Scales

Feed, per 100 g fish per day			Average temperature, °C		
Worms, g moist	Pellets, g dry	P, mg	11	19 - 20	23 - 27
0.9	---	1.0	0.0010 ± 0.0005	----	----
1.4 - 1.6	---	1.7 - 1.9	----	(0.003)	0.002 ± 0.001(1) 0.003 ± 0.001 0.031 ± 0.009
2.4 - 2.6	---	2.9 - 3.1	----	(0.008)	0.004 ± 0.001
2.9 - 3.0	---	3.5 - 3.6	----	----	0.005 ± 0.003 0.005 ± 0.004 0.044 ± 0.012
---	0.3 - 0.5	4.7 - 5.6	0.005 ± 0.005	0.008 ± 0.005	0.071 ± 0.025
---	0.5 - 0.6	6.6 - 8.5	----	0.065 ± 0.009 <0.0005(1)	----
---	0.8 - 1.0	10.8 - 12.1	----	0.008 ± 0.008 0.027 ± 0.007	0.040 ± 0.010 (0.097)
---	1.1	15.1	----	----	(0.11)

Table 7g

Specific Activity in Tissue Relative to Food in Fish
Maintained 9 Days in Aquaria: Gills

Feed, per 100 g fish per day			Average temperature, °C		
Worms, g moist	Pellets, g dry	P, mg	11	19 - 20	23 - 27
0.9	---	1.0	0.023 ± 0.011	----	----
1.4 - 1.6	---	1.7 - 1.9	----	(0.10)	0.030 ± 0.020(1) 0.043 ± 0.011 0.040 ± 0.009
2.4 - 2.6	---	2.9 - 3.1	----	(0.12)	0.063 ± 0.020
2.9 - 3.0	---	3.5 - 3.6	----	----	0.046 ± 0.019 0.063 ± 0.046 0.056 ± 0.014
---	0.3 - 0.5	4.7 - 5.6	0.006 ± 0.006	0.11 ± 0.05	0.14 ± 0.03
---	0.5 - 0.6	6.6 - 8.5	----	0.081 ± 0.008 <0.0005(1)	----
---	0.8 - 1.0	10.8 - 12.1	----	0.069 ± 0.067 0.036 ± 0.010	0.063 ± 0.011 (0.12)
---	1.1	15.1	----	----	(0.084)

Table 7h

Specific Activity in Tissue Relative to Food in Fish Maintained 9 Days in Aquaria: Viscera

Feed, per 100 g fish per day			Average temperature, °C		
Worms, g moist	Pellets, g dry	P, mg	11	19 - 20	23 - 27
0.9	---	1.0	0.07 ± 0.02	----	----
1.4 - 1.6	---	1.7 - 1.9	----	(0.27)	0.12 ± 0.05(1) 0.11 ± 0.04 0.09 ± 0.03
2.4 - 2.6	---	2.9 - 3.1	----	(0.34)	0.12 ± 0.02
2.9 - 3.0	---	3.5 - 3.6	----	----	0.15 ± 0.05 0.10 ± 0.07 0.15 ± 0.05
---	0.3 - 0.4	4.7 - 5.6	0.05 ± 0.05	0.26 ± 0.13	0.19 ± 0.03
---	0.5 - 0.6	6.6 - 8.5	----	0.19 ± 0.04 <0.001(1)	----
---	0.8 - 0.9	10.8 - 12.1	----	0.16 ± 0.13 0.11 ± 0.05	0.13 ± 0.01 (0.32)
---	1.1	15.1	----	----	(0.34)

Food phosphorus intake. The increase in P-32 accumulation with food intake by worm-fed bluegill in aquaria at three feeding rates is consistent with the increase observed in the flow-through system. Worm-fed catfish in aquaria show the same trend. For pellet-fed catfish, however, P-32 accumulation decreased with higher food intake in aquaria, both at 20° and at 24° C. Combined with the data from the flow-through system, this trend would indicate decreasing accumulation between phosphorus intake rates of 5 and 11 mg/d per 100-g fish, followed by an increase between 11 and 15 mg/d per 100-g fish. Such a minimum does not seem reasonable and may be an artifact due to poor acclimation to the aquaria.

Catfish vs. Bluegill. Catfish fed worms in aquaria at approximately 25° C at two feeding rates had approximately twice the P-32 accumulation in muscle and bone as bluegill, while accumulation in gills and viscera was approximately equal. Comparison of pellet-fed fish was not conclusive because of the wide range of replicate bluegill results. Data for all tissues except scales plus skin are consistent. The latter can not be compared because that tissue is mostly scales in bluegill and skin in catfish, with widely different phosphorus concentrations and turnover constants.

Worm vs. pellet feed. Only approximate comparisons are possible because worms and pellets were not fed at identical levels of daily phosphorus intake. The closest comparison is for catfish in aquarium water at 24° C fed pellets at 0.32 g/d per 100-g fish (a phosphorus intake rate of 4.7 mg/d per 100-g fish) and at 26° C fed worms at 3.0 g/d per 100-g fish (3.6 mg/d per 100 g). Accumulation from pellets averaged 1.8 times the accumulation from worms, considerably higher than would be expected from the trend based on the P-32 accumulation in worm-fed catfish. On the other hand, catfish in aquaria fed even more pellets -- 0.80 g/d per 100-g fish -- at 25° C accumulated approximately the same P-32 levels as these worm-fed catfish. The comparison of bluegill in aquarium water at 19° C fed pellets at 0.41 g/d per 100-g fish (5.6 mg/d per 100 g) with bluegill at 24 - 25° C fed worms at 2.9 g/d per 100-g fish (3.5 mg/d per 100 g) also suggests greater accumulation than would be expected from the increase in phosphorus intake rate but at a lower water temperature.

Analyses of the water in all aquaria on the eighth day of the study show that, with a few exceptions, approximately one-half of the P-32 fed on that day was in the water (see Appendices B.3-1 and B.3-2). This fraction is consistent with the ratio of the average daily turnover (uptake) rates to feeding rates for bluegill in Table 5. The very low uptake values for fish in water at 11° C (aquaria No. 1, App. B.3-1 and B.3-2) are supported by the observation that more than 90 percent of the P-32 in the feed was in the water. The worm-fed catfish (in aquaria No.7 and 8), on the other hand, retained more than 80 percent of the feed, consistent with the much higher accumulation by these fish than by bluegill (see Table 7). The P-32 in water is attributed to endogenous material rather than phosphorus dissolved or leached from feed because the feed was promptly consumed, little feed remained uneaten, and there appears to be little difference in the P-32 fraction from worms and pellets.

In summary, the aquarium experiments indicate higher phosphorus turnover constants for catfish than for bluegill, phosphorus uptakes increasing with daily intake rates at least for lower values, and possibly higher uptakes with pellets compared to worms. The higher turnover constants in catfish may be due to their lesser body phosphorus contents. The turnover constant is expected to increase less rapidly than phosphorus intake at high feeding rates, although this was not the case for the catfish in the flow-through system. Any difference between pellet and worm feed may be due to different forms of P-32. It was added to pellets as phosphate ions, whereas the worms undoubtedly metabolized much of the P-32 to form organic compounds.

5.5 <u>Phosphorus uptake from water</u>

The specific activities in tissue relative to water summarized in Table 8 confirm the conclusion reached earlier (Ka80) that fish take up very little dissolved phosphorus directly from water, compared to their uptake from food. The relative specific activity in the control fish, even at the extremely high dissolved phosphorus concentration (5.6 mg/L) in aquarium water, was lower by factors between 40 and 250 than on the 4th day of feeding the smaller daily portions.

The turnover constants in these control fish at the indicated low uptake rates were only $2 \times 10^{-5}\ d^{-1}$ for bluegill muscle and $3 \times 10^{-5}\ d^{-1}$ for catfish muscle (see Table 9). The constants in muscle, skeleton, and head sections were similar for bluegill and catfish exposed to the same phosphorus concentrations in water.

The daily phosphorus uptake rates for a 100-g fish of 27.8 µg in bluegill and 13.0 µg in catfish (Table 9) correspond to respective water intake rates of 5.1 and 2.4 ml/d. Drinking rates between 0 and 18 ml/d have been reported for freshwater fish (Ka80).

The remarkable observation for both bluegill and catfish with blocked esophagus is that the specific activity in tissues relative to water was approximately double the value in the control fish, as summarized in Table 8. Hence, the turnover constants and daily uptake rates in muscle as well as in the whole fish were twice as great as in control fish (see Table 9). Although small amounts of P-32 measured in these fish may be due to accumulation on surfaces externally and in the mouth, the higher specific activities throughout the fish when the esophagus is blocked suggest an additional mechanism, such as stimulation of ionic uptake at some surfaces, e.g. the gills and mouth.

Table 8

Specific Activity in Tissue Relative to Water for Unfed Fish
Maintained 4 Days in Aquaria (1)

Species	Treatment	Muscle	Skeleton	Head	Skin/Scales	Gills	Viscera
Bluegill	Blocked	0.18 ± 0.01	0.10 ± 0.02	0.06 ± 0.01	0.06 ± 0.01	2.0 ± 0.1	8.8 ± 0.6
	Control	0.08 ± 0.03	0.05 ± 0.03	0.03 ± 0.01	0.03 ± 0.01	0.6 ± 0.1	4.7 ± 2.5
Catfish	Blocked	0.18 ± 0.02	0.12 ± 0.01	0.08 ± 0.02	0.24 ± 0.05	0.64± 0.02	1.2 ± 0.6
	Control	0.10 ± 0.01	0.05 ± 0.01	0.03 ± 0.01	0.08 ± 0.02	< 0.3	1.1 ± 0.3
Bluegill	- worms, low (2)	11	2	2	1.5	50	200
	- worms, high(2)	17	4	4	3.0	70	350
Catfish	- pellets, low (2)	20	5	4	20	40	110
	- pellets, high(2)	40	10	6	40	60	200

(1) Divide all values by 1,000

(2) Specific activity in tissue relative to food was interpolated for 4th day from data for fish in flow-through tank

(3) Specific activity in water was 57,000 c/min.mg for bluegill and 60,200 c/min.mg for catfish.

(4) Catfish fin spines and bluegill tails are with skeleton, and catfish fins with the head.

Table 9

Phosphorus Uptake Rate and Turnover Constant for Unfed Fish

Tissue	$a_t/a_f \times 10^3$		P, mg/g wet	Tissue, g/100-g fish		P uptake rate x 10^3, mg/d.100-g fish		P turnover constant x 10^3, d^{-1}	
	B	U		B	U	B	U	B	U
Bluegill									
Muscle	0.18	0.08	2.5	26.1	25.1	3.2	1.4	0.050	0.022
Skeleton	0.10	0.05	17.6	21.2	23.4	10.3	5.7	0.028	0.014
Head	0.06	0.03	18.9	29.2	33.2	9.1	5.2	0.016	0.008
Scales	0.06	0.03	41.5	11.1	11.3	7.6	3.9	0.016	0.008
Gills	2.0	0.6	3.0	0.50	0.41	0.8	0.2	0.55	0.16
Viscera	8.8	4.7	2.2	4.8	4.05	21.3	11.4	2.4	1.3
Whole fish			15.4	92.9	97.4	52.3	27.8	0.037	0.019
Catfish									
Muscle	0.18	0.10	2.6	31.3	28.3	4.0	2.0	0.050	0.028
Skeleton	0.12	0.05	8.6	15.0	16.8	4.3	2.0	0.033	0.014
Head	0.08	0.03	14.2	27.1	28.3	8.5	3.3	0.022	0.008
Skin	0.24	0.08	2.1	7.3	9.6	1.0	0.4	0.066	0.022
Gills	0.64	<0.3	3.2	0.62	0.58	0.3	<0.2	0.18	<0.08
Viscera	1.2	1.1	2.0	8.8	8.9	5.8	5.3	0.33	0.30
Whole fish			6.4	90.1	92.5	23.9	13.0	0.041	0.022

Note: B: fish with blocked esophagus; U: control fish

Direct uptake of P-32 at very low rates has been observed earlier, both for unfed fish (He45) and for fish with blocked esophagus (To58). Uptake of HPO_4^{-2} ions at gill and oral cavity membranes has been postulated without further discussion (La77).

5.6 P-32 discharged at a nuclear power station

The brief environmental survey at the Sequoyah Nuclear Power Plant, operated by TVA at the Tennessee River (Chicamauga Lake) near Chattanooga, TN, showed the presence of P-32 in liquid effluent, and in periphyton, zooplankton, bluegill sunfish and catfish (see Table 10). Similar concentrations in liquid effluent have been found at other nuclear power stations (Bl76, Ka74).

The aquatic samples were collected by TVA staff from the river and from a pond into which the liquid effluent was discharged prior to further dilution in the river. The concentration of P-32 in pond water was estimated by TVA staff to be between 0.1 and 0.5 pCi/L during discharge of liquid waste at the concentrations indicated in Table 10.

The observed P-32 levels in catfish flesh and whole sunfish suggest a concentration factor of one to several thousand relative to pond water (Ma73). Because waste discharges are periodic, these values do not reflect steady-state conditions. On the other hand, exposure to P-32 is not usually as brief as indicated by discharge periods because P-32 tends to accumulate in sediment and then gradually reenter the water column (Ha52, Ha58, Po65). The higher P-32 concentrations in some pond periphyton samples support the high P-32 bioaccumulation factor predicated on rapid phosphorus turnover relative to radioactive decay.

Most samples from the river were below detection levels for P-32, but several positive measurements were obtained in fish and zooplankton. These may be briefly elevated levels during the period of waste release, or could be due to transfer of suspended material with high P-32 levels from pond to lake. Without further studies, the P-32 levels observed here indicate the potential for detectable P-32 concentrations downstream from nuclear power stations, but do not provide [illegible]$_r$ values.

Table 10

P-32 Concentrations in the Aquatic Environment at the Sequoyah Nuclear Plant (1)

Description	Location	Date Collected	P-32, pCi/kg(2)
periphyton	river	09/08/81	< 5,000
periphyton	pond	09/08/81	20,000 ± 60%
zooplankton	pond	09/08/81	< 15,000
zooplankton	river discharge	09/08/81	< 15,000
zooplankton	river (intake background)	09/08/81	< 15,000
catfish flesh	river	09/10/81	< 30
catfish bone & viscera	river	09/10/81	< 120
sunfish flesh	river	09/10/81	< 80
sunfish bone & viscera	river	09/10/81	< 400
catfish flesh	pond	09/10/81	280 ± 12%
catfish bone, etc.	pond	09/10/81	750 ± 17%
H_2O unfiltered	pond inflow	09/11/81	< 1
H_2O unfiltered	pond inflow	09/11/81	< 1
H_2O filtered	pond - gate	09/11/81	< 1
H_2O filtered	pond - gate	09/11/81	< 1
H_2O unfiltered	pond inflow	09/15/81	< 1
H_2O unfiltered	pond - gate	09/15/81	< 1
H_2O unfiltered	pond inflow	09/15/81	< 1
H_2O filtered	pond - gate	09/15/81	< 1
catfish flesh	pond	09/15/81	125 ± 12%
catfish bone, etc.	pond	09/15/81	280 ± 30%
sunfish - whole	pond	09/15/81	740 ± 15%
catfish flesh	river	09/15/81	< 30
catfish bone, etc.	river	09/15/81	< 90
sunfish flesh	river	09/15/81	130 ± 20%
sunfish bone, etc.	river	09/15/81	330 ± 50%
zooplankton	pond	09/17/81	20,000 ± 90%
zooplankton	river (487)	09/17/81	20,000 ± 90%
zooplankton	river (483.4)	09/17/81	< 12,000
periphyton	river	09/17/81	< 2,000
periphyton	pond	09/17/81	15,000 ± 70%
H_2O discharge	waste tank	09/15/81	1,500 ± 10%
H_2O composite	waste tank	09/09-15/81	1,950 ± 5%
H_2O composite	waste tank	09/16-22/81	680 ± 10%
H_2O discharge	waste tank	09/22/81	820 ± 10%

(1) All values were reported by Robert J. Lyon, Eastern Environmental Radiation Facility, Office of Radiation Programs, USEPA.

(2) Percent indicates standard deviation of counting.

6. Conclusions

A phosphorus turnover constant of 0.0043 d^{-1}, corresponding to a bioaccumulation factor ratio for P-32 relative to phosphorus of 0.081, was obtained for bluegill muscle. These bluegill were fed worms at a rate of 2.6 g/d. per 100-g body weight in a flow-through tank maintained at 16 - 22° C. The phosphorus content of the worms was 1.2 mg/g. The initial weight of the bluegill averaged 121 g (range 86 - 164 g), and they gained an average 0.19 percent/d in the 79-day study period. Combined with the generic phosphorus bioaccumulation factor of 70,000 recommended earlier, the ratio yields a P-32 bioaccumulation factor of 6,000. This value is the bioaccumulation in muscle relative to water under these conditions if P-32 accumulates rapidly in the food chain. The bioaccumulation factor ratio was approximately 20 percent lower for bluegill fed fewer worms, at a rate believed to be just above maintenance level.

In parallel studies with catfish (average weight, 168 g) fed pellets that contained five times as much phosphorus, in water at 24 - 26° C, bioaccumulation factor ratios were twice as high. Ancillary studies suggest that bioaccumulation factor ratios increase with water temperature between 11 to 27° C, and with phosphorus intake from 1 to 5 mg/d per 100-g fish. The bioaccumulation factor ratio also appears to be higher for catfish, which have a much lower phosphorus body content than bluegill, and higher with pellet feed with ionic P-32 content than with worms that contain metabolized P-32.

Measurements of P-32 and phosphorus concentrations in other fish tissue show phosphorus turnover constants approximately 5-fold lower than muscle in bluegill skeleton, head, and scales and catfish skeleton, head, and fins. Turnover constants are several times higher than muscle in the viscera and gills of both species and in catfish skin. Turnover constants for whole fish were approximately one-fifth the muscle value in bluegill and two-fifths the muscle value in catfish.

Uptake and depuration of P-32 in bluegill muscle, skeleton, head, and scales can be described with a simple 1-compartment model that relates the specific activity in tissue to that in feed by means of the phosphorus turnover constant and the P-32 radioactive decay constant. The specific activity data observed for viscera and gills require additional turnover constants to account for the movement of phosphorus among tissues.

This study demonstrates that the bioaccumulation factor for P-32 is substantially lower than that for phosphorus because phosphorus turnover in fish muscle is slow compared to the radioactive decay of P-32. If the whole fish is considered rather than muscle, the bioaccumulation factor is slightly higher because the higher muscle turnover constant is outweighed by the lower phosphorus concentration in muscle than in the whole fish. In bluegill, average phosphorus concentrations relative to wet weight in muscle and whole fish were 2.4 and 15.4 mg/g, respectively; in catfish, they were 2.2 and 8.8 mg/g.

That the major intake pathway for phosphorus is food rather than water is established by phosphorus uptakes between 1 and 4 mg/d per 100-g fish. Typical phosphorus concentrations in water are in the range of only 0.005 - 0.5 mg/L. An experiment with unfed fish in water with extremely high (5.6 mg/L) phosphorus concentration, approximately equi-molar in the forms of mono- and di-hydrogen phosphate, yielded P-32 uptakes associated with a water intake of 2 - 5 ml/d. At this very small phosphorus uptake, however, the unexpected result was that fish with a blocked esophagus accumulated twice as much P-32 in their tissues as control fish. Hence, some uptake of phosphate may be due to ion transfer at surfaces, stimulated by the stress of blockage.

The P-32 bioaccumulation factor presented above for bluegill that were fed 2.6 percent/d and gained 0.19 percent/d is believed to apply on an annual average basis in the environment, but wide variations would be expected due to different phosphorus intakes at certain time periods and locations. Species differences that could affect phosphorus turnover constants need also to be considered. Where P-32 discharges by nuclear facilities could lead to significant radiation doses to persons eating fish, detailed monitoring is desirable to consider possibly higher P-32 transfers as a function of specific fish species and metabolism, pathway, form of phosphorus, or ambient conditions.

The flow-through system was found to be effective in maintaining fish healthy and growing for a sufficiently long period and is recommended for use in similar uptake studies. Specific activity measurements during both accumulation and depuration provided unambiguous values of turnover constants and bioaccumulation factors. Similar determinations in fish are suggested for radionuclides with uncertain BF_r due to widely different observed values.

7. References

AP80 APHA, 1980, Standard Methods for the Examination of Water and Wastewater, 15th Edition, American Public Health Association, 1015 Fifteenth St., NW, Washington, DC 20005, pp 415-417.

Be75 Bernhard, M., Bruschi, A., and Moller, F., 1975, "Use of Compartmental Models in Radioecological Laboratory Studies" in Design of Radiotracer Experiments in Marine Biological Systems, IAEA, Vienna, pp. 241-289.

Bl76 Blanchard, R. et al., 1976, "Radiological Surveillance Study at the Oyster Creek BWR Nuclear Power Station," U.S. EPA Rept. EPA-520/5-76-003.

Br57 Brown, M.E., 1957, The Physiology of Fishes. Academic Press, New York, 386.

Br82 Branagan, E.F., Nichols, C.R. and Willis, C.A., 1982, "The Importance of P-32 in Nuclear Reactor Liquid Effluent," Health Phys. 43, 115 (Abstract).

Da30 Dawes, B., 1930, "Growth and Maintenance in the Plaice (Pleuronectes Platessa L.) Part I," J. Mar. Biol. Assoc. U.K., 17, 103.

Da58 Davis, J.J., Perkins, R.W., Palmer, R.F., Hanson, W.C., and Cline, J.F., 1958, "Radioactive Materials in Aquatic and Terrestrial Organisms Exposed to Reactor Effluent Water," Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, 1958, Vol. 18, United Nations, New York, 432.

Fo59 Foster, R.F., 1959, "Radioactive Tracing of the Movement of an Essential Element through an Aquatic Community with Specific Reference to Radiophosphorus," Pubbl. Stn. Zool. Napoli (Suppl.), 31, 34.

Fo62 Foster, R.F. and McConnon, D., 1962, "Relationships Between the Concentration of Radionuclides in Columbia River Water and Fish," Biological Problems in Water Pollution, C.M. Tarzwell, ed., U.S. PHS publication 999-WP-25.

Ha52 Hayes, F.R., McCarter, J.A., Cameron, M.L. and Livingstone, D.A., 1952, "On the Kinetics of Phosphorus Exchange in Lakes," J. Ecol., 40, 202.

Ha58 Hayes, F.R. and Phillips, J.E., 1958, "Lake Water and Sediment, IV. Radiophosphorus Equilibrium with Mud, Plants and Bacteria under Oxidized and Reduced Conditions," Limnol. Oceanogr., 3, 459.

He45 Hevesy, G., 1945, "Rate of Renewal of the Fish Skeleton," Acta. Physiol. Scand., 9, 234.

Il61 Il'in, D.I. and Moskalev, Yu. I., 1961, "Distribution, Elimination and Coefficients of Accumulation of Strontium-90, Cesium-137, and Phosphorus-32 in Fish," Distribution, Biological Effects and Migration of Radioactive Isotopes, A.V. Ledbedinskii and Yu. I. Moskalev, eds., U.S. AEC Rept. AEC-TR-7512, 379.

Ka74 Kahn, B. et al., 1974, "Radiological Surveillance Study at the Haddam Neck PWR Nuclear Power Station," U.S. EPA Rept. EPA-520/3-74-007.

Ka80 Kahn, B. and Turgeon, K.S., 1980, "The Bioaccumulation Factor for Phosphorus-32 in Edible Fish Tissue," U.S. NRC Rept. NUREG/CR-1336; also Health Phys. 46, 321 (1984).

Ki75 Kitchell, J.F., Koonce, J.F. and Tennis, P.S., 1975, "Phosphorus Flux Through Fishes," Verh. Internat. Verein. Limnol., 19, 2478.

Ko79 Koonce, J.F., and Seadler, A.W., 1979, "Phosphorus Release by the Bluegill Sunfish (Lepomis macrochirus) and Other Aquatic Organisms," U.S. ERDA Rept. ORNL-Sub-4271-2.

Kr56 Krumholtz, L.A., 1956, "Observations on the Fish Population of a Lake Contaminated by Radioactive Wastes," Bull. Am. Mus. Nat. Hist., 110, 277.

La77 Lagler, K.R., Bardach, J.E., Miller, R.R. and Passino, D.R., 1977, "Excretion and Osmotic Regulation," Icthyology, John Wiley and Sons, New York, 258.

Lo71 Lowman, F.G., Rice, T.R. and Richards, F.A., 1971, "Accumulation and Redistribution of Radionuclides by Marine Organisms," Radioactivity in the Marine Environment, National Academy of Sciences - National Research Council, Washington, D.C., 161.

Ma71 Magnuson, J.J. and Kitchell, J.J., 1971, "Energy Nutrient Flux Through Fishes-Lake Wingra," Progress Report, 1970-71 Annual Report, Lake Wingra Study, Eastern Deciduous Forest Biome Memo Report #71-58.

Ma83 Matheny, M.D., Robinson, M.S., Doty, R.L. and Dills, J.T., Jr., 1983, "The Trauma of P-32," Health Phys. 45, 211 (Abstract).

NC78 NCRP, 1978, "A Handbook of Radioactivity Measurements Procedures," National Council on Radiation Protection and Measurements, 7910 Woodmont Ave., Bethesda, MD 20014, p. 284.

Ni74 Niimi, A.J. and Beamish, F.W.H., 1974, "Bioenergetics and Growth of Largemouth Bass (Micropterus salmoides) in Relation to Body Weight and Temperature," Canadian J. Zool., 52, 447.

Pe39 Pentelow, F.T.K., 1939, "The Relation Between Growth and Food Consumption in the Brown Trout," J. Exp. Biol., 16, 446.

Pe71 Peterson, H.T. Jr., 1971, "Stable Element and Radionuclide Reconcentration in Aquatic Ecosystems," in Health Physics Aspects of Nuclear Facility Siting, P.E. Voilleque' and B.R. Baldwin, eds., B.R. Baldwin, P.O. Box 2431, Idaho Falls, ID 83401, 289.

Po65 Pomeroy, L.R., Smith, E.E. and Grant, C.M., 1965, "The Exchange of Phosphate Between Estuarine Water and Sediments," Limnol. Oceanogr., 10, 167.

Po66 Polikarpov, G.G., 1966, Radioecology of Aquatic Organisms, Reinhold Book Division, New York, 123-127, 167.

Ra74 Radiation Data and Reports, 1974, "Hanford Atomic Products Operation, Calendar Year 1970," Radiation Data and Reports, 15, 203; earlier years referenced as follows: 1965, 6, 61; 1966, 7, 113; 1967, 8, 113; 1968, 9, 123; 1969, 10, 408; 1971, 12, 344; 1971, 12, 643.

Ri56 Rigler, F.H., 1956, "A Tracer Study of the Phosphorus Cycle in Lake Water," Ecology, 37, 550.

St74 Stanley, J.G., 1974, "Nitrogen and Phosphorus Balance of Grass Carp, Ctenopharyngodon idella, Fed Elodea, Egeria densa," Trans. Am. Fish. Soc., 103, 587.

Th72 Thompson, S.E., Burton, C.A., Quinn, P.J. and Ng, Y.C., 1972, Concentration Factors of Chemical Elements in Edible Aquatic Organisms, U.S. AEC Rept. UCRL-50564 (Rev. 1).

To58 Tomiyama, T. and Kobayashi, K., 1958, "Direct Absorption of Radioisotopes in Water by Salt and Fresh-water Fish," Proceedings of the Second Japan Conference on Radioisotopes, February 1958, U.S. AEC Rept. AEC-tr-4482.

Va75 Vanderploeg, H.A. et al., 1975, "Bioaccumulation Factors for Radionuclides in Fresh-water Biota," U.S. ERDA Rept. ORNL-5002.

Wa57 Watson, D.G. and Davis, J.J., 1957, "Concentration of Radioisotopes in Columbia River Whitefish in the Vicintiy of the Hanford Atomic Products Operation," U.S. AEC Rept. HW-48523.

Wh61 Whittaker, R.H., 1961, "Experiments with Radiophosphorus Tracer in Aquarium Microcosms," Ecol. Monogr., 31, 157.

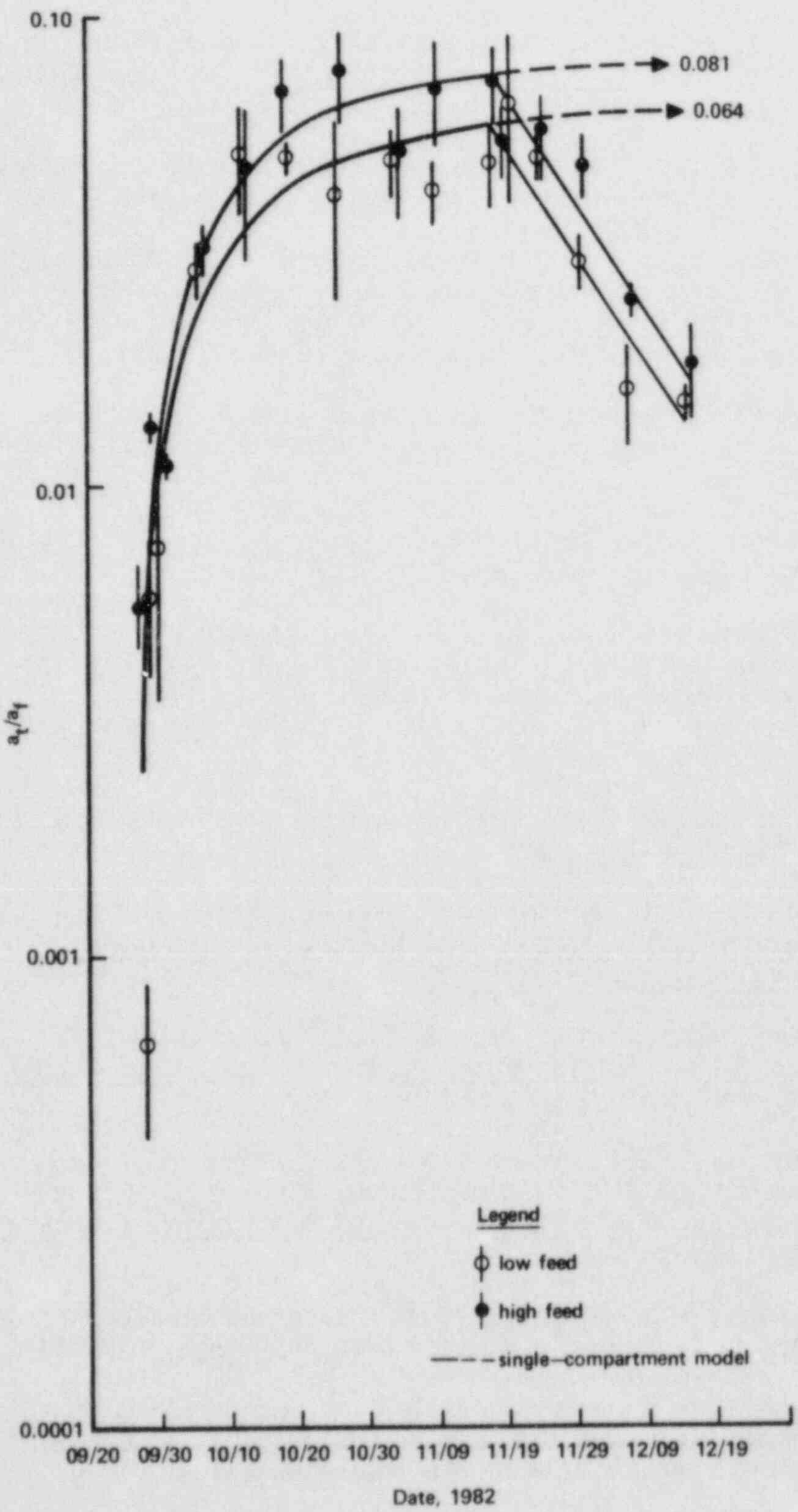


Fig. 1a. Phosphorus–32 specific activity in bluegill tissue relative to food: muscle

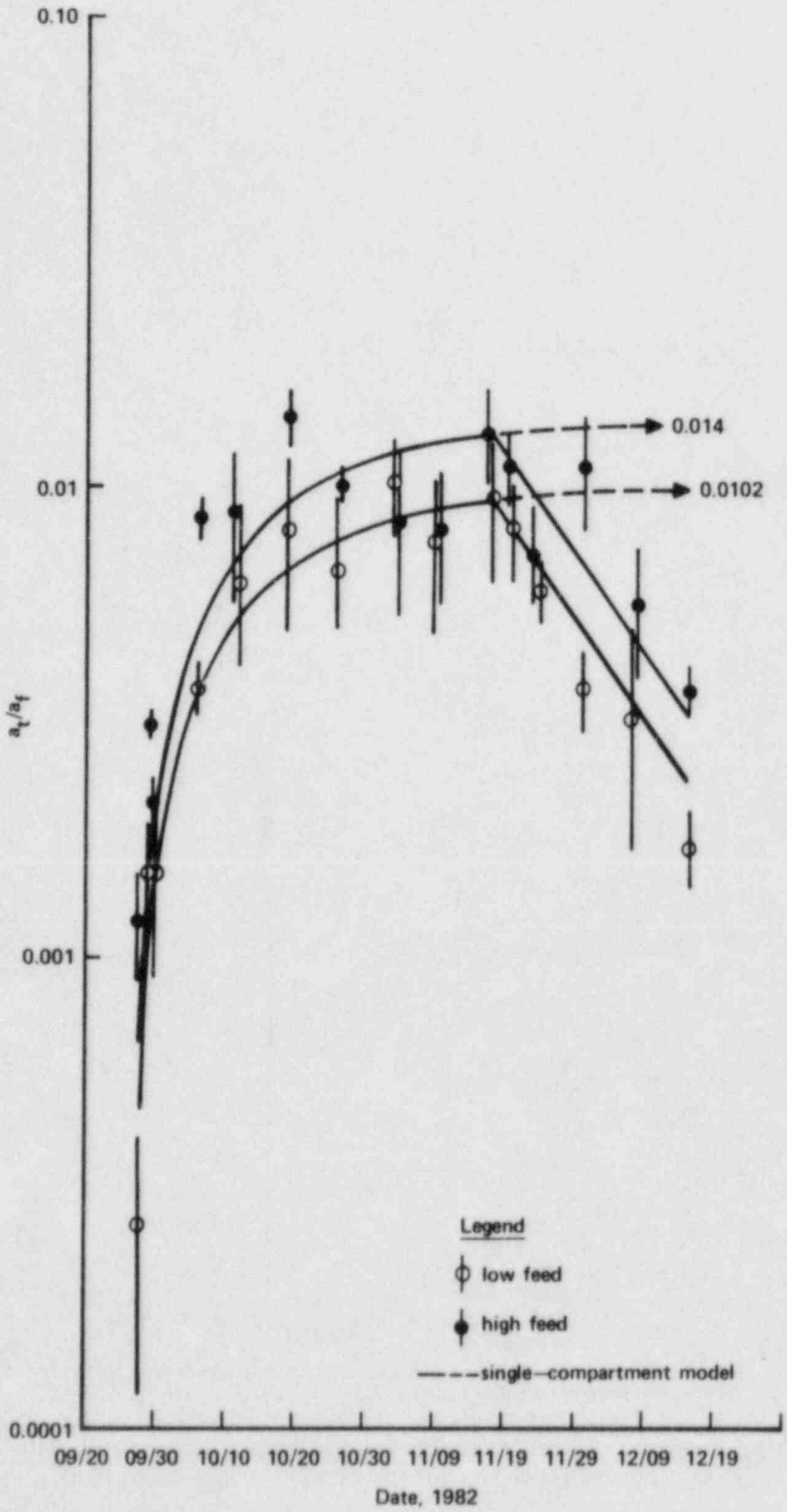


Fig. 1b. Phosphorus–32 specific activity in bluegill tissue relative to food: skeleton

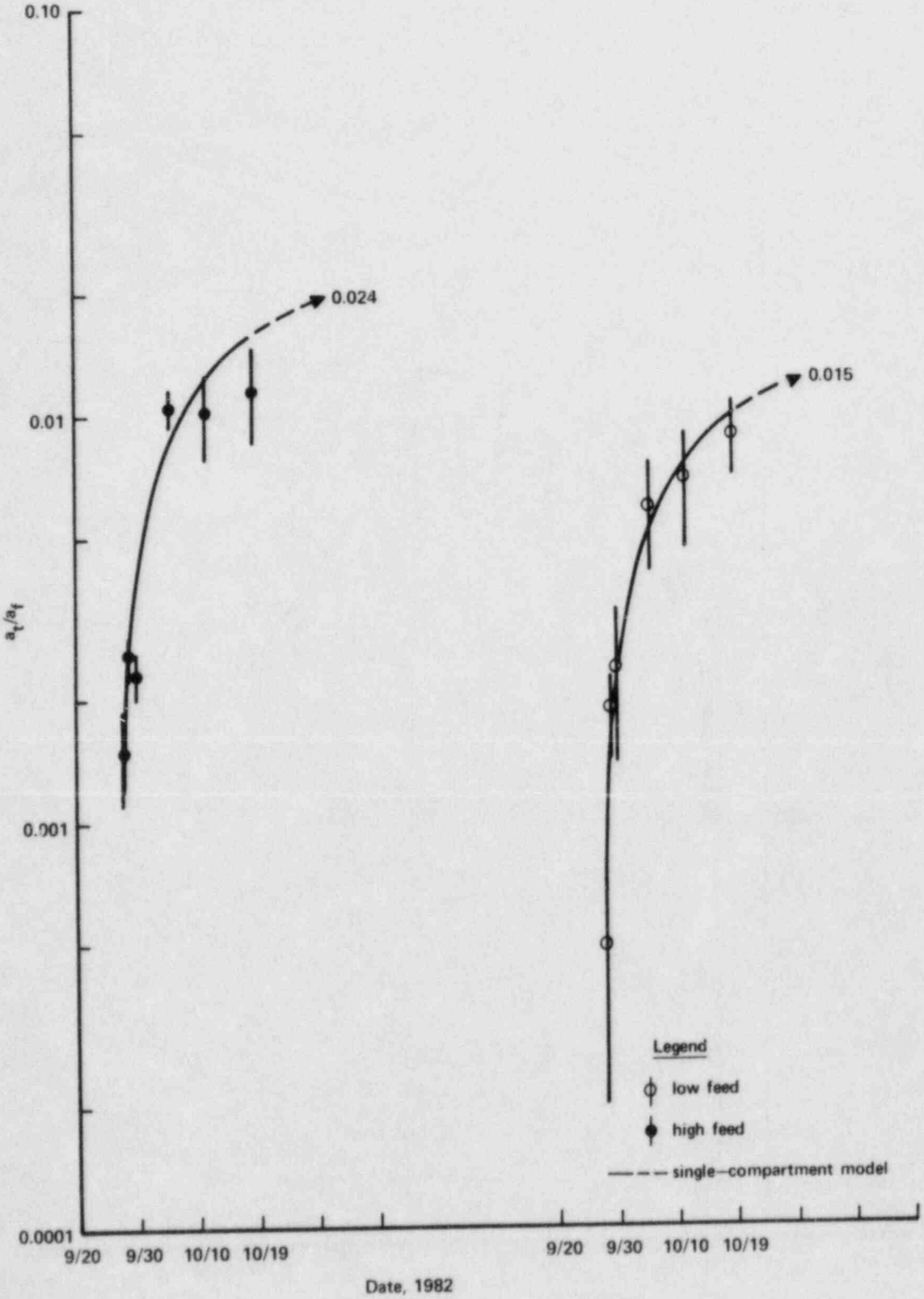


Fig. 1c. Phosphorus–32 specific activity in bluegill tissue relative to food: tail

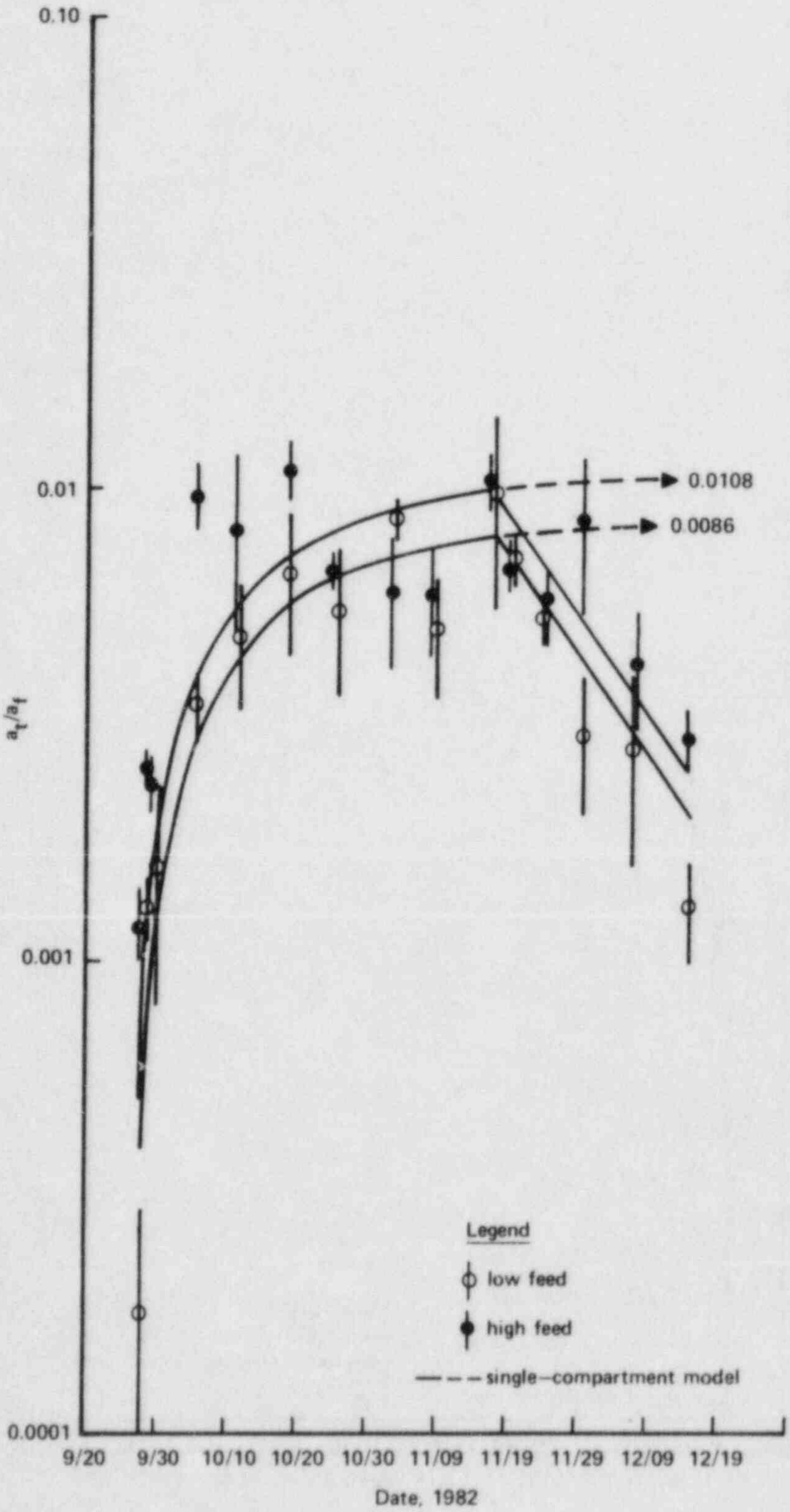


Fig. 1d. Phosphorus-32 specific activity in bluegill tissue relative to food: head

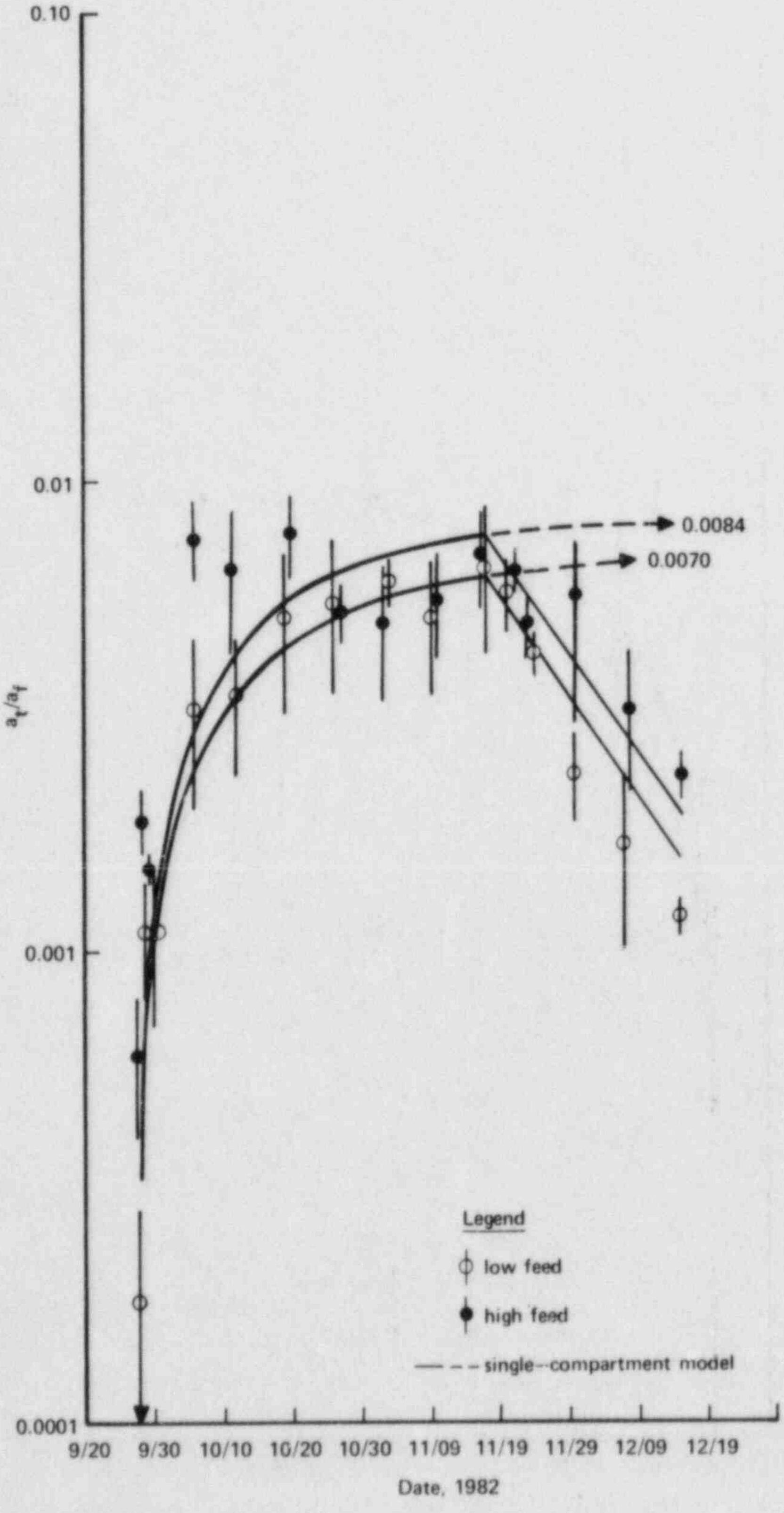


Fig. 1e. Phosphorus-32 specific activity in bluegill tissue relative to food: scales

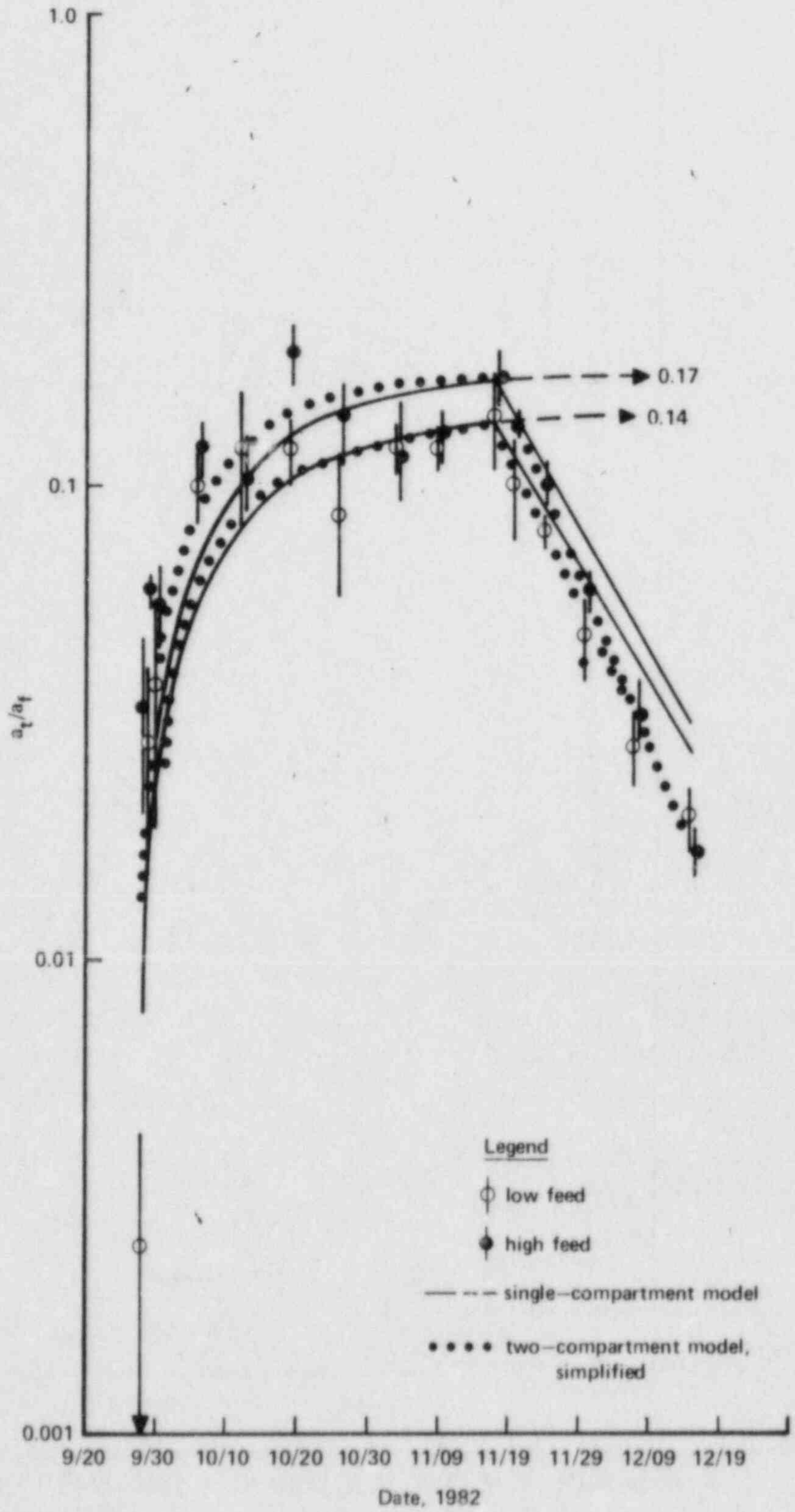


Fig. 1f. Phosphorus–32 specific activity in bluegill tissue relative to food: gills

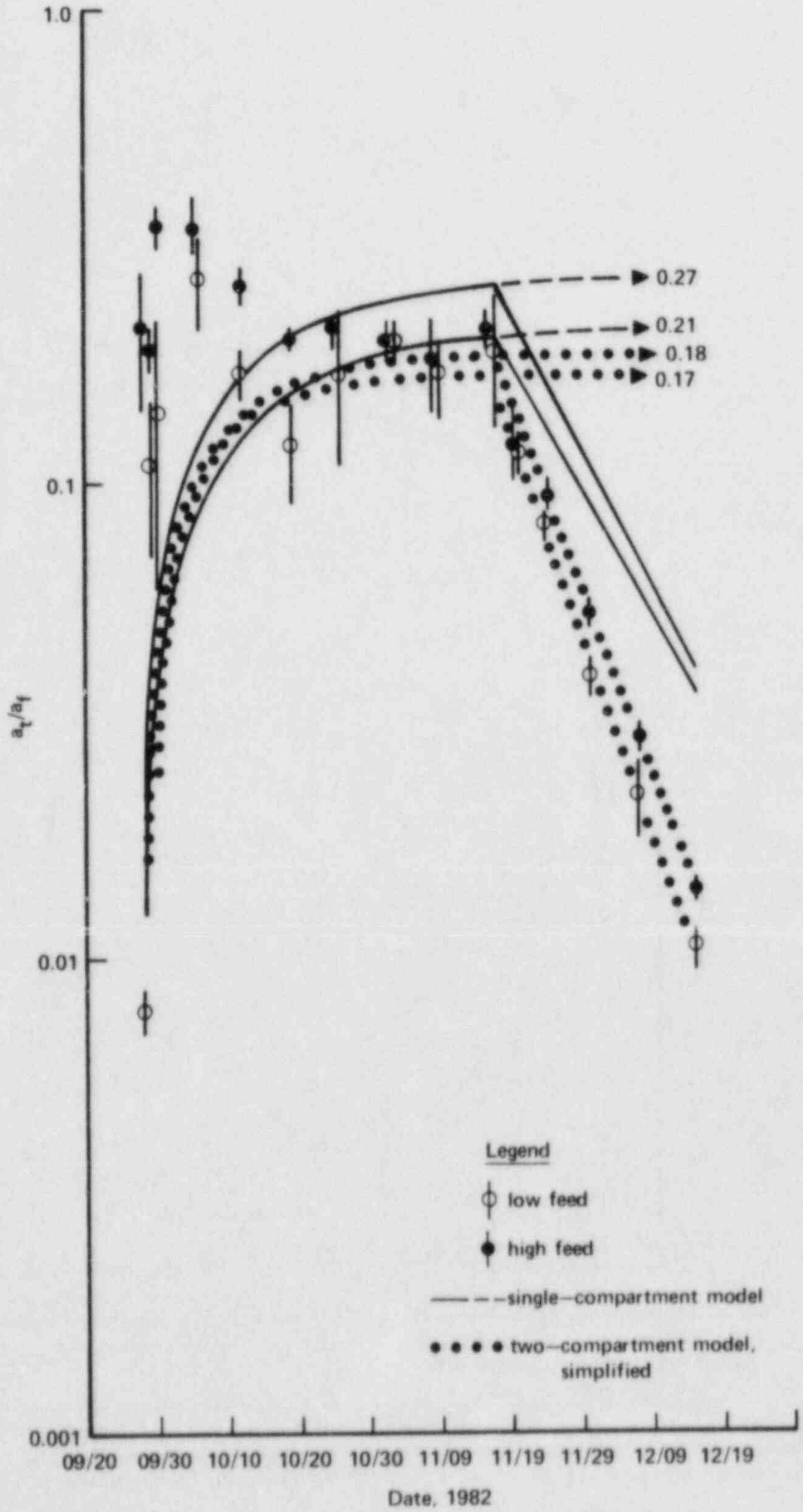


Fig. 1g. Phosphorus–32 specific activity in bluegill tissue relative to food: viscera

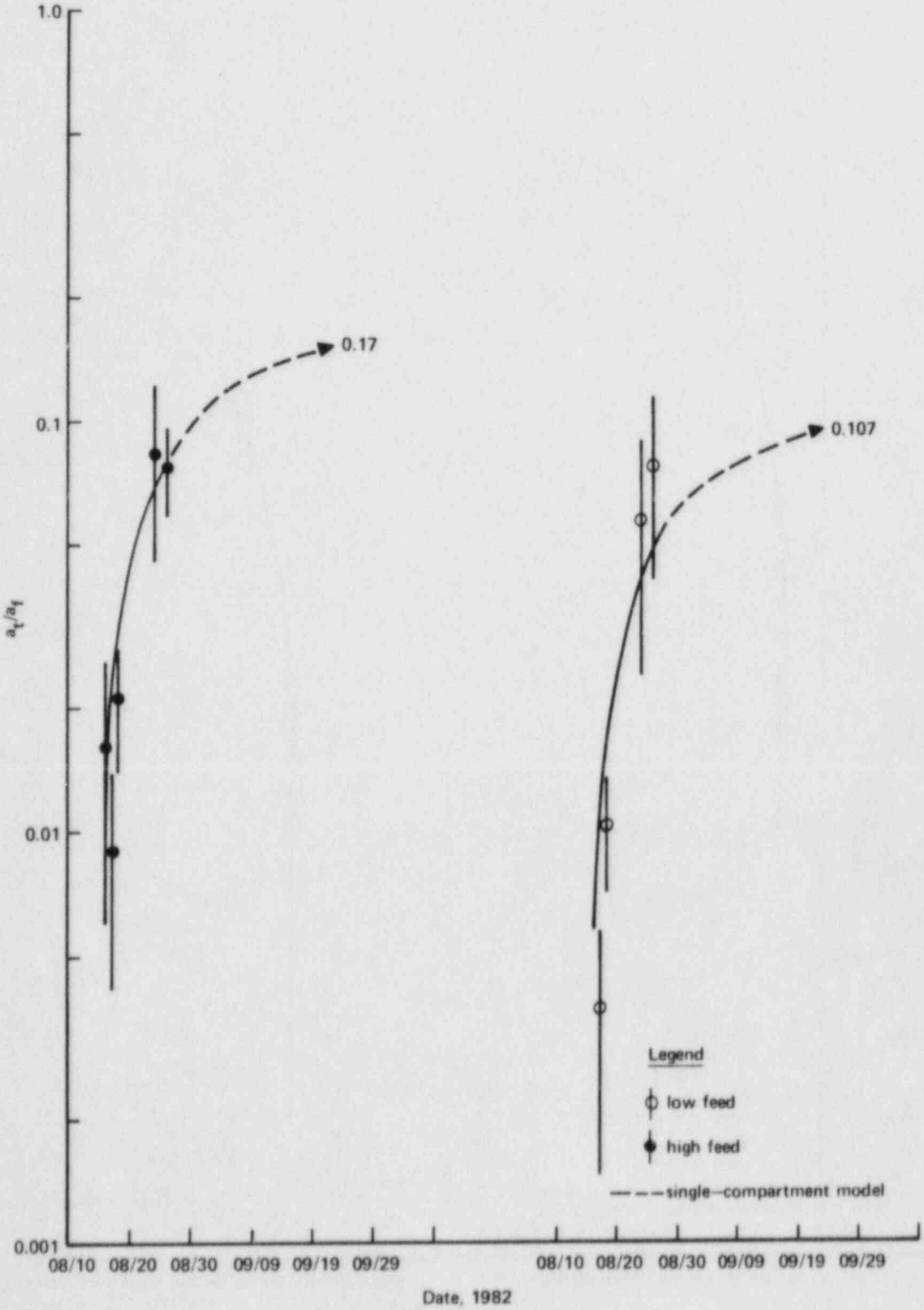


Fig. 2a. Phosphorus-32 specific activity in catfish tissue relative to food: muscle

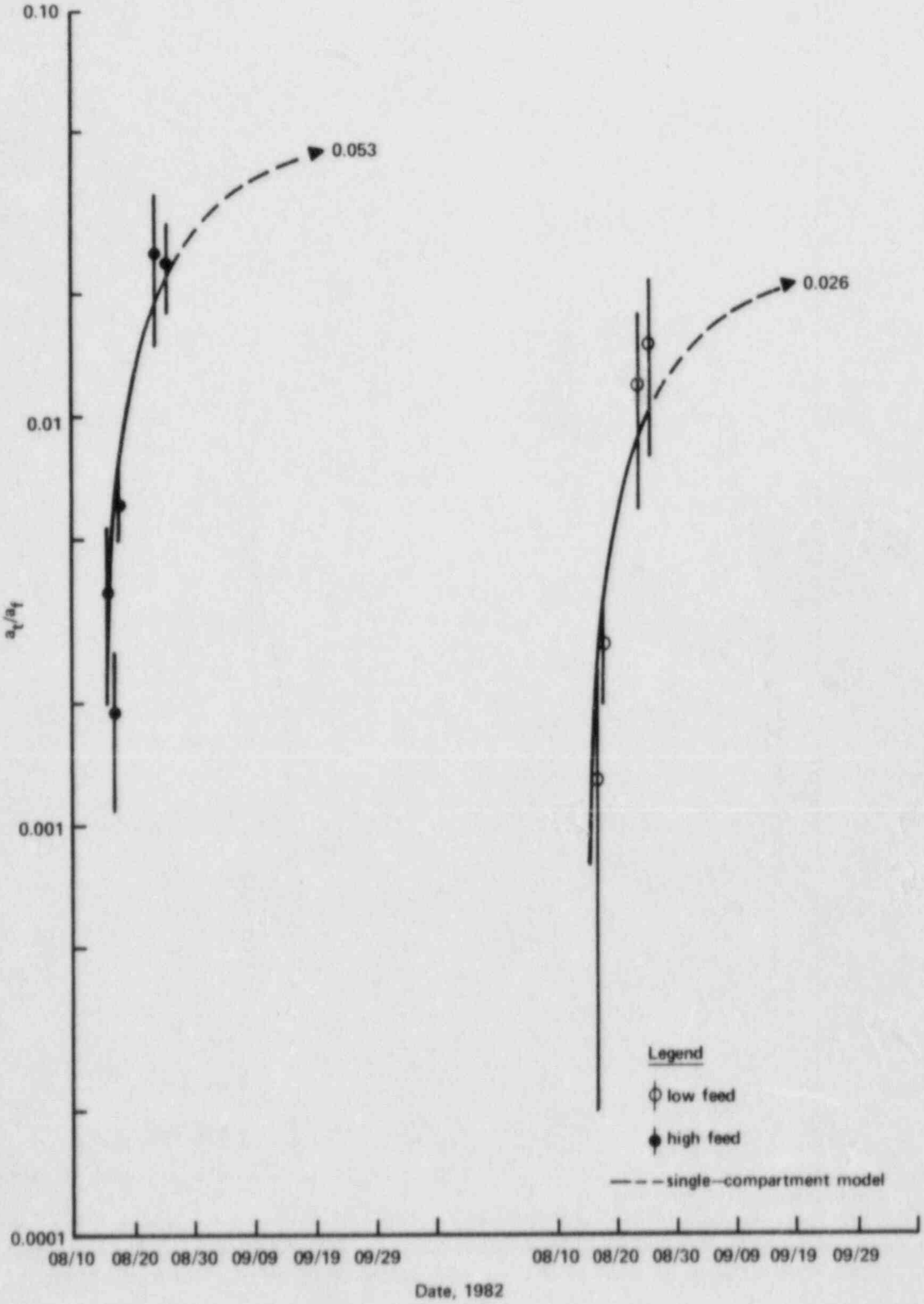


Fig. 2b. Phosphorus–32 specific activity in catfish tissue relative to food: skeleton

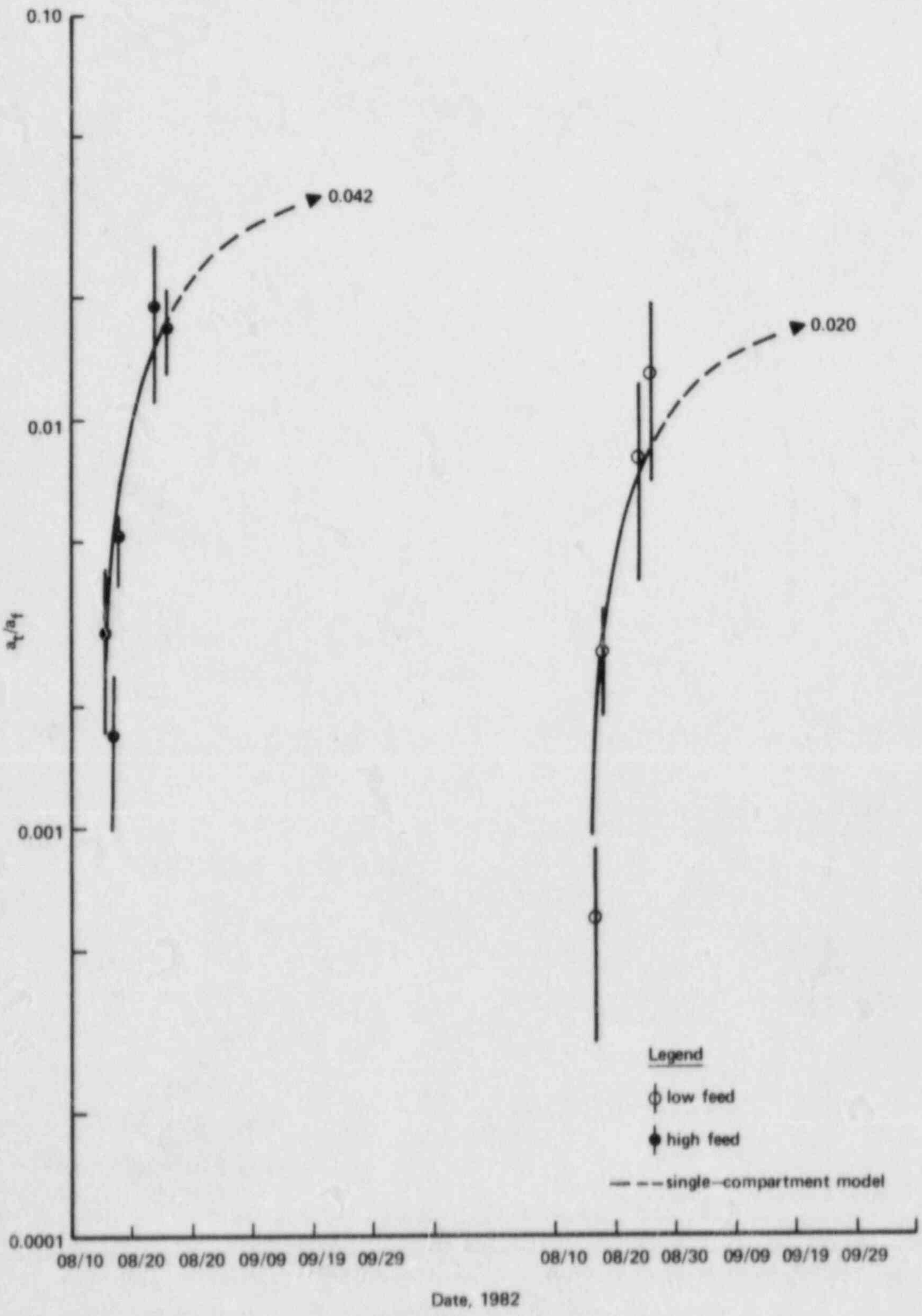


Fig. 2c. Phosphorus–32 specific activity in catfish tissue relative to food: head

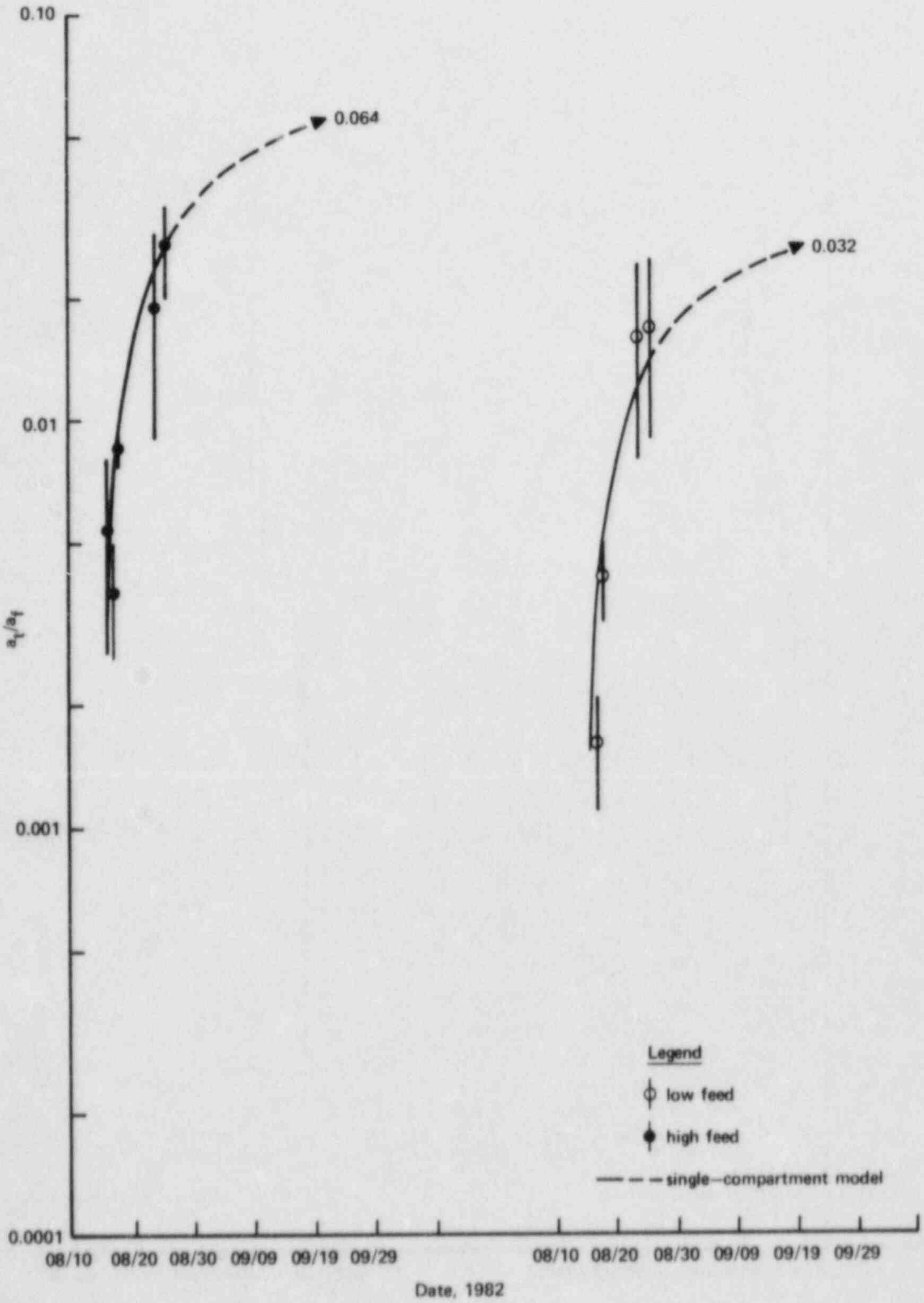


Fig. 2d. Phosphorus–32 specific activity in catfish tissue relative to food: fins

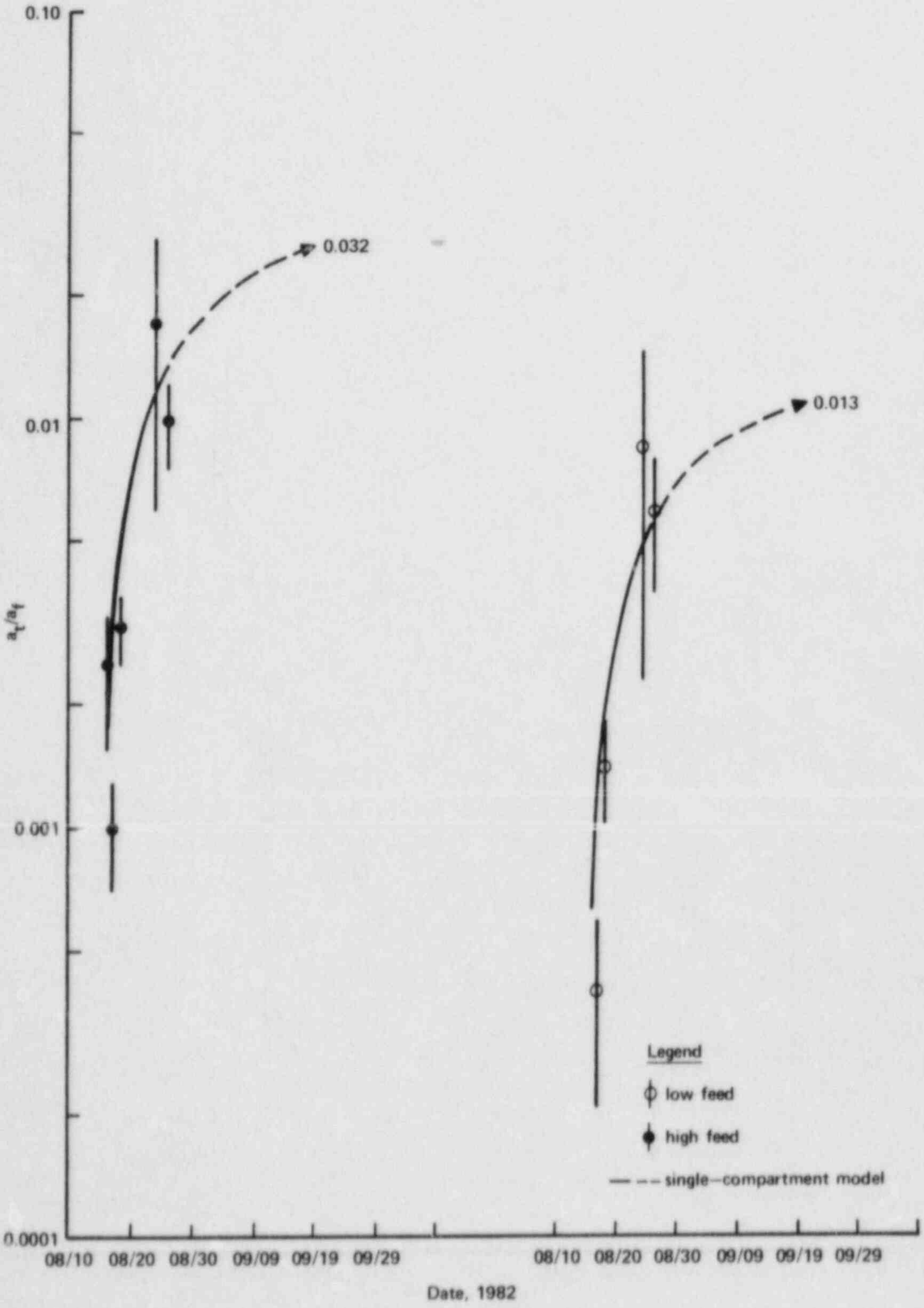


Fig. 2e. Phosphorus–32 specific activity in catfish tissue relative to food: fin spines

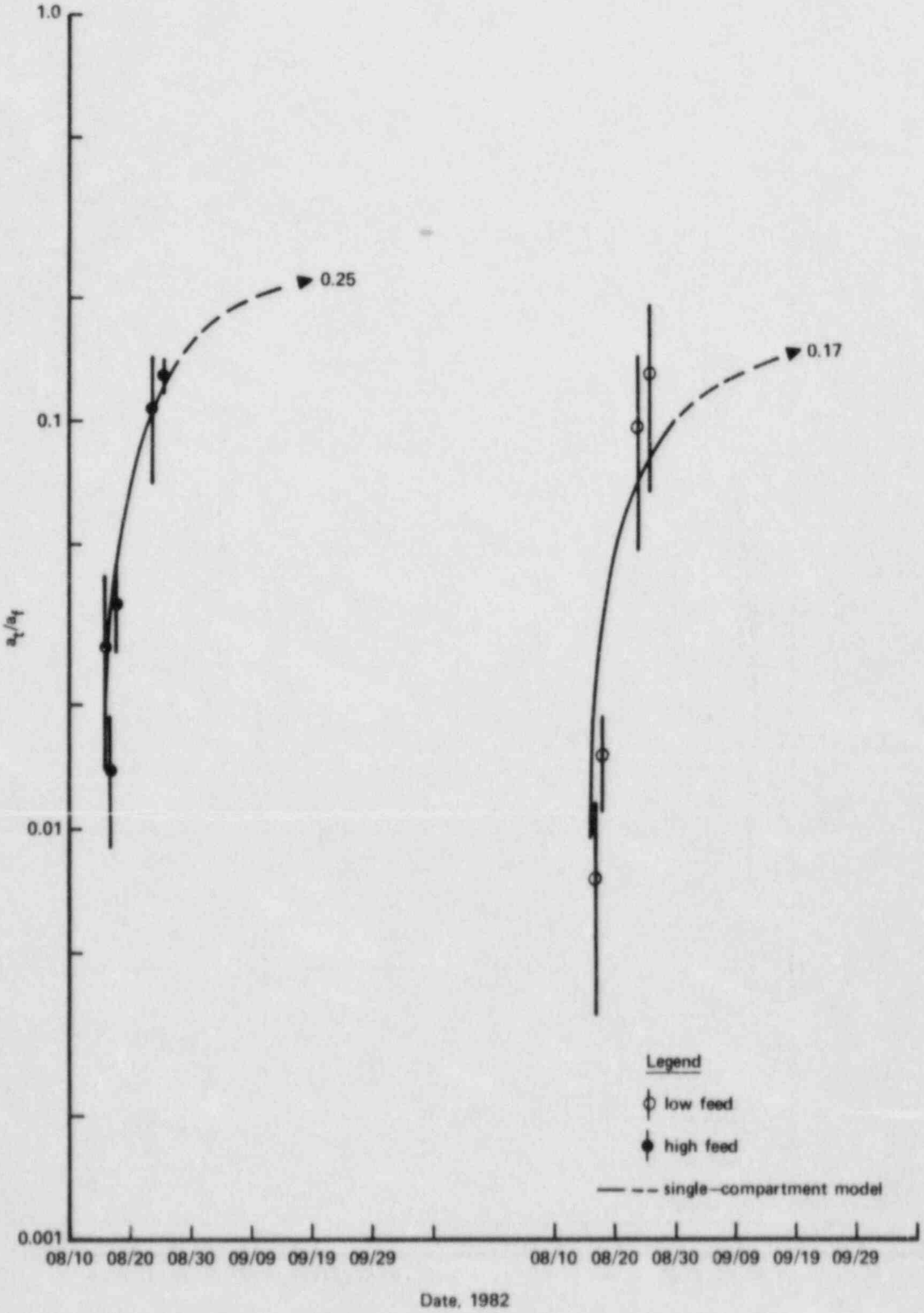


Fig. 21. Phosphorus-32 specific activity in catfish tissue relative to food: skin

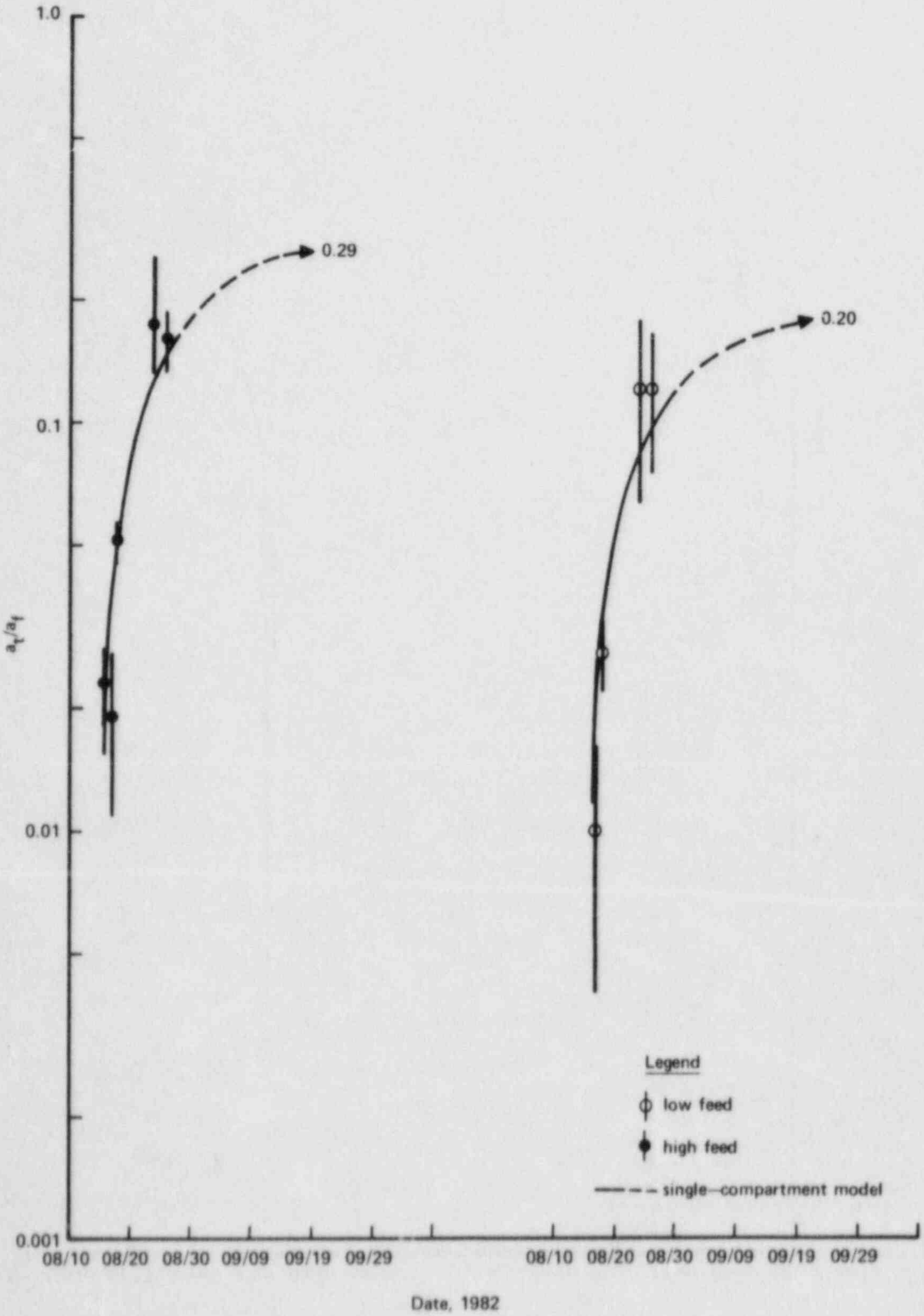


Fig. 2g. Phosphorus–32 specific activity in catfish tissue relative to food: gills

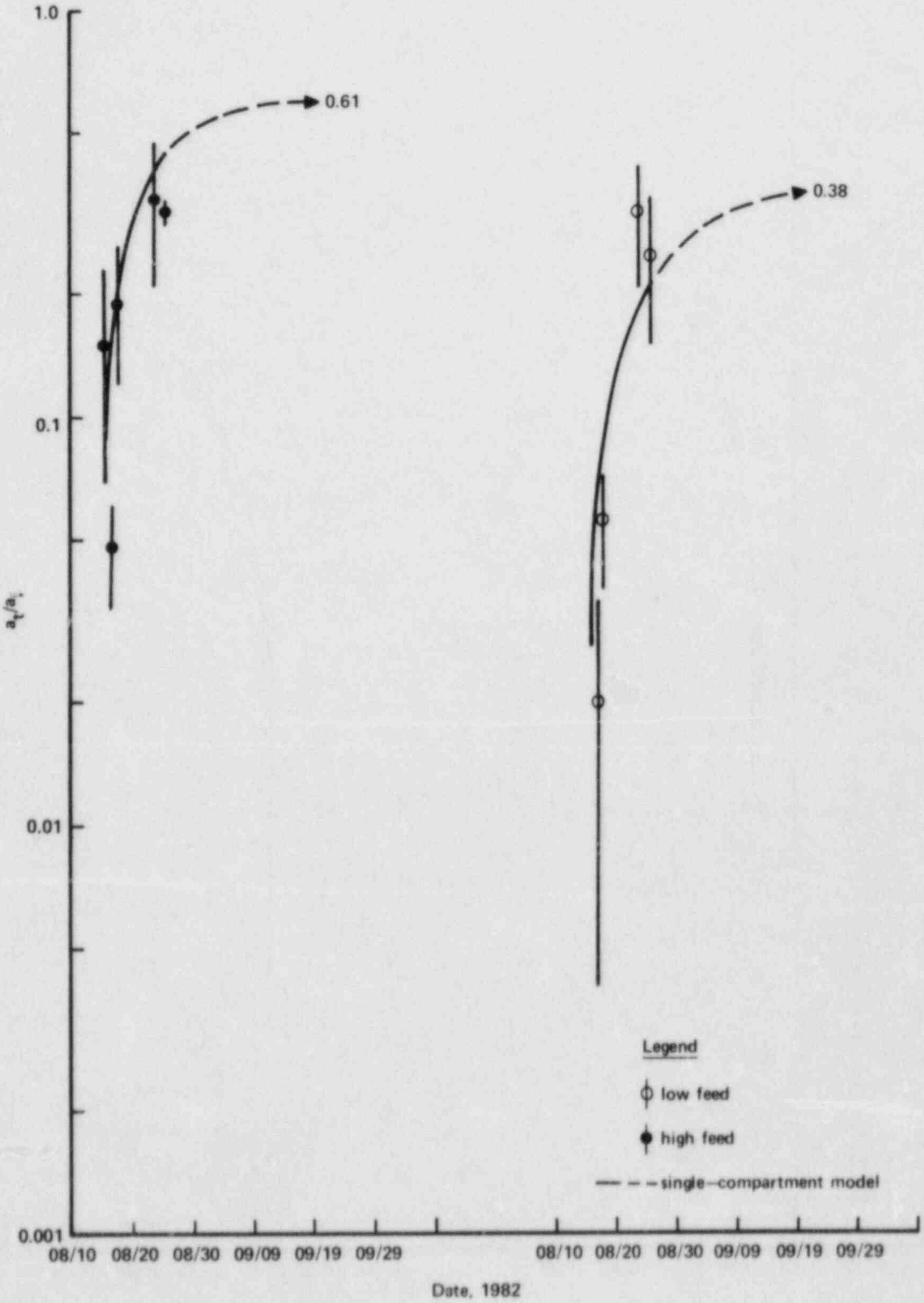


Fig. 2h. Phosphorus–32 specific activity in catfish tissue relative to food: viscera

APPENDICES

A.1-1
P-32 Uptake and Depuration in Bluegill
Muscle

Fish No.(1)	Date of death, 1982 (hr)	Weight,(2) wet	Weight,(2) dry	Weight,(2) ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.(3)	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
761E	09/28	22.5	4.10	277	285	10/12(18)	0.498	33.0	14.7	2.31	6.4
794E	(08)	23.1	3.48	307	326	10/15(05)	0.441	10.6	5.2	2.43	2.1
879E		34.3	6.23	398	314	10/14(21)	0.447	22.5	7.3	2.31	3.2
499W		16.3	2.42	169	315	10/14(23)	0.447	120	82.3	1.93	42.6
708W		30.7	5.53	403	334	10/19(10)	0.360	136	61.5	2.60	23.7
787W		29.1	5.75	347	325	10/14(12)	0.456	231	87.0	2.42	36.0
684E	09/29	42.3	7.74	470	452	11/02(18)	0.189	69.2	43.3	2.16	20.0
859E	(08)	31.8	--	333	443	11/02(17)	0.189	137.	114	2.14	53.3
863E		20.9	4.33	254	457	11/03(01)	0.186	54.4	70.0	2.27	30.8
608W		27.1	5.67	334	458	11/04(14)	0.173	183.	195	2.28	85.5
682W		39.1	7.47	424	444	11/03(11)	0.182	231.	162	2.16	75.0
890W		33.8	6.50	394	571	11/09(13)	0.136	233	243	3.01	80.7
619E	09/30	37.3	6.54	401	503	11/05(19)	0.170	28.0	22.1	2.03	11.1
872E	(08)	39.2	7.52	474	420	10/25(20)	0.291	248	109	2.43	44.9
635E		38.0	7.46	468	433	10/26(01)	0.288	381	174	2.25	77.3
706W		29.2	5.38	347	451	11/03(14)	0.191	204	183	2.63	69.6
704W		32.4	6.61	405	454	11/03(14)	0.191	192	155	2.49	62.3
480W		45.9	9.80	610	415	10/25(18)	0.292	429	160	2.41	66.4
759E	10/06	24.3	3.85	118(6)	532	11/06(18)	0.218	259	244	1.86	131
674E	(08)	20.1	4.05	266	584	11/09(15)	0.190	306	401	2.05	196
762E		28.6	5.94	339	459	11/03(15)	0.254	514	354	1.85	191
613W		33.4	7.25	417	460	11/03(15)	0.254	646	381	2.32	164
680W		22.2	4.73	256	466	11/04(11)	0.244	528	487	2.53	193
792W		32.1	7.12	396	549	11/07(22)	0.206	770	582	2.57	227
699E	10/12	29.9	5.31	357	597	11/10(12)	0.243	1,167	803	2.28	352
784E	(08)	35.7	6.88	455	494	11/04(17)	0.322	2,048	891	2.27	393
733E		21.0	3.59	228	475	11/04(14)	0.325	500	366	2.09	175
488W		34.2	6.90	398	518	11/04(22)	0.319	1,957	897	1.99	451
490W		23.0	4.72	302	586	11/09(16)	0.253	766	658	2.66	247
476W		40.0	8.00	497	523	11/04(22)	0.319	948	371	2.45	151

(1) W fish received twice as much feed as E fish, at same specific activity (2) Wet and dry weight in gram; ashed weight in mg. (3) Duplicate 20-ml aliquots of 100-ml samples were analyzed for P-32 by counting Cherenkov radiation for 50-min when < 200 c/min and for 10-min when > 200 c/min (4) Tail samples were combined with skeleton samples after 10/19 (5) Month 01 is in 1983 (6) Weight appears to be erroneous (7) For actual times of death on 11/09, 11/20, 11/24, 11/30, 12/07, and 12/15, see Appendix A.3

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Muscle

Fish No.	Date of death, 1982 (hr)	Weight, wet	dry	ashed	Sample No.	P-32 Date of counting, 1982 (hr)	decay fraction	net c/min	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
769E	10/19	28.4	6.01	351	613	11/17(11)	0.244	1,044	753	2.35	320
482E	(08)	25.4	5.38	301	617	11/17(13)	0.243	735	595	1.96	304
677E		21.9(6)	2.79	198	556	11/08(08)	0.379	724	436	1.51(6)	289
497W		23.4	4.96	287	555	11/08(08)	0.379	1,640	925	2.56	361
873W		40.2	8.35	416	624	11/17(14)	0.243	2,770	1,418	2.62	541
607W		39.8	8.00	478	627	11/17(15)	0.243	1,770	915	2.64	347
876E	10/26	29.4	5.67	332	673	11/23(13)	0.255	1,121	748	2.18	343
763E	(08)	26.8	5.33	331	654	11/23(11)	0.255	1,118	818	2.34	350
881E		23.6	5.07	300	695	11/24(06)	0.246	177	152	2.63	57.8
785W		33.2	7.05	422	651	11/23(10)	0.256	1,592	937	2.39	392
716W		33.3	7.23	427	647	11/18(14)	0.325	2,660	1,229	1.97	624
875W		40.4	8.90	528	646	11/18(14)	0.325	2,450	933	2.64	353
882E	11/03	22.8	4.37	268	703	11/24(22)	0.351	1,200	750	2.46	305
456E	(08)	24.1	5.20	298	701	11/24(18)	0.354	1,095	642	2.59	248
627E		34.7	6.97	448	795	12/10(11)	0.166	1,427	1,239	2.65	468
858E		38.4	7.86	471	698	11/24(16)	0.356	1,569	574	2.65	217
722E		36.4	7.68	434	702	11/24(20)	0.352	1,452	567	2.28	249
884W		34.5	7.21	435	705	11/25(01)	0.349	1,939	805	2.47	326
672W		25.0	4.53	301	670	11/23(12)	0.375	765	408	2.26	181
679W		34.3	6.51	430	685	11/24(13)	0.358	2,438	993	2.30	406
799E	11/09	28.2	5.51	374	717	11/25(21)	0.448	2,213	875	2.45	357
790E	(08)	41.3	8.91	539	719	11/26(01)	0.444	2,355	642	2.50	257
486E		23.7	4.04	274	715	11/25(18)	0.451	689	323	2.14	151
602W		38.1	8.06	489	785	12/03(14)	0.308	1,334	568	2.36	241
893W		19.5	3.47	267	790	12/10(10)	0.221	1,155	1,342	2.50	537
798W		43.3	8.74	572	718	11/25(01)	0.466	5,069	1,256	2.61	481
899E	11/17	23.3	4.58	301	763	12/02(15)	0.477	1,971	887	2.44	364
713E	(08)	31.2	6.63	412	766	12/02(16)	0.476	2,293	772	2.35	329
880E		28.4	5.49	360	765	12/02(16)	0.476	1,240	459	2.33	197
886W		29.8	5.96	379	759	12/02(14)	0.477	3,781	1,330	2.34	568
622W		41.4	8.63	536	757	12/02(13)	0.477	3,515	890	2.44	365
698W		37.4	7.29	467	826	12/10(24)	0.317	2,024	854	2.38	359

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Muscle

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982(hr)(5)	P-32 decay fraction	P-32 net c/min	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
782E	11/20	34.6	7.31	444	846	12/12(22)	0.334	1,646	712	2.34	304
767E	(08)	48.7	10.52	582	849	12/16(10)	0.282	1,406	512	2.47	207
728E		46.7	10.41	592	848	12/13(01)	0.333	4,081	1,312	1.97	666
715W		47.7	10.71	605	931	12/22(10)	0.211	1,454	722	2.73	265
889W		44.5	10.11	596	1017	12/31(24)	0.133	1,283	1,084	2.66	408
606W		43.2	9.64	548	847	12/12(23)	0.334	1,762	611	1.98	309
477E	11/24	39.4	8.26	483	876	12/16(20)	0.336	1,671	631	2.54	248
738E	(08)	31.3	6.39	431	845	12/12(20)	0.408	3,101	1,214	3.62	335
691E		49.0	10.37	640	881	12/16(22)	0.335	2,467	751	2.41	312
668W		34.1	7.40	438	878	12/16(21)	0.336	1,856	810	2.50	324
717W		22.9	5.00	325	932	12/22(10)	0.256	1,372	1,170	2.72	430
891W		43.5	9.12	583	868	12/16(17)	0.338	1,872	637	2.50	255
637E	11/30	37.0	7.52	450	853	12/16(11)	0.458	1,785	527	2.52	209
721E	(08)	24.7	4.88	316	852	12/16(11)	0.458	854	377	2.54	148
723E		31.5	6.25	385	885	12/16(23)	0.446	1,291	459	2.55	180
892W		56.5	12.12	720	880	12/16(21)	0.449	4,748	935	2.58	362
885W		31.7	7.02	406	877	12/16(20)	0.449	2,101	738	2.64	280
636W		52.2	11.10	670	851	12/16(11)	0.458	3,010	630	2.74	230
730E	12/07	38.7	8.04	478	898	12/18(03)	0.593	1,670	364	2.65	137
871E	(08)	32.7	6.64	377	897	12/18(01)	0.595	652	168	2.33	72.1
705E		30.4	5.41	367	896	12/17(23)	0.598	720	198	2.45	80.8
641W		34.9	7.30	456	900	12/18(09)	0.586	1,664	407	2.63	155
615W		45.6	8.62	527	895	12/17(22)	0.599	1,919	349	2.33	150
735W		32.1	6.71	404	901	12/17(08)	0.616	1,556	393	2.54	155
694E	12/15	24.7	4.44	373	1088	01/14(15)	0.230	236	208	2.44	85.2
485E	(08)	38.4	7.36	498	1025	01/01(14)	0.434	784	235	2.62	89.7
894E		54.1	11.22	716	1089	01/14(15)	0.230	634	255	2.61	97.7
692W		55.0	11.54	677	998	12/30(16)	0.476	1,921	367	2.51	146
854W		57.0	12.62	748	1090	01/14(15)	0.230	643	245	2.72	90.1
630W		35.6	7.63	472	1091	01/14(16)	0.230	353	216	2.50	86.4

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Skeleton

Fish No.(1)	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, /min.mg.
761E	09/28	22.4	6.79	2,470	371	10/20(22)	0.334	89.3	59.7	17.6	3.39
794E	(08)	23.9	6.84	3,300	310	10/14(06)	0.463	34.7	15.7	24.1	0.65
879E		30.0	9.10	2,990	328	10/15(07)	0.439	34.9	13.2	17.5	0.75
499W		23.6	6.79	2,870	329	10/15(11)	0.439	302	146	19.9	7.34
708W		24.3	6.59	2,580	327	10/14(13)	0.456	191	86.2	20.3	4.25
787W		29.7	8.49	2,780	335	10/19(11)	0.360	338	158	15.8	10.0
684E	09/29	32.0	9.39	3,370	418	10/25(19)	0.264	160	94.7	20.0	4.74
859E	(08)	28.5	8.85	3,230	469	11/04(12)	0.173	222	225	20.6	10.9
863E		20.8	6.31	1,540	468	11/03(16)	0.184	120	157	13.9	11.3
608W		21.7	6.79	2,020	467	11/04(12)	0.173	212	282	16.3	17.3
682W		33.7	10.12	2,540	416	10/25(19)	0.264	491	276	14.3	19.3
890W		29.6	8.52	---	484	11/04(14)	0.173	329	321	16.2	19.8
619E	09/30	14.6	--	2,210	453	11/02(20)	0.197	31.4	54.6	22.4	2.44
872E	(08)	27.0	8.81	3.010	417	10/25(19)	0.291	390	248	21.4	11.6
635E		25.1	8.13	2,630	409	10/25(16)	0.293	419	285	21.0	13.6
706W		21.4	6.60	2,650	419	10/25(20)	0.291	306	246	20.4	12.1
704W		19.1	6.84	1,910	398	10/25(15)	0.294	309	275	17.7	15.5
480W		25.1	9.20	3,070	473	11/04(13)	0.182	232	254	23.8	10.7
759E	10/06	24.0	6.22	2,260	572	11/09(13)	0.191	280	305	16.8	18.2
674E	(08)	22.1	6.82	2,380	491	11/04(16)	0.242	520	486	18.9	25.7
762E		26.2	8.27	2,570	471	11/04(12)	0.243	529	415	17.5	23.7
613W		20.9	6.52	1,740	598	11/10(12)	0.182	560	736	15.1	48.7
680W		16.2	5.20	1,390	449	11/03(13)	0.255	743	899	15.6	57.6
792W		22.9	7.48	1,700	567	11/10(10)	0.183	614	733	15.8	46.4
699E	10/12	33.9	9.01	3,400	566	11/09(12)	0.255	1,054	610	18.1	33.7
784E	(08)	32.8	9.35	2,920	541	11/07(09)	0.283	1,720	926	14.3	64.8
733E		22.5	5.59	2,390	447	11/03(12)	0.341	506	330	16.3	20.2
488W		20.9	6.70	1,710	564	11/09(11)	0.255	1,399	1,313	16.4	80.1
490W		19.2	5.83	1,880	548	11/07(21)	0.277	672	632	12.7	49.8
476W		30.4	8.64	3,140	596	11/10(11)	0.244	726	489	18.4	26.6

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Skeleton

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
769E	10/19	23.2	7.15	1,970	554	11/08(07)	0.380	1,539	873	14.0	62.4
482E	(08)	21.4	6.66	1,590	562	11/09(10)	0.360	1,119	726	12.9	56.3
677E		19.9	5.50	2,620	594	11/10(11)	0.343	806	590	23.7	24.9
497W		18.7	5.39	1,290	553	11/08(05)	0.382	1,645	1,151	13.5	85.3
873W		36.9	10.36	2,860	561	11/09(10)	0.360	3,675	1,383	13.7	100.9
607W		39.7	11.81	3,720	592	11/09(16)	0.356	2,444	865	13.9	62.2
876E	10/26	22.4	7.00	2,060	683	11/23(16)	0.254	1,207	1,061	16.3	65.1
763E	(08)	27.5	9.00	3,640	773	12/03(11)	0.158	811	933	26.8	34.8
881E		18.1	5.62	1,650	743	12/02(11)	0.165	194	325	17.5	18.6
785W		30.8	9.37	3,020	687	11/24(14)	0.243	1,449	968	17.3	56.0
716W		34.9	10.56	3,390	688	11/24(14)	0.243	1,981	1,168	17.9	65.3
875W		33.0	10.38	3,320	749	12/02(12)	0.165	1,196	1,098	18.4	59.6
882E	11/03	23.7	7.00	2,630	788	12/10(09)	0.166	689	876	20.4	42.9
456E	(08)	22.7	7.12	1,730	770	12/03(10)	0.232	1,211	1,150	14.0	82.1
627E		33.5	9.83	3,420	787	12/10(09)	0.166	1,295	1,164	18.0	64.7
858E		32.3	9.93	2,680	678	11/23(15)	0.374	1,855	768	14.6	52.6
722E		28.1	8.98	2,050	786	12/10(08)	0.166	802	860	12.5	68.8
884W		25.6	8.05	4,210(6)	771	12/03(11)	0.232	1,326	1,116	14.3	78.0
672W		24.0	6.96	2,890	747	12/02(12)	0.243	633	543	20.5	26.5
679W		34.1	10.31	4,080	793	12/10(11)	0.166	1,131	1,002	21.3	47.0
799E	11/09	24.3	7.36	2,630	730	11/26(18)	0.430	2,023	968	20.0	48.4
790E	(08)	24.5	8.47	2,090	724	11/26(09)	0.438	2,414	1,126	16.2	69.5
486E		26.4	8.07	3,280	767	12/03(09)	0.310	643	393	20.1	20.0
602W		27.8	9.47	2,300	731	11/26(20)	0.427	1,765	743	15.2	48.8
893W		24.2	8.32	3,750	768	12/03(10)	0.310	1,462	974	29.7	32.8
798W		35.2	11.03	3,450	733	11/26(23)	0.425	3,807	1,272	20.2	63.0
899E	11/17	29.7	8.31	2,810	822	12/10(17)	0.322	2,013	1,052	18.2	57.8
713E	(08)	18.7	6.02	1,610	824	12/10(21)	0.320	1,679	1,403	17.3	81.1
880E		25.4	7.64	2,860	817	12/10(15)	0.323	1,002	611	21.1	29.0
886W		31.9	9.26	3,000	828	12/11(16)	0.308	3,197	1,627	18.8	86.5
622W		30.6	9.06	2,520	835	12/12(04)	0.299	2,802	1,531	15.0	102.0
698W		31.0	9.07	3,200	816	12/10(14)	0.323	2,083	1,040	19.0	54.7

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Skeleton

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
782E	11/20	37.5	10.08	3,130	858	12/16(13)	0.281	1,443	685	16.7	41.0
767E	(08)	33.8	10.18	3,100	1013	12/31(18)	0.134	654	722	19.7	36.6
728E		34.1	10.26	3,290	1016	12/31(23)	0.133	1,038	1,144	16.8	68.1
715W		31.1	10.26	3,090	832	12/11(22)	0.351	1,850	847	17.7	47.9
889W		40.0	12.00	3,480	834	12/12(02)	0.348	3,993	1,434	16.7	85.9
606W		52.8	14.51	3,990	857	12/16(13)	0.281	3,028	1,020	15.3	66.6
477E	11/24	30.8	9.68	2,860	875	12/16(20)	0.336	1,419	686	17.0	40.4
738E	(08)	23.0	7.38	2,870	856	12/16(12)	0.341	989	630	23.3	27.0
691E		29.7	9.52	3,160	936	12/22(12)	0.255	1,374	907	21.7	41.8
668W		37.7	11.59	3,640	855	12/16(12)	0.341	1,809	704	21.1	33.4
717W		26.7	8.41	2,740	864	12/16(15)	0.339	2,037	1,125	18.8	59.8
891W		26.0	8.18	2,830	907	12/18(18)	0.306	1,076	676	19.1	35.4
637E	11/30	30.7	9.25	2,930	1043	01/07(12)	0.157	535	555	22.0	25.2
721E	(08)	24.0	7.68	2,890	866	12/16(16)	0.452	677	312	22.2	14.1
723E		25.4	7.93	2,650	862	12/16(14)	0.456	1,040	449	17.6	25.5
892W		45.2	14.97	4,300	867	12/16(17)	0.452	4,706	1,152	16.1	71.6
885W		20.9	6.65	1,460	939	12/22(12)	0.341	1,673	1,175	12.4	94.8
636W		30.5	10.21	3,440	1035	01/02(06)	0.213	1,025	788	19.1	41.3
730E	12/07	26.0	7.97	2,420	1006	12/31(06)	0.314	826	506	14.4	35.1
871E	(08)	26.1	7.77	2,210	966	12/23(10)	0.459	523	218	15.0	14.5
705E		30.0	8.98	3,570	987	12/23(13)	0.456	444	162	19.2	8.44
641W		21.4	6.64	1,840	1000	12/30(20)	0.320	789	576	15.3	37.6
615W		28.1	8.54	3,160	979	12/23(12)	0.457	875	341	19.9	17.1
735W		27.3	8.31	1,960	1002	12/30(24)	0.318	1,170	674	14.4	46.8
694E	12/15	26.1	7.38	3,140	1083	01/07(15)	0.323	299	177	21.3	8.31
485E	(08)	33.1	10.08	3,890	1026	01/01(16)	0.432	600	210	24.3	8.64
894E		37.4	11.21	3,550	992	12/30(07)	0.484	907	251	18.8	13.4
692W		39.1	12.26	3,700	1030	01/01(22)	0.426	1,089	327	17.7	18.5
854W		28.3	9.67	2,490	993	12/30(08)	0.483	1,069	391	16.1	24.3
630W		26.0	8.11	1,660(6)	1102	01/14(18)	0.229	337	283	12.1	23.4

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Viscera

Fish No.(1)	Date of death, 1982 (hr)	Weight, wet	dry	ashed	Sample No.	P-32 Date of counting, 1982 (hr)	decay fraction	net c/m(2)	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
761E	09/28	8.4	1.20	104	305	10/13(13)	0.481	747	92.4	2.08	44.4
794E	(08)	6.6	1.08	128(6)	288	10/12(22)	0.493	66.2	102	2.37	43.0
879E		11.2	2.54	136	343	10/20(00)	0.349	95.6	122	2.28	53.5
499W		10.5	1.33	113	301	10/13(12)	0.481	2,515	2,490	1.61	1,546
708W		10.9	1.55	119	298	10/13(10)	0.481	3,119	2,970	1.77	1,677
787W		16.3	3.56	201	320	10/14(11)	0.458	1,855	1,242	2.46	504
684E	09/29	8.6	1.55	101	410	10/25(17)	0.279	377	786	1.99	395
859E	(08)	13.4	1.80	126	374	10/21(13)	0.341	1,518	1,650	1.42	1,162
863E		5.7	0.97	60.0	406	10/25(16)	0.279	253	795	1.77	449
608W		7.2	1.30	68.9	377	10/21(14)	0.341	783	1,595	1.62	985
682W		9.4	2.60	82.8	368	10/21(13)	0.341	1,071	1,671	1.44	1,160
890W		11.3	1.61	110	405	10/25(16)	0.279	1,374	2,180	1.67	1,305
619E	09/30	6.4	1.34	67.2	403	10/21(11)	0.360	84.6	184	2.18	84.4
872E	(08)	11.1	1.79	128	381	10/25(12)	0.295	1,596	2,440	1.68	1,452
635E		11.5	1.75	140	375	10/21(14)	0.358	2,046	2,480	2.42	1,025
706W		12.1	1.71	118	404	10/25(16)	0.293	2,390	3,370	1.68	2,006
704W		10.0	3.13	88.7	380	10/25(11)	0.295	1,623	2,750	1.34	2,050
480W		12.0	2.42	116	369	10/21(13)	0.358	3,077	3,580	1.54	2,320
759E	10/06	5.0	0.83	69.4	465	11/03(16)	0.253	1,040	4,110	2.12	1,939
674E	(08)	7.9	1.15	90.2	462	11/03(16)	0.253	1,392	3,480	1.78	1,955
762E		6.7	1.30	86.9	606	11/17(11)	0.130	458	2,630	2.60	1,012
613W		5.6	0.72	---	602	11/10(13)	0.182	770	3,780	2.22	1,702
680W		4.6	1.10	55.4	485	11/04(14)	0.242	1,023	4,600	2.14	2,150
792W		7.2	2.64	76.1	488	11/04(14)	0.242	1,485	4,260	1.93	2,210
699E	10/12	8.7	1.50	126	510	11/04(20)	0.322	1,570	2,800	2.87	976
784E	(08)	8.9	1.68	105	577	11/09(14)	0.254	1,198	2,650	2.19	1,210
733E		4.3	0.65	57.2	516	11/04(21)	0.322	496	1,791	2.14	837
488W		5.9	1.93	63.3	580	11/09(14)	0.254	925	3,090	2.07	1,493
490W		7.0	1.35	73.6	513	11/04(21)	0.322	1,388	3,080	1.91	1,613
476W		11.4	1.61	146	537	11/07(02)	0.287	1,590	2,430	1.51	1,609

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Viscera

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
769E	10/19	6.3	1.41	71.4	615	11/17(12)	0.243	596	1,947	2.27	858
482E	(08)	5.3	1.63	53.1	614	11/17(12)	0.243	385	1,485	1.76	844
677E		6.2	0.85	84.6	625	11/17(14)	0.242	294	980	2.28	430
497W		6.5	1.32	74.6	610	11/17(11)	0.243	695	2,200	1.81	1,215
873W		12.1	2.17	151	622	11/17(14)	0.242	1,418	2,420	2.01	1,204
607W		14.4	2.30	162	605	11/10(13)	0.341	2,256	2,300	1.90	1,211
876E	10/26	7.0	1.53	85.5	692	11/24(15)	0.242	1,213	3,580	2.42	1,479
763E	(08)	11.7	1.85	158	699	11/24(16)	0.242	1,468	2,590	2.55	1,016
881E		3.9	0.84	44.9	700	11/24(16)	0.242	240	1,271	2,45	519
785W		11.7	1.98	138	713	11/25(14)	0.231	1,428	2,640	2.25	1,173
716W		11.1	1.98	127	640	11/18(13)	0.325	1,847	2,560	2.13	1,202
875W		9.2	1.92	114	638	11/18(12)	0.325	1,905	3,180	2.22	1,432
882E	11/03	8.1	1.30	86.3	779	12/03(13)	0.231	1,187	3,170	2.06	1,539
456E	(08)	4.0	0.95	32.9	775	12/03(12)	0.231	348	1,833	2.06	890
627E		8.0	1.49	118	804	12/10(12)	0.165	679	2,570	2.86	899
858E		8.0	2.19	68.5	780	12/03(13)	0.231	799	2,160	1.60	1,350
722E		7.3	2.25	56.3	736	12/02(10)	0.243	305	860	0.62(6)	1,387
884W		6.4	1.53	77.8	796	12/10(11)	0.165	626	2,960	2.19	1,352
672W		8.8	1.16	85.9	776	12/03(12)	0.231	814	2,000	1.99	1,005
679W		9.0	1.65	114	778	12/03(13)	0.231	1,456	3,500	2.70	1,296
799E	11/09	6.8	1.29	74.5	806	12/10(13)	0.220	907	3,040	2.57	1,183
790E	(08)	7.3	2.67	58.2	805	12/10(13)	0.220	608	1,895	1.80	1,053
486E		6.4	1.03	64.6	761	12/02(15)	0.323	645	1,543	1.96	787
602W		7.5	3.61(6)	55.2	762	12/02(15)	0.323	614	1,268	1.61	788
893W		6.3	1.09	64.9	812	12/10(14)	0.220	853	3,080	2.15	1,433
798W		9.3	2.12	107	807	12/10(13)	0.220	1,144	2,800	2.63	1,065
899E	11/17	6.9	1.31	79.4	818	12/12(15)	0.293	1,414	3,500	2.55	1,373
713E	(08)	5.5	1.18	56.3	821	12/12(16)	0.293	976	3,030	1.87	1,620
880E		7.1	1.37	104	1019	01/01(02)	0.114	269	1,662	3.21	518
886W		14.7	2.49	154	1018	01/01(01)	0.115	851	2,520	2.05	1,229
622W		10.6	2.23	108	815	12/10(14)	0.324	3,042	2,970	2.00	1,485
698W		9.0	1.73	110	1020	01/01(04)	0.114	573	2,790	2.55	1,094

A.1-1 cont'd

P-32 Uptake and Depuration in Bluegill

Viscera

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
782E	11/20	8.7	1.62	95.6	947	12/22(13)	0.210	639	1,749	2.58	678
767E	(08)	8.6	2.08	92.3	882	12/16(22)	0.275	668	1,412	2.19	645
728E		8.1	1.74	73.5	948	12/22(13)	0.210	629	1,849	2.35	786
715W		8.4	1.94	87.9	1022	01/01(09)	0.131	391	1,777	2.32	766
889W		8.1	1.88	101.5	954	12/22(14)	0.209	578	1,707	2.87	595
606W		8.7	2.30	81.8	953	12/22(14)	0.209	665	1,829	2.16	847
477E	11/24	7.8	2.04	83.7	1031	01/01(24)	0.153	284	1,190	2.34	509
738E	(08)	6.0	1.16	74.6	1041	01/07(11)	0.118	172	1,215	2.43	500
691E		9.6	2.03	107.5	1040	01/07(11)	0.118	283	1,249	2.61	479
668W		9.1	1.78	97.0	943	12/22(13)	0.255	641	1,381	2.59	533
717W		5.8	1.30	70.8	942	12/22(12)	0.255	548	1,853	3.04	610
891W		8.1	1.68	94.5	1032	01/02(02)	0.153	362	1,461	2.68	545
637E	11/30	8.7	1.58	89.5	962	12/22(16)	0.339	397	673	2.55	264
721E	(08)	5.1	0.90	61.4	892	12/16(06)	0.461	285	605	3.00	202
723E		6.1	1.17	70.6	890	12/16(23)	0.469	400	735	3.02	243
892W		16.2	4.19	179.1	964	12/23(10)	0.326	896	847	2.77	306
885W		5.3	1.89	46.5	961	12/22(15)	0.339	243	677	2.03	333
636W		12.4	2.24	125	963	12/23(09)	0.326	607	750	2.34	321
730E	12/07	5.0	1.21	56.5	910	12/18(21)	0.573	272	475	2.66	179
871E	(08)	6.7	1.63	78.0	984	12/25(01)	0.424	151	266	2.52	106
705E		9.1	1.51	107.0	981	12/24(22)	0.426	205	264	2.37	111
641W		5.7	1.39	63.8	982	12/23(13)	0.456	234	450	2.84	158
615W		8.6	1.36	88.0	972	12/23(11)	0.458	373	473	2.77	171
735W		5.2	1.22	49.7	983	12/24(24)	0.424	192	435	2.31	188
694E	12/15	12.0	1.64	144.0	997	12/30(15)	0.476	162	142	2.23	63.7
485E	(08)	11.3	1.93	135.0	999	12/30(18)	0.474	183	171	2.37	72.2
894E		13.8	2.84	187.0	1024	01/01(12)	0.435	180	150	2.69	55.8
692W		13.9	2.96	148.0	1080	01/07(15)	0.323	190	211	2.37	89.0
854W		9.6	3.02	94.5	1023	01/01(10)	0.437	158	188	2.08	90.4
630W		7.6	2.66	69.4	989	12/30(02)	0.489	112	151	2.13	70.9

A.1-1 cont'd
P-23 Uptake and Depuration in Bluegill
Scales and Skin

Fish No.(1)	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
761E	09/28	15.2	5.39	2,160	309	10/14(04)	0.465	113	79.9	35.3	2.26
794E	(08)	14.6	6.82	3,570	319	10/15(02)	0.443	37.6	29.1	61.2	0.48
879E		18.1	7.02	2,800	321	10/15(04)	0.443	32.4	20.2	40.7	0.50
499W		18.0	7.21	3,020	322	10/14(11)	0.456	215	131	40.4	3.24
708W		12.7	5.91	2,840	370	10/19(20)	0.353	134	149	49.8	2.99
787W		19.2	8.14	3,280	318	10/14(11)	0.456	340	194	38.3	5.07
684E	09/29	19.8	7.68	3,150	388	10/25(12)	0.281	150	135	37.6	3.59
859E	(08)	17.1	7.00	3,600	396	10/25(14)	0.281	283	294	43.8	6.71
863E		12.1	4.25	983(6)	481	11/04(03)	0.176	79.6	187	20.9	8.95
608W		14.6	6.00	1,960	474	11/04(13)	0.173	146	289	33.4	8.65
682W		18.1	6.45	2,090	399	10/25(15)	0.279	352	349	32.1	10.9
890W		16.3	6.44	2,610	608	11/16(20)	0.094	148	483	33.3	14.5
619E	09/30	12.6	4.85	1,720	501	11/05(17)	0.171	29.1	67.5	31.2	2.16
872E	(08)	20.3	8.39	3,330	389	10/25(12)	0.295	356	297	37.0	8.03
635E		16.6	7.34	3,010	414	10/25(18)	0.292	411	424	44.5	9.53
706W		17.2	7.03	2,800	411	10/25(18)	0.292	328	327	37.0	8.63
704W		14.0	5.38	1,660	401	10/25(15)	0.293	235	286	29.4	9.73
480W		18.3	7.85	3,250	432	10/25(24)	0.288	348	330	37.2	8.87
759E	10/06	12.0	6.07	2,680	568	11/09(12)	0.191	248	541	57.5	9.41
674E	(08)	10.6	4.30	1,650	595	11/10(11)	0.182	365	946	28.0	33.8
762E		10.3	5.10	2,150	492	11/04(16)	0.241	373	751	43.9	17.1
613W		8.0	3.66	1,270	583	11/09(14)	0.190	445	1,464	28.3	51.7
680W		8.0	3.11	838	531	11/06(16)	0.219	442	1,261	22.5	56.0
792W		8.8	3.87	1,270	569	11/09(12)	0.191	384	1,142	37.6	30.4
699E	10/12	16.7	8.21	3,810	546	11/07(18)	0.278	1,032	1,111	42.9	25.9
784E	(08)	14.1	6.23	2,970	502	11/04(19)	0.320	1,244	1,379	49.5	27.9
733E		12.8	5.29	1,940	570	11/09(13)	0.255	256	392	42.2	9.29
488W		11.4	4.76	1,520	522	11/04(22)	0.319	1,181	1,624	30.0	54.1
490W		9.5	3.79	1,440	565	11/09(11)	0.256	536	1,102	25.5	43.2
476W		15.8	8.06	3,620	539	11/07(06)	0.285	934	1,037	54.7	19.0

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Scales and Skin

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
769E	10/19	9.0	4.17	1,510	630	11/17(16)	0.254	690	1,509	31.5	47.9
482E	(08)	7.6	3.48	1,090	652	11/23(11)	0.182	326	1,178	37.1	31.8
677E		16.1	6.57	2,960	649	11/18(15)	0.230	434	586	43.7	13.4
497W		6.6	3.03	1,050	633	11/18(11)	0.232	648	2,120	35.7	59.4
873W		13.9	6.28	2,560	653	11/23(11)	0.182	1,088	2,150	44.4	48.4
607W		16.9	7.74	3,110	657	11/23(12)	0.182	881	1,432	41.4	34.6
876E	10/26	8.0	3.96	1,540	802	12/10(12)	0.112	393	2,190	41.2	53.2
763E	(08)	16.0	7.23	3,220	680	11/23(15)	0.254	1,102	1,356	47.0	28.9
881E		7.5	3.33	1,130	679	11/23(15)	0.254	246	646	36.6	17.7
785W		14.7	6.63	2,680	681	11/23(16)	0.254	1,080	1,446	42.3	27.6
716W		15.5	7.76	3,400	689	11/24(14)	0.243	1,137	1,509	53.0	28.5
875W		16.6	7.43	3,020	684	11/24(13)	0.243	1,226	1,520	39.0	39.0
882E	11/03	13.8	5.64	2,420	723	11/26(07)	0.328	996	1,100	43.6	25.2
456E	(08)	8.8	3.40	940	720	11/26(02)	0.331	803	1,378	30.7	44.9
627E		17.8	7.56	3,390	746	12/02(11)	0.244	1,321	1,521	41.2	36.9
858E		18.5	6.95	2,290	791	12/10(10)	0.166	729	1,187	30.2	39.3
722E		9.6	4.23	1,350	774	12/03(12)	0.231	636	1,434	36.4	39.4
884W		11.0	4.78	1,810	789	12/10(09)	0.166	651	1,783	41.5	43.0
672W		12.5	5.94	2,820	722	11/26(06)	0.329	621	765	49.5	15.5
679W		17.4	8.28	3,770	677	11/23(14)	0.374	1,943	1,493	46.0	32.5
799E	11/09	12.1	5.22	2,180	728	11/26(14)	0.434	1,548	1,474	41.6	35.4
790E	(08)	10.7	5.03	1,650	726	11/26(11)	0.436	1,590	1,705	39.6	43.1
486E		15.9	7.16	3,100	734	11/27(01)	0.423	921	684	45.3	15.1
602W		12.2	5.62	1,800	729	11/26(16)	0.431	1,100	1,046	37.9	27.6
893W		13.1	6.57	3,190	758	12/02(14)	0.324	1,112	1,308	51.8	25.3
798W		15.6	7.24	3 060	732	11/26(21)	0.427	2,605	1,955	39.2	49.9
899E	11/17	11.7	5.31	2,310	825	12/10(22)	0.319	1,154	1,546	44.5	34.7
713E	(08)	8.1	3.37	990	819	12/10(15)	0.323	960	1,835	29.3	62.6
880E		13.1	5.55	2,440	829	12/11(18)	0.306	717	894	41.9	21.3
886W		16.5	6.82	3,110	831	12/11(21)	0.305	2,529	1,631	46.1	35.4
622W		11.0	4.40	1,670	823	12/10(19)	0.320	1,696	2,410	41.3	58.4
698W		14.3	6.35	2,930	827	12/11(02)	0.315	1,390	1,543	46.7	33.0

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Scales and Skin

Fish No.	Date of death, 1982 (hr)	Weight, wet	dry	ashed	Sample No.	P-32: Date of counting, 1982 (hr)	decay fraction	net c/min	c/min.g. wet	p, mg/g wet	P-32/P, c/min.mg.
782E	11/20	16.8	6.69	2,850	861	12/16(14)	0.280	1,051	1,117	45.1	24.8
767E	(08)	15.9	6.53	2,070	1011	12/31(14)	0.135	533	1,242	31.7	39.2
728E		15.9	7.18	3,280	950	12/22(14)	0.209	1,254	1,887	45.8	41.2
715W		14.2	6.45	2,760	830	12/11(19)	0.353	1,400	1,396	43.3	32.2
889W		21.1	9.08	3,920	833	12/11(24)	0.350	2,783	1,884	45.9	41.0
606W		23.4	9.05	3,080	860	12/16(14)	0.280	2,105	1,606	37.2	43.2
477E	11/24	15.8	6.77	2,680	1037	01/02(10)	0.150	474	1,000	37.3	26.8
738E	(08)	9.8	4.65	2,070	925	12/22(09)	0.257	565	1,122	50.1	22.4
691E		13.5	6.14	2,620	1033	01/02(03)	0.152	551	1,343	44.2	30.0
668W		18.2	7.86	3,300	865	12/16(15)	0.339	1,346	1,091	42.2	25.9
717W		14.4	5.80	2,250	879	12/16(21)	0.336	1,480	1,529	40.8	37.5
891W		15.0	6.65	2,800	1036	01/02(08)	0.151	525	1,159	41.7	27.8
637E	11/30	15.2	6.50	2,480	935	12/22(11)	0.342	757	729	39.2	18.6
721E	(08)	12.8	6.02	2,690	863	12/16(15)	0.453	600	517	50.0	10.3
723E		14.0	6.29	2,510	906	12/18(16)	0.411	793	689	45.8	15.0
892W		18.4	8.86	3,900	859	12/16(13)	0.456	2,813	1,677	57.3	29.3
885W		12.0(6)	3.33	1,080	905	12/18(14)	0.412	1,249	1,263	23.9(6)	52.8
636W		13.2	6.60	2,820	934	12/22(11)	0.342	1,084	1,202	52.6	22.9
730E	12/07	12.2	4.83	2,000	893	12/17(18)	0.603	1,014	689	43.0	16.0
871E	(08)	13.4	4.55	1,660	899	12/18(14)	0.592	486	306	33.0	9.27
705E		16.3	7.50	3,680	921	12/19(17)	0.548	506	283	61.2	4.62
641W		8.0	3.08	1,130	902	12/18(10)	0.584	778	833	39.3	21.2
615W		12.0	5.26	2,550	894	12/17(20)	0.601	775	537	56.0	9.59
735W		8.9	3.03	890	903	12/18(11)	0.584	884	850	30.4	28.0
694E	12/15	15.2	6.50	3,280	994	12/30(10)	0.481	442	302	48.6	6.21
485E	(08)	20.5	8.53	3,790	1010	12/31(13)	0.456	665	356	46.5	7.66
894E		18.1	7.19	2,980	995	12/30(12)	0.479	573	330	39.0	8.46
692W		19.4	7.85	3,140	1009	12/31(11)	0.458	895	504	38.0	13.3
854W		15.9	6.13	2,040	996	12/30(14)	0.477	774	510	29.9	17.0
630W		12.6	4.48	1,400	1027	01/01(17)	0.431	406	374	27.9	13.4

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Gills

Fish No.(1)	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
761E	09/28	0.64	0.096	7.7	296	10/13(06)	0.486	8.4	135	3.93	34.4
794E	(08)	1.06	0.161	18.5	300	10/13(23)	0.469	<2.2	<22	3.79	< 6
879E		0.76	0.138	10.0	339	10/19(18)	0.354	<2.2	<41	3.00	<14
499W		0.91	0.133	9.3	289	10/12(23)	0.493	48.1	536	2.00	268
708W		0.49	0.081	9.3	313	10/14(19)	0.449	12.7	289	2.38	121
787W		0.68	0.121	16.1	302	10/14(00)	0.469	44.6	699	3.17	221
684E	09/29	0.73	0.102	9.5	376	10/21(01)	0.348	13.6	268	2.49	108
859E	(08)	0.74	0.104	11.5	378	10/21(03)	0.348	37.3	724	2.22	326
863E		0.37	0.066	3.8	476	11/03(20)	0.179	3.4	257	2.84	90.5
608W		0.73	0.107	6.5	603	11/11(03)	0.126	13.1	712	1.92	371
682W		0.71	0.117	6.0	367	10/19(19)	0.370	35.5	676	2.08	325
890W		0.71	0.097	5.3	477	11/03(21)	0.179	17.2	677	1.73	391
619E	09/30	0.51	0.169	10.5	412	10/22(17)	0.338	<2.2	<64	2.29	<28
872E	(08)	1.11	0.157	16.9	373	10/21(00)	0.367	58.7	720	2.33	309
635E		0.74	---	6.7	366	10/19(17)	0.390	47.6	825	2.32	356
706W		1.11	0.177	6.4	379	10/21(18)	0.354	56.2	715	2.09	342
704W		0.80	0.119	10.0	402	10/22(09)	0.344	44.9	816	2.70	302
480W		1.05	0.153	10.0	384	10/21(23)	0.351	70.5	956	2.60	368
759E	10/06	0.44	0.073	3.7	575	11/09(22)	0.187	16.8	1,021	2.45	417
674E	(08)	0.36	0.068	4.6	456	11/02(23)	0.262	37.2	1,972	2.83	697
762E		0.63	0.110	7.2	508	11/05(20)	0.228	52.2	1,817	2.63	691
613W		0.52	0.088	6.0	574	11/09(20)	0.188	36.2	1,851	3.01	615
680W		0.55	0.087	4.7	464	11/03(04)	0.260	55.6	1,944	2.28	853
792W		0.58	0.102	6.4	470	11/03(18)	0.252	51.8	1,772	2.34	757
699E	10/12	0.97	0.114	8.0	578	11/10(01)	0.249	84.4	1,747	1.83	955
784E	(08)	0.79	0.120	12.5	550	11/07(24)	0.274	98.8	2,280	2.64	864
733E		0.78	0.087	5.2	576	11/09(23)	0.250	24.6	631	1.80	351
488W		0.69	0.102	5.4	581	11/10(04)	0.247	80.6	2,360	45.7 (6)	---
490W		0.48	0.070	5.2	551	11/08(02)	0.274	44.9	1,707	2.28	749
476W		0.76	0.102	7.2	573	11/09(18)	0.252	41.4	1,081	2.18	496

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Gills

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
769E	10/19	0.48	0.058	---	604	11/11(04)	0.315	58.0	1,918	2.10	913
482E	(08)	0.46	0.080	6.7	588	11/10(17)	0.338	46.7	1,501	2.51	598
677E		0.77	0.105	9.0	558	11/08(10)	0.378	68.2	1,172	1.67	702
497W		0.44	0.078	5.7	590	11/10(20)	0.335	68.9	2,340	2.52	929
873W		0.67	0.101	8.3	591	11/10(22)	0.335	119	2,650	2.30	1,152
607W		1.18	0.163	13.8	557	11/08(09)	0.378	192	2,150	1.64	1,311
876E	10/26	0.37	0.074	6.7	696	11/24(08)	0.245	32.0	1,765	2.80	630
763E	(08)	0.71	0.135	10.9	694	11/24(04)	0.248	70.4	1,999	2.83	706
881E		0.26	0.059	6.9(6)	693	11/24(03)	0.248	11.2	868	4.16	210
785W		0.88	0.118	7.3	711	11/25(11)	0.232	53.7	1,315	1.46	901
716W		0.65	0.127	12.5	741	12/01(20)	0.170	48.2	2,180	3.76	580
875W		0.60	0.161	66.4(6)	697	11/24(09)	0.245	55.3	1,881	1.92	980
882E	11/03	0.71	0.089	5.0	704	11/24(23)	0.351	67.9	1,362	1.54	884
456E	(08)	0.40	0.066	3.2	706	11/25(03)	0.351	40.9	1,457	2.44	597
627E		1.04	0.132	11.2	803	12/10(02)	0.168	65.2	1,866	1.67	1,117
858E		0.76	0.123	8.1	738	12/01(15)	0.254	55.6	1,440	2.40	600
722E		0.65	0.096	5.4	740	12/01(18)	0.252	44.4	1,355	2.55	531
884W		0.42	0.077	8.5	739	12/01(16)	0.254	33.4	1,565	3.35	467
672W		0.67	0.071	5.5	794	12/09(18)	0.170	20.2	887	1.26	704
679W		0.87	0.120	11.6	797	12/09(19)	0.170	44.1	1,488	1.62	919
799E	11/09	0.47	0.073	7.2	781	12/02(19)	0.320	45.2	1,504	1.89	796
790E	(08)	0.75	0.114	5.9	783	12/02(22)	0.318	77.8	1,631	2.07	788
486E		0.65	0.096	4.6	782	12/02(21)	0.318	55.0	1,332	2.12	628
602W		0.76	0.091	7.5	750	12/02(01)	0.332	54.8	1,086	1.66	654
893W		0.88	0.120	9.4	737	12/01(13)	0.341	104.	1,735	2.14	811
798W		0.76	0.092	5.9	784	12/02(24)	0.317	64.0	1,329	1.58	841
899E	11/17	0.56	0.091	6.0	756	12/02(08)	0.483	128.	2,370	2.09	1,134
713E	(08)	0.45	0.061	6.5	753	12/02(04)	0.486	72.1	1,648	2.80	589
880E		0.64	0.096	7.4	754	12/02(06)	0.486	106.	1,704	2.00	852
886W		0.67	0.103	9.0	755	12/02(13)	0.479	133.	2,070	1.72	1,203
622W		0.63	0.103	9.2	813	12/11(07)	0.312	83.4	2,120	2.47	858
698W		1.18	0.145	12.7	1021	01/01(07)	0.113	41.6	1,560	1.53	1,020

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Gills

Fish No.	Date of death, 1982 (hr)	Weight, wet	dry	ashed	Sample No.	P-32 Date of counting, 1982 (hr)	decay fraction	net c/min	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
782E	11/20	0.84	0.116	9.8	883	12/15(18)	0.291	65.1	1,332	2.15	620
767E	(08)	0.75	0.118	11.4	884	12/15(20)	0.291	52.3	1,198	3.08	389
728E		0.75	0.105	--	946	12/23(18)	0.198	54.4	1,832	2.25	814
715W		0.76	0.108	3.7	949	12/23(19)	0.197	44.2	1,476	2.04	724
889W		1.00	0.146	10.9	951	12/23(21)	0.197	61.4	1,558	2.15	725
606W		1.18	0.173	5.7	952	12/23(22)	0.196	87.6	1,894	2.21	857
477E	11/24	0.50	0.080	2.4	888	12/16(01)	0.349	41.0	1,175	2.55	461
738E	(08)	0.88	0.142	11.4	960	12/24(05)	0.235	55.4	1,339	2.61	513
691E		0.72	0.112	9.7	889	12/16(02)	0.349	71.7	1,427	3.04	469
668W		0.81	0.119	8.4	959	12/24(04)	0.236	48.4	1,266	2.05	618
717W		0.50	0.090	6.1	937	12/22(01)	0.261	46.1	1,766	2.69	657
891W		1.00	0.146	11.0	938	12/22(03)	0.260	66.9	1,287	2.44	527
637E	11/30	0.79	0.101	8.2	887	12/15(23)	0.469	52.6	709	1.95	364
721E	(08)	0.76	0.091	7.0	1039	01/07(18)	0.156	9.9	417	1.87	223
723E		0.56	0.071	5.8	891	12/16(04)	0.464	26.8	515	1.90	271
892W		1.65	0.221	19.9	1038	01/02(12)	0.200	55.7	845	2.08	406
885W		0.47	0.066	6.2	1034	01/02(05)	0.203	13.0	682	2.05	333
636W		0.90(6)	0.072	4.5	886	12/15(22)	0.470	30.0	355	1.02(6)	348
730E	12/07	0.61	0.102	9.0	1003	12/31(01)	0.317	24.5	634	2.68	237
871E	(08)	0.52	0.084	3.6	1005	12/31(04)	0.315	12.4	379	3.05	124
705E		1.13	0.162	9.8	1001	12/30(22)	0.319	30.4	422	2.85	148
641W		0.75	0.102	8.8	904	12/18(13)	0.581	40.9	469	3.53	133
615W		0.80	0.098	5.3	911	12/18(24)	0.568	46.9	516	2.16	239
735W		0.53	0.070	4.1	1004	12/31(03)	0.315	17.1	512	2.26	227
694E	12/15	1.04	0.151	10.5	1054	01/11(12)	0.268	12.6	226	2.52	89.7
485E	(08)	0.94	0.134	1.2(6)	1101	01/14(07)	0.234	15.2	346	2.52	137
894E		1.53	0.250	12.4	1098	01/14(02)	0.236	23.4	324	2.28	142
692W		1.69	0.306	---	1096	01/13(22)	0.238	43.8	544	5.11(6)	106
854W		0.78	0.151	7.9	990	12/30(04)	0.487	23.9	315	2.85	111
630W		0.76	0.142	9.7	1081	01/12(19)	0.252	10.5	274	3.25	84.3

A.1-1 cont'd

P-32 Uptake and Depuration in Bluegill

Head

Fish No.(1)	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg g/wet	P-32/P, c/min.mg.
761E	09/28	35.9	9.16	3,530	385	10/22(01)	0.317	123	54.0	22.3	2.42
794E	(08)	41.2	11.26	4,890	312	10/14(18)	0.452	42.4	11.4	25.2	0.45
879E		50.3	14.24	4,660	333	10/15(09)	0.439	42.6	9.6	17.6	0.55
499W		46.1	12.39	5,000	323	10/14(12)	0.456	559	133	21.3	6.24
708W		34.3	9.91	3,610	324	10/14(12)	0.456	347	111	18.9	5.87
787W		42.6	11.40	3,970	394	10/25(14)	0.268	433	190	18.7	10.2
684E	09/29	47.3	13.13	4,520	489	11/04(15)	0.172	181	111	19.8	5.61
859E	(08)	43.2	11.86	4,470	446	11/03(12)	0.188	335	206	23.3	8.84
863E		28.5	8.32	1,980	533	11/06(20)	0.162	140	152	15.3	9.93
608W		29.6	9.02	2,640	472	11/04(12)	0.173	291	284	19.9	14.3
682W		34.1	13.86	3,340	445	11/03(12)	0.188	408	318	20.7	15.4
890W		40.2	10.28	3,790	359	10/21(11)	0.343	904	328	18.7	17.5
619E	09/30	32.7	---	---	395	10/22(06)	0.346	77.4	34.2	19.3	1.77
872E	(08)	46.2	13.05	4,310	390	10/25(12)	0.295	611	229	19.1	12.0
635E		38.6	10.95	---	391	10/25(13)	0.295	658	289	19.2	15.1
706W		28.5	7.12	2,590	520	11/06(08)	0.166	222	235	18.9	12.4
		14.0	4.13	434(6)	478	11/03(23)	0.187	149	285	19.3	14.8
704W		33.9	10.35	2,750	392	10/25(13)	0.295	618	309	19.1	16.2
480W		44.8	13.78	4,330	497	11/04(17)	0.180	424	263	21.2	12.4
759E	10/06	31.2	9.14	3,400	498	11/04(18)	0.240	569	380	25.9	14.7
674E	(08)	33.0	9.34	3,270	500	11/04(18)	0.240	892	563	23.4	24.1
762E		33.6	9.59	2,800	493	11/04(16)	0.241	872	538	22.7	23.7
613W		26.0	7.69	2,100	593	11/09(16)	0.189	754	767	15.9	48.2
680W		25.7	7.28	1,780	609	11/17(11)	0.129	694	1,047	13.9	75.3
792W		31.2	10.64	2,330	585	11/09(15)	0.190	954	805	14.8	54.4
699E	10/12	48.5	12.96	4,980	526	11/04(23)	0.319	1,563	505	25.5	19.8
784E	(08)	48.0	12.89	4,230	547	11/07(19)	0.277	2,543	956	18.9	50.6
733E		40.8	10.39	4,320	563	11/09(11)	0.256	684	327	20.6	15.9
488W		37.0	10.81	2,600	540	11/07(08)	0.284	2,686	1,298	16.5	78.7
490W		32.0	9.07	2,800	560	11/09(10)	0.256	1,626	992	18.7	53.0
476W		58.3	16.17	5,510	525	11/04(23)	0.319	1,488	400	22.6	17.7

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Head

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
769E	10/19	28.1	9.0	2,410	643	11/18(13)	0.231	1,154	889	15.7	56.6
482E	(08)	27.5	8.8	2,150	650	11/18(15)	0.230	1,006	795	17.1	46.5
677E		36.7	10.0	4,280	634	11/18(11)	0.232	690	405	24.5	16.5
497W		26.7	8.1	1,990	635	11/18(12)	0.231	1,504	1,219	17.5	69.7
873W		48.8	13.8	3,970	648	11/18(14)	0.231	2,995	1,328	16.8	79.0
607W		53.8	15.9	4,880	636	11/22(08)	0.192	1,634	791	15.6	51.0
876E	10/26	31.4	9.4	2,660	686	11/24(13)	0.243	1,595	1,045	20.8	50.2
763E	(08)	47.0	13.7	5,210	690	11/24(15)	0.242	1,697	746	25.0	29.8
881E		24.8	7.5	2,120	644	11/18(04)	0.331	501	305	17.3	17.6
785W		42.6	12.7	4,280	801	12/10(12)	0.112	813	852	19.7	43.2
716W		42.3	12.7	4,230	682	11/23(16)	0.254	2,016	938	21.7	43.2
875W		50.2	15.3	4,670	645	11/18(13)	0.325	2,347	725	19.1	38.0
882E	11/03	40.7	11.0	3,990	742	12/02(11)	0.243	1,504	760	20.1	37.8
456E	(08)	27.0	8.1	1,970	772	12/03(11)	0.232	1,401	1,118	15.1	74.0
627E		51.0	14.3	5,070	691	11/24(15)	0.356	3,620	997	20.4	48.9
858E		45.7	13.9	3,590	672	11/23(13)	0.376	2,497	726	16.2	44.8
722E		39.2	12.1	2,660	748	12/02(12)	0.243	1,518	797	14.2	56.1
884W		33.7	10.3	2,790	721	11/26(04)	0.331	2,251	1,009	18.9	53.4
672W		41.5	10.7	4,230	792	12/10(10)	0.166	622	453	22.8	19.9
679W		50.9	13.7	5,150	676	11/23(14)	0.375	3,066	803	21.7	37.0
799E	11/09	43.9	11.8	3,940	727	11/26(13)	0.434	2,753	723	18.8	38.5
790E	(08)	39.4	12.6	2,900	725	11/26(10)	0.436	3,591	1,046	28.5	36.7
486E		50.5	13.9	5,300	760	12/02(14)	0.323	1,091	329	24.3	13.5
602W		40.0	12.9	3,020	735	11/27(02)	0.422	2,359	700	27.4	25.5
893W		45.1	13.4	---	764	12/02(16)	0.323	2,035	700	23.1	30.3
798W		54.8	16.3	4,500	769	12/03(10)	0.310	2,650	780	15.3	51.1
899E	11/17	41.7	11.1	3,980	820	12/10(16)	0.323	2,544	944	20.5	46.0
713E	(08)	28.2	8.0	1,940	837	12/12(07)	0.298	2,382	1,417	13.6	104.
880E		38.4	10.3	3,660	838	12/12(08)	0.298	1,272	556	20.8	26.7
886W		61.1	17.1	5,450	909	12/18(21)	0.217	3,444	1,299	16.8	77.3
622W		42.9	12.3	3,350	908	12/18(20)	0.217	2,075	1,114	19.3	57.7
698W		47.1	12.2	4,050	836	12/12(05)	0.299	2,762	981	17.4	56.4

A.1-1 cont'd

P-32 Uptake and Depuration in Bluegill

Head

Fish No.	Date of death, 1982 (hr)	Weight, wet	dry	ashed	Sample No.	P-32 Date of counting, 1982 (hr)	decay fraction	net c/min	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
782E	11/20	56.0	14.3	4,440	933	12/22(11)	0.211	1,444	611	16.0	38.2
767E	(08)	55.2	15.4	4,190	1014	12/31(20)	0.133	934	636	15.8	40.3
728E		48.7	14.5	4,460	843	12/12(17)	0.338	3,507	940	19.1	49.2
715W		53.3	16.9	4,550	872	12/16(19)	0.277	2,057	697	19.0	36.7
889W		47.1	13.7	4,220	1015	12/31(21)	0.133	1,203	960	20.0	48.0
606W		61.2	18.2	5,200	1012	12/31(16)	0.135	1,175	711	18.0	39.5
477E	11/24	46.9	14.1	4,160	871	12/16(18)	0.338	1,917	605	20.4	29.7
738E	(08)	38.1	10.6	3,820	870	12/16(18)	0.338	1,449	563	19.4	29.0
691E		51.5	14.8	4,380	850	12/16(10)	0.343	2,448	693	18.4	37.7
668W		54.5	15.0	5,290	839	12/12(10)	0.416	2,793	616	20.8	29.6
717W		41.7	12.3	4,030	840	12/12(12)	0.414	3,427	993	21.8	45.6
891W		43.9	12.3	3,790	842	12/12(15)	0.412	2,439	674	22.8	29.6
637E	11/30	48.9	13.4	3,910	841	12/12(14)	0.554	2,451	452	16.9	26.7
721E	(08)	36.9	10.3	3,810	869	12/16(18)	0.451	839	252	26.4	9.54
723E		42.9	12.2	3,970	873	12/16(19)	0.451	1,385	358	20.2	17.7
892W		74.4	22.4	6,370	874	12/16(19)	0.451	4,551	678	18.6	36.5
885W		42.5	12.4	2,490	854	12/16(12)	0.453	3,849	999	14.0	67.0
636W		54.6	15.4	4,720	844	12/12(18)	0.547	2,911	488	3.15(6)	----
730E	12/07	37.4	10.9	3,130	918	01/14(14)	0.157	545	464	16.4	28.3
871E	(08)	40.0	11.7	3,180	1007	12/31(08)	0.312	558	224	15.2	14.7
705E		53.3	14.9	---	1060	01/07(14)	0.219	378	162	22.4	7.23
641W		31.1	9.2	2,250	988	12/23(14)	0.455	1,306	461	16.6	27.8
615W		49.5	13.0	4,440	919	12/19(14)	0.552	1,487	272	19.3	14.1
735W		32.2	9.5	2,180	916	12/19(09)	0.558	2,064	574	16.2	35.4
694E	12/15	48.5	12.9	5,290	1045	01/07(12)	0.325	423	134	22.1	6.06
485E	(08)	55.1	15.6	5,650	1028	01/01(19)	0.428	623	132	22.9	5.76
894E		53.6	15.4	4,460	1058	01/07(13)	0.325	774	222	18.8	11.8
692W		61.2	18.1	5,130	1029	01/01(20)	0.428	1,100	210	17.7	11.9
854W		45.4	14.1	2,140	1059	01/07(13)	0.325	940	319	15.3	20.8
630W		33.2	10.1	2,140	991	12/30(05)	0.486	910	282	14.1	20.0

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Tail (4)

Fish No.(1)	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
761E	09/28	1.19	0.478	240	455	11/02(22)	0.178	9.4	222	34.1	6.51
794E	(08)	1.21	0.517	289	299	10/13(21)	0.472	3.8	33.3	40.0	0.83
879E		1.63	0.635	293	292	10/13(03)	0.488	5.2	32.7	29.7	1.10
499W		1.61	0.714	372	303	10/14(22)	0.447	40.1	279	30.4	9.17
708W		1.31	0.536	261	290	10/13(01)	0.490	25.8	201	35.1	5.73
787W		1.75	0.671	333	297	10/13(19)	0.472	54.6	331	28.0	11.8
684E	09/29	1.39	0.523	266	382	10/21(20)	0.336	23.5	252	33.7	7.48
859E	(08)	1.27	0.488	255	293	10/12(04)	0.538	70.0	512	36.2	14.1
863E		0.65	0.240	107	361	10/20(12)	0.358	18.1	389	31.5	12.3
608W		0.66	0.283	133	607	11/16(18)	0.096	6.4	505	38.2	13.2
682W		1.17	0.407	195	286	10/12(20)	0.520	66.7	548	34.5	15.9
890W		1.31	---	225	365	10/20(15)	0.358	54.1	577	32.0	18.0
619E	09/30	1.27	0.497	223	387	10/22(04)	0.348	7.3	82.6	23.1	3.58
872E	(08)	1.45	0.532	261	362	10/20(14)	0.375	70.5	648	29.7	21.8
635E		1.08	0.436	225	383	10/21(21)	0.353	57.0	748	41.0	18.2
706W		1.17	0.460	233	413	10/25(09)	0.298	28.7	412	39.3	10.5
704W		0.77	0.283	121	407	10/22(12)	0.341	25.8	491	31.6	15.5
480W		1.30	0.570	266	408	10/22(14)	0.341	46.9	529	34.3	15.4
759E	10/06	1.12	0.487	236	552	11/08(04)	0.214	39.0	814	36.3	22.4
674E	(08)	1.08	0.485	231	483	11/04(06)	0.246	62.2	1,171	38.2	30.7
762E		1.08	0.416	192	461	11/03(03)	0.260	94.1	1,676	31.1	53.9
613W		0.81	0.322	147	587	11/10(15)	0.181	65.1	2,220	34.8	63.8
680W		0.78	0.293	117	496	11/05(16)	0.230	71.2	1,984	28.9	68.7
792W		0.95	0.351	149	479	11/04(01)	0.249	80.2	1,699	28.8	59.0
699E	10/12	1.15	0.444	236	514	11/06(02)	0.301	104	1,502	35.1	42.8
784E	(08)	1.60	0.564	290	511	11/04(20)	0.320	178	1,738	28.4	61.2
733E		0.99	0.385	210	538	11/07(04)	0.286	47.2	834	38.1	21.9
488W		1.01	0.354	170	579	11/10(02)	0.250	131	2,590	31.1	83.3
490W		0.90	0.317	160	545	11/07(16)	0.279	96.4	1,920	30.6	62.7
476W		1.41	0.534	275	509	11/05(22)	0.303	122	1,428	35.2	40.6

A.1-1 cont'd
P-32 Uptake and Depuration in Bluegill
Tail (4)

Fish No.(1)	Date of death, 1982 (hr)	Weight, wet	dry	ashed	Sample No.	P-32 Date of counting, 1982 (hr)	decay fraction	net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
769E	10/19	0.84	0.310	132	582	11/10(06)	0.346	133.	2,270	33.5	67.8
482E	(08)	0.60	0.240	117	600	11/10(24)	0.333	83.1	2,070	36.6	56.6
677E		0.88	0.347	173	589	11/10(18)	0.337	73.3	1,236	32.8	37.7
497W		0.76	0.276	122	601	11/11(01)	0.332	124.	2,470	26.7	92.5
873W		1.31	0.462	210	559	11/08(09)	0.379	283.	2,850	33.9	84.1
607W		1.64	0.678	333	599	11/10(12)	0.341	187.	1,672	44.8	37.3

A.1-2
P-32 Uptake in Catfish
Muscle

Fish No.(1)	Date of death, 1982 (hr)	Weight, (2) wet	Weight, (2) dry	Weight, (2) ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.(3)	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
351E	08/16	69.1	17.1	955	101*(4)	09/17(13)	0.209	306	212	2.28	93.0
317E	(08)	93.9	--	1,130	17	08/31(17)	0.474	4,240	476	2.17	219.
362E		87.4	18.6	1,170	107	09/17(09)	0.212	199	53.7	2.26	23.8
395W		70.9	16.1	841	47*	09/07(21)	0.336	14.3	6.0	2.30	2.6
418W		66.8	15.4	601	16	08/31(03)	0.488	15.5	2.4	1.70	1.4
409W		105.3	26.3	1,260	15	08/31(02)	0.488	31.0	3.0	2.07	1.5
359E	08/17	78.3	18.5	1,360	22*	09/01(10)	0.481	537	143.	2.18	65.6
357E	(08)	32.9	10.1	498	104	09/17(03)	0.225	42.2	28.5	2.36	12.1
		34.5	9.06	461	109	09/17(17)	0.219	49.2	32.6	2.36	13.8
		33.1	8.72	475	112	09/17(21)	0.218	39.0	27.0	2.25	12.0
300E		47.5	14.1	664	100	09/17(13)	0.220	535	256	2.16	119.
		52.6	13.4	630	159	09/21(14)	0.183	547	284	2.42	117.
421W		95.5	21.3	1,430	23*	08/31(18)	0.493	414	87.9	1.71	51.4
422W		38.9	8.89	430	44	09/03(08)	0.439	18.6	5.4	2.25	2.4
		29.3	7.07	383	108	09/17(16)	0.219	13.8	10.8	2.22	4.9
380W		39.8	9.50	637	24	08/31(18)	0.493	157	40.0	1.85	21.6
		31.3	7.77	420	103	09/16(16)	0.230	85.4	59.3	2.25	26.4
		24.6	6.23	---	76	09/14(17)	0.252	55.0	44.5	2.37	18.8
365E	08/18	70.1	--	773	18	08/31(18)	0.522	1,518	207	3.02	68.5
361E	(08)	119.0	29.1	1,440	128	09/20(16)	0.199	2,627	555	2.48	224.
385E		98.6	24.4	1,110	160	09/21(14)	0.190	1,317	351	2.16	163.
373W		79.9	19.3	1,030	127	09/20(15)	0.199	755	237	2.55	92.9
424W		86.1	21.5	1,020	126	09/20(15)	0.199	321	93.7	2.46	38.1
398W		49.7	10.0	446	195	09/29(07)	0.131	206	158	1.80	87.8
307E	08/24	63.3	16.0	701	123	09/20(14)	0.264	7,137	2,140	2.17	986.
	(08)	35.6	8.78	444	124	09/20(14)	0.264	4,169	2,220	2.20	1,009.
449E		117.8	28.9	1,490	135	09/21(10)	0.256	2,965	492	2.37	208.
276E		70.6	18.4	838	116	09/20(11)	0.269	5,845	1,539	2.72	566.
372W		110.3	30.3	1,260	125	09/20(14)	0.264	1,038	178	2.25	79.1
401W		100.7	19.9	1,180	42	09/02(18)	0.627	10,280	814	2.26	360.
416W		88.7	20.2	1,020	114	09/20(11)	0.269	8,040	1,691	2.18	776.

(1) E fish received twice as much feed as W fish, at same specific activity (2) Wet and dry weight in gram; ashed weight in mg. (3) Duplicate 20-ml aliquots of 100-ml samples were analyzed for P-32 by counting Cherenkov radiation for 50-min. when < 200 c/min and for 10-min. when > 200 c/min. (4) One asterisk indicates a 200-ml solution and two asterisks, 250-ml. (5) Weight appears to be erroneous

A.1-2 cont'd
P-32 Uptake in Catfish
Muscle

Fish No.(1)	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
314E	8/26	45.4	10.9	489	257	10/08(14)	0.123	1,532	1,373	2.05	670
	(08)	54.2	13.3	597	258	10/08(14)	0.123	1,844	1,384	2.07	669
369E		57.7	11.9	641	282	10/11(12)	0.107	2,401	1,950	2.27	859
		47.3	9.89	545	276	10/11(09)	0.107	1,983	1,965	2.59	759
332E		46.2	10.7	536	279	10/11(10)	0.107	1,324	1,343	2.33	576
		43.7	10.5	496	278	10/11(10)	0.107	1,002	1,075	2.16	498
448W		31.5	7.64	383	284	10/12(17)	0.100	189	300	2.39	126
		43.2	10.0	495	275	10/11(09)	0.107	250	271	2.12	128
439W		57.0	12.9	647	280	10/11(11)	0.107	2,333	1,918	2.15	892
		71.0	15.2	784	316	10/14(11)	0.092	2,349	1,790	2.14	836
389W		57.6	14.8	666	281	10/11(11)	0.107	1,741	1,416	2.27	624
		64.2	17.4	705	619	11/17(13)	0.018	347	1,493	2.26	661
355E	9/01	51.4	---	583	261	10/08(15)	0.164	2,242	1,330	2.16	616
	(08)	50.0	---	576	270	10/08(17)	0.164	2,466	1,501	2.31	655
393E		77.0	16.5	903	671	11/23(12)	0.018	334	1,205	2.42	498
348E		33.4	7.68	377	674	11/23(13)	0.018	275	2,290	2.20	1,041
		38.0	9.03	430	752	12/02(13)	0.012	211	2,310	2.12	1,090
414W		47.2	11.0	536	745	12/01(22)	0.012	98.2	867	2.13	407
		59.5	---	676	260	10/08(15)	0.164	1,528	783	2.14	366
403W		49.6	11.1	494	656	11/22(20)	0.018	22.7	127	1.93	65.8
404W		65.9	---	759	271	10/08(17)	0.164	1,809	836	1.10(5)	760
		30.0	6.80	331	675	11/23(14)	0.018	188	1,741	2.48	702
321E	9/10	83.0	17.9	943	267	10/08(16)	0.254	741	176	2.30	76.5
363E	(08)	36.5	8.06	418	197	09/30(15)	0.374	2,083	763	2.24	341
		54.4	12.2	608	225	09/30(22)	0.370	3,142	780	2.14	364
356E		25.7	5.44	313	222	09/30(21)	0.370	202	106	2.34	45.3
387W		91.8	20.0	1,060	266	10/08(16)	0.254	4,263	914	2.48	369
429W		74.8	14.6	865	198	09/30(15)	0.374	2,111	377	2.22	170
431W		79.0	16.4	919	227	09/30(22)	0.370	1,893	324	2.30	141
428W	9/23	129.1	29.2	1,620	291	10/13(09)	0.379	10,950	1,119	2.56	437
410W	(08)	91.0	18.8	1,110	272	10/08(17)	0.474	7,943	921	2.47	373
390W		91.9	20.2	1,080	3	10/13(16)	0.374	1,750	255	2.40	106

A.1-2 cont'd
P-32 Uptake in Catfish
Skeleton

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
351E	08/16	19.0	7.17	1,350	41*	09/03(02)	0.423	303	377	14.9	25.3
317E	(08)	19.1	7.90	1,460	11/12	08/31(15)	0.476	1,296	712	15.8	45.1
362E		19.8	7.44	1,370	117	09/17(20)	0.207	103.2	126	14.7	8.57
395W		22.6	8.66	1,760	7/8	08/30(18)	0.498	7.5	3.3	17.2	0.19
418W		16.7	7.13	1,110	118	09/17(22)	0.206	6.4	9.3	13.0	0.72
409W		21.1	8.79	1,440	28*	09/01(04)	0.465	<2.2	<2.2	13.8	<0.16
359E	08/17	18.4	7.26	1,220	157	09/21(13)	0.182	154	230	13.3	17.3
357E	(08)	18.0	8.09	1,460	158	09/24(07)	0.159	28.7	50.1	17.0	2.95
300E		16.5	7.26	1,300	119	09/20(12)	0.200	215	326	15.5	21.0
421W		17.7	7.86	1,670	106*	09/17(05)	0.225	85.3	214	9.30	23.0
422W		12.2	5.07	926	130	09/22(12)	0.173	<2.2	<5.2	15.1	<0.34
380W		17.5	7.80	1,670	131	09/22(14)	0.173	52.7	87.0	19.7	4.42
365E	08/18	10.4	4.12	732	133	09/21(09)	0.191	209	526	13.3	39.5
361E	(08)	17.7	8.03	1,570	122	09/20(13)	0.200	727	1,027	18.0	57.1
385E		18.1	8.07	1,330	121	09/20(13)	0.200	358	494	14.9	33.2
373W		15.7	6.46	1,200	120	09/20(12)	0.200	195	311	14.3	21.7
424W		12.6	5.74	1,000	132	09/23(12)	0.173	76.9	176	16.2	10.9
398W		7.3	3.03	599	134	09/21(10)	0.191	103.6	372	13.0	28.6
307E	08/24	17.2	6.45	1,250	35	09/02(16)	0.636	8,480	3,880	14.5	268
449E	(08)	22.6	--	---	129	09/21(09)	0.256	707	611	14.3	42.7
276E		14.5	5.88	870	115	09/20(11)	0.269	2,036	2,610	12.0	218
372W		26.4	11.0	1,630	162	09/21(14)	0.254	310	231	11.0	21.0
401W		24.5	9.25	1,680	163	09/21(14)	0.254	1,323	1,063	12.5	85.0
416W		20.7	8.07	1,610	164	09/21(15)	0.254	2,296	2,183	13.9	157

A.1-2 cont'd
P-32 Uptake in Catfish
Skeleton

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
314E	8/26	19.2	7.93	1,270	259	10/08(14)	0.123	1,019	2,160	12.4	174
369E	(08)	17.5	6.72	1,400	277	10/11(10)	0.118	1,452	3,520	14.7	239
332E		20.0	7.24	1,400	269	10/08(17)	0.123	583	1,186	11.4	104
448W		13.5	5.45	1,120	263	10/08(16)	0.123	155	467	15.6	29.9
439W		22.2	9.46	1,750	450	11/03(14)	0.035	424	2,710	15.5	175
389W		20.1	8.87	1,480	262	10/08(15)	0.123	912	1,846	15.3	120
355E	9/01	23.6	8.58	1,620	256	10/08(13)	0.165	2,121	2,720		
393E	(08)	----	8.38	1,500	632	11/17(20)	0.023	119	-----		
348E		17.1	5.97	1,000	631	11/17(16)	0.023	248	3,150		
414W		22.4	8.47	1,580	637	11/17(22)	0.023	102	990		
403W		13.0	4.84	971	668	11/23(23)	0.017	3.4	76.9		
404W		19.4	7.41	1,480	714	11/25(16)	0.016	182	2,930		
321E	9/10	24.1	8.16	1,480	228	09/30(22)	0.368	414	233		
363E	(08)	25.5	8.88	1,400	199	09/30(15)	0.374	4,799	2,520		
356E		8.1	2.64	434	245	10/06(24)	0.274	65.8	148		
387W		22.5	7.81	1,420	229	09/30(23)	0.368	3,007	1,816		
429W		22.4	6.80	1,390	254	10/08(13)	0.255	1,216	1,064		
431W		27.7	9.46	1,700	255	10/21(15)	0.135	347	464		
428W	9/23	26.8	9.89	1,840	274	10/11(09)	0.416	7,913	3,550		
410W	(08)	21.8	7.19	1,300	273	10/21(15)	0.254	2,098	1,894		
390W		25.2	9.42	1,700	283	10/11(12)	0.416	902	430		

A.1-2 cont'd
P-32 Uptake in Catfish
Viscera

Fish No.	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
351E	08/16	13.0	3.91	131	38	09/02(16)	0.298	1,608	2,080	2.05	1,015
317E	(08)	31.0	9.96	450	13	08/31(15)	0.476	8,340	2,820	1.50	1,880
362E		15.5	4.87	---	85	09/15(09)	0.233	214	296	1.44	206
395W		9.8	2.09	---	83	09/14(24)	0.237	<2.2	<4.7	1.57	< 3
418W		15.6	5.43	105	59	09/08(08)	0.328	<2.2	<2.1	1.49	< 2
409W		19.8	7.76	141	55	09/08(02)	0.332	<2.2	<1.7	1.75	< 1
359E	08/17	17.2	7.14	---	78	09/15(08)	0.257	384	434	1.20	362
357E	(08)	21.6	9.13	155	27	08/31(14)	0.501	655	303	1.62	187
300E		18.4	7.65	---	81	09/15(09)	0.257	485	513	1.11	462
421W		17.7	5.14	253	204	09/30(16)	0.117	197	476	1.47	324
422W		11.5	4.34	---	84	09/15(01)	0.249	<2.2	<3.8	1.39	< 3
380W		21.3	8.43	---	77	09/14(19)	0.252	144	134	1.34	100
365E	08/18	12.3	4.73	---	87	09/15(10)	0.256	386	613	1.33	461
361E	(08)	31.8	9.00	339	192	09/30(13)	0.123	2,615	3,340	1.70	1,965
385E		19.6	6.56	191	193	09/30(13)	0.123	1,468	3,040	1.85	1,643
373W		11.8	3.19	121	63	09/10(14)	0.320	1,210	1,602	2.63	609
424W		16.9	7.36	---	79	09/15(09)	0.256	314	363	1.63	223
398W		7.3	2.38	53.2	62	09/10(17)	0.320	243	520	1.45	359
307E	08/24	30.6	9.86	487	185	09/30(12)	0.165	8,526	8,440	2.30	3,670
449E	(08)	21.2	6.75	173	156	09/21(13)	0.255	1,348	1,247	1.36	917
276E		16.1	6.26	153	36	09/02(16)	0.631	9,050	4,450	1.66	2,680
372W		25.3	11.6	183	152	09/21(13)	0.254	1,744	1,357	1.50	905
401W		20.3	4.57	237	75	09/10(16)	0.428	9,263	5,330	1.79	2,980
416W		29.2	9.14	356	153	09/21(13)	0.255	8,818	5,920	1.98	3,020

A.1-2 cont'd
P-32 Uptake in Catfish
Viscera

Fish No.	Date of death, 1982(hr)	Weight, wet	dry	ashed	Sample No.	P-32 Date of counting, 1982 (hr)	decay fraction	net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
314E	8/26	40.5	12.9	588	372	10/21(13)	0.066	3,354	6,300	2.88	2,190
369E	(08)	33.7	8.55	316	330	10/15(11)	0.089	2,630	3,660	1.56	2,350
332E		27.5	6.84	425	363	10/21(12)	0.066	2,189	6,060	2.56	2,370
448W		15.5	5.51	116	308	10/13(17)	0.096	206	691	1.39	497
439W		42.7	11.4	616	360	10/21(12)	0.066	2,970	5,290	2.41	2,200
389W		31.7	10.7	391	331	10/15(11)	0.089	2,906	5,170	2.03	2,550
355E	9/01	32.9	10.2	267	744	12/01(22)	0.012	83.0	1,051	1.46	720
393E	(08)	15.2	3.00	158	751	12/02(01)	0.012	55.0	1,508	1.81	833
348E		26.9	9.01	296	716	11/25(20)	0.016	523	6,080	1.94	3,130
414W		23.2	7.75	163	669	11/24(01)	0.017	77.4	981	1.26	779
403W		12.4	3.23	97.2	639	11/17(23)	0.023	8.9	156	1.37	114
404W		24.4	7.23	232	707	11/25(04)	0.016	240	3,070	1.70	1,806
321E	9/10	15.4	3.63	150	251	10/08(12)	0.255	751	956	1.52	
363E	(08)	25.7	6.49	276	344	10/19(12)	0.150	1,374	1,782	1.71	
356E		5.8	1.89	42.5	247	10/07(03)	0.273	50.6	160	1.45	
378W		26.9	7.11	300	252	10/08(12)	0.255	3,154	2,300	1.99	
429W		14.8	3.34	128	236	10/21(15)	0.136	479	1,190	1.42	
431W		17.8	3.53	240	221	09/30(20)	0.370	2,362	1,793	2.04	
428W	9/23	25.1	8.39	211	336	10/19(11)	0.150	2,221	2,950	1.99	
410W	(08)	18.9	6.19	174	357	10/21(11)	0.136	1,029	2,000	1.78	
390W		20.1	5.18	219	337	10/19(11)	0.150	931	1,544	1.91	

A.1-2 cont'd
P-32 Uptake in Catfish
Gills

Fish No.	Date of death, 1982(hr)	Weight, wet	dry	ashed	Sample No.	P-32 Date of counting, 1982 (hr)	decay fraction	net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
351E	08/16	1.11	0.227	13.3	51	09/07(22)	0.334	33.6	453	2.93	155.
317E	(08)	2.20	0.453	23.0	50	09/08(14)	0.324	171	1,199	4.50(5)	266
362E		2.54	0.510	24.1	94	09/16(07)	0.223	20.8	184	2.59	71.0
395W		2.10	0.548	--	73	09/11(08)	0.285	<2.2	<18	2.21	< 8
418W		1.90	0.322	19.2	90	09/15(16)	0.230	<2.2	<25	2.70	< 9
409W		1.60	0.280	16.8	68	09/11(03)	0.285	4.8	48	2.17	22.1
359E	08/17	2.00	0.386	23.3	88	09/15(03)	0.248	35.2	355	2.88	123.
357E	(08)	1.74	0.359	--	80	09/14(20)	0.251	9.8	112	2.01	55.7
300E		1.90	0.374	16.3	98	09/16(18)	0.228	47.4	547	2.38	230.
421W		1.80	0.345	20.5	21	08/30(07)	0.538	79.7	412	3.26	126.
422W		1.23	0.188	8.2	19	08/30(03)	0.538	<2.2	<17	2.49	< 7
380W		2.50	0.497	23.3	102	09/16(23)	0.228	20.0	175	1.98	88.4
365E	08/18	1.10	0.174	11.7	92	09/15(21)	0.250	41.0	745	2.26	330.
361E	(08)	2.28	0.486	23.9	91	09/17(13)	0.231	118.3	1,123	2.69	417.
385E		1.62	0.362	--	82	09/14(22)	0.263	102.4	1,202	3.26	369
373W		1.10	0.250	15.0	97*	09/16(17)	0.240	22.4	848	3.34	254
424W		1.81	0.379	19.0	93	09/16(03)	0.248	37.0	412	2.39	172
398W		0.53	0.100	5.4	64	09/10(20)	0.320	11.3	333	2.18	153
307E	08/24	2.20	0.439	17.6	111	09/17(13)	0.310	607	4,450	2.13	2,090
449E	(08)	2.11	0.404	25.0	69	09/11(04)	0.422	217	1,219	2.98	409
276E		0.88	0.165	8.9	71	09/11(07)	0.418	208	2,830	2.44	1,1[illegible]0
372W		2.10	0.458	15.4	110	09/17(19)	0.308	61.8	478	2.01	238
401W		2.04	0.284	12.0	96	09/17(13)	0.310	187	1,480	1.72	860
416W		1.95	0.399	23.6	66	09/10(14)	0.437	564	3,310	2.35	1,409

A.1-2 cont'd
P-32 Uptake in Catfish
Gills

Fish No.	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
314E	8/26	1.28	0.214	16.1	618	11/17(02)	0.018	7.3	1,576	1.48	1,065
369E	(08)	1.40	0.227	10.9	662	11/23(05)	0.013	6.8	1,821	1.32	1,380
332E		1.37	0.202	12.3	482	11/04(05)	0.033	10.2	1,117	1.30	859
448W		0.85	0.145	9.5	661	11/23(03)	0.013	<2.2	<970	1.25	< 800
439W		2.17	0.309	10.7	660	11/23(02)	0.013	8.4	1,451	1.13	1,284
389W		1.40	0.211	9.7	659	11/22(24)	0.013	4.0	1,071	1.29	830
355E	9/01	1.49	0.243	14.0	486	11/05(12)	0.042	32.0	2,560		
393E	(08)	1.65	0.233	15.0	708	11/25(06)	0.016	10.6	2,040		
348E		1.71	0.274	16.2	641	11/18(01)	0.023	26.6	3,380		
414W		2.11	0.395	--	515	11/06(03)	0.041	33.4	1,930		
403W		1.48	0.209	11.6	665	11/23(18)	0.018	<2.2	<410		
404W		2.75	0.354	21.8	798	12/09(21)	0.0081	12.3	2,760		
321E	9/10	2.01	0.325	20.0	224	09/29(24)	0.385	78.5	507		
363E	(08)	2.33	0.407	30.6	238	10/07(14)	0.268	210	1,682		
356E		0.41	0.067	--	358	10/20(10)	0.143	2.1	179		
387W		2.56	0.429	16.4	220	09/30(20)	0.368	383	2,030		
429W		2.32	0.376	22.2	230	09/30(23)	0.368	296	1,734		
431W		2.01	0.306	18.0	241	10/06(23)	0.275	99.0	896		
428W	9/23	3.67	0.557	28.5	347	10/19(12)	0.280	373	1,815		
410W	(08)	3.50	0.509	26.7	356	10/20(09)	0.269	214	1,136		
390W		2.25	0.354	20.3	355	10/20(07)	0.269	86.6	715		

A.1-2 cont'd
P-32 Uptake in Catfish
Skin

Fish No.	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
351E	08/16	9.8	3.38	88.8	49	09/08(14)	0.324	147	231	2.00	116
317E	(08)	13.9	5.02	96.4	37	09/02(15)	0.423	572	486	1.10	442
362E		11.1	3.94	75.6	105	09/17(04)	0.214	34	71.6	1.59	45.0
395W		8.7	2.87	67.1	53	09/08(03)	0.331	<2.2	<3.8	1.56	< 2.4
418W		13.5	5.02	83.9	5/6	08/30(15)	0.500	<2.2	<1.6	2.80(5)	< 0.6
409W		10.5	4.25	113.	65	09/10(21)	0.291	<2.2	<3.6	1.37	< 2.6
359E	08/17	10.6	3.65	79.0	26	09/01(04)	0.487	126	122	1.32	92.4
357E	(08)	14.1	5.15	175.	67	09/10(23)	0.303	40.5	47.4	1.11	42.7
300E		11.2	4.83	76.6	33	09/02(15)	0.454	202	199	1.28	155
421W		10.7	3.82	73.7	95	09/16(16)	0.230	51.8	105	1.04	101
422W		8.8	3.20	60.	99	09/16(21)	0.228	8.5	21.2	1.40	15.1
380W		11.8	5.05	102.	70	09/11(05)	0.300	40.9	57.8	1.38	41.9
365E	08/18	5.9	2.08	41.1	89	09/15(05)	0.259	81.0	265	1.49	178
361E	(08)	14.7	5.75	123.	61	09/10(13)	0.325	461	482	1.38	349
385E		17.2	7.59	135.	150	09/21(12)	0.191	228	347	1.48	234
373W		13.4	4.69	107.	208	09/29(19)	0.140	84.5	225	1.56	144
424W		11.0	4.26	90.1	148	09/23(15)	0.172	45.8	121	1.73	69.9
398W		5.1	1.86	37.3	213	09/29(21)	0.140	23.5	165	1.52	109
307E	08/24	10.6	3.35	80.8	34	09/02(15)	0.631	1,996	1,492	1.28	1,166
449E	(08)	11.4	3.97	20.5(5)	113	09/17(15)	0.305	306	440	1.17	376
276E		8.6	3.46	---	86	09/15(09)	0.344	693	1,171	1.55	755
372W		13.1	4.64	73.1	39	09/02(19)	0.631	266	161	1.03	156
401W		14.3	5.26	109.	74	09/10(15)	0.428	1,080	882	1.21	729
416W		11.0	3.95	94.0	72	09/10(15)	0.428	1,545	1,641	1.39	1,181

A.1-2 cont'd
P-32 Uptake in Catfish
Skin

Fish No.	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
314E	8/26	10.1	3.71	72.0	338	10/19(12)	0.072	256	1,751	1.86	941
369E	(08)	9.7	2.83	79.4	311	10/14(10)	0.092	32	1,796	1.93	931
332E		11.9	4.06	95.2	519	11/06(06)	0.030	94.0	1,295	1.60	809
448W		9.2	3.43	---	620	11/17(04)	0.018	9.3	279	1.29	216
439W		16.6	5.54	107.	664	11/23(08)	0.013	81.8	1,847	1.24	1,490
389W		12.0	4.70	61.3	663	11/23(06)	0.013	32.9	1,028	1.07	961
355E	9/01	14.8	4.72	104.	517	11/06(05)	0.041	133	1,096		
393E	(08)	13.7	4.60	106.	712	11/25(13)	0.016	41.5	947		
348E		7.9	2.76	37.7	777	12/02(17)	0.011	17.0	978		
414W		15.9	5.87	104.	800	12/09(24)	0.0080	15.7	617		
403W		7.9	2.42	44.6	709	11/25(08)	0.016	2.5	98.9		
404W		10.7	4.18	71.4	463	11/03(16)	0.046	117	1,189		
321E	9/10	10.4	3.15	61.0	253	10/07(05)	0.271	71.2	126		
363E	(08)	13.3	4.68	89.6	233	10/06(08)	0.284	512	678		
356E		3.7	1.25	24.3	265	10/07(07)	0.271	13.6	67.8		
387W		13.3	4.19	107.	249	10/07(20)	0.264	563	802		
429W		9.6	2.91	69.9	264	10/08(16)	0.254	303	621		
431W		15.7	4.63	108.	250	10/08(04)	0.260	259	317		
428W	9/23	18.3	5.97	140.	350	10/21(11)	0.256	902	963		
410W	(08)	11.1	3.13	80.6	346	10/19(12)	0.281	384	616		
390W		12.8	4.54	80.0	354	10/21(11)	0.256	146	223		

A.1-2 cont'd
P-32 Uptake in Catfish
Head

Fish No.	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
351E	08/16	47.1	16.3	4,510	14	08/31(17)	0.472	1,734	390	20.1	19.4
317E	(08)	55.9	21.5	5,430	46**	09/08(13)	0.325	1,316	905	26.1	34.7
362E		55.6	18.9	5,100	203	09/30(16)	0.111	212	172	20.7	8.31
395W		55.5	18.6	4,880	342*	10/19(23)	0.044	6.7	27.4	22.3	0.81
418W		44.3	18.1	4,270	143	09/23(13)	0.157	5.9	4.2	24.1	0.17
409W		51.1	18.3	4,490	29	09/01(03)	0.465	19.0	4.0	16.8	0.24
359E	08/17	48.4	16.6	4,670	31*	09/01(10)	0.481	676	299	19.0	15.7
357E	(08)	23.3	8.36	2,190	25	09/01(00)	0.490	116	50.8	20.4	2.49
		36.6	14.8	3,510	187	09/28(21)	0.127	54.5	58.6	23.2	2.53
300E		17.1	6.83	1,010	205	09/30(17)	0.117	201	502	22.0	22.8
		23.8	9.58	2,590	32	09/01(10)	0.481	783	342	25.7	13.3
		11.4	5.15	1,190	188	09/28(23)	0.127	158	546	29.5	18.5
421W		52.7	20.5	6,020	196	09/30(13)	0.117	270	219	29.2	7.5
422W		18.0	6.17	1,540	144	09/23(13)	0.165	5.0	8.4	22.4	0.38
		15.8	6.04	1,610	237	10/06(20)	0.087	2.6	9.5	31.1	0.31
380W		38.1	15.4	4,330	189	09/28(24)	0.127	113	117	25.2	4.64
		23.1	9.71	2,560	60*	09/08(16)	0.336	77.2	99.4	30.0	3.31
365E	08/18	30.8	11.3	2,770	209	09/30(18)	0.122	519	691	19.6	35.3
361E	(08)	58.3	22.1	5,930	214	09/30(19)	0.122	1,680	1,181	23.2	50.9
385E		57.3	23.9	5,750	210	09/30(18)	0.122	787	563	22.3	25.2
373W		51.5	19.2	5,190	211	09/30(18)	0.122	488	388	19.9	19.5
424W		43.8	17.8	4,250	207	09/30(17)	0.122	239	224	2[illegible].1	10.6
398W		23.8	8.60	2,030	212	09/30(19)	0.122	314	541	20.3	26.7
307E	08/24	53.7	20.3	5 600	181	09/24(14)	0.220	10,530	4,460	20.6	217.
449E	(08)	65.8	24.2	6,380	217	09/30(20)	0.162	1,848	867	20.8	41.7
276E		34.9	15.1	3,460	190	09/30(12)	0.165	4,303	3,310	22.5	147.
372W		60.2	23.7	5,770	215	09/30(19)	0.162	618	317	23.4	13.5
401W		64.1	23.5	6,180	180	09/24(14)	0.220	3,705	1,314	22.5	58.4
416W		59.1	18.4	5,810	45*	09/18(13)	0.527	8,020	2,580	26.4	97.7

A.1-2 cont'd
P-32 Uptake in Catfish
Head

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
314E	8/26	56.1	20.1	4,920	332	10/15(12)	0.096	2,445	2,270	19.9	114
369E	(08)	57.7	19.3	5,220	287	10/13(08)	0.097	3,818	3,400	21.1	161
332E		52.0	18.5	4,740	448	11/03(13)	0.035	555	1,514	17.4	87.0
448W		40.8	15.0	3,840	295	10/13(09)	0.097	551	695	21.9	31.7
439W		80.6	26.8	6,530	543	11/07(12)	0.029	1,358	2,950	20.0	148.
389W		59.4	23.9	5,570	495	11/04(17)	0.033	780	1,969	22.6	87.1
355E	9/01	72.6	24.9	6,440	626	11/17(15)	0.024	978	2,810		
393E	(08)	58.5	21.0	5,880	616	11/17(12)	0.024	410	1,460		
348E		44.1	16.7	4,340	499	11/04(18)	0.044	1,632	4,200		
414W		63.2	25.2	5,970	621	11/17(13)	0.024	399	1,315		
403W		37.9	14.4	4,070	623	11/17(05)	0.024	18.1	99.5		
404W		55.5	20.7	5,370	397	10/25(14)	0.072	2,342	2,930		
321E	9/10	54.0	18.2	5,510	243	10/07(19)	0.264	882	309		
363E	(08)	73.7	22.8	5,740	246	10/07(20)	0.264	4,181	1,074		
356E		20.3	6.53	1,930	223	09/30(21)	0.370	420	280		
387W		54.8	18.0	4,910	226	09/30(21)	0.370	7,634	1,883		
429W		51.8	16.1	5,300	242	10/07(19)	0.264	4,623	1,690		
431W		64.0	20.8	6,170	244	10/07(19)	0.264	1,713	507		
428W	9/23	71.0	23.6	6,210	294	10/13(09)	0.379	20,980	3,900		
410W	(08)	61.9	19.0	5,110	307	10/13(16)	0.374	8,604	1,858		
390W		55.0	18.9	5,190	304	10/13(12)	0.376	1,706	412		

A.1-2 cont'd
P-32 Uptake in Catfish
Fins

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
351E	08/16	3.8	1.19	244	58	09/06(15)	0.320	131	539	17.3	31.2
317E	(08)	7.6	2.63	371	9/10	08/31(14)	0.477	680	938	13.6	69.0
362E		5.2	1.78	303	166	09/24(21)	0.147	26.8	175	13.7	12.8
395W		5.6	2.24	335	57	09/08(06)	0.330	<2.2	< 6.0	14.5	< 0.4
418W		5.1	2.39	265	52	09/07(23)	0.334	<2.2	< 6.5	12.8	< 0.5
409W		5.8	2.30	359	141	09/23(13)	0.156	<2.2	<12.2	14.0	< 0.9
359E	08/17	5.6	2.05	289	169	09/25(02)	0.152	53.2	312	12.7	24.6
357E	(08)	6.1	2.40	351	171	09/25(05)	0.152	35.0	189	12.3	15.4
300E		6.4	3.26	389	170	09/25(03)	0.152	77.0	396	9.8	40.4
421W		5.3	2.22	398	30	09/01(07)	0.484	132	257	18.3	14.0
422W		3.9	1.43	---	lost sample						----
380W		5.8	2.67	377	145	09/23(14)	0.164	25.9	136	15.6	8.72
365E	08/18	2.9	1.20	188	173	09/25(09)	0.159	71.6	776	13.4	57.9
361E	(08)	7.2	2.70	393	191	09/30(13)	0.123	174	982	14.2	69.2
385E		5.9	2.75	335	177	09/25(15)	0.156	130	706	12.8	55.2
373W		5.9	2.32	379	234	10/06(18)	0.087	49.6	483	13.4	36.0
424W		5.8	2.25	306	174	09/25(10)	0.159	45.8	248	14.0	17.7
398W		2.1	0.90	133	178	09/25(17)	0.156	33.2	507	15.0	33.8
307E	08/24	5.5	2.10	321	155	09/21(14)	0.255	1,044	3,720	14.5	257.
449E	(08)	6.4	2.75	431	216	09/30(19)	0.162	171	825	17.1	48.2
276E		3.8	1.70	248	138	09/21(11)	0.255	358	1,847	16.7	110.
372W		6.1	2.62	336	184	09/28(18)	0.186	83.1	366	13.6	26.9
401W		6.5	2.97	1,120(5)	179	09/24(14)	0.220	489	1,710	14.3	120.
416W		5.0	1.94	332	43	09/02(18)	0.635	1,850	2,910	15.2	191.

A.1-2 cont'd
P-32 Uptake in Catfish
Fins

Fish No.	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
314E	8/26	6.6	2.69	323	611	11/16(23)	0.018	56.1	2,350	9.52	246.
369E	(08)	5.7	2.03	332	364	10/21(12)	0.066	254	2,930	13.9	211.
332E		5.6	2.02	344	487	11/05(14)	0.031	58.2	1,653	15.1	109.
448W		4.4	1.61	283	710	11/25(10)	0.012	5.3	486	14.0	34.7
439W		9.4	3.19	493	490	11/04(15)	0.033	153	2,440	12.1	202.
389W		7.4	3.07	347	393	10/25(13)	0.054	140	1,742	13.3	131.
355E	9/01	6.4	2.71	417	542	11/07(11)	0.039	126	2,520		
393E	(08)	5.2	2.09	357	655	11/22(19)	0.018	26.4	1,410		
348E		7.9(5)	1.38	167	629	11/17(18)	0.023	50.3	1,384		
414W		6.6	3.10	418	524	11/06(11)	0.041	62.1	1,147		
403W		4.0	1.01	170	799	12/09(23)	0.0080	<2.2	<340		
404W		6.1	2.28	323	521	11/06(10)	0.041	113	2,260		
321E	9/10	5.3	1.92	364	218	09/29(22)	0.387	153	373		
363E	(08)	8.1	2.98	409	231	09/30(19)	0.372	763	1,266		
356E		2.2	0.83	152	341	10/19(21)	0.146	18.5	288		
387W		6.9	2.64	408	219	10/01(01)	0.367	993	1,961		
429W		5.1	1.82	351	235	10/21(15)	0.135	188	1,365		
431W		5.8	2.50	357	200	09/30(15)	0.372	288	667		
428W	9/23	7.6	2.68	435	348	10/21(10)	0.256	1,163	2,990		
410W	(08)	5.7	1.85	325	353	10/21(10)	0.256	551	1,888		
390W		4.4	1.69	---	349	10/20(04)	0.273	141	587		

A.1-2 cont'd
P-32 Uptake in Catfish
Fin Spines

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982(hr)	P-32: decay fraction	P-32: net c/min.	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
351E	08/16	0.55	0.377	211	54	09/08(02)	0.330	53.0	1,460	63.3	23.1
317E	(08)	0.68	0.424	227	48	09/08(13)	0.322	84.8	1,936	80.0	24.2
362E		0.66	0.432	237	165	09/24(20)	0.147	11.1	572	86.7	6.60
395W		0.59	0.411	232	140	09/23(15)	0.156	<2.2	<120	86.9	< 2
418W		0.65	0.468	269	56	09/08(05)	0.330	<2.2	< 51	98.0	< 0.6
409W		0.63	0.448	238	142	09/08(18)	0.322	<2.2	< 54	73.2	< 0.8
359E	08/17	0.60	0.415	227	168	09/24(01)	0.161	17.4	901	88.2	10.2
357E	(08)	0.80	0.522	281	186	09/28(20)	0.127	6.7	330	83.9	3.93
300E		0.77	0.573	354	20	08/31(06)	0.510	75.9	966	133.0	7.26
421W		0.81	0.603	338	167	09/24(23)	0.154	10.6	425	80.5	5.28
422W		0.44	0.326	183	172	09/25(09)	0.151	<2.2	<170	88.6	< 2
380W		0.62	0.478	272	40	09/02(24)	0.445	16.6	301	98.5	3.06
365E	08/18	0.55	0.379	208	147	09/24(05)	0.166	38.8	2,120	90.3	23.5
361E	(08)	0.81	0.589	321	176	09/25(16)	0.156	71.6	2,830	103.6	27.3
385E		0.35	0.260	144	161	09/24(10)	0.166	20.5	1,764	124.5	14.2
373W		0.84	0.603	333	146	09/23(24)	0.169	20.9	736	93.5	7.87
424W		0.51	0.369	211	175	09/25(14)	0.156	12.0	754	109.8	6.87
398W		0.29	0.210	118	194	09/29(03)	0.132	12.7	1,659	109.4	15.2
307E	08/24	0.64	0.428	228	137	09/21(10)	0.254	619	19,040	76.4	249.
449E	(08)	0.75	0.563	318	139	09/23(13)	0.231	87.5	2,520	122.7	20.5
276E		0.49	0.837(5)	672(5)	154	09/21(13)	0.255	232	9,280	104.9	88.5
372W		0.74	0.550	310	149	09/24(07)	0.222	23.5	715	Lost	----
401W		0.80	0.605	342	151	09/21(12)	0.254	92.0	2,260	91.9	24.6
416W		0.64	0.491	272	136	09/21(10)	0.254	306	9,410	99.6	94.5

A.1-2 cont'd
P-32 Uptake in Catfish
Fin Spines

Fish No.	Date of death, 1982 (hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/min.	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
314E	8/26	0.62	0.443	257	612	11/16(24)	0.018	11.2	4,990	72.4	68.9
369E	(08)	0.64	0.445	251	317	10/14(03)	0.094	109	9,030	95.9	94.2
332E		0.61	0.426	241	512	11/05(24)	0.031	14.2	3,710	80.7	46.0
448W		0.58	0.421	237	658	11/22(21)	0.013	2.5	1,615	85.6	18.9
439W		1.10	0.732	408	628	11/17(07)	0.018	19.1	4,800	76.1	63.1
389W		0.72	0.532	308	480	11/04(02)	0.034	17.1	3,460	79.5	43.5
355E	9/01	0.71	0.509	277	386	10/21(02)	0.089	98.5	7,790		
393E	(08)	1.12(5)	0.460	269	642	11/18(02)	0.023	4.6	893		
348E		0.68	0.424	253	667	11/23(22)	0.017	22.8	9,860		
414W		0.75	0.558	311	400	10/21(08)	0.089	29.6	2,220		
403W		0.48	0.408	239	666	11/23(20)	0.017	<2.2	<1,400		
404W		0.43	0.315	179	544	11/07(14)	0.038	24.6	7,530		
321E	9/10	0.59	0.357	219	268	10/07(10)	0.269	39.8	1,254		
363E	(08)	0.89	0.511	305	232	09/30(02)	0.383	187	2,740		
356E		0.30	0.213	134	248	10/07(04)	0.273	10.1	617		
387W		0.52	0.343	216	352	10/21(08)	0.137	92.1	6,460		
429W		0.46	0.332	212	240	10/07(18)	0.265	163	6,690		
431W		0.79	0.528	331	239	10/06(21)	0.277	3.8	1,229		
428W	9/23	0.63	0.376	225	351	10/20(05)	0.272	382	11,150		
410W	(08)	0.21	0.109	62.6	345	10/20(02)	0.273	47.2	4,120		
390W		0.55	0.311	191	340	10/19(19)	0.277	76.7	2,520		

A.2-1
Bluegill Food

Date of feeding, 1982	Vial No.	Weight, mg. Dry	Weight, mg. Ash	amt. fed, g E	amt. fed, g W	Number of fish E	Number of fish W	P-32 counting date, 1982/83	P-32 Decay factor	P-32 c/min net	P-32 c/min.g.	P,mg/g wet wt	P-32/P, c/min.mg
09/27	536	595	---	104.	204	55	51	11/07(01)	0.139	5,217	93,800		
28	504	144	---	99.3	196.3	52	48	11/04(19)	0.162	5,917	91,300		
29			---	93.9	185.5	49	45						
30	529	160	---	88.5	174.7	46	42	11/04(24)	0.177	5,264	74,400		
10/01			---	10.0	32.0	46	42						
02			---	88.5	104.5	46	42						
03	507		16.8	88.5	174.7	46	41	11/04(20)	0.207	1,887	22,800	1.37	16,642
04				88.5	174.7	46	41						
05	442		---	78.0	120.2	46	41	10/26(03)	0.365	2,269	15,540	1.13	13,752
06	505		9.4	65.2	92.3	43	38	11/04(19)	0.239	400	4,180	0.77	5,421
07	506		12.9	78.1	128.	43	38	11/04(19)	0.251	843	8,400	1.22	6,885
08	530		14.1	78.2	163.	43	38	11/04(24)	0.261	513	4,910	1.21	4,058
09	527		17.6	78.4	112.5	43	38	11/04(23)	0.275	1,815	16,500	1.38	11,956
10	535		14.6	78.3	172.	43	38	11/06(23)	0.262	992	9,470	1.30	7,284
11	534		17.6	78.2	71.0	43	38	11/06(22)	0.275	717	6,520	1.32	4,939
12	528		13.8	83.1	145.3	40	35	11/04(23)	0.319	655	5,130	1.13	4,540
13				75.3	65.1	40	35						
14		feed not eaten		0.0	0.0	40	35						
15	1111	301	21.2	83.2	129.5	40	34	01/19(20)	0.0095	19.0	5,000	1.30	3,846
16	1112	355	24.5	95.1	125.5	40	34	01/19(22)	0.0099	41.8	10,560	1.51	6,993
17	1113	233	18.2	83.2	110.5	40	34	01/19(24)	0.0104	20.2	4,860	0.98	4,985
18	1114	305	21.2	83.5	150.2	40	34	01/20(01)	0.0109	16.4	3,760	1.30	2,892
19	1115	332	21.4	65.2	125.4	37	31	01/20(03)	0.0113	13.8	3,050	1.44	2,118
20	1116	254	18.4	65.5	155.2	37	31	01/20(04)	0.0119	12.8	2,690	1.07	2,514
21	1117	320	20.8	55.2	45.4	37	31	01/20(06)	0.0124	47.0	9,480	1.48	6,405
22	1118	311	21.2	52.5	75.3	37	31	01/20(11)	0.0129	37.5	7,270	1.32	5,508
23	1119	304	17.5	85.2	125.6	37	31	01/20(12)	0.0135	56.0	10,370	1.33	7,797
24	1120	292	18.6	90.1	120.5	37	31	01/20(14)	0.0142	38.0	6,690	1.24	5,395
25	1121	295	17.3	90.0	85.0	37	31	01/20(16)	0.0148	33.2	5,610	1.20	4,675
26	1122	252	16.3	75.2	84.3	34	28	01/20(17)	0.0155	45.4	7,320	1.03	7,106
27	1123	273	15.2	65.3	65.7	34	28	01/20(19)	0.0162	51.4	7,930	1.17	6,777
	1124	300	17.2					01/20(21)	0.0162	69.8	10,770	1.35	7,977
28	1125	321	17.2	50.3	61.5	34	28	01/20(22)	0.0169	95.4	14,110	1.45	9,731
29	1126	288	15.8	60.3	120.5	34	28	01/20(24)	0.0177	38.2	5,400	1.43	3,776
30	1127	264	14.7	90.2	155.0	34	28	01/21(02)	0.0185	63.8	8,620	1.11	7,766
31	1128	268	14.5	90.	150.	34	28	01/21(03)	0.0194	60.2	7,760	1.11	6,991

A.2-1 cont'd
Bluegill Food

Date of feeding, 1982	Vial No.	Weight, mg.		amt. fed, g		Number of fish		P-32				P,mg/g wet wt	P-32/P, c/min.mg
		Dry	Ash	E	W	E	W	counting date, 1982/83	Decay factor	c/min net	c/min.g		
11/01	1129	287	16.1	85.2	20.1	34	28	01/21(05)	0.020	45.8	5,720	1.14	5,018
02	1130	232	13.4	80.1	105.2	29	25	01/21(07)	0.021	67.4	8,020	1.05	7,638
03	1131	219	12.4	65.3	110.5	29	25	01/21(08)	0.022	62.0	7,050	0.93	7,580
04	1132	279	15.0	40.5	90.2	29	25	01/21(10)	0.023	50.1	5,450	1.15	4,739
05	1134	212	12.3	71.3	103.4	29	25	01/21(13)	0.024	45.0	4,690	0.88	5,317
06	1135	254	13.7	61.7	111.8	29	25	01/21(15)	0.025	39.5	3,950	1.11	3,559
07	1136	297	14.8	50.8	101.3	29	25	01/21(17)	0.027	107.	9,910	1.23	8,057
08	1137	212	12.3	60.1	81.3	29	25	01/21(18)	0.028	67.2	6,000	0.94	6,417
09	1138	315	15.1	55.2	85.6	26	22	01/21(20)	0.029	5.6	483	1.35	358
10	1139	282	15.3	42.3	78.2	26	22	01/21(22)	0.030	73.0	6,080	1.24	4,903
11	1140	374	19.2	40.5	55.3	26	22	01/21(23)	0.032	277.	21,640	1.66	13,036
12	1141	308	15.8	25.3	42.6	26	22	01/22(01)	0.033	123.	9,320	1.32	7,060
13	1142	291	15.6	38.5	63.2	26	22	01/22(03)	0.035	133.	9,500	1.28	7,422
14	1143	243	14.0	50.3	72.6	26	22	01/22(04)	0.036	102.	7,080	1.10	6,436
15	1144	314	16.5	55.1	85.3	26	22	01/22(06)	0.038	116.	7,630	1.45	5,262
16	1145	307	16.7	41.3	70.4	26	22	01/22(08)	0.039	117	7,500	1.30	5,769
Average for period 10/06 - 11/16 (± standard deviation of mean)												1.23 ± 0.03	6,020 ± 370

Notes: 1. Feed samples were worms, 2 g moist weight; 20-ml aliquots of 100-ml samples were counted

2. Amount fed is moist weight; total amount was based on estimated fish weight, as 1.5% (E) or 3.0% (W) of body weight. Lesser amounts were fed if fish reduced their intake.

A.2-2
Catfish Food

Date of feeding, 1982	Vial No.	Dry wt., g	Amt fed, g E	Amt fed, g W	Number of fish E	Number of fish W	P-32 counting date, 1982/83	P-32 Decay factor	P-32 c/min net	P-32 c/min.g	P,mg/g dry wt	P-32/P, c/min.mg
08/15	438	0.98	238.2	151.2	69	69	10/26(02)	0.031	629	103,500	13.5	7,670
16			47.8	33.5	65	64						
17			89.0	34.2	62	60						
18	423	0.94	78.7	50.7	59	55	10/25(21)	0.036	672	99,300	12.5	7,940
19			77.9	115.2	59	55						
20			26	18.1	58	54						
21	430	0.96	156	81	58	50	10/25(23)	0.042	741	91,900	13.4	6,860
22			148	100	58	50						
23			86	40	55	50						
24			129	65	52	47						
25	436	1.02	142	119	52	47	10/26(01)	0.050	937	91,900	14.5	6,340
26			20	20	9	15						
27	431	1.03	20	20	6	12	10/25(24)	0.055	1,070	94,400	14.2	6,650
28			14.7	13.2	6	12						
29			4.9	4.6	6	12						
30	429	1.04	7.0	9.2	6	12	10/25(23)	0.065	1,238	91,600	13.0	7,046
	434	1.05					10/26(01)	0.065	1,203	88,100	14.6	6,034
31			1.3	2.3	6	12						
09/01			8.8	3.4	3	9						
02	425	0.98	4.3	10.0	3	9	10/25(22)	0.071	659	47,400	14.4	3,292
03			6.6	9.3	3	9						
04			4.8	15.0	3	9						
05	427	1.01	4.2	8.6	3	9	10/25(22)	0.082	801	48,400	14.4	3,361
06			2.1	8.8	3	9						
07			3.1	8.8	3	9						
08	421	1.00	2.9	15.0	3	9	10/25(20)	0.095	904	47,600	13.2	3,606
09			3.3	9.6	3	9						
10			---	1.2	0	6						
11	424	0.98	---	3.5	0	6	10/25(21)	0.110	1,119	51,900	15.1	3,437
12			---	3.0	0	6						
13					0	6						
14	422	0.98	---	12.0	0	6	10/25(21)	0.127	1,209	48,600	14.6	3,329
	428	1.01					10/25(23)	0.127	1,158	45,100	15.8	2,854

A.2-2 cont'd
Catfish Food

Date of feeding, 1982	Vial No.	Dry wt., g	Amt fed, g E	Amt fed, g W	Number of fish E	Number of fish W	P-32 counting date, 1982/83	P-32 Decay factor	P-32 c/min net	P-32 c/min.g	P, mg/g dry wt	P-32/P, c/min.mg
09/15				5.2	0	6						
16				5.3	0	6						
17	426	1.00	---	9.9	0	6	10/25(22)	0.147	1,337	45,500	14.7	3,095
18				8.3	0	6						
19				10.6	0	6						
20				9.	0	6						
21	435	1.02	---	3.1	0	6	10/26(01)	0.177	1,543	42,700	13.5	3,163
22					0	6						
23				1.2	0	3						
Average for period 08/15 - 08/27 (± std. dev. of mean)											13.6 ± 0.4	7,090 ± 300

Notes: 1. 20-ml aliquots of 100-ml samples were counted.
2. Amount fed was based on estimated fish weight, as 2.0% (E) or 1.0 % (W) of body weight. Lesser amounts were fed if fish reduced their intake.

A.3-1

P-32 in Water During Bluegill Uptake and Depuration Study

Collection date, 1982 (hour)	Sample	Vial No.	P-32: Counting date, 1982-1983 (hr)	P-32: Decay fraction	P-32: net c/min.	P-32: c/min / L	P-32: c/min. / fish.day	P, mg/L	P-32/P, c/min.mg.
11/09 (17)	E - 1 water*	1106	01/14(22)	0.040	2.2	68.8	952	----	----
	1 filter*	1146	01/22(09)	0.028	<2.2	<98	<1,400	0.034	<3,000
	W - 1 water*	1105	01/14(14)	0.040	16.9	528	7,300	0.41	1,290
	1 filter*	1147	01/22(11)	0.028	<2.2	<98	<1,400	0.023	<5,000
11/20 (11)	E - 1 water no filtration	957	12/23(24)	0.196	141.	450	3,600	----	----
	2 water no filtration	958	12/24(02)	0.195	81.2	260	2,080	0.36	722
	W - 1 water no filtration	955	12/22(15)	0.209	535	1,600	12,800	0.58	2,760
	2 water no filtration	956	12/22(15)	0.209	150	449	3,590	0.53	847
	Inflow	1162	02/02(04)	0.028	<2.2	<49		0.39	<130
11/24 (11)	E - 1 water	1133	01/21(12)	0.060	6.2	65	520	0.71	92
	1 filter	Lost	---	---	---	---	---	----	----
	2 water	1110	01/19(18)	0.065	<2.2	<21	<170	----	----
	2 filter	1151	01/22(18)	0.056	<2.2	<25	<200	0.028	<900
	W - 1 water	1109	01/15(03)	0.081	15.5	120	960	0.69	174
	1 filter	1150	01/22(16)	0.056	3.6	40.2	322	0.082	490
	2 water	1108	01/15(01)	0.081	17.0	131	1,048	0.76	172
	2 filter	1149	01/22(14)	0.056	<2.2	<25	<200	0.057	<500
	Inflow	1164	02/02(09)	0.034	<2.2	<40		0.76	<60

Notes:
1. Four-liter samples were taken from 24-L aquaria (41.5-L on 11/09) and processed to 50-ml volumes. These were filtered and the filters were processed to 50-ml volumes.
2. One asterisk indicates that only a 2-L sample was collected.
3. Two asterisks indicate approximately 15% loss during processing, for which the result was corrected.

A.3-1 cont'd

P-32 in Water During Bluegill Uptake and Depuration Study

Collection date, 1982 (hour)	Sample	Vial No.	P-32: Counting date, 1982-1983 (hr)	Decay fraction	net c/min.	c/min L	c/min. fish.day	P, mg/L	P-32/P, c/min.mg.
11/30 (15)	E - 1 water	1152	01/22(19)	0.075	4.2	35.0	280	----	----
	1 filter	1183	02/03(22)	0.042	<2.2	<33.	<270	0.057	<600
	2 water	1153	01/22(21)	0.075	3.3	27.5	220	0.99	27.8
	2 filter	1184	02/03(24)	0.042	<2.2	<33.	<270	0.051	<500
	W - 1 water	1107	01/14(24)	0.109	65.3	374	2,990	----	----
	1 filter	1148	01/22(13)	0.076	6.0	49.3	394	0.033	1,494
	2 water	1157	01/28(17)	0.056	53.2	594	4,750	0.80	742
	2 filter	1188	02/04(06)	0.041	3.2	48.8	390	0.029	1,683
12/07 (11)	E - 1 water	1155	01/28(14)	0.079	<2.2	<17	<140	0.95	<18
	1 filter	1186	02/04(03)	0.058	<2.2	<24	<200	0.028	<900
	2 water	1156	01/28(16)	0.079	<2.2	<17	<140	0.90	<19
	2 filter	1187	02/04(05)	0.058	<2.2	<24	<200	0.044	<600
	W - 1 water	1158	01/28(19)	0.079	6.4	50.6	405	0.56	90.4
	1 filter	1189	02/04(10)	0.057	<2.2	<24	<200	0.049	<500
	2 water	1154	02/01(23)	0.064	4.3	42.0	336	0.45	93.3
	2 filter	1185	02/04(02)	0.058	<2.2	<24	<200	0.013	<1,900
12/15 (11)	E - 1 water	1161	02/02(02)	0.094	<2.2	<15	<120	0.45	<40
	1 filter	1192	02/04(15)	0.084	<2.2	<16	<130	0.013	<1,300
	2 water	1163	02/02(05)	0.094	<2.2	<15	<120	----	----
	2 filter	1216	02/08(22)	0.068	<2.2	<20	<160	<0.06	----
	W - 1 water	1159	01/28(21)	0.115	<2.2	<12	<100	0.59	<20
	1 filter	1190	02/04(12)	0.084	<2.2	<16	<130	0.018	<900
	2 water**	1160	02/01(24)	0.094	<2.2	<17	<140	0.72	<30
	2 filter	1191	02/04(13)	0.084	<2.2	<16	<130	0.014	<1,200

P-32 in Suspended Solids During Bluegill Uptake and Depuration Study

Collection date, 1982 (hr)	Sample	Vial No.	P-32 Counting date, 1982-1983 (hr)	Decay fraction	net c/min.	c/min. L	c/min. fish.day	P, mg/L	P-32/P, c/min.mg
11/09 (17)	E-large	945	12/23(16)	0.125	12.0	11.6	160	0.018	640
	E-250µ	944	12/22(06)	0.127	21.7	20.6	285	0.011	1,900
	E-75µ	811	12/11(05)	0.217	66.5	36.9	510	0.022	1,700
	E-0.45µ(4)	1042	01/07(20)	0.057	<2.2	<380	<5,300	<0.2	---
		808	12/10(04)	0.228	<2.2	<100	<1,400	<0.2	---
		814	12/11(08)	0.216	2.4	110	1,520	<0.2	---
		809	12/10(06)	0.228	<2.2	<100	<1,400	<0.2	---
	W-large	810	12/11(03)	0.218	5.4	3.0	41	0.0020	1,500
	W-250µ	1008	12/31(10)	0.082	9.6	14.1	195	0.0052	2,700
	W-75µ	922	12/21(15)	0.131	39.3	36.1	499	0.024	1,500
	W-0.45µ(4)	923	12/21(17)	0.131	<2.2	<170	<2,400	<0.2	---
		940	12/22(03)	0.128	<2.2	<170	<2,400	<0.2	---
		924	12/21(18)	0.130	<2.2	<170	<2,400	<0.3	---
		941	12/22(04)	0.128	<2.2	<170	<2,400	<0.3	---
11/20 (11)	E	1167	02/02(14)	0.027	3.9	30	240	0.017	1,760
	W	1172	02/02(22)	0.027	<2.2	<17	<140	0.018	<1,000
11/24 (11)	E	1174	02/03(02)	0.032	<2.2	<14	<120	0.011	<1,300
	W	1168	02/02(16)	0.033	<2.2	<14	<120	0.013	<1,100
11/30 (15)	E	1169	02/02(17)	0.046	<2.2	<10	<80	0.027	<400
	W	1171	02/02(20)	0.046	<2.2	<10	<80	0.018	<600
12/07 (11)	E	1173	02/02(24)	0.061	<2.2	<8	<70	0.018	<500
	W	1170	02/02(19)	0.062	<2.2	<8	<70	0.017	<500
12/15 (11)	E	1166	02/02(12)	0.093	<2.2	<5	<40	0.013	<400
	W	1165	02/02(10)	0.093	<2.2	<5	<40	0.0051	<1,000

Notes;
1. For 11/09 samples, water volume was 41.5 L but only 0.50 L was passed through each 0.45 filter; samples were made up to 100 ml
2. For all other samples, water volume was 24 L and samples were made up to 100 ml
3. Large solids were collected on 11/09 with a small net; solids were collected on all other dates by siphoning them from the aquarium bottom and retaining them on a 75-µ filter

A.4-1
Bluegill Wet Weight in Flow-through Tank

Fish No.	Weight, g 09/03	10/01	11/12	Death Date	Weight gain, d^{-1} 09/03 on	10/01 on	11/12 on
				09/28			
761 E	118.0			114.5	-0.001		
794 E	130.0			119.6	-0.003		
879 E	151.0			153.3	0.001		
499 W	121.0			121.6	0.002		
708 W	111.0			123.6	0.004		
787 W	142.5			149.4	0.002		
Avg E					-0.001		
Avg W					0.002		
				09/29			
684 E	159.0			156.5	-0.001		
859 E	133.5			139.8	0.002		
863 E	95.0			93.6	-0.001		
608 W	102.5			107.9	0.002		
682 W	137.0			148.7	0.003		
890 W	126.0			139.7	0.004		
Avg E					0.000		
Avg W					0.003		
				09/30			
619 E	106.5			122.4	0.005		
872 E	152.0			153.5	0.000		
635 E	135.0			142.5	0.002		
706 W	131.0			133.8	0.001		
704 W	121.5			119.2	-0.001		
480 W	150.6			158.5	0.002		
Avg E					0.002		
Avg W					0.001		

Notes: 1. Fish were initially weighed before P-32 feeding was begun on 09/27.
2. Weighing on 10/01 was not used to compute weight changes for fish killed on 10/06, and weighing on 11/12 was not used to compute weight change for fish killed on 11/17 because of short time interval.

A.4-1 cont'd
Bluegill Wet Weight in Flow-through Tank

Fish No.	Weight, g 09/03	10/01	11/12	Death Date	Weight gain, d^{-1} 09/03 on	10/01 on	11/12 on
				10/06			
759 E	113.5	103.9		98.6	-0.004		
674 E	95.0	101.1		102.4	0.002		
762 E	122.5	119.8		114.0	-0.002		
613 W	96.0	102.7		103.5	0.002		
680 W	80.5	84.5		82.4	0.001		
792 W	105.0	114.4		109.2	0.001		
Avg E					-0.001		
Avg W					0.001		
				10/12			
699 E	143.0	142.8		147.2	0.000	0.003	
784 E	138.9	153.1		148.3	0.003	-0.003	
733 E	---	109.4		107.6	---	-0.002	
488 W	110.9	115.3		118.5	0.001	0.002	
490 W	85.6	93.3		98.5	0.003	0.005	
476 W	153.5	163.1		164.9	0.002	0.001	
Avg E					0.001	-0.001	
Avg W					0.002	0.003	
				10/19			
769 E	94.0	101.0		101.4	0.003	0.000	
482 E	94.6	92.0		92.9	-0.001	0.000	
677 E	119.0	105.2		116.1	-0.004	0.005	
497 W	81.0	83.4		86.9	0.001	0.002	
873 W	132.0	149.5		161.4	0.004	0.004	
607 W	164.0	159.3		172.4	-0.001	0.004	
Avg E					-0.001	0.002	
Avg W					0.001	0.003	

A.4-1 cont'd

Bluegill Wet Weight in Flow-through Tank

Fish No.	Weight, g 09/03	10/01	11/12	Death Date	Weight gain, d^{-1} 09/03 on	10/01 on	11/12 on
				10/26			
876 E	93.0	99.5		105.0	0.002	0.002	
763 E	129.0	132.8		140.5	0.001	0.002	
881 E	89.5	88.1		85.9	-0.001	-0.001	
785 W	130.5	135.5		147.6	0.001	0.003	
716 W	---	135.7		148.6	---	0.004	
875 W	145.0	153.5		158.2	0.002	0.001	
Avg E					0.001	0.001	
Avg W					0.002	0.003	
				11/03			
882 E	119.0	111.2		117.0	-0.002	0.002	
456 E	89.5	91.4		91.5	0.001	0.000	
627 E	130.0	141.8		151.1	0.003	0.002	
858 E	149.0	148.2		149.7	0.000	0.000	
722 E	125.0	124.1		126.4	0.000	0.001	
884 W	106.0	117.0		116.7	0.004	0.000	
672 W	121.0	118.1		119.7	-0.001	0.000	
679 W	140.0	148.6		154.7	0.002	0.001	
Avg E					0.000	0.001	
Avg W					0.002	0.000	
				11/09			
799 E	122.0	118.5		124.1	-0.001	0.001	
790 E	120.5	135.7		132.6	0.004	-0.001	
486 E	146.0	134.4		132.6	-0.003	0.000	
602 W	134.5	136.6		135.0	0.001	0.000	
893 W	119.0	109.1		118.0	-0.003	0.002	
798 W	150.5	161.7		169.2	0.003	0.001	
Avg E					0.000	0.000	
Avg W					0.000	0.001	

A.4-1 cont'd
Bluegill Wet Weight in Flow-through Tank

Fish No.	Weight, g 09/03	10/01	11/12	Death Date	Weight gain, d^{-1} 09/03 on	10/01 on	11/12 on
				11/17			
899 E	118.0	117.3	120.2	120.8	0.000	0.001	
713 E	93.0	94.0	94.5	96.9	0.000	0.001	
880 E	129.0	120.1	120.5	118.8	-0.003	0.000	
886 W	124.0	135.6	155.2	162.7	0.003	0.004	
622 W	118.5	126.9	139.9	145.0	0.002	0.003	
698 W	135.0	139.1	144.7	146.9	0.001	0.001	
Avg E					-0.001	0.001	
Avg W					0.002	0.003	
				11/20			
782 E	142.0	155.0	160.6	160.0	0.003	0.001	0.000
767 E	159.0	166.0	172.4	171.3	0.002	0.001	-0.001
728 E	---	149.0	164.6	162.7	---	0.002	-0.001
715 W	---	151.7	164.2	166.0	---	0.002	0.001
889 W	104.5	154.5	169.8	169.5	---	0.002	0.000
606 W	153.5	175.4	196.5	196.5	0.005	0.003	0.000
Avg E					0.002	0.001	-0.001
Avg W					---	0.002	0.000
				11/24			
477 E	135.0	140.7	148.9	147.0	0.001	0.001	-0.001
738 E	114.0	111.0	115.3	115.7	-0.001	0.001	0.000
691 E	140.0	155.0	161.5	160.7	0.003	0.001	0.000
668 W	131.0	150.3	161.2	161.1	0.005	0.002	0.000
717 W	---	108.9	117.8	118.3	---	0.002	0.000
891 W	135.0	143.3	143.2	143.3	0.002	0.000	0.000
Avg E					0.001	0.001	0.000
Avg W					0.004	0.001	0.000

A.4-1 cont'd
Bluegill Wet Weight in Flow-through Tank

Fish No.	Weight, g 09/03	10/01	11/12	Death Date	Weight gain, d^{-1} 09/03 on	10/01 on	11/12 on
				11/30			
637 E	126.0	132.6	143.7	149.0	0.002	0.002	0.002
721 E	---	106.6	108.7	112.0	---	0.000	0.002
723 E	---	118.6	122.7	128.2	---	0.001	0.002
892 W	153.0	179.1	214.9	225.0	0.006	0.004	0.003
885 W	91.0	102.0	112.4	117.5	0.004	0.002	0.002
636 W	140.5	151.7	164.2	174.7	0.003	0.002	0.003
Avg E					---	0.001	0.002
Avg W					0.004	0.003	0.003
				12/07			
730 E	---	117.6	123.2	125.6	---	0.001	0.001
871 E	112.5	121.9	122.2	122.8	0.003	0.000	0.000
705 E	155.5	148.5	143.7	148.4	-0.002	-0.001	0.001
641 W	96.0	96.4	102.4	109.2	0.000	0.001	0.003
615 W	128.0	146.6	156.1	154.1	0.005	0.001	0.000
735 W	98.0	95.5	105.0	113.2	-0.001	0.002	0.003
Avg E					0.000	0.000	0.001
Avg W					0.001	0.001	0.002
				12/15			
694 E	119.0	120.8	121.9	135.5	0.000	0.000	0.003
485 E	142.0	142.9	161.8	166.6	0.000	0.003	0.001
894 E	160.0	172.1	176.7	184.6	0.003	0.001	0.001
692 W	150.0	161.8	186.5	201.3	0.003	0.004	0.002
854 W	132.0	140.2	155.3	163.3	0.002	0.002	0.002
630 W	104.0	105.6	112.3	121.8	0.000	0.001	0.002
Avg E					0.001	0.001	0.002
Avg W					0.002	0.002	0.002

A.4-2

Catfish Wet Weight in Flow-through Tank

Fish Number	Weight, g Start	Weight, g Death	Weight gain, d^{-1}
	08/09	08/16	
351 E	175.0	179.7	0.004
317 E	220.0	240.7	0.013
362 E	207.0	209.4	0.002
395 W	193.0	186.8	-0.005
418 W	186.0	179.0	-0.005
409 W	258.0	231.9	-0.015
Avg E			0.006
Avg W			-0.008
		08/17	
359 E	199.0	---	---
357 E	244.0	236.5	-0.004
300 E	227.5	225.5	-0.001
421 W	226.0	---	---
422 W	163.0	155.0	-0.006
380 W	236.0	235.5	0.000
Avg E			-0.002
Avg W			-0.003
		08/18	
365 E	146.0	142.3	-0.003
361 E	261.0	265.6	0.002
385 E	226.5	232.7	0.003
373 W	191.0	193.8	0.002
424 W	193.5	193.3	0.000
398 W	107.0	104.0	-0.003
Avg E			0.001
Avg W			0.000
		08/24	
307 E	201.0	237.8	0.011
449 E	284.0	260.7	-0.006
276 E	157.0	165.1	0.003
372 W	261.0	261.4	0.000
401 W	223.0	244.9	0.006
416 W	211.0	234.1	0.007
Avg E			0.003
Avg W			0.004

Note: Fish were initially weighed before P-32 feeding was begun on 08/15.

A.4-2 cont'd

Catfish Wet Weight in Flow-through Tank

Fish Number	Weight, g Start	Death	Weight gain, d^{-1}
	08/09	08/26	
314 E	208.0	250.0	0.011
369 E	196.0	250.0	0.014
332 E	202.0	224.0	0.006
448 W	179.0	173.0	-0.002
439 W	267.0	325.0	0.012
389 W	241.5	270.0	0.007
Avg E			0.010
Avg W			0.006
		09/01	
355 E	243.0	260.7	
393 E	189.0	208.6	
348 E	156.0	181.0	
414 W	254.0	256.3	
403 W	145.5	134.4	
404 W	227.5	226.7	
		09/10	
321 E	200.0	205.8	
363 E	216.0	258.5	
356 E	78.0	70.6	
387 W	201.0	229.7	
429 W	132.0	193.3	
431 W	205.0		
		09/23	
428 W	234.0	297.2	
410 W	185.5	223.7	
390 W	225.0	225.0	

A.5-1

Weight Balances for Dissected Bluegill
in Flow-through Tank

Fish No.	Date of death, 1982 (hr)	Total Wet Weight, g		
		Sum	Death Weight	Percent
761E	09/28	106.2	114.5	92.8
794E	(08)	111.7	119.6	93.4
879E		146.3	153.3	95.4
499W		117.0	121.6	96.2
708W		114.7	123.6	92.8
787W		139.3	149.4	93.3
684E	09/29	152.1	156.5	97.2
859E	(08)	136.0	139.8	97.3
863E		89.0	93.6	95.1
608W		101.6	107.9	94.2
682W		136.3	148.7	91.6
890W		133.2	139.7	95.4
619E	09/30	105.4	122.4	86.1
872E	(08)	146.4	153.5	95.3
635E		131.6	142.5	92.4
706W		124.7	133.8	93.2
704W		111.0	119.2	93.1
480W		148.5	158.5	93.7
759E	10/06	98.1	98.6	99.5
674E	(08)	95.1	102.4	92.9
762E		107.1	114.0	94.0
613W		95.2	103.5	92.0
680W		78.0	82.4	94.7
792W		103.7	109.2	95.0
699E	10/12	139.8	147.2	95.0
784E	(08)	141.9	148.3	95.7
733E		103.2	107.6	95.9
488W		111.1	118.5	93.8
490W		92.1	98.5	93.5
476W		158.2	164.9	96.0

A.5-1 (cont'd)

Weight Balances for Dissected Bluegill
in Flow-through Tank

Fish No.	Date of death, 1982 (hr)	Total Wet Weight, g Sum	Death Weight	Percent
769E	10/19	96.3	101.4	95.0
482E	(08)	88.3	92.9	95.0
677E		102.5	116.1	88.2
497W		83.1	86.9	95.6
873W		153.9	161.4	95.3
607W		167.4	172.4	97.1
876E	10/26	98.6	105.0	93.9
763E	(08)	129.7	140.5	92.3
381E		78.2	85.9	91.0
785W		133.9	147.6	90.7
716W		137.8	148.6	92.7
875W		150.0	158.2	94.8
882E	11/03	109.8	117.0	93.9
456E	(08)	87.0	91.5	95.1
627E		146.0	151.1	96.6
858E		143.7	149.7	96.0
722W		121.3	126.4	96.0
884W		111.6	116.7	95.6
672W		112.5	119.7	94.0
679W		146.6	154.7	94.7
799E	11/09	115.8	124.1	93.3
790E	(08)	124.0	132.6	93.5
486E		123.5	132.6	93.2
602W		126.4	135.0	93.6
893W		109.1	118.0	92.4
798W		159.0	169.2	94.0
899E	11/17	113.9	120.8	94.3
713E	(08)	92.2	96.9	95.1
880E		113.0	118.8	95.1
886W		154.1	162.7	94.7
622W		137.1	145.0	94.6
698W		140.0	146.9	95.3

A.5-1 (cont'd)

Weight Balances for Dissected Bluegill
in Flow-through Tank

Fish No.	Date of death, 1982 (hr)	Total Wet Weight, g Sum	Death Weight	Percent
782E	11/20	154.4	160.0	96.5
767E	(08)	163.0	171.3	95.1
728E		154.3	162.7	94.8
715W		155.5	166.0	93.6
889W		161.8	169.5	95.5
606W		190.5	196.5	97.0
477E	11/24	141.2	147.0	96.1
738E	(08)	109.1	115.7	94.3
691E		154.0	160.7	95.8
668W		154.4	161.1	95.8
717W		112.0	118.3	94.7
891W		137.5	143.3	96.0
637E	11/30	141.3	149.0	94.8
721E	(08)	104.3	112.0	93.1
723E		120.5	128.2	94.0
892W		212.4	225.0	94.4
885W		112.9	117.5	96.1
636W		163.8	174.7	93.8
730E	12/07	119.9	125.6	95.5
871E	(08)	119.4	122.8	97.2
705E		140.2	148.4	94.5
641W		101.9	109.2	93.3
615W		144.6	154.1	93.8
735W		106.2	113.2	93.8
694E	12/15	127.5	135.5	94.1
485E	(08)	159.3	166.6	95.6
894E		178.5	184.6	96.7
692W		190.3	201.3	94.5
854W		157.0	163.3	96.1
630W		115.8	121.8	95.0

A.5-2

Weight Balances for Dissected Catfish in Flow-through Tank

Fish No.	Date of death, 1982 (hr)	Total Wet Weight, g		
		Sum	Death Weight	Percent
351E	08/16	163.5	179.7	91.0
317E	(08)	224.3	240.7	93.2
362E		197.8	209.4	94.5
395W		175.8	186.8	94.1
418W		164.6	179.0	92.0
409W		215.8	231.9	93.1
359E	08/17	181.1	---	---
357E	(08)	222.7	236.5	94.2
300E		207.6	225.5	92.1
421W		202.2	---	---
422W		140.1	155.0	90.4
380W		216.4	235.5	91.9
365E	08/18	134.1	142.3	94.2
361E	(08)	251.8	265.6	94.8
385E		218.7	232.7	94.0
373W		180.2	193.8	93.0
424W		178.5	193.3	92.4
398W		96.1	104.0	92.4
307E	08/24	219.3	237.8	92.2
449E	(08)	248.1	260.7	95.2
276E		149.9	165.1	90.8
372W		244.3	261.4	93.4
401W		233.2	244.9	95.2
416W		216.3	234.1	92.4

A.5-2 (cont'd)

Weight Balances for Dissected Catfish
in Flow-through Tank

Fish No.	Date of death, 1982 (hr)	Total Wet Weight, g		
		Sum	Death Weight	Percent
314E	08/26	234.0	250.0	93.6
369E	(08)	231.3	250.0	92.5
332E		208.9	224.0	93.3
448W		159.5	173.0	92.2
439W		302.8	325.0	93.2
389W		254.5	270.0	94.3
355E	09/01	253.9	260.7	97.4
393E	(08)	192.4	208.6	92.2
348E		177.7	181.0	98.2
414W		240.8	256.3	94.0
403W		126.8	134.4	94.3
404W		215.2	226.7	94.9
321E	09/10	194.8	205.8	94.6
363E	(08)	240.4	258.5	93.0
356E		66.5	70.6	94.2
387W		219.3	229.7	95.5
429W		181.3	193.3	93.8
431W		212.8	---	---
428W	09/23	282.2	297.2	95.0
410W	(08)	214.1	223.7	95.7
390W		212.2	225.0	94.3

B.1-1

P-32 Uptake in Worm-fed Bluegill and Catfish Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight			Sample No.	Counting date, 1983 (hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
			Wet	Dry	Ash							
							Bluegill Muscle					
0.87	11	1-1	45.3	9.77	596	1198	02/08(10)	0.559	1,148.	227.	2.66	85.3
		1-2	29.4	6.40	379	1315	02/16(13)	0.377	32.9	14.8	2.64	5.6
		1-3	31.1	6.20	396	1241	02/09(11)	0.531	380.	115.	2.52	45.6
1.6	23	2-1	27.4	5.82	327	1289	02/15(05)	0.402	775.	352.	2.35	150.6
		2-2	25.7	4.92	268	1201	02/07(23)	0.572	39.2	13.3	1.93	6.9
		2-3	43.7	9.43	559	1317	02/15(23)	0.388	4,126	1217.	2.57	474.
2.9	24	3-1	24.6	5.31	307	1262	02/14(20)	0.409	2,325	1,155	2.58	448.
		3-2	24.0	4.14	294	1342	02/16(08)	0.381	329	180	2.39	75.3
		3-3	50.2	11.0	619	1220	02/08(23)	0.545	9,772	1,786	2.62	682.
1.5	27	4-1	33.9	4.22	287	1215	02/08(13)	0.556	1,305	346	1.82	190.
		4-2	27.8	5.39	340	1219	02/08(14)	0.554	1,630	529	2.25	235.
		4-3	41.5	8.87	495	1221	02/08(14)	0.554	1,802	392	2.51	156.
2.4	27	5-1	32.3	4.94	263	1242	02/09(12)	0.530	1,683	492	1.33	370.
		5-2	33.3	6.94	406	1222	02/08(15)	0.554	2,843	771	2.28	338.
		5-3	34.4	7.28	445	1345	02/21(16)	0.294	1,438	711	2.71	262.
2.9	25	6-1	32.8	5.01	310	Lost	---	---	---	---	---	---
		6-2	27.5	4.44	222	1195	02/07(18)	0.577	11.6	3.6	1.31	2.8
		6-3	25.6	5.30	312	1316	02/15(22)	0.389	1,220	562.	2.21	254.
		6-4	51.7	11.5	600	1261	02/14(20)	0.409	6,825	1,614	2.49	648.
							Catfish Muscle					
1.4	27	7-1	92.3	22.9	1,094	1343	02/16(08)	0.381	8,663	1,232	2.50	493.
		7-2	53.6	12.8	603	1287	02/15(05)	0.402	6,454	1,498	2.32	646.
		7-3	51.1	12.1	621	1263	02/14(21)	0.409	1,926	461	2.26	204.
3.0	26	8-1	49.0	11.6	908	1284	02/15(04)	0.403	3,221	816	2.26	361.
		8-2	47.8	11.8	540	1243	02/09(12)	0.530	7,251	1,431	2.26	633.
		8-3	48.4	10.7	549	1255	02/14(18)	0.411	9,783	1,907	2.29	833.

Notes: 1) Exposure period was 01/18-01/27(10) except fish 4-1 was removed on 01/25, 5-1, on 01/26, and 6-1, on 01/20 because of illness, and fish 6-2 was exposed beginning 01/20. 2) Wet and dry wts. are in grams, ash weight is in mg. 3) Duplicate 20-ml aliquots of 100-ml samples were analyzed for P-32 by Cherenkov counting with 50-min. counts when < 200 c/min. and 10-min counts when > 200 c/min.

B.1-1 (cont'd)

P-32 Uptake in Worm-fed Bluegill and Catfish
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983 (hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Bluegill Skeleton					
0.87	11	1-1	27.2	8.66	2,310	1207	02/08(12)	0.557	1,830	604	14.9	40.5
		1-2	23.6	7.49	2,010	1314	02/15(22)	0.389	144	78.4	15.7	5.00
		1-3	18.5	5.53	1,880	1244	02/09(12)	0.529	638	326	17.6	18.5
1.6	23	2-1	18.7	6.90	1,560	1291	02/15(06)	0.401	1,061	707	16.0	44.2
		2-2	18.0	5.59	1,650	1197	02/07(20)	0.575	44.1	21.3	16.5	1.29
		2-3	33.4	11.4	3,400	1356	02/22(12)	0.282	3,269	1,735	19.8	87.6
2.9	24	3-1	20.8	6.48	1,840	1275	02/15(01)	0.406	3,321	1,966	16.1	122
		3-2	21.4	6.00	2,440	1248	02/14(16)	0.413	494	279	23.7	11.8
		3-3	35.0	11.5	2,840	1274	02/14(24)	0.406	7,363	2,590	15.3	169
1.5	27	4-1	20.0	5.57	2,040	1203	02/08(11)	0.506	1,182	584	19.3	30.3
		4-2	15.7	4.90	1,570	1277	02/15(01)	0.406	2,013	1,579	21.3	74.0
		4-3	33.9	11.1	2,590	1224	02/08(15)	0.551	3,126	837	15.3	54.7
2.4	27	5-1	18.1	5.24	1,890	1240	02/09(11)	0.531	2,566	1,335	19.5	68.5
		5-2	23.3	7.61	2,177	1225	02/08(12)	0.557	4,330	1,668	16.0	104
		5-3	23.6	9.85	2,662	1353	02/22(11)	0.283	2,102	1,574	25.4	619
2.9	25	6-1	18.1	4.84	1,760	1176	02/03(05)	0.513	30.7	16.5	20.0	0.825
		6-2	12.6	3.75	1,350	1200	02/07(22)	0.573	14.8	10.2	20.9	0.488
		6-3	20.8	7.08	2,280	1318	02/15(23)	0.388	1,667	1,033	21.5	48.1
		6-4	30.7	9.52	2,280	1286	02/15(04)	0.403	7,474	3,020	15.3	197
							Catfish Skeleton					
1.4	27	7-1	38.6	12.7	1,604	1340	02/16(07)	0.382	4,319	1,465	8.62	170
		7-2	25.5	8.19	874	1323	02/16(01)	0.386	3,738	1,899	6.51	292
		7-3	34.8	10.9	1,310	1245	02/14(12)	0.416	?,149	742	7.73	96.0
3.0	26	8-1	28.9	8.69	1,100	1321	02/15(24)	0.387	2,139	956	7.08	135
		8-2	24.7	8.52	926	1273	02/14(24)	0.406	4,357	2,170	8.10	268
		8-3	26.7	8.30	945	1352	02/22(11)	0.283	4,563	3,020	6.43	470

P-32 Uptake in Worm-fed Bluegill and Catfish
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Dry	Ash	Sample No.	Counting date, 1983 (hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Bluegill Viscera					
0.87	11	1-1	11.0	2.69	113	1212	02/08(12)	0.557	4,144	3,380	2.05	1,496
		1-2	6.27	1.55	67.9	1331	02/16(04)	0.384	520	1,080	2.26	478
		1-3	6.70	130.	77.0	1339	02/16(07)	0.382	1,553	3,030	2.07	1,464
1.6	23	2-1	5.53	1.55	56.3	1298	02/15(16)	0.393	1,862	4,280	1.81	2,360
		2-2	5.97	1.25	37.9	1214	02/08(13)	0.556	546	822	1.24	663
		2-3	10.1	2.44	110	1299	02/15(17)	0.393	4,346	5,470	1.85	2,960
2.9	24	3-1	7.19	1.63	68.8	1279	02/15(02)	0.405	3,412	5,860	1.65	3,550
		3-2	3.68	0.516	47.5	1257	02/14(19)	0.410	610	2,020	1.94	1,041
		3-3	11.3	3.97	112	1272	02/14(24)	0.406	4,406	4,800	1.74	2,760
1.5	27	4-1	5.17	0.879	39.3	1196	02/08(10)	0.507	707	1,349	1.72	784
		4-2	3.74	1.06	34.1	1235	02/09(10)	0.533	1,743	4,370	1.53	2,860
		4-3	8.29	2.56	99.6	1232	02/09(09)	0.534	3,310	3,740	1.95	1,918
2.4	27	5-1	6.45	1.06	52.1	1337	02/16(06)	0.383	1,012	2,050	1.58	1,297
		5-2	8.24	1.94	92.7	1234	02/09(10)	0.533	4,603	5,240	2.26	2,320
		5-3	8.57	2.08	105	1341	02/16(08)	0.381	3,881	5,940	2.50	2,380
2.9	25	6-1	6.26	0.870	46.6	1178	02/03(08)	0.509	<2.2	<3.5	1.43	< 2.4
		6-2	3.48	0.738	36.1	1213	02/08(20)	0.548	4.8	12.6	2.14	5.9
		6-3	5.30	1.38	73.7	1304	02/15(18)	0.392	1,906	4,590	2.81	1,633
3.0	27	6-4	12.17	4.90	120	1281	02/15(03)	0.404	6,441	6,550	1.87	3,500
							Catfish Viscera					
1.4	26	7-1	19.3	6.23	180	1326	02/16(02)	0.385	4,310	2,900	1.63	1,779
		7-2	9.00	3.35	71.5	1333	02/16(05)	0.384	2,151	3,110	1.53	2,030
		7-3	12.4	4.95	127	1344	02/16(09)	0.380	1,119	1,187	2.51	473
3.0	25	8-1	8.66	3.26	72.4	1305	02/15(19)	0.391	1,403	2,070	1.49	1,389
		8-2	9.00	3.37	84.7	1249	02/14(16)	0.413	3,543	4,770	1.92	2,480
		8-3	12.0	3.67	115	1332	02/16(05)	0.384	5,175	5,620	1.52	3,530

B.1-1 (cont'd)

P-32 Uptake in Worm-fed Bluegill and Catfish
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983 (hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Bluegill Scales and Skin					
0.87	11	1-1	15.3	5.66	1,900	1202	02/08(11)	0.558	1,265.	741	26.5	28.0
		1-2	10.4	4.15	1,417	1350	02/22(23)	0.276	73.6	128	29.3	4.37
		1-3	9.69	3.99	1,550	1265	02/14(21)	0.409	407.	513	32.3	15.9
1.6	23	2-1	7.19	2.96	1,040	1285	02/15(04)	0.403	491.	847	30.8	27.5
		2-2	7.76	3.12	1,200	1237	02/09(03)	0.540	16.2	19.3	30.7	0.63
		2-3	12.2	5.40	2,230	1330	02/16(04)	0.384	2,794	2,980	39.9	74.4
2.9	24	3-1	7.13	3.13	1,210	1266	02/14(22)	0.407	1,882	3,240	35.7	90.8
		3-2	10.5	4.37	1,910	1276	02/15(01)	0.406	345	415	35.5	11.7
		3-3	13.8	5.65	2,160	1264	02/14(21)	0.409	5,252	4,650	35.1	132.
1.5	27	4-1	7.32	2.98	1,230	1206	02/08(12)	0.505	770	1,041	38.6	27.0
		4-2	8.21	3.07	897	1278	02/15(02)	0.405	1,155	1,737	27.5	63.2
		4-3	11.4	4.91	2,050	1230	02/09(09)	0.534	2,151	1,767	34.4	51.4
2.4	27	5-1	8.02	3.28	1,430	1256	02/14(18)	0.411	1,805	2,720	36.3	74.9
		5-2	10.4	4.19	1,540	1223	02/08(15)	0.553	2,987	2,600	32.8	79.3
		5-3	15.4	6.73	2,890	1313	02/15(21)	0.390	1,908	1,588	41.7	38.1
2.9	25	6-1	7.63	2.59	917	1177	02/03(06)	0.512	24.7	31.6	26.2	1.21
		6-2	3.99	1.61	654	1236	02/09(01)	0.542	8.3	19.2	32.2	0.60
		6-3	9.94	4.46	1,757	1354	02/22(11)	0.283	1,084	1,927	35.2	54.7
		6-4	19.5	6.65	1,970	1290	02/15(06)	0.400	5,728	3,670	21.1	174.
							Catfish Skin					
1.4	27	7-1	20.5	6.62	176	1348	02/21(16)	0.294	1,031	855	1.47	582.
		7-2	8.89	2.46	56.2	1336	02/16(06)	0.383	519	762	1.11	686.
		7-3	6.98	2.16	60.1	1251	02/14(17)	0.412	209	363	1.38	263.
3.0	26	8-1	8.28	2.75	64.2	1334	02/16(05)	0.384	331	521	1.28	407.
		8-2	7.09	2.63	54.4	1311	02/15(21)	0.390	596	1,078	1.39	776.
		8-3	11.8	3.63	96.5	1359	02/22(13)	0.282	973	1,462	1.46	1,001.

P-32 Uptake in Worm-fed Bluegill and Catfish
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983 (hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Bluegill Head					
0.87	11	1-1	42.3	12.8	3,040	1199	02/08(10)	0.559	2,958	625	14.0	44.6
		1-2	33.5	10.1	2,600	1319	02/15(23)	0.388	193	74.2	14.8	5.01
		1-3	33.9	9.10	2,740	1254	02/14(18)	0.411	982	352	15.2	23.2
1.6	23	2-1	25.0	7.66	1,950	1329	02/16(04)	0.384	1,003.	522	15.7	33.2
		2-2	27.0	8.02	2,220	1204	02/08(01)	0.569	49.0	15.9	15.3	1.04
		2-3	53.4	16.9	4,790	1292	02/15(06)	0.400	7,266.	1,700	17.9	95.0
2.9	24	3-1	27.9	8.39	2,280	1267	02/14(22)	0.407	3,836	1,689	15.6	108.
		3-2	33.2	8.07	3,200	1247	02/14(12)	0.416	720	261	18.7	14.0
		3-3	50.4	15.7	3,830	1227	02/08(16)	0.552	11,910	2,140	14.4	149.
1.5	27	4-1	36.1	9.27	2,960	1205	02/08(11)	0.506	1,755	480	16.3	29.4
		4-2	27.0	7.59	1,990	1229	02/09(08)	0.535	3,258	1,128	13.0	86.8
		4-3	44.0	14.3	3,430	1226	02/08(16)	0.554	4,409	904	13.5	67.0
2.4	27	5-1	33.5	8.64	2,630	1253	02/14(17)	0.412	3,571	1,294	15.5	83.5
		5-2	38.2	11.6	3,090	1228	02/09(08)	0.535	6,454	1,579	15.5	102.
		5-3	47.8	14.9	4,540	1324	02/16(01)	0.386	2,854	773	19.0	40.7
2.9	25	6-1	28.5	6.98	2,210	1175	02/03(03)	0.515	48.4	16.5	14.9	1.11
		6-2	20.0	5.09	1,560	1238	02/09(04)	0.539	17.7	8.2	15.6	0.53
		6-3	32.1	10.1	3,030	1325	02/16(01)	0.386	2,428	980	19.2	51.0
		6-4	50.3	15.3	3,280	1288	02/15(05)	0.402	10,480	2,590	12.2	212.
							Catfish Head					
1.4	27	7-1	65.1	21.3	4,430	1351	02/22(10)	0.279	5,591	1,539	13.2	117.
		7-2	43.7	12.9	2,430	1322	02/15(24)	0.387	7,503	2,220	11.6	191.
		7-3	40.7	13.2	2,650	1357	02/22(12)	0.277	2,121	941	11.8	79.7
3.0	26	8-1	45.1	13.9	2,740	1320	02/15(24)	0.387	3,460	991	12.0	82.6
		8-2	44.0	14.3	2,590	1355	02/22(12)	0.277	5,937	2,440	11.5	212.
		8-3	47.3	13.9	2,760	1246	02/14(12)	0.416	13,240	3,360	11.3	297.

P-32 Uptake in Worm-fed Bluegill and Catfish
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Dry	Ash	Sample No.	Counting date, 1983 (hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Bluegill Gills					
0.87	11	1-1	0.540	0.101	7.0	1210	02/08(06)	0.564	133.	2,180	3.62	602
		1-2	0.237	0.046	4.3	1338	02/16(15)	0.375	6.5	366	4.38	83.6
		1-3	0.485	0.087	6.1	1346	02/22(18)	0.279	40.6	1,500	3.45	435
1.6	23	2-1	0.502	0.079	0.5	1297	02/16(12)	0.378	54.6	1,439	3.10	464.
		2-2	0.502	0.129	3.7	1211	02/08(18)	0.550	4.8	86.9	2.66	32.7
		2-3	0.672	0.114	8.9	1302	02/15(18)	0.392	154.	2,920	3.00	973
2.9	24	3-1	0.425	0.079	5.6	1303	02/15(18)	0.392	112.	3,360	3.87	868
		3-2	0.574	0.071	6.5	1358	02/22(23)	0.295	14.6	431	1.83	236
		3-3	0.692	0.122	9.7	1269	02/14(23)	0.407	232.	4,120	3.53	1,167
1.5	27	4-1	0.653	0.059	2.7	1208	02/08(03)	0.515	48.4	720	1.59	453
		4-2	0.304	0.043	2.4	1268	02/14(22)	0.408	76.2	3,070	3.17	968
		4-3	0.560	0.103	6.7	1231	02/09(09)	0.534	136.	2,270	3.14	723
2.4	27	5-1	0.773	0.094	12.0	1347	02/22(20)	0.278	62.4	1,452	3.49	416
		5-2	0.742	0.129	9.7	1233	02/09(10)	0.533	342.	4,320	3.30	1,309
		5-3	0.703	0.134	9.8	1295	02/15(15)	0.394	310.	5,600	4.01	1,397
2.9	25	6-1	0.534	0.076	10.9	1179	02/03(10)	0.507	4.1	75.7	4.30	17.6
		6-2	0.269	0.042	5.4	1209	02/08(04)	0.566	2.4	78.8	4.96	15.9
		6-3	0.530	0.089	5.8	1310	02/15(20)	0.391	120.	2,900	3.36	863
		6-4	0.850	0.091	8.8	1280	02/15(02)	0.405	348.	5,050	2.27	2,220.
							Catfish Gills					
1.4	27	7-1	1.24	1.24	16.6	1293	02/15(07)	0.400	251.	2,530	3.25	778
		7-2	0.951	0.188	10.3	1294	02/15(07)	0.400	216.	2,840	3.43	828
		7-3	1.09	0.220	14.0	1270	02/14(23)	0.407	103.	1,161	3.05	381
3.0	26	8-1	1.22	0.238	14.7	1349	02/22(21)	0.277	95.8	1,417	2.66	5[illegible]
		8-2	0.828	0.164	10.6	1250	02/14(16)	0.413	246.	3,600	3.49	1,032
		8-3	1.08	0.215	12.5	1309	02/15(20)	0.391	335.	3,970	3.29	1,207

B.1-1 (cont'd)

P-32 Uptake in Worm-fed Bluegill and Catfish
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983 (hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Catfish Fin Spines					
1.5	25	7-1	0.712	0.494	261	1296	02/15(16)	0.393	291.	5,200	82.4	63.1
1.5	25	7-2	0.395	0.251	129	1300	02/15(17)	0.392	212.	6,850	81.0	84.6
1.5	25	7-3	0.451	0.302	151	1335	02/16(06)	0.382	105.	3,050	75.6	40.3
3.0	25	8-1	0.493	0.312	168	1306	02/15(19)	0.391	122.	3,160	48.1	65.7
3.0	25	8-2	0.363	0.226	118	1271	02/14(23)	0.407	245.	8,290	62.1	133
3.0	25	8-3	0.390	0.254	126	1301	02/15(17)	0.392	244.	7,980	74.1	108
							Catfish Fins					
1.5	25	7-1	8.41	3.33	370	1327	02/16(02)	0.385	1,226	1,893	9.21	206
1.5	25	7-2	4.73	1.52	170	1312	02/15(21)	0.388	833	2,270	8.19	277
1.5	25	7-3	4.17	1.63	206	1328	02/16(02)	0.385	365	1,137	13.3	85.5
3.0	25	8-1	5.50	2.08	252	1307	02/15(19)	0.390	563	1,312	10.1	130
3.0	25	8-2	4.13	1.64	214	1252	02/14(17)	0.412	1,147	3,370	11.7	288
3.0	25	8-3	4.15	1.38	165	1308	02/15(20)	0.390	931	2,880	8.01	360

B.1-2
P-32 Uptake in Pellet-fed Bluegill and Catfish
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983(hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Catfish Muscle					
0.41	11	1-1	51.9	11.0	617	1527	03/14(18)	0.293	953.	313.	2.65	118.
		1-2	44.7	10.4	506	1430	03/04(19)	0.475	23.6	5.6	2.15	2.6
		1-3	51.0	12.3	580	1530	03/12(09)	0.329	28.2	8.4	1.19	7.1
0.48	20	3-1	51.2	12.2	569	1503	03/09(04)	0.384	36.4	9.3	2.21	4.2
		3-2	33.0	7.22	350	1458	03/05(17)	0.454	15.4	5.1	2.19	2.3
		3-3	49.0	11.4	575	1372	02/25(20)	0.665	31.1	4.8	2.41	2.0
0.62	20	4-1	51.0	11.6	579	1477	03/09(09)	0.380	16,161	4,170	2.40	1,738.
		4-2	45.5	10.2	528	1386	02/28(08)	0.589	16,270	3,036	2.60	1,168
		4-3	53.3	12.0	590	1531	03/14(19)	0.292	9,049.	2,907	2.37	1,227
0.88	20	5-1	52.4	11.7	590	1524	03/14(17)	0.293	2,814	916	2.32	395
		5-2	41.3	9.67	463	1433	03/07(14)	0.415	6,500	1,896	2.43	780
		5-3	41.8	9.62	470	1529	03/14(19)	0.292	2,221	910	2.33	391
0.34	24	7-1	54.9	12.6	625	1508	03/09(17)	0.374	13,474	3,281	2.34	1,402
		7-2	63.7	13.7	744	1525	03/14(18)	0.293	5,149	1,379	2.29	602
		7-3	64.3	15.3	734	1523	03/14(17)	0.293	18,954	5,030	2.30	2,187
0.80	24	8-1	51.6	12.3	564	1528	03/14(19)	0.292	7,897	2,621	2.27	1,155
		8-2	40.4	9.14	449	1526	03/14(18)	0.293	3,026	1,278	2.08	614
		8-3	42.6	9.96	464	1381	02/28(09)	0.588	6,881	1,374	2.27	605
							Bluegill Muscle					
0.41	20	2-1	27.4	6.21	342	1456	03/07(17)	0.412	8,326	3,688	4.02(4)	917
		2-2	17.4	3.55	201	1455	03/05(15)	0.456	54.1	34.1	2.60	13.1
		2-3	36.2	7.81	455	1457	03/07(18)	0.411	7,620	2,561	2.51	1,020
0.79	19	6-1	21.6	4.40	259	1459	03/05(18)	0.453	171	87.3	2.16	40.4
		6-2	27.5	5.05	303	1532	03/12(11)	0.327	27.4	15.2	2.37	6.4
		6-3	33.3	7.20	424	1460	03/07(18)	0.411	18,270	6,675	2.45	2,724

1) Exposure period was 02/08 - 02/17(10). 2) Wet and dry weights are in grams; ash weight is in mg. 3) Duplicate 20-ml aliquots of 100-ml samples were analyzed for P-32 by Cherenkov counting with 50-min counts when < 200 c/min and 10-min counts when > 200 c/min. 4) Weight appears to be erroneous

B.1-2 (cont'd)
P-32 Uptake in Pellet-fed Catfish and Bluegill
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983(hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Catfish Skeleton					
0.41	11	1-1	26.0	7.25	1,060	1559	03/15(01)	0.289	630.	419.	8.66	48.4
		1-2	26.0	7.89	937	1383	02/25(21)	0.664	17.5	5.1	6.33	0.805
		1-3	22.3	7.49	922	1551	03/12(21)	0.319	11.9	8.4	8.25	1.02
0.48	20	3-1	23.8	7.69	887	1485	03/08(17)	0.393	17.0	9.1	7.76	1.17
		3-2	26.5	7.76	844	1490	03/08(20)	0.390	18.6	9.0	6.60	1.36
		3-3	19.7	5.91	804	1435	03/04(21)	0.473	14.8	7.9	8.75	0.903
0.62	20	4-1	24.8	8.01	996	1489	03/09(13)	0.377	7,907	4,229	7.26	583
		4-2	20.7	6.09	762	1434	03/07(14)	0.415	6,273	3,651	6.72	543
		4-3	27.9	8.23	810	1566	03/15(03)	0.287	5,389	3,365	5.81	579
0.88	20	5-1	21.7	6.41	847	1486	03/09(12)	0.378	1,954	1,191	7.27	164
		5-2	18.2	5.69	736	1432	03/07(13)	0.415	3,824	2,531	6.90	367
		5-3	24.8	7.54	825	1555	03/14(24)	0.289	1,549	1,081	6.50	166
0.34	24	7-1	33.5	10.2	1,010	1484	03/09(11)	0.379	11,989	4,721	5.90	800
		7-2	40.8	11.2	1,741	1534	03/14(20)	0.292	4,218	1,770	8.65	205
		7-3	26.2	8.12	985	1561	03/15(02)	0.288	10,394	6,887	7.34	938
0.80	24	8-1	25.7	8.61	857	1556	03/15(01)	0.289	4,448	2,994	6.95	431
		8-2	20.3	6.04	730	1567	03/15(04)	0.287	1,606	1,378	6.69	206
		8-3	29.8	9.07	997	1431	03/07(13)	0.415	4,285	1,732	6.39	271
							Bluegill Skeleton					
0.41	20	2-1	15.1	5.31	1,420	1475	03/09(09)	0.380	5,948	4,748	18.8	252
		2-2	17.4	5.19	1,670	1492	03/08(22)	0.389	135	99.7	18.1	5.51
		2-3	21.1	6.76	1,800	1506	03/09(16)	0.375	10,305	6,512	13.4	486
0.79	19	6-1	15.4	4.87	1,480	1504	03/09(16)	0.375	251.	217	18.9	11.5
		6-2	17.4	5.42	1,730	1554	03/12(24)	0.319	56.2	50.6	18.4	2.75
		6-3	18.7	6.22	1,750	1509	03/09(17)	0.374	15,037	10,750	17.3	621

B.1-2 (cont'd)
P-32 Uptake in Pellet-fed Catfish and Bluegill
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983(hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Catfish Viscera					
0.41	11	1-1	12.0	2.52	140	1536	03/14(20)	0.292	5,052	7,208	2.26	3,190
		1-2	11.0	3.38	101	1418	02/27(13)	0.612	32.1	23.8	1.96	12.1
		1-3	14.8	6.13	111	1498	03/09(01)	0.386	42.8	37.5	1.77	21.2
0.48	20	3-1	10.8	3.86	86.6	1446	03/05(05)	0.465	14.4	14.3	1.60	8.9
		3-2	6.53	1.80	54.9	1454	03/05(13)	0.458	6.6	11.0	1.63	6.7
		3-3	9.49	3.47	74.4	1416	02/27(10)	0.616	41.1	35.2	1.57	22.4
0.62	20	4-1	13.9	4.08	142	1550	03/14(24)	0.289	7,828	9,743	1.87	5,210
		4-2	12.0	4.17	123	1448	03/07(17)	0.412	6,837	6,914	1.59	4,350
		4-3	16.3	4.67	178	1515	03/09(19)	0.373	8,021	6,596	2.21	2,990
0.88	20	5-1	11.8	3.63	123	1499	03/09(15)	0.376	2,231	2,514	2.60	965
		5-2	14.2	4.22	159	1420	02/27(18)	0.606	13,271	7,711	1.94	3,970
		5-3	15.5	5.04	166	1537	03/14(21)	0.291	4,520	5,011	2.05	2,440
0.34	24	7-1	12.8	3.04	125	1544	03/14(22)	0.291	5,953	7,991	1.63	4,900
		7-2	11.4	2.44	119	1514	03/09(19)	0.373	5,866	6,898	1.74	3,970
		7-3	22.3	7.77	272	1463	03/07(19)	0.410	16,488	9,017	2.61	3,460
0.80	24	8-1	15.1	6.17	120	1470	03/07(21)	0.409	4,818	3,901	1.32	2,950
		8-2	8.69	2.47	93.4	1548	03/14(23)	0.290	2,925	5,803	1.96	2,960
		8-3	13.2	3.96	146	1414	02/28(13)	0.583	8,330	5,412	2.24	2,420
							Bluegill Viscera					
0.41	20	2-1	7.22	2.02	96.7	1465	03/07(19)	0.410	10,098	17,060	2.10	8,120
		2-2	3.45	0.624	42.0	1467	03/05(22)	0.450	301	969	2.20	440
		2-3	13.0	3.40	201	1469	03/07(20)	0.410	22,769	21,360	2.51	8,510
0.79	19	6-1	4.19	0.911	56.5	1462	03/07(18)	0.411	1,220	3,542	2.27	1,559
		6-2	4.40	0.869	48.7	1427	03/04(16)	0.478	198	471	2.33	202
		6-3	10.9	3.12	169	1468	03/07(20)	0.410	20,648	23,100	2.58	8,950

B.1-2 (cont'd)

P-32 Uptake in Pellet-fed Catfish and Bluegill
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983(hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Catfish Skin					
0.41	11	1-1	10.5	2.72	89.1	1535	03/14(20)	0.292	293	478	1.71	280
		1-2	9.16	2.88	70.3	1415	02/27(09)	0.617	19.4	17.1	1.37	12.5
		1-3	10.0	3.16	77.0	1443	03/04(24)	0.470	12.2	13.0	1.58	8.23
0.48	20	3-1	12.7	4.60	107	1403	02/26(22)	0.631	29.0	18.1	1.73	10.5
		3-2	7.24	2.20	55.9	1406	02/26(24)	0.629	12.0	13.2	1.42	9.30
		3-3	10.1	3.60	72.7	1417	02/27(12)	0.613	8.9	7.2	1.45	4.97
0.62	20	4-1	8.94	2.76	63.8	1542	03/14(22)	0.291	1,124	2,160	1.21	1,785.
		4-2	8.05	2.41	62.7	1402	02/28(11)	0.586	1,763	1,869	1.47	1,271.
		4-3	8.58	2.57	65.6	1500	03/09(15)	0.375	1,171	1,820	1.51	1,205.
0.88	20	5-1	12.1	3.68	103	1413	02/28(12)	0.584	1,025	725	1.57	462.
		5-2	8.25	2.71	62.2	1411	02/28(12)	0.584	1,325	1,375	1.56	881.
		5-3	7.90	2.84	56.6	1543	03/14(22)	0.291	267	581	1.31	444.
0.34	24	7-1	9.04	2.77	66.5	1520	03/14(16)	0.294	1,127	2,120	1.28	1,656.
		7-2	9.82	2.79	76.1	1495	03/09(14)	0.376	782	1,060	1.47	721.
		7-3	9.46	3.12	68.0	1471	03/09(08)	0.381	2,048	2,841	1.23	2,310.
0.80	24	8-1	9.42	3.23	67.7	1464	03/07(19)	0.410	1,251	1,620	1.30	1,246
		8-2	8.76	2.73	70.7	1472	03/09(08)	0.381	611	915	1.60	572
		8-3	8.32	2.71	65.6	1408	02/28(12)	0.585	1,027	1,055	1.33	793
							Bluegill Scales and Skin					
0.41	20	2-1	7.54	3.25	1,130	1511	03/09(18)	0.373	2,982	5,300	32.1	165.
		2-2	8.26	3.15	1,890	1474	03/08(11)	0.397	111	169	28.3	5.97
		2-3	7.32	2.99	1,090	1478	03/09(10)	0.379	6,389	11,510	32.7	352.
0.79	19	6-1	5.91	2.79	1,110	1479	03/08(13)	0.396	168	359	40.8	8.80
		6-2	8.61	3.44	1,320	1557	03/13(02)	0.317	19.2	35.2	31.9	1.10
		6-3	7.54	3.32	1,230	1510	03/09(18)	0.373	8,682	15,440	35.1	440.

B.1-2 (cont'd)
P-32 Uptake in Pellet-fed Catfish and Bluegill
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983(hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P/32/P, c/min.mg
Catfish Head												
0.41	11	1-1	48.5	14.2	4,080	1564	03/15(03)	0.287	1,277	459	16.2	28.3
		1-2	44.5	13.0	2,640	1384	02/25(23)	0.661	33.3	5.7	11.2	0.51
		1-3	39.7	12.6	2,600	1552	03/12(23)	0.319	21.9	8.6	12.7	0.68
0.48	20	3-1	40.2	12.8	2,610	1487	03/08(18)	0.392	30.4	9.6	12.8	0.75
		3-2	34.0	9.51	1,860	1533	03/12(13)	0.326	30.6	13.8	10.0	1.38
		3-3	40.8	12.8	2,820	1385	02/26(01)	0.658	27.7	5.2	13.1	0.40
0.62	20	4-1	43.7	13.3	2,860	1491	03/09(13)	0.377	14,902	4,522	13.4	337.
		4-2	37.7	11.2	2,320	1436	03/07(14)	0.414	14,027	4,494	12.2	368.
		4-3	44.6	13.0	2,380	1553	03/14(24)	0.289	8,835	3,427	10.3	333.
0.88	20	5-1	36.9	11.0	2,480	1493	03/09(13)	0.377	3,626	1,303	13.2	98.7
		5-2	33.9	10.8	2,270	1437	03/07(15)	0.414	8,313	2,962	12.6	235.
		5-3	38.7	12.0	2,390	1562	03/15(02)	0.288	2,576	1,156	12.1	95.5
0.34	24	7-1	52.9	14.1	2,880	1502	03/09(15)	0.375	23,891	6,022	10.6	568
		7-2	66.1	19.3	5,530	1488	03/09(12)	0.378	9,751	1,951	17.2	113
		7-3	43.7	13.1	2,776	1560	03/15(01)	0.289	18,723	7,412	11.5	644
0.80	24	8-1	54.9	16.9	3,019	1565	03/15(03)	0.287	9,077	2,880	10.4	277
		8-2	41.1	12.5	2,652	1563	03/15(02)	0.288	3,242	1,369	12.9	106
		8-3	38.9	12.5	2,440	1438	03/07(15)	0.414	7,258	2,253	12.6	179
Bluegill Head												
0.41	20	2-1	25.4	8.21	1,970	1505	03/09(16)	0.375	7,221	3,791	13.8	275.
		2-2	27.9	7.58	2,360	1480	03/08(15)	0.394	215	97.8	16.3	6.00
		2-3	31.9	9.41	2,300	1507	03/09(17)	0.374	12,991	5,444	13.7	397.
0.79	19	6-1	24.3	7.31	1,990	1461	03/05(20)	0.451	344	157	15.5	10.1
		6-2	23.5	7.07	2,050	1558	03/13(04)	0.316	47.4	31.9	16.0	1.99
		6-3	30.4	9.02	2,290	1476	03/09(09)	0.380	20,188	8,738	14.0	624.

B.1-2 (cont'd)
P-32 Uptake in Pellet-fed Catfish and Bluegill
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983(hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Catfish Gills					
0.41	11	1-1	1.08	0.194	13.4	1540	03/12(16)	0.324	83.5	1,193	2.91	410
		1-2	1.09	0.175	12.2	1396	02/26(17)	0.637	<2.1	<15	2.79	< 5
		1-3	0.975	0.177	11.5	1393	02/26(12)	0.644	3.9	31.1	3.01	10.3
0.48	20	3-1	1.34	0.237	16.3	1392	02/26(11)	0.645	4.0	23.1	2.89	8.0
		3-2	1.27	0.214	14.5	1387	02/26(02)	0.657	3.7	22.2	2.71	8.2
		3-3	0.985	0.173	11.4	1378	02/25(18)	0.668	5.1	38.8	3.49	11.1
0.62	20	4-1	0.989	0.182	11.5	1541	03/14(21)	0.291	344	5,980	2.83	2,110.
		4-2	0.758	0.132	9.0	1421	03/07(11)	0.417	274	4,330	2.64	1,640
		4-3	0.885	0.143	8.9	1513	03/09(19)	0.372	309	4,690	2.98	1,574
0.88	20	5-1	0.814	0.145	9.2	1389	02/26(06)	0.652	213	2,010	2.97	677
		5-2	0.752	0.139	8.2	1419	02/27(16)	0.609	329	3,590	3.05	1,177
		5-3	1.04	0.179	20.5	1539	03/12(14)	0.325	100	1,479	2.88	514
0.34	24	7-1	1.11	0.187	9.2	1517	03/09(20)	0.372	721	8,730	2.67	3,270
		7-2	1.56	0.261	16.7	1512	03/09(18)	0.373	576	4,950	2.55	1,941
		7-3	0.856	0.160	9.8	1424	03/07(12)	0.416	824	11,570	3.03	3,820
0.80	24	8-1	1.52	0.202	12.1	1516	03/09(20)	0.372	435	3,850	2.33	1,652
		8-2	0.695	0.128	11.0	1444	03/04(24)	0.470	212	3,240	3.33	973
		8-3	1.11	0.196	12.2	1405	02/28(11)	0.586	564	4,340	2.87	1,512
							Bluegill Gills					
0.41	20	2-1	0.539	0.101	6.3	1452	03/05(10)	0.460	678	13,670	3.46	3,950
		2-2	0.406	0.060	3.9	1451	03/05(08)	0.462	10.8	288	2.81	102
		2-3	0.782	0.143	10.4	1450	03/07(17)	0.412	648	10,060	3.35	3,000
0.79	19	6-1	0.344	0.063	3.7	1453	03/05(12)	0.459	19.8	627	3.88	162.
		6-2	0.436	0.080	5.9	1521	03/12(07)	0.330	3.0	104	5.30(4)	19.6
		6-3	0.667	0.122	8.6	1426	03/07(12)	0.416	824	14,850	3.44	4,320.

B.1-2 (cont'd)
P-32 Uptake in Pellet-fed Catfish and Bluegill
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983(hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Catfish Fins					
0.41	11	1-1	5.22	1.59	270	1545	03/12(18)	0.322	349	1,038	10.6	97.9
		1-2	5.10	1.97	223	1412	02/27(07)	0.620	8.1	12.8	10.5	1.22
		1-3	3.90	1.42	187	1409	02/27(04)	0.623	7.7	15.8	9.59	1.65
0.48	20	3-1	3.73	1.39	181	1404	02/26(24)	0.629	8.5	18.1	9.43	1.92
		3-2	4.34	1.59	190	1445	03/05(04)	0.466	<2.1	≤5	8.72	< 0.6
		3-3	3.94	1.43	196	1449	03/05(07)	0.463	3.5	9.6	9.45	1.02
0.62	20	4-1	4.71	1.57	199	1549	03/14(23)	0.290	1,306	4,781	9.07	527.
		4-2	3.82	1.25	162	1447	03/07(16)	0.413	1,285	4,072	8.51	478.
		4-3	5.18	1.69	204	1497	03/09(14)	0.376	1,494	3,835	8.79	436
0.88	20	5-1	4.85	1.61	204	1439	03/04(22)	0.472	653	1,426	8.53	167
		5-2	3.15	1.18	149	1429	03/07(13)	0.415	766	2,930	11.4	257
		5-3	4.15	1.[illegible]6	198	1546	03/12(19)	0.322	382	1,428	9.69	147
0.34	24	7-1	5.85	1.79	227	1538	03/14(21)	0.291	2,021	5,936	7.86	755
		7-2	8.13	2.50	400	1446	03/05(05)	0.465	14.4	19.0	2.56(4)	7.42
		7-3	4.35	1.48	188	1466	03/07(20)	0.409	3,039	8,541	9.17	931
0.80	24	8-1	4.68	1.67	202	1547	03/14(3)	0.290	1,051	3,872	8.94	433
		8-2	4.32	1.58	212	1473	03/09(08)	0.381	567	1,722	11.7	147
		8-3	4.86	1.82	208	1407	02/28(11)	0.586	1,296	2,275	8.85	257

B.1-2 (cont'd)
P-32 Uptake in Pellet-fed Catfish and Bluegill
Maintained in Aquaria for Nine Days

Feed %/day	Temp, °C	Fish No.	Weight Wet	Weight Dry	Weight Ash	Sample No.	Counting date, 1983(hr)	Decay fraction	Net c/min.	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg
							Catfish Fin Spines					
0.41	11	1-1	0.778	0.471	280	1519	03/12(06)	0.331	62.0	1,204	73.0	16.5
		1-2	0.453	0.226	120	1388	02/26(04)	0.654	2.1	35.4	57.3	0.62
		1-3	0.390	0.211	114	1428	03/04(17)	0.477	3.2	86.0	57.8	1.49
0.48	20	3-1	0.426	0.247	128	1397	02/26(19)	0.635	2.5	46.2	62.3	0.74
		3-2	0.373	0.198	107	1391	02/26(09)	0.648	<2.1	<43	38.1	< 1
		3-3	0.434	0.249	134	1394	02/26(14)	0.641	<2.1	<31	60.4	< 0.6
0.62	20	4-1	0.427	0.223	116	1518	03/09(20)	0.372	292	9,190	64.2	143
		4-2	0.363	0.202	111	1399	02/28(10)	0.587	413	9,690	59.2	164
		4-3	0.388	0.189	95.2	1494	03/08(23)	0.388	210	6,980	60.0	116
0.88	20	5-1	0.383	0.219	122	1395	02/26(16)	0.639	135	2,760	68.1	40.5
		5-2	0.421		93.5	1390	02/26(07)	0.650	233	4,260	44.7	95.3
		5-3	0.388	0.196	100	1398	02/26(21)	0.632	124	2,530	58.1	43.5
0.34	24	7-1	0.491	0.229	116	1522	03/14(17)	0.294	417	14,440	52.2	277
		7-2	0.780	0.474	293	1501	03/09(03)	0.385	169	2,810	75.0	37.5
		7-3	0.413	0.231	123	1425	03/07(12)	0.416	750	21,830	56.7	385
0.80	24	8-1	0.421	0.210	113	1422	03/07(11)	0.417	321	9,140	60.5	151
		8-2	0.393	0.218	121	1423	03/04(14)	0.479	113	3,000	64.5	46.5
		8-3	0.447	0.227	119	1410	02/27(05)	0.622	246	4,420	58.4	75.7

B.2-1

P-32 Concentration in Worms Fed to Bluegill & Catfish in Aquaria

Feeding Date, 1983	Amount fed, g	Vial No.	Weight, mg Dry	Weight, mg Ash	No. of worms	Counting date, 1983 (hr)	Decay factor	P-32 net c/min.	P-32 c/min g wet	P, mg/g wet wt.	P-32/P, c/min.mg.
01/18	64.5	1360	207	14.6	4	02/22(13)	0.182	356	4,890	0.90	5,464
		1361	263	16.2	8	02/22(13)	0.182	759	10,430	1.13	9,230
01/19	62.8	1362	297	18.7	8	02/22(14)	0.191	2,298	30,080	1.23	24,455
		1363	295	18.8	6	02/22(14)	0.191	2,173	28,440	1.23	23,122
01/20	67.0	1364	264	16.2	8	02/22(14)	0.200	1,500	18,750	1.10	17,045
		1365	318	18.4	8	02/22(15)	0.200	1,571	19,640	1.27	15,465
01/21	71.5	1366	259	15.2	6	02/22(15)	0.210	1,885	22,440	1.00	22,440
		1367	335	18.5	9	02/22(15)	0.210	1,979	23,560	1.38	17,072
01/22	64.2	1368	285	16.4	9	02/22(16)	0.220	2,441	27,740	1.23	22,553
		1369	267	13.5	6	02/22(16)	0.220	1,566	17,800	1.03	17,282
01/23	61.2	1370	256	15.8	9	02/23(07)	0.224	1,194	13,330	1.06	12,575
01/24	68.5	1371	251	14.0	11	02/23(07)	0.235	1,385	14,730	1.00	14,730
01/25	68.5	1372	271	14.8	5	02/23(08)	0.246	1,900	19,310	1.11	17,396
		1373	315	18.6	9	02/23(08)	0.246	2,233	22,690	1.25	18,152
01/26	68.5	1374	272	14.7	8	02/23(08)	0.258	1,541	14,930	1.12	13,330
		1375	310	16.3	8	02/23(09)	0.258	1,812	17,560	1.34	13,104
Average (± standard deviation of mean)										1.15 ± 0.03	16,500 ± 1,300

Notes: 1) Feed samples were 2 g moist weight; 20-ml aliquots of 100-ml samples were counted.
2) Amount fed is moist weight; amount of feed was based on fish weight.
3) P-32 added to worm feed was 3.21×10^5 c/min.g worm wet weight

B.2-2

P-32 Concentration in Pellets Fed to Bluegill & Catfish in Aquaria

Feeding Date, 1983	Amount fed, g	Vial No.	Weight, mg Dry	Weight, mg Ash	Counting date, 1983 (hr)	Decay factor	P-32 net c/min.	P-32 c/min. g wet	P, mg/g wet wt.	P-32/P, c/min.mg
02/08	12.3	1568	545	58.5	03/18(10)	0.159	5,053	291,600	13.3	21,900
		1569	579	60.9	03/18(11)	0.158	5,545	301,400	12.9	23,400
02/09	12.3	1570	477	51.2	03/18(11)	0.166	4,856	306,700	13.6	22,600
		1571	561	59.6	03/18(11)	0.166	5,546	297,700	13.5	22,100
02/10	12.3	1572	565	53.8	03/18(12)	0.174	5,934	301,800	14.0	21,600
		1573	638	68.0	03/18(12)	0.174	6,258	281,900	14.8	19,000
02/11	12.3	1574	535	53.8	03/18(12)	0.183	5,699	291,000	13.2	22,000
		1575	608	64.3	03/18(13)	0.182	6,770	305,900	14.2	21,500
02/12	12.3	1576	563	58.5	03/18(13)	0.191	6,615	307,600	13.9	22,100
		1577	665	68.6	03/18(13)	0.191	7,395	291,100	14.1	20,600
02/13	12.3	1578	491	51.4	03/18(14)	0.200	6,048	307,900	14.2	21,700
		1579	422	45.2	03/18(14)	0.200	5,255	311,400	13.9	32,400
02/14	24.5	1580	426	44.8	03/18(14)	0.210	5,409	302,300	12.1	25,000
		1581	689	74.7	03/18(15)	0.210	8,723	301,500	13.0	23,000
02/15	37.0	1582	588	58.5	03/18(15)	0.220	7,626	294,700	29.8	21,800
		1583	660	69.1	03/18(15)	0.220	8,601	296,200	15.7	18,900
02/16	37.0	1584	603	61.5	03/18(16)	0.231	8,413	302,000	12.9	23,400
		1585	721	73.2	03/18(16)	0.231	9,733	292,200	13.5	21,600
Average (± standard deviation of mean)									13.7 ± 0.2	21,900 ± 350

Notes: 1. Feed samples were dry weight as shown; 20-ml aliquots of 100-ml samples were counted.

2. Amount fed is dry weight; amount of feed was based on fish weight.

3. P-32 added was 3.36×10^5 c/min.g pellet.

B.3-1

P-32 in Aquarium Water During 9-day Studies of
Worm-fed Bluegill and Catfish

Aquarium No.	Feed, g	Vial No.	Counting date, 1983 (hr)	Decay factor	P-32 net c/min.	P-32 c/min.L	P-32 water/feed	P, mg/L	P-32/P, c/min.mg
1	3.2	1193	02/04(17)	0.644	848	823	0.91	0.31	2,540
2	5.5	1194	02/04(18)	0.643	572	556	0.36	0.36	1,540
3	10.6	1217	02/08(13)	0.535	1,064	1,243	0.41	0.46	2,700
4	5.3	1218	02/0[illegible]	0.534	553	674	0.45	0.39	1,730
5	9.2	1239	02/09(11)	0.512	1,105	1,349	0.51	----	---
		1258	02/14(19)	0.395	821	1,299		0.47	6,440
6	10.1	1259	02/14(19)	0.395	911	1,441	0.50	0.49	2,940
7	[illegible].4	1260	02/14(20)	0.394	153	[illegible]43	0.10	0.22	1,100
		1282	02/15(03)	0.389	156	251		0.25	1,000
8	14.0	1283	02/15(03)	0.389	411	660	0.17	0.24	2,750

Notes: 1) 4-l samples of 70 l water in each aquarium were collected at daily water change on 01/26(15); samples were filtered with a 75-μ mesh and processed to 50 ml volumes.
2) Samples are 20-ml aliquots of 50 ml.
3) c/min in feed is 1.2 mg/g x 16,500 c/min.mg x g in column 2.

P-32 in Aquarium Water During 9-day Studies of
Pellet-fed Bluegill and Catfish

Aquarium No.	Feed, g	Vial No.	Counting date, 1983 (hr)	Decay factor	P-32 net c/min.	P-32 c/min.L	P-32 water/feed	P, mg/L	P-32/P, c/min.mg
1	3.6	1379	02/28(08)	0.567	13,320	14,680	0.95	0.77	19,100
2	2.4	1380	02/28(09)	0.566	3,118	3,440	0.34	0.46	7,480
3	3.8	1400	02/28(10)	0.565	9,257	10,240	0.63	0.79	13,000
4	5.4	1401	02/28(10)	0.565	7,969	8,820	0.38	0.62	14,200
5	7.0	1440	03/07(15)	0.398	9,061	14,230	0.48	0.75	19,000
		1441	03/07(16)	0.397	9,316	14,670		0.78	18,800
6	4.1	1442	03/07(16)	0.397	5,192	8,174	0.47	0.54	15,100
7	3.8	1481	03/09(10)	0.365	1,826	3,127	0.20	0.60	5,210
		1482	03/09(10)	0.365	2,016	3,452		0.72	4,790
8	6.9	1483	03/09(11)	0.364	8,161	14,110	0.47	0.76	18,600
In		1376	02/23(01)	0.807	2.1	<1.6	----	0.27	<6
		1377	02/23(02)	0.806	8.7	6.7		0.26	26

Notes: 1) 4-l samples of 70 l water in each aquarium were collected at daily water change on 02/16(15); samples were filtered with a 75-μ mesh and processed to 50 ml volumes.
2) Samples are 20-ml aliquots of 50 ml.
3) c/min in feed is 13.7 mg/g x 21,900 c/min.mg x g in column 2.

B.4-1
Fish Weights and Amount of Worms Fed in Aquaria

Tank No.	Fish No.	Comments(1)	Fish wt, g Start	End	Weight gain, d^{-1}	Amount fed, g	Feeding ratio g/d. 100 g.wt.
	1-1	---	150.0	149.3	0.000		
1(B)	1-2	---	118.0	111.0	-0.007		
	1-3	---	107.0	107.9	0.001		
	Avg.				-0.002	28.8	0.87
	2-1	2	103.1	88.8	-0.017		
2(B)	2-2	3	107.6	91.2	-0.018		
	2-3	1 01/19-22	161.2	161.2	0.000		
	Avg.				-0.012	49.4	1.61
	3-1	---	99.3	91.0	-0.001		
3(B)	3-2	---	109.0	97.6	-0.012		
	3-3	1	167.0	172.8	0.004		
	Avg.				-0.003	95.4	2.93
	4-1	---	106.7	110.0	0.004		
4(B)	4-2	---	98.8	87.8	-0.013		
	4-3	1	154.3	147.6	-0.005		
	Avg.				-0.005	47.6	1.53
	5-1	2	129.3	111.7	-0.016		
5(B)	5-2	1	104.1	122.0	0.017		
	5-3	3 01/23-25	173.4	146.3	-0.019		
	Avg.				-0.006	82.8	2.42
	6-2	---	73.0	74.3	0.002		
6(B)	6-3	---	95.0	100.3	0.006		
	6-4	---	164.6	169.1	0.003		
	Avg.				0.004	91.1	2.94
	7-1		271.0	262.4	-0.004		
7(C)	7-2		160.0	152.5	-0.005		
	7-3		169.0	160.6	-0.006		
	Avg.				-0.005	75.5	1.45
	8-1		167.1	156.1	-0.008		
8(C)	8-2		155.0	147.6	-0.005		
	8-3		169.0	161.2	-0.005		
	Avg.				-0.006	126.1	3.01

B: bluegills; C: catfish

(1) Number indicates order of feeding and/or territorial dominance determined by observation; date refers to period during 01/18-27 for which fish was isolated by screen. Isolated fish were fed approximately 1/3 of daily feed.

B.4-2

Fish Weights and Amount of Pellets Fed in Aquaria

Tank No.	Fish No.	Comments(1)	Fish wt, g Start	End	Weight gain, d^{-1}	Amount fed, g	Feeding ratio g/d. 100 g.wt.
1(C)	1-1		166.0	163.0	-0.002		
	1-2		158.0	148.0	-0.007		
	1-3		158.0	149.6	-0.006		
	Avg.				-0.005	16.8	0.41
2(B)	2-1	3	---	86.5	---		
	2-2	2	---	80.2	---		
	2-3	1 02/08-17	104.5	115.8	0.011		
	Avg.					10.5	0.41
3(C)	3-1		178.5	150.5	-0.019		
	3-2		137.5	118.2	-0.017		
	3-3		169.0	140.8	-0.020		
	Avg.				-0.019	17.7	0.48
4(C)	4-1		150.0	154.8	0.003		
	4-2		133.7	134.6	0.001		
	4-3		173.0	163.2	-0.005		
	Avg.				0.000	25.0	0.62
5(C)	5-1		163.0	148.5	-0.010		
	5-2		122.3	126.4	0.004		
	5-3		141.5	140.0	-0.001		
	Avg.				-0.002	32.8	0.88
6(B)	6-1	---	86.5	75.6	-0.015		
	6-2	---	94.4	86.2	-0.010		
	6-3	1	94.5	105.7	0.012		
	Avg.				-0.004	19.0	0.79
7(C)	7-1		182.0	181.4	0.000		
	7-2		210.0	212.4	0.001		
	7-3		171.0	180.0	0.006		
	Avg.				0.002	17.5	0.34
8(C)	8-1		165.0	171.5	0.004		
	8-2		146.0	133.7	-0.010		
	8-3		152.5	146.3	-0.005		
	Avg.				-0.004	32.3	0.80

B: bluegill; C: catfish

(1) Number indicates order of feeding and/or territorial dominance determined by observation; date refers to period during 02/08-17 for which fish was isolated by screen. Isolated fish was fed approximately one-third of daily feed.

B.5-1

Weight Balances for Dissected Bluegill & Catfish,
Worm-fed in Aquaria

Fish No.	Total Wet Weight, g Sum	Death Weight	Percent
		Bluegill	
1-1	141.6	149.3	94.8
1-2	103.4	111.0	93.2
1-3	100.4	107.9	93.1
2-1	84.3	88.8	95.0
2-2	84.9	91.2	93.1
2-3	153.5	161.2	95.2
3-1	88.1	91.0	96.8
3-2	93.4	97.6	94.3
3-3	161.4	172.8	93.4
4-1	103.1	110.0	93.8
4-2	82.8	87.8	94.3
4-3	139.7	147.6	94.6
5-1	99.1	111.7	88.8
5-2	114.2	122.0	93.6
5-3	130.5	146.3	89.2
6-1	---	---	---
6-2	68.8	74.3	92.7
6-3	94.3	100.3	94.0
6-4	165.2	169.1	97.7
		Catfish	
7-1	246.2	262.4	93.8
7-2	146.8	152.5	96.2
7-3	151.7	160.6	94.5
8-1	147.2	156.1	94.3
8-2	137.9	147.6	93.4
8-3	151.8	161.2	94.2

B.5-2

Weight Balances for Dissected Bluegill & Catfish, Pellet-fed in Aquaria

Fish No.	Total Wet Weight, g Sum	Death Weight	Percent
	Catfish		
1-1	156.0	163.0	95.7
1-2	142.0	148.0	95.9
1-3	143.1	149.6	95.6
3-1	144.2	150.5	95.8
3-2	113.3	118.2	95.8
3-3	134.5	140.8	95.5
4-1	148.5	154.8	96.0
4-2	128.9	134.6	96.2
4-3	157.1	163.2	96.3
5-1	141.0	148.5	94.9
5-2	120.2	126.4	95.1
5-3	134.3	140.0	95.5
7-1	170.6	181.4	94.0
7-2	202.3	212.4	95.2
7-3	171.6	180.0	95.3
8-1	163.3	171.5	95.2
8-2	124.7	133.7	93.0
8-3	139.2	146.3	95.2
	Bluegill		
2-1	83.2	86.5	96.2
2-2	74.8	80.2	93.3
2-3	110.3	115.8	95.3
6-1	71.7	75.6	94.9
6-2	80.1	86.2	93.7
6-3	101.5	105.7	96.0

C.1
Non-food Uptake of 32-P

Fish No.(1)	Date of death,(2) 1982 (hr)	Weight,(3) wet	dry	ashed	Sample No.	P-32 Date of counting, 1982 (hr)	decay fraction	net c/min	c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
						Bluegill Muscle					
683 B	12/10	57.7	11.2	714	927	12/21(20)	0.577	174	26.1	2.51	10.4
857 B	(12)	70.4	14.2	854	926	12/22(09)	0.562	196	24.8	2.40	10.3
626 U		40.8	7.94	529	965	12/23(07)	0.537	33.5	7.6	2.54	3.0
628 U		22.1	4.44	298	917	12/19(10)	0.649	26.3	9.2	2.50	3.7
638 U		11.8	2.34	154	967	12/23(08)	0.537	22.0	17.4	2.61	6.7
878 U		38.5	7.59	509	920	12/19(14)	0.644	68.9	13.9	2.72	5.1
						Catfish Muscle					
210.1 B	12/17	61.4	14.0	725	1087	01/13(04)(4)	0.274	74.3	22.1	2.42	9.1
160.4 B	(11)	51.0	11.9	591	1072	01/12(08)	0.285	86.4	29.7	2.42	12.3
150.7 B		49.6	11.4	---	Lost	---	---	---	---	---	---
137.0 U		33.7	9.62	485	1086	01/13(01)	0.275	27.6	18.2	2.99	6.1
117.4 U		35.8	8.09	413	1064	01/11(20)	0.292	26.8	12.8	2.56	5.0
128.0 U		38.3	8.90	436	1079	01/12(17)	0.280	37.1	17.3	2.36	7.3

Notes:
(1) B: blocked esophagus; U: unblocked
(2) Bluegill exposure began on 12/6 (1700) except for 857 and 878 which were exposed from 12/8(11) to 12/12(11); catfish exposure began on 12/13(1100).
(3) Wet and dry weight in gram; ashed weight in mg.
(4) Month 01 is in 1983.
(5) Bluegill skeleton includes tail; catfish skeleton includes fin spines, and head includes fins.
(6) Weight appears to be erroneous.

C.1 cont'd
Non-food Uptake of 32-P

Fish No.(1)	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/m	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
Bluegill Skeleton (5)											
683 B	12/10	58.7	6.4	5,104	968	12/23(10)	0.534	535.	85.3	18.7	4.56
857 B	(12)	45.7	14.9	4,557	1094	01/14(16)	0.200	188.	103.	16.3	6.32
626 U		41.4	2.1	4,360	1049	01/11(06)	0.214	53.7	30.3	21.6	1.40
628 U		20.9	4.09	1,317	1051	01/11(08)	0.214	22.0	24.6	11.0	2.24
638 U		8.1	2.37	753	976	12/24(15)	0.504	67.6	82.8	16.4	5.05
878 U		44.2	3.2	4,674	1055	01/11(13)	0.212	89.9	48.0	21.7	2.21
Catfish Skeleton (5)											
210.1 B	12/17	31.0	10.8	1,940(6)	1084	01/12(23)	0.277	82.7	48.2	13.4	3.59
160.4 B	(11)	24.8	8.32	948	1071	01/12(06)	0.286	97.6	68.8	7.51	9.16
150.7 B		22.4	7.65	878	1044	01/11(23)	0.291	61.4	47.1	7.65	6.16
137.0 U		33.7(6)	7.02	807	1095	01/13(20)	0.265	19.7	11.0	4.47(6)	2.46
117.4 U		20.0	6.43	770	1063	01/11(18)	0.293	21.2	18.1	7.20	2.51
128.0 U		21.0	7.05	872	1067	01/12(01)	0.289	32.0	26.4	7.11	3.71

C.1 cont'd
Non-food Uptake of 32-P

Fish No.(1)	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32: Date of counting, 1982 (hr)	P-32: decay fraction	P-32: net c/m	P-32: c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
Bluegill Scales and Skin											
683 B	12/10	31.3	13.2	5,928	977	12/24(17)	0.502	536.	171.	54.5	3.14
857 B	(12)	23.7	9.77	4,125	1050	01/07(16)	0.255	212.	175.	45.8	3.82
626 U		23.5	9.65	4,323	978	12/24(18)	0.501	80.6	34.2	55.7	0.61
628 U		6.2	2.27	693	1085	01/13(01)	0.217	11.5	42.7	27.7	1.54
638 U		4.9	1.51	373	975	12/24(14)	0.505	47.2	95.4	21.0	4.54
878 U		24.2	10.0	4,325	1056	01/11(15)	0.211	82.0	80.3	44.3	1.81
Catfish Skin											
210.1 B	12/17	17.6	5.59	149	1092	01/13(06)	0.273	26.6	27.7	2.40	11.5
160.4 B	(11)	12.2	3.73	92.9	1062	01/11(17)	0.294	25.8	36.0	1.73	20.8
150.7 B		8.8	2.58	53.9	1048	01/11(04)	0.302	14.5	27.3	1.76	15.5
137.0 U		11.7	3.92	108	1093	01/13(18)	0.266	5.8	9.3	2.55	3.65
117.4 U		11.4	3.18	91.1	1066	01/11(23)	0.291	6.8	10.2	2.10	4.86
128.0 U		13.3	4.57	98.1	1065	01/11(22)	0.291	11.8	15.2	1.88	8.09

C.1 cont'd
Non-food Uptake of 32-P

Fish No.(1)	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/m	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
						Bluegill Head					
683 B	12/10	78.2	21.7	7,137	928	12/22(10)	0.561	563.	64.2	18.8	3.41
857 B	(12)	65.9	20.1	5,912	1057	01/07(13)	0.257	268.	79.1	19.2	4.12
626 U		69.9	19.3	6,733	929	12/21(22)	0.575	94.4	11.7	20.2	0.58
628 U		21.5	5.60	1,489	1046	01/11(01)	0.217	28.6	30.7	16.5	1.86
638 U		13.6	3.54	972	930	12/21(23)	0.575	122.	78.0	18.2	4.29
878 U		64.7	18.2	6,176	980	12/24(20)	0.499	163.	25.2	20.6	1.22
						Catfish Head					
210.1 B	12/17	61.6	18.7	5,170	1103	01/14(10)	0.258	181.	56.9	19.1	2.98
160.4 B	(11)	42.2	12.5	2,484	1074	01/07(14)	0.358	275.	91.0	12.1	7.52
150.7 B		38.5	12.1	2,307	1061	01/07(14)	0.358	206.	74.7	14.1	5.30
137.0 U		36.7	11.6	2,159	1104	01/14(12)	0.245	34.5	19.2	13.0	1.48
117.4 U		34.5	10.3	1,927	1075	01/12(12)	0.283	42.9	22.0	12.8	1.72
128.0 U		36.5	12.1	2,437	1073	01/12(09)	0.285	80.0	38.5	14.4	2.67

C.1 cont'd
Non-food Uptake of 32-P

Fish No.(1)	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/m	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
						Bluegill Viscera					
683 B	12/10	12.4	2.61	146.	971	12/23(11)	0.533	1,506	1,139	2.40	475
857 B	(12)	11.2	2.90	91.5	973	12/23(12)	0.533	1,281	1,073	2.03	529
626 U		8.1	1.44	92.0	986	12/23(13)	0.533	185	214	1.87	114
628 U		2.2	0.376	23.8	969	12/24(10)	0.509	141	630	1.95	323
638 U		1.8	0.318	19.8	974	12/23(12)	0.533	223	1,162	2.62	444
878 U		8.1	1.56	93.7	1052	01/07(16)	0.255	215	520	2.61	199
						Catfish Viscera					
210.1 B	12/17	15.1	3.29	134.	1100	01/14(05)	0.261	122.	155.	2.29	67.7
160.4 B	(11)	14.4	4.64	115.	1069	01/07(16)	0.356	277.	270.	1.97	137
150.7 B		15.3	5.87	103.	1047	01/11(02)	0.303	63.6	68.6	2.76	24.9
137.0 U		12.8	5.94	86.8	1099	01/14(03)	0.262	44.1	65.8	1.63	40.4
117.4 U		9.3	4.13	60.6	1076	01/12(14)	0.282	63.6	121.	1.78	68.0
128.0 U		12.1	5.22	82.6	1077	01/07(15)	0.358	135.	156.	1.85	84.3

C.1 cont'd
Non-food Uptake of 32-P

Fish No.(1)	Date of death, 1982(hr)	Weight, wet	Weight, dry	Weight, ashed	Sample No.	P-32 Date of counting, 1982 (hr)	P-32 decay fraction	P-32 net c/m	P-32 c/min.g. wet	P, mg/g wet	P-32/P, c/min.mg.
						Bluegill Gills					
683 B	12/10	1.38	0.201	15.1	985	12/25(03)	0.492	38.8	286	2.38	120
857 B	(12)	1.09	0.168	12.9	914	12/19(06)	0.654	64.4	452	3.48	130
626 U		1.04	0.154	12.8	970	12/24(12)	0.507	6.2	58.8	2.82	20.9
628 U		0.21	0.036	2.6	915	12/19(07)	0.653	3.0	109	3.17	34.4
638 U		0.13	0.021	0.2	912	12/19(02)	0.660	2.1	122	3.42	35.7
878 U		0.92	0.138	8.3	913	12/19(04)	0.657	17.7	146	2.83	51.6
						Catfish Gills					
210.1 B	12/17	1.27	0.237	10.4	1082	01/12(20)	0.279	7.7	109	2.64	41.3
160.4 B	(11)	0.75	0.137	4.9	1068	01/12(03)	0.288	5.4	125	2.74	45.6
150.7 B		0.97	---	6.1	1053	01/11(10)	0.298	6.7	116	2.69	43.1
137.0 U		1.05	0.207	7.7	1097	01/13(24)	0.263	<2.2	<40	3.39	< 12
117.4 U		0.69	0.128	4.4	1078	01/12(15)	0.281	<2.2	<57	2.71	< 21
128.0 U		0.49	0.133	5.6	1070	01/12(04)	0.288	<2.2	<78	5.14	< 15

C.2

P-32 Concentration in Water for Test of Non-food Uptake

Date of death, 1982 (hr)	Vial No.	Description	P-32 date counted	decay fraction	net c/min	c/min.ml	P, mg/L	P-32/P, c/min.mg
Bluegill								
12/10	10	Initial	12/11(11)	0.955	6,633	347	5.44	63,800
(12)	11	Final T1	12/11(12)	0.953	6,659	349	5.58	62,500
	12	Final T2	12/11(14)	0.949	6,716	354	5.52	64,100
	13	Final T3	12/16(23)	0.806	5,145	319	5.88	54,300
	14	Final T4	12/16(24)	0.804	5,184	322	5.40	59,600
		Average Final				320	5.64	57,000
Catfish								
12/17	20	Initial	12/17(14)	0.994	7,198	362	5.40	67,000
(11)	21	Final T1	12/17(14)	0.994	7,332	369	5.44	67,800
	22	Final T2	12/17(15)	0.992	7,017	354	5.66	62,500
	23	Final T3	12/17(15)	0.992	6,979	352	5.59	63,000
	24	Final T4	12/17(15)	0.992	6,967	351	6.10	57,500
		Average Final				352	5.84	60,200

Notes: 1. Fish were 2 days in Tanks 1 or 2 and then 2 days in Tanks 3 or 4.
2. Each tank contained 48 L water; 464 g NaH_2PO_4 and 549 g Na_2HPO_4 were dissolved in each tank to obtain a phosphorus concentration of 5.0 mg/L, equimolar in the two species at pH 7.0.

C.3

Bluegill and Catfish Wet Weights in 4-Day Test of Non-food Uptake

Bluegill

Fish Number		Weight, g Start	End	Weight gain, d⁻
683	B	255.7	(265.4)?	----
857	B	237.4	239.2	0.002
626	U	196.6	193.5	-0.004
628	U	73.0	70.1	-0.010
638	U	43.7	42.6	-0.006
878	U	193.8	190.5	-0.004
Avg.	B		246.	----
Avg.	U		124.	-0.006

Catfish

Fish Number		Start	End	Weight gain, d⁻
210.1	B	217.8	210.1	-0.009
160.4	B	168.5	160.4	-0.012
150.7	B	154.6	150.7	-0.006
137.0	U	139.1	137.0	-0.002
117.4	U	122.5	117.4	-0.010
128.0	U	137.4	128.0	-0.018
Avg.	B		173.	-0.009
Avg.	U		127.	-0.010

C.4

Weight Balances for Dissected Bluegill & Catfish, Unfed in Aquaria

Fish No.	Total Wet Weight, g		
	Sum	Death Weight	Percent
		Bluegill	
683 B	239.7	(265.4)?	(90.3)?
857 B	218.0	239.2	91.1
626 U	184.8	193.5	95.5
628 U	73.1	70.1	104.3
638 U	40.3	42.6	94.7
878 U	180.6	190.5	94.8
		Catfish	
210.1 B	188.0	210.1	89.5
160.4 B	145.4	160.4	90.6
150.7 B	135.4	150.7	89.8
137.0 U	129.6	137.0	94.6
117.4 U	111.7	117.4	95.1
128.0 U	121.7	128.0	95.0

Appendix D.1

Pellet Contents Reported by Supplier

Element	%
Na	0.5
K	0.9
Mg	0.2
Ca	1.6
P	1.0
Cl	0.9

Notes:
1. Pellets are Purina Trout Chow L.F., purchased July 17, 1982.
2. Values are approximations based on ingredients.
3. Basis is "dry weight" which is 90% dry matter.

Appendix D.2

Phosphate Concentration in Atlanta Water
Reported by Treatment Plant

Month	Water plant sample, mg/L	Distribution system sample, mg/L
Nov. 82	0.68 (0.07 - 1.60)[1]	0.45 (Nov. 22)[2]
Dec. 82	0.49 (0.26 - 0.74)	0.38 (Dec. 30)
Jan. 83	0.43 (0.11 - 0.78)	0.48 (Jan. 31)
Feb. 83	0.70 (0.45 - 0.85)	0.44 (March 1)

Notes: (1) average of daily values (range in parentheses)
(2) collected at indicated date from nearest sampling point (Luckie and Hunnicutt Sts.) to Georgia Tech

Appendix E

General Equation for Calculating Specific Activity in a Compartment

The following calculation applies to an open, non-steady-state system with rapidly decaying radionuclide. The approach is based on the compartmental model for a closed system and long-lived radionuclide (Be75).

Growth rate in compartment t:

$$\frac{dQ_t}{dt} = \sum_{s=1}^{n} R_{st} - \sum_{s=1}^{n} R_{ts} + R_{ft} - R_{tx} \qquad (E1)$$

Change of count rate in compartment t:

$$\frac{dq_t}{dt} = \sum_{s=1}^{n} R_{st}\, a_s - a_t \sum_{s=1}^{n} R_{ts} + R_{ft}\, a_f - R_{tx}\, a_t - q_t\, \lambda_r \qquad (E2)$$

Relation among change with time in count rate, amount, and specific activity:

$$\frac{dq_t}{dt} = \frac{d(Q_t a_t)}{dt} = Q_t \frac{da_t}{dt} + a_t \frac{dQ_t}{dt} \qquad (E3)$$

Solution for da_t/dt based on equations (E1), (E2), and (E3):

$$\frac{da_t}{dt} = \sum_{s=1}^{n} \frac{R_{st}}{Q_t} a_s - a_t \sum_{s=1}^{n} \frac{R_{ts}}{Q_t} + a_f \frac{R_{ft}}{Q_t} - a_t \frac{R_{tx}}{Q_t} - \frac{q_t}{Q_t} \lambda_r$$

$$- a_t \sum_{s=1}^{n} \frac{R_{st}}{Q_t} + a_t \sum_{s=1}^{n} \frac{R_{ts}}{Q_t} - a_t \frac{R_{ft}}{Q_t} + a_t \frac{R_{tx}}{Q_t}$$

$$= \sum_{s=1}^{n} \frac{R_{st}}{Q_t} a_s - a_t \sum_{s=1}^{n} \frac{R_{st}}{Q_t} + a_f \frac{R_{ft}}{Q_t} - a_t \frac{R_{ft}}{Q_t} - a_t \lambda_r \qquad \text{(E4)}$$

If R_{ft} is considered simply another rate, R_{st}:

$$\frac{da_t}{dt} = \sum_{s=1}^{n} \frac{R_{st}}{Q_t} a_s - a_t \sum_{s=1}^{n} \frac{R_{st}}{Q_t} - a_t \lambda_r$$

Definitions:

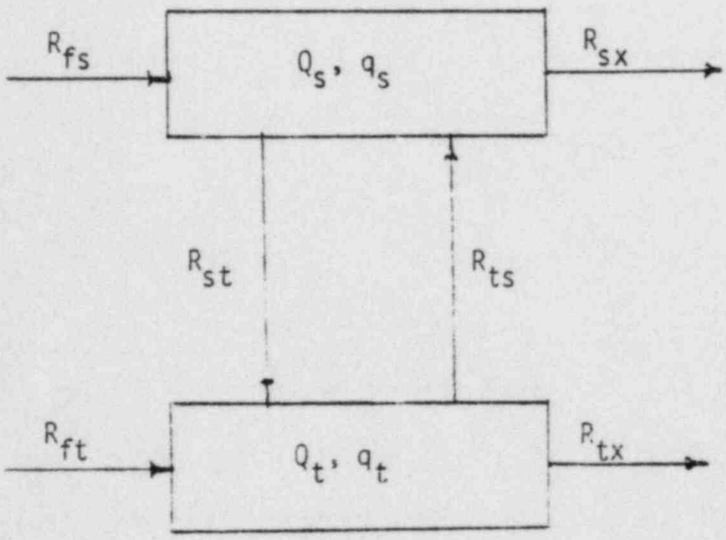
- Q_t: amount of phosphorus in compartment t, mg
- q_t: P-32 in compartment t, count/min
- a_t: P-32 specific activity in compartment t, count/min.mg ($a_t = q_t/Q_t$)
- R_{st}: transport rate of phosphorus from compartment s into t, mg/d
- t: time, d
- λ_r: radioactive decay constant of P-32, d^{-1}

subscripts: t: compartment of interest

s: any other compartment

f: feed

x: excretion



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Bluegill and catfish maintained in flow-through tanks were fed P-32 at two feeding levels. Fish were analyzed in triplicate for P-32 and phosphorus at intervals of 1 - 8 days. Additional aquaria experiments were performed to determine the effects of other factors and to observe P-32 uptake from water by unfed fish (including fish with blocked esophagus). The bluegill showed a weight gain of 0.2 %/d, a phosphorus turnover constant in muscle of 0.43 %/d, and a BF_r/BF ratio of 0.081 at the higher feeding rate, and 0.05 %/d, 0.34 %/d, and 0.064 at the lower feeding rate. Hence, respective P-32 BF_r values are 6,000 and 4,000 at a phosphorus BF of 70,000. The BF_r values for catfish were approximately twice as high. The aquarium experiments suggest that the higher factors are due to a much higher phosphorus intake, higher water temperature, higher retention from pellets than from worms, and possible higher retention by catfish than bluegill under the same conditions.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Fish
Phosphorus-32

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BF
Bluegill, Catfish
P-32

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