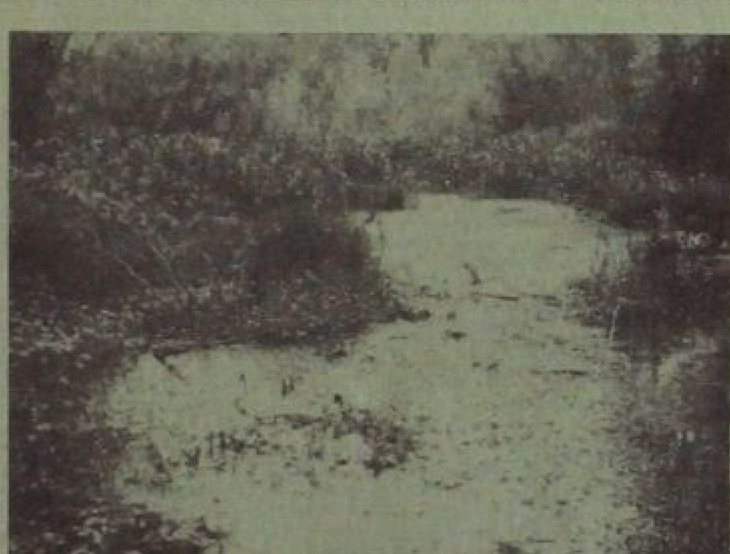
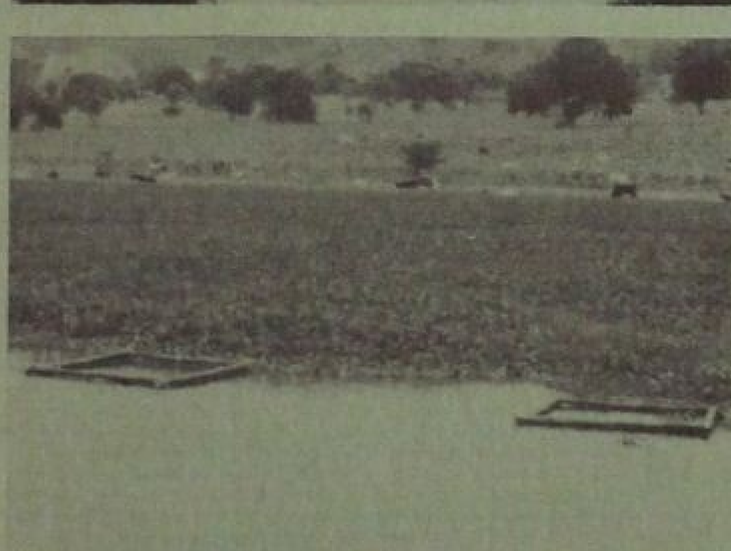
AQUATIC PLANT CONTROL RESEARCH PROGRAM

APCRP





TECHNICAL REPORT A-79-3

EVALUATION OF TWO FLURIDONE FORMULATIONS FOR THE CONTROL OF HYDRILLA IN GATUN LAKE PANAMA CANAL ZONE

By Dana R. Sanders, Sr., Russell F. Theriot

Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

And Wendell R. Arnold, Sheldon D. West

Lilly Research Laboratories
P. O. Box 708
Greenfield, Ind. 46140

November 1979

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for Panama Canal Company
Balboa Heights, Canal Zone

6121804 c.3

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report A-79-3	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF TWO FLURIDONE FORMULATIONS FOR THE CONTROL OF HYDRILLA IN GATUN LAKE, PANAMA CANAL ZONE		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Dana R. Sanders, Sr. Russell F. Theriot Wendell R. Arnold Sheldon D. West		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Environmental Laboratory P. O. Box 631, Vicksburg, Miss. 39180 and Lilly Research Laboratories P. O. Box 708, Greenfield, Ind. 46140		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Aquatic Plant Control Research Program
11. CONTROLLING OFFICE NAME AND ADDRESS Panama Canal Company Balboa Heights, Canal Zone		12. REPORT DATE November 1979 13. NUMBER OF PAGES 44
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aquatic plant control
Fluridone
Gatun Lake
Hydrilla

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Hydrilla has become a significant aquatic plant problem in the Panama Canal Zone in recent years. To combat this growing threat to the use of Gatun Lake, fluridone, 1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1*H*)-pyridinone, was applied as a 4 lb/gal aqueous suspension and 5 percent pellet at rates of 0, 0.84, 1.70, 3.36, and 6.72 kg/ha active ingredient in 18 hydrilla test plots. Significant reduction in hydrilla biomass occurred after 84 days in plots treated

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

at rates of 1.70 kg/ha or greater, while insufficient control of hydrilla occurred in plots treated at 0.84 kg/ha. Fluridone did not adversely affect dissolved oxygen and other water quality parameters, nor were there any noticeable disturbances of the plankton and benthic communities. The residue levels in both the water column and hydrosoil had decreased to less than 15 percent of the applied compound by 56 days after application. The observed responses were attributed to the small quantity of herbicide added to the water column.

Preface

This study was sponsored by the Panama Canal Company (PCC), Balboa Heights, Canal Zone, and the Corps of Engineers' Aquatic Plant Control Research Program (APCRP). The project was a cooperative effort between the APCRP, the Dredging Division of the PCC, and Lilly Research Laboratories. The work was initiated in January 1978 under the general supervision of Mr. W. G. Shockley, Chief, Mobility and Environmental Systems Laboratory (MESL), of the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., and Mr. B. O. Benn, Chief, Environmental Systems Division (ESD), MESL. The project was under the direct supervision of Mr. J. L. Decell, Chief, Aquatic Plant Research Branch, at WES, and Mr. Cesar Von Chong in the Canal Zone.

The work was performed by Dr. Dana R. Sanders, Sr., and Mr. Russell F. Theriot of WES; Dr. Wendell R. Arnold and Sheldon D. West of Lilly Research Laboratories, Greenfield, Ind.; and LTC Phillip E. Custer and Messrs. Von Chong, Francis D. Halverson, and George Bouche, of PCC. Additional assistance was provided by personnel of the Water Quality Laboratory, PCC, and Dr. K. K. Steward and Mr. Thomas Taylor of the U. S. Department of Agriculture Aquatic Plant Management Laboratory, Fort Lauderdale, Fla.

The APCRP and the ESD are now part of the reorganized WES Environmental Laboratory of which Dr. John Harrison is Chief. Mr. Decell is now Manager, APCRP.

Commanders and Directors of the WES during the conduct of this study and preparation of the report were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

Contents

EVALUATION OF TWO FLURIDONE FORMULATIONS FOR THE CONTROL OF HYDRILLA IN GATUN LAKE, PANAMA CANAL ZONE

Introduction

1. Aquatic plants have been a constant maintenance problem in Gatun Lake since the Panama Canal was opened. Waterhyacinth (*Eichhornia crassipes* (Mart.) Solms.) and hydrilla (*Hydrilla verticillata* Royle) (Figure 1) are the major problem species. These plants block channels

Figure 1. *Hydrilla verticillata* Royle

needed to maintain navigation aids, render many recreation areas unfit for use, and increase the threat of mosquito-transmitted diseases by providing breeding grounds for the insects. Although the Panama Canal Company has had an aquatic plant control program since construction days, it became apparent 2 years ago that the pest plants were increasing and the Company was spending more and more money each year on aquatic plant control (Custer et al. 1979).

2. During August 1976, the Company began investigating more efficient economical ways to control aquatic plants. At the request of the Panama Canal Company, representatives of the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., visited the Canal Zone in November 1976 to advise Panama Canal Company officials on new methods of aquatic plant control. At the same time, WES was very interested in fluridone (1-methyl-3-phenyl-5-[3-(triflurometh yl)phenyl]-4(1H)-pyridinone), a new herbicide developed by Lilly Research Laboratories (Waldrep and Taylor 1976). Subsequent small pond studies revealed it to have considerable potential as a control for problem aquatic macrophytes (Parka et al. 1978). Due to the success of these initial studies and the need for new chemical herbicides for aquatic plant control, a cooperative research effort was initiated by Lilly Research Laboratories and the Aquatic Plant Research Branch (APRB) of the WES to evaluate fluridone as a chemical herbicide for the control of hydrilla. Because the APRB had decided to assist the Panama Canal Company in the development of a plan for the management of hydrilla in Gatun Lake (Figure 2), a decision was made to utilize Gatun Lake as the site for the fluridone tests. This report describes the results of the hydrilla efficacy tests; the effects of fluridone on water quality, plankton, and benthos; and fluridone residues within the test sites. The specific objectives of the proposed study were:

- a. To determine the effectiveness of bottom-placed fluridone liquid and granular formulations in controlling hydrilla.
- b. To establish the range of treatment rates of fluridone for control of hydrilla.
- c. To determine the effect of fluridone on water quality, phytoplankton and zooplankton, and benthos.
- d. To determine fluridone residues in water and hydrosoil.

Materials and Methods

Test herbicide

3. Fluridone is the first of a new family of herbicides called pyridinones. The primary physiological effect of fluridone on plants is

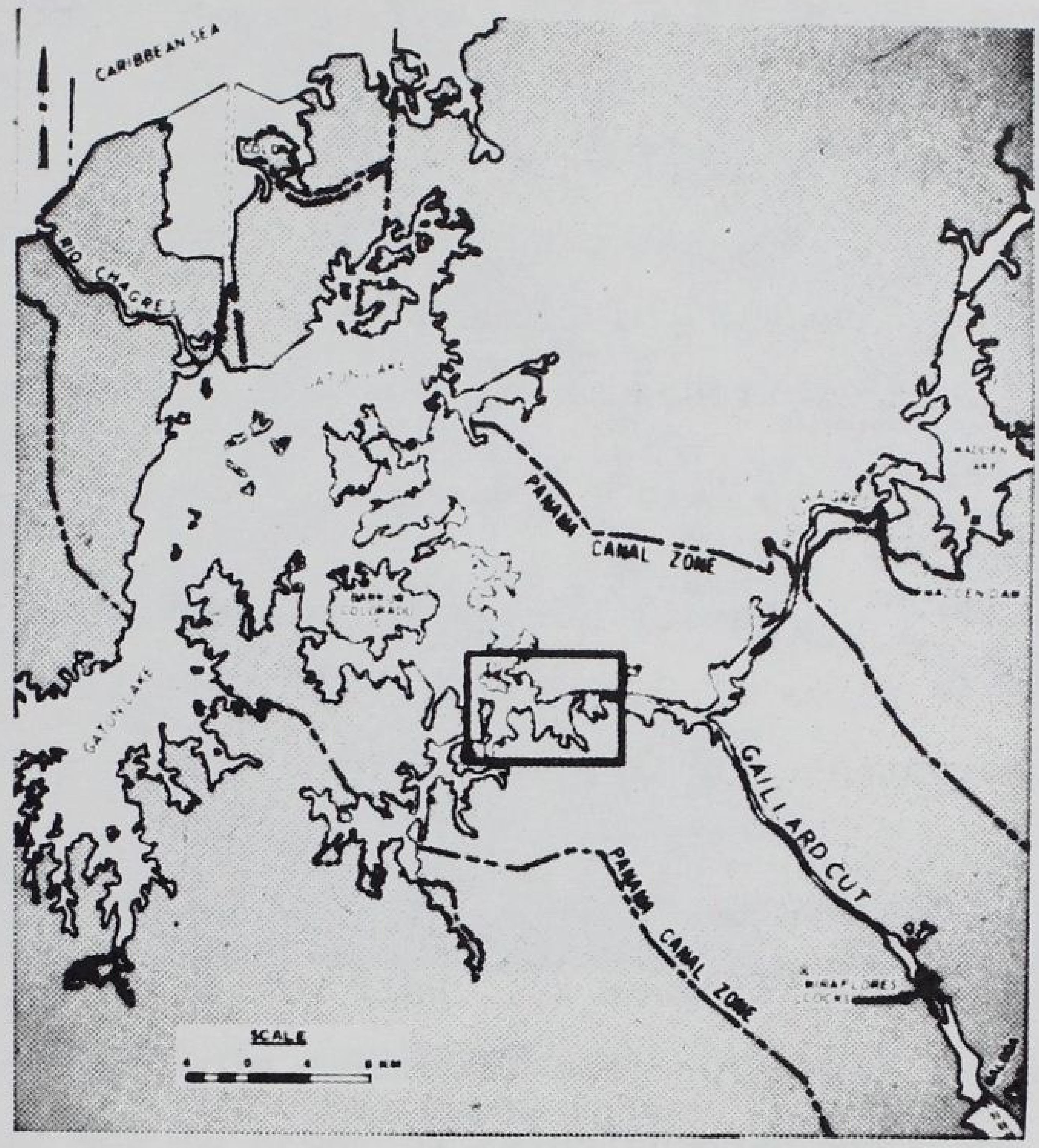


Figure 2. Panama Canal Zone showing general location of fluridone treatment plots

the inhibition of carotenoid synthesis (Bartels and Watson 1978), the net effect of which is a failure of the photosynthetic processes to transform physical energy into chemical energy in the proper manner. Because of this failure, the plant loses its ability to produce food and dies as soon as stored food reserves have been depleted. The toxicity of fluridone is limited to autotrophic organisms that employ photosynthetic processes, and it is, therefore, a relatively safe pesticide.

Formulations and treatment rates

4. Two formulations of fluridone were evaluated--fluridone 4AS and 5P.* Fluridone 4AS, containing 4 lb active ingredient/gallon (479.3 kg active ingredient/m^3) of formulation, was applied at 0.84, 1.70, 3.36, and 6.72 kg of active ingredient per hectare on a bottom acre-foot basis. Fluridone 5P, a pellet formulation with 5 percent active

---

* AS = aqueous suspension, P = pellet.

ingredient (a.i.), was applied at 0.84, 1.70, 3.36, and 6.72 kg of active ingredient per hectare on a bottom acre-foot basis.

Test plots

5. Nine test plots, ranging in size from 0.65 to 1.0 ha and water depth from 2.1 to 8.2 m, were selected from each of two dredged material disposal areas (Dumps 8 and 12) of Gatun Lake (Figure 3). Hydrilla growth was present at the surface in at least 50 percent of each plot area.

Herbicide application

6. One plot from each spoil dump was treated with either the 5P or 4AS formulation at rates of 0.84, 1.70, 3.36, or 6.72 kg/ha a.i. (Table 1). One untreated control plot was also located in each disposal area.

7. The 5P formulation was applied using a rotary spreader mounted on the front of an airboat (Figure 4). Half of the formulation was applied on parallel lines across the treatment plot, while the other half was applied on lines perpendicular to those of the first application. Any remaining pellets were applied diagonally across the plot.

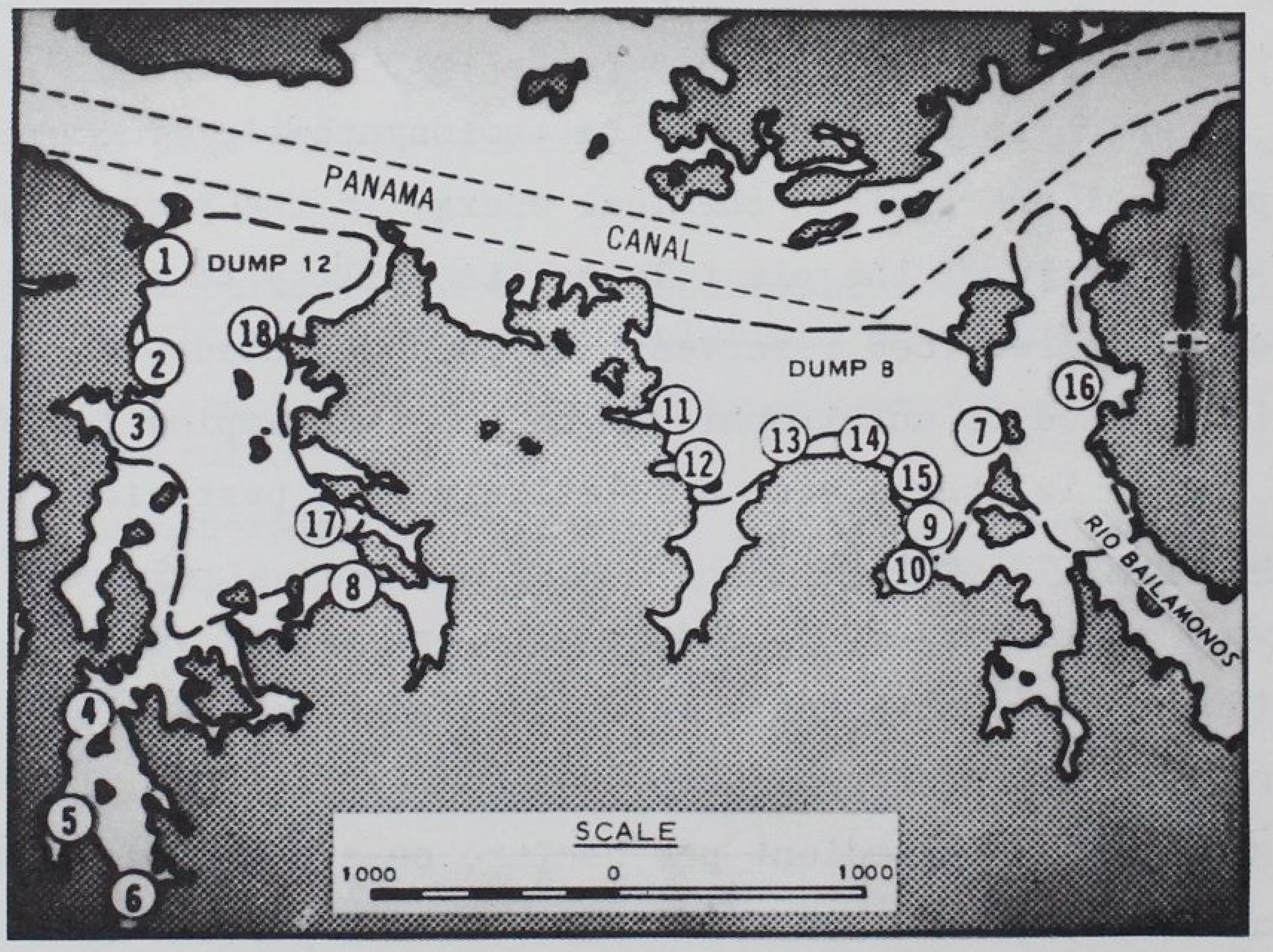


Figure 3. Location of fluridone treatment plots in Gatun Lake

Figure 4. Application of fluridone 5P formulation using rotary spreader

The 4AS formulation was applied below the water surface from an airboat equipped with a conventional spray pump and weighted 6.1-m trailing hoses (Figure 5). This placed the compound as near as possible to the bottom where the plants were rooted. The required quantity of 4AS was uniformly distributed over the test plot following the same general distribution pattern as used for the 5P application.

Field data collection

8. Vegetation. A biomass sampler (Figure 6) was used to collect samples prior to treatment and at 28, 42, 56, and 84 days posttreatment from six locations within each plot treated at 0, 1.70, and 6.72 kg/ha of each formulation. For the 0.84- and 3.36-kg/ha treatment rates, only pretreatment, 56- and 84-day biomass samples were collected. Sampling locations were determined by using a restricted random method, and biomass samples were collected using a cylindrical sampling head that was lowered slowly through the water column while a circular cutting bar severed the vegetation, which was collected in a chamber (Figure 7). Each hydrilla sample was then removed from the sampling head, washed to

Figure 5. Application of fluridone 4AS formulation using spray pump and weighted trailing hoses

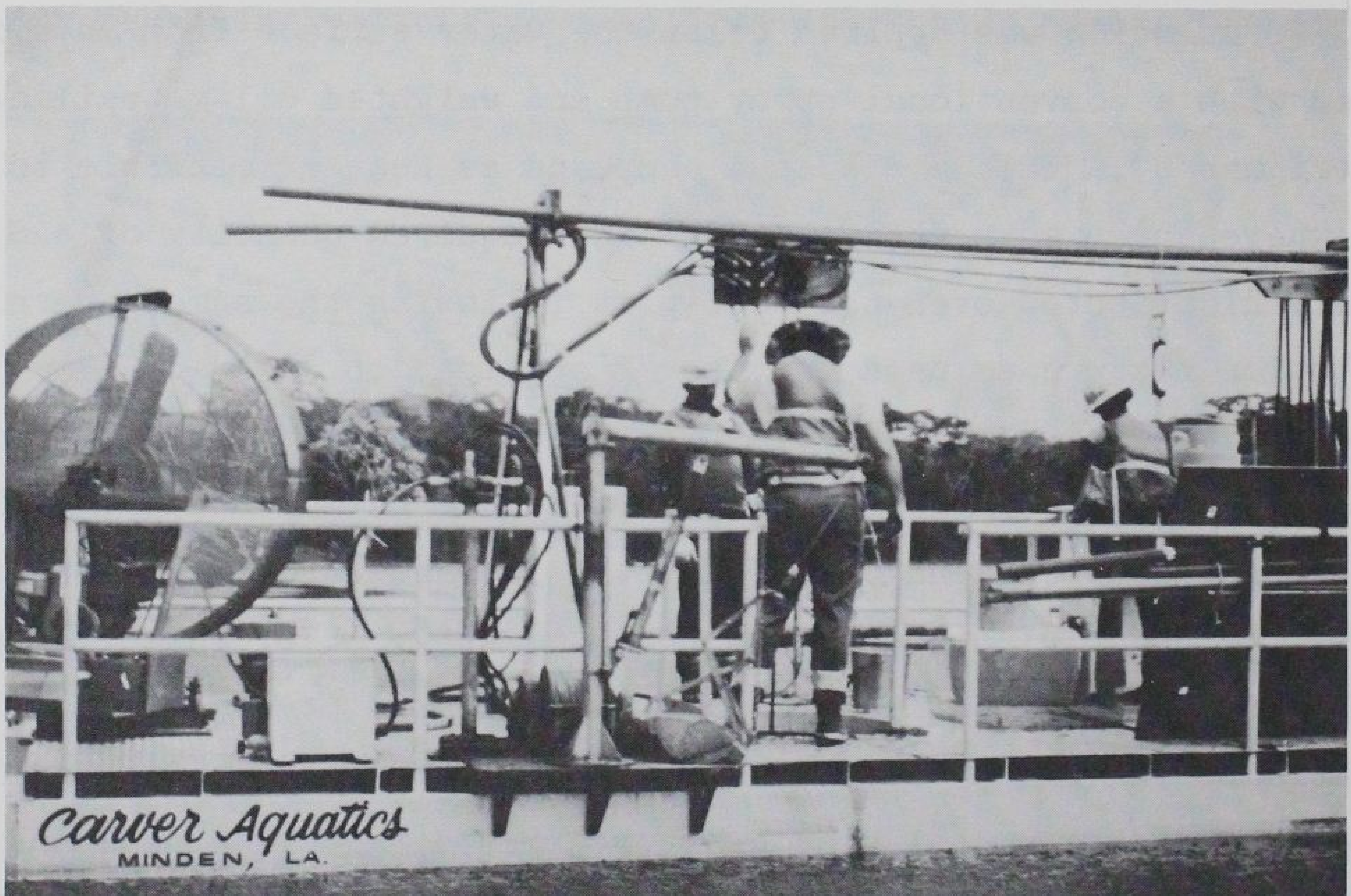


Figure 6. Data collection team sampling vegetation from biomass sampler

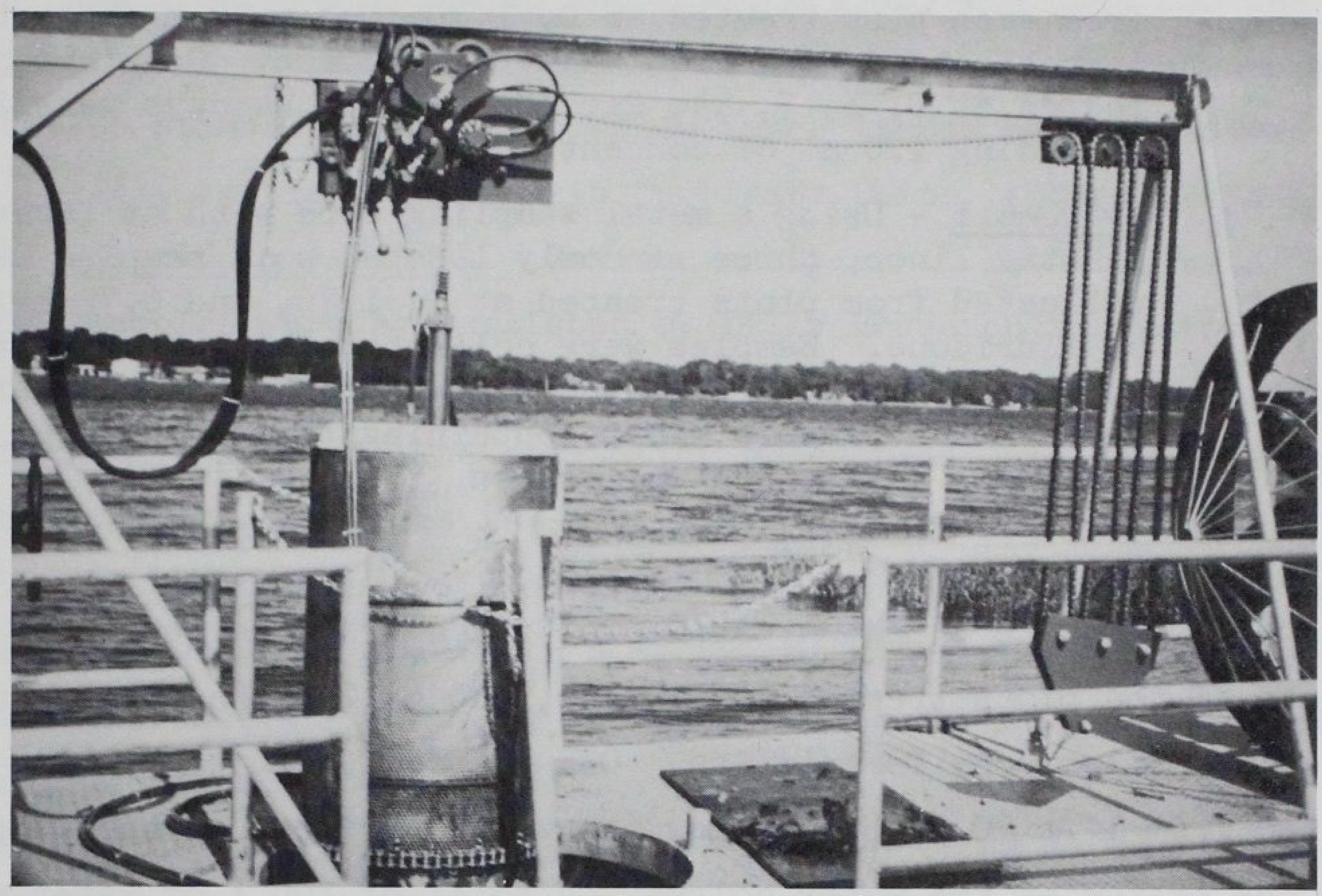


Figure 7. Sampling head cylinder mounted on barge showing hydraulic hoses and chain used in retrieving vegetation sample

remove soil particles and debris, drained of free water for 2 min, and weighed to the nearest 45 g. Any floating aquatic plant species were removed prior to weighing.

9. Water quality. Water samples were collected from three randomly selected locations in plots treated at 0, 1.70, and 6.72 kg/ha of fluridone formulation prior to treatment and at 1, 7, 14, 28, 42, and 56 days posttreatment. A submersible pump was lowered to 30 cm below the water surface and 4.0 ℓ of water was collected in a plastic container. The pump was then lowered to a depth of 3.0 m and 4.0 ℓ of water was collected in a separate plastic container. The boat was then moved to another location in the plot and the process was repeated. After adding water from a third location in the plot, 500-ml composite samples from each depth were placed on ice until laboratory analyses were performed.

10. Fluridone residues. Water and hydrosoil samples were collected for fluridone residue analyses as follows:

a. Water - A submersible pump was used to collect a 250-ml water sample from the top and bottom of the water column from each plot treated at 0, 1.70, and 6.72 kg/ha active ingredient of each fluridone formulation. Samples collected at 0, 1, 7, 14, 21, 28, 56, and 84 days were fixed by adding 1.0 ml of concentrated H_2SO_4.

b. Hydrosoil - Using a metal sampling tube with an inserted plastic liner, three randomly located soil samples were collected from plots treated at 0, 1.70, and 6.72 kg/ha of fluridone. Samples were collected prior to treatment and at 1, 7, 14, 21, 28, 56, and 84 days following treatment. Each plastic liner containing the upper 15 cm of hydrosoil was capped and frozen.

Plankton

11. A composite plankton sample was taken from the center of each replicate of the plots treated at 0, 1.70, and 6.72 kg/ha active ingredient of each fluridone formulation. One third of each sample was collected from 1 ft (0.3048 m) below the water surface, at the midpoint, and at the bottom of the water column. A total of 100 ℓ of water was filtered using a submersible pump and a 60 mesh plankton net. Twenty-five millilitres of 30 percent isopropyl alcohol, 10 percent formalin solution, was added to each composite sample to preserve organisms. Samples were collected prior to treatment and at 7, 14, 28, 56, and 84 days after treatment and stored for analysis.

Benthos

12. A Ponar dredge was used to collect three hydrosoil samples from each control plot and plots treated at 1.70 and 6.72 kg/ha active ingredient of each formulation of fluridone. Each sample consisted of the upper 10 cm of hydrosoil collected prior to treatment and 14, 28, 42, and 84 days after treatment. Samples were washed, and organisms were removed, preserved, and stored until analyzed.

Laboratory analysis of samples

13. Water. Using a Yellow Springs Instrument Company meter, ambient water temperature (°C) and dissolved oxygen (mg/ℓ) were measured at the 30.5-cm and 3.0-m level of the water column at each point where a water sample was collected. Laboratory analyses were performed on all composite water samples by the Water Quality Laboratory of the Panama Canal Company within 24 hours after samples had been collected. Standard

Methods (American Public Health Association 1976) was used for the determination of nitrate nitrogen (mg/ℓ), hardness (mg/ℓ), apparent color (Pt/Co standard), specific conductance (μmhos/cm), dissolved oxygen (mg/ℓ), turbidity (Formazin Turbidity Units (FTU's)), and pH.

14. Fluridone residues. Residue analyses of both the water and hydrosoil samples were accomplished by Lilly Research Laboratories by using the high pressure liquid chromotography or electron-capture gas chromotography methods. The extraction procedures were developed by Lilly Research Laboratories.

15. Plankton. Analysis of water samples for both zooplankton and phytoplankton was conducted with a Sedgwick/Rafter counting cell and Whipple ocular micrometer using standard procedures outlined in Welch's Limnological Methods (Welch 1948).

16. Benthos. Benthic organisms were identified to major groups by using a dissecting microscope and appropriate identification keys.

Data analysis

17. Vegetation. The six biomass samples from each treatment plot on each sampling date were averaged. Means of the replicates of each treatment were averaged and plotted on graphs. To further illustrate the changes in hydrilla biomass with time, means for each treatment on each sampling date were divided by the pretreatment mean for that treatment to show percent change in biomass with time.

18. Water quality. Values for each water quality parameter at each treatment rate and collection date were averaged and presented in tabular form.

19. Fluridone residues. Half-lives ($t_{1/2}$) for fluridone in the water were tabulated and graphed by plotting the percent of fluridone remaining versus the number of days after treatment. Total residues for both water and hydrosoil for all study plots were tabulated.

20. Plankton. Using selected plots, percent composition of major taxa and total numbers from both zooplankton and phytoplankton were graphed against time. Comparisons were made between controls and treated plots in order to determine the effect of fluridone applications on community structure and total population.

21. Benthos. Average numbers of total organisms in selected treatment plots were graphed against time to determine the effects of fluridone on total benthic population. In order to determine the effect of fluridone on benthic community structure, the benthic organisms were identified by major taxa for control plots and selected treatment plots and compared for each sampling date in tabular form.

Results and Discussion

Vegetation

22. Fluridone symptoms were noted in several treatment plots as early as 1 week after treatment, but few changes in biomass were observed until 4 to 8 weeks posttreatment. Early symptoms included chlorosis of leaves near the stem apices, which had purplish growing tips (Figure 8). In plots where the hydrilla biomass eventually was significantly reduced, chlorosis became more pronounced. In plots where little control was achieved, later observations revealed a zone of chlorotic leaves 5 to 10 cm from the stem apices, with normally pigmented areas distally. This suggests absorption of sublethal quantities of fluridone by the plants. The observed symptoms are consistent with the described mode of action of fluridone. Mode of action studies with seedlings have demonstrated that fluridone inhibits the biosynthesis of carotenoid precursors. The inhibition of cartenoid pigments removes the chloropyll protection system from the plant and the chlorophyll degrades (Bartels and Watson 1978, Berard, Rainey, and Lin 1978, Devlin, Saras, and Kisiel 1978).

23. Average hydrilla biomass values for each treatment plot are presented in Table 2. Biomass increased in control plots by approximately 50 percent during the study (Figure 9). This suggests that hydrilla grows most actively during the dry season when the total solar radiation is greater, due to decreased cloud cover. Although the biomass of plots treated at 0.84 kg/ha of either formulation decreased slightly, the decrease was so slight that the 0.84-kg/ha rate was concluded to be a no-effect treatment level. On the other hand, hydrilla biomass decreased substantially in some plots (Plots 6 and 17) treated

Figure 8. Typical symptoms of fluridone-affected hydrilla showing chlorosis of stem tip 1 week posttreatment

at 1.70 kg/ha (Table 2 and Figure 9), and 1.70 kg/ha was concluded to be the lowest rate tested that provided effective control of hydrilla. The pretreatment hydrilla population level in plot 6 is shown in Figure 10, while control achieved in plot 6 after 90 days is shown in Figure 11. The biomass of hydrilla was significantly reduced in some plots treated at the 3.36-kg/ha rate (Plots 4 and 5), while satisfactory hydrilla control was not achieved in plots treated at 6.72 kg/ha of fluridone.

24. In considering an explanation of these results, the effect of plot location was found to be critical. All plots in Dump 8 and those plots in Dump 12 that were treated at 6.72 kg/ha of either fluridone

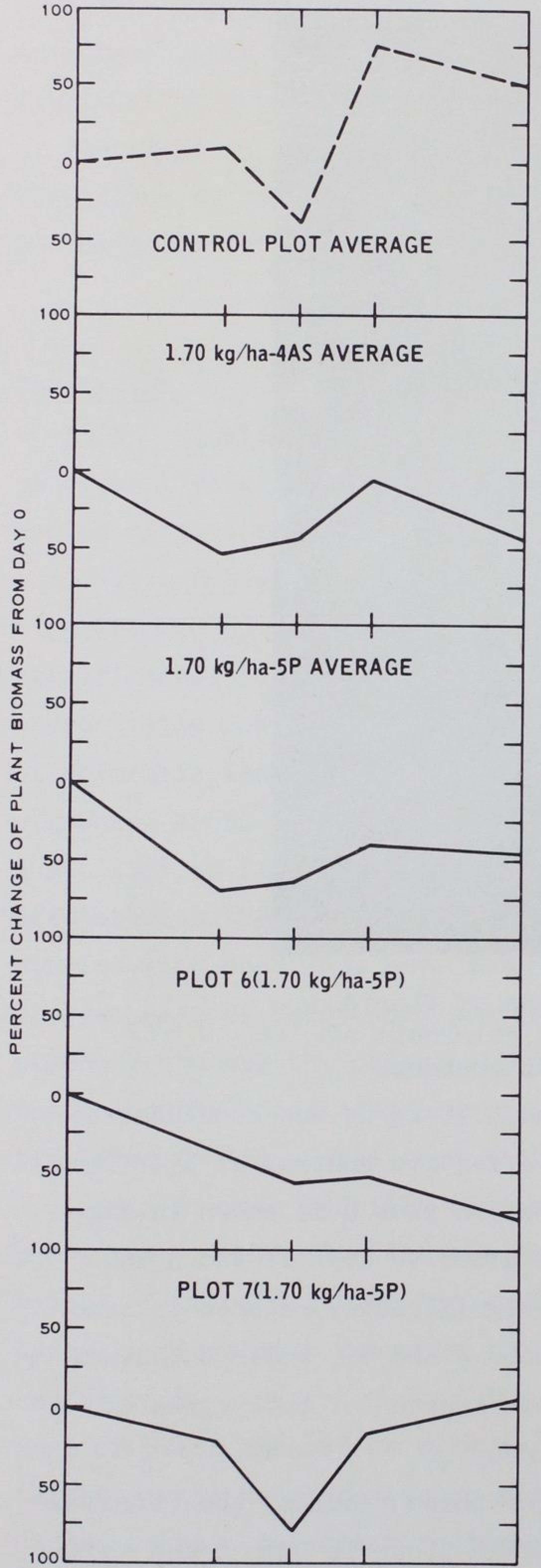


Figure 9. Percent change in hydrilla biomass in plots treated at 1.70 kg/ha 4AS and 5P fluridone formulations, as compared to control plots

Figure 10. Plot 6 showing 90 percent coverage of hydrilla prior to application of fluridone

Figure 11. Plot 6 showing 95 percent open water 90 days posttreatment

formulation were located near the ship channel. These plots were subjected to extreme water movement each time a large ship passed in the channel. As a result, the applied herbicide was rapidly dissipated from the plots before sufficient time had elapsed for herbicide absorption by the standing crop of hydrilla. The effect of this activity is clearly shown by comparing (Figure 9) the percent changes in hydrilla biomass in Plots 6 (Dump 12) and 7 (Dump 8), both treated with 1.70 kg/ha of 5P fluridone. After 84 days, the hydrilla biomass in Plot 6 had decreased by more than 80 percent, while the biomass in Plot 7 showed no significant change.

25. A comparison of effects of the 4AS and 5P fluridone formulations on hydrilla biomass (Figure 9) led to the conclusion that the formulations were equally effective after 84 days. However, symptoms of fluridone activities appeared earlier in plots treated with the 4AS formulation. This is probably due to the immediate availability of the 4AS formulation for absorption by hydrilla, while the 5P was released from the carrier over a longer period of time. Subsequent laboratory tests conducted by Lilly Research Laboratories revealed that only 15 percent of the active ingredient in the 5P formulation is released within the first 24 hours after application. However, a greater percentage of total active ingredient of the 5P formulation may have been absorbed by the plant tissue.

26. Continued observations past the 84-day sampling date revealed prolonged control of hydrilla by fluridone. Plots 6 and 17 were rated on 30 January 1979 and were found to remain 70 to 80 percent free of hydrilla.

Water quality

27. The effects of the 1.70-kg/ha treatments of fluridone on selected water quality characteristics are shown in Table 3. The average dissolved oxygen (DO) concentration within any plot changed relatively little throughout the study. At the same time, the average DO concentration varied considerably between plots prior to treatment, ranging from a high of 8.9 mg/ℓ in Plot 7 to a low of 4.8 mg/ℓ in Plot 6. The lower DO concentration in Plot 6 was due to the effects of the extremely dense macrophyte population in reducing diffusion of

atmospheric oxygen into the water by eliminating wave action, restricting normal water movement, and outcompeting phytoplankton for available solar radiation. The relatively stable DO concentrations at 1, 7, and 14 days posttreatment in all plots receiving 1.70 kg/ha fluridone suggest that the herbicide had little effect on phytoplankton. The slight decrease in DO at 42 days posttreatment was probably due to the increased rate of decomposition of hydrilla tissue at that time. After most of the hydrilla biomass had decomposed (56 days), the DO concentration returned to or exceeded pretreatment levels (Table 3, Plot 6).

28. Values for nitrate nitrogen, ammonia nitrogen, and total phosphate varied slightly from one sampling date to the next (Table 3), but no discernible effects of fluridone on these water quality characteristics were observed. This was also true for other water quality parameters measured during the study (Table 3), including total alkalinity, specific conductance, apparent color, hardness, and pH. Water temperature varied from 27° to 31°C at the 30-cm level, but was a constant 27°C at the 3-m depth in all plots for the entire study.

29. Two factors explain the lack of dramatic effect on water quality. First, herbicide application rates were so low that there were no direct effects on water quality (e.g. immediate lowering of pH upon herbicide application). Second, the described mode of action is a slow process, and rapid decomposition of biomass often associated with herbicide application did not occur. Instead, the decomposition process occurred slowly over an extended period of time. Thus, there was no significant depression of DO or rapid nutrient release as a result of treatment application.

Fluridone residues

30. Half-lives ($t_{1/2}$) for fluridone in the water are summarized in Table 4, and these were determined by plotting the percent of fluridone remaining versus the number of days after treatment (Figure 12). In these trials, fluridone exhibited a half-life in the lake water ranging from 2 to 5 days. Furthermore, the half-life values were similar for both the 4AS and 5P formulations. The presence of fluridone in the water from untreated control plots (Table 5) suggests that the

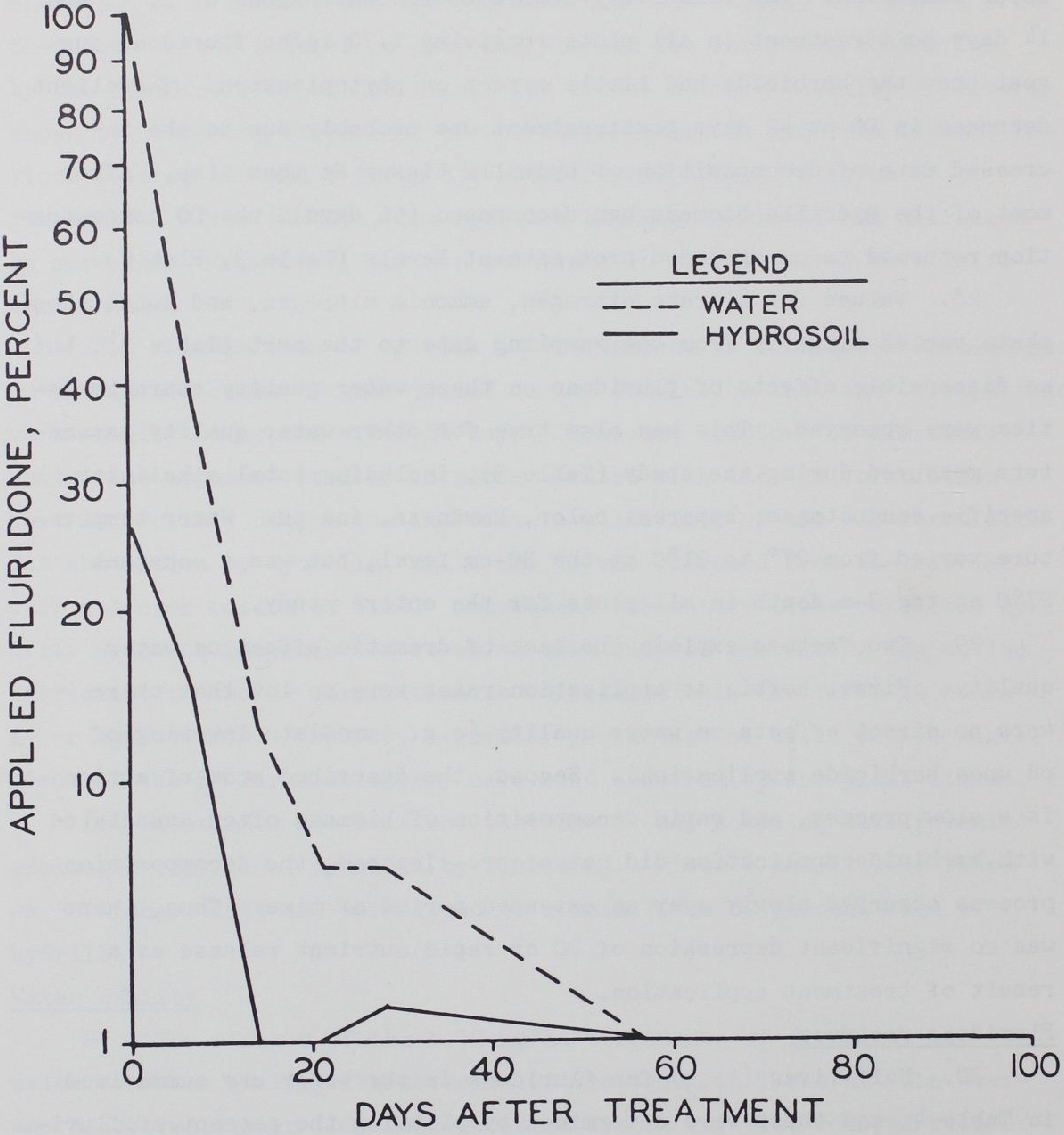


Figure 12. Dissipation curve of fluridone in plot treated with 6.72 kg/ha of 5 percent pellet formulation

dissipation may have been due in part to movement of the herbicide out of the treated areas.

31. Fluridone residues were not detected in the majority of hydrosoil samples from plots treated with the 4AS formulation, and residues in the sediments accounted for a maximum of only 1 percent of the amount theoretically applied to these plots (Table 5). Fluridone residues in the sediments from the 5P treatments ranged from a nondetectable level to 2.19 mg/kg at the 1.7-kg/ha rate, and the majority of hydrosoil samples contained less than 3 percent of the amount theoretically applied to the water.

Plankton

32. Phytoplankton. The average total number of all phytoplanktors per millilitre in each treatment plot on each sampling date is presented in Table 6. The average number of phytoplanktor cells per millilitre decreased during the study (Table 6), but similiar decreases occurred in both control and treated plots. Genera identified from the samples are listed by Division in Table 7. Generic diversity was greatest in the Division Chlorophyta, with 26 genera, followed by the Division Chrysophyta with 14 genera, and the Division Cyanophyta with 10 genera. Data from the control plots (Figure 13) revealed a compositional shift in community structure during the study. At the beginning of the test, the Chlorophyta and Chrysophyta shared dominance, but there was a shift to a strong dominance by the Chrysophyta in the 84-day samples. Although average number of phytoplankton cells per millilitre and generic composition shifted during the study, there is clear evidence that the shifts in community structure are attributable to seasonal changes from the dry season in January to the beginning of the rainy season in April.

33. Because it was expected that the highest treatment rates of fluridone would produce the greatest impact on phytoplankton, data from plots treated with 6.72 kg/ha fluridone were compared to those obtained from control plots. The comparisons are shown in Figures 13, 14, and 15. The total number of cells per millilitre did not change drastically as a result of the fluridone application, and the observed changes (Figure 15) were similar in both control and treated plots. The structure

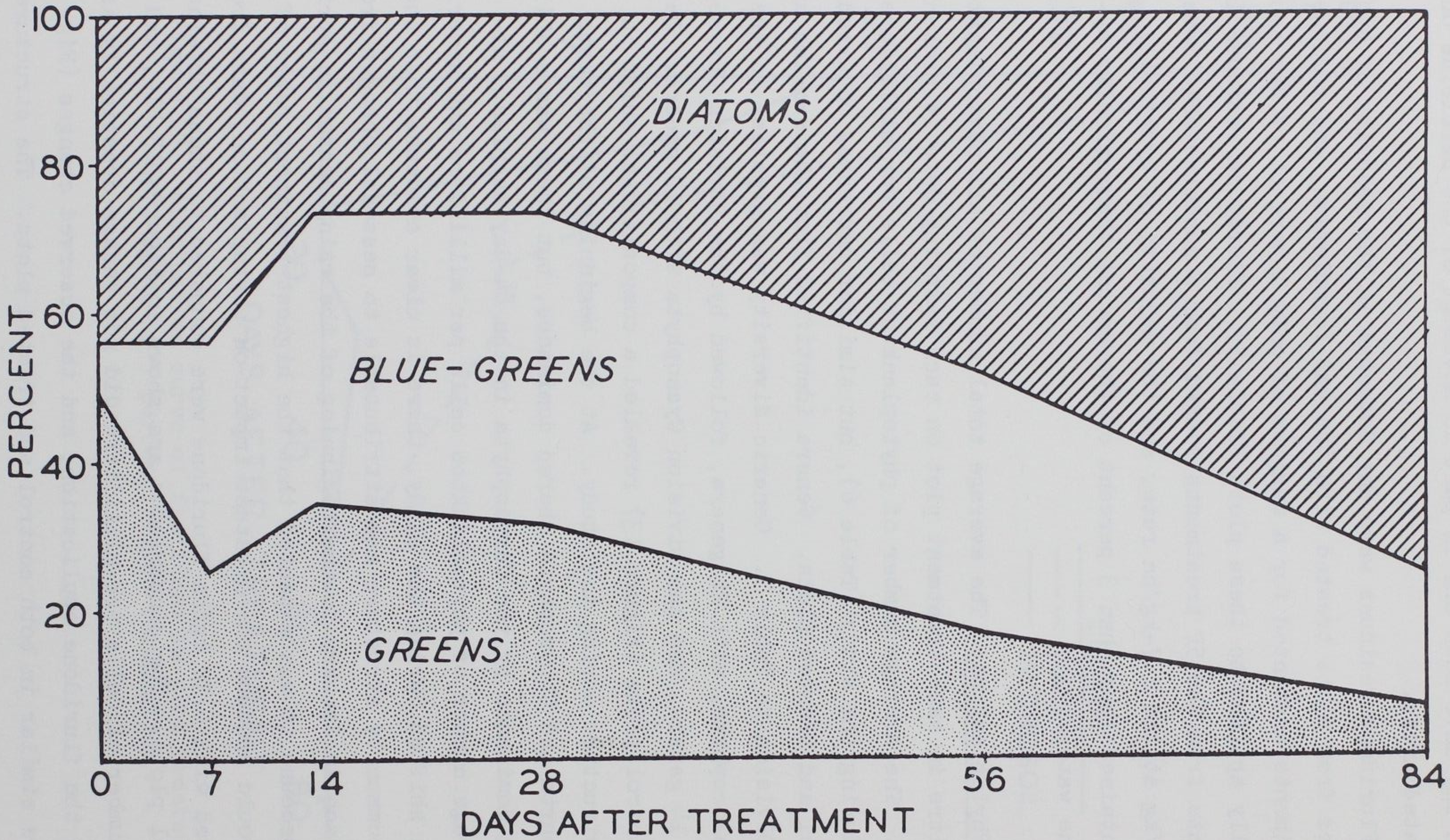


Figure 13. Phytoplankton, relative proportions of major taxa; control

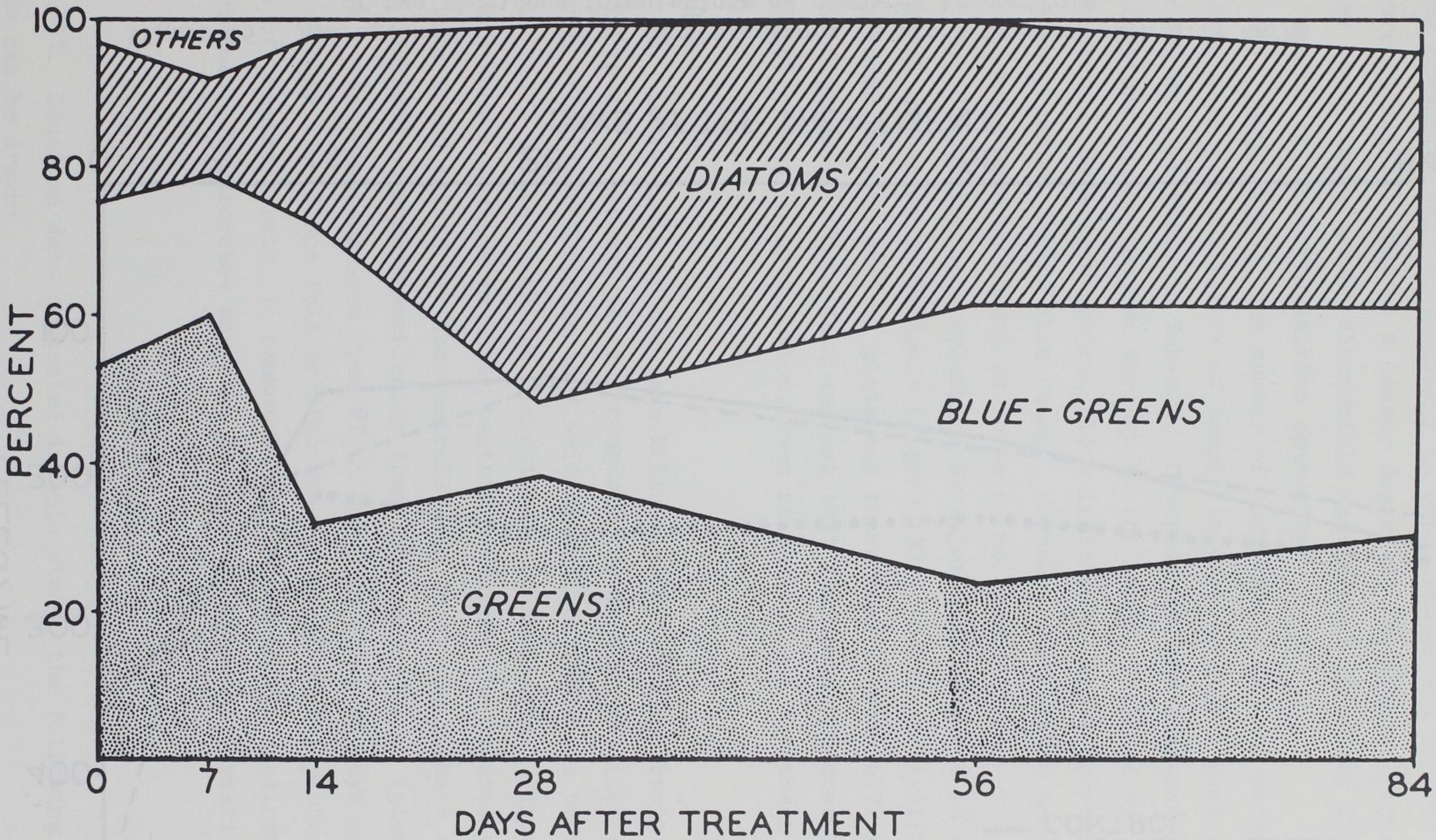


Figure 14. Phytoplankton, relative proportions of major taxa; plot treated with 6.72 kg/ha of 4AS fluridone

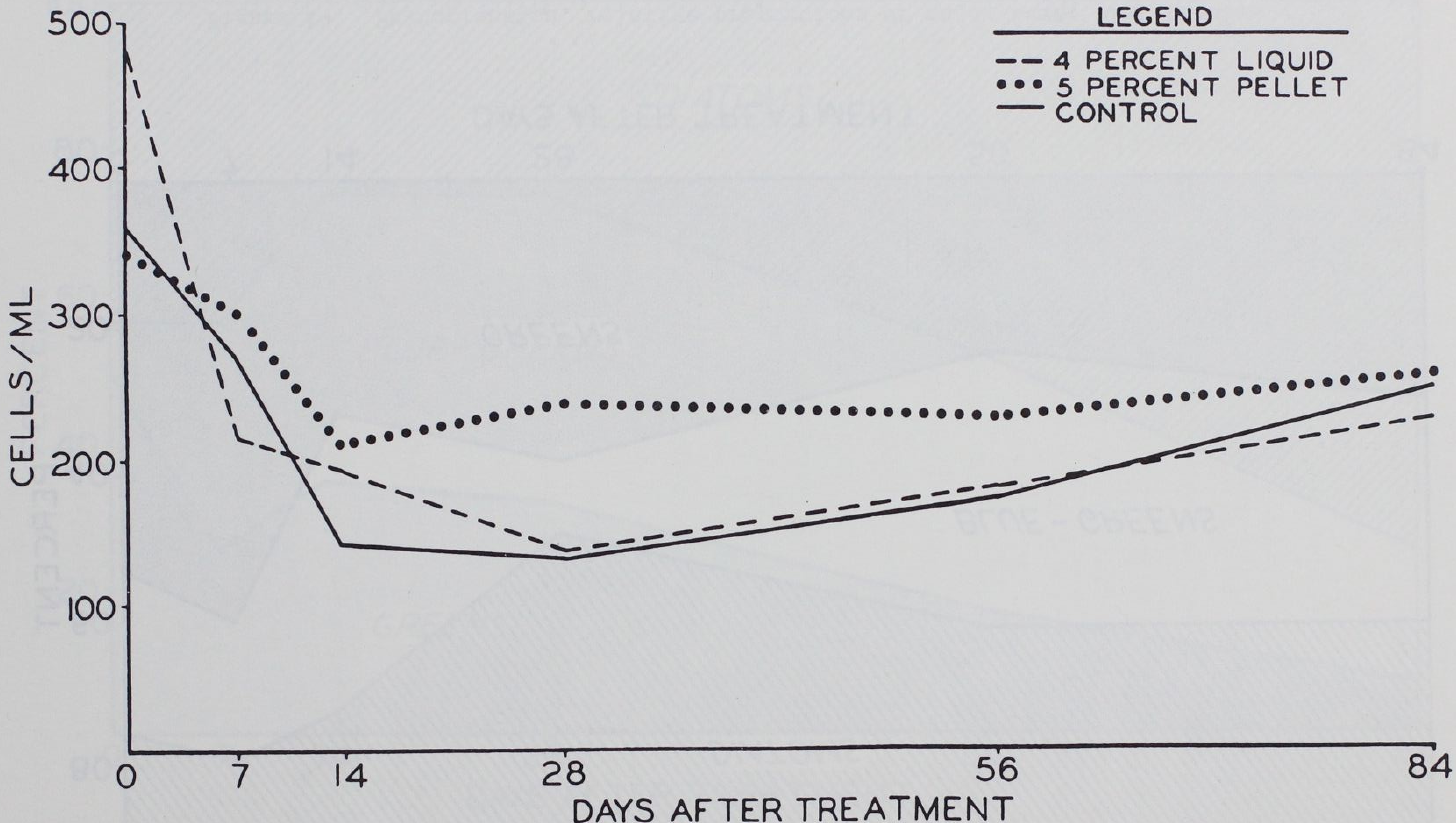


Figure 15. Average number of total phytoplanktors in plots treated with 6.72 kg/ha of two fluridone formulations as compared to controls

of the community shifted similarly in both treated and control plots (Figure 13 and 14), but to a lesser degree in the treated plots. In either case, there was no discernible detrimental impact of fluridone application on the phytoplankton community.

34. Zooplankton. The number of individuals in each major zooplankton taxa per millilitre of sample in each treatment plot for each sampling date is shown in Table 8. Copepoda was the dominant group of zooplanktors in the samples throughout the study, followed by Cladocerans. Data from control plots indicate a slight increase in total zooplankton during this study. However, the changes noted during the study were so slight as to be of no significance.

35. Comparison of zooplankton by major taxa (Figures 16 and 17) and total number of individuals (Figure 18) revealed no significant differences between control plots and those treated with 6.72 kg/ha a.i. of 4AS fluridone. These data suggest that fluridone produces little or no direct effect on zooplankton, even at the highest treatment rate used.

Benthos

36. Individuals of the taxa Mollusca dominated the benthic community in all treatment plots throughout the test period (Table 9). Any adverse effect attributable to fluridone application would be revealed in the plots treated with the highest rate of fluridone. Figure 19 and Table 9 show a decline in total benthic organisms for treated plots, but the same trend exists for the controls. In fact, the numbers of individuals declined no more dramatically than in a control plot (plot 18), where total organisms went from 87 at day 0 to 24 at 84 days posttreatment (Table 9). Since this decline was evidenced in all plots regardless of treatment rate, it cannot be attributed to the application of fluridone. The decrease may have been due to seasonal variations.

Conclusions

37. Based on data presented in this study, the following conclusions can be drawn:

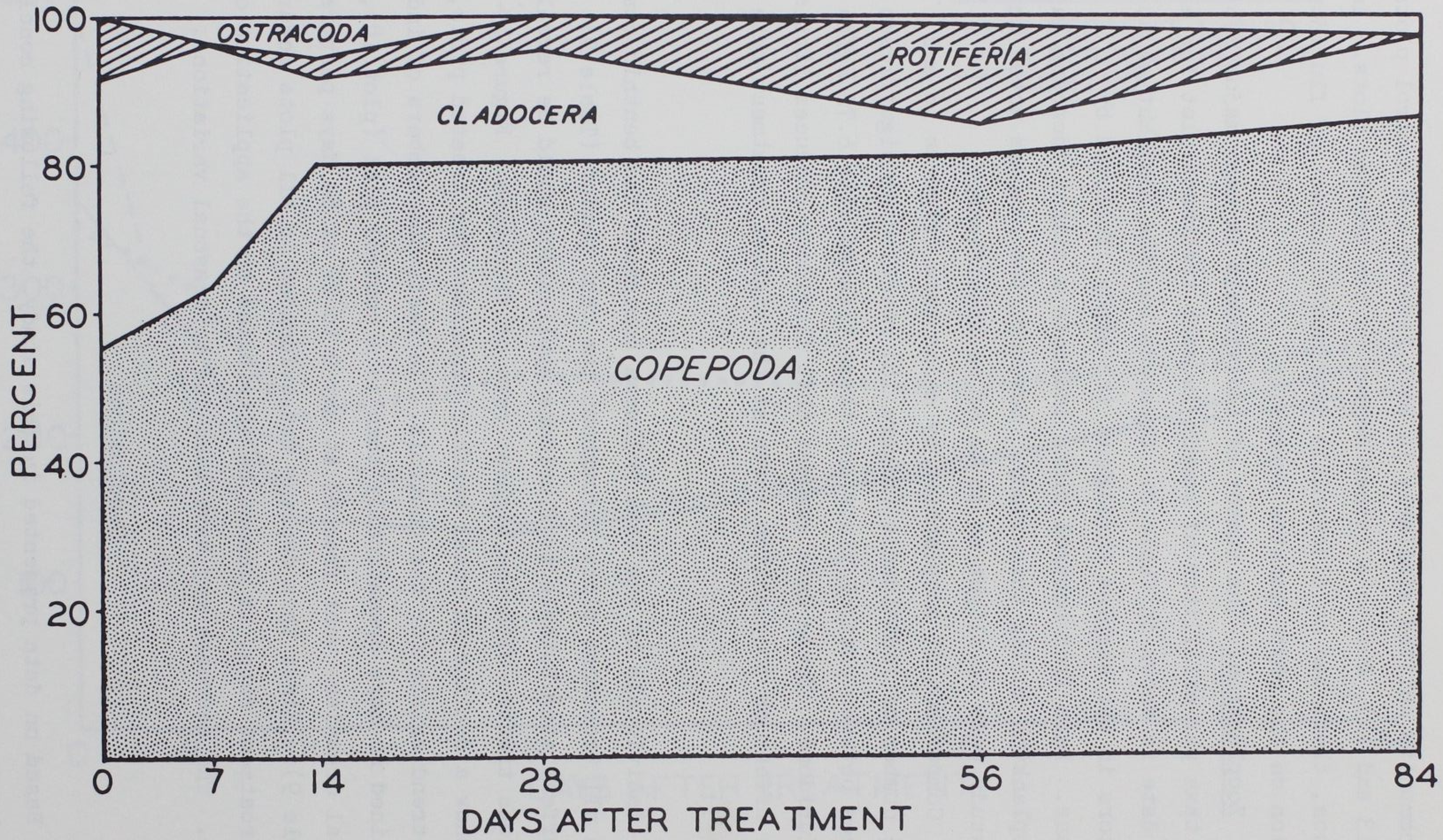


Figure 16. Zooplankton, relative proportions of major taxa; control

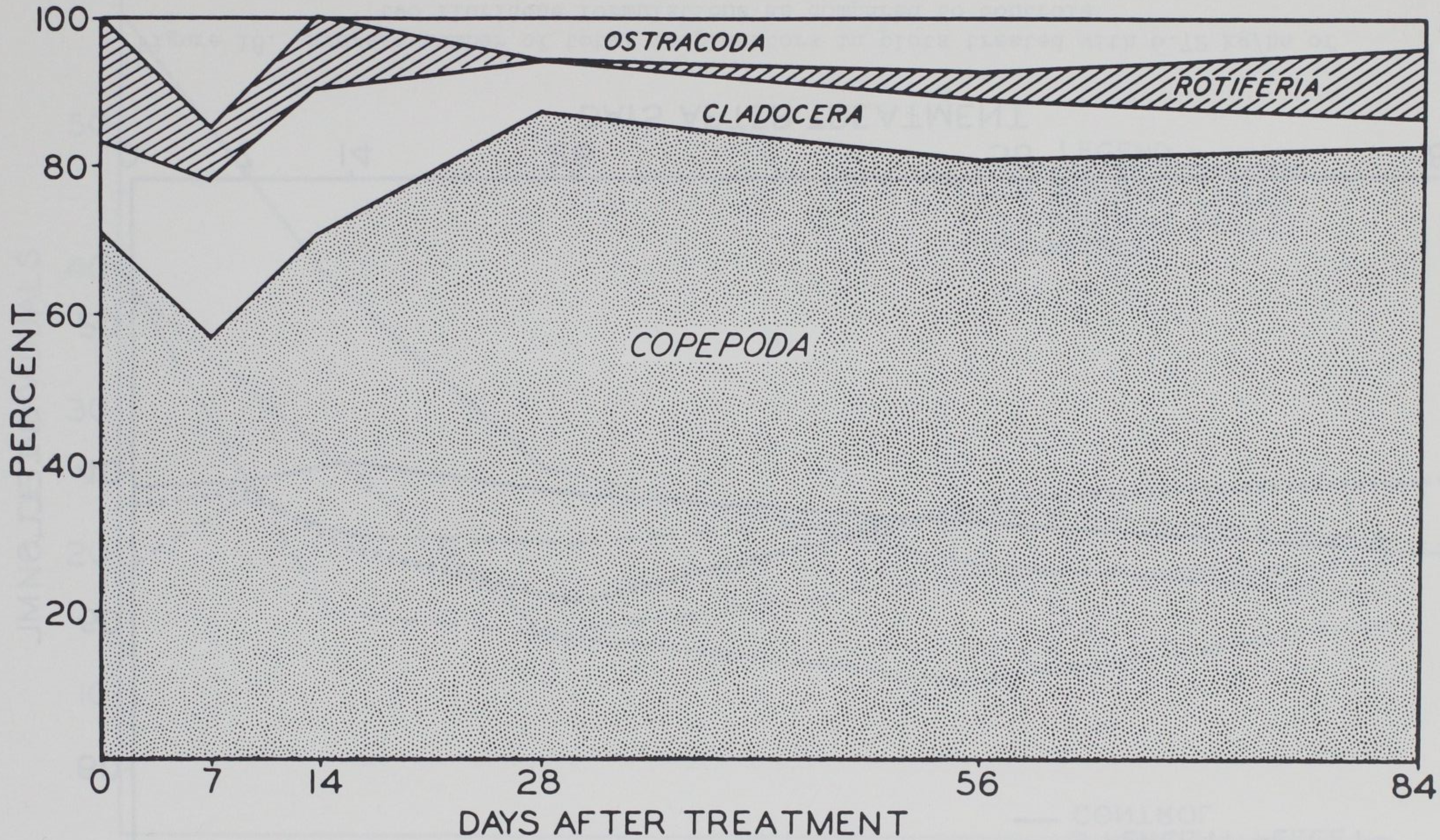


Figure 17. Zooplankton, relative proportions of major taxa; plot treated with 6.72 kg/ha of 4AS fluridone

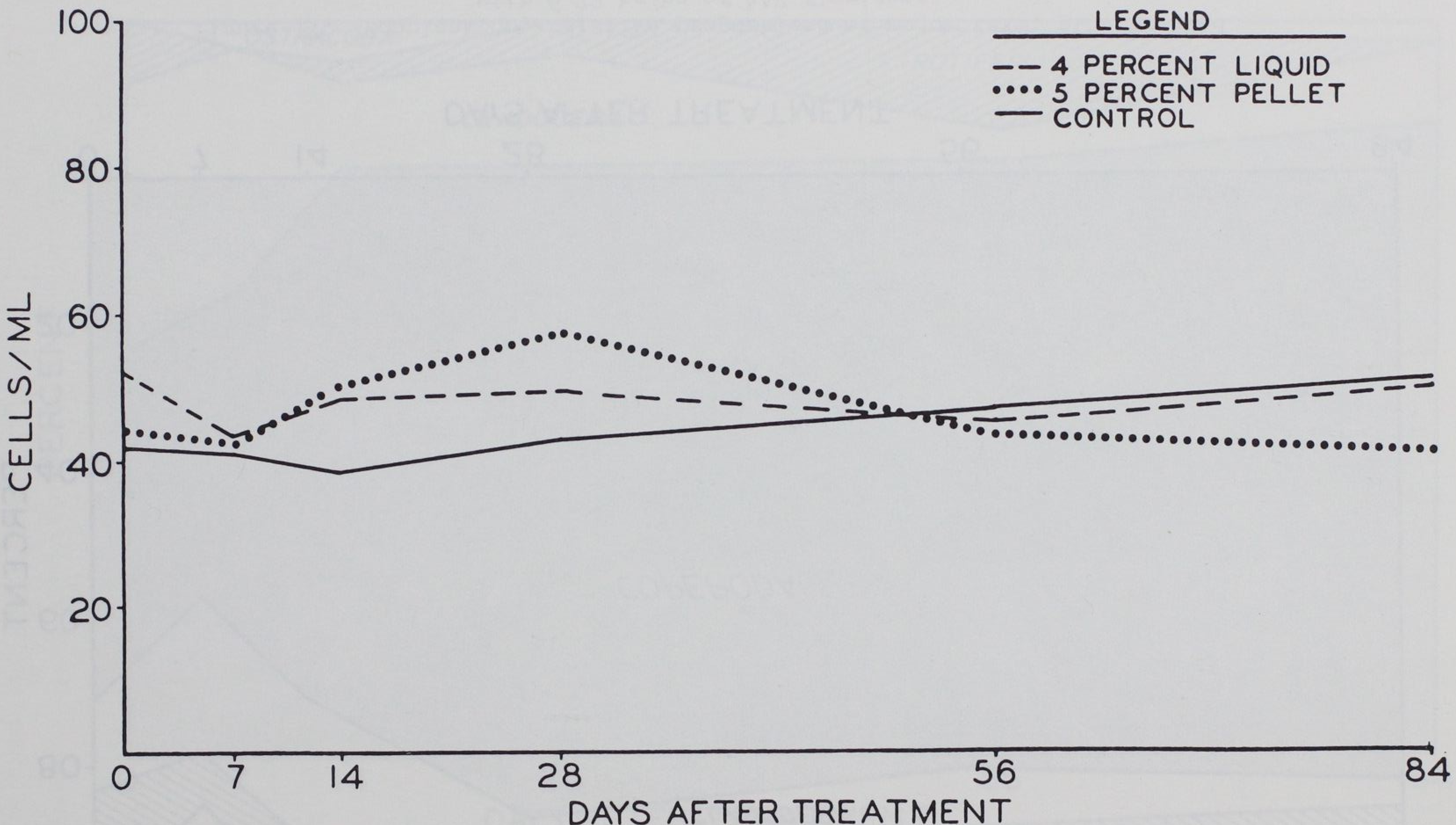


Figure 18. Average number of total zooplanktors in plots treated with 6.72 kg/ha of two fluridone formulations as compared to controls

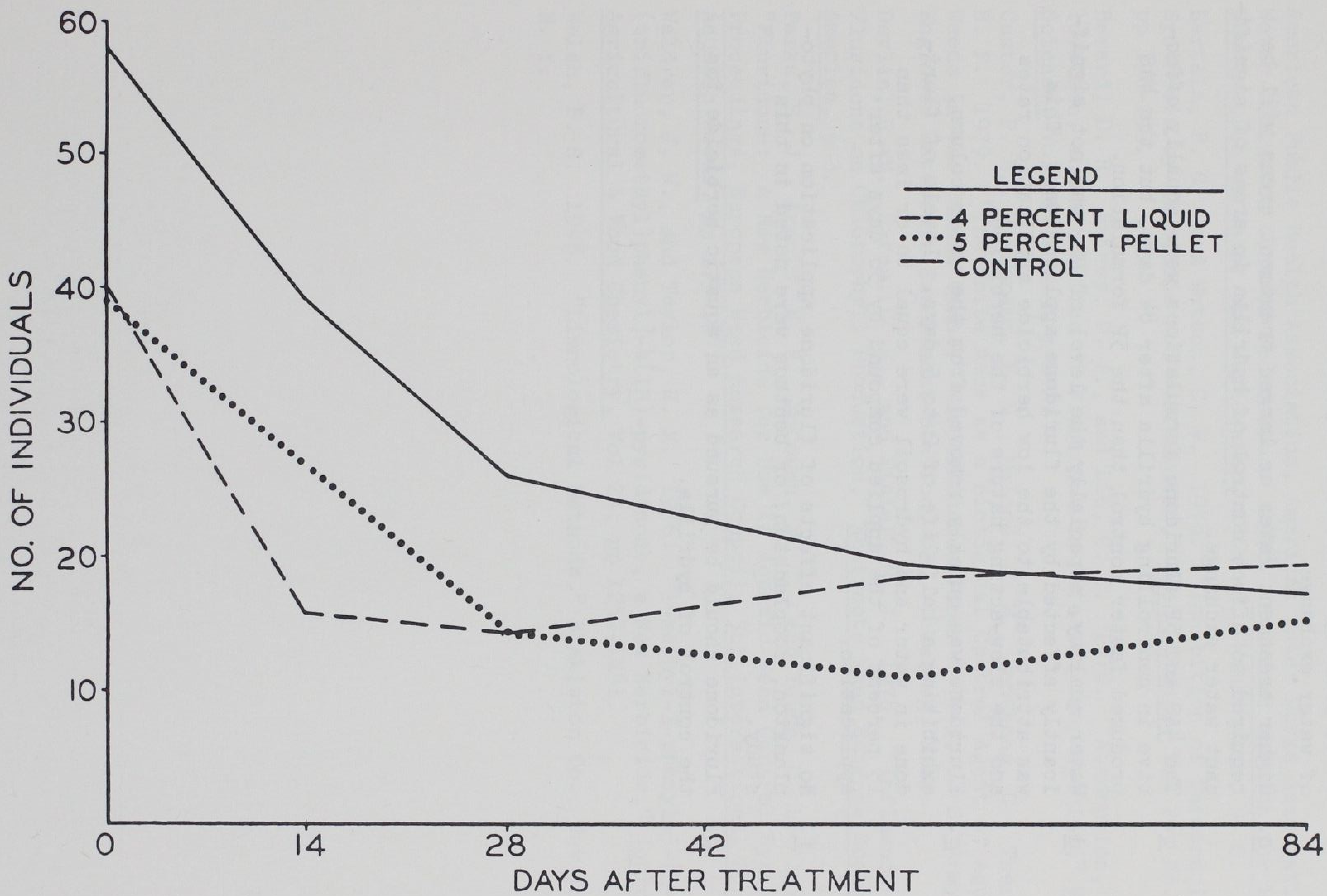


Figure 19. Average number of total benthic organisms in plots treated with 6.72 kg/ha of two fluridone formulations as compared to controls

a. Fluridone at rates as low as 1.70 kg/ha can provide effective, prolonged control of hydrilla in areas of low rates of water exchange.

b. Higher treatment rates or larger treatment areas will be required to effect control of hydrilla in areas of significant water exchange.

c. The 4AS and 5P fluridone formulations were equally effective in controlling hydrilla after 84 days, but the 4AS produced faster control than the 5P formulation.

d. Water quality, especially the level of DO, was not significantly affected by the fluridone applications. This was attributable to the low herbicide application rates and the slow-acting nature of the herbicide.

e. Fluridone was quickly removed from the water column, exhibiting a half-life of 2 to 5 days. Levels of fluridone in water and hydrosoil were equal to or less than 15 percent of the applied compound by 56 days after application.

f. No significant effects of fluridone application on phytoplankton, zooplankton, or benthos were noted in this study.

g. Fluridone should be pursued as an aquatic herbicide for the control of hydrilla.

References

American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1976. Standard Methods for the Examination of Water and Wastewater, 13th ed., Washington, D. C.

Bartels, P. G., and Watson, C. W. 1978. "Inhibition of Carotenoid Synthesis by Fluridone and Norflurofen," Weed Science, Vol 26, No. 3, pp 198-203.

Berard, D. R., Rainey, D. P., and Lin, C. C. 1978. "Absorption, Translocation, and Metabolism of Fluridone in Selected Crop Species," Weed Science, Vol 26, No. 3, p 252.

Custer, P. E., Halverson, F. D., Malone, J. M., VonChong, C., Theriot, R. F. 1979. "The White Amur as a Biological Control Agent of Aquatic Weeds in the Panama Canal," Miscellaneous Paper A-79-1, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Devlin, R. M., Saras, C. H., and Kisiel, M. J. 1978. "Influence of Fluridone on Chlorophyll Production," Abstracts Weed Science Society America, p 3.

Parka, S. J., Arnold, W. R., McCowen, M. C., and Young, C. L. 1978. "Fluridone: A New Herbicide for Use in Aquatic Weed Control System," Proceedings, European Weed Research Council, 5th International Symposium Aquatic Weeds, pp 179-187.

Waldrep, J. W., and Taylor, H. M. 1976. "1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1H)-pyridinone, a New Herbicide," Journal, Agricultural & Food Chemistry, Vol 24, pp 1250-1251.

Welch, P. S. 1948. "Limnological Methods," Blakiston Co., New York, N. Y.

Table 1

Location and Treatment Rates of Plots

Treatment, kg/ha	Dump 8	Dump 12
6.72 4AS	14*	1
6.72 5P	13	3
3.36 4AS	11	4
3.36 5P	9	5
1.70 4AS	12	17
1.70 5P	7	6
0.84 4AS	10	2
0.84 5P	16	8
0	15	18

* These numbers are the treatment plot numbers as indicated in Figure 3.

Table 2

Effect of Fluridone on Hydrilla Biomass in Gatun Lake

Treatment Rate, kg/ha*	Plot Number	Hydrilla Biomass, kg/ha × 10^4 Days Posttreatment 0	28	42	56	84
6.72 AS	1	4.1	3.4	3.3	2.5	2.5
	14	2.3	3.5	3.1	2.2	1.6
6.72 P	3	1.9	1.5	2.0	1.7	2.1
	13	2.1	3.7	2.7	2.9	3.6
3.36 AS	4	5.4	-**	-	2.4	1.4
	11	2.0	-	-	4.3	-
3.36 P	5	4.5	-	-	6.2	1.8
	9	2.4	-	-	3.0	2.5
1.70 AS	12	3.0	2.0	2.5	4.0	3.0
	17	4.1	1.3	1.4	3.0	1.1
1.70 P	6	4.5	-	2.0	2.2	0.8
	7	3.0	2.3	0.6	2.5	3.1
0.84 AS	2	2.6	-	-	2.8	3.1
	10	3.0	-	-	1.6	1.5
0.84 P	8	3.3	-	-	2.3	2.6
	16	4.1	-	-	2.9	2.4
0	15	1.7	2.7	0.9	3.2	2.8
	18	1.9	1.1	1.4	3.1	2.5

* Active ingredient.
** Not sampled.

Table 3

Effect of Fluridone on Selected Water Quality Characteristics in Gatun Lake

Water Quality Characteristic	Treatment Rate, kg/ha	Plot Number	Days Posttreatment						
			0	1	7	14	28	42	56
Dissolved oxygen, mg/ℓ	6.72 AS	1	6.8	7.1	6.3	6.5	5.0	5.6	5.3
		14	8.0	6.2	8.4	5.7	5.7	6.1	8.3
	6.72 P	3	8.9	6.1	6.3	5.0	5.7	6.4	5.6
		13	7.2	7.2	7.4	5.9	5.8	5.4	5.3
	1.70 AS	12	7.7	6.3	6.1	5.5	5.3	5.8	7.6
		17	6.0	6.4	5.8	5.2	5.5	5.0	5.9
	1.70 P	6	4.8	4.0	5.6	4.2	4.4	4.1	5.9
		7	7.9	7.6	6.9	4.8	5.8	6.3	7.8
	0	15	6.6	7.9	7.2	5.4	6.1	6.7	6.8
		18	7.6	7.3	7.9	6.2	6.0	5.8	7.3
Temperature, °C	6.72 AS	1	27.5	27.5	27.3	27.7	27.8	27.5	27.8
		14	28.0	27.0	28.0	27.5	28.5	29.0	28.2
	6.72 P	3	27.5	28.0	27.3	27.7	28.0	27.8	27.5
		13	27.5	28.5	27.7	27.7	28.3	27.3	28.0
	1.70 AS	12	28.0	27.5	28.0	27.8	28.2	27.7	28.5
		17	27.5	27.5	27.7	27.7	25.5	27.8	27.0
	1.70 P	6	28.0	27.8	27.7	27.3	27.8	27.8	27.5
		7	26.7	27.5	27.7	26.8	28.3	28.3	28.2
	0	15	27.5	28.0	27.7	27.3	28.5	28.8	27.8
		18	27.5	27.5	27.3	27.5	27.8	27.3	27.5
pH	6.72 AS	1	7.3	8.8	-	7.9	8.4	7.7	7.7
		14	7.7	8.3	-	8.0	8.7	7.6	7.8
	6.72 P	3	7.3	7.7	-	7.7	7.8	7.5	7.6
		13	7.5	8.5	-	8.0	8.5	7.6	7.6
	1.70 AS	12	7.5	8.1	-	7.6	7.7	7.5	7.9
		17	7.2	7.8	-	7.7	7.7	7.6	7.6
	1.70 P	6	7.1	7.4	-	7.6	7.7	7.5	7.6
		7	7.4	8.3	-	7.8	8.6	7.7	8.3
	0	15	7.6	9.0	-	7.9	8.5	7.6	8.2
		18	7.3	8.8	-	8.2	8.3	7.7	7.7
NO_3-N, mg/ℓ	6.72 AS	1	0.03	0.03	0.01	0.02	0.02	0.01	0.01
		14	0.06	0.06	0.06	0.05	0.03	0.06	0.02
	6.72 P	3	0.00	0.00	0.00	0.00	0.00	0.02	0.01
		13	0.01	0.01	0.02	0.02	0.03	0.06	0.02
	1.70 AS	12	0.01	0.01	0.00	0.00	0.00	0.01	0.03
		17	0.01	0.01	0.00	0.20	0.01	0.01	0.01
	1.70 P	6	0.04	0.01	0.03	0.02	0.50	0.02	0.00
		7	0.07	0.07	0.05	0.04	0.03	0.07	0.05

(Continued)

(Sheet 1 of 3)

Table 3 (Continued)

Water Quality Characteristic	Treatment Rate, kg/ha	Plot Number	Days Posttreatment						
			0	1	7	14	28	42	56
NO_3-N, mg/ℓ (Continued)	0	15	0.04	0.03	0.01	0.03	0.02	0.04	0.03
		18	0.04	0.03	0.03	0.03	0.03	0.02	0.03
Apparent Color	6.72 AS	1	20.0	10.0	20.0	20.0	20.0	17.5	12.5
		14	30.0	35.0	50.0	35.0	60.0	50.0	45.0
	6.72 P	3	20.0	5.0	20.0	15.0	35.0	12.5	15.0
		13	20.0	12.5	20.0	20.0	35.0	35.0	22.5
	1.70 AS	12	10.0	5.0	20.0	17.5	40.0	20.0	35.0
		17	12.5	5.0	15.0	12.5	15.0	15.0	12.5
	1.70 P	6	12.0	5.0	20.0	17.5	50.0	15.0	15.0
		7	40.0	25.0	50.0	40.0	40.0	50.0	55.0
	0	15	30.0	7.0	30.0	40.0	45.0	40.0	40.0
		18	10.0	10.0	15.0	20.0	40.0	17.5	22.5
Hardness, mg/ℓ	6.72 AS	1	39	-	-	-	-	-	38
		14	44	-	-	-	-	-	45
	6.72 P	3	36	-	-	-	-	-	37
		13	43	-	-	-	-	-	44
	1.70 AS	12	41	-	-	-	-	-	45
		17	39	-	-	-	-	-	39
	1.70 P	6	36	-	-	-	-	-	38
		7	44	-	-	-	-	-	45
	0	15	46	-	-	-	-	-	45
		18	41	-	-	-	-	-	41
Turbidity, FTU's	6.72 AS	1	12.0	3.5	5.2	9.5	5.6	5.3	2.1
		14	25.0	17.0	19.5	32.0	26.5	17.5	23.0
	6.72 P	3	2.9	2.9	3.5	2.6	4.1	0.6	1.2
		13	3.7	6.5	6.7	7.7	10.0	12.5	7.7
	1.70 AS	12	1.3	1.4	2.6	6.5	5.1	2.1	11.5
		17							
	1.70 P	6	12.0	2.2	3.6	2.1	6.6	1.1	1.3
		7	17.5	14.5	20.0	19.0	13.5	23.0	29.0
	0	15	15.0	5.6	10.2	33.5	13.1	15.0	19.0
		18	8.2	5.4	5.9	6.3	15.5	4.3	15.7
Specific conductance µmhos/cm	6.72 AS	1	99.1	104.5	105.2	98.6	99.0	97.5	105.5
		14	110.2	116.4	107.9	105.7	110.3	120.5	120.5
	6.72 P	3	93.8	97.5	92.1	93.3	94.7	103.5	105.5
		13	108.6	114.8	106.9	105.3	109.0	119.0	120.5
	1.70 AS	12	102.6	107.2	98.6	98.4	103.2	116.5	119.5
		17	99.2	98.4	94.8	95.7	99.3	107.0	109.5
	1.70 P	6	93.8	94.4	91.2	91.0	95.7	102.5	104.0
		7	110.8	112.2	113.9	104.4	110.6	120.0	120.0

(Continued)

Table 3 (Concluded)

Water Quality Characteristic	Treatment Rate, kg/ha	Plot Number	Days Posttreatment 0	1	7	14	28	42	56
Specific conductance µmhos/cm (Continued)	0	15	109.7	115.3	109.2	108.3	109.8	121.5	122.5
		18	104.4	100.0	99.5	101.2	104.4	101.0	122.5
NH_3-N, mg/ℓ	6.72 AS	1	0.03	0.06	0.01	0.01	0.02	0.07	0.01
		14	0.03	0.10	0.06	0.02	0.06	0.09	0.04
	6.72 P	3	0.01	0.02	0.01	0.01	0.02	0.06	0.01
		13	0.03	0.18	0.5	0.02	0.04	0.06	0.04
	1.70 AS	12	0.04	0.11	0.04	0.01	0.03	0.08	0.02
		17	0.04	0.17	0.07	0.03	0.07	0.10	0.05
	1.70 P	6	0.03	0.03	0.03	0.02	0.05	0.07	0.01
		7	0.01	0.12	0.03	0.03	0.02	0.01	0.03
	0	15	0.04	0.02	0.05	0.04	0.05	0.10	0.04
		18	0.04	0.09	0.09	0.03	0.05	0.11	0.05
T-PO_4, mg/ℓ	6.72 AS	1	0.04	0.01	0.02	0.02	0.01	0.02	0.02
		14	0.05	0.02	0.04	0.03	0.03	0.04	0.05
	6.72 P	3	0.03	0.01	0.03	0.06	0.01	0.02	0.03
		13	0.03	0.02	0.02	0.02	0.03	0.04	0.04
	1.70 AS	12	0.03	0.01	0.02	0.02	0.02	0.03	0.04
		17	0.04	0.01	0.03	0.05	0.01	0.02	0.04
	1.70 P	6	0.08	0.01	0.04	0.03	0.02	0.02	0.04
		7	0.03	0.02	0.04	0.03	0.02	0.05	0.05
	0	15	0.09	0.02	0.03	0.04	0.02	0.04	0.05
		18	0.03	0.01	0.01	0.01	0.02	0.03	0.03
Total alkalinity, mg/ℓ	6.72 AS	1	40.5	-	-	-	-	-	30.0
		14	37.5	-	-	-	-	-	27.5
	6.72 P	3	38.0	-	-	-	-	-	30.5
		13	40.5	-	-	-	-	-	36.0
	1.70 AS	12	38.0	-	-	-	-	-	33.0
		17	38.0	-	-	-	-	-	33.5
	1.70 P	6	39.5	-	-	-	-	-	30.5
		7	38.0	-	-	-	-	-	25.0
	0	15	41.5	-	-	-	-	-	32.5
		18	41.5	-	-	-	-	-	29.0

Table 4

Fluridone Half-Lives in Water

Formulation Rate	Plot Number	Half-Life Days
6.72 AS	1	4
	14	2
6.72 P	3	4
	13	4
1.70 AS	12	4
	17	4
1.70 P	6	5
	7	3

Table 5

Fluridone Residues in Water and Hydrosoil

Formulation Rate kg/ha	Plot Number	DAT*	Fluridone in Water mg/ℓ Top	Bottom	Average	Percent of Initial	Fluridone in Soil mg/kg	lb/acre	Percent of Applied**
6.72 AS	1	1	0.045	0.046	0.046	100	0.012	0.01	<1
		7	0.019	0.012	0.015	33	<0.010	<0.02	<1
		14	0.003	0.004	0.004	9	NDR	NDR	0
		21	<0.001	0.001	<0.001	<2	--	--	--
		28	0.001	0.002	0.002	4	NDR	NDR	0
		56	<0.001	<0.001	<0.001	<2	NDR	NDR	0
		84	<0.001	NDR†	<0.001	<2	<0.010	<0.03	0
	14	1	0.037	0.035	0.036	100	0.025	0.03	<1
		7	0.006	0.001	0.004	11	0.010	0.02	<1
		14	0.002	0.003	0.003	8	NDR	NDR	0
		21	NDR	NDR	NDR	0	NDR	NDR	0
		28	<0.001	0.002	0.001	3	<0.010	<0.02	<1
		56	0.001	NDR	<0.001	<3	NDR	NDR	0
		84	<0.001	<0.001	<0.001	<3	NDR	NDR	0
6.72 P	3	1	0.032	0.026	0.029	100	2.19	1.75	26
		7	0.016	0.006	0.011	38	0.660	1.08	16
		14	0.003	0.006	0.004	14	0.058	0.04	1
		21	0.001	0.002	0.002	7	0.014	<0.01	<1
		28	0.002	0.002	0.002	7	0.109	0.16	2
		56	0.001	<0.001	<0.001	<3	0.086	0.07	1
		84	<0.001	<0.001	<0.001	<3	0.063	0.08	1

(Continued)

* DAT = Days after treatment.

** Percent of applied = (kg/ha in soil ÷ kg/ha applied) × 100 percent.

† NDR = No detectable residue at a test sensitivity of 0.001 mg/ℓ in water and 0.010 mg/kg in hydrosoil.

Table 5 (Continued)

Formulation Rate kg/ha	Plot Number	DAT*	Fluridone in Water mg/ℓ Top	Bottom	Average	Percent of Initial	Fluridone in Soil mg/kg	lb/acre	Percent of Applied**
6.72 P (Continued)	13	1	0.029	0.024	0.027	100	0.059	0.13	2
		7	0.015	0.005	0.010	37	NDR	NDR	0
		14	0.005	0.006	0.006	22	0.017	0.02	<1
		21	NDR	0.002	0.001	4	0.015	<0.01	<1
		28	0.002	0.002	0.002	7	NDR	NDR	0
		56	<0.001	<0.001	<0.001	<4	0.674	1.01	15
		84	<0.001	0.001	<0.001	<4	0.024	0.07	1
1.70 AS	12	1	0.033	0.045	0.039	100	0.010	0.02	1
		7	0.019	0.006	0.012	31	NDR	NDR	0
		14	0.003	0.003	0.003	8	0.010	0.02	1
		21	0.001	0.001	0.001	3	NDR	NDR	0
		28	<0.001	0.001	<0.001	<3	NDR	NDR	0
		56	0.001	<0.001	<0.001	<3	NDR	NDR	0
		84	0.006	0.003	0.005	13	NDR	NDR	0
	17	1	0.012	0.011	0.012	100	0.011	0.01	<1
		7	0.005	0.003	0.004	33	<0.010	<0.02	<1
		14	0.003	0.008	0.006	50	NDR	NDR	0
		21	<0.001	<0.001	<0.001	<8	NDR	NDR	0
		28	0.001	0.001	0.001	8	NDR	NDR	0
		56	<0.001	<0.001	<0.001	<8	<0.010	<0.01	<1
		84	<0.001	NDR	<0.001	<8	NDR	NDR	0
1.70 P	6	1	0.033	0.030	0.032	100	0.017	0.01	<1
		7	0.009	0.003	0.006	19	0.039	0.03	2
		14	0.002	0.002	0.002	6	NDR	NDR	0
		21	0.001	0.004	0.003	9	NDR	NDR	0

(Continued)

Table 5 (Concluded)

Formulation Rate kg/ha	Plot Number	DAT*	Fluridone in Water mg/ℓ Top	Bottom	Average	Percent of Initial	Fluridone in Soil mg/kg	lb/acre	Percent of Applied**
1.70 P (Continued)		28	0.002	0.002	0.002	6	NDR	NDR	0
		56	<0.001	0.001	<0.001	<3	0.041	0.02	1
		84	<0.001	<0.001	<0.001	<3	NDR	NDR	0
	7	1	0.013	0.008	0.011	100	0.028	0.06	3
		7	0.005	0.004	0.005	45	0.033	0.02	1
		14	0.002	0.005	0.004	36	NDR	NDR	0
		21	0.001	0.001	0.001	9	NDR	NDR	0
		28	<0.001	0.001	<0.001	<9	NDR	NDR	0
		56	<0.001	NDR	<0.001	<9	<0.010	<0.01	0
		84	<0.001	0.001	<0.001	<9	NDR	NDR	0
0	15	1	0.008	0.019	0.014	--	NDR	NDR	--
		7	0.013	0.003	0.008	--	<0.010	<0.02	--
		14	0.003	0.005	0.004	--	NDR	NDR	--
		14	0.003	0.005	0.004	--	NDR	NDR	--
		21	0.001	NDR	<0.001	--	NDR	NDR	--
		28	0.001	0.002	0.002	--	NDR	NDR	--
		56	NDR	<0.001	<0.001	--	NDR	NDR	--
		84	<0.001	NDR	<0.001	--	NDR	NDR	--
		1	0.008	0.004	0.006	--	NDR	NDR	--
		7	0.014	0.003	0.009	--	0.012	0.02	--
		14	0.002	0.002	0.002	--	NDR	NDR	--
		21	<0.001	NDR	<0.001	--	NDR	NDR	--
		28	NDR	0.001	<0.001	--	NDR	NDR	--
		56	NDR	<0.001	<0.001	--	NDR	NDR	--
		84	NDR	NDR	NDR	--	<0.010	<0.02	--

(Sheet 3 of 3)

Table 6

Total Number of Phytoplanktors per Millilitre of Sample from Controls and Plots Treated with Fluridone During This Study

Treatment Rate kg/ha	Plot	Days Posttreatment 0	7	14	28	56	84
6.72 AS	1	156*	151	111	114	72	196
	14	806	276	269	160	281	268
6.72 P	3	297	417	234	233	121	166
	13	381	182	189	239	330	342
1.70 AS	12	142	139	96	166	158	214
	17	593	351	209	79	113	116
1.70 P	6	209	319	388	385	188	122
	7	116	238	271	335	218	211
0	15	191	256	107	146	152	146
	18	531	279	180	112	186	348

* Individuals per millilitre.

Table 7

Genera Identified During This Study,

Arranged According to Division

Division Cyanophyta (Blue-Green Algae)

Agmenellum	Gleotrichia
Anabaena	Phormidium
Anacystis	Rivularia
Cocconeis	Spirulina
Coelosphaerium	Tetrapedia

Division Chlorophyta (Green Algae)

Actinastrum	Pediastrum
Ankistrodesmus	Protococcus
Arthrodesmus	Rhizoclonium
Chlorococcum	Scenedesmus
Chlorogonium	Selenastrum
Closterium	Sphaerocystis
Coelastrum	Staurastrum
Cosmarium	Tetraedron
Euastrum	Tetraspora
Micrasterias	Ulothrix
Microspora	Volvox
Mougeotia	Xanthidium
Oocystis	Zygnema

Division Chrysophyta (Diatoms)

Asterionella	Melosira
Botrydiopsis	Nitzchia
Botryococcus	Pinnularia
Chromulina	Surirella
Diatoma	Synedra
Dinobryon	Tabellaria
Fragilaria	Tribonema

Division Euglenophyta (Euglenoids)

Euglena

Division Pyrrophyta (Dinoflagellates)

Ceratium

Table 8

Total Number of Zooplanktors per Millilitre of Sample from Controls and Plots Treated with Fluridone During This Study

Treatment Rate (kg/ha)	Plot Number	Taxon	Day Posttreatment 0	7	14	28	56	84
6.72 AS	1	Copepoda	12*	8	15	13	21	19
		Cladocera	2	3	4	1	2	1
		Ostracoda	0	2	0	1	2	
		Rotifera	3	1	2		1	2
		TOTAL	17	14	21	15	26	22
	14	Copepoda	63	67	60	72	58	67
		Cladocera	11	3	13	9	3	1
		Ostracoda	8	0	1	0	1	3
		Rotifera	4	2	0	1	1	5
		TOTAL	86	72	74	82	63	76
6.72 P	3	Copepoda	18	21	35	24	12	18
		Cladocera	8	4	2	8	5	2
		Ostracoda	3	2	8	3	3	4
		Rotifera	6	3	5	2	4	3
		TOTAL	35	30	50	37	24	27
	13	Copepoda	37	39	48	63	51	45
		Cladocera	12	8	1	11	5	9
		Ostracoda	2	4	1	2	4	
		Rotifera	1	2	1	1	2	1
		TOTAL	52	53	50	77	62	55
1.70 AS	12	Copepoda	18	41	6	44	31	49
		Cladocera	9	2	13	8	3	3
		Ostracoda	4	0	1	3	0	2
		Rotifera	3	2	3	5	2	0
		TOTAL	34	45	23	60	36	54
	17	Copepoda	54	59	69	73	39	37
		Cladocera	7	3	1	1	26	24
		Ostracoda	8	4	2	1	5	8
		Rotifera		2	0	1	2	7
		TOTAL	69	68	72	76	72	76
1.70 P	6	Copepoda	37	24	31	39	42	18
		Cladocera	5	11	4	3	2	12
		Ostracoda	2	3	3	5	1	3
		Rotifera	0	2	4	1	3	2
		TOTAL	44	40	42	48	48	35

(Continued)

* Individuals per millilitre.

Table 8 (Concluded)

Treatment Rate (kg/ha)	Plot Number	Taxon	Day Posttreatment 0	7	14	28	56	84
1.70 P (Continued)	7	Copepoda	12	21	33	30	21	13
		Cladocera	5	2	11	2	11	10
		Ostracoda	3	1	1	1	3	5
		Rotifera	1	1	0	1	2	1
		TOTAL	21	25	45	34	37	29
0	15	Copepoda	12	17	28	33	39	24
		Cladocera	8	9	4	6	2	3
		Ostracoda	0	1	2	0	1	1
		Rotifera	2	0	1	2	6	0
		TOTAL	22	27	35	41	48	28
	18	Copepoda	38	30	29	39	51	58
		Cladocera	19	28	8	1	0	5
		Ostracoda	4	2	2	4	3	9
		Rotifera	1	5	1	0	1	1
		TOTAL	62	65	40	44	55	73

Table 9

Total Number of Benthic Organisms per Sample from Controls and Plots Treated with Fluridone During This Study

Treatment Rate (kg/ha)	Plot Number	Taxon	Days Posttreatment 0	14	28	42	84
6.72 AS	1	Mollusca	56	3	7	8	7
		Crustacea	1	0	0	0	0
		*Other	0	0	0	0	2
		TOTAL	57	3	7	8	9
		Mollusca	22	28	21	26	16
		Crustacea	0	0	0	0	0
		Other	0	0	0	1	1
		TOTAL	22	28	21	27	17
6.72 P	3	Mollusca	26	24	28	5	7
		Crustacea	0	1	1	1	0
		Other	0	0	0	2	2
		TOTAL	26	25	29	8	9
	13	Mollusca	52	28	9	13	20
		Crustacea	0	0	0	1	0
		Other	0	0	0	2	2
		TOTAL	52	28	9	16	22
1.70 AS	12	Mollusca	73	16	10	7	8
		Crustacea	1	0	0	1	0
		Other	0	0	0	0	0
		TOTAL	74	16	10	8	8
	17	Mollusca	15	14	6	9	19
		Crustacea	0	0	0	0	0
		Other	0	0	0	1	1
		TOTAL	15	14	6	10	20
1.70 P	6	Mollusca	9	2	7	16	1
		Crustacea	0	0	0	0	1
		Other	0	0	0	0	1
		TOTAL	9	2	7	16	3
	7	Mollusca	49	101	160	4	29
		Crustacea	1	1	1	0	0
		Other	0	0	0	1	3
		TOTAL	50	102	161	5	32

(Continued)

* Includes insects, Oligochaeta, and Polychaeta.

Table 9 (Concluded)

Treatment Rate (kg/ha)	Plot Number	Taxon	Days Posttreatement				
			0	14	28	42	84
0	15	Mollusca	28	38	41	16	9
		Crustacea	0	0	1	1	1
		Other	0	0	0	1	0
		TOTAL	28	38	42	18	10
	18	Mollusca	86	38	10	14	15
		Crustacea	1	1	0	1	2
		Other	0	0	0	4	7
		TOTAL	87	39	10	19	24