STUDIES OF THE IMPACT OF AERIAL APPLICATIONS OF THE SYNTHETIC PYRETHROID NRDC-143 ON AQUATIC ECOSYSTEMS

by

P. D. Kingsbury

Chemical Control Research Institute

Department of the Environment

Ottawa, Ontario

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ABSTRACT

NRDC-143 applied by aircraft to small lakes at emitted dosages of 35 g AI/ha and 140 g AI/ha affected zooplankton and bottom fauna populations and led to changes in the type and quantity of food ingested by native fish. Effects at the lower dosage were relatively short lasting and much less severe than effects at the higher dosage, which included some fish mortality, heavy mortality of shallow dwelling arthropods, and supression of zooplankton and bottom fauna populations over several months. NRDC-143 applied to a creek at the rate of 70 g AI/ha caused dramatic but short lasting increases in the drift of aquatic insects but did not significantly affect bottom fauna populations. Substantial impact on terrestrial arthropods was revealed by knockdown onto the creek's surface.

RESUME

Du NRDC-143 appliqué par avion sur de petits lacs à des doses de 35 et de 140 grammes d'ingrédient actif (IA) par hectare a eu un effet marqué sur le zooplancton et la faune des fonds et provoqué des changements quantitatifs et qualitatifs sur la nourriture ingérée par les poissons indigènes. Les effets des faibles doses ont été relativement de courte durée et beaucoup moins graves que ceux des fortes doses (mortalité des poissons, mortalité nombreuse des arthropodes d'eau peu profonde et suppression du zooplancton et de la faune du fond pour plusieurs mois). Le NRDC-143 appliqué sur un ruisseau à une dose de 70 grammes IA/hectare a provoqué une augmentation brusque, mais de courte durée, du comportement de dérive des insectes aquatiques mais n'a pas influé de façon significative sur la faune du fond. L'effet de choc sur les arthropodes terrestres a été assez marqué, comme l'a révélé le nombre de ces derniers flottant à la surface du ruisseau.

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INTRODUCTION

For many years large scale insecticide spraying has been conducted over Eastern Canadian forest regions in order to reduce the damage caused by the spruce budworm, *Choristoneura fumiferana* Clem. Over the years, many insecticides have been tested for their suitability for controlling this pest species with minimum disruption to non-target organisms of the forest habitat. Recently, interest has been focused on newly developed synthetic pyrethroids as promising new tools for spruce budworm control operations. These compounds are structurally similar to the natural pyrethrins which have been used for controlling insects for years, but they are more suitable for use in forest pest control operations because they are more stable, more toxic to insects and less hazardous to mammals and birds than natural pyrethrins (Abernathy and Casida 1973, Nishizawa 1971). Unfortunately, the synthetic pyrethroids are similar to natural pyrethrins in that they are highly toxic to fish (Mauck et al, 1976). Natural pyrethrins have also been found to be highly toxic to some aquatic insects (Bridges and Cope, 1965) and as synthetic pyrethroids display greater toxicity to insects in general, they can be expected to be highly toxic to aquatic insects as well as to fish.

During May and June of 1976 personnel of the Chemical Control Research Institute (CCRI) conducted field trials to test the synthetic pyrethroid NRDC-143 (Permethrin) against the spruce budworm. In conjunction with the efficacy trials, field trials to determine the effects of several dosage rates of NRDC-143 on aquatic fauna were carried out. The purpose of these trials was to determine if NRDC-143 presents too great a hazard to aquatic ecosystems to be used in forest pest control operations and if not, what dosage rates of this chemical would be reasonably safe in terms of hazard to aquatic organisms.

SITE DESCRIPTIONS

Petawawa Forest Experimental Station: One treatment lake, the treatment stream and the untreated control lake and stream were located within the Petawawa Forest Experimental Station (PFES) near Chalk River, Ontario (Fig. 1).

The treatment lake, Thomas Lake, is a small (approx. 10 ha), shallow (max, depth 3 m) circular bog lake. The lake has been used for many years as a holding pond for logs for a research sawmill located on its shore, and as a result the bottom is covered with a thick layer of bark and wood debris and the lake water is highly coloured (Secchi disc reading of only 0.75 m). Much of the shoreline of the lake consists of a floating layer of sphagnum moss, *Sphagnum sp.*, supporting thick growths of heaths, primarily laborador tea, *Ledum sp.*, and sheep laurel, *Kalmia angustifolia* Linnaeus. The outlet stream flows out the north end of the lake through an alder, *Alnus sp.*, swamp and had little flow throughout the study period. The surrounding forest is primarily a mixture of tamarack, *Larix laricina* (Du Roi) K. Koch, and black spruce, *Picea mariana* (Mill.) B.S.P., with occasional large white pine, *Pinus strobis* Linnaeus. Aquatic vegetation in the lake is limited to sparse growth of spatterdock (yellow water lily), *Nuphar luteum*, because the floating masses of sphagnum moss cover the true shoreline and the bottom drops off very rapidly from the shore leaving almost no shallow areas suitable for rooted aquatic plants.

The untreated control lake, Youngs Lake, is located about 6 km west of Thomas Lake and is twice as large and deep (approx. 20 ha in area with max. depth about 6 m). It is a bog lake with a bottom of organic debris and silt but has somewhat clearer water (Secchi disc readings of 1.5 to 2m)

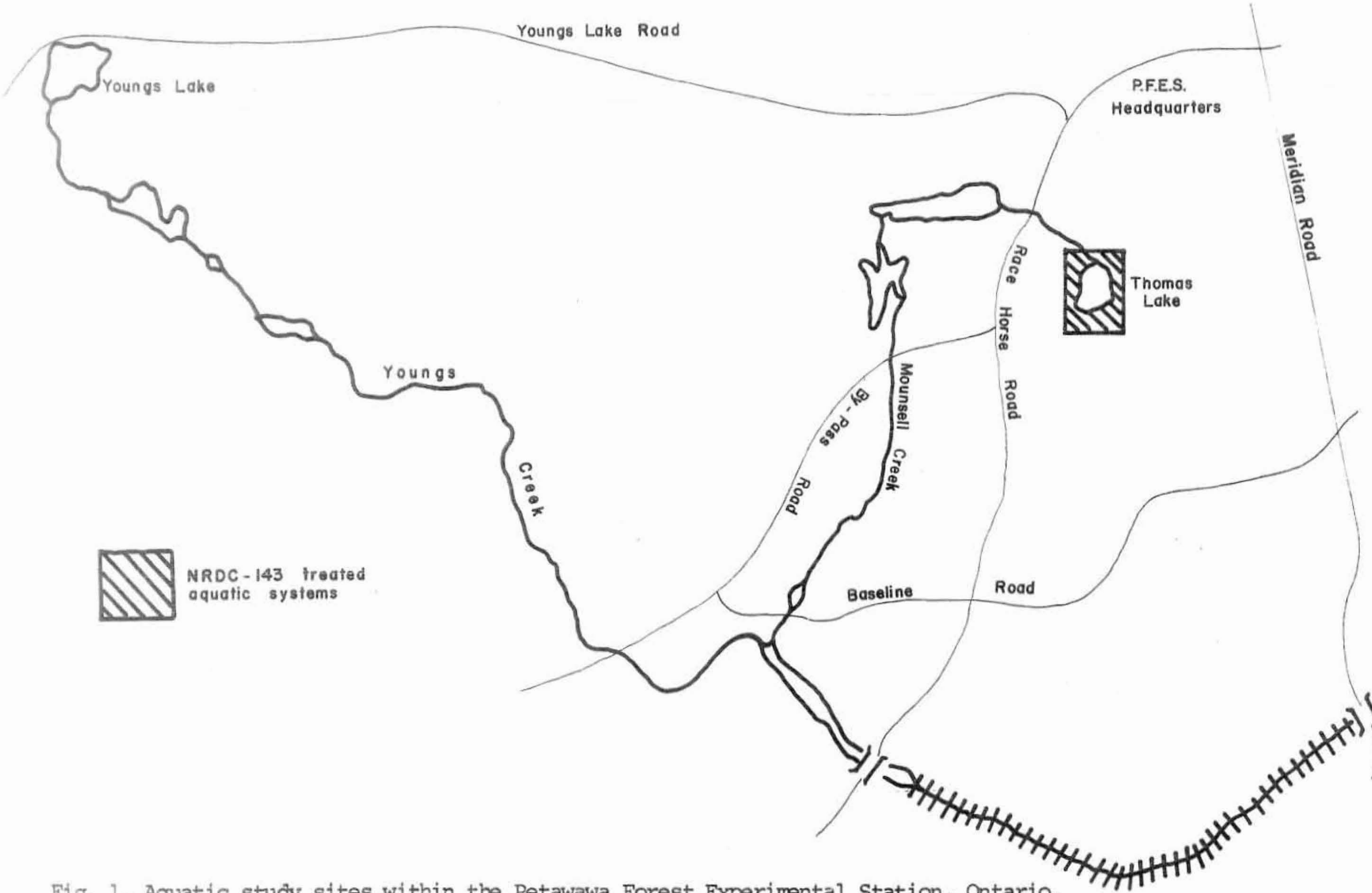

Fig. 1. Aquatic study sites within the Petawawa Forest Experimental Station, Ontario.

than Thomas Lake. It also has a more gradual sloping bottom which supports a 15 to 30 m wide compact band of white water lily, *Nymphaea odorata*, along the shallow margin of the lake. The shoreline vegetation consists primarily of alders in front of a forest of black spruce, white pine and white birch, *Betela papyrifera* Marsh.

A stretch of Youngs Creek about 5 km in length, between Race Horse Road and Meridian Road, was treated to study effects on stream fauna. Youngs Creek flows out of Youngs Lake about 6 km above the treated portion of the creek and flows into the Ottawa River about 8 km downstream from the treated section. The creek flows at a moderate pace through an open valley approximately 50 to 100 m wide. The creek varies from about 3 to 10 m in width and from about 30 cm to 1.5 m in depth. The creek bed is primarily fine sand which is covered with silt and aquatic plant growth (mostly wildcelery, *Vallisneria americana*) in some sections. Alders and grasses grow along the banks but there is no overhead forest canopy. Maunsell Creek, the untreated control stream, flows into Youngs Creek about 1.25 km above the treated portion and was sampled just upstream from where it enters Youngs Creek as it passes under Baseline Road. It is similar to Youngs Creek but smaller and shallower with less flow.

<u>Lac Tassel, Quebec:</u> Lac Tassel is a fairly small (approx. 30 ha), relatively deep (max. depth 14 m) oligotrophic lake located in Perche Township, Pontiac County, Quebec about 120 km north of Ottawa and 42 km west of Maniwaki, Quebec (Fig. 2). It has clear waters (average Secchi disc reading of about 3.5 m) and a wide variety of bottom types ranging from areas of sand, stones, rooted aquatic vegetation (primarily pipewort, *Eriocaulon septangulare*), large rocks, wood debris or thick silt along the shoreline to the thick,

oozy silt found in deeper portions of the lake. A small outlet stream flows from the south side of the lake (Fig. 3) and a shallow sandy area at its mouth is utilized in the spring as a spawning area by white suckers, *Catastomus commersoni* (Lacépède). There are three beaver lodges with adjacent submerged wood piles along the shore of the lake where large numbers of fish were observed on many occasions. A shallow silt bottomed bay at the west end of the lake is the only area where large schools of minnows can be found in the lake. Smallmouth bass, *Microterus dolomieu* Lacépède, nest along the shoreline of all but the west shore of the lake.

The shoreline of Lac Tassel is forested primarily with stands of balsam fir, *Abies balsamea* (L.) Mill., interspersed with poplars, *Populus sp.*

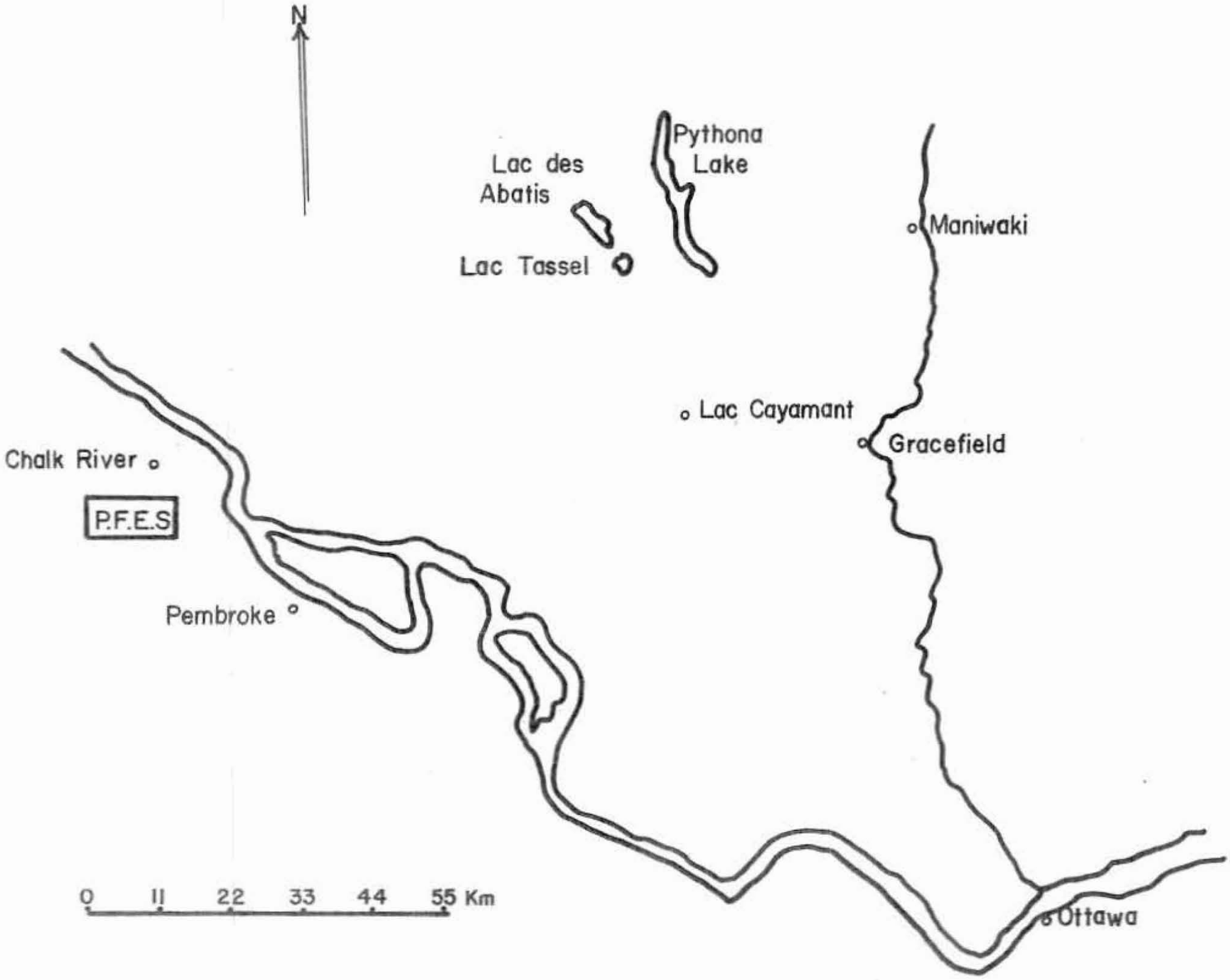

Fig. 2. Location of study site at Lac Tassel, Quebec.

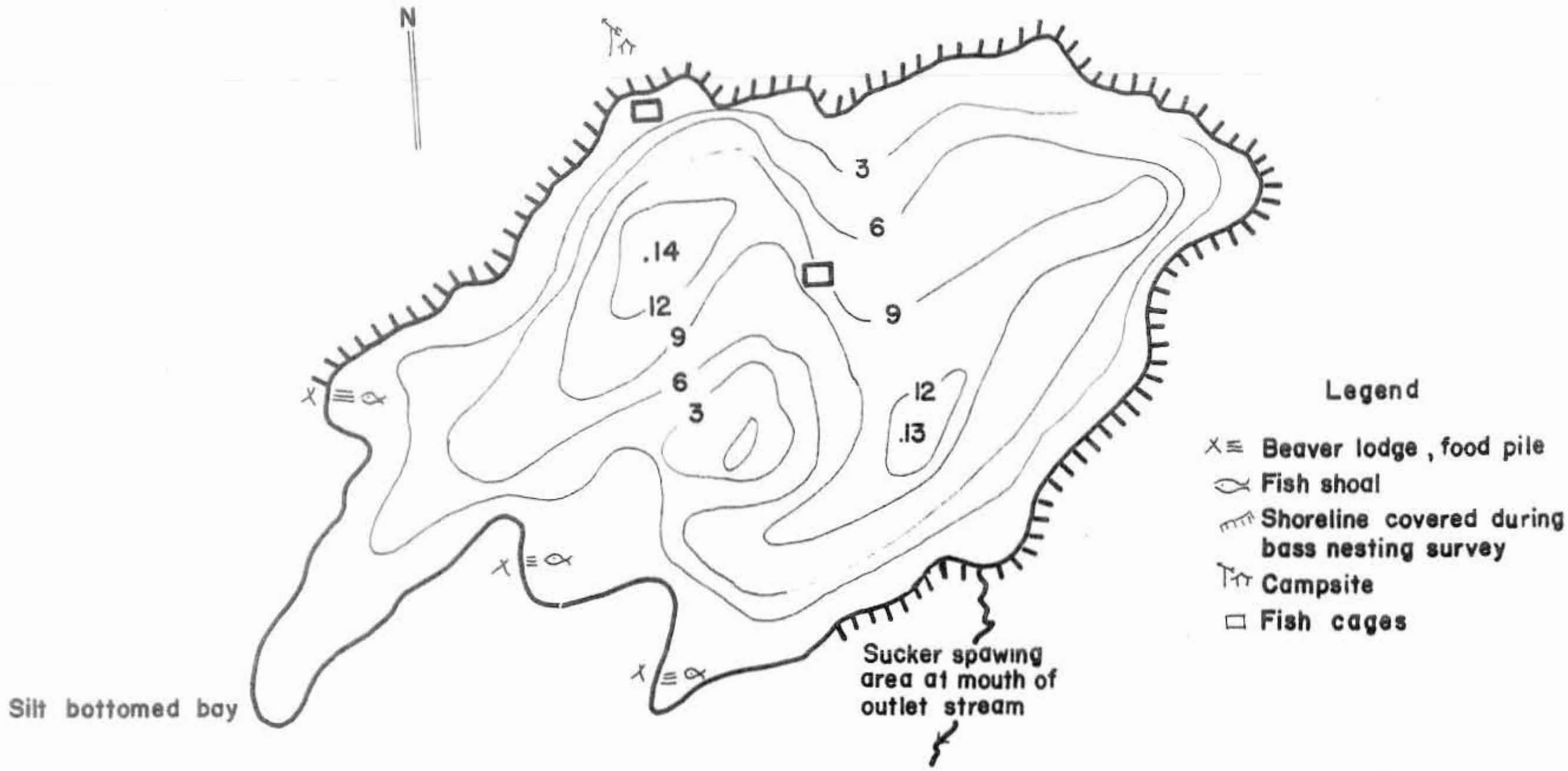

Fig. 3. Depth contours (in metres) and features mentioned in the text, Lac Tassel, Quebec.

METHODS

Treatment Procedures and Deposit Measurement: Three application rates of NRDC-143 were applied directly over study areas to determine their effects on aquatic fauna (Table 1). All spray formulations were dyed with Automate B dye to facilitate measurement of insecticide deposit.

Table 1

NRDC-143 formulations applied to aquatic study areas, 1976

Thomas Lake: 35 g AI/ha applied in 4.68 ℓ/ha formulation (0.5 oz.AI/acre applied in 0.5 gpa formulation)

Formulation: 104 fl. oz. NRDC-143*
64 fl. oz. Automate B dye
53.7 gallons No. 2 fuel oil

Youngs Creek: 35 g AI/ha in 4.68 ℓ/ha formulation applied twice to give an effective dosage of 70 g AI/ha applied in 9.36 ℓ/ha formulation (0.5 oz.AI/acre in 0.5 gpa formulation applied twice)

Formulation: 184 fl.oz. NRDC-143*
64 fl.oz. Automate B dye
88.0 gallons No. 2 fuel oil

Lac Tassel: 140 g AI/ha applied in 4.68 ℓ/ha formulation (2.0 oz. AI/acre applied in 0.5 gpa formulation)

Formulation: 160 fl. oz.NRDC-143 †
32 fl. oz.Automate B dye
38.5 gallons No. 2 fuel oil

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* Chipman Chemicals Ltd., 50% oil concentrate

† FMC Canada Ltd., 80% oil concentrate

All applications were made by CCRI's Cessna 185 aircraft fitted with a Micronair® spray emission system. Wind speed and direction, temperature and relative humidity were measured during treatments at PFES by the forest meteorology unit of CCRI. A portable anemometer was used to determine wind conditions at the time of treatment at Lac Tassel.

Insecticide deposit in the treated areas was estimated by two methods: colorimetric measurement of dye deposited on aluminum pans, and counting of spray droplets landing on Kromekote cards. Deposit samplers consisting of two aluminum pans 13 x 17 cm and a 10 x 10 cm Kromekote card were put out immediately before spraying began. On the treated lakes a line of ten deposit samplers on styrofoam floats was anchored across the lake perpendicular to the direction in which the lake was sprayed. At the treated steam, three lines of four deposit samplers were placed on the shore across the creek bed at each end and the middle of the treated section of stream. Insecticide deposit on the aluminum pans was determined by washing the dye off the pans with toluene and determining the amount of dye deposited on the pans with a colorimeter. This was compared with the amount of dye in a reference standard taken from the original spray formulation to determine the actual deposit.

The Kromekote cards were sent to the National Aeronautical Establishment where insecticide deposit on them was determined by a computerized spot-counting system (Slack, 1973).

<u>Water Chemistry and Temperature Profiles:</u> Physical and chemical parameters of the aquatic systems studied were monitored throughout the study period. Temperature profiles of the lakes were taken using a portable thermistor*.

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* Hydrolab Corporation, Austin, Texas.

Dissolved oxygen, pH, alkalinity and hardness at various depths were determined by the use of Kemmerer water samplers ** and Hack water chemistry kits***. Temperature and water chemistry of the study streams were also monitored as well as changes in their water level.

Zooplankton: Zooplankton populations in the treatment and control lakes were sampled throughout the study period. Zooplankton populations in Thomas and Youngs Lake were sampled by towing a silk bolting cloth (49 meshes to the centimetre) tow net with a 500 cm^2 opening along the surface near the centre of the lake for approximately a ten-metre stretch between two marker buoys. Zooplankton in Lac Tassel was sampled with a Schindler-Patalas plankton trap (Schindler, 1969) with a 154 mesh to the centimetre straining net, which captured all the zooplankton present in 12-litre water samples. These samples were taken from the surface at the shoreline of the lake and from the surface, 4 m and 8 m at a buoy anchored near the centre of the lake. All zooplankton samples were preserved with formaldehyde and later counted and identified in the laboratory by placing them in a gridded dish under a dissecting microscope. Zooplankton numbers from tow net samples were obtained by extrapolating from the numbers counted in appropriately sized subsamples, but plankton trap samples were counted in their entirety.

Benthic Invertebrates: Bottom fauna populations in the lakes were sampled with an Ekman grab which sampled a 232 cm^2 (36 $in.^2$) area of the bottom. Five samples were collected on each sampling date at Thomas and Youngs Lakes and ten samples on each date at Lac Tassel. Samples were collected from the same area

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** Wildlife Supply Company, Saginaw, Michigan

*** Hach Chemical Company, Ames, Iowa.

of bottom on each occasion and from a relatively narrow range of depths. Bottom samples from the creeks were collected from shallow (10 to 60 cm) areas using a 0.093 m^2 (foot square) Surber sampler (Surber, 1936). Two stations were sampled in the treatment stream: Station 1 (Fig. 4) was located on a gravel bottom immediately downstream from Meridian Road and Station 2 (Fig. 5) was situated along a silt covered, sand bottomed stretch of stream near the centre of the treated stretch of Youngs Creek. The control station on Maunsell Creek was located immediately downstream from Baseline Road on a silt covered, gravel bottomed portion of streambed (Fig. 6). All bottom samples were preserved in their entirety in the field with formaldehyde and the organisms in them were later separated from the substrate in the lab with the aid of a "bubbler" (Kingsbury and Beveridge, in press). Benthic organisms were then counted and identified to order or family.

Aquatic insects emerging as adults from the surface of Thomas and Youngs lakes were sampled with submerged emergence traps (Flannagan and Lawler, 1972) suspended from styrofoam floats. Ten traps were set along the shoreline of Thomas Lake while five were used in Youngs Lake. Adult insects which had emerged into the traps were removed daily and counted.

Drifting aquatic invertebrates were sampled in Youngs Creek by placing a drift net in the creek for thirty minute periods each morning and evening (Fig. 7). The net sampled a 46 cm (18 in) wide portion of the creek's flow from surface to bottom, including the surface film. Two additional one hour drift net sets were made immediately prior to and following the insecticide application to document immediate effects on aquatic invertebrates and to sample terrestrial arthropods knocked into the creek. Drifting aquatic and terrestrial organisms were also captured in a blocking seine set across the entire width of the creek (Fig. 8) and emptied each morning and evening.

Fig. 4 Youngs Creek, PFES
Treatment Station 1.

Fig. 5 Youngs Creek, PFES
Surber sampling at
treatment Station 2.

Fig. 6. Maunsell Creek, PFES. Surber sampling at the untreated control stream.

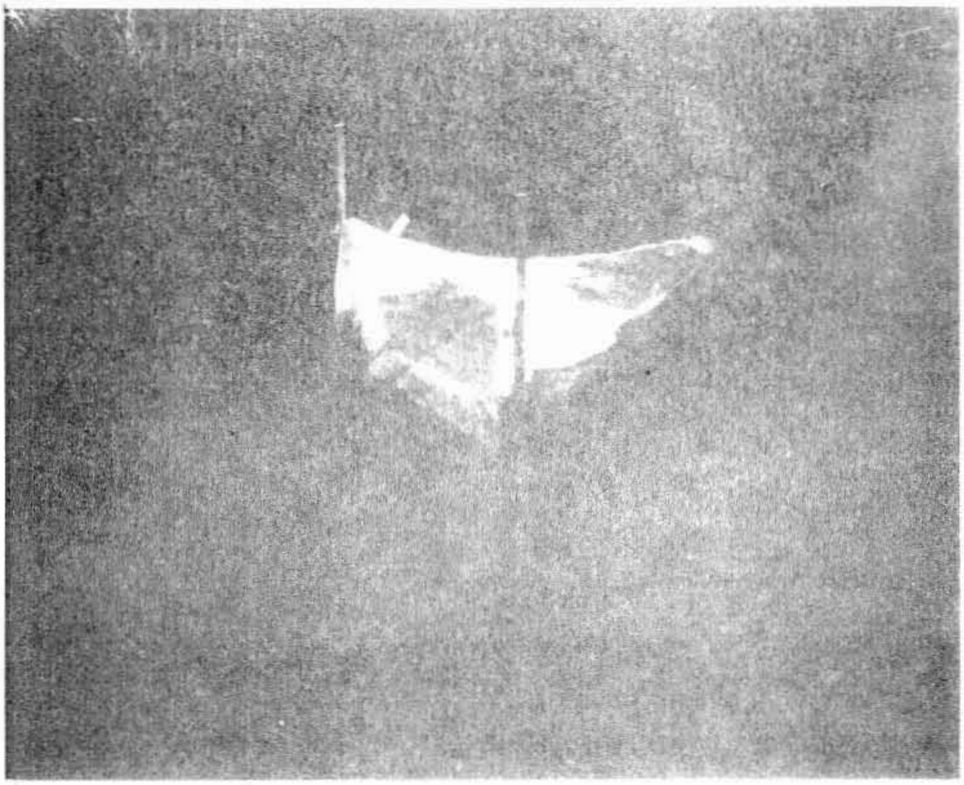

Fig. 7. Drift net set [illegible]

<u>Fish</u>: Fish mortality related to NRDC-143 treatment was studied by trapping fish and caging them in the study lakes and creek. In Thomas and Youngs lakes, small fish of a number of families were placed in cages which were attached at various depths on a line running from the surface to the bottom anchored near the centre of the lake. Cages were held at the surface, 1 m, 2 m, and 3 m (bottom) in Thomas Lake and at the surface, 2 m and 4 m (bottom) in Youngs Lake. Each day all cages were raised to the surface and examined for mortality among their contents. A single cage of cyprinids *(Cyprinidae)* and mudminnows *(Umbridae)* was held in Youngs Creek at the downstream end of the treated area and checked twice daily for mortality.

At lac Tassel, hatchery raised brook trout, *Salvelinus fontinalis* Mitchill, and native white suckers and yellow perch, *Perca flavescens* (Mitchill), were caged in the lake prior to treatment. Six brook trout and ten suckers were held in cages right along the shoreline. Cages of brook trout, suckers and perch were anchored at various depths near the centre of the lake. Brook trout were held at the surface (Fig. 9) and 4 m, white suckers at the surface and 2 m and a single small cage containing two perch was held at 6 m. These cages were not brought to the surface to examine their contents but were checked for mortality by snorkeling down to where they were held.

Five minnow traps baited with bread were set in each of the study lakes and the catch removed, counted and returned to the lake daily. Two minnow traps were set in Youngs Creek and checked twice daily in the morning and evening. In each case, the traps were emptied prior to treatment on the treatment date. In addition, a large trap net was set in Lac Tassel and its catch removed, counted and returned to the lake daily.

The fish populations of the study lakes were sampled periodically by leaving gill nets set in the lakes overnight. Gangs of gill nets with 30 m sections of various mesh size ranging from 1.3 to 5.1 cm square were run out in the late afternoon from points of attachment along the shoreline towards the centre of the lake,and pulled the following morning (Fig. 10). Fish caught in the net were removed and preserved whole with formaldehyde. A cut was made into the abdominal cavity of the larger fish to facilitate penetration of the preservative and stop digestive processes within the stomach and intestine. Preserved gill net catches were returned to the laboratory where a number of fish of each species were selected for measuring, weighing, sexing and analysis of stomach contents. Ideally, for each sampling period twenty fish of each species were selected from the treatment lakes and ten fish of each species from the control lake. It was not always possible to capture the desired number of fish of each species for each sample. On some occasions fish sampled by gill netting were supplemented with fish caught angling to increase the sample size. After recording the total length, fork length, preserved weight and sex of each fish, the stomach and intestine was removed and preserved until a later date when the contents of the digestive tract were removed, their volume recorded and their composition determined under a dissecting microscope. The contents of only the stomach were analyzed for fish with distinct stomachs (smallmouth bass, pumpkinseed, *Lepomis gibbosus* (Linnaeus), yellow perch, brown bullheads, *Ictalurus nebulosus* (Lesueur)) but the contents of the entire digestive tract were analyzed for fish without a distinct stomach (white sucker, fallfish, *Semotilus corporalis* (Mitchill)). In measuring the volume of the digestive tract contents,the amount of indigestible material present (ingested substrate etc.) was estimated and the measured volume corrected accordingly so as to only represent actual volume of food items.

The effects of the insecticide application on smallmouth bass reproduction in Lac Tassel was studied by conducting surveys of nesting bass using scuba and snorkeling equipment. The entire shoreline of the lake was surveyed initially and the stretches of shoreline suitable for bass nesting were subsequently surveyed repeatedly and individual bass nests marked. A numbered aluminum marker was placed beside each bass nest and on each visit to the nest the presence or absence of the guarding male, eggs and fry were recorded. Repeated observations were also made on aggregations of fish around the mouth of the outlet stream and near several submerged beaver food piles along the shoreline. During these underwater surveys, observations were also made on aquatic invertebrate, minnow, spotted newt *(Triturus viridescens)*, and tadpole populations.

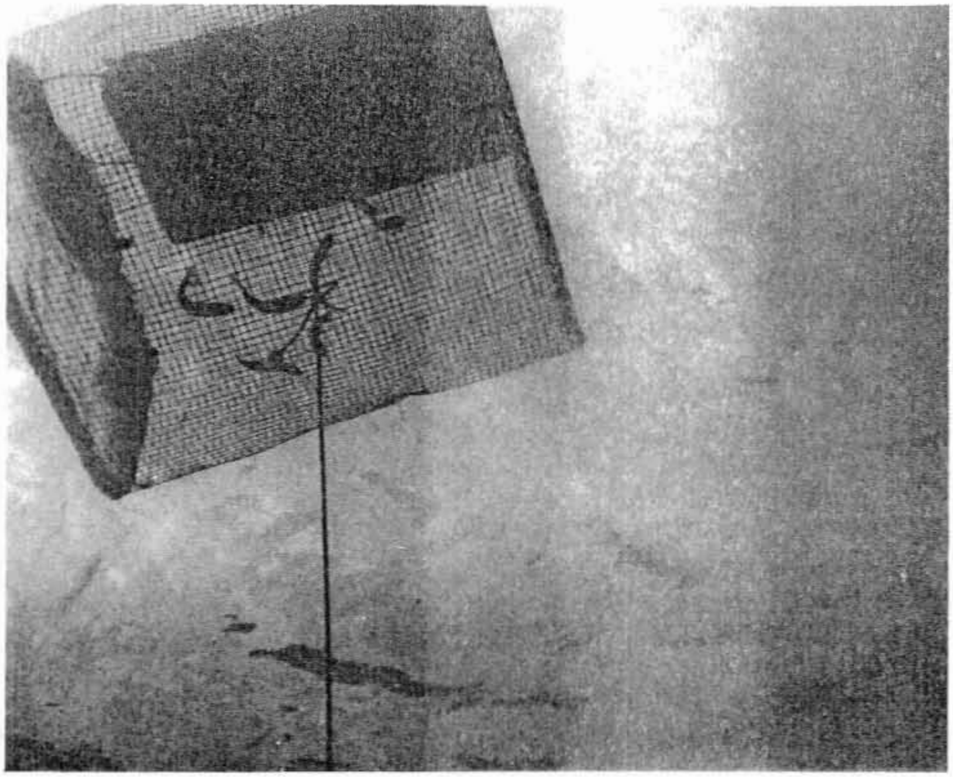

Fig. 9. Caged brook trout anchored near the centre of Lac Tassel, Quebec. This cage is held at the surface, while other cages are attached at various depths along the line running to the bottom of the lake.

Fig. 10. Removing a gill net from Thomas Lake, PFES, after an overnite set.

RESULTS

Thomas Lake - PFES - 35 g AI/ha: Thomas Lake was treated from 1912 to 1920 hours on 25 May (Fig. 11). The lake was treated in a north-south direction beginning at the west side and progressing east. Meteorological conditions over a 45 minute period from the beginning of treatment were:

Mean wind speed	1.51 m/s	
Δ T	-0.5°C	
Turbulence factor	1.6	
Stability ratio	-2.19	
Dry bulb temperature	22 m:	Mean 13.5°C, Range (14.0 - 12.9)
	6 m:	Mean 14.0°C, Range (14.6 - 13.4)
Relative humidity	22 m:	Mean 68.9%, Range (67.1 - 72.2)
	6 m:	Mean 62.7%, Range (61.2 - 64.8)

Spray deposit on Thomas Lake is presented in Table II. Although the spray was applied under neutral to slightly unstable conditions (stability ratio -2.19), a very good mean deposit of the emitted dosage was achieved. Spray deposit was fairly uniform over the whole lake's surface but a slight increase in the wind from the east towards the end of the application caused a somewhat lighter deposit of spray materials on the east side of the lake (E1, E2, E3) and a heavier deposit near the centre of the lake (E4, E5, W5).

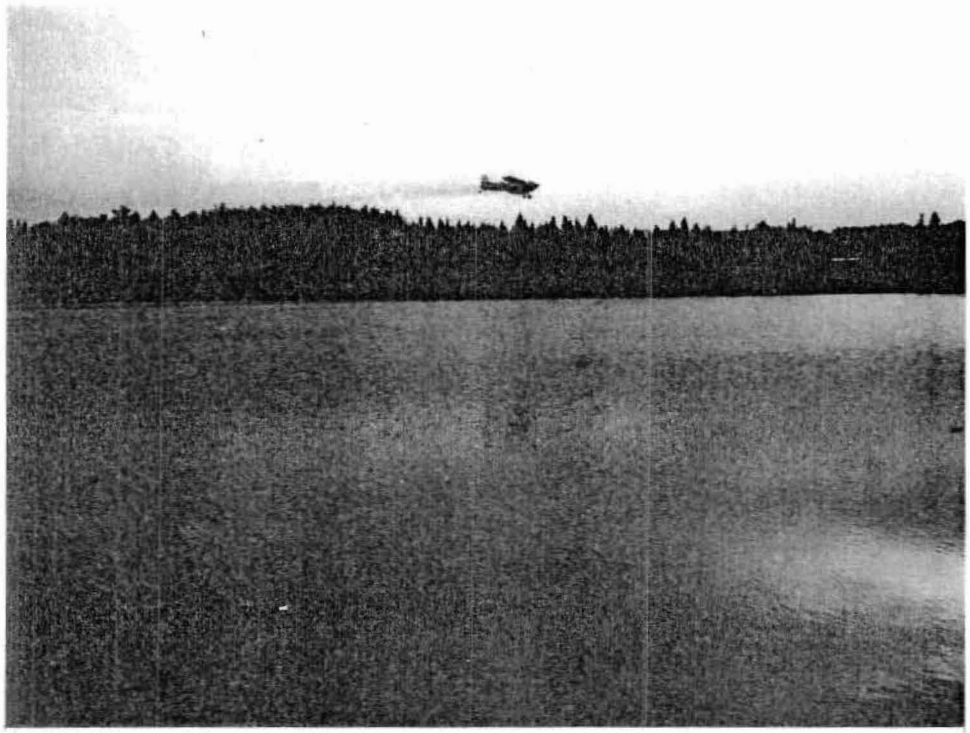

Fig. 11. CCRI's Cessna 185 treating Thomas Lake, PFES, with NRDC-143.

Table II

Deposit of the fomulation of NRDC-143 (7.48 g AI/ℓ) applied at 4.68 ℓ/ha to Thomas Lake, PFES.

Deposit sampler	Colorimetric Assessment		NAE Spot Counting Assessment	
	Average deposit in two pans (ℓ/ha)	Percentage of emitted rate	Deposit on Kromekote card (ℓ/ha)	Percentage of emitted rate
W1 (west side of lake)	2.37	50.7	*	-
W2	2.18	46.6	3.59	76.7
W3	2.22	47.5	3.62	77.4
W4	1.97	42.1	2.16	46.2
W5	2.93	62.6	*	-
E5	2.46	52.6	4.60	98.3
E4	2.58	55.2	*	-
E3	1.86	39.8	2.71	57.9
E2	1.27	27.2	2.14	45.7
E1 (east side of lake)	1.13	24.2	*	-
Average	2.09 (15.6g AI/ha)	44.7	3.13 (23.4 g AI/ha)	67.0

* No estimate of deposit given by the computer because of the large area covered by overlapping droplets relative to the total area covered by droplets.

At the time of treatment Thomas Lake was essentially unstratified but stratified rapidly over the next few days of warm weather (Fig. 12). Water chemistry parameters in Thomas Lake showed little variation over the study period until early in July when some oxygen depletion in the bottom waters of the lake became noticeable (Table III). Similar oxygen depletion in the bottom waters of Youngs Lake was evident in July (Table IV). Temperature stratification in Youngs Lake developed much the same over the study period as in Thomas Lake (Fig. 13).

The heavy deposit of emitted spray on the surface of Thomas Lake was apparent immediately following treatment. The carrier oil was easily seen on the suface of the lake and strands of dye were clumped along the windward shoreline. Adult blackflies showed an immediate reaction and could be seen to fall distressed into the lake minutes after the plane passed over. No other distressed organisms were observed the evening the lake was treated but over the next two days one distressed minnow and several dead and distressed aquatic insects were found (Table V).

Survival of caged fish in Thomas and Youngs lakes was excellent during the period from caging until treatment (8 to 12 days in duration) but all the darters caged escaped due to their small size. Mortality among caged fish in both lakes after the treatment date is recorded in Table VI. Mortality was heaviest in the surface cage in Thomas Lake where the caged cyprinids, bullheads and sunfish suffered almost complete mortality between the third and ninth day after treatment. Less extensive mortality occurred among cyprinids, bullheads, sunfish and sticklebacks held one meter below the surface. Little to no mortality occurred among other groups of caged fish held deeper in Thomas Lake or in Youngs Lake.

Minnow trap catches in Thomas and Youngs lakes before and after treatment are recorded in Table VII and total minnow catch from both lakes is presented grapically in Fig. 14. Minnow trap catches in Thomas Lake consisted mainly of the cyprinids, *Chrosomus eos* Cope (northern redbelly dace), Notropis cornutus (Mitchill) (common shiner), *Pimephales promelas* Rafinesque (fathead minnow) and *Notemigonus crysolencas* (Mitchill) (golden shiner) along with small pumpkinseeds. Small brown bullheads, Johnny darters, *Etheostoma nigrum* Rafinesque, Iowa darters, *Etheostoma exile* (Girard), and brook sticklebacks, *Culaea inconstans* (Kirtland), were also caught in Thomas Lake. The minnow fauna in Youngs Lake was very similar but also included many small yellow perch.

The daily catch of minnows in the treatment lake was consistently high throughout the study period but dropped off somewhat for a short time immediately after treatment due to a sharp decrease in the numbers of cyprinids caught. Minnow trap catches in the control lake were much smaller than in the treatment lake throughout the study period, particularily after the catch of perch fell off in response to warming of the lake's surface waters. No noticeable decrease in catches occurred in the control lake on the two days after treatment when catches were depressed in the treatment lake.

Plankton tow net catches in Thomas and Youngs lakes throughout the treatment period are recorded in Tables VIII and IX. The composition of the plankton fauna in these two lakes was similar with four genera of cladocerans (*Bosmina*, *Daphnia*, *Diapanosoma*, and Holopedium) and a mixture of calanoid and cyclopoid copepods represented in the catches. No downward trends in plankton numbers in the treatment lake were seen until the sample taken on the ninth day after treatment when numbers of all four genera of cladocerans were found to have dropped dramatically and numbers of copepods also showed a substantial decrease. All groups except for *Holopedium* were present again in large numbers when the lake was sampled forty days after treatment. Plankton numbers in Youngs Lake were increasing during the period of decrease in Thomas Lake,but numbers of cladocerans were much reduced in the early July sample.

Emerging insects were trapped from Thomas and Youngs lakes over a three week period around the treatment date. The catch from both lakes consisted almost entirely of emerging midges (Diptera:Chironomidae). Very few emerging insects were trapped from the treatment lake except for one day, ten days before treatment (Table X). Aside from the catch on this day,the numbers of emerging insects trapped before and after treatment in Thomas lake were fairly similar. Far larger numbers of emerging insects were trapped from Youngs Lake even though only half the number of emergence traps were used there. A very high number of insects were also caught in Youngs Lake on the tenth day preceeding treatment of Thomas Lake.

All Ekman grab samples taken from Thomas Lake sampled a very similar bottom type consisting of a thick layer of fibrous wood debris covered with silt. The bottom fauna present consisted almost entirely of chironomid larvae (Diptera:Chironomidae) and "glassworms", larvae of non-biting mosquitoes (Diptera:Culicidae) of the genus *Chaoborus* (Table XI). A somewhat greater variety of bottom types were sampled in Youngs Lake ranging from areas of wood debris and silt similar to Thomas Lake to areas of hard packed silt and aquatic plant roots and hard bottoms of small stones covered with sticks and silt. Benthic populations sampled also showed a greater variety of organisms present but somewhat similar total numbers as in Thomas Lake (Table XII). Following treatment, bottom fauna populations in Thomas Lake decreased substantially due to a large drop in the number of *Chaoborus* larvae present and a somewhat smaller decline in chironomid larvae populations (Fig. 15). *Chaoborus* larvae populations gradually increased back to about two-thirds their pretreatment level by early July but chironomid larvae populations were quite low again in July after showing some recovery by the eleventh day after treatment. Total bottom fauna, *Chaoborus* larvae and chironomid larvae populations in Youngs Lake were all quite stable over the study period.

Fish stomach samples from Thomas Lake showed large changes in the volume and composition of their contents following treatment of the lake. Both white suckers (Appendix, Table I) and brown bullheads (Appendix, Table II) had much larger volumes of food material in their stomachs four days after treatment than at any other time, primarily due to the presence of hundreds of *Chaoborus* larvae in almost all the stomachs sampled. White suckers showed an almost complete switch to *Chaoborus* larvae (an average of 94.5% of the volume of each stomach) from a varied pre-spray diet of chironomid pupae (31.7%), copepods (28.9%), chironomid larvae (21.9%) and *Chaoborus* larvae (13.6%). Later sampling periods showed large decreases in the number of *Chaoborus* found in each stomach and smaller decreases in the contribution of *Chaoborus* to the volume of food in the stomachs while the numbers and contribution to volume of chironomid larvae and copepods increased. Brown bullhead stomachs before treatment contained primarily chironomid larvae (35.0%), *Chaoborus* larvae (27.5%), minnow remains (23.8%)

and chironomid pupae (12.5%). Four days after treatment *Chaoborus* larvae predominated in the stomachs (67.9%) but sizeable contributions to the average percent volume of each stomach were still being made by minnow remains (20.5%) and chironomid larvae (7.6%). By twelve days after treatment only small numbers of *Chaoborus* were found in bullhead stomachs and their diet consisted almost entirely of minnows (48.3%) and chironomid larvae (46.7%). In early July minnows (35.0%) and terrestrial insects (32.5%) predominated with small numbers of *Chaoborus* larvae and pupae contributing fairly large percentages to the volume of each stomach (12.5% and 9.6% respectively). Larger aquatic insects were very scarce in Thomas Lake and were not found in any of the fish stomachs except for four days after treatment when one caddisfly larva and two dragonfly nymphs were found in sucker stomachs and one aquatic beetle, one dobsonfly larva and one dragonfly nymph were found in bullhead stomachs.

Stomach samples of four fish species from Youngs Lake generally showed a decrease in the average volume of food per stomach over the study period with no evidence of a large increase in the volume of stomach contents around the treatment date. White sucker stomachs did, however, show a similar change in diet in late May towards *Chaoborus* larvae as seen in the treatment lake (Appendix,Table III). Stomach contents changed from a mixture composed primarily of chironomid larvae (45.9% volume of each stomach), *Chaoborus* larvae (14.0%), caddisfly larvae (10.5%) and dragonfly nymphs (8.0%) in the pre-spray sample to mainly *Chaoborus* larvae (57.8%) and chironomid larvae (26.7%) four days after treatment. Twelve days after treatment the diet was almost exclusively *Chaoborus* larvae (64.0%) and chironomid larvae (31.5%). By early July only small numbers of

Chaoborus larvae and pupae appeared in sucker stomachs and chironomid larvae (35.7%) and cladocerans (24.3%) dominated their diet. Brown Bullheads in Youngs Lake were never found to feed on *Chaoborus* to any extent. Their diet in May consisted of a wide variety of aquatic insects, minnows and crayfish but became more limited by early June when it consisted almost entirely of fingernail clams, dragonfly nymphs, unknown aquatic larvae of some dipteran and chironomid pupae (Appendix, Table IV). Pumpkinseed diets in Youngs Lake changed from a wide range of aquatic insects in early May to a fairly equal mixture of snails, terrestrial beetles and a somewhat narrower range of aquatic insects by early June (Appendix, Table V). The majority of the yellow perch taken from Youngs Lake had empty stomachs with minnows, chironomid larvae, crayfish, chironomid pupae and caddisfly larvae making up the contents of the rest of the stomachs sampled (Appendix, Table VI).

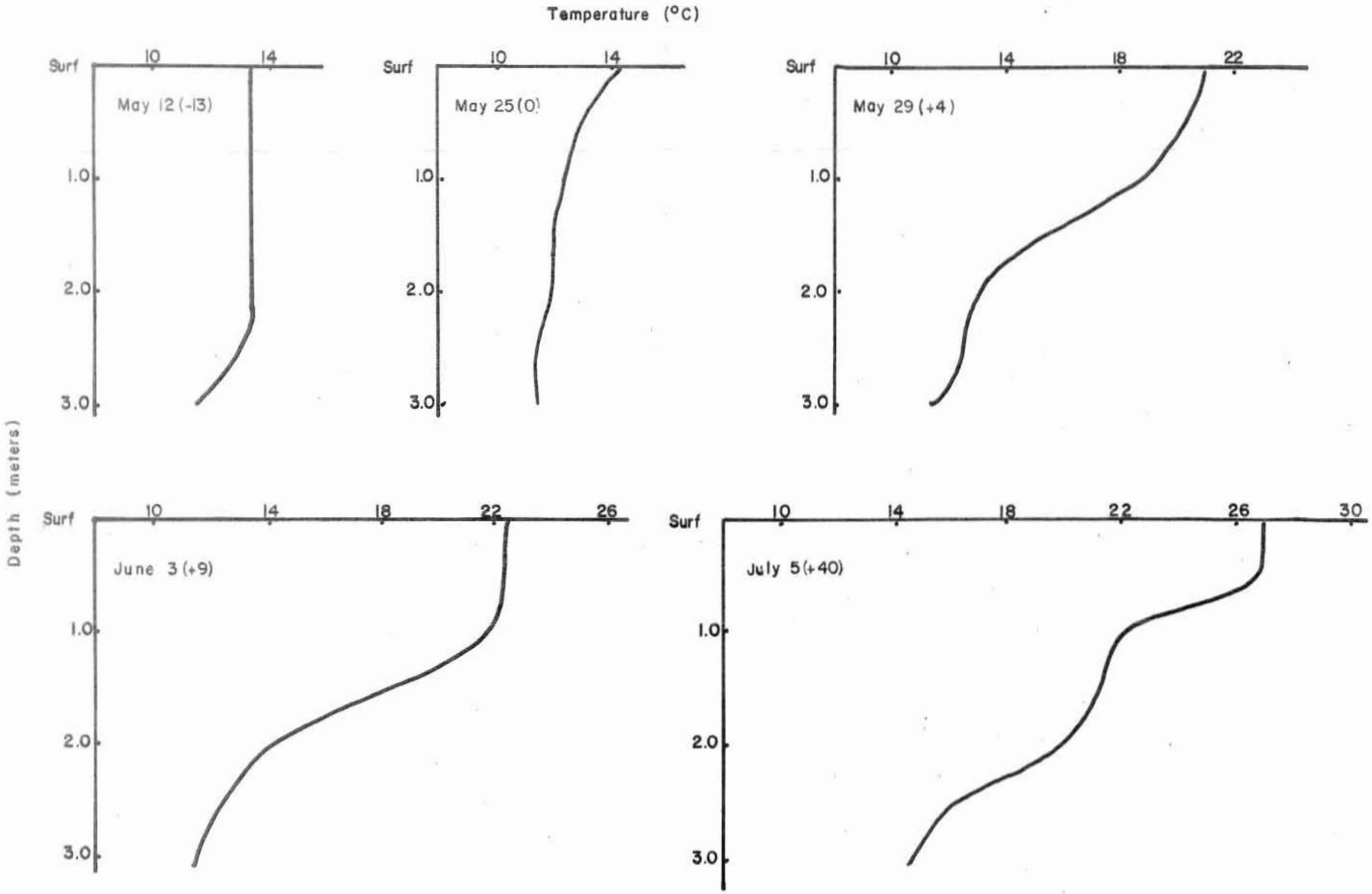

Fig. 12. Temperature profiles in Thomas Lake, PFES, 1976.

Table III

Water chemistry parameters in Thomas Lake, PFES, 1976.

Date	Depth	Temperature (°C)	Dissolved oxygen (ppm)	pH	Alkalinity (gpg $CaCO_3$)*	Hardness (gpg $CaCO_3$)*
May 12 (-13)	Surface	13.5	9	6.5	1	2
	Bottom (3 m)	11.5	9	6.5	1	2
May 29 (+4)	Surface	21.0	11	7.0	1	3
June 3 (+9)	Surface	22.5	10	7.0	1	2
	Bottom (3 m)	11.5	10	6.0	2	2
July 5 (+40)	Surface	27.0	8	6.5	1	2
	Bottom (3 m)	14.5	5	6.0	1	2

* grains per gallon calcium carbonate.

Table IV

Water chemistry parameters in Youngs Lake, PFES, 1976.

Date	Depth	Temperature (^{o}C)	Dissolved oxygen (ppm)	pH	Alkalinity (gpg $CaCO_3$,*	Hardness (gpg $CaCO_3$)*
May 13	Surface	13.5	11	6.5	1	2
	Bottom (4 m)	12.5	10	6.5	1	2
May 28	Surface	17.5	10	7.0	2	2
June 4	Surface	22.5	9	7.5	1.5	2
	Bottom (5 m)	11.5	7	6.5	1.5	2
July 6	Surface	25.0	9	6.8	1	3
	3 meters	16.0	6	6.5	1	2
	Bottom (4.5 m)	11.5	0	6.0	2	2

* grains per gallon calcium carbonate.

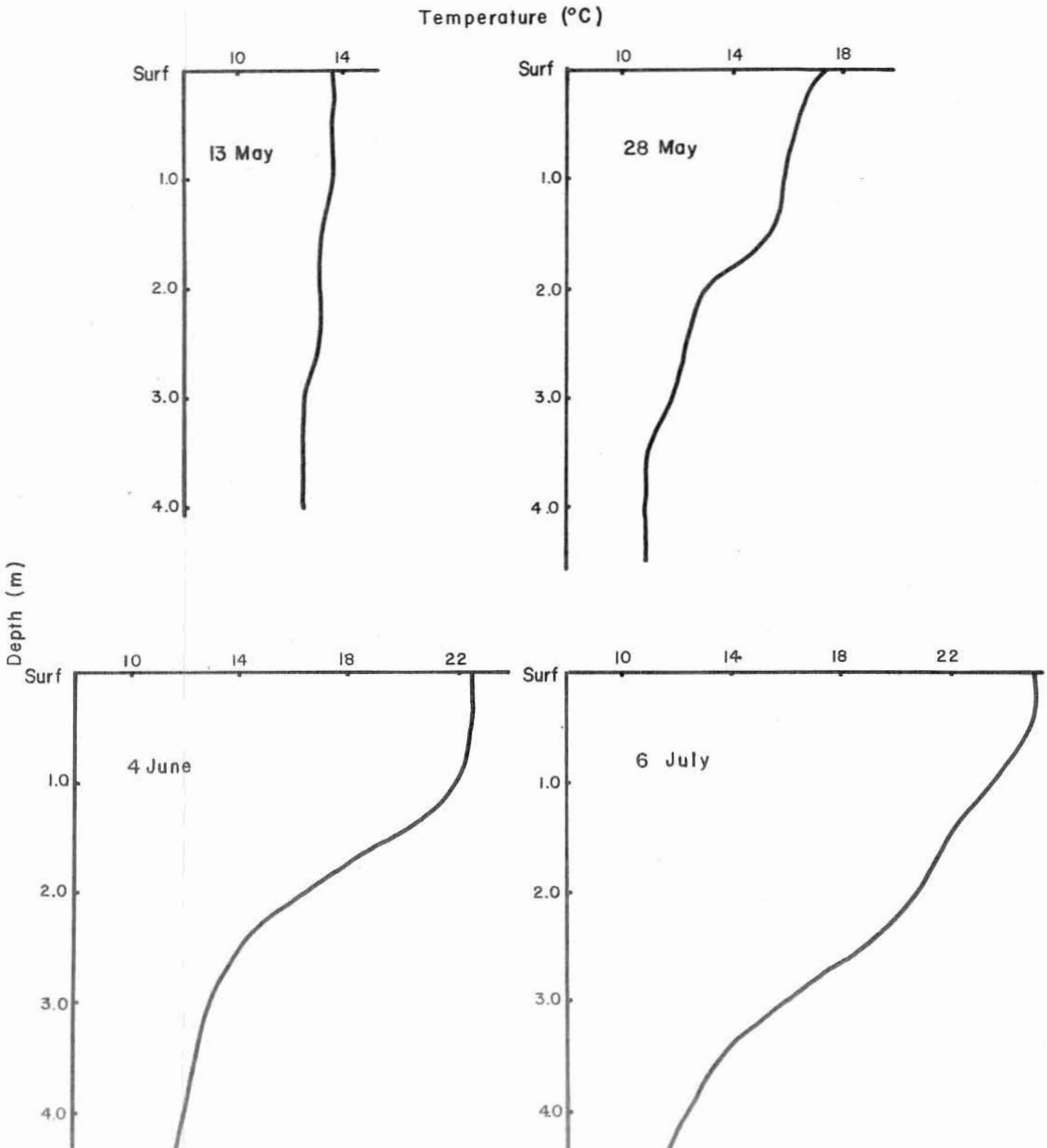

Fig. 13. Temperature profiles in Youngs Lake, PFES, 1976.

Table V

Aquatic organisms found dead or distressed following treatment of Thomas Lake with NRDC-143, 25 May 1976.

May 26 --	Pisces	One fathead minnow *Pimephales promelas* (Rafinesque) Total length 72 mm.
	Hemiptera:Belestomatidae	One giant waterbug *Lethocerus americanus* Leidy (70 mm)
	Nepidae	Two water scorpions *Ranatra sp.*
	Coleoptera:Dytiscidae	Three predaceous diving beetles *Dytiscus sp.* (37, 39 and 43 mm) One unknown predaceous diving beetle (18 mm)
	Hydrophilidae	Two water scavenger beetles *Hydrophilus sp.* One unknown hydrophilid larva
	Gyrinidae	Two whirligig beetles
May 27 --	Coleoptera:Dytiscidae	One predaceous diving beetle *Dytiscus sp.* (42 mm) One unknown predaceous diving beetle (11 mm)

Table VI

Mortality among caged fish in Thomas and Youngs Lakes, PFES, May 25 to June, 1976.

Each X indicates an individual found dead on the day indicated.

	No. in cage on treatment day	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	Total Mortality
THOMAS LAKE												
Surface												
Cyprinids	2	-	-	X	-	-	X	-	-	-	-	2
Bullheads	2	-	-	-	XX	-	-	-	-	-	-	2
Sunfish	3	-	-	-	-	-	-	-	-	XX	-	2
1 meter												
Cyprinids	2	-	-	-	-	-	-	-	-	X	-	1
Bullheads	1	-	-	-	-	-	-	-	-	X	-	1
Sunfish	2	-	-	-	-	-	-	-	X	-	-	1
Sticklebacks	2	-	-	-	-	-	-	-	-	-	X	1
2 meter												
Cyprinids	2	-	-	-	-	-	-	-	-	-	-	0
Bullheads	1	-	-	-	-	-	-	-	-	-	-	0
Sunfish	2	-	-	-	-	-	-	-	-	-	-	0
Sticklebacks	2	-	-	-	X	-	-	-	-	-	-	1
3 meter												
Cyprinids	2	-	-	-	-	-	-	-	All fish died due			
Bullheads	1	-	-	-	-	-	-	-	to cage being			
Sunfish	2	-	-	-	-	-	-	-	pulled into oxygen			
Sticklebacks	2	-	-	-	-	-	-	-	depleted silt.			
YOUNGS LAKE												
Surface												
Cyprinids	3	-	-	-	-	-	-	-	All fish escaped			
Bullheads	1	-	-	-	-	-	-	-	due to cage			
Sunfish	2	-	-	-	-	-	-	-	falling open.			
Perch	2	-	-	-	-	-	-	-				

Continued ...

Table VI Cont'd.

	No. in cage on treatment day	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	Total Mortality
YOUNGS LAKE Cont'd												
2 meter												
Cyprinids	3	-	-	-	-	-	-	-	-	-	-	0
Bullheads	1	-	-	-	-	-	-	-	-	-	-	0
Perch	2	-	-	-	-	-	-	-	-	-	-	0
4 meter												
Cyprinids	3	-	-	-	-	-	-	-	-	-	-	0
Bullheads	1	-	-	-	-	-	-	-	-	-	-	0
Sunfish	1	-	-	-	-	-	-	X	-	-	-	1
Perch	2	-	-	-	-	-	-	-	-	-	-	0

Table VII

Minnow trap catches in Thomas and Youngs Lakes, PFES, 15 May to 4 June, 1976.

Number of days before or after treatment	Cyprinids		Bullheads		Sunfish		Darters		Perch		Sticklebacks		Totals	
	Thomas	Youngs	Thomas	Youngs	Thomas	Youngs	Thomas	Youngs	Thomas	Youngs	Thomas	Youngs	Thomas	Youngs
-10	171	1		8	27			4		40			198	53
-9	104	5	1	8	51	1				22			156	36
-8	271	2	2	3			1			54	1		275	59
-7	260	12		45	15					49			275	106
-6	131	10	2	22	4					29	5		142	61
-5	210			22	7		2	1			1	2	220	27
-4					TRAPS	NOT	EMPTIED							
-3	291			10	5		1			1	1		298	11
-2	288	4		22	2					6	1		301	32
-1	285	6	1	23	3			1		4			289	34
-0*	298			6	1		5						304	6
+1	158	1	1	20	6	2				4			165	27
+2	83			22	8		1	1					92	25
+3	197			18	43						1		241	18
+4	220			5	45		1			1	1		267	6
+5	264			3	24		1			4			289	7
+6	200		1	1	22	1	1			1			224	4
+7	235			3	22					5			257	9
+8	280		1		7					1			288	1
+9	185	2		4	3					5			188	11
+10	128	4		3	52					2			180	9

* Traps emptied before lake was treated.

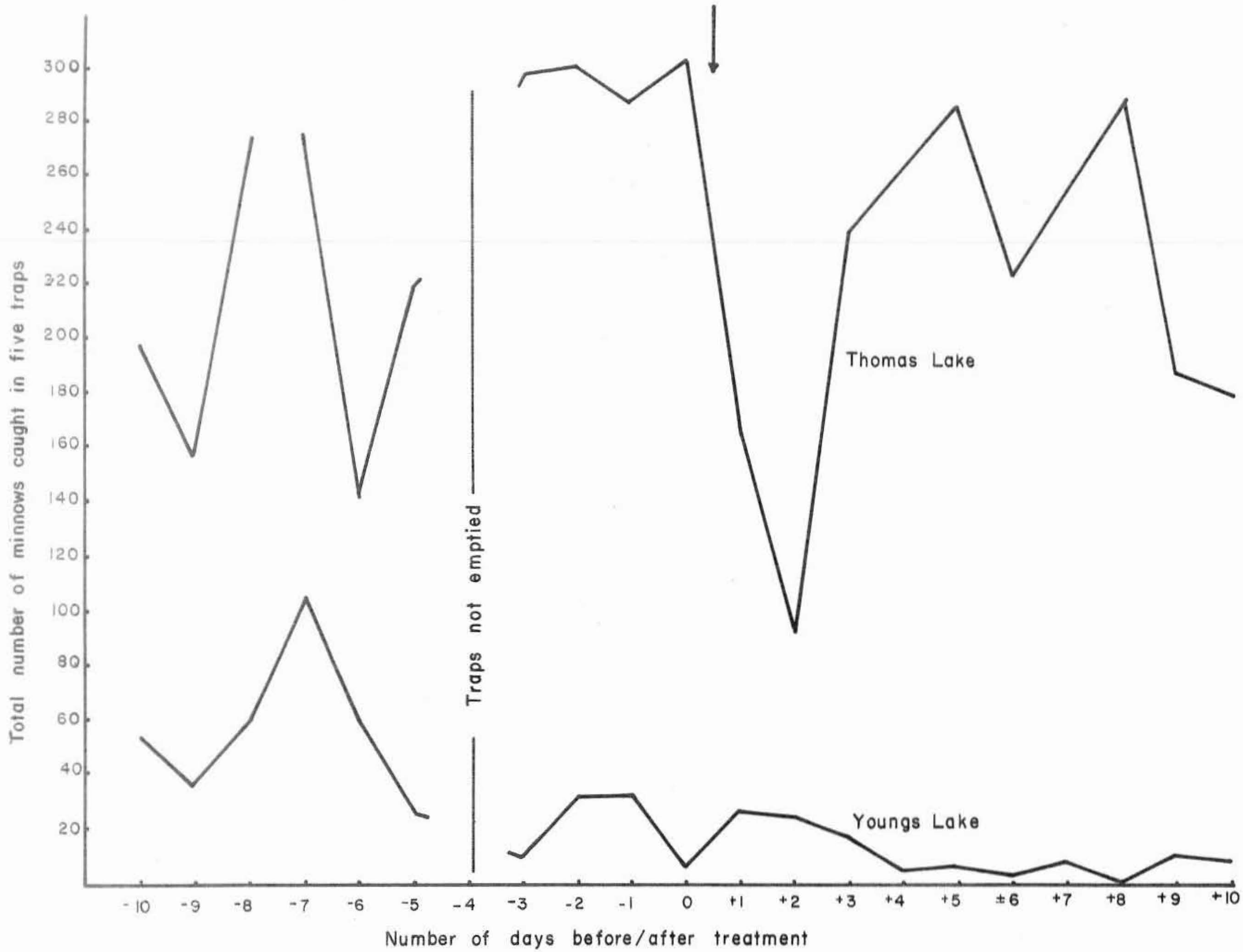

Fig. 14. Total numbers of minnows caught in Thomas and Youngs Lakes, PFES, 15 May to 4 June, 1976.

Table VIII

Plankton tow net catches in Thomas Lake, PFES, 1976.

	May 12 (-13)	May 25 (0)	May 29 (+4)	June 3 (+9)	July 5 (+40)
Bosmina	890	10,650	3,180	5	13,700
Daphnia	-	-	1,380	5	1,700
Diaphanosoma	60	-	2,520	10	7,000
Holopedium	-	-	18,600	10	-
Total cladocerans	950	10,650	25,680	30	22,400
Calanoid copepods	130	4,900	-	200	1,300
Cyclopoid copepods	230	425	10,140	2,300	15,700
Capepodids	930	-	-	-	-
Nauplii	4,720	4,075	4,260	550	13,200
Total copepods	6,010	9,400	14,400	3,050	30,200

Table IX

Plankton tow net catches in Youngs Lake, PFES, 1976.

	May 13	May 28	June 4	July 6
Bosmina	400	3,900	9,200	220
Daphnia	200	450	1,200	-
Diaphanosoma	-	-	500	30
Holopedium	300	3,000	23,200	70
Total cladocerans	900	7,350	34,100	320
Calanoid copepods	350	1,350	650	980
Cyclopoid copepods	28,050	14,400	14,850	8,200
Copepodids	-	450	-	-
Nauplii	5,550	1,150	9,050	5,000
Total copepods	33,950	17,350	24,550	14,180

Table X

Numbers of emerging insects caught in ten traps set in Thomas Lake and five traps set in Youngs Lake, PFES, 14 May to 3 June, 1976.

Number of days before or after treatment	Thomas Lake	Youngs Lake
-11	1	26
-10	11	52
-9	2	13
-8	0	23
-7	0	11
-6	Traps not emptied	
-5	2	9
-4	Traps not emptied	
-3	1	11
-2	1	2
-1	0	3
-0 *	1	13
+1	2	10
+2	1	5
+3	2	13
+4	2	9
+5	2	22
+6	0	30
+7	1	17
+8	1	16
+9	1	16

* Traps emptied before lake was treated

Table XI

Mean numbers and standard deviations of benthic organisms collected in Ekman grab samples from Thomas Lake, PFES, 12 May to 6 July, 1976.

Date	May 12 (-13)	May 25 (0)	May 29 (+4)	June 5 (+11)	July 6 (+41)
Average depth samples taken from (meters)	2.25	2.15	2.35	2.40	2.45
Diptera:Chironomidae (midge larvae)	3.6 ± 2.7	4.4 ± 0.9	1.6 ± 1.1	2.6 ± 2.3	1.2 ± 1.3
Diptera:Culicidae (*Chaoborus* larvae)	11.8 ± 15.0	12.0 ± 3.8	2.6 ± 2.7	4.6 ± 2.2	7.8 ± 4.7
Diptera:Heleidae (*Culicoides* larvae)	-	0.4 ± 0.9	-	0.2 ± 0.5	-
Amphipoda	-	-	0.2 ± 0.5	-	-
Total	15.4 ± 12.8	16.8 ± 3.1	4.4 ± 3.2	7.4 ± 2.5	9.0 ± 3.2

Table XII

Mean numbers and standard deviations of benthic organisms collected in Ekman grab samples from Youngs Lake, PFES, 13 May to 6 July, 1976.

Date	May 13	May 28	June 4	July 6
Average depth samples taken from (meters)	2.15	1.75	1.55	2.15
Ephemeroptera:Baetidae	-	-	0.4 ± 0.6	-
Odonata:Libellulidae	0.2 ± 0.5	0.2 ± 0.5	-	-
Trichoptera	-	-	-	0.2 ± 0.5
Diptera:Chironomidae	5.8 ± 2.9	4.4 ± 2.7	5.6 ± 5.3	4.6 ± 4.8
Diptera:Culicidae	1.2 ± 0.8	1.2 ± 1.8	0.8 ± 1.1	0.8 ± 1.3
Diptera:Heleidae	0.4 ± 0.9	0.2 ± 0.5	0.4 ± 0.6	0.4 ± 0.9
Oligochaeta	1.0 ± 1.2	0.8 ± 0.8	0.6 ± 0.6	-
Hydracarina	0.2 ± 0.5	-	-	-
Gastropoda	0.4 ± 0.9	1.8 ± 3.0	2.6 ± 2.5	1.8 ± 2.1
Pelecypoda:Sphaeridae	0.6 ± 0.6	0.4 ± 0.9	0.2 ± 0.5	0.8 ± 0.2
Pelecypoda:Unionidae	-	-	0.4 ± 0.6	0.2 ± 0.5
Total	9.8 ± 3.0	9.0 ± 3.6	11.0 ± 6.1	8.8 ± 5.3

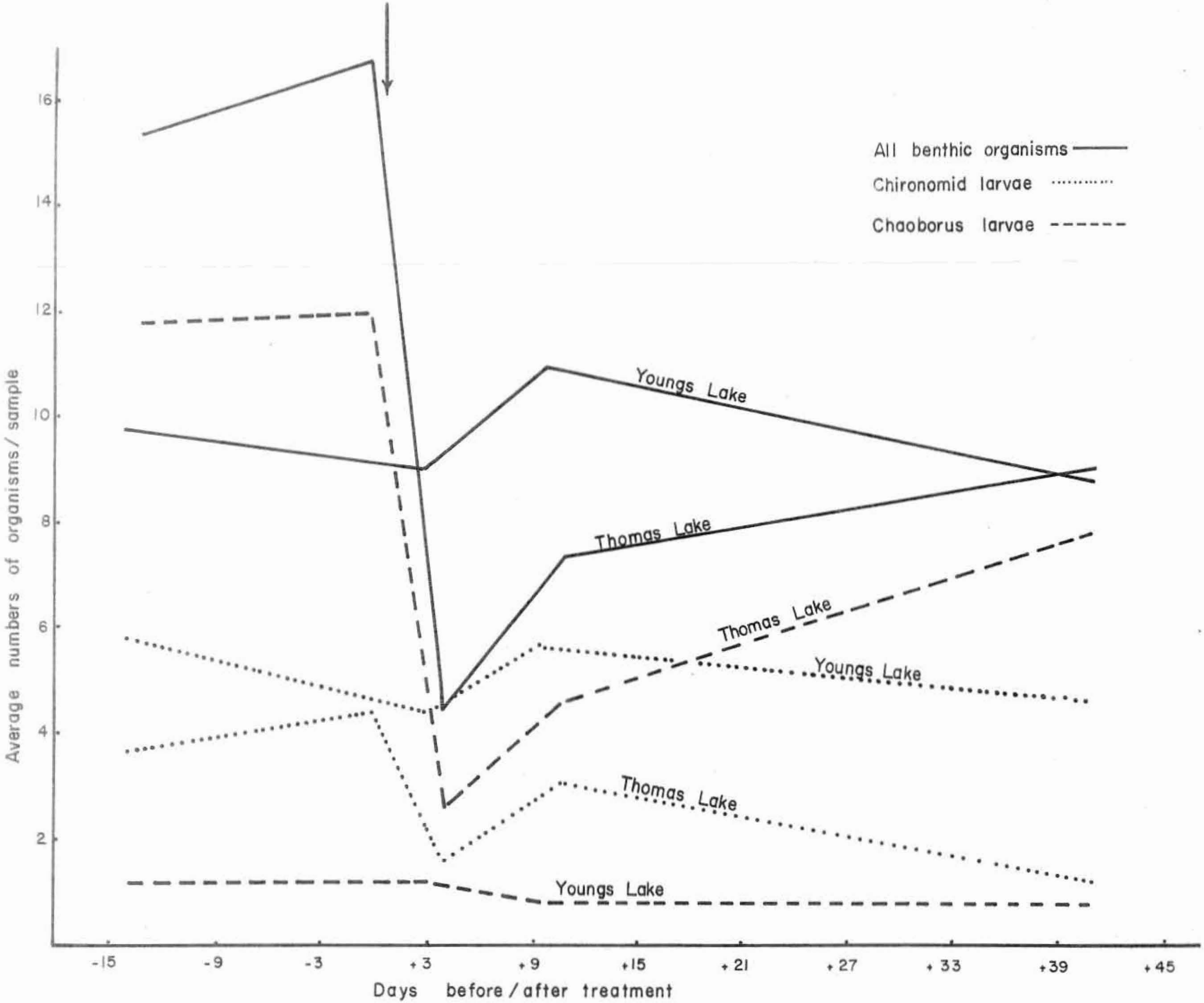

Fig. 15. Bottom fauna populations in Thomas and Youngs Lakes, PFES, 1976.

Youngs Creek - PFES - 70 g AI/ha: The 5 km stretch of Youngs Creek between Meridian and Racehorse Roads was treated between 1935 and 1945 hours on 2 June. Two identical swaths were flown up the centre of the creek valley from east to west (in an upstream direction) emitting 35 g AI/ha on each swath for a combined emitted deposit of 70 g AI/ha (1.0 oz AI/acre). Meteorological conditions over a 30 minute period beginning at the start of spraying were:

Mean wind speed	0.85 m/s
Δ T	+ 0.9°C
Turbulence factor	1.8
Stability ratio	+12.45
Dry bulb temperature	22 m: Mean 20.4°C, Range 20.7 - 20.0
	6 m: Mean 20.3°C, Range 21.2 - 19.2
Relative humidity	22 m: Mean 38.7%, Range 38.2 - 39.8
	6 m: Mean 37.1%, Range 36.4 - 40.0

Deposit of emitted spray at three points along the treated portion of the stream varied considerably (Table XIX), probably due in large part to variations in the amount of screening overstory and general "openness" of the stream valley at each location. Despite the stable conditions under which the spray was applied (stability ratio +12.45), the average overall measured deposit at the three stations was only about one fifth of the emitted dosage. Loss of spray products to the atmosphere through evaporation was probably high because of the high temperature and low relative humidity.

Table XIII

Deposit of the formulation of NRDC-143 (7.48 g AI/ℓ) applied at a total of 9.36 ℓ/ha to Youngs Creek, PFES.

Deposit sampler		Colorimetric Assessment		NAE Spot Counting Assessment	
		Average deposit in two pans (ℓ/ha)	Percentage of emitted rate	Deposit on Kromekote card (ℓ/ha)	Percentage of emitted rate
Station 1 (Meridian Rd.)	1	3.46	37.0	*	-
	2	3.18	34.0	*	-
	3	3.40	36.4	*	-
	4	4.00	42.8	*	-
Average	1-4	3.51 (26.2 g AI/ha)	37.5	-	-
Station 2	5	0.94	10.0	0.71	7.6
	6	1.26	13.4	0.83	8.8
	7	1.40	14.9	1.36	14.5
	8	0.91	9.7	0.76	8.1
Average	5-8	1.13 (8.4 g AI/ha)	12.1	0.92 (6.9 g AI/ha)	9.8
Racehorse Rd.	9	0.17	1.8	<0.01	<0.1
	10	0.14	1.4	<0.01	<0.1
	11	1.15	12.3	0.56	6.0
	12	1.63	17.4	*	-
Average	9-12	0.77 (5.8 g AI/ha)	8.2	-	-
All samplers		1.80 (13.5 g AI/ha)	19.2	-	-

* No estimate of deposit given by the computer because of the large area covered by overlapping droplets relative to the total area covered by droplets.

Water chemistry parameters in Youngs Creek were quite similar to those of the surface waters of Youngs Lake, with a pH of about 6.5 and alkalinity and hardness both equivalent to 2 grains per gallon. Maunsell Creek had a pH of 6.0 and alkalinity of 1 gpg $CaCO_3$ while hardness approached 4 gpg $CaCO_3$. Its waters were generally warmer than Youngs Creek due to the presence of lakes and slow flowing boggy areas along its length and they held less dissolved oxygen than Youngs Creek. Water levels in Youngs Creek dropped about 40 cm between 27 May and 6 June, climbed about 15 cm by mid-June and then fell a further 25 cm by the end of the first week in July. During the same period water levels at the station in Maunsell Creek did not vary by more than 10 cm.

As soon as treatment of Youngs Creek began, knocked down terrestrial and knocked up aquatic organisms were observed in large numbers on the creek's surface. These included spiders, ants, caterpillars, flies, adult mayflies and caddisflies, hymenopterans, terrestrial bugs and beetles, springtails, water striders, water boatmen and larval and adult aquatic coleoptera. Minnows were observed picking these organisms from the creek's surface. A heavy deposit of oil was noticeable on the surface for about an hour after treatment, two minnows were found swimming belly-up in distress in front of the blocking seine set across the creek below the treatment area. No other affected fish were seen after this time, even though the creek was visited twice daily over the nex three days.

Minnow trap catches from Youngs Creek consisted of Northern red-belly dace, common shiners, brook sticklebacks and central mudminnows *Umbra limi* (Kirtland). Numbers of minnows caught fluctuated considerably (Table XIV) but catches were relatively low over the first thirty-six hours after treatment of the creek. No mortality occurred up to four days after treatment among a group of cyprinids and mudminnows held caged in the creek.

Drift net catches prior to treatment consisted almost entirely of blackfly and midge larvae (Table XV). Immediately following treatment a large variety of aquatic insects were found to be drifting. Numbers and variety of insects in drift net samples remained high the morning after treatment, dropped somewhat by that evening, and then fell to very low levels. The very small drift net catches three and four days after treatment reflect the large decrease in the creeks flow noted during this period. Only a small increase in the rate of drift of other aquatic invertebrates, primarily amphipods and water mites, was observed. Numbers of fish caught in drift nets before and after treatment were quite similar. Terrestrial insects and spiders occurred in very large numbers and variety in the drift net sample taken immediately after treatment (Table XVI). The knockdown was very short-lived except among some dipterans, lepidoptera, coleoptera, hymenoptera and spiders, where it lasted from twelve hours to several days.

Similar effects of the NRDC-143 treatment were seen in aquatic insect catches in the blocking seine set across Youngs Creek as in drift net catches (Table XVII). Pre-spray catches again consisted mainly of blackfly and midge larvae with larger numbers drifting during the late evening and night and being removed from the seine in morning (am) samples. The sample taken the morning following treatment contained very large numbers of a wide variety of aquatic insects with particularly large numbers of springtails (Collembola), heptagenid mayfly nymphs (Ephemeroptera:Heptagenidae), water scavenger beetle larvae (Coleoptera:Hydrophilidae), midge larvae and pupae, water boatmen (Hemiptera: Corixidae), predaceous diving beetles (Coleoptera:Dytiscidae) and caddisfly larvae (Trichoptera). Aside from another large catch of heptagenid mayfly nymphs over the second evening and night after treatment, numbers of aquatic insects caught in the blocking seine in subsequent periods were relatively low though still quite diverse in variety. Water mites showed up in large numbers in the blocking seine immediately after treatment. Fish were not caught in the blocking seine in large numbers except for fairly substantial numbers of apparently healthy brook sticklebacks captured in the seine between two and four days after treatment. Extremely large numbers of terrestrial insects knocked down into the stream following treatment were captured in the blocking seine (Table XVIII). Knockdown to some extent up to three days after treatment was still apparent among some groups of dipterans, beetles, hymenopterans, lepidoptera larvae, caddisflies and spiders.

Surber samples taken from Youngs Creek (Tables XIX and XX) and Maunsell Creek (Table XXI) did not differ significantly with respect to changes in aquatic insect populations over the treatment period in the treatment versus the control stream (Fig. 16). The areas sampled yielded fairly low densities of aquatic insect populations made up primarily of midge larvae and other diptera larve, but the few mayfly nymphs, dragonfly nymphs, stonefly nymphs, caddisfly larvae and coleoptera larvae sampled generally reveal no distinct adverse effects of the treatment. There were also no significant effect noticeable on populations of the other bottom organisms sampled. Substantial numbers of fish eggs were found in several bottom samples from both streams before treatment. The presence of larger number of fry with and without yolk sacs following treatment indicated that egg development and hatching wasn't noticeably affected by the treatment.

Table XIV

Minnow trap catches in Youngs Creek, PFES,
1 June to 6 June, 1976.

Number of days before or after treatment	Cyprinids	Mudminnows	Sticklebacks	Totals
-1 am	129	0	1	130
-1 pm	0	0	0	0
-0 am	3	1	0	4
-0 pm*	8	0	0	8
+1 am	3	0	0	3
+1 pm	2	0	0	2
+2 am	4	0	0	4
+2 pm	13	0	3	16
+3 am	6	1	0	7
+3 pm		Traps not emptied		
+4 am	31	0	0	31

* Traps emptied before creek was treated.

Table XV

Aquatic insects, other aquatic invertebrates and fish

caught in 30 min. drift net sets in Youngs Creek, PFES, 31 May to 6 June, 1976.

Number of days before or after treatment	-2 pm	-1 am	-1 pm	-0 am	-0 pm	Immediately* Before	Immediately* After	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am
Collembola	-	-	-	-	-	-	14	1	1	1	-	-	-	-
Ephemeroptera:Baetidae	-	-	1	1	-	-	15	-	1	-	-	-	-	-
Heptageniidae	-	-	-	-	-	-	-	8	1	-	-	-	-	-
Odonata	-	-	-	-	-	-	-	2	1	1	-	-	-	-
Plecoptera	-	-	-	-	-	-	9	2	-	-	-	-	-	-
Hemiptera:Corixidae	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Hebridae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Coleoptera:Haliplidae	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Dytiscidae	-	-	-	-	-	-	3	-	-	-	-	-	-	-
Gyrinidae	-	-	-	-	-	-	5	1	-	-	-	-	-	-
Hydrophilidae	-	-	-	-	-	-	2	4	1	2	1	-	-	-
Elmidae	-	-	-	-	-	-	1	3	1	-	-	-	-	-
Trichoptera:Hydroptilidae	-	-	-	-	-	-	12	-	-	-	-	-	-	-
Unknown	2	-	-	-	-	-	2	3	1	-	-	-	-	-
Diptera:Culicidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Chironomidae	12	2	6	6	1	14	78	60	32	6	7	2	1	3
Simuliidae	60	84	20	19	17	31	196	54	43	10	5	1	-	1
Unknown	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Total aquatic insects	74	86	26	26	19	45	342	138	83	20	13	3	1	4
Oligochaeta	-	-	-	-	-	1	-	-	-	-	2	-	-	-
Hirundinea	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Amphipoda	-	-	-	-	-	-	1	-	2	-	-	-	-	-
Acari	-	-	-	-	-	-	-	1	6	1	-	-	-	-
Total other aquatic invertebrates	-	-	-	-	-	2	1	2	8	1	2	-	-	-
Fish	2	2	-	2	1	1	-	2	-	2	-	2	1	-

* 1 hour sets

Table XVI

Terrestrial arthropods caught in 30 min. drift net set in Youngs Creek, PFES, 31 May to 6 June, 1976.

Number of days before or after treatment	-2 pm	-1 am	-1 pm	-0 am	-0 pm	Immediately * Before	Immediately * After	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am
Thysanoptera	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Hemiptera: Nabidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Tingidae	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Lygaeidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Coriscidae	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Unknown	-	-	-	-	1	-	-	-	-	-	-	1	-	-
Homoptera: Cicadellidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Delphacidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Aphididae	-	-	-	-	-	-	2	1	-	-	-	-	-	-
Fulgoroidea	-	-	-	-	-	-	14	-	-	-	-	-	-	-
Coleoptera: Cicindelidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Carabidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Staphylinidae	-	-	-	-	-	-	8	1	3	-	-	-	-	-
Elateridae	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Curculionidae	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Unknown	-	-	-	-	-	-	5	-	1	1	-	-	-	-
Trichoptera (adults)	-	-	-	-	-	-	14	2	-	-	-	-	-	-
Lepidoptera (larvae)	-	-	-	-	-	-	20	7	5	2	-	1	-	-
Diptera: Tipulidae	-	-	-	-	-	-	5	-	-	-	-	-	-	-
Culicidae	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Chironomidae	-	-	2	1	-	-	125	19	6	10	1	4	-	3
Simuliidae	6	2	8	3	1	2	17	2	6	7	1	1	-	-
Bibionidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Unknown	-	-	-	-	-	-	71	5	7	3	1	7	3	-
Hymenoptera: Braconidae	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Ichneumonidae	-	-	-	-	-	-	3	-	-	-	-	-	-	-
Formicidae	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Unknown	-	-	-	-	-	-	8	-	1	1	-	-	1	-
Arachnida	-	-	-	-	-	-	7	2	1	2	-	-	-	-
Total	6	2	10	4	2	2	325	39	30	26	3	14	4	3

* 1 hour sets.

Table XVII

Aquatic insects, other invertebrates and fish removed from a blocking seine set across Youngs Creek, PFES, 31 May to 6 June, 1976.

Number of days before or after treatment	-2 pm	-1 am	-1 pm	-0 am	-0 pm	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am
Collembola	-	-	-	-	-	5872*	28*	6	8	-	-	-
Ephemeroptera:Ephemeridae	-	-	-	-	-	23	3	1	-	-	-	-
:Heptageniidae	-	-	-	-	-	638	3	331	-	11	1	1
:Baetidae	-	-	-	5	-	17	2	2	-	1	1	1
Odenata:Aeshnidae	-	-	-	-	-	2	-	-	-	-	-	-
:Cordulegastridge	-	-	-	-	-	1	-	-	-	-	-	-
:Libellulidae	-	-	-	-	-	1	-	-	-	-	-	3
:Agrionidae	-	-	-	-	-	15*	-	1	-	1	-	1
:Coenagrionidae	-	-	-	-	-	-	-	-	-	-	-	1
Hemiptera:Corixidae	-	-	-	-	-	316*	16	5	-	-	-	-
:Notonectidae	-	-	1	-	-	-	-	-	-	-	-	-
:Nepidae	-	-	-	-	-	2	1	-	-	-	-	-
:Gerridae	-	-	-	-	1	38	11	3	-	-	-	-
:Hebridae	-	-	-	-	-	3	7*	-	1	-	-	-
Coleoptera:Haliplidae	-	-	-	-	-	3	-	-	-	-	-	-
:Dytiscidae (larvae)	-	-	-	-	-	-	16*	-	1	-	-	-
:Dytiscidae (adults)	-	-	-	-	-	258*	58	-	3	-	-	1
:Gyrinidae	-	-	-	-	-	18	7	5	1	-	-	-
:Hydrophilidae (larvae)	-	-	1	-	1	415*	68	15	7	-	1	-
:Hydrophilidae (adults)	-	-	-	-	-	7	1	-	-	-	-	-
:Elmidae	-	1	1	-	-	-	-	-	1	1	-	1
:Unknown	-	-	-	-	-	3	-	-	-	-	-	-

Table XVII (Continued)

Number of days before or after treatment	-2 pm	-1 am	-1 pm	-0 am	-0 pm	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am
Trichoptera:larvae	-	2	-	1	2	244*	7	10	2	4	1	4
:pupae	1	-	-	-	-	2	-	2	-	-	-	-
Diptera:Tipulidae	-	-	1	-	-	-	1	-	-	-	-	-
:Chironomidae (larvae)	16	28	13	61	44	328*	14*	54	4	40	7	57
:Chironomidae (pupae)	-	-	-	-	-	96*	-	-	-	-	-	-
:Simuliidae	363	286	19	454	37	5	-	4	4	1	-	1
:Unknown	1	-	-	-	2	-	6*	-	-	-	-	-
Total aquatic insects	381	317	36	521	87	8323*	228*	440	31	59	11	71
Nematoda	-	1	-	2	-	2	-	1	-	-	1	2
Oligochaeta	-	1	-	-	-	-	-	-	-	1	-	2
Hirudinea	-	1	1	-	-	-	-	1	-	-	-	-
Acari	-	-	-	-	-	192*	24	1	-	-	-	-
Gastropoda	8	2	22	12	-	55	19	58	7	75	9	3
Total other aquatic invertebrates	8	5	23	14	-	249*	43	61	7	76	10	7
Fish	1	1	1	-	-	5	1	1	11	19	2	16

* Includes numbers extrapolated from subsamples.

Table XVIII

Terrestrial arthropods removed from a blocking seine set across Youngs Creek, PFES, 31 May to 6 June, 1976.

Number of days before or after treatment	-2 pm	-1 am	-1 pm	-0 am	-0 pm	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am
Ephemeroptera	-	-	1	-	-	18	2	2	-	-	-	-
Odonata	-	-	-	-	-	-	-	1	1	-	-	-
Plecoptera	-	-	-	-	-	-	6	-	-	-	-	-
Thysanoptera	-	-	-	-	-	3	1	-	-	-	-	-
Hemiptera	-	-	-	-	-	102*	2	-	-	-	-	-
Homoptera:Fulgoroidea	-	-	-	-	-	1124*	-	1	1	-	-	-
:Aphidoidea	-	-	-	-	-	397*	2	-	3	-	-	-
:Unknown	-	-	-	-	-	5	21	-	-	2	-	-
Coleoptera:Staphylinidae	-	-	-	-	1	131*	17	4	4	-	-	-
:Elateridae	-	-	1	-	-	105*	2	2	3	1	-	-
:Coccinellidae	-	-	1	1	-	17	31	5	-	2	-	-
:Chrysomelidae	-	-	-	-	-	-	-	-	1	-	1	1
:Curculionidae	-	-	-	-	-	97*	1	1	-	-	-	-
:Unknown	2	5	2	-	-	389*	76	20	13	2	-	1
Trichoptera	2	-	-	-	-	449*	54	27	4	5	2	1
Lepidoptera (larvae)	2	-	-	-	-	1023*	106*	2	33	1	3	-
(adults)	-	-	-	-	-	2	-	1	-	-	-	-
Diptera:Tipulidae	-	-	-	-	-	2	-	2	1	-	-	-
:Chironomidae + Culicidae	-	-	-	1	1	12789*	196*	129	97	11	-	1
:Simuliidae	-	-	-	-	1	42	362*	12	70	-	3	2
:Unknown	-	1	-	-	-	1	456*	54	61	3	9	2
Hymenoptera:Formicidae	1	1	2	-	1	96	16	2	35	-	14	-
:Unknown	3	-	1	-	-	1561*	79*	5	19	1	-	2
Unknown Insecta	-	-	-	-	-	12	-	7	1	1	4	-
Arachnida	-	-	-	-	-	651*	29*	10	3	1	1	-
Totals	10	7	8	2	4	18980*	1459*	287	350	30	37	10

* Includes numbers extrapolated from subsamples.

Table XIX

Mean numbers and standard deviations of benthic invertebrates collected in Surber samples from Station 1, Youngs Creek, PFES, 27 May to 7 July, 1976.

Date	May 27 (-6)	June 6 (+4)	June 16 (+14)	July 7 (+35)
Number of samples	3	4	4	4
Ephemeroptera:Heptagenidae	1.0 ± 1.0	1.2 ± 1.0	0.5 ± 0.6	0.5 ± 1.0
:Baetidae	-	0.2 ± 0.5	-	-
Odonata:Libellulidae	-	-	0.5 ± 1.0	-
:Cordulagastridae	-	-	-	0.5 ± 1.0
Plecoptera:Unknown	-	0.5 ± 1.0	-	-
Coleoptera:Haliplidae	0.3 ± 0.6	-	-	-
:Elmidae	-	0.2 ± 0.5	-	0.2 ± 0.5
Diptera:Chironomidae	1.0 ± 0.0	4.5 ± 2.1	0.5 ± 1.0	8.8 ± 4.3
:Simuliidae	-	0.2 ± 0.5	-	-
:Tabanidae	0.3 ± 0.6	0.2 ± 0.5	-	-
Nematoda	0.3 ± 0.6	0.2 ± 0.5	-	-
Oligochaeta	1.0 ± 1.7	2.2 ± 2.1	9.8 ± 2.6	7.5 ± 11.8
Hirudinea	1.3 ± 2.3	1.2 ± 1.5	0.8 ± 0.5	0.8 ± 1.0
Amphipoda	-	-	-	0.8 ± 1.5
Decapoda	-	-	-	0.8 ± 1.0
Gastropoda	0.3 ± 0.6	-	-	-
Total	5.7 ± 4.6	11.0 ± 6.3	12.0 ± 1.6	19.8 ± 15.6

Table XX

Mean numbers and standard deviations of benthic invertebrates collected in Surber samples from Station 2, Youngs Creek, PFES, 30 May to 7 July, 1976.

Date	May 30 (-3)	June 6 (+4)	June 16 (+14)	July 7 (+35)
Number of samples	4	4	4	4
Ephemeroptera:Ephemeridae	0.5 ± 0.6	-	-	-
:Heptagenidae	0.2 ± 0.5	0.2 ± 0.5	-	-
:Baetidae	0.8 ± 1.5	1.2 ± 1.5	-	-
Odonata:Gomphidae	-	0.2 ± 0.5	0.2 ± 0.5	0.2 ± 0.5
:Aeshnidae	-	-	0.5 ± 1.0	-
:Cordulegastridae	-	0.2 ± 0.5	-	-
:Libellulidae	-	0.5 ± 1.0	-	-
Trichoptera:Unknown	0.5 0.6	0.8 ± 1.0	-	0.8 ± 1.0
Coleoptera:Elmidae	-	0.5 ± 0.6	-	-
Diptera:Tipulidae	0.2 ± 0.5	-	-	0.2 ± 0.5
:Chironomidae	6.2 ± 7.1	4.5 ± 4.5	-	20.5 ± 14.2
:Heleidae	-	-	-	0.5 ± 1.0
:Simuliidae	0.2 ± 0.5	-	-	-
:Tabanidae	0.5 ± 0.6	0.5 ± 1.0	0.2 ± 0.5	-
Nematoda	0.5 ± 0.6	0.2 ± 0.5	-	-
Oligochaeta	8.5 ± 6.4	8.5 ± 7.8	3.0 ± 2.9	3.2 ± 1.7
Hirudinea	-	-	0.8 ± 1.0	0.5 ± 0.6
Amphipoda	-	-	-	0.5 ± 1.0
Decapoda	-	0.5 ± 0.6	-	0.2 ± 0.5
Gastropoda:Ancylidae	0.2 ± 0.5	0.2 ± 0.5	-	-
:Unknown	0.2 ± 0.5	-	-	-
Pelecypoda:Sphaeridae	-	0.5 ± 0.6	0.8 ± 0.5	0.5 ± 0.6
Total	18.8 ± 11.5	18.8 ± 11.5	5.5 ± 3.5	27.2 ± 17.6

Table XXI

Mean numbers and standard deviations of benthic invertebrates collected in Surber samples from Maunsell Creek, PFES, 1 June to 7 July, 1976.

Date	June 1	June 6	July 16	July 7
Number of samples	3	4	4	4
Ephemeroptera:Baetidae	-	0.2 ± 0.5	0.2 ± 0.5	-
Odonata:Cordulegastridae	-	-	0.2 ± 0.5	-
:Libellulidae	0.3 ± 0.6	0.2 ± 0.5	0.2 ± 0.5	0.5 ± 0.6
Coleoptera:Gyrinnidae	0.3 ± 0.6	-	-	0.2 ± 0.5
Diptera:Chironomidae	12.7 ± 19.4	5.8 ± 3.3	2.8 ± 1.5	27.8 ± 22.2
:Heleidae	0.3 ± 0.6	-	0.2 ± 0.5	0.8 ± 1.0
:Simuliidae	0.3 ± 0.6	-	-	-
Nematoda	0.7 ± 0.6	0.2 ± 0.5	-	-
Oligochaeta	7.3 ± 2.3	17.5 ± 24.9	13.5 ± 10.9	28.2 ± 29.8
Hirudinea	0.7 ± 1.2	-	-	1.2 ± 1.5
Amphipoda	-	0.2 ± 0.5	1.0 ± 2.0	0.2 ± 0.5
Gastropoda	-	0.2 ± 0.5	2.0 ± 3.4	2.8 ± 5.5
Pelcypoda:Sphaeridae	0.7 ± 1.2	-	0.8 ± 0.5	0.5 ± 1.0
Total	23.3 ± 18.8	24.5 ± 15.5	21.0 ± 9.5	62.2 ± 46.4

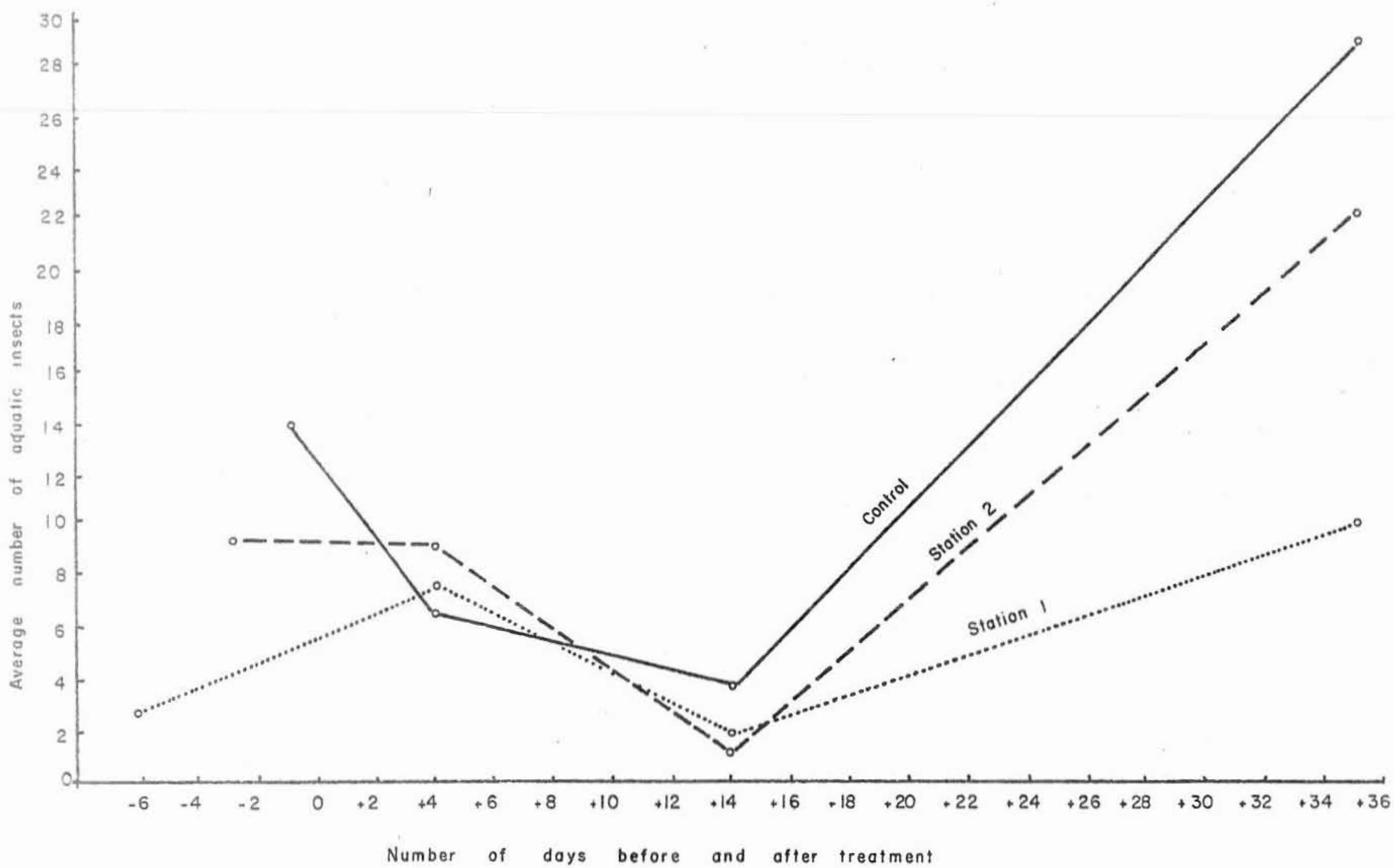

Fig. 16. Aquatic insect populations (mean number per Surber sample) from the two NRDC-143 treated and control station, PFES.

Lac Tassel-Quebec-140 g AI/ha: Lac Tassel was treated from 0600 to 0612 hours on 31 May in an east-west direction beginning at the south shore and progressing north (Fig. 17). Portable weather equipment showed zero wind velocity at the time of treatment with the temperature at 10°C and relative humidity was 90%. These conditions and the probable presence of a strong temperature inversion immediately over the lake at the time of spraying resulted in an extremely high recovery of emitted spray on the deposit samplers on the lake's surface (Table XXII). The very dense deposit of spray droplets on the Kromekote cards made it impossible to accurately assess the volume deposited by the spot counting method because of the large numbers of overlapping droplets.

At the time of treatment Lac Tassel showed a moderate degree of temperature stratification with a fairly distinct thermocline lying between two and three metres (Fig. 18). The top two metres of the lake's surface continued to warm rapidly through to mid-June with the themocline continuing to lie between two and three metres and becoming more distinct. Water chemistry parameters during this period remained quite stable (Table XXIII) and continued to be so until late August when some depletion of oxygen in the lake's bottom waters became noticeable.

Some fish mortality (Table XXIV) and heavy aquatic and terrestrial arthropod mortality (Table XXV) were observed following treatment of Lac Tassel. Shortly after the lake was treated large numbers of knocked down terrestrial insects were present on the surface. Most dead insects disappeared from the surface by the next day and some were found on the bottom along the shoreline between six hours and two days after treatment. By six hours after treatment large numbers of aquatic insects and amphipods were found distressed on the bottom. Dragonfly, damselfly and non-burrowing mayfly nymphs were overturned

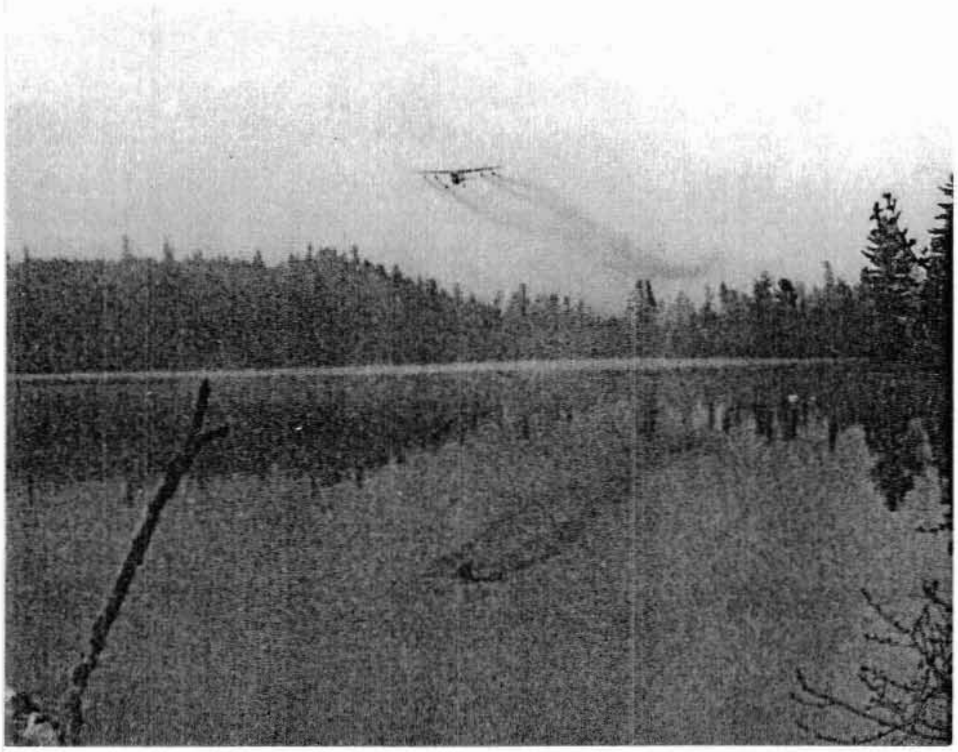

Fig. 17. CCRI's Cessna 185 treating Lac Tassel, Quebec, with NRDC-143.

Table XXII

Deposit of the formulation of NRDC-143 (29.9 g AI/ℓ) applied at 4.68 ℓ/ha to Lac Tassel, Quebec.

Deposit sampler	Average deposit in two pans (ℓ/ha)	% deposited
S1 (south side of lake)	3.10	66.3
S2	5.76	123.2
S3	5.31	113.5
S4	6.04	129.1
S5	4.50	96.1
N5	4.86	103.3
N4	4.98	106.6
N3	2.76	59.1
N2	2.20	47.1
N1 (north side of lake)	3.50	74.7
All samplers	4.30 (128.6 g AI/ha)	92.0

onto their backs and showing weak respiratory movements while burrowing mayfly nymphs, caddisfly larvae and amphipods were either prostrate or writhering on the bottom. Water mites exhibited apparently normal behavior. Large masses of dead *Chaoborus* larvae and pupae were found along the shoreline the day after treatment. Most of the affected aquatic insects and amphipods had died by the first or second day after treatment although distressed burrowing mayfly nymphs were still found three days post-spray. Fungal growth was apparent on the dead insects by this time and all but the largest dragonfly nymphs had disappeared at the end of a week.

Affected native fish were first seen distressed on the surface about twelve hours after treatment. After the first day post-treatment no more distressed fish were seen but numerous dead fish were found either on the bottom or along the shoreline. Throughout the entire treatment period observations were made of large numbers of apparently unaffected fish of all species present in the lake. No noticeable effect was seen on the large shoals of suckers, perch, fallfish and bass repeatedly observed near submerged beaver food piles. Normal overall dace and darter activity was seen at the same time dead and distressed individuals were being found. White suckers were observed spawning in the shallow mouth of the outlet stream the day after treatment of the lake. Tadpole and spotted newt populations also appeared normal after treatment.

Among the caged fish held in the lake two brook trout in the shoreline cage showed signs of distress twelve hours after treatment of the lake and had died by the next morning. One white sucker was found dead in the shoreline cage a week after treatment but the rest of the brook trout and suckers held in the lake remained healthy until released eighteen days after treatment. The two yellow perch held at 6 metres died the day after treatment but may have been affected more by handling and temperature change than by exposure to the insecticide.

Minnow trap catches in Lac Tassel consisted mainly of Johnny darters, Iowa darters and Northern redbelly dace, with a few small bass, perch and suckers being caught as well. Many potted newts and tadpoles were also caught in the minnow traps. Minnow trap catches were generally small in Lac Tassel (Table XXVI), particularly following treatment of the lake when only five fish were caught in the first four days after spray compared to fourteen fish the four days before treatment. Trap net catches showed no decline following treatment with large numbers of white suckers being caught throughout the period the net was set.

Plankton samples from along the shoreline (Table XXVII) and near the centre (Table XXVIII) of Lac Tassel indicate a dramatic and relatively long lasting effect of NRDC-143 on zooplankton populations. Cladoceran populations in both locations dropped off immediately after treatment with no cladocerans at all present in samples taken after one week. Cladoceran populations remained at extremely low levels up until mid-July along the shoreline and until August near the centre of the lake. Copepod populations showed less dramatic, more gradual declines in numbers following treatment with populations remaining quite depressed up until August.

Bottom fauna populations in Lac Tassel are given in Table XXIX and presented graphically in Fig. 19. Aquatic insect populations showed a gradual decline following treatment with the numbers of burrowing mayfly nymphs, dragonfly nymphs, and chironomid larvae steadily dropping to very low levels by mid-July. Caddisfly larvae disappeared completely from bottom samples shortly after treatment while numbers of aquatic coleoptera larvae remained at or above pre-spray levels throughout the summer. Oligochaete, snail and fingernail clam populations increased until mid-June when they declined again. Amphipods and isopods disappeared from bottom samples right after treatment. In late summer populations of almost all benthic invertebrates were very low and showed no signs of increasing.

Analysis of large numbers of white sucker stomachs over the study period revealed changes in diet related to the effects of NRDC-143 on populations of fish food organisms within Lac Tassel (Appendix, Table VII). Pre-spray samples showed that in mid-May suckers were feeding almost exclusively on cladocerans which made up a mean of 78.4% of the volume of each stomach. Immediately before treatment they showed a more varied diet consisting primarily of *Chaoborus* larvae (35.0%), cladocerans (23.1%) and chironomid larvae (15.8%). Following treatment suckers were found to have fed extensively on affected aquatic insects: primarily burrowing mayfly nymphs, alderfly larvae (Megaloptera:Sialidae), caddisfly larvae, *Chaoborus* pupae and heptagenid mayfly nymphs. As plankton and most aquatic insect populations fell to low levels in mid-June suckers began feeding on chironomid larvae (63.2%) and snails (12.1%). Chironomid larvae and molluscs (snails and fingernail clams) remained prominent in sucker stomachs throughout the remainder of the summer but as plankton populations recovered suckers began to feed heavily on copepods and later on cladocerans. *Chaoborus* larvae and pupae totally disappeared from sucker stomachs from mid-June on. Smallmouth bass stomach contents reflected even greater changes due to effects of the treatment on fish food organisms (Appendix, Table VIII). Extreme gorging on dragonfly nymphs occurred after treatment of the lake followed by an almost total disappearance of aquatic insects from bass stomachs. By mid-June bass were feeding almost exclusively on terrestrial and flying insects with a small amount of feeding on minnows including one case of predation on bass fry.

Late in the summer the small amounts of food present in bass stomachs consisted primarily of cladocerans, terrestrial insects and minnows. Yellow perch in Lac Tassel fed primarily on *Chaoborus* larvae and pupae prior to treatment of the lake (Appendix, Table IX). Following treatment, extensive feeding on affected burrowing mayfly nymphs was evident. Shortly after treatment the mean volumes of food present in yellow perch stomachs fell to very low levels with the majority of the fish caught having empty stomachs. *Chaoborus* completely disappeared from yellow perch stomachs from mid-June on. Fallfish stomachs were only sampled on one occasion in late August when analysis of eleven stomachs showed they were feeding primarily on terrestrial insects (63.3%), snails (17.8%), minnows (11.1%) and cladocerans (5.6%).

Smallmouth bass in Lac Tassel first began spawning two days before treatment of the lake and by the time the lake was treated eighteen bass nests containing eggs had been located (Figs. 20 and 21, Table XXX). In the first four days following treatment of the lake guarding males disappeared from ten nests containing eggs and four nests without eggs while eggs were laid in twelve nests which previously had no eggs in them (Table XXXI). Of the forty-seven active nests located, forty-three produced eggs and fry were hatched from twenty of these. Three weeks after the treatment date bass nesting had been completed and large numbers of free swimming bass fry were observed along portions of the shoreline (Fig. 22). Underwater observations in July and August found small numbers of the fry present. During these surveys in mid and late summer an almost complete lack of aquatic insects along the shoreline was evident. A few larval and adult aquatic beetles were found as well as abundant numbers of freshwater sponges, bryozoans, flatworms, water mites, snails and clams.

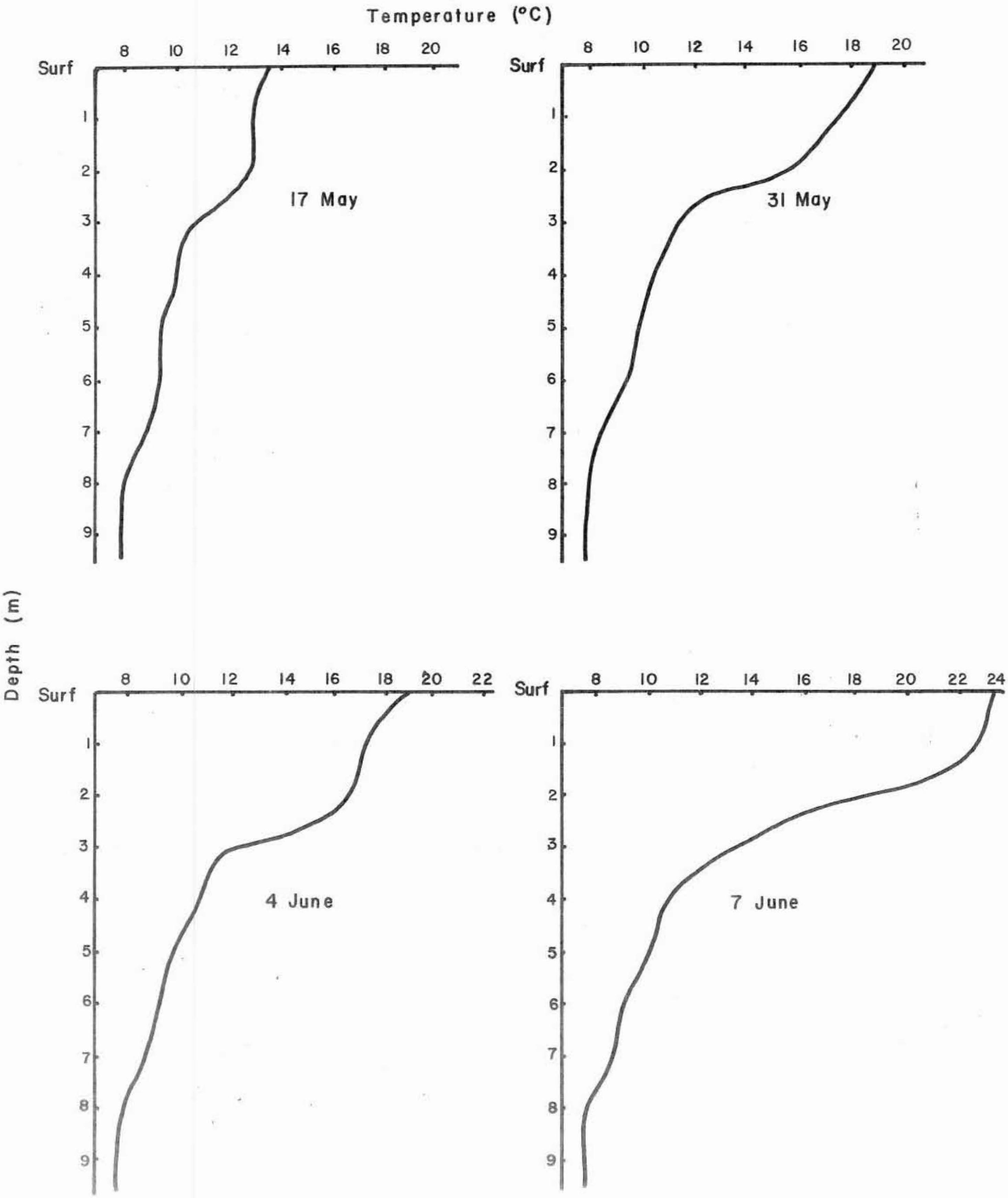

Fig. 18. Temperature profiles in Lac Tassel, Quebec, 1976

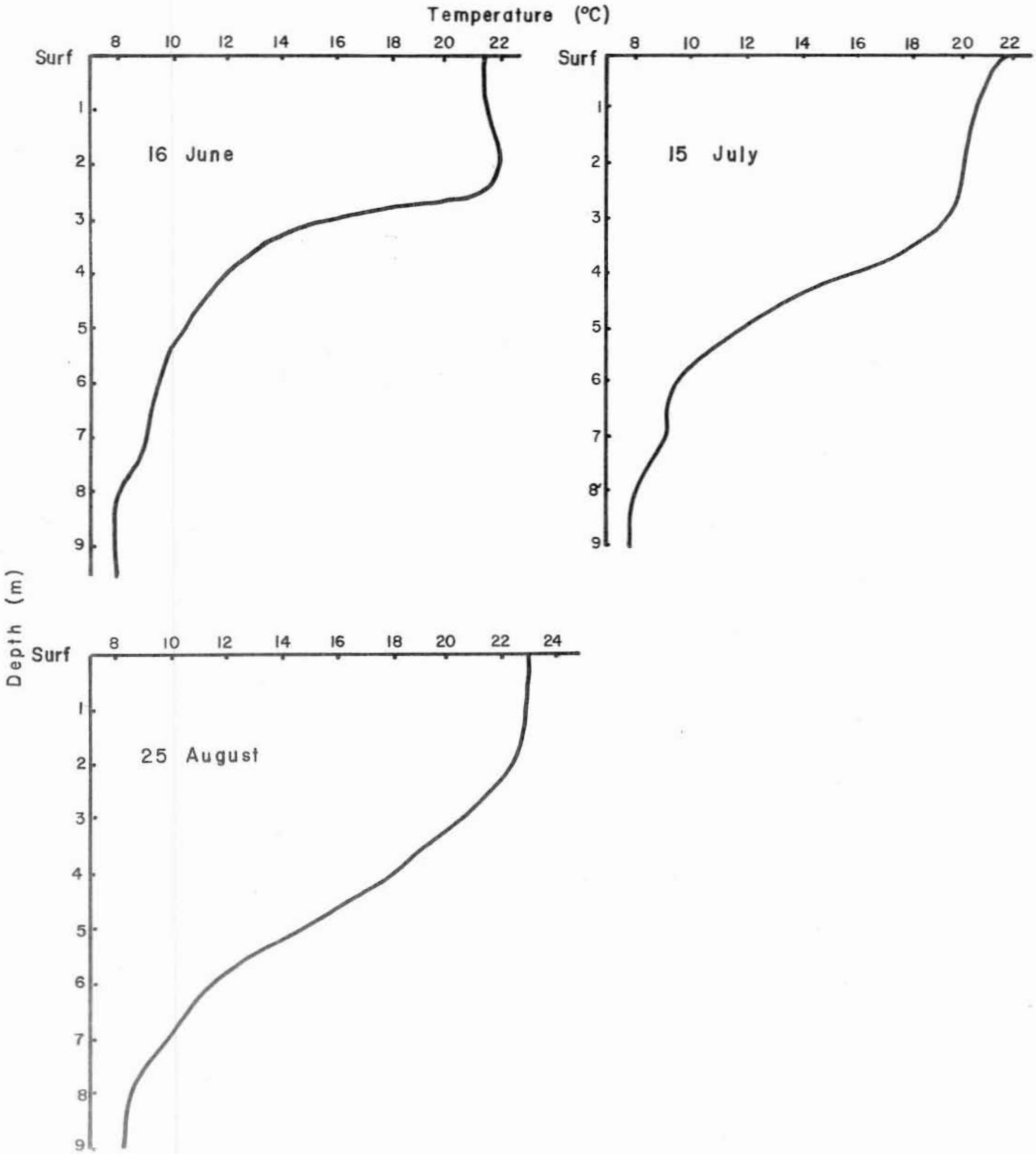

Fig. 18 (Continued)

Table XXIII

Water chemistry parameters in Lac Tassel, Quebec, 1976.

Date	Depth	Temperature (^{o}C)	Dissolved oxygen (ppm)	pH	Alkalinity (gpg $CaCO_3$)*	Hardness (gpg $CaCO_3$)*
May 17	Surface	13.5	10	6.7	1	2
	9m	8.0	10	6.7	1	2
June 4	Surface	19.0	10	6.5	1	2
	8m	8.0	9	6.5	1	2
June 7	Surface	23.5	9	6.5	1	2
	8m	8.0	10	6.0	1	2
June 16	Surface	21.5	8	6.6	1	2
	9m	8.0	7	6.0	1	2
July 15	Surface	21.5	8	6.5	1	2
	8m	8.2	7	6.0	1	2
Aug. 25	Surface	23.0	9	7.5	1	2
	4m	18.0	9	6.5	1	2
	8m	8.5	4	6.0	1	2

* grains per gallon calcium carbonate.

Table XXIV

Dead and distressed native fish found in Lac Tassel, Quebec following aerial treatment with NRDC-143.

+12 hours	Two white suckers (158 mm and 108 mm) -	Distressed on surface
	Seven northern redbelly dace (mean length 60 mm) -	"
+1 day	One brown bullhead (122 mm, gorged with insects) -	Distressed on bottom
	One northern redbelly dace (69 mm) -	"
	One Johnny darter (49 mm) -	"

Found dead

+1 day	Three smallmouth bass (190 mm and 69 mm, both large males gorged with insects). One white sucker (230 mm, not gorged with insects). Three yellow perch (181 mm, 91 mm, and 52 mm). Two northern redbelly dace (69 mm and 50 mm). One common shiner (81 mm).
+2 day	Four smallmouth bass (187 mm, 184 mm, 71 mm and 70 mm). Three yellowperch (95 mm, 81 mm, and 81 mm). Four northern redbelly dace (mean length 60 mm). One common shiner (135 mm). One Johnny darter (46 mm).
+3 day	Two smallmouth bass (340 mm and 192 mm). Two northern redbelly dace (72 mm and 69 mm).
+7 day	Seven minnows seen dead on bottom ($\sim$4 m) in the course of scuba diving observations.
+9 day	One yearling smallmouth bass and two minnows seen dead along shoreline during bass nesting surveys.

Table XXV

Dead aquatic and terrestrial arthropods found in Lac Tassel, Quebec following aerial treatment with NRDC-143.

Terrestrial "knockdown" - very extensive over entire surface of lake shortly after treatment.

∿ 90% Dipterans (primarily midges and blackflies) Also numerous terrestrial beetles, spiders, hymenopterans, caddisflies and mayflies.

Aquatic "knock up" - very extensive, noticeable effect by six hours after treatment.

Chaoborus (Diptera:Culicidae) - masses of thousands of dead larvae and pupae (about 95% larvae) found along windward shorelines.

Dragonfly nymphs (Odonata:Anisoptera) - Libellulidae- *Didymops sp.*- very large numbers dead on bottom along shoreline.
-Aeshnidae-*Aeshna sp.*- small numbers dead on bottom
-Gomphidae-*Gomphus sp.*-small numbers dead on bottom.

Mayfly nymphs (Ephemeroptera) - Heptagenidae - *Stenonema sp.*? - extremely large numbers dead on bottom along shoreline.
-Ephemeridae (burrowing mayfly nymphs) - *Hexagenia sp.* very large numbers dead on bottom along shoreline.
-Baetidae - *Leptophlebia sp.* - fairly small numbers dead on bottom.
- *Ephemerella sp.* - small numbers dead on bottom.

Caddisfly larvae (Trichoptera) - various families - moderately large numbers of larvae and a few pupae representing a number of species dead on bottom.

Amphipods (Amphipoda:Gammaridae) - *Crangonyx sp.*? - moderately large numbers dead on bottom.

Damselfly nymphs (Odonata:Zygoptera) - Coenagrionidae-*Enallagma sp.* ? - a few dead on bottom.

Aquatic lepidoptera larva (Lepidoptera:Pyralidae) - one individual found dead on bottom.

Giant water bug (Hemiptera:Belestomatidae) - *Lethocerus americanus* (Leidy) - one very large individual found dead on surface along shoreline.

Table XXVI

Daily minnow trap and trap net catches in Lac Tassel, Quebec, before and after treatment with NRDC-143.

Number of days before or after treatment	-4	-3	-2	-1	-0*	+1	+2	+3	+4	+7	+8
Minnow traps											
Darters	16	1	2	2	3	2	-	1	2	1	7
Cyrinids	-	-	-	2	4	-	-	-	-	-	-
Smallmouth bass	1	-	-	-	-	-	-	-	-	-	-
White suckers	-	-	-	-	-	-	-	-	-	-	1
Perch	-	-	-	-	-	-	-	-	-	1	-
Newts	1	-	2	3	-	2	-	-	-	2	-
Tadpoles	4	6	-	-	-	4	-	-	-	1	-
Trap net											
White suckers	Net	60	79	6	14	30	97	82	43		Net
Brown bullheads	not	-	-	-	-	-	2	1	-		not
Perch	set	2	-	-	-	-	-	-	-		set
Smallmouth bass		-	-	-	-	1	-	-	-		

* Traps emptied before lake was treated.

Table XXVII

Plankton catches from the surface at the shoreline of Lac Tassel, Quebec, 17 May to 25 August, 1976.

	May 17 (-14)	May 31 (0)	June 4 (+4)	June 7 (+7)	June 16 (+16)	July 15 (+45)	Aug. (+86)
)smina	1	-	-	-	-	-	47
ıphnia	-	38	-	-	-	-	-
.aphanosoma	-	-	-	-	-	-	73
)lopedium	-	44	1	-	-	1	-
)lyphemus	2	82	-	-	-	85	36
ımature	-	16	-	-	-	-	-
ıknown	-	5	-	-	1	-	-
)tal cladocerans	3	185	1	0	1	86	156
ılanoid copepods	2	9	-	-	-	5	53
'clopoid copepods	5	4	4	-	-	-	42
ıuplii	17	3	-	1	2	-	32
)tal copepods	24	16	4	1	2	5	127

Table XXVIII

Total plankton catch from surface, 4 m and 8 m samples taken from near the centre of Lac Tassel, Quebec, 17 May to 25 August, 1976.

	May 17 (-14)	May 31 (0)	June 4 (+4)	June 7 (+7)	June 16 (+16)	July 15 (+45)	Aug.25 (+86)
Bosmina	1	-	-	-	-	-	1
Daphnia	96	87	2	-	1	-	-
Diaphanosoma	1	-	-	-	-	-	100
Holopedium	106	317	3	-	-	-	3
Polyphemus	-	3	-	-	-	3	-
Immature	23	4	-	-	-	-	1
Unknown	-	1	1	-	-	-	1
Total cladocerans	227	412	6	0	1	3	106
Calanoid copepods	169	177	19	14	-	34	291
Cyclopoid copepods	126	37	24	22	5	17	226
Copepodids	1	1	-	-	-	-	15
Nauplii	230	159	187	15	7	23	85
Unknown	1	-	-	1	-	-	-
Total copepods	527	374	230	52	12	74	617

Table XXIX

Mean numbers and standard deviations of benthic organisms collected in Ekman grab samples from Lac Tassel, Quebec, 17 May to 26 August, 1976.

	May 17 (-14)	June 4 (+4)	June 8 (+8)	June 17 (+17)	July 15 (+45)	Aug. 26 (+86)
Mean depth (m)	2.05	2.25	2.00	1.78	2.05	1.95
Ephemeroptera:Ephemeridae	1.5 ± 1.8	1.3 ± 2.5	0.7 ± 1.5	0.1 ± 0.3	-	-
Odonata:Gomphidae	0.2 ± 0.4	-	-	0.1 ± 0.3	-	-
:Libellulidae	0.1 ± 0.3	0.1 ± 0.3	0.1 ± 0.3	-	-	0.1 ± 0.3
:Coenagrionidae	-	0.1 ± 0.3	-	-	-	-
Lepidoptera:Pyralidae	0.1 ± 0.3	-	-	-	-	-
Trichoptera:Unknown	1.1 ± 1.7	0.5 ± 0.7	-	-	-	-
Coleoptera:Elmidae	0.3 ± 0.7	1.1 ± 2.2	1.9 ± 4.3	0.3 ± 0.5	0.5 ± 1.1	0.7 ± 1.3
Diptera:Chironomidae	18.1 ± 6.8	13.3 ± 8.0	14.2 ± 12.2	7.0 ± 6.0	1.0 ± 0.8	1.4 ± 1.4
:Heleidae	0.9 ± 1.1	0.2 ± 0.6	0.8 ± 1.3	0.2 ± 0.4	0.1 ± 0.3	0.1 ± 0.3
:Simuliidae	0.2 ± 0.6	-	-	-	-	-
:Tipulidae	-	0.1 ± 0.3	-	-	-	-
:Unknown	-	-	-	-	-	0.1 ± 0.3
Turbellaria	-	-	-	0.2 ± 0.4	-	0.3 ± 0.7
Oligochaeta	0.7 ± 1.5	1.2 ± 1.9	0.5 ± 0.5	3.6 ± 2.9	1.9 ± 2.2	2.3 ± 1.4
Amphipoda	0.6 ± 0.8	0.1 ± 0.3	-	-	-	-
Isopoda	0.1 ± 0.3	-	-	-	-	-
Gastropoda	0.4 ± 0.7	0.4 ± 0.7	2.2 ± 2.6	3.7 ± 4.6	0.5 ± 1.1	0.5 ± 0.9
Pelecypoda:Sphaeridae	0.2 ± 0.4	1.4 ± 2.2	1.3 ± 2.8	2.8 ± 2.6	-	-
Total	24.5 ± 6.9	19.8 ± 12.7	21.7 ± 14.9	18.0 ± 8.3	4.0 ± 3.0	5.5 ± 3.7

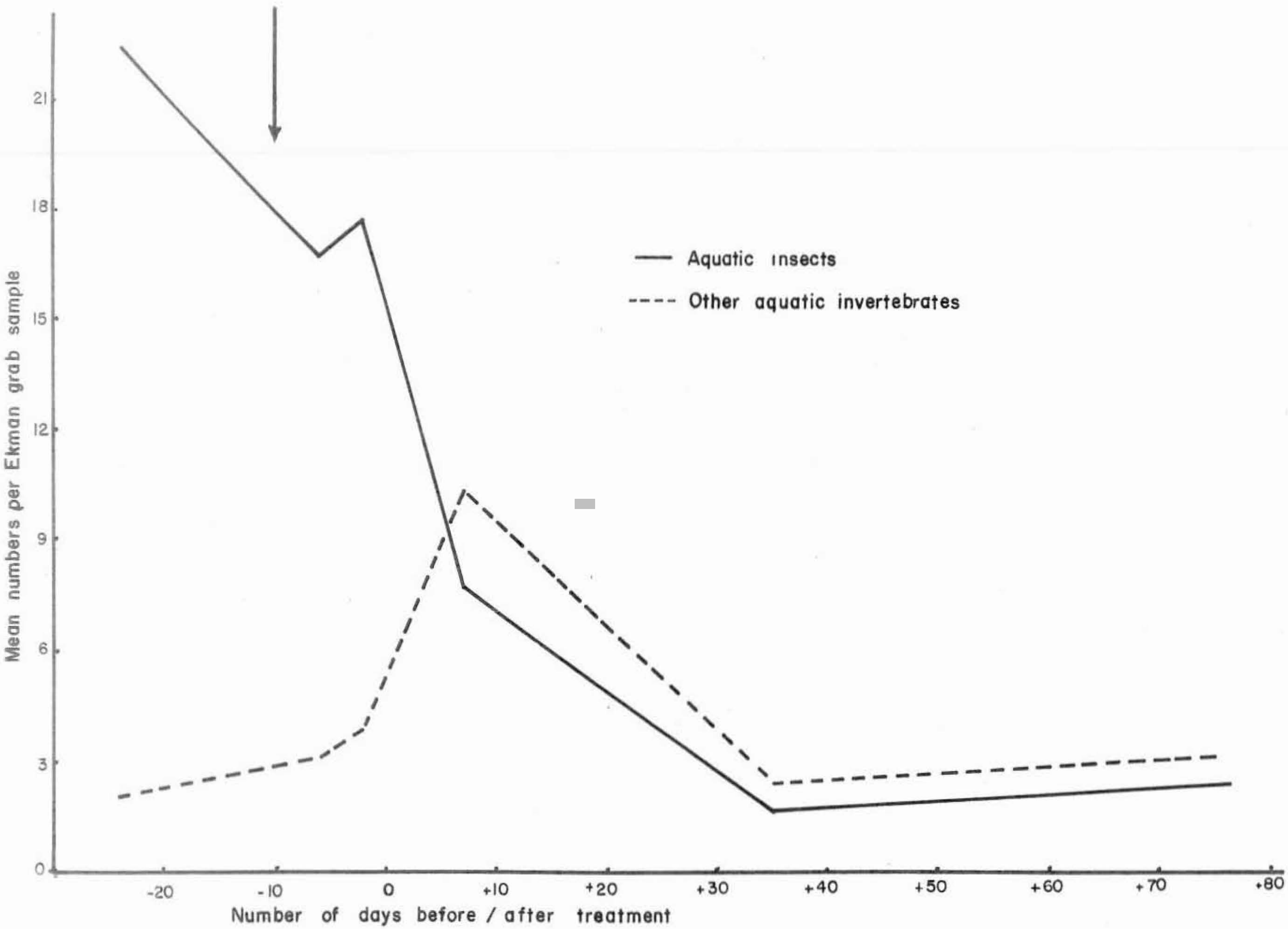

Fig. 19. Bottom fauna populations in Lac Tassel, Quebec, 1976.

Fig. 20. Male smallmouth bass guarding his nest, Lac Tassel, Quebec.

Fi[illegible]

Table XXX

Condition of forty-seven marked bass nests in Lac Tassel, Quebec, from 30 May to 17 June, 1976.

Number of days before or after treatment	Number of nests with :								
	No male, eggs or fry	Male but no eggs or fry	Male with eggs	No male or eggs on nest which previously had male	Eggs only on nest which previously had male and eggs	Male with fry	Male only on nest which previously had male and fry	Fry only on nest which previously had male and fry	No male or fry on nest which previously had male and fry
-1	22	7	18	0	0	0	0	0	0
+½	16	1	25	3	2	0	0	0	0
+1	14	0	23	4	6	0	0	0	0
+2	14	0	21	4	8	0	0	0	0
+3	13	0	20	4	10	0	0	0	0
+9	0	2	6	4	19	15	0	1	0
+17	0	0	0	4	23	6	2	4	8

Table XXXI

Numbers of bass nests in Lac Tassel on which spawning activity was terminated or initiated following treatment with NRDC-143.

Number of days after treatment	Male disappearing from nest without eggs	Male disappearing from nest with eggs	Eggs being laid in nest previously occupied by a male	Eggs being laid in previously unoccupied nest
$+\frac{1}{2}$	3	2	3	6
+1	1	4	0	2
+2	0	2	0	0
+3	0	2	1	0
+9	0	10	0	12
+17	0	1	0	0

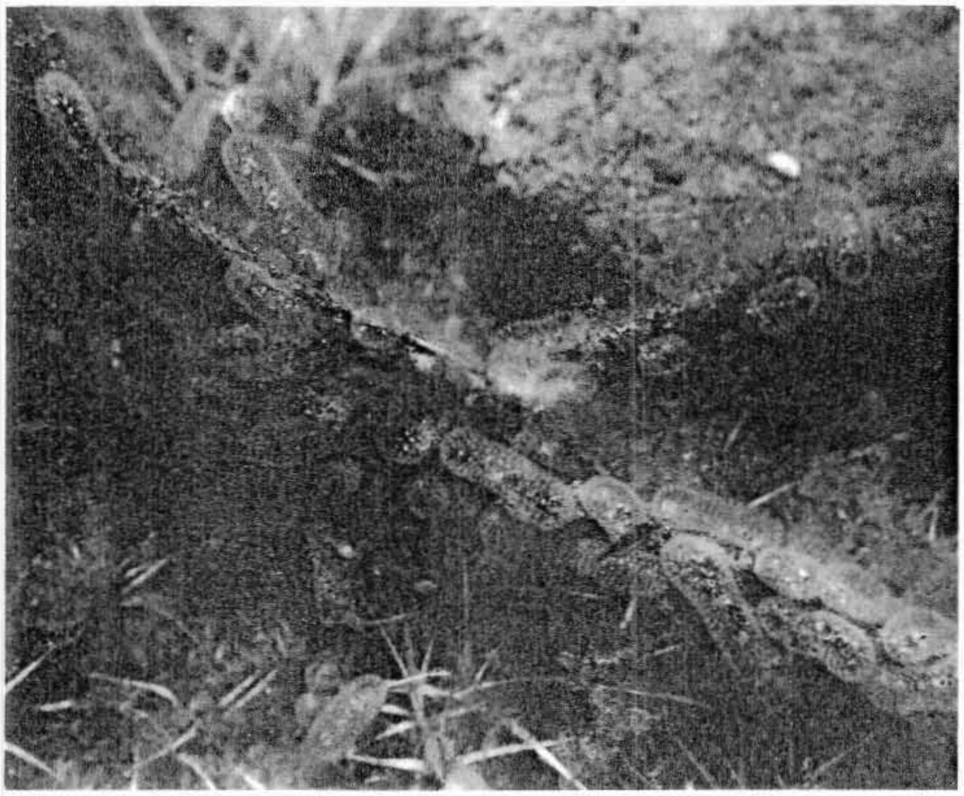

Fig. 22. Smallmouth bass fry swimming in front of a bryozoan covered stick in Lac Tassel three weeks after the NRDC-143 treatment.

DISCUSSION AND CONCLUSIONS

Thomas Lake, PFES: The measured deposit on Thomas Lake of between 15.6 and 23.4 g NRDC-143/ha of the 35 g AI/ha emitted can be considered representative of a high level of contamination likely to occur only occasionally in aquatic systems in areas treated with this dosage of NRDC-143 under operational conditions. The effects of this deposit on the fauna of Thomas Lake were moderate and short-lived. Mortality occurred among caged fish held right at the surface of the lake with rapidly diminishing effects on fish held progressively deeper. Native fish suffered essentially no mortality but a short lasting drop in minnow trap catches may indicate a slight behavioral effect. There were indications of a delayed effect on zooplankton, particularly cladocerans, but recovery appeared to be rapid and complete. Some mortality occurred among surface breathing aquatic coleoptera and hemiptera. An immediate and substantial impact occurred on bottom fauna due to the lake's shallow nature. The effect on *Chaoborus* larvae populations was partial and recovery was evident and well advanced within six weeks of treatment. A smaller but apparently longer lasting effect occurred on chironomid larvae populations. No effect on emerging insects was apparent, reflecting the generally greater resistance of pupal stages of insects to insecticides than shown by larval stages.

Following treatment of the lake, white suckers and to a lesser extent brown bullheads gorged themselves on *Chaoborus* larvae. Very heavy feeding of white suckers on *Chaoborus* larvae also occurred in the control lake at this time but did not result in the kind of large increases in mean volume of stomach contents seen in fish from the treatment lake. *Chaoborus* larvae continued to contribute significantly to fish stomach contents throughout June and into July in Thomas Lake indicating that they remained available as important fish food items despite the adverse effects of treatment on their populations. Similarly, chironomid larvae continued to be available to fish in fairly large numbers after treatment. This indicates that the effects of the treatment on fish food organisms were not severe enough to seriously deprive the lake's fish populations of food organisms. The presence of larger aquatic insects in fish stomachs immediately after treatment suggests they were affected by the treatment and made susceptible to predation because of lethal or sublethal effects of it.

Youngs Creek, PFES: The measured deposit of 13.5 g/ha of NRDC-143 on Youngs Creek represents light contamination of an aquatic system treated at the dosage of 70 g AI/ha, and cannot be considered representative of the greatest impact likely to occur in streams treated operationally at this dosage. It had minimal effects on caged or native fish in Youngs Creek but caused dramatic, short-lived increases in the drift of aquatic insects, particularly springtails, heptagenid mayfly nymphs, some larval and adult aquatic beetles, waterboatmen and chironomid larvae. Bottom fauna samples showed that despite this increased drift, aquatic insect populations did not decrease significantly when compared to population changes in the control creek. Knockdown of terrestrial insects and spiders into the creek was very heavy and lasted up to two days despite the small area actually treated with NRDC-143. Heavy and relatively long lasting impact was particularly noticeable of flies, beetles, wasps, caterpillars, caddisflies and spiders.

Lac Tassel, Quebec: The measured deposit of 128.6 g NRDC-143/ha on Lac Tassel represents a level of contamination unlikely to occur under operational conditions except at extreme dosage rates or in the event of accidental multiple swathing. It resulted in heavy impact on aquatic organisms. Within hours of treatment extremely heavy mortality of shallow dwelling aquatic insects and amphipods occurred. Substantial numbers of individual fish representing most of the species present in the lake were killed by the treatment, however overall mortality was not significant in terms of total fish populations and the majority of native and caged fish did not appear to be directly affected by toxic effects of the spray. Zooplankton populations were severely reduced after treatment with copepods somewhat less affected and recovering faster than cladocerans. Substantial recovery of the total zooplankton community was not evident until three months after treatment. Bottom fauna populations sampled from depths between 1 and 3 meters decreased relatively slowly after treatment and were not severely depleted until July. This suggests that they were affected primarily by the overall ecological disruption within the lake rather than by mortality related to direct toxic effects. The severe effects on aquatic invertebrate populations resulted in dramatic changes in the volume and composition of food found in fish stomachs. In particular, the severe effects on plankton and larger aquatic insects eliminated these food items from the available prey of fish over most or all of the summer. Suckers utilized available chironomid larvae and molluscs for food in the absence of other items while smallmouth bass fed primarily on available terrestrial insects and to a small extent on minnows. It is not yet clear what effects these changes in diet could have on fish growth but attempts to evaluate this will be made after the completion of the growing season. Overall smallmouth bass reproduction in the lake was not noticeably affected by the treatment but the question remains as to the survival and growth of the 1976 year class of bass because of effects on its food supply, particularly the zooplankton on which the newly hatched fry feed.

* * * * *

In summary, it is concluded that heavy deposits of NRDC-143 applied at 140 gm/hectare (2 oz./acre) present a substantial hazard to aquatic environments in terms of potential effects on zooplankton, aquatic insects, fish and the ecological relationships between these and other components of aquatic systems. The effects of application rates of 70 gm/hectare or less do not appear at first appraisal to be overly hazardous to the integrity of aquatic systems, but require further evaluation before they can be fairly compared to the environmental hazards posed by chemical insecticides currently in use.

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A P P E N D I X

Stomach contents of native fish from
lakes treated with NRDC-143 and
an untreated control lake.

Table I

Percent occurance, average percent contribution to the volume of each stomach and average number in each stomach present in of various food items found in white sucker stomachs from Thomas Lake, PFES, 11 May to 6 July, 1976.

Date	May 11 (-14)	May 29 (+4)	June 6 (+12)	July 6 (+41)
Number of fish sampled	20	20	20	6
Mean total length (mm)	262.4	280.1	273.0	294.3
Mean fork length	244.0	262.6	254.6	278.3
Mean preserved weight (g)	208.9	260.0	230.9	299.3
Sex ratio (males:females)	4:16	3:17	8:12	1:5
Mean volume food present/stomach (ml)	0.80	2.77	0.83	0.50
Percent occurance of food items:				
Empty stomachs	10	-	5	-
Caddisfly larvae (Trichoptera)	-	5	-	-
<u>Chaoborus</u> larvae (Diptera:Culicidae)	30	95	70	67
Chironomid larvae (Diptera:Chironomidae)	75	15	80	83
Chironomid pupae (Diptera:Chironomidae)	70	-	10	-
Copepods (Copepoda)	45	-	35	17
<u>Culicoides larvae</u> (Diptera:Heleidae)	25	5	5	-
Dragonfly nymphs (Odonata)	-	5	-	-
Snails (Gastropoda)	5	-	-	-

Table I (Continued)

Date	May 11 (-14)	May 29 (+4)	June 6 (+12)	July 6 (+41)
Average percent volume contributed by:				
Caddisfly larvae	-	1.3	-	-
Chaoborus larvae	13.6	94.5	56.6	53.3
Chironomid larvae	21.9	1.0	32.9	30.0
Chironomid pupae	31.7	-	1.8	-
Copepods	28.9	-	8.4	16.7
Culicoides larvae	2.8	0.3	0.3	-
Dragonfly nymphs	-	3.0	-	-
Snails	1.1	-	-	-
Average number/stomach present in:				
Caddisfly larvae	-	1	-	-
Chaoborus larvae	approx. 60	approx. 415	approx. 130	approx. 20
Chironomid larvae	approx. 6	1	approx. 6	approx. 8
Chironomid pupae	6	-	1	-
Copepods	approx. 800	-	approx. 120	approx. 100
Culicoides larvae	2	1	1	-
Dragonfly nymphs	-	2	-	-
Snails	3	-	-	-

Table II

Percent occurance, average percent contribution to the volume of each stomach and average number in each stomach present in of various food items found in brown bullhead stomachs from Thomas Lake PFES, 11 May to 6 July, 1976.

Date	May 11 (-14)	May 29 (+4)	June 6 (+12)	July 6 (+41)
Number of fish sampled	11	20	7	8
Mean total length (mm)	170.1	174.0	154.0	192.2
Mean fork length (mm)	167.2	170.0	151.3	188.8
Mean preserved weight (g)	76.0	85.2	56.8	99.2
Sex ratio (males:females)	5:6	6:14	4:3	0:8
Mean volume food present/stomach (ml)	0.11	2.87	0.83	0.56
Percent occurance of food items:				
Empty stomachs	64	5	14	25
Aquatic beetles (Coleoptera)	-	5	-	-
<u>Chaoborus</u> larvae (Diptera:Culicidae)	27	85	28	50
Chaoborus pupae (Diptera:Culicidae)	-	35	-	62
Chironomid larvae (Diptera:Chironomidae)	36	55	57	38
Chironomid pupae (Diptera:Chironomidae)	18	10	14	-
Copepods (Copepoda)	9	-	-	-
<u>Culicoides</u> larvae (Diptera:Heleidae)	-	15	14	12
Dobsonfly larvae (Megaloptera:Corydalidae)	-	5	-	-
Dragonfly nymphs (Odonata)	-	5	-	-
Flying insects	-	-	-	25
Minnow remains	9	35	43	38
Terrestrial beetles (Coleoptera)	-	5	-	38

Table II (Continued)

Date	May 11 (-14)	May 29 (+4)	June 6 (+12)	July 6 (+41)
Average percent volume contributed by:				
Aquatic beetles	-	0.3	-	-
Chaoborus larvae	27.5	67.9	4.2	12.5
Chaoborus pupae	-	1.6	-	9.6
Chironomid larvae	35.0	7.6	46.7	3.8
Chironomid pupae	12.5	0.3	0.8	-
Copepods	1.2	-	-	-
Culicoides larve	-	0.6	<0.1	6.7
Dobsonfly larvae	-	0.3	-	-
Dragonfly nymph	-	0.5	-	-
Flying insects	-	-	-	21.7
Minnow remains	23.8	20.5	48.3	35.0
Terrestrial beetles	-	0.5	-	10.8
Average number/stomach present in:				
Aquatic beetles	-	1	-	-
Chaoborus larvae	14	approx. 300	9	7
Chaoborus pupae	-	3	-	2
Chironomid larvae	3	1½	approx. 20	3
Chironomid pupae	2	1	1	-
Copepods	1	-	-	-
Culicoides larvae	-	2	1	2
Dobsonfly larvae	-	1	-	-
Dragonfly nymphs	-	1	-	-

Table II (Continued)

Date	May 11 (-14)	May 29 (+4)	June 6 (+12)	July 6 (+41)
Flying insects	-	-	-	2
Minnow remains	?	?	?	?
Terrestrial beetles	-	2	-	2

Table III

Percent occurance, average percent contribution to the volume of each stomach and average number in each stomach present in of various food items found in white sucker stomachs from Youngs Lake, PFES, 12 May to 6 July, 1976

Date	May 12	May 28	June 5	July 6
Number of fish sampled	10	10	10	9
Mean total length (mm)	252.5	271.2	273.9	241.1
Mean fork length (mm)	238.5	256.7	257.3	226.8
Mean preserved weight (g)	157.1	206.9	224.7	135.3
Sex ratio (males:females)	5:5	2:8	0:10	1:9
Mean volume food present/stomach (ml)	2.19	1.67	1.45	0.53
Percent occurance of food items:				
Empty stomachs	-	10	-	22
Amphipods (Amphipoda)	20	-	-	-
Borrowing mayfly nymphs (Ephemeroptera:Ephemeridae)	10	-	-	-
Caddisfly larvae (Trichoptera)	40	10	-	-
Chaoborus larvae (Diptera:Culicidae)	40	70	70	22
Chaoborus pupae (Diptera:Culicidae)	-	-	-	11
Chironomid larvae (Diptera:Chironomidae)	90	70	80	78
Chironomid pupae (Diptera:Chironomidae)	60	20	10	44
Cladocerans (Cladocera)	10	-	-	33
Copepods (Copepoda)	10	10	-	11
Culicoides larvae (Diptera:Heleidae)	70	30	30	11
Dragonfly nymphs (Odonata)	20	20	-	11
Fingernail clams (Petecypoda:Sphaeridae)	20	10	-	11
Mayfly nymphs (Ephemeroptera:Baetidae)	-	10	-	-
Snails (Gastropoda)	-	-	10	-

Table III (Continued)

Date	May 12	May 28	June 5	July 6
Average percent volume contributed by:				
Amphipods	2.5	-	-	-
Burrowing mayfly nymps	4.5	-	-	-
Caddisfly larvae	10.5	1.1	-	-
Chaoborus larvae	14.0	57.8	64.0	6.4
Chaoborus pupae	-	-	-	5.0
Chironomid larvae	45.9	26.7	31.5	35.7
Chironomid pupae	5.6	1.7	0.5	7.8
Cladocerans	<0.1	-	-	24.3
Copepods	<0.1	0.6	-	5.7
Culicoides larvae	5.0	5.6	3.0	4.3
Dragonfly nymphs	8.0	3.9	-	5.0
Fingernail clams	4.0	0.6	-	5.7
Mayfly nymphs	-	2.2	-	-
Snails	-	-	1.0	-

Table III (Continued)

Date	May 12	May 28	June 5	July 6
Average number/stomach present in:				
Amphipods	10	-	-	-
Burrowing mayfly nymphs	1	-	-	-
Caddisfly larvae	6	1	-	-
<u>Chaoborus</u> larvae	approx.60	approx.300	approx.200	8
<u>Chaoborus</u> pupae	-	-	-	1
Chironomid larvae	38	18	39	4
Chironomid pupae	8	$1\frac{1}{4}$	1	1
Cladocerans	approx.10	-	-	approx.500
Copepods	approx.10	approx.100	-	approx. 500
<u>Culicoides</u> larvae	6	5	12	2
Dragonfly nymphs	9	2	-	2
Fingernail clams	6	1	-	12
Mayfly nymphs	-	2	-	-
Snails	-			

Table IV

Percent occurance, average percent contribution to the volume of each stomach and average number in each stomach present in of various food items found in brownbullhead stomachs from Youngs Lake, PFES, 12 May to 5 June, 1976

Date	May 12	May 28	June 5
Number of fish sampled	10	10	10
Mean total length (mm)	202.3	204.0	188.6
Mean fork length (mm)	198.6	200.8	186.1
Mean preserved weight (g)	101.8	106.5	87.7
Sex ratio (males:females)	8:2	4:6	8:2
Mean volume food present/stomach (ml)	1.33	0.72	0.11
Percent occurance of food items:			
Empty stomachs	20	10	60
Aquatic beetles (Coleoptera)	-	10	-
Burrowing mayfly nymphs (Ephemeroptera:Ephemeridae)	10	-	-
Caddisfly larvae (Trichoptera	20	30	-
<u>Chaoborus</u> larvae (Diptera:Culicidae)	-	20	-
Chironomid larvae (Diptera:Chironomidae	10	20	20
Chironomid pupae (Diptera:Chironomidae)	20	10	10
Crayfish (Decapoda)	10	10	-
<u>Culicoides</u> larvae (Diptera:Heleidae)	10	40	10
Dragonfly nymphs (Odonata)	50	70	10
Fingernail clams (Pelecypoda:Sphaeridae)	-	10	10

Table IV (Continued)

Date	May 12	May 28	June 5
Mayfly nymps (Ephemeroptera:Baetidae)	10	-	-
Mayfly nymphs (Ephemeroptera:Heptagenidae)	-	10	-
Minnow remains	20	20	-
Snails (Gastropoda)	10	-	-
Tabanid larvae (Diptera:Tabanidae)	10	10	-
Terrestrial beetles (Coleoptera	-	10	-
Unknown aquatic dipteran larvae (Diptera: ?)	-	-	10
Unknown terrestrial insects	-	30	-
Average percent volume contributed by:			
Aquatic beetles	-	3.3	-
Burrowing mayfly nymphs	12.5	-	-
Caddisfly larvae	5.6	8.3	-
Chaoborus larvae	-	2.6	-
Chironomid larvae	2.5	2.8	5.0
Chironomid pupae	1.6	1.1	20.0
Crayfish	9.4	7.2	-
Culicoides larvae	0.2	2.1	1.2
Dragonfly nymphs	41.9	30.6	25.0
Fingernail clams	-	0.3	25.0
Mayfly nymphs (Baetidae)	0.6	-	-
Mayfly nymphs (Heptagenidae)	-	8.9	-
Minnow remains	23.8	15.6	-

Table IV (Continued)

Date	May 12	May 28	June 5
Snails	0.6	-	-
Tabanid larvae	1.2	6.7	-
Terrestrial beetles	-	3.3	-
Unknown dipteran larvae	-	-	23.8
Unknown terrestrial insects	-	7.2	-
Average number/stomach present in:			
Aquatic beetles	-	1	-
Burrowing mayfly nymphs	1	-	-
Caddisfly larvae	1	1	-
Chaoborus larvae	-	1	-
Chironomid larvae	2	5	1
Chironomid pupae	1	2	3
Crayfish	1	1	-
Culicoides larvae	1	1½	2
Dragonfly nymphs	1	1	1
Fingernail clams	-	1	1
Mayfly nymphs (Baetidae)	1	-	-

Table IV (Continued)

Date	May 12	May 28	June 5
Mayfly nymphs (Heptagenidae)	-	1	-
Minoow remains	1	?	-
Snails	1	-	-
Tabanid larvae	1	1	-
Terrestrial beetles	-	1	-
Unknown dipteran larvae	-	-	6
Unknown terrestrial insects	-	1	-

Table V

Percent occurance, average percent contribution to the volume of each stomach and average number in each stomach present in of various food items found in pumpkinseed stomachs from Youngs Lake, PFES, 12 May to 5 June, 1976.

Date	May 12	May 28	June 5
Number of fish sampled	10	10	10
Mean total length (mm)	117.5	123.6	123.5
Mean fork length (mm)	113.5	118.9	117.4
Mean preserved weight (g)	30.5	31.3	32.4
Sex ratio (males:females)	8:2	6:4	3:7
Mean volume food present/stomach (ml)	0.20	0.24	0.10
Percent occurance of food items:			
Empty stomachs	10	30	30
Burrowing mayfly nymps (Ephemeroptera:Ephemeridae)	30	-	-
Caddisfly larvae (Trichoptera)	30	20	-
Chaoborus larvae (Diptera:Culicidae)	20	-	10
Chironomid larvae (Diptera:Chironomidae)	40	20	20
Chironomid pupae (Diptera:Chironomidae)	30	-	-
Culicoides larvae (Diptera:Heleidae)	10	20	10
Dragonfly nymphs (Odonata)	20	10	10
Mayfly nymphs (Ephemeroptera:Baetidae)	-	10	10
Snails (Gastropoda)	20	20	30
Tabanid larvae (Diptera:Tabanidae)	10	-	-

Table V (Continued)

Date	May 12	May 28	June 5
Terrestrial beetles (Coleoptera)	-	30	30
Unknown terrestrial insects	-	10	-
Water mites (Acari)	-	-	10
Average percent volume contributed by:			
Burrowing mayfly nymphs	11.1	-	-
Caddisfly larvae	11.1	14.3	-
Chaoborus larvae	20.0	-	9.3
Chironomid larvae	20.2	15.7	5.7
Chironomid pupae	6.1	-	-
Culicoides larvae	1.7	3.6	0.7
Dragonfly nymphs	16.1	9.3	3.6
Manfly nymphs	-	2.1	12.8
Snails	2.6	15.7	33.6
Tabanid larvae	11.1	-	-
Terrestrial beetles	-	27.8	33.6
Unknown terrestrial insects	-	11.4	-
Water mites	-	-	0.7

Table V (Continued)

Date	May 12	May 28	June 5
Average number/stomach present in:			
Burrowing mayfly nymphs	1	-	-
Caddisfly larvae	1	1	-
Chaoborus larvae	8	-	5
Chironomid larvae	20	6	1½
Chironomid pupae	2	-	-
Culicoides larvae	8	1	1
Dragonfly nymphs	1	1	1
Mayfly nymphs	-	1	10
Snails	1	2	8
Tabanid larvae	1	-	-
Terrestrial beetles	-	1	1
Unknown terrestrial insects	-	4	-
Water mites	-	-	1

Table VI

Percent occurance, average percent contribution to the volume of each stomach and average number in each stomach present in of various food items found in yellow perch stomachs from Youngs Lake, PFES, 12 May to 6 July, 1976.

Date	May 12	May 28	June 5	July 6
Number of fish sampled	10	10	10	2
Mean total length (mm)	273.5	165.3	188.0	282.0
Mean fork length (mm)	265.4	159.1	180.9	272.5
Mean preserved weight (g)	203.0	46.5	76.0	251.0
Sex ratio (males:females)	7:3	9:1	10:0	2:0
Mean volume food present/stomach (ml)	0.31	0.14	0.17	0.00
Percent occurance of food items:				
Empty stomachs	60	30	70	100
Caddisfly larvae (Trichoptera)	-	10	-	-
Chironomid larvae (Diptera:Chironomidae)	-	30	10	-
Chironomid pupae (Diptera:Chironomidae)	-	20	-	-
Crayfish (Decapoda	-	-	10	-
Minnow remains	40	10	10	-

Table VI (Continued)

Date	May 12	May 28	June 5	July 6
Average percent volume contributed by:				
Caddisfly larvae	-	14.3	-	-
Chironomid larvae	-	42.8	33.3	-
Chironomid pupae	-	28.6	-	-
Crayfish	-	-	33.3	-
Minnow remains	100	14.3	33.3	-
Average number/stomach present in:				
Cuddisfly larvae	-	1	-	-
Chironomid larvae	-	1	10	-
Chironomid pupae	-	1	-	-
Crayfish	-	-	1	-
Minnow remains	?	?	?	-

Table VII

Percent occurance, average percent contribution to the volume of each stomach and average number in each stomach present in of various food items found in white sucker stomachs from Lac Tassell, Quebec, 18 May to 26 August, 1976.

Date	May 18 (-13)	May 31 (-0)	June 4 (+4)	June 8 (+8)	June 17 (+17)	July 15 (+45)	Aug. 26 (+86)
Number of fish sampled	20	10	10	17	20	20	20
Mean total length (mm)	345.3	268.5	281.9	353.6	276.7	389.9	342.4
Mean fork length	320.8	252.0	263.1	334.0	261.1	368.1	316.4
Mean preserved weight (g)	-	304.6	289.2	553.9	284.7	-	440.4
Sex ratio (males:females:immatures)	14:6:0	3:4:3	5:4:1	4:13:0	18:2:0	5:10:0	12:7:1
Mean volume food present/stomach (ml)	2.62	1.25	3.45	4.27	2.15	1.11	1.62
Percent occurance of food items:							
Empty stomachs	5	20	10	12	-	7	15
Aquatic beetles (Coleoptera)	-	-	-	-	10	7	-
Aquatic beetle larvae (Coleoptera)	5	-	-	6	5	7	-
Amphipods (Amphipoda)	5	10	-	-	-	-	-
Alderfly larvae (Megaloptera:Sialidae)	-	20	50	76	10	13	5
Burrowing mayfly nymphs (Ephemeroptera:Ephemeridae)	15	-	90	82	20	7	-
Caddisfly larvae (Trichoptera)	10	30	20	71	-	7	-
Chaoborus larvae (Diptera:Culicidae)	10	40	-	-	-	-	-
Chaoborus pupae (Diptera:Culicidae)	-	20	-	65	-	-	-
Chironomid larvae (Diptera:Chironomidae)	20	40	30	47	100	67	45
Chironomid pupae (Diptera:Chironomidae)	5	-	-	6	35	13	30
Cladocerans (Cladocera)	90	40	-	6	-	-	55
Copepods (Copepoda)	5	-	-	-	-	27	20
Culicoides larvae (Diptera:Heleidae)	10	40	20	18	75	47	10
Damselfly nymphs (Odonata:Zygoptera)	5	-	-	6	-	-	-
Dragonfly nymphs (Odonata:Anisoptera)	-	20	10	6	10	-	10
Fish eggs	5	-	-	-	-	-	-

Table VII (Continued)

Date	May 18 (-13)	May 31 (-0)	June 4 (+4)	June 8 (+8)	June 17 (+17)	July 15 (+45)	Aug. 26 (+86)
Fingernail clams (Pelecypoda:Sphaeridae)	-	-	-	-	5	33	5
Mayfly nymphs (Ephemeroptera:Baetidae)	5	-	-	18	-	-	-
Mayfly nymphs (Ephemeroptera:Heptagenidae)	-	-	60	18	-	-	-
Snails (Gastropoda)	5	20	-	6	45	40	25
Unidentified aquatic insects	5	-	-	-	-	-	-
Water boatmen (Hemiptera:Corixidae)	-	-	-	6	-	-	-
Water mites (Acari)	-	-	-	-	-	-	5
Average percent volume contributed by:							
Aquatic beetles	-	-	-	-	1.8	1.1	-
Aquatic beetle larvae	0.5	-	-	0.7	0.5	1.4	-
Amphipods	0.2	2.5	-	-	-	-	-
Alderfly larvae	-	5.0	11.2	16.3	2.8	6.4	0.9
Burrowing mayfly nymphs	4.2	-	69.9	33.9	4.9	4.3	-
Caddisfly larvae	1.0	7.5	2.8	20.7	-	0.4	-
Chaoborus larvae	4.7	35.0	-	-	-	-	-
Chaoborus pupae	-	1.2	-	12.1	-	-	-
Chironomid larvae	4.5	15.8	3.6	11.1	63.2	27.5	20.0
Chironomid pupae	0.3	-	-	0.1	4.5	1.8	5.2
Cladocerans	78.4	23.1	-	0.1	-	-	45.6
Copepods	3.9	-	-	-	-	21.4	12.4
Culicoides larvae	0.4	1.8	0.3	0.4	5.4	3.9	3.0
Damselfly nymphs	0.3	-	-	0.7	-	-	-
Dragonfly nymphs	-	6.9	0.6	1.0	4.8	-	2.0
Fish eggs	0.3	-	-	-	-	-	-
Fingernail clams	-	-	-	-	0.2	13.1	0.3

Table VII (Continued)

Date	May 18 (-13)	May 31 (-0)	June 4 (+4)	June 8 (+8)	June 17 (+17)	July 15 (+45)	Aug. 26 (+86)
Mayfly nymphs (Baetidae)	0.5	-	-	1.3	-	-	-
Mayfly nymphs (Heptagenidae)	-	-	11.7	1.3	-	-	-
Snails	0.5	1.2	-	0.1	12.1	18.0	10.3
Unidentified aquatic insects	0.3	-	-	-	-	-	-
Water boatmen	-	-	-	0.2	-	-	-
Water mites	-	-	-	-	-	-	0.3
Average number/stomach present in:							
Aquatic beetles	-	-	-	-	1	1	-
Aquatic beetle larvae	10	-	-	1	1	3	-
Amphipods	5	5	-	-	-	-	-
Alderfly larvae	-	1	6	6	1	2½	1
Burrowing mayfly nymphs	1	-	11	4½	1	2	-
Caddisfly larvae	4	3	4	10	-	1	-
Chaoborus larvae	~250	~375	-	-	-	-	-
Chaoborus pupae	-	5	-	14	-	-	-
Chironomid larvae	9	24	7	24	~80	26	11
Chironomid pupae	3	-	-	1	4	3	1½
Cladocerans	~1100	~600	-	1	-	-	~400
Copepods	~1000	-	-	-	-	~1500	~300
Culicoides larvae	2½	3	2	3	7	7	1
Damselfly nymphs	2	-	-	1	-	-	-
Dragonfly nymphs	-	2	1	1	1½	-	2½
Fish eggs	10	-	-	-	-	-	-
Fingernail clams	-	-	-	-	1	26	1
Mayfly nymphs (Baetidae)	6	-	-	1	-	-	-
Mayfly nymphs (Heptagenidae)	-	-	3	1	-	-	-
Snails	1	1½	-	1	7	5	9
Unidentified aquatic insects	1	-	-	-	-	-	-
Water boatmen	-	-	-	1	-	-	-
Water mites	-	-	-	-	-	-	1

Table VIII

Percent occurrance, average percent contributed to the volume of each stomach and average number in each stomach present in of various food items found in smallmouth bass stomachs from Lac Tassel, Quebec, 18 May to 26 August, 1976

Date	May 18-30 (-13 to -1)	June 1-3 (+1 to +3)	June 8 (+8)	June 18-22 (+18 to +22)	June 14 (+44)	Aug. 26 (+86)
Number of fish sampled	2	8	2	19	2	9
Mean total length (mm)	247.5	229.6	246.0	250.1	305.0	223.7
Mean fork length	241.0	223.6	235.0	240.3	288.0	212.3
Mean preserved weight (g)	196.5	206.6	252.5	-	-	160.6
Sex ratio (males:females:immatures)	2:0:0	5:3:0	2:0:0	11:4:4	0:2:0	7:1:1
Mean volume food present/stomach (ml)	0.1	5.21	0.80	0.75	0.00	0.34
Percent occurance of food items:						
Empty stomachs	50	-	-	26	100	33
Adult dragonfly (Odonata)	-	-	-	5	-	-
Adult Midges (Diptera:Chironomidae)	-	-	-	10	-	11
Burrowing mayfly nymphs (Ephemeroptera:Ephemeridae)	-	75	50	16	-	-
Cladocerans (Cladocera)	-	-	-	-	-	44
Chaoborus larvae (Diptera:Culicidae)	-	12	-	-	-	-
Chaoborus pupae (Diptera:Culicidae)	-	38	-	-	-	22
Chironomid larvae (Diptera:Chironmidae)	-	-	50	-	-	-
Chironomid pupae (Diptera:Chironomidae)	-	-	-	5	-	-
Damselfly nymphs (Odonata:Zygoptera)	-	50	-	-	-	-
Dragonfly nymphs (Odonata:Anisoptera)	-	62	-	-	-	-
Flying ants (Hymenoptera)	50	-	-	16	-	-
Minnows	-	-	-	5	-	11
Mayfly nymphs (Ephemeroptera:Baetidae)	-	25	-	-	-	-
Mayfly nymphs (Ephemeroptera:Heptagenidae)	-	62	-	-	-	-
Spiders (Arachnida)	-	-	-	5	-	-
Smallmouth bass fry	-	-	-	5	-	-
Terrestrial beetles (Coleoptera)	-	-	50	47	-	-
Unidentified flying insects	-	12	50	26	-	-
Unidentified terrestrial insects	-	-	50	-	-	22
Water mites (Acari)	-	-	50	-	-	-

Table VIII (Continued)

Date	May 18-30 (-13 to -1)	June 1-3 (+1 to +3)	June 8 (+8)	June 18-22 (+18 to +22)	June 14 (+44)	Aug. 26 (+86)
Average percent volume contributed by:						
Adult dragonflies	-	-	-	2.8	-	-
Adult midges	-	-	-	4.3	-	3.3
Burrowing mayfly nymphs	-	24.4	40.0	3.6	-	-
Cladocerans	-	-	-	-	-	45.8
Chaoborus larvae	-	0.1	-	-	-	-
Chaoborus pupae	-	8.1	-	-	-	-
Chironomid larvae	-	-	2.5	-	-	-
Chironomid pupae	-	-	-	2.8	-	4.2
Damselfly nymphs	-	3.4	-	-	-	-
Flying ants	100	-	-	12.8	-	-
Minnows	-	-	-	7.1	-	16.7
Mayfly nymphs (Baetidae)	-	2.5	-	-	-	-
Mayfly nymphs (Heptagenidae)	-	24.0	-	-	-	-
Spiders	-	-	-	0.4	-	-
Smallmouth bass fry	-	-	-	1.4	-	-
Terrestrial beetles	-	-	5.0	47.1	-	-
Unidentified flying insects	-	1.9	25.0	17.5	-	-
Unidentified terrestrial insects	-	-	25.0	-	-	30.0
Water mites	-	-	2.5	-	-	-

Table VIII (Continued)

Date	May 18-30 (-13 to -1)	June 1-3 (+1 to +3)	June 8 (+8)	June 18-22 (+18 to +22)	July 14 (+44)	Aug. 26 (+86)
Average number/stomach present in:						
Adult dragonflies	-	-	-	1	-	-
Adult midges	-	-	-	1	-	1
Burrowing mayfly nymphs	-	11	?	1	-	-
Cladocerans	-	-	-	-	-	~110
Chaoborus larvae	-	5	-	-	-	-
Chaoborus pupae	-	~45	1	-	-	-
Chironomid larvae	-	-	1	-	-	-
Chironomid pupae	-	-	-	1	-	3
Damselfly nymphs	-	6	-	-	-	-
Dragonfly nymphs	-	8	-	-	-	-
Flying ants	1	-	-	2	-	-
Minnows	-	-	-	1	-	3
Mayfly nymphs (Baetidae)	-	5	-	-	-	-
Mayfly nymphs (Heptagenidae)	-	18	-	-	-	-
Spiders	-	-	-	1	-	-
Smallmouth bass fry	-	-	-	9	-	-
Terrestrial beetles	-	-	1	2	-	-
Unidentified flying insects	-	?	?	3	-	-
Unidentified terrestrial insects	-	-	?	-	-	3
Water mites	-	-	1	-	-	-

Table IX

Percent occurance, average percent contribution to the volume of each stomach and average number in each stomach present in of various food items found in yellow perch stomachs from Lac Tassel, Quebec, 18 May to 26 August, 1976.

Date	May 18 (-13)	May 31 (-0)	June 4 (+4)	June 8 (+8)	July 15 (+45)	Aug. 26 (+86)
Number of fish sampled	7	11	13	23	2	20
Mean total length (mm)	143.3	198.4	210.5	210.7	210.0	160.0
Mean fork length	138.1	191.9	201.3	203.2	200.0	153.0
Mean preserved weight (g)	42.3	96.1	124.2	124.2	109.0	46.0
Sex ratio (males:females)	7:0	7:1	10:3	14:9	1:1	7:13
Mean volume food present /stomach (ml)	0.68	0.51	1.21	0.14	0.05	0.01
Percent occurance of food items:						
Empty stomachs	29	-	15	48	50	80
Burrowing mayfly nymphs (Ephemeroptera:Ephemeridae)	29	-	85	48	50	-
Caddisfly larvae (Trichoptera)	-	18	15	13	-	-
Chaoborus larvae (Diptera:Culicidae)	43	91	-	-	-	-
Chaoborus pupae (Diptera:Culicidae)	-	73	-	4	-	-
Chironomid larvae (Diptera:Chironomidae)	14	-	-	-	-	-
Chironomid pupae (Diptera:Chironomidae)	14	9	-	-	-	-
Cladocerans (Cladocera)	29	36	-	-	-	20
Copepods (Copepoda)	-	-	-	-	-	5
Dragonfly nymphs (Odonata:Anisoptera)	-	9	15	4	-	-
Mayfly nymphs (Ephemeroptera:Baetidae)	14	-	-	-	-	-
Mayfly nymphs (Ephemeroptera:Heptagenidae)	29	-	8	-	-	-
Unidentified flying insects	-	-	-	4	-	-

Table IX (Continued)

Date	May 18 (-13)	May 31 (-0)	June 4 (+4)	June 8 (+8)	July 15 (+45)	Aug. 26 (+86)
Average percent volume contributed by:						
Burrowing mayfly nymphs	21.0	-	87.3	85.8	100	-
Caddisfly larvae	-	3.6	2.3	2.9	-	-
Chaoborus larvae	54.0	50.4	-	-	-	-
Chaoborus pupae	-	27.3	-	0.4	-	-
Chironomid larvae	1.0	-	-	-	-	-
Chironomid pupae	1.0	0.4	-	-	-	-
Cladocerans	5.0	9.1	-	-	-	78.8
Copepods	-	-	-	-	-	21.2
Dragonfly nymphs	-	9.1	9.5	8.3	-	-
Mayfly nymphs (Baetidae)	8.0	-	-	-	-	-
Mayfly nymphs (Heptagenidae)	10.0	-	0.9	-	-	-
Unidentified flying insects	-	-	-	2.5	-	-
Average number/stomach present in:						
Burrowing mayfly nymphs	1	-	10	3	1	-
Caddisfly larvae	-	1	1½	2	-	-
Chaoborus larvae	~230	37	-	-	-	-
Chaoborus pupae	-	40	-	1	-	-
Chironomid larvae	1	-	-	-	-	-
Chironomid pupae	7	1	-	-	-	-
Cladocerans	~250	~270	-	-	-	6
Copepods	-	-	-	-	-	~140
Dragonfly nymphs	-	1	1½	1	-	-
Mayfly nymphs (Baetidae)	2	-	-	-	-	-
Mayfly nymphs (Heptagenidae)	1½	-	1	-	-	-
Unidentified flying insects	-	-	-	1	-	-