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THE EFFECTS OF AN AERIAL APPLICATION OF THE ORGANOPHOSPHATE INSECTICIDE FENITROTHION ON THE ECOLOGY OF NATIVE FISH SPECIES IN A SMALL QUEBEC LAKE

by

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Thesis submitted to the School of Graduate Studies of the University of Ottawa in partial fulfillment of the requirements for the degree of Master of Science

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ABSTRACT

Fenitrothion was applied as an emulsion in water to a small lake at the rate of 420 g active ingredient per hectare. Peak residues of 21.6 µg/ℓ were present in surface waters one hour after treatment, but rapidly dispersed throughout the lake, with complete mixing within the epilimnion after 12 hours and maximum penetration into the hypolimnion (2.14 µg/ℓ) after 24 hours. All fish species in the lake rapidly accumulated fenitrothion residues with each species accumulating distinctly different residue levels. The highest residue found in each species was 1.01 µg/g in white suckers, *Catastomus commersoni* (Lacépède), 0.76 µg/g in fallfish, *Semotilus corporalis* (Mitchill), 0.44 µg/g in brown bullheads, *Ictalurus nebulosus* (Lesueur), and 0.34 µg/g in smallmouth bass, *Micropterus dolomieu* Lacépède. Rapid loss of accumulated residues was seen in all species except white suckers.

The fenitrothion application had little effect on populations of fish food organisms or on the diet of native fish species, with the possible exception of cladoceran populations and their contribution to the diets of planktivorous fish species.

Static bioassays in the laboratory gave 24 to 96 hour LC50 values between 1.2 and 5.4 mg/ℓ fenitrothion for seven species representing five families. Sensitivity to fenitrothion followed family lines with Salmonidae (trout) the most susceptible family and Ictaluridae (catfish) and Cyprinidae (minnows) the least sensitive.

The results of the field and laboratory studies carried out indicate that fenitrothion applied at dosages registered for forest insect control does not appear to present a serious hazard to native fish populations in lakes exposed to aerial applications.

RÉSUMÉ

L'eau d'un petit lac a été traitée avec une émulsion de fénitrothion à la dose de 420 g d'ingrédient actif par hectare. Les résidus étaient en concentration maximale (21.6 µg/ℓ) dans les eaux superficielles une heure après le traitement mais se sont dispersés rapidement dans tout le lac, atteignant mixtion totale dans l'épilimnion après 12 heures et une pénétration maximale dans l'hypolimnion (2.14 µg/ℓ) après 24 heures. Ils se sont rapidement accumulés dans toutes les espèces de poisson du lac à des concentrations variant selon l'espèce. La plus forte teneur trouvée chez chaque espèce a été 1.01 µg/g chez le catostome noir, *Catastomus commersoni* (Lacépède); 0.76 µg/g chez l'ouitouche, *Semotilus corporalis* (Mitchill); 0.44 g/g chez la barbotte brune, *Ictalurus nebulosus* (Lesueur); et 0.34 µg/g chez l'achigan à petite bouche, *Micropterus dolomieu* (Lacépède). Toutefois les résidus ont disparu rapidement chez toutes les espèces sauf le catostome noir.

L'épandage du fénitrothion a eu peu d'effets sur les populations servant de nourriture aux poissons ou sur le régime alimentaire des espèces de poissons indigènes, sauf peut-être dans les cas des populations de cladocères et de leur contribution à l'alimentation des espèces de poissons planctivores.

La CL_{50} mesurée en laboratoire en conditions statiques après une période de 24 à 96 heures a varié entre 1.2 et 5.4 mg/ℓ de fénitrothion pour sept espèces représentant cinq familles. La sensibilité des espèces suivait des tendances familiales, les Salmonidae (truites) étant les plus sensibles, et les Ictaluridae (barbottes et barbues) et les Cyprinidae (cyprins), les moins.

Les résultats des études sur le terrain et en laboratoire indiquent que les épandages aériens de fénitrothion sur les lacs aux doses employées dans la lutte contre les insectes des forêts, ne semblent pas représenter un danger grave pour les populations de poissons indigènes.

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A. The History of Forest Pest Control Practices in Canada

Large scale forest spraying to control forest pests has been carried out in Canada since 1952, when spruce budworm, *Choristoneura fumiferana* (Clem.) control programs were initiated in New Brunswick. From the earliest days of aerial forest spraying, concern has been expressed about the effects of these programs upon aquatic fauna living in streams, rivers and lakes within the treated areas. A great number of experimental and monitoring programs have been conducted to study the effects of the applied insecticides on fish and aquatic invertebrates (recently reviewed by Kingsbury, 1975). The nature and focus of these studies have shifted as the application procedures and insecticides used in pest control programs have changed.

Early large scale forest spraying in Canada was carried out using Boeing Stearman aircraft and applying the chlorinated (aryl) hydrocarbon insecticide 1,1,1-trichloro-2,2-bis (*p*-chlorophenyl) ethane (DDT). These small biplanes had a carrying capacity of only 568 litres (150 U.S. gallons) of formulated insecticide per load. Increased size and scope of control operations led to the introduction in 1956 of Grumman Avenger (TBM) aircraft which could treat much larger blocks of forest with their 3180 litre (840 U.S. gallon) maximum capacity. The aircraft maintained their swath track positioning by marking systems (balloons, flags, smoke, etc.) established on the ground and in later years by the use of "pointer" aircraft flying above the spray plane (Randall, 1972). These guidance systems lacked precision but made it possible to avoid directly introducing insecticides into lakes and large rivers. Unsprayed boundary areas could be maintained around the edges of the lakes and rivers and the pilot could shut off

spray when crossing major streams visible from the air (Crouter and Vernon, 1959). For these reasons, undesirable insecticide effects were limited to the fish and aquatic invertebrates living in forest streams, and aquatic monitoring studies were confined to these ecosystems and their fauna.

The use of DDT in forest insect control programs was known to have adverse effects on the fish and invertebrate life of forest streams (Crouter and Vernon 1959, Kerswill 1967). This led to the introduction of organophosphate insecticides, which had been found to be considerably less toxic to fish. In 1968, the use of DDT in operational control programs against forest insects was discontinued. Since 1968, the principle insecticide applied to Canadian forests has been the organophosphate fenitrothion (O,O-dimethyl O-(4-nitro-m-tolyl) phosphorothioate).

In 1967 a spruce budworm infestation broke out in Quebec and rapidly spread to encompass millions of acres by 1969. In order to economically control the damage threatened by this outbreak, four-engined spray aircraft were developed capable of applying 15,140 litre (4000 U.S. gallon) loads and utilizing inertial guidance systems. Calibration trials showed that these aircraft could deposit spray formulation over a 914 m (3000 ft.) swath, with measurable deposit occurring as far as 2.2 km (1.4 miles) downwind of the aircraft's flight path (Randall and Zylstra, 1972). In 1972, Douglas DC-7B aircraft flying at 370 km/h (230 mph) along parallel swath tracks 914 m (3000 ft.) apart were used to spray budworm infested forests in Quebec. Since then, large multi-engine aircraft of several types have been used to apply insecticides to millions of acres of forest in Quebec and New Brunswick. The necessity of flying these aircraft over the forest at high speed along straight lines and the great width of their deposit swath make it impossible to avoid introducing insecticide directly into small lakes present in the treated

areas. This has opened up a new area of concern over possible effects of forest spraying on aquatic fauna.

B. Insecticides in Lakes

Few studies have been carried out on the effects of insecticides in lakes, as they have never before been directly applied to lakes in such a widescale manner. Most of the studies which have been carried out have been aimed at studying the persistence, distribution and long term effects of chlorinated hydrocarbon insecticide residues accumulating in lakes (e.g. Hunt and Bischoff 1960, Hunt and Keith 1963, Hickey *et al* 1966, Hannon *et al* 1970). Only a few studies have reported the acute effects of insecticides applied directly to lakes. Shane (1948) reported the upset of the biological balance in a reservoir caused by toxic effects of aerially applied DDT on zooplankton. Murphy and Chandler (1948) and Lindquist and Roth (1950) reported the effects on plankton, littoral fauna and fish of 1,1-dichloro-2, 2 bis (*p*-chlorophenyl) ethane (TDE) applied directly to lakes to control gnat larvae, *Chaoborus astictopus* Dyar and Shannon.

There are a few reports of fish mortality in Canadian lakes attributed to forest pest control operations. Mortality among salmonid and cyprinid fish in lakes was observed following DDT spraying in New Brunswick in 1952, 1953 and 1954 (Kerswill and Edwards, 1967). Crouter and Vernon (1959) reported some trout mortality in lakes resulting from DDT spraying against western black-headed budworm, *Acleris gloverana* (Wals.), on Northern Vancouver Island in 1957. Aside from these early incidents, there was little indication of forest pest control operations having direct effects on lake fauna until the inception of spraying with four-engined aircraft. In 1973, brook trout, *Salvelinus fontinalis* (Mitchill), mortality in a small Quebec lake was attributed to fenitrothion spraying from large aircraft

(Kingsbury, 1973). This incident and other reports of fish mortality within fenitrothion treated areas pointed out the need to study the effects of this insecticide on the ecology of the fish population of small lakes.

C. Fenitrothion in Aquatic Systems

Fenitrothion and other organophosphorus insecticides inhibit cholinesterase activity within animal nervous systems, preventing the hydrolysis of acetylcholine at the postsynaptic membrane (Fest and Schmidt, 1973). This prevents the return of the synapse to its resting state following nerve transmission, with the result that nervous function is seriously impaired. Details of the manufacture, use, toxicology and chemistry of fenitrothion have been compiled by Krehm (1973) and the National Research Council Associate Committee on Scientific Criteria for Environmental Quality (1975). The structure of fenitrothion and some of its metabolites mentioned in the text are illustrated in Fig. 1.

a. Toxic effects on fish

Most toxicological studies of fenitrothion with fish have used salmonid fish as test species. Twenty-four hour LC50's (concentrations lethal to 50% of the test organisms exposed to the toxicant for 24 hours) have been determined to be 7.4 mg/ℓ for young Atlantic salmon, *Salmo salar* L., (Wildish *et al* 1971) and 4.0 mg/ℓ for rainbow trout, *Salmo gairdneri* Rich., (Klaverkamp *et al* 1975). Bull (1971) found the 96 hr. LC50 of fenitrothion to be 1.3 mg/ℓ for juvenile coho salmon, *Oncorhynchus kisutch* Walbaum, while the corresponding value for Atlantic salmon parr was reported as 1.0 mg/ℓ (Hatfield and Anderson, 1972). No values have been published for the toxicity of fenitrothion to other families of fish, but Macek and McAllister (1970) reported that for fenitrothion the relative susceptiblity of an ictalurid or cyprinid to a centrarchid is 2:1 or less. They concluded that for phosphorothioate organophosphorus insecticides in general, there is

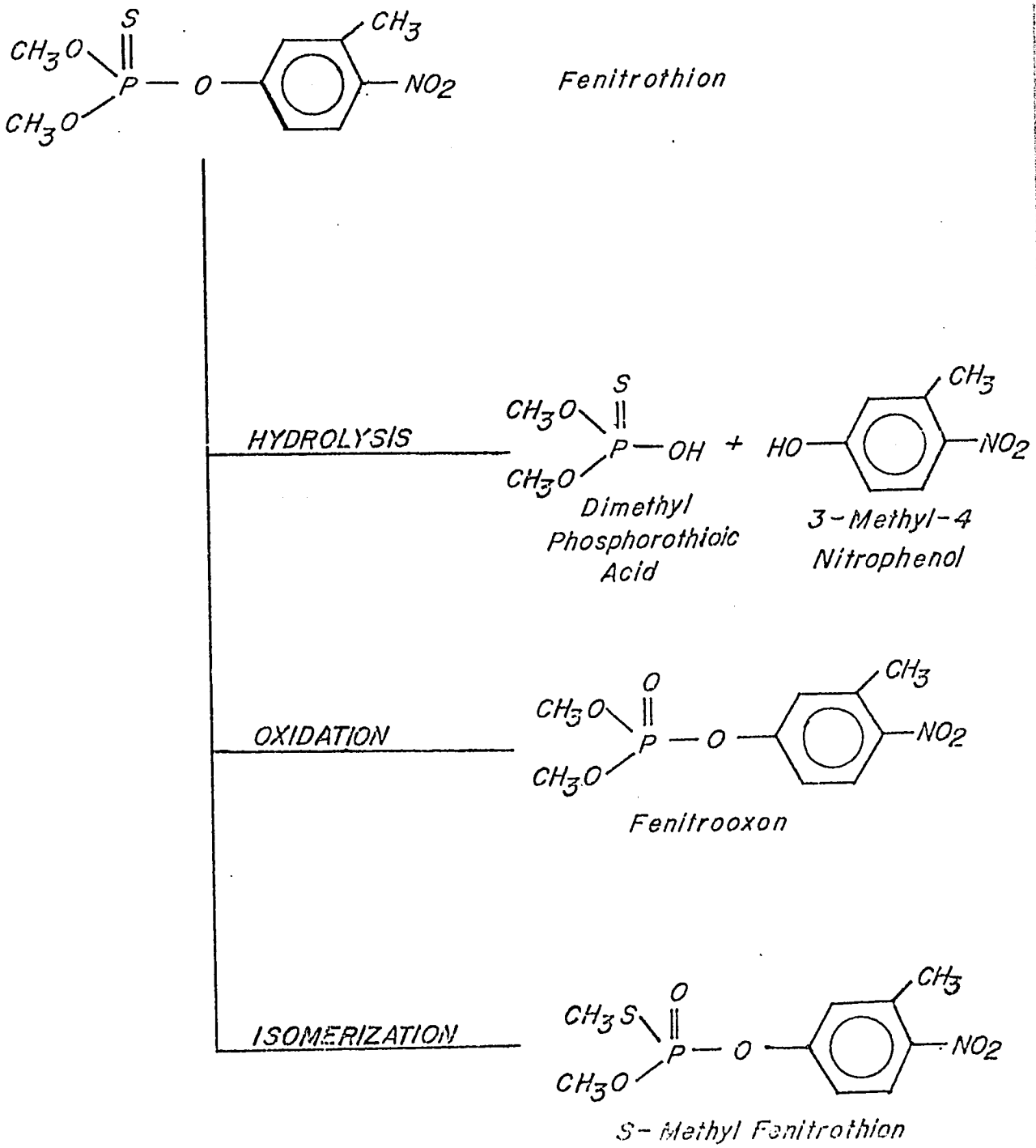

Fig. 1. Chemical structure of fenitrothion and some of its metabolites (after National Research Council Associate Committee on Scientific Criteria for Environmental Quality, 1975).

little difference in the relative susceptibilities of different fish families. S-methyl fenitrothion, a major impurity in technical fenitrothion, was reported by Zitko and Cunningham (1975) to be approximately as toxic to juvenile Atlantic salmon as fenitrothion.

Aerial application of fenitrothion at rates between 0.21 and 0.56 kg/ha have repeatedly been found to cause little or no direct mortality among caged or wild fish populations in streams (Kingsbury, 1975). Aerial spraying with fenitrothion in New Brunswick did not cause any significant change in acetylcholinesterase activity in salmon and trout, but did lower it in suckers from a treated stream (Zitko *et al* 1970). Caged rainbow trout exposed to aerially applied fenitrothion in Manitoba accumulated whole body residues as high as 1.84 µg/g without exhibiting effects on brain acetylcholinesterase activity or serum chemistry (Lockhart *et al* 1973). Hatfield and Riche (1970) reported whole body residues up to 0.77 µg/g in caged and wild salmon and brook trout from water systems in Newfoundland exposed to fenitrothion spraying. Inhibition of brain cholinesterase activity by direct exposure to fenitrothion in the laboratory has been studied with Atlantic salmon, brook trout and rainbow trout (Zitko *et al* 1970, Lockart *et al* 1973, Klaverkamp *et al* 1975). Brook trout in th laboratory fed food containing 10 mg fenitrothion/kg showed no depression of brain acetylcholinesterase activity, but a dose of 10 mg/g did depress activity of this enzyme (Wildish and Lister 1973, Wildish 1974).

b. Effects on fish behavior

The effects of sublethal exposure to fenitrothion on the behavior of salmonid fish has been studied widely. Twenty-four hour exposure of Atlantic salmon parr to 1 mg/ℓ fenitrothion completely inhibited learning (Hatfield and Johansen 1972) and increased vulnerability to predation by large brook trout (Hatfield and Anderson 1972); neither ability was affected by 24 hour

exposure to 0.1 mg/ℓ fenitrothion. Symons (1973) found that 15-16 hour exposure to 1 mg/ℓ caused a 50% decrease in the number of Atlantic salmon holding territories, with a lesser reduction (20%) following similar exposure to 0.1 mg/ℓ fenitrothion. Peterson (1976) found no singificant effect on temperature selection when juvenile Atlantic salmon were exposed to fenitrothion at 1 mg/ℓ for 24 hours. Bull and McInerney (1974) found that juvenile coho salmon suffered physiological impairment reducing most behaviors when exposed to 0.48 or 0.75 mg/ℓ fenitrothion, while at lower exposure levels (0.10 and 0.23 mg/ℓ) comfort movements increased and social behaviors and feeding decreased from normal levels. Critical swimming velocities of brook trout following exposure to 0.15, 0.5 and 1.5 mg/ℓ fenitrothion were found to be 100, 83 and 70% of the performance of control fish (Peterson 1974). Wildish and Lister (1973) found that feeding brook trout with food containing 10 mg fenitrothion/g reversed the hierarchical pattern among groups of fish as determined by food partitioning.

There is some evidence that fish avoid fenitrothion present in water or food material. Scherer (1975) found that goldfish, *Carassius auratus* (L.), avoided water containing as little as 10 µg/ℓ fenitrothion, with a larger avoidance response to higher test concentrations. Symons (1973) found that Atlantic salmon would not voluntarily eat mealworms (*Tenebrio* sp) if they had been injected with pure fenitrothion and often regurgitated such worms 8 to 12 hours after being force fed them. Brook trout were found to have a threshold for tolerance of fenitrothion in the stomach of 376 mg fenitrothion per kg of wet fish weight, above which levels regurgitation occurred (Wildish and Lister 1973).

c. Effects on fish food organisms

Some toxicological studies have been conducted with fenitrothion on various freshwater invertebrates. These have yielded the following 24 hour LC50's for the organisms listed: 0.5 to 5.0 µg/ℓ for different species of mosquito larvae; 2.0 µg/ℓ for the stonefly nymph *Acroneuria* sp.; 32 µg/ℓ for small crayfish, *Orconectes limosus*; 50 µg/ℓ for the cladoceran, *Daphnia pulex*; 66 µg/ℓ for the dragonfly nymph, *Ophiogomphus* sp.; greater than 100 µg/ℓ for the amphipod, *Gammarus locustris* and large crayfish, *O. limosus*; 186 µg/ℓ for the alderfly larva, *Nigronia serricornis*; 610 µg/ℓ for the caddisfly larva, *Pycnosyche* sp.; 40.4 mg/ℓ for the cranefly larvae, *Eriocera spinosa*; and greater than 50 mg/ℓ for the snail, *Symnaea elodos* (Wildish and Phillips 1972, Flannagan 1973, McLeese 1976). Rorke *et al* (1974) reported LD 50 values (dosage of insecticide lethal to 50% of the test organisms) of 175 µg/ℓ for fenitrothion and 140 µg/ℓ for fenitro-oxon applied directly to the foot of estivating snails, *Helix aspersa*.

Many studies have been conducted to determine the effects of fenitrothion on bottom fauna populations in streams (e.g. Flannagan 1973, Peterson and Zitko 1974, Eidt 1975, review in Kingsbury 1975). These studies have generally shown that aerial applications of fenitrothion cause increases in the drift of aquatic insects but do not seriously deplete the standing crop of benthos. Some attempts have been made to determine if the reductions in biomass of fish food caused by fenitrothion spraying are reflected in reduced fish growth. MacDonald and Penney (1968) found no difference between growth of salmon parr sampled from fenitrothion treated and control streams as measured by calculation of average condition factors. Symons and Harding (1974) found that the average early summer increase in biomass of fish and salamanders in three fenitrothion sprayed streams was

less than the average increase in two unsprayed streams. They reported this decrease in biomass to be about one-quarter the effect found in a stream where fish food was almost completely eliminated by the addition of levels of fenitrothion not lethal to fish.

Very few determinations have been made on the quantities of fenitrothion accumulated by fish food organisms. Wildish and Lister (1973) quote levels of fenitrothion in aquatic insects from treated areas ranging from 0.15 to 3.19 µg/g. Their studies show this to be 3,000 times lower than the levels of fenitrothion which must be fed to brook trout in the laboratory to produce behavioral changes. They conclude that it is unlikely that ingestion of insects killed by operational spray dosages of fenitrothion can cause direct lethal or sublethal effects in salmonids. Crayfish, *Orconectes virilis* (Hagen), caged in a fenitrothion treated stream accumulated whole body residues up to 1.37 µg/g without suffering mortality or behavioral changes (Leonhard, 1974).

d. Persistence and fate in aquatic ecosystems.

The hydrolysis of fenitrothion and the subsequent formation of 3-methyl-4-nitrophenol has been shown to proceed very slowly under environmenal conditions (Zitko and Cunningham, 1974). Despite this, fenitrothion has been found to disappear rapidly from natural waters, indicating that processes other than hydrolysis are important in its degradation. Zitko and Cunningham (1974) found a half-life of 30 to 50 hours for fenitrothion in river water and attributed this rapid disappearance to microbiological processes. Lockhart *et al* (1973) found that fenitrothion in a Pyrex® flask exposed to sunlight disappeared far more quickly (half time of less than a day) than in an aluminum foil covered flask and concluded that photodecomposition was probably an important mechanism of fenitrothion disappearance.

Sundaram (1974a) found that aerial applications of fenitrothion resulted in peak concentrations of from 22.5 to 9.0 µg/ℓ in shallow forest ponds. Half-lives of the insecticide in these ponds ranged from 0.25 to 3.5 days. Fenitrothion persisted and accumulated in surrounding conifer foliage to a small degree but not in pond surface waters (Sundaram, 1974b). The presence of trace amounts of the insecticide in pond water a year after spraying was attributed to litter fall and foliar leaching during rainfall. Concentrations of fenitrothion in flowing waters exposed to aerial applications usually peak at less than 15 µg/ℓ and diminish rapidly (Eidt and Sundaram, 1975).

II MATERIALS AND METHODS

A. Effects of Fenitrothion on Lake Fauna

a. Study site and treatment procedures

Field studies were conducted in two lakes located in Perche Township, Pontiac County, 120 km north of Ottawa, Ontario and 42 km west of Maniwaki, Quebec (Fig. 2). Lac Tassel, a small (32.4 ha) but relatively deep (maximum depth 14 m) oligotrophic lake (Fig. 3), was treated with fenitrothion. Lac Herman, a slightly smaller (25.9 ha) and shallower (maximum depth 12 m) lake (Fig. 4) about 1.6 km northeast of Lac Tassel, served as the untreated control lake. Lac Tassel has clear waters (average Secchi disc reading 3.5 m) and a wide variety of bottom types along its shoreline, changing to oozy silt in deeper portions of the lake. Shallow portions of the shoreline support dense growths of rooted aquatic plants, primarily consisting of pipewort, *Eriocaulon septagulare* Withering. Lac Herman has slightly clearer waters (average Secchi disc reading close to 4 m) but similar bottom types to Lac Tassel. The shoreline of both lakes is densely forested with stands of balsam fir, *Abies balsamea* (L.) Mill. interspersed with poplars, *Populus sps.* and occasional white pine, *Pinus strobis* L. Lac Herman can be reached by truck along logging roads but it was necessary to use an all terrain vehicle to reach Lac Tassel. Breakdown of this vehicle resulted in some disruption of the sampling regime and limited the scope of some aspects of the study.

Temperature profiles of the lakes were taken throughout the study using a thermistor with a submersible temperature probe[1]. Basic water

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[1] T-4 Marine Thermometer and P-4 Probe Hydrolab Corp., Austin, Texas.

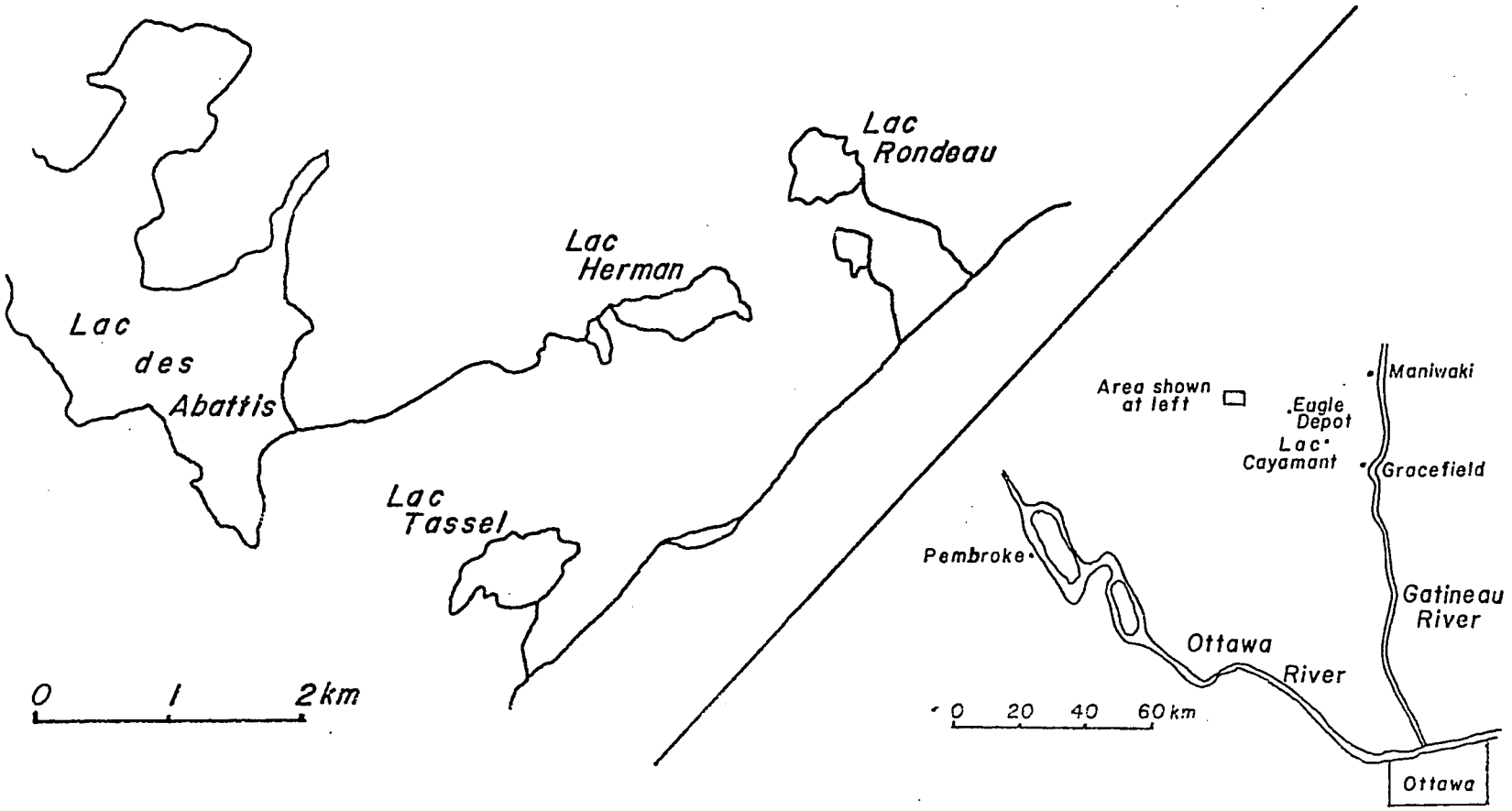

Fig. 2. Location of the study lakes.

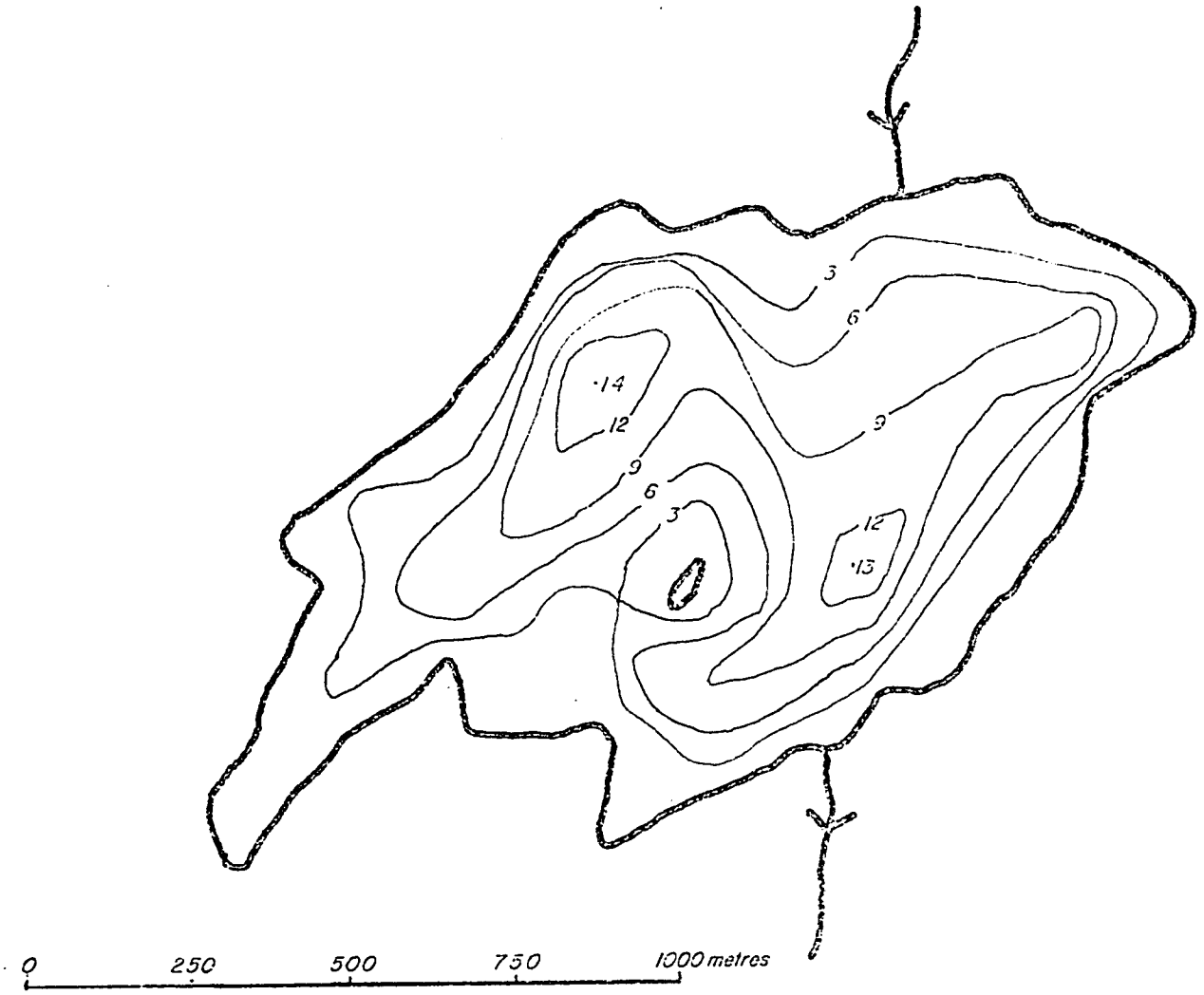

Fig. 3. Depth contours (in metres), Lac Tassel, Quebec.

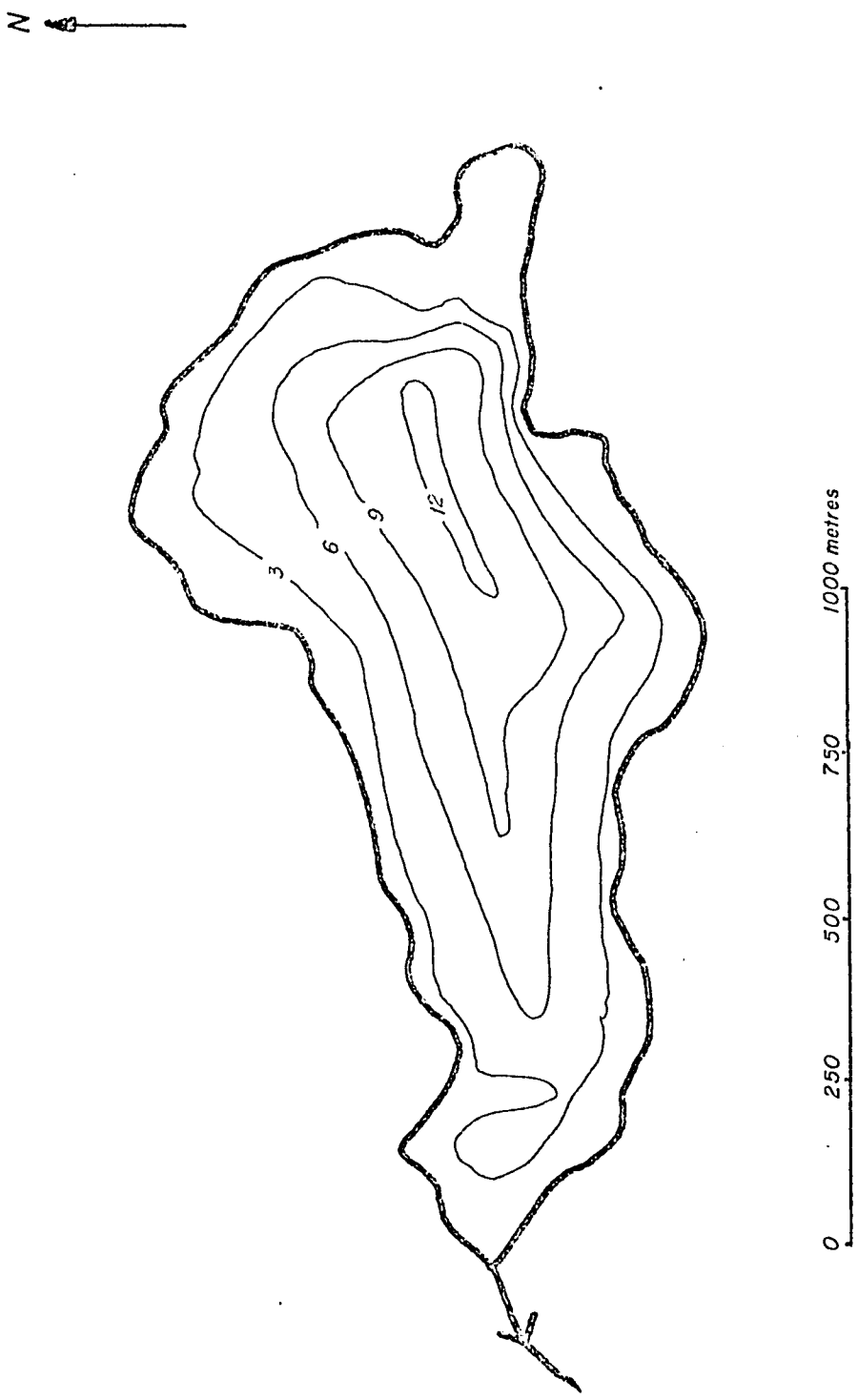

Fig. 4. Depth contours (in metres), Lac Herman, Quebec.

chemistry parameters (dissolved oxygen, pH, alkalinity, hardness) at various depths were measured by taking water samples with a Kemmer water sampler[2] and testing them with a Hach water analysis kit[3]. Portable weather instruments monitored air temperatures, atmospheric pressure, rainfall and solar radiation in the study area around the treatment date.

Fenitrothion was applied to Lac Tassel as an emulsion in water. Technical fenitrothion was mixed with an aromatic solvent (Arotex® 3470)[4] and an emulsifier (Atlox® 3409)[5] and the emulsifiable concentrate formed was mixed with water (Table 1). A small quantity of Rodamine B dye was added to the spray mixture for deposit measurement. The spray was applied to Lac Tassel at 0545 hours on 28 May, 1975 by a Cessna 185 aircraft fitted with a Micronair® spray emission system. The nominal application rate was 420 g fenitrothion/hectare (6 oz/acre) applied in 1.46 ℓ/ha (20 fl. oz/acre) formulation. This is twice the dosage of fenitrothion usually applied in forest pest control operations, where two applications of 210 g fenitrothion/ha are applied as close as four days apart.

b. Insecticide deposit and residue analysis

1. Deposit measurement

Spray deposit on the surface of the lake was measured by setting out ten deposit samplers on a line of styrofoam floats stretching across the lake perpendicular to the spray plane's line of flight. Each sampler consisted of two aluminum pans 13 x 17 x 2 cm and a 10 x 10 cm Kromekote card.

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2 Model 1220, Wildlife Supply Company, Saginaw, Michigan, U.S.A.
3 Model AL-36B. Hach Chemical Company, Ames, Texas, U.S.A.
4 Atlas Chemical Industries Inc., Wilmington, Del., U.S.A.
5 Texaco Canada Ltd., Don Mills, Ont., Canada.

Table 1

Spray formulation applied to Lac Tassel.

13.25	ℓ	Technical fenitrothion
1.32	ℓ	Arotex
1.32	ℓ	Atlox
15.89	ℓ	Fenitrothion emulsifiable concentrate
41.64	ℓ	Water
0.95	ℓ	Rodamine B dye
58.48	ℓ	Spray formulation

Fenitrothion deposit on one aluminum pan was determined by gas-liquid chromatographic (GLC) analysis. Deposited insecticide was washed from the surface of the pan in the field with two 10 mℓ aliquots of toluene which was then passed through a plug (10 g) of anhydrous sodium sulfate and stored in a brown glass bottle in a cooler until transport to the laboratory. There, the toluene was flash-evaporated to 1 mℓ and analyzed by GLC. Spray deposit on the other aluminum pan was measured by washing the dyed formulation off the pan with 5 mℓ of absolute methanol and determining the amount of dye deposited on the pan using a colorimeter. This was compared with the amount of dye in a sample of the original spray mixture to determine the proportion of emitted spray products actually deposited on the pan. The Kromekote cards were sent to the National Aeronautical Establishment where deposit on them was determined by a computerized spot-counting system (Slack, 1973).

2. Fenitrothion extraction and analysis - Water

Water samples for GLC analysis of fenitrothion residues were collected at intervals from the study lakes (Table 2). Water samples from various depths were collected with a Kemmer water sampler and poured into glass jars perviously rinsed with acetone. The Kemmer bottle was submerged in the closed position and opened underwater, in order to avoid introducing fenitrothion present in the surface film into the sampling device. Surface water samples were taken by slightly submerging a glass jar so as to collect as much of the surface film as possible. Water samples were extracted in the field by pouring 750 mℓ into a separatory funnel and mixing with 100 mℓ pesticide grade toluene. After being left to stand for two hours, the water was drained and the toluene portion passed through a plug (25 g) of

Table 2

Water samples collected from the study lakes.

	Date	Time relative to treatment	Sampling sites: Shoreline station Surface	Deep station Surface	1m	2m	4m	6m	8m
Lac Tassel	22 May, 1975	Prespray		X				X	
	28 May, 1975	+ 1 hr	X	X	X	X	X	X	
		+ 6 hr	X	X	X	X	X	X	
		+ 12 hr	X	X	X	X	X	X	
	29 May, 1975	+ 26 hr	X	X	X	X	X	X	
		+ 36 hr	X	X	X	X	X	X	
	30 May, 1975	+ 50 hr	X	X	X	X	X	X	
	31 May, 1975	+ 75 hr	X	X	X	X	X	X	
	2 June, 1975	+ 5 days	X	X	X	X	X	X	
	5 June, 1975	+ 8 days	X	X	X	X	X	X	
	12 June, 1975	+ 2 weeks	X	X	X	X	X	X	
	18 May, 1976	+ 1 year		X			X		X
Lac Herman	22 May, 1975	Prespray	X						

anhydrous sodium sulfate. The separatory funnel was rinsed with 10 mℓ of toluene and then the sodium sulfate was rinsed with an additional 40 mℓ. The toluene portion was collected in a brown glass bottle, sealed and stored in a dry ice chest for transportation back to the laboratory. There it was flash-evaporated to a small volume, transferred to a graduated centrifuge tube and adjusted to a volume of 10 mℓ for GLC analysis without further cleanup.

GLC analysis was carried out with a Hewlett-Packard model 7610A gas chromatograph (GC) fitted with a flame photometric detector. Operating parameters of the GC are given in Table 3. This method allows for identification of the parent compound, fenitrothion, and two of its metabolites, fenitrooxon and S-methyl fenitrothion. Gas chromatographs were standardized with freshly prepared solutions of analytical grade samples obtained from the Sumitomo Chemical Company, Japan.

3. Fenitrothion extraction and analysis - Animal Tissue.

Prior to treatment of Lac Tassel, native smallmouth bass, *Micropterus dolomieu* Lacépède, white suckers, *Catastomus commersoni* (Lacépêde), fallfish, *Semotilus corporalis* (Mitchill) and brown bullheads, *Ictalurus nebulosus* (Lesueur) were trap netted and held in cages along the shoreline. Freshwater clams (*Eulamellibranchia:Unionidae*) were also collected and held at the same site. Following treatment of the lake, individual fish of each species available were taken from the cages at intervals, killed, wrapped in aluminum foil and frozen on dry ice. Dead fish from the cages were also removed and kept for analysis, as were "wild" fish found dead or distressed in the lake. When no caged fish were left, "wild" fish for GLC analysis were trapped or angled from the lake wherever possible. Clams were sampled for GLC analysis by removing five live individuals from the cage, removing them from their

Table 3

Operating parameters of Hewlett-Packard 7610A gas chromatograph

Detector	FPD (P-mode)
Column:	
Length	1.83 m
Inside diameter	4 mm
Support	Chromosorb W, AW-DMCS
Mesh	80/100
Temperature:	
Injection port	240°C
Oven	195°C
Detector	175°C
Gas flow:	
Nitrogen (carrier)	1.30 ml/s
Air	2.50 ml/s
Oxygen	0.83 ml/s
Hydrogen	0.33 ml/s
Attenuation	32
Range	10^3
Chart speed	0.21 mm/s
Retention time	4.4 min. (fenitrothion)

shells, wrapping them together in aluminum foil and freezing them on dry ice. On one occasion (32 hours after treatment), a sample of clams was collected at a depth of 2 m and sealed there in a plastic bag to compare their accumulated residue level with clams from the surface cage sampled at the same time. Fish and clams sampled for residue analysis are summarized in Table 4.

Individual fish and pooled clams were weighed and fenitrothion and its metabolites extracted from them in 200 mℓ of pesticide grade ethyl acetate in a Sorvall-Omni-Mixer (5 min. at speed 6). The extract was filtered through a sharkskin filter paper and washed with an additional 25 mℓ of ethyl acetate. An aliquot of the extract was taken proportional to the extract from 5 g of animal tissue. After being passed through a plug (50 g) of anhydrous sodium sulfate into a 500 mℓ round-bottomed flask, this extract was flash-evaporated to 5 mℓ. The residue was dissolved in 25 mℓ of acetonitrile and partitioned twice with 25 mℓ of hexane. The hexane phase was discarded and the acetonitrile phase flash-evaporated to approximately 2 mℓ. The residue was transferred quantitatively to a column containing 2.5 g of an activated charcoal-Celite 545 mixture (6:4 w/w ratio) between two 5 g layers of anhydrous sodium sulfate, then eluted with 100 mℓ of 25% benzene in ethyl acetate. The eluate was then flash-evaporated to 2 mℓ for GLC analysis. Gas chromatograph operating conditions were the same as those used in analysis of residues in water.

Samples of fish tissue, water, sediment, soil and balsam fir foliage were collected at Lac Tassel on 18 May 1976, to analyze for persistent fenitrothion residues. The extraction, cleanup and analysis of residues in sediment, soil and foliage were similar to those of Yule and Duffy (1972).

Table 4

Fish and clams collected for GLC analysis from Lac Tassel

	Time relative to treatment	Caged Live	Caged Dead	"Wild"	
Smallmouth bass	15 min.			X	(Distressed)*
	6 hr.	X			
	12 hr.	X			
	26.5 hr.	X	X		
	36 hr.	X	X		
	50 hr.	X	X		
	75 hr.	X	X		
	5 days	X		X	(T)
	8 days	X		X	(A)
Fallfish	6 hr.	X			
	12 hr.	X			
	26.5 hr.	X			
	30 hr.			X	(Dead)*
	36 hr.	X			
	50 hr.	X	X	X	(T)
	75 hr.		X	X	(T)
White suckers	6 hr.	X			
	12 hr.		X		
	50 hr.			X	(T)
	75 hr.			X	(T)
	5 days			X	(T)
	1 year			X	(T)
Brown bullheads	6 hr.	X	X		
	12 hr	X	X		
	26.5 hr.		X		
	51 hr.			X	(T)
Freshwater clams	26.5 hr.	X			
	32 hr.	X		X	(Collected from 2 m)
	36 hr.	X			
	50 hr.	X			
	75 hr.	X			
	5 days	X			
	8 days	X			

* - distressed and dead wild fish were found on surface of the lake.

T - captured in a trap net.

A - caught angling with lures.

c. Biological sampling

1. Zooplankton

Zooplankton populations in the study lakes were sampled with a Schindler-Patalas plankton trap (Schindler, 1969). The trap was lowered to the desired depth and a 12ℓ water sample taken and strained through a 154 mesh to the cm straining net to capture the zooplankton present in this volume of water. On each sampling date samples were taken from the shoreline and from the surface, 4 m and 8 m at a buoy anchored at a deep station in each 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.

2. Bottom fauna and insect emergence

Bottom fauna populations were sampled with an Ekman grab which took 232 cm^2 bottom samples. Ten samples were taken from Lac Tassel on each sampling date while five were collected from Lac Herman. Samples were taken from the same portion of shoreline on each occasion and from a relatively narrow range of depths (1 to 3 m). All bottom samples were preserved with formaldehyde in the field in their entirety and organisms later separated from substrate in the laboratory with the aid of a "bubbler" (Kingsbury and Beveridge, 1977). Benthic organisms were then counted and identified to order or family.

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

3. Fish

The native 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 (1.3 to 5.1 cm^2) were run from points of attachment along the shoreline in the late afternoon and left until the following morning. Fish caught in the net were removed and preserved whole with formaldehyde. An incision was made into the abdominal cavity of each 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 representative sample of twenty fish of each species was selected for measuring, weighing, sexing and analysis of stomach contents. It was not always possible to capture twenty fish of each species for each sample and on some occasions bass and fallfish samples from gill nets were supplemented with fish caught angling with lures in order to increase the sample size. After recording the total length, fork length, preserved weight and sex of each fish the stomach and intestine were removed and preserved. Later, the contents of the digestive tract were removed, their volumes recorded and their composition determined under a dissecting microscope. The contents of only the stomach were examined for fish with distinct stomachs (smallmouth bass, brook trout, brown bullhead) but the contents of the entire digestive tract were examined for fish without a distinct stomach (white sucker, fallfish). In measuring the volume of the digestive tract contents the amount of non-food material present (ingested substrate, parasites, etc.) was estimated and the measured volume corrected accordingly so as to represent only actual volume of food items. No measurements were taken of the volume of food present in white sucker digestive tracts because of the large

proportion of non-food material present in most individual digestive tracts.

Some direct observations on native fish populations and smallmouth bass reproduction were made in Lac Tassel with the aid of scuba and snorkeling equipment.

B. Toxicity of Fenitrothion to Different Fish Species

Static bioassays were conducted in the laboratory to determine the toxicity of fenitrothion to a number of fish species native to small Quebec lakes. Groups of small fish suitable for this kind of testing were collected from a number of locations close to Ottawa, Ontario (Table 5). Pumpkinseeds, *Lepomis gibbosus* (Linnaeus), largemouth bass, *Micropterus salmoide* (Lacépède), golden shiners, *Notemigonus crysoleucas* (Mitchill), white suckers and brown bullheads were collected from ponds, creeks and rivers with a seine net. Smallmouth bass fry just off the nest were collected at Lac Tassel with a hand net. Brook trout were obtained from the Quebec Service de Pisciculture hatchery at Lac des Écorces, Quebec. All groups of fish were held in the laboratory at 19°C for a period of not less than a week before being used in bioassays.

Bioassays were carried out in 48.5 x 38.0 x 20.0 cm polycarbonate animal cages (Maryland Plastics, Inc.) in a temperature controlled room held at 19 ± 1°C. Twenty litres of water were added to each test container and left overnight before adding the toxicant and test fish. The depth of water in each tank was 12 cm with a surface area of 0.176 m^2. Fenitrothion was added to the tanks as an emulsion in water made up with Arotex and Atlox used in the same proportions as in the formulation applied to Lac Tassel. Each fish species was first tested in a logarithmic series of fenitrothion

Table 5

Fish used in fenitrothion toxicity studies

Family	Species	Collection site and date	Mean length (mm)	Mean weight (g)	Number used per test tank
Salmonidae	*Salvelinus fontinalis* (brook trout)	Lac des Écorces hatchery, Jan. 1976	115.2	13.4	5
Cyprinidae	*Notemigonus crysoleucas* (golden shiner)	Larose Forest, Aug. 1975	68.5	2.5	10
Catastomidae	*Catostomus commersoni* (white sucker)	Green Creek, Nov. 1975	77.5	4.2	5
Ictaluridae	*Ictalurus nebulosus* (brown bullhead)	Larose Forest, Aug. 1975	87.9	7.0	5
Centrarchidae	*Lepomis gibbosus* (pumpkinseed)	Larose Forest, Aug. 1975	34.8	0.4	10
	Micropterus dolomieu (smallmouth bass)	Lac Tassel, June 1976	7.0	0.02	20
	Micropterus salmoides (largemouth bass)	Ottawa River, July 1976	53.2	1.8	10

concentrations (1.0, 2.2, 4.7 and 10 mg/ℓ) with additional intermediate concentrations used where more data were needed. A control group of fish was exposed to a mixture of Arotex and Atlox equal to the amount present in the highest test concentration. After the toxicant had been added and stirred into the test tanks, from five to twenty test fish were placed in each tank in random fashion. Two tanks of five brook trout, white suckers and brown bullhead were tested at each concentration, while single tanks contained ten individuals were used for pumpkinseeds, largemouth bass and golden shiners. Twenty smallmouth bass were tested in a single tank at each fenitrothion concentration. The fish were not fed and the water was not aerated during the duration of the bioassays. Fish mortality and symptoms of poisoning were recorded 0.5, 1, 3, 6, 12, 24, 36 and 48 hours after the tests were started and at 24 hour intervals beyond this time. All dead fish were removed from the tanks at the times mortality was being recorded. All tests were run for at least 96 hours and some were extended beyond this time in cases where mortality was still occurring among surviving groups of fish.

III RESULTS

A. Field Studies

a. Water chemistry and weather data

Both Lac Herman and Lac Tassel showed an extensive degree of thermal stratification by the third week of May in 1975 (Figs. 5 and 6). Lac Herman had quite low dissolved oxygen levels in its bottom waters throughout the spring and early summer (Table 6), indicating that the lake waters did not undergo complete mixing in the period between breakup and the onset of thermal stratification. By August Lac Herman's bottom waters showed severe oxygen depletion. Dissolved oxygen levels in Lac Tassel's bottom waters decreased to a lesser extent over the summer (Table 7). Both lakes underwent complete turnover and oxygen replenishment in May of 1976.

Weather data around the treatment date are presented in Table 8. Moderate to heavy rainfall fell 64 and 94 hours after treatment of the lake. Weather conditions at the time the lake was treated were highly conducive to a heavy deposit of emitted spray products. The low air temperature (2.2°C) and high relative humidity (100%) minimized loss by evaporation, while the complete absence of wind restricted off-target drift.

b. Distribution and persistence of fenitrothion residues in Lac. Tassel.

1. Deposit

Measurement by GLC analysis and computerized spot counting show a relatively high and evenly distributed deposit of emitted spray products onto the surface of Lac Tassel (Table 9). The somewhat lower and more

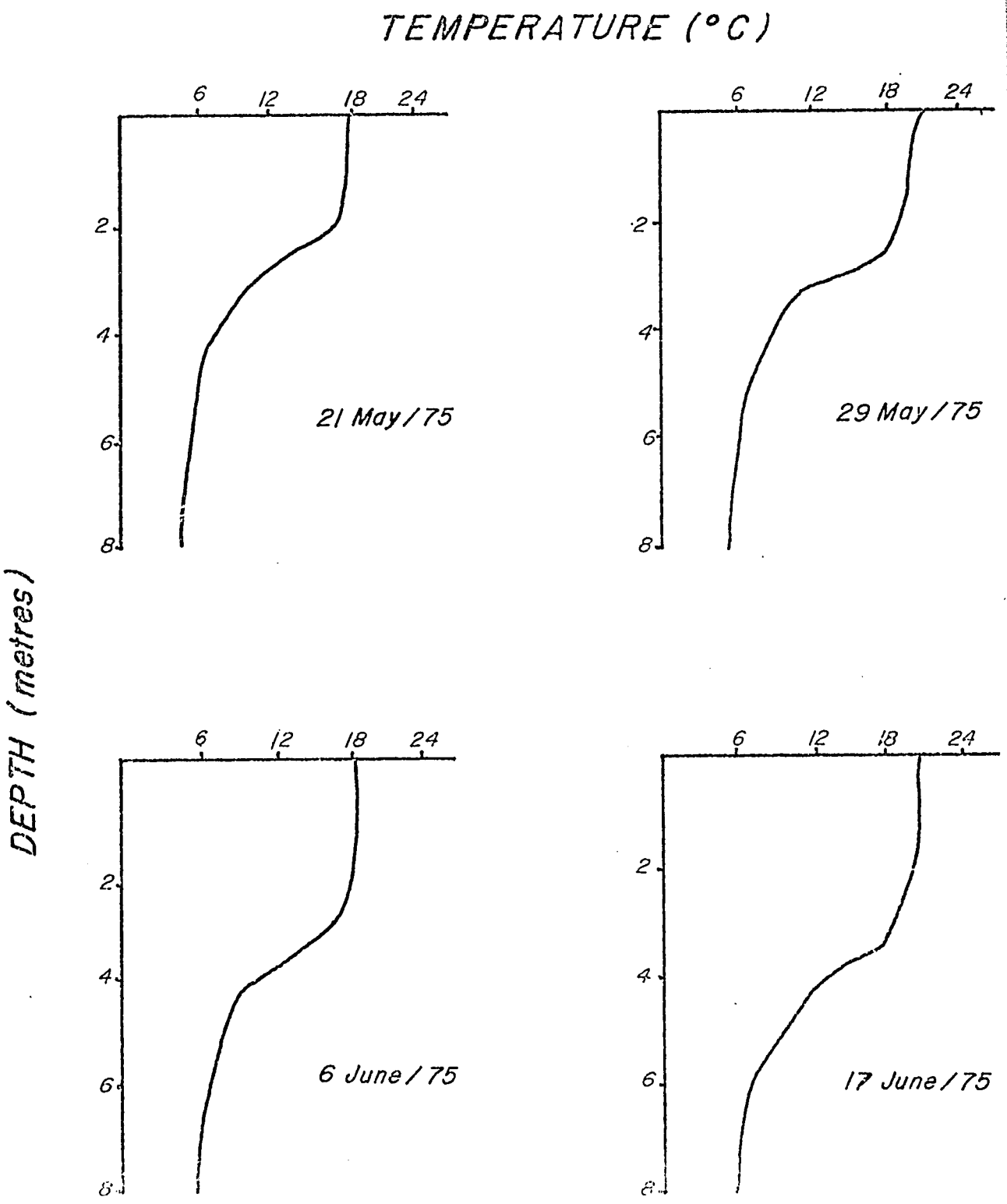

Fig. 5. Temperature profiles in Lac Herman, Quebec, May 1975 to May 1976.

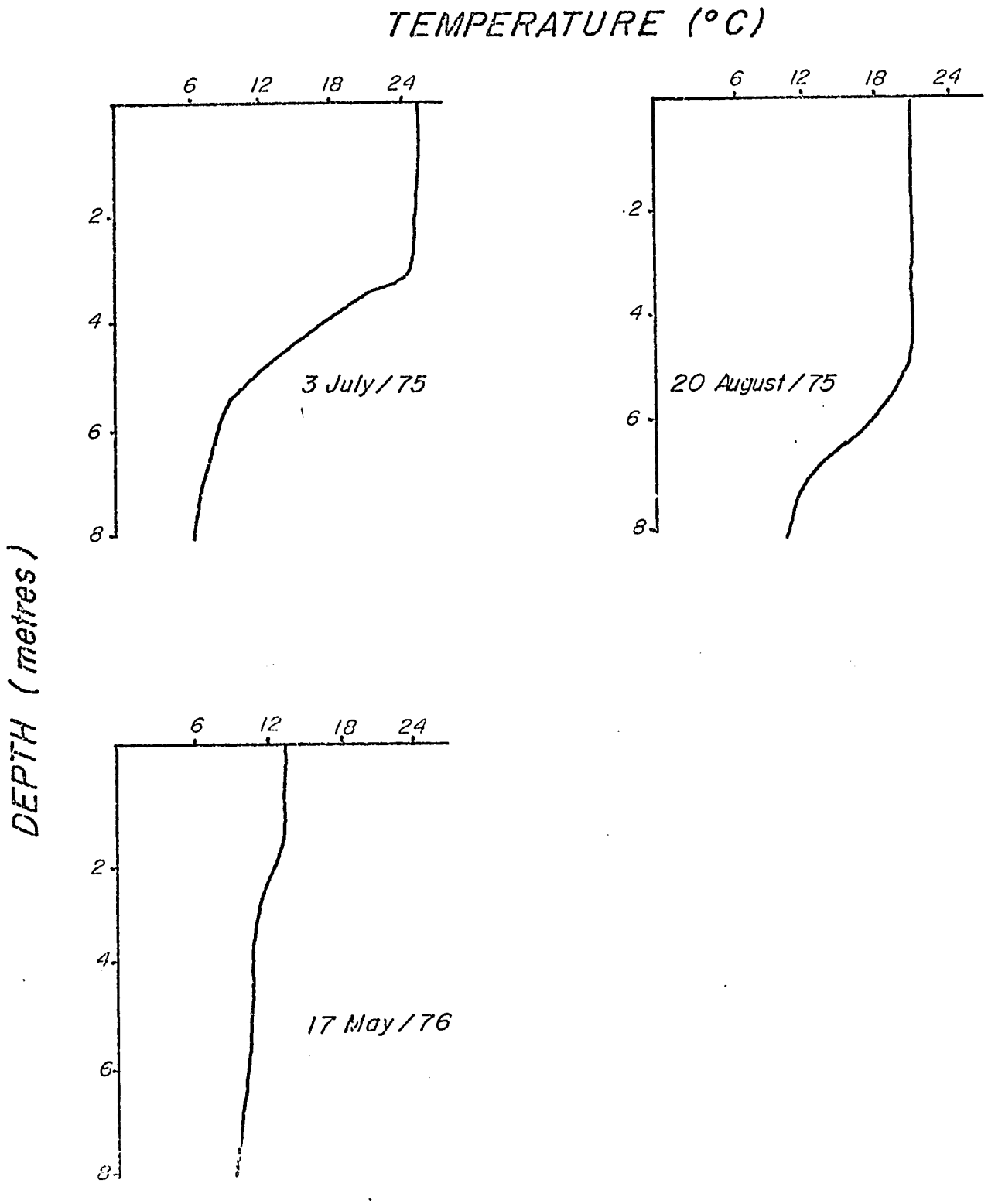
TEMPERATURE (°C)
6
12
18
24
2
4
6
8
3 July / 75
20 August / 75
17 May / 76
DEPTH (metres)

Fig. 5. (Cont'd.)

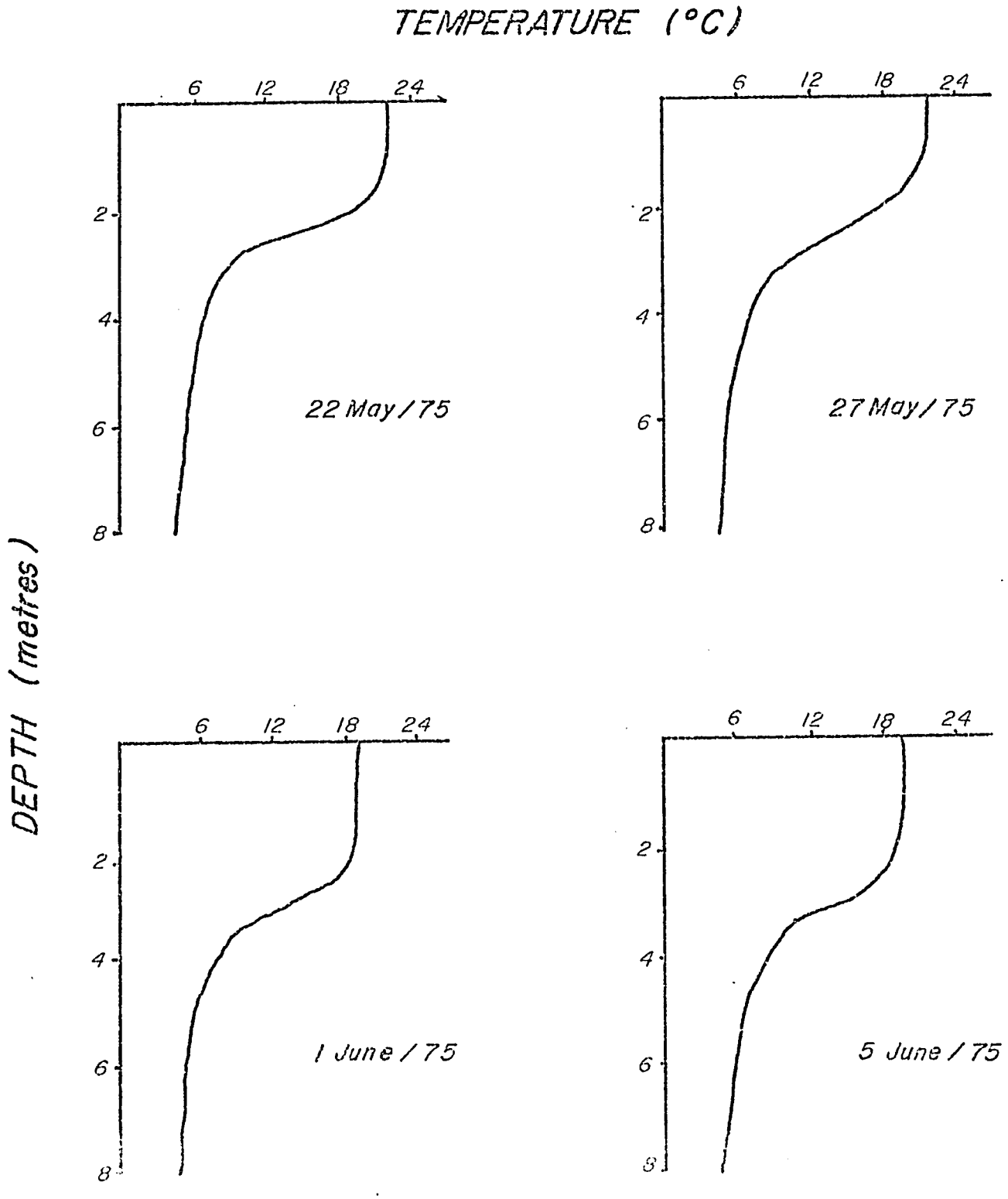

Fig. 6. Temperature profiles in Lac Tassel, Quebec, May 1975 to May 1976.

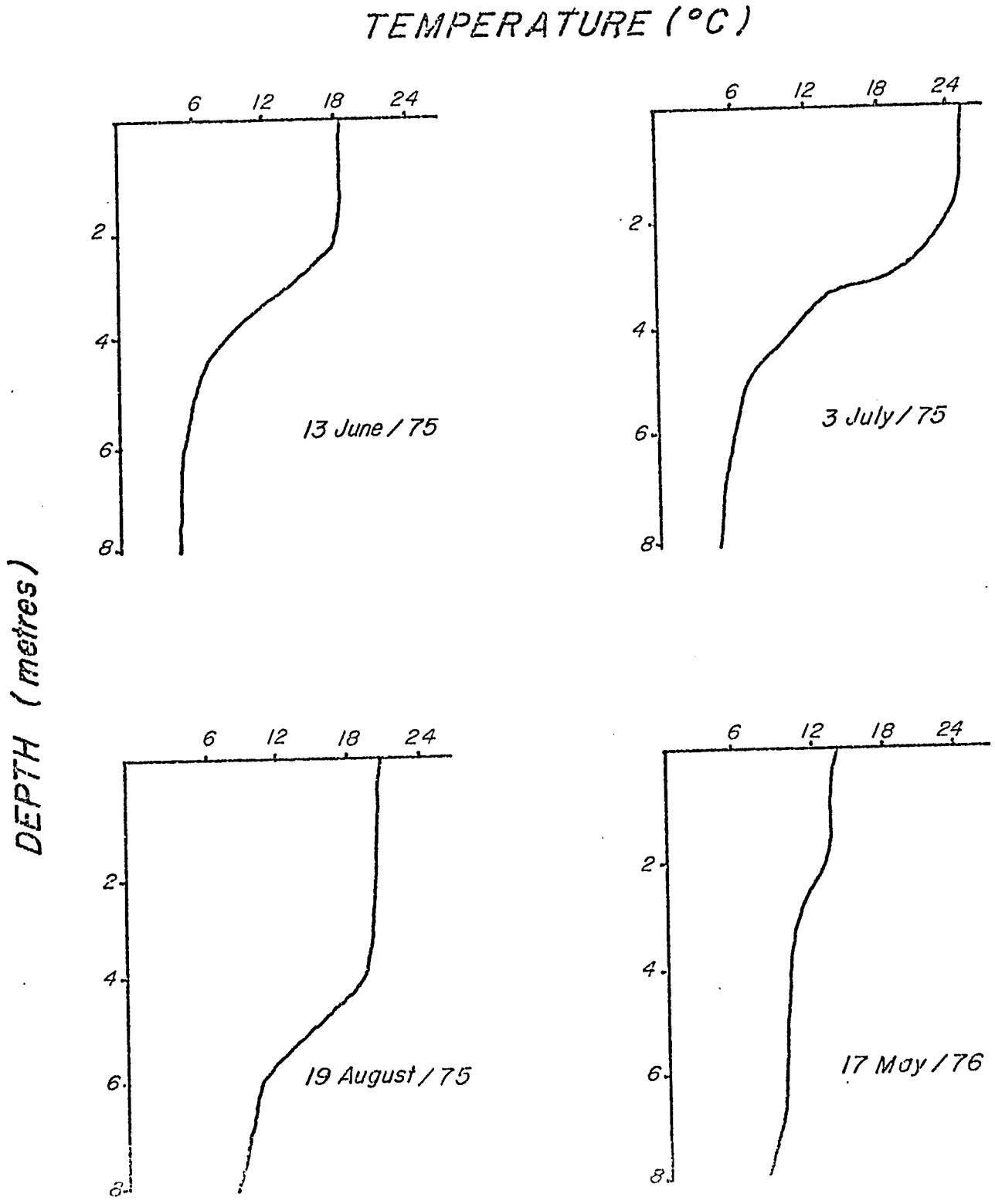
TEMPERATURE (°C)
DEPTH (metres)
6
12
18
24
2
4
6
8
13 June / 75
3 July / 75
19 August / 75
17 May / 76

Fig. 6. (Cont'd.)

Table 6

Water chemistry parameters in Lac Herman, May 1975 to May 1976

Date	Secchi disc reading metres	Depth metres	Dissolved oxygen mg/ℓ	pH	Alkalinity gpg $CaCO_3$*	Hardness gpg $CaCO_3$*
21 May 1975	3.50	Surface	11	6.5	2	2
		4	9			
		8	4	6.0	1	1
29 May 1975	3.75	Surface	11	6.6	1	1
		4	11			
		8	6	6.0	1	1
6 June 1975	3.50	Surface	9	6.4	1	1
		4	11			
		8	5	6.0	1	1
17 June 1975	4.00	Surface	9	6.5	1	2
		4	10			
		8	3	6.0	1	2
3 July 1975	4.00	Surface	9	7.0	1	2
		4	7			
		8	6	6.0	1	2
8 August 1975	5.00	Surface	8	6.8	1	1
		4	8			
		8	1	6.0	1	2
17 May 1975	3.50	Surface	12	6.7	1	2
		4	12			
		8	12	6.5	1	2

* grains per gallon calcium carbonate.

Table 7

Water chemistry parameters in Lac Tassel

Date	Secchi disc reading metres	Depth metres	Dissolved oxygen mg/ℓ	pH	Alkalinity gpg $CaCO_3$*	Hardness gpg $CaCO_3$*
22 May 1975	3.50	Surface	10	6.3	1	2
		4	10			
		8	7	6.0	1	2
27 May 1975	3.25	Surface	9	6.6	1	1
		4	10			
		8	9	6.0	1	1
1 June 1975	3.25	Surface	10	6.5	1	2
		4	11			
		8	7	6.0	1	2
5 June 1975	3.50	Surface	10	6.7	1	1
		4	11			
		8	8	5.8	1	1
13 June 1975	3.00	Surface	9	6.8	1	1
		4	9			
		8	7	5.5	1	1
3 July 1975	3.50	Surface	8	7.0	1	1
		4	12			
		8	5	6.0	1	2
19 August 1975	3.00	Surface	8	6.8	1	1
		4	11			
		8	4	5.8	1	1
17 May 1976	2.50	Surface	10	6.7	1	2
		4	10			
		8	10	6.7	1	2

* grains per gallon calcium carbonate.

Table 8

Meteorolgical data from Lac Tassel, 24 May to 4 June, 1975

	Temperature (°C)			Atmospheric pressure (millibars Hg)		Solar radiation (cal/cm^2/day)	Rainfall (cm)
	Max.	Min.	Mean	High	Low		
24 May	32.2	5.0	15.6	1003	1000	558	0.00
25 May	30.0	1.1	16.0	1006	1002	434	0.00
26 May	20.6	10.0	15.8	1002	990	93	2.59
27 May	22.2	5.5	13.2	996	988	93	1.47
28 May	24.4	2.2	15.6	1000	992	636	0.00
29 May	27.8	0.0	12.5	1005	1000	434	0.00
30 May	15.6	5.0	12.9	1001	989	78	0.65
31 May	25.0	8.9	16.8	992	987	264	0.00
1 June	18.9	5.6	12.0	997	990	217	1.12
2 June	21.7	0.6	11.0	1002	997	512	0.00
3 June	26.7	0.6	14.2	999	993	496	0.00
4 June	24.4	-	--	-	-	542	-

Table 9

Deposit of emitted spray products on the surface of Lac Tassel, 28 May, 1976

Deposit sampler	Method of measuring deposit: GLC analysis kg/ha AI deposited*	% deposit	Computerized spot counting ℓ/ha deposited**	% deposit	Colorimetric analysis ℓ/ha deposited**	% deposit
1	0.161	38.3	0.793	54.3	0.161	10.7
2	0.196	46.7	0.706	48.4	0.088	6.0
3	0.164	39.0	0.657	45.0	0.117	8.0
4	0.241	57.4	0.390	26.7	0.102	7.0
5	0.096	22.8	0.097	6.6	0.066	4.5
6	0.270	64.3	0.938	64.2	0.197	13.5
7	0.140	33.3	0.422	28.9	0.073	5.0
8	0.270	64.3	0.192	13.2	0.102	7.0
9	0.163	38.8	0.472	32.3	0.066	4.5
10	0.113	26.9	0.093	6.4	0.036	2.5
Mean	0.181	43.1	0.476	32.6	0.101	6.9

* 0.420 kg/ha AI emitted

** 1.460 ℓ/ha emitted

variable results from spot counting may reflect loss of water from descending spray droplets through evaporation. Mean deposit determined by colorimetric analysis is four to five times less than that measured by the other methods. This is believed to be due to fading of the Rodamine B dye during the approximately 70 day interval spent in the sampling pan. Results more consistent with the other methods of deposit assessment might have been obtained by washing the dye off the pans in the field with a solvent in which the dye had been shown to be stable. An interesting result of the GLC analysis is that from 5.0 to 37.5% (mean 22.8%) of the active ingredient (AI) measured was present as fenitrooxon. This may be due to catalysis of the photooxidation of fenitrothion by the aluminum pans.

2. Dispersion and distribution in lake waters

Pre-treatment water samples from Lac Tassel contained total residues of 0.16 µg/ℓ fenitrothion and fenitrooxon, with most of this consisting of the oxon. Lac Herman surface waters contained 0.18 µg/ℓ fenitrooxon. Following treatment of Lac Tassel, fenitrothion residues rapidly dispersed throughout the lake waters (Table 10). Peak total residues of 21.6 µg/ℓ were present in the surface waters after one hour and by twelve hours residue levels of about 3 µg/ℓ were found at all depths between the surface and 4 m. Residues in the bottom waters (6 m) peaked at 2.14 µg/ℓ (after twenty-six hours) and beyond this time residues below 2 m generally declined, while residues between the surface and 2 m remained relatively constant for a few days before gradually declining to less than 1 µg/ℓ after two weeks. Residues at the surface along the shoreline were often quite different from residues found in surface waters at the deep station. Fenitrooxon levels generally remained

Table 10

Fenitrothion and fenitrooxon residues* in Lac Tassel, 22 May 1975 to 17 May 1976.

Time relative to treatment		Pre-spray	+ 1 h	+ 6 h	+ 12 h	+ 26 h	+ 36 h	+ 50 h	+ 75 h	+ 5 days	+ 8 days	+ 14 days	+ 1 year
Shoreline Station													
Surface	Fenitrothion		4.63	11.33	5.67	2.87	1.47	N.D.	2.83	2.20	0.78	0.15	
	Fenitrooxon		0.35	0.17	0.37	0.24	0.31	N.D.	0.05	0.08	0.13	0.09	
	Total		4.98	11.50	6.04	3.11	1.78	N.D.	2.88	2.28	0.91	0.24	
Deep Station													
Surface	Fenitrothion	N.D.	21.33	7.67	2.63	2.90	1.47	3.50	3.90	2.77	0.23	0.57	T
	Fenitrooxon	0.16	0.29	0.55	0.26	0.23	0.28	0.26	0.34	0.28	0.10	0.16	N.D.
	Total	0.16	21.62	8.22	2.89	3.13	1.75	3.76	4.24	3.05	0.33	0.73	T
1 m	Fenitrothion		15.47	7.57	2.40	1.75	1.71	2.74	Sample	2.67	2.17	0.67	
	Fenitrooxon		0.18	2.63	0.23	0.26	0.32	0.28	lost	0.20	0.27	0.16	
	Total		15.65	10.20	2.63	2.01	2.03	3.02		2.87	2.44	0.83	
2 m	Fenitrothion		11.80	5.67	2.86	1.67	3.88	1.63	2.93	3.07	1.83	0.69	
	Fenitrooxon		0.70	0.33	0.26	0.25	0.25	0.24	0.25	0.24	0.60	0.19	
	Total		12.50	6.00	3.12	1.92	4.13	1.87	3.18	3.31	2.43	0.88	
4 m	Fenitrothion		1.25	0.40	2.13	0.83	1.50	1.13	0.45	0.17	0.08	0.12	0.02
	Fenitrooxon		0.70	0.29	0.27	0.28	0.52	0.35	0.21	0.09	0.13	0.10	N.D.
	Total		1.95	0.69	2.40	1.11	2.02	1.48	0.66	0.26	0.21	0.22	0.02
6 m	Fenitrothion	0.04	0.36	0.24	0.24	0.90	0.24	0.07	0.06	0.30	0.32	0.07	
	Fenitrooxon	0.12	0.70	0.20	0.14	1.24	0.23	0.17	0.12	0.10	0.18	0.07	
	Total	0.16	1.06	0.44	0.38	2.14	0.47	0.24	0.18	0.40	0.50	0.14	
8m	Fenitrothion												0.03
	Total												N.D. 0.03

* expressed in µg/ℓ (ppb) N.D. - not detected T - Traces (< 0.02 µg/ℓ)

constant around the 0.20 - 0.30 µg/ℓ level but occasionally were found to be up to ten time higher. Water samples did not contain any detectable amounts of S-methyl-fenitrothion.

A year after treatment only trace amounts of fenitrothion were present in Lac Tassel surface waters while bottom waters contained 0.03 µg/ℓ fenitrothion and the insecticide was still present in small amounts in balsam fir foliage (0.08 µg/g) and soil (0.01 µg/g). No fenitrooxon was detected in either aquatic or terrestrial samples.

3. Accumulation and persistence in fish and clams

Fenitrothion residues were found in all fish and clams sampled over the first eight days after treatement of Lac Tassel (Table 11). Distinct differences were apparent in the extent to which live individuals of different species of fish accumulated fenitrothion residues (Fig. 7). White suckers accumulated the highest residue levels, followed by fallfish, brown bullheads and smallmouth bass. Residues also persisted longer in white suckers. All fish species reached maximum residue levels within about 24 hours of treatment and "wild" fish appeared to accumulate residue levels similar to those detected in caged fish. Dead fish taken from the cages contained residue levels similar to or lower than those in live fish sampled at the same time. Clams contained relatively small amounts of fenitrothion. Neither fish nor clams contained detectable quantitites of S-methyl fenitrothion and fenitrooxon was found only in smallmouth bass sampled within 36 hours of treatment of the lake.

A smallmouth bass found distressed on the surface of the lake 15 minutes after treatment contained more fenitrothion than any other bass sampled, indicating that it was exposed to and rapidly accumulated relatively concentrated insecticide. The fallfish found dead in the lake

Table 11

Fenitrothion residues* in fish and clams from Lac Tassel, 28 May to 5 June, 1975

Time relative to treatment	+15 min	+6h	+12h	+26.5h	+30h	+32h	+36h	+50h	+75h	+5 days	+8 days
Smallmouth bass											
Caged - live		0.14**	0.18**	0.28***			0.12**	0.05	0.06	0.08	0.03
Caged - dead				0.07			0.08	0.07	0.07		
Wild	0.34									0.04	0.05
Fallfish											
Caged - live		0.43	0.71	0.76			0.54	0.34			
Caged - dead								0.35	0.28		
Wild					0.18			0.36	0.40		
White suckers											
Caged - live		1.01									
Caged - dead			0.15								
Wild								0.91	0.89	0.91	
Brown bullheads											
Caged - live		0.28	0.44								
Caged - dead		0.11	0.24	0.41							
Wild								0.24			
Clams											
Caged - live				0.06		0.07	0.03	0.03	0.02	0.12	0.02
Wild						0.02					

* expressed in µg/g (ppm) ** includes 0.02 µg/g fenitrooxon *** includes 0.03 µg/g fenitrooxon

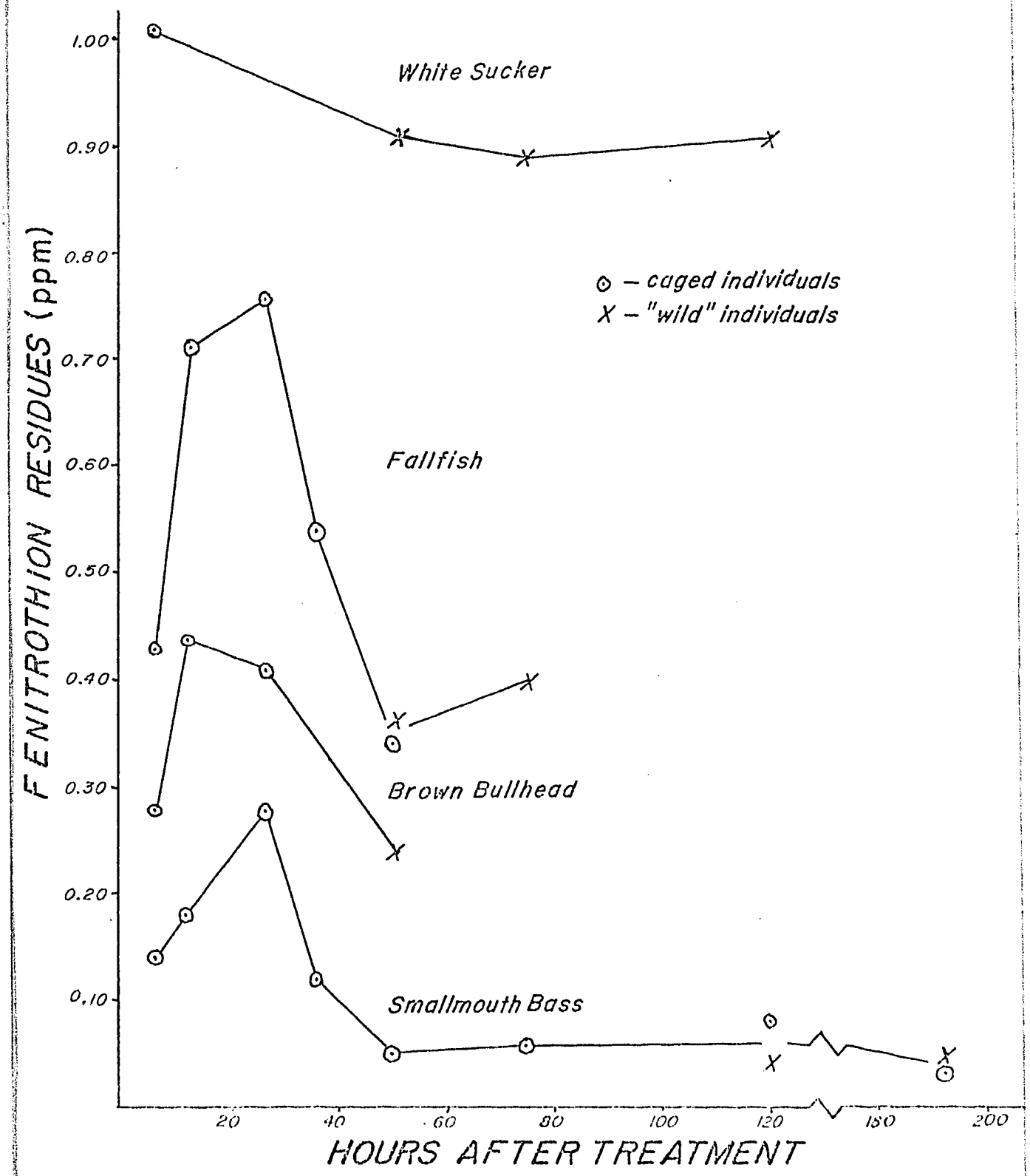

Fig. 7. Fenitrothion residues in live fish from Lac Tassel following aerial spraying of the lake.

had relatively small amounts of insecticide in it. The clams sealed at 2 m contained smaller amounts of fenitrothion than those sampled at the surface at the same time. A year after treatment 0.01 µg/g fenitrothion was found in a ripe female white sucker, but no insecticide was detected in her eggs.

C. Changes in biological populations

1. Zooplankton

Throughout the study period the genera *Daphnia* and *Holopedium* dominated cladoceran catches in zooplankton samples from the deep station in Lac Tassel (Table 12). Cladoceran populations at the deep station in Lac Herman were dominated by the genus *Bosmina* but moderate numbers of *Daphnia*, *Holopedium* and *Diaphanosoma* also appeared in most samples (Table 13). Both lakes had large, mixed populations of calanoid, cyclopoid and immature copepods present at their deep station. Surface zooplankton catches at the shoreline station in both lakes generally showed similar composition to deep station catches (Tables 14 and 15).

Cladoceran populations at the deep station in Lac Tassel doubled over pre-spray levels by the eighth day after treatment and then fell to low levels until increasing to near pre-spray levels in late summer. In Lac Herman, cladoceran populations increased to very high levels in early summer. Cladoceran populations at the shoreline station of Lac Tassel fell to low levels shortly after treatment while those at the shoreline in Lac Herman showed the same increase seen at the deep station. Copepod populations at both stations followed similar patterns of relative abundance in the two lakes, although actual numbers of copepods were consistently higher in Lac Herman samples. With

Table 12

Plankton trap catches* at the deep station in Lac Tassel, 22 May 1975 to 17 May 1976

Number of days before or after treatment	-6				-1				+4				+8			
	Surf	4m	8m	Total	Surf	4m	8m	Total	Surf	4m	8m	Total	Surf	4m	8m	Total
Cladocera																
Polyphemidae: *Polyphemus*	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-
Holopedidae: *Holopedium*	54	30	-	84	7	1	20	28	25	15	4	44	27	330	-	357
Sididae: *Diaphanosoma*	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Daphnidae: *Daphnia*	2	44	1	47	-	119	3	122	-	25	44	69	3	6	18	27
Ceriodaphnia	-	5	-	5	-	-	-	-	-	-	-	-	-	-	-	-
Bosminidae: *Bosmina*	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-
Macrothricidae: *Macrothrix*	46	-	-	46	-	-	2	2	-	-	-	-	-	-	-	-
Ilyocryptus	-	-	-	-	-	7	-	7	-	-	-	-	-	-	-	-
Immatures	-	12	-	12	-	-	-	-	-	-	-	-	-	-	-	-
Unknowns	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-
Total	103	91	1	195	7	128	25	160	27	40	48	115	30	336	18	384
Copeopoda																
Calanoida	84	53	4	141	10	133	26	169	-	173	81	254	81	742	33	856
Cyclopoida	-	243	11	254	-	24	21	45	-	55	34	89	8	34	42	84
Nauplii	75	75	8	158	17	71	37	125	81	240	37	358	35	246	5	286
Copepodids	6	6	-	12	-	36	16	52	-	12	5	17	10	-	4	14
Total	165	377	23	565	27	264	100	391	81	480	157	718	134	1022	84	1240
Diptera																
Culicidae: *Chaoborus*	-	1	-	1	-	1	-	1	-	-	1	1	-	-	-	-

* from single 12ℓ Shindler-Patalas plankton trap samples

Table 12 (Cont'd.)

Number of days before or after treatment	+16				+36				+84				+354			
	Surf	4m	8m	Total	Surf	4m	8m	Total	Surf	4m	8m	Total	Surf	4m	8m	Total
Cladocera																
Polyphemidae: *Polyphemus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Holopedidae: *Holopedium*	-	25	1	26	9	4	-	13	14	7	1	22	59	44	3	106
Sididae: *Diaphanosoma*	-	-	-	-	-	-	-	-	8	74	-	82	1	-	-	1
Daphnidae: *Daphnia*	-	5	29	34	-	5	2	7	1	5	21	27	37	49	10	96
Ceriodaphnia	-	-	-	-	-	-	-	-	-	12	-	12	-	-	-	-
Bosminidae: *Bosmina*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Macrothricidae: *Macrothrix*	-	-	-	-	-	2	-	2	-	-	-	-	-	-	-	-
Ilyocryptus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Immatures	-	-	-	-	-	-	-	-	-	-	-	-	-	23	-	23
Unknowns	-	3	-	3	1	-	-	1	-	-	1	1	-	-	-	
Total	-	33	30	63	10	11	2	23	23	98	23	144	97	116	14	227
Copeopoda																
Calanoida	1	85	39	125	2	61	21	84	35	19	7	61	49	34	17	170
Cyclopoida	10	14	39	63	12	11	107	130	32	67	12	111	25	76	25	126
Nauplii	13	515	7	535	70	36	18	124	23	77	1	101	86	112	32	230
Copepodids	-	19	7	26	-	14	8	22	8	-	16	24	1	-	-	1
Total	24	633	92	749	84	122	154	360	98	163	36	297	231	222	74	527
Diptera																
Culicidae: *Chaoborus*	-	-	3	3	-	-	-	-	1	1	-	2	-	-	-	-

Table 13

Plankton trap catches* at the deep station in Lac Herman, 21 May 1975 to 17 May 1976

Number of days before or after treatment	-7				+1				+20			
	Surf	4m	8m	Total	Surf	4m	8m	Total	Surf	4m	8m	Total
Cladocera												
Holopedidae: *Holopedium*	-	1	-	1	8	-	1	9	2	7	3	12
Sididae: *Diaphanosoma*	2	1	-	3	8	1	-	9	2	1	3	6
Daphnidae: *Daphnia*	-	2	-	2	2	6	2	10	3	51	9	63
Bosminidae: *Bosmina*	11	4	4	19	138	316	44	498	-	2	2174	2176
Immatures	-	-	-	-	-	-	-	-	-	-	-	-
Total	13	8	4	25	156	323	47	526	7	61	2189	2257
Copepoda												
Calanoida	131	16	7	154	906	950	151	2007	420	191	498	1109
Cyclopoida	29	38	13	80	54	192	277	523	38	46	180	264
Nauplii	301	646	101	1048	144	208	70	422	3	23	516	542
Copepodids	25	23	13	61	-	18	-	18	-	-	-	-
Total	486	723	134	1343	1104	1368	498	2970	461	260	1194	1915

* from single 12ℓ Shindler-Patalas plankton trap samples.

Table 13 (Cont'd)

Number of days before or after treatment	+36				+85				+354			
	Surf	4m	8m	Total	Surf	4m	8m	Total	Surf	4m	8m	Total
Cladocera												
Holopedidae:*Holopedium*	-	-	5	5	-	-	6	6	18	9	3	30
Sididae:*Diaphanosoma*	9	28	4	41	-	5	-	5	2	-	-	2
Daphnidae:*Daphnia*	3	3	11	17	-	102	58	160	7	15	5	27
Bosminidae:*Bosmina*	2	-	104	106	3	8	1	12	3	6	7	16
Immatures	-	-	-	-	-	6	5	11	-	-	-	-
Total	14	31	124	169	3	121	70	194	30	30	15	75
Copepoda												
Calanoida	201	250	464	915	225	412	6	643	434	390	118	942
Cyclopoida	7	9	128	144	2	6	13	21	62	111	83	256
Nauplii	4	-	486	490	7	8	551	566	346	294	357	997
Copepodids	-	17	-	17	-	-	-	-	-	57	31	88
Total	212	276	1078	1566	234	426	570	1230	842	852	589	2283

Table 14

Surface plankton trap catches* at the shoreline station in Lac Tassel, 22 May 1975 to 17 May 1976

Number of days before or after treatment	-6	-1	+4	+16	+36	+84	+354
Cladocera							
Polyphemidae: *Polyphemus*	-	10	-	-	-	128	2
Holopedidae: *Holopedium*	-	4	16	-	1	-	-
Sididae: *Diaphanosoma*	-	-	-	-	-	14	-
Daphnidae: *Daphnia*	-	-	-	-	-	1	-
Bosminidae: *Bosmina*	2	86	-	-	-	-	1
Total	2	100	16	-	1	143	3
Copepoda							
Calanoida	90	16	-	9	5	30	2
Cyclopoida	2	3	1	5	24	126	5
Nauplii	115	86	20	11	32	34	17
Copepodis	14	-	1	16	-	-	-
Total	221	105	22	41	61	190	24

* from single 12ℓ Shindler-Patalas plankton trap samples

Table 15

Surface plankton trap catches* at the shoreline station in Lac Herman, 21 May 1975 to 17 May 1976.

Number of days before or after treatment	-7	+1	+20	+36	+85	+354
Cladocera						
Polyphemidae: *Polyphemus*	-	-	-	-	1	-
Holopedidae: *Holopedium*	-	-	-	-	-	1
Sididae: *Diaphanosoma*	2	-	-	2	5	-
Daphnidae: *Daphnia*	-	1	1	-	1	-
Bosminidae: *Bosmina*	11	48	85	4	10	6
Total	13	49	86	6	17	7
Copepoda						
Calanoida	116	528	28	7	16	112
Cyclopoida	8	92	24	18	-	36
Nauplii	684	114	41	14	25	276
Copepodids	37	24	-	-	-	-
Total	845	758	93	39	41	424

* from single 12ℓ Shindler-Patalas plankton trap samples.

the exception of copepods at the shoreline station of Lac Tassel, relative abundance of zooplankters was similar in the springs of 1975 and 1976 at both stations in the two lakes.

2. Bottom fauna and insect emergence

Bottom fauna populations in Lac Tassel and Lac Herman were very similar in numbers and composition prior to treatment (Tables 16 and 17). Total numbers of benthic organisms in Lac Tassel decreased slightly after treatment but were generally very stable over the entire summer. Dragonfly nymphs (Odonata:Anisoptera), marl beetle larvae (Coleoptera:Elmidae) and amphipods (Amphipoda) showed the most substantial reductions in numbers present in Ekman grab samples following treatment. In Lac Herman, benthic populations were stable until mid-June when large numbers of midge larvae (Diptera:Chironomidae) appeared in bottom samples. These fell to very low numbers by August. Dragonfly nymph and amphipod populations were somewhat more stable in Lac Herman than in Lac Tassel. Marl beetle larvae were not found in bottom samples from Lac Herman. Bottom fauna populations in the two lakes in May of 1976 were similar in composition and somewhat higher in numbers than in the spring of 1975.

Insect emergence trap catches in Lac Tassel and Lac Herman around the treatment date followed similar patterns (Fig. 8). Catches consisted primarily of adult midges but a few adult mayflies (Ephemeroptera) were caught in the two lakes two and three days before treatment and 20 adult caddisflies (Trichoptera) were caught emerging from Lac Tassel in the week following treatment. Two caddisflies were caught emerging from

Table 16

Benthic organisms* collected in Ekman grab samples from Lac Tassel, 22 May 1975 to 17 May 1976

Number of days before or after treatment	-6	-1	+4	+8	+16	+36	+84	+354
Mean depth sampled (m)	1.48	2.08	1.95	2.08	1.78	2.03	2.00	2.05
Ephemeroptera:Ephemeridae	-	0.1 ± 0.3	0.2 ± 0.4	-	-	0.1 ± 0.3	0.4 ± 0.5	1.5 ± 1.8
:Baetidae	-	0.1 ± 0.3	-	-	0.1 ± 0.3	-	-	-
Odonata:Gomphidae	0.3 ± 0.5	0.4 ± 1.0	-	-	-	-	-	0.2 ± 0.4
:Libellulidae	0.8 ± 1.1	-	-	-	0.2 ± 0.4	-	-	0.1 ± 0.3
Lepidoptera:Pyralidae	-	0.3 ± 0.5	-	-	-	-	-	0.1 ± 0.3
Trichoptera:Various families	0.2 ± 0.4	0.7 ± 1.1	0.6 ± 0.5	0.6 ± 0.7	0.5 ± 0.5	0.2 ± 0.4	0.4 ± 0.5	1.1 ± 1.7
Megaloptera:Sialidae	-	-	0.1 ± 0.3	-	-	-	0.2 ± 0.5	-
Coleoptera:Elmidae	1.2 ± 1.3	1.5 ± 2.0	0.2 ± 0.4	0.4 ± 1.0	0.3 ± 0.5	0.3 ± 1.0	0.6 ± 1.3	-
:Psephenidae	0.1 ± 0.3	-	-	-	-	-	-	-
Diptera:Chironomidae	13.0 ± 9.4	11.5 ± 9.4	10.9 ± 7.2	12.5 ± 4.4	10.1 ± 9.5	10.3 ± 5.8	11.2 ± 6.1	18.1 ± 6.8
:Heleidae	0.7 ± 0.8	0.9 ± 1.0	0.6 ± 0.8	1.4 ± 1.3	0.7 ± 1.3	0.3 ± 0.5	0.6 ± 0.9	0.9 ± 1.1
:Tipulidae	-	-	0.1 ± 0.3	-	-	-	-	-
Turbellaria	0.1 ± 0.3	-	0.2 ± 0.6	-	-	-	-	-
Oligochaeta	1.4 ± 1.3	1.4 ± 1.8	0.9 ± 1.0	0.9 ± 1.9	1.2 ± 1.2	3.5 ± 4.4	1.6 ± 1.5	0.7 ± 1.5
Hirundinea	-	0.1 ± 0.3	-	-	-	-	-	-
Amphipoda	1.4 ± 2.1	0.1 ± 0.3	1.5 ± 2.9	-	0.1 ± 0.3	0.1 ± 0.3	-	0.6 ± 0.8
Acari	0.2 ± 0.4	-	-	-	-	-	-	-
Gastropoda	0.9 ± 0.9	0.4 ± 0.5	0.5 ± 1.1	0.1 ± 0.3	0.2 ± 0.4	0.5 ± 1.1	0.6 ± 0.9	0.4 ± 0.7
Pelecypoda:Sphaeriidae	0.1 ± 0.3	0.1 ± 0.3	0.1 ± 0.3	0.2 ± 0.4	-	-	-	0.2 ± 0.4
:Unionidae	-	-	0.1 ± 0.3	-	-	-	-	-
Total	20.4 ± 10.7	17.6 ± 12.0	16.0 ± 7.6	16.1 ± 6.3	13.4 ± 10.5	15.3 ± 8.8	15.6 ± 7.4	24.2 ± 6.9

* expressed as mean number and standard deviation found in ten 232 cm^2 Ekman grab samples

Table 17

Benthic organisms* collected in Ekman grab samples from Lac Herman, 21 May 1975 to 17 May 1976

Number of days before or after treatment	-7	+1	+8	+20	+36	+85	+354
Mean depth sampled (m)	1.80	1.90	1.65	1.85	2.00	1.75	1.35
Ephemeroptera:Ephemeridae	0.2 ± 0.4	0.6 ± 0.5	0.8 ± 1.3	-		-	0.4 ± 0.5
Odonata:Gomphidae	0.6 ± 0.9	0.4 ± 0.5	-	0.8 ± 0.8	0.2 ± 0.4	-	0.4 ± 0.5
:Libellulidae	0.2 ± 0.4	-	-	-	-	-	-
Lepidoptera:Pyralidae	-	-	-	0.2 ± 0.4	-	0.4 ± 0.5	1.4 ± 1.7
Megaloptera:Sialidae	-	-	-	-	-	0.4 ± 0.5	-
Trichoptera:Various families	1.2 ± 0.8	-	-	0.2 ± 0.4	0.4 ± 0.5	-	0.2 ± 0.4
Diptera:Chironomidae	13.0 ± 5.8	11.4 ± 10.6	15.4 ± 12.4	32.0 ±13.1	16.6 ± 10.5	2.8 ± 1.6	20.6 ± 6.8
:Heleidae	0.4 ± 0.9	2.0 ± 2.5	0.6 ± 0.5	0.4 ± 0.5	0.4 ± 0.5	-	1.0 ± 1.7
:Tipulidae	-	-	0.2 ± 0.4	-	-	-	-
Nematoda	-	-	-	-	-	0.2 ± 0.4	-
Turbellaria	-	-	0.2 ± 0.4	0.4 ± 0.9	-	-	-
Oligochaeta	2.6 ± 1.8	3.6 ± 2.5	-	2.8 ± 2.6	5.2 ± 4.1	1.0 ± 0.7	1.2 ± 1.3
Hirundinea	0.2 ± 0.4	-	-		0.2 ± 0.4	0.4 ± 0.9	-
Amphipoda	1.6 ± 2.2	2.0 ± 1.2	0.4 ± 0.9	9.2 ± 6.4	2.2 ± 2.5	5.4 ± 4.9	5.2 ± 5.1
Gastropoda	0.8 ± 0.8	0.4 ± 0.5	0.6 ± 0.9	-	-	-	0.4 ± 0.5
Total	20.8 ± 7.2	20.4 ± 13.7	18.2 ± 13.1	46.0 ± 9.1	25.2 ± 10.9	10.6 ± 3.8	30.8 ± 11.4

* expressed as mean number and standard deviation found in five 232 cm^2 Ekman grab samples.

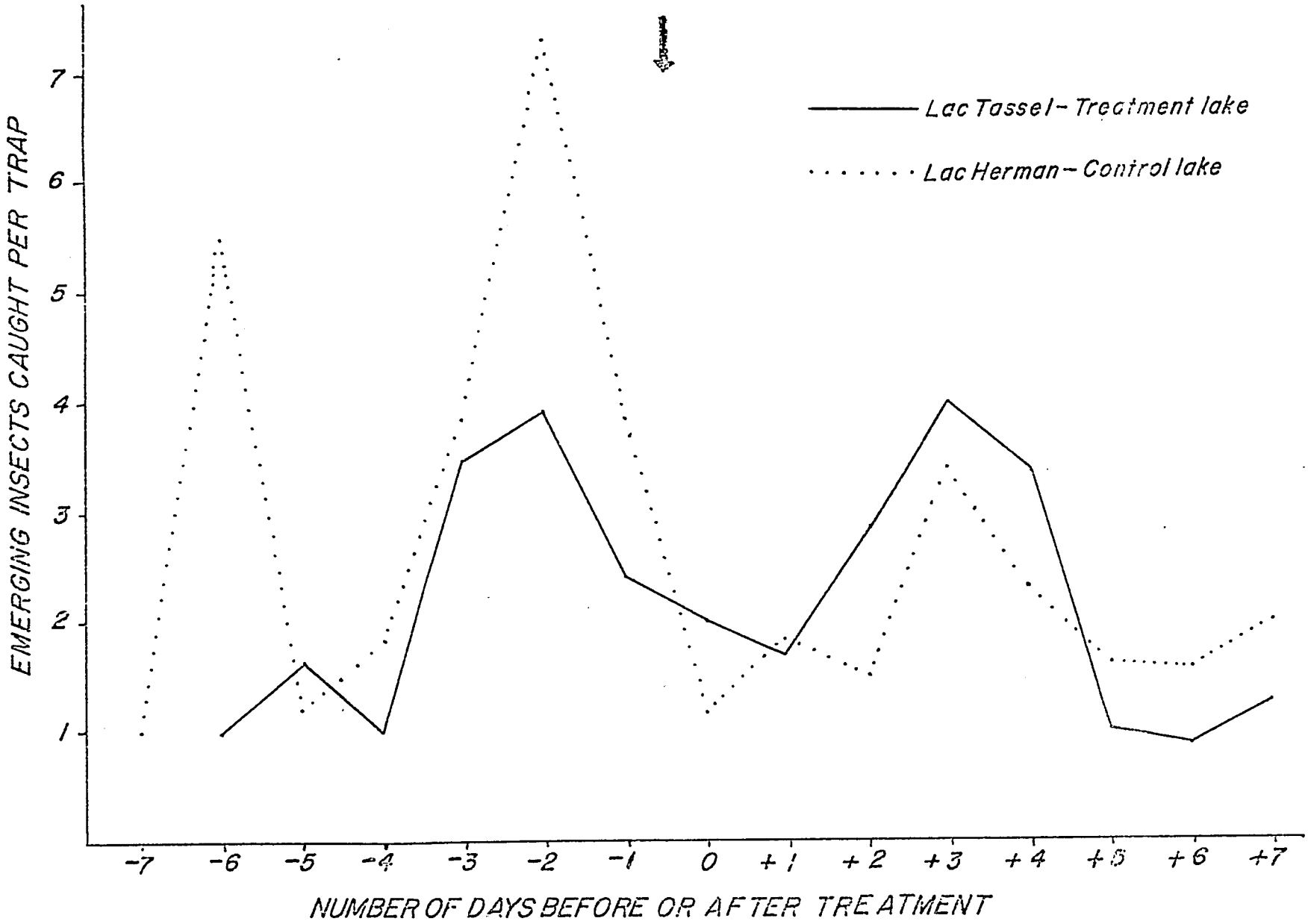

Fig. 8. Insect emergence trap catches in Lac Tassel and Lac Herman, 22 May to 4 June, 1975.

Lac Herman during the same period.

3. Fish diets and condition

Large numbers of fish were obtained for stomach analysis from Lac Tassel and Lac Herman (Appendix, Tables 1 and 2), mostly by gill netting but also by angling and trap netting. White suckers were consistently sampled in large numbers from both lakes. Smallmouth bass, fallfish, brown bullheads and yellow perch, *Perca flavescens* (Mitchill), from Lac Tassel and brook trout and brown bullheads from Lac Herman were captured in less consistent numbers over the study period. Small numbers of common shiners, *Notropis cornutus* (Mitchill), were also captured from Lac Tassel and analyzed for stomach content. A small number of creek chub, *Semotilus atromaculatus* (Mitchill), were caught in a gill net set in Lac Herman on 22 May 1975, but no other individuals of this species were captured on later sampling dates.

White suckers in both lakes fed primarily on aquatic insects and planktonic organisms (Fig. 9, Appendix Tables 4 to 9), with suckers from Lac Herman feeding more extensively on aquatic insects. In both lakes feeding activity was consistent throughout the study period, with no more than 20% of the individual fish in any sample having empty digestive tracts. The diet of white suckers in Lac Tassel was relatively stable over the study period, particularly in terms of the mean numbers of various food items found in their digestive tracts. The most noticeable variation was the decrease in occurrence and percent volume contributed by cladocerans in mid-June, with a subsequent increase of cladocerans in the diet through the rest of the summer. In Lac Herman suckers, cladocerans increased in their occurrence, numbers and contribution to the volume of food up until

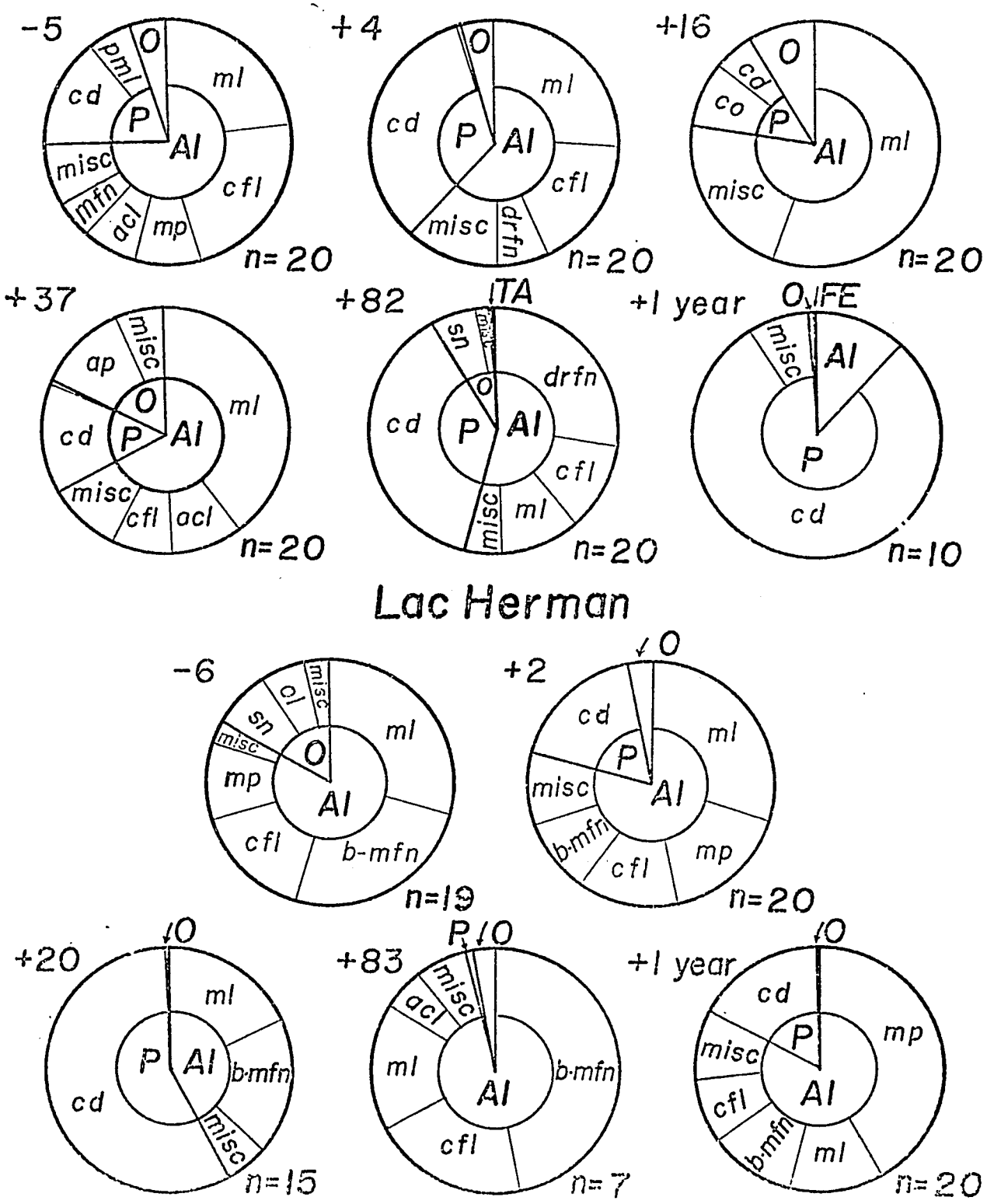

Fig. 9. Contributions of various food items to the diet of white suckers in the study lakes. AI-aquatic insects (acl-aquatic beetle larvae, b-mfn-burrowing mayfly nymphs, cfl-caddisfly larvae, drfn-dragonfly nymphs, mfn-mayfly nymphs, ml-midge larvae, mp-midge pupae, misc.-miscellaneous), P-plantonic organisms (cd-cladocerans, co-copepods, pml-phantom midge larvae), O-other aquatic invertebrates (ap-amphipods, ol-oligochaetes, sn-snails, misc.-miscellaneous), TA - terrestrial arthropods, FE-fish eggs, n = number of fish sampled, -5, +4 etc. - days before or after treatment.

mid-June but were no longer found in sucker stomachs in July. Caddisfly larvae decreased in importance in sucker diets in both lakes in mid-June and became important again later in the summer.

Smallmouth bass in Lac Tassel fed primarily on minnows, large aquatic insects (mayfly and dragonfly nymphs) and flying insects (Fig. 10 Appendix, Tables 10 to 12). On about half the sampling dates, close to 50% of bass stomachs were empty, and the mean volume of stomach contents fluctuated widely over the study period. The composition of the stomach contents also fluctuated widely between the three predominant food groups without showing any distinct pattern in change of diet. Numbers of both flying and aquatic insects in bass stomachs were higher in the first few days following treatment than at any other time. Fallfish in Lac Tassel fed on a varied diet of aquatic insects (mainly caddisfly larvae, dragonfly nymphs and burrowing mayfly nymphs), flying insects, plankton and occasional minnows (Fig. 11, Appendix Tables 13 to 15). A large percentage of the fallfish caught from mid-June through August had empty stomachs and the mean volume of digestive tract contents was generally much lower throughout the summer than in May. Cladocerans were numerous and important in their contribution to the diet of fallfish before treatment, but almost completely absent after treatment. Large numbers of flying insects were found in a single fallfish caught 15 hours after treatment of Lac Tassel, indicating heavy feeding on insect knockdown. Relatively large mean numbers of some aquatic insect groups were found in stomachs a few days after treatment, particularly dragonfly nymphs.

Brook trout in Lac Herman fed on a varied diet of aquatic insects, minnows, flying insects and plankton (Fig. 12, Appendix Tables 16 to 18).

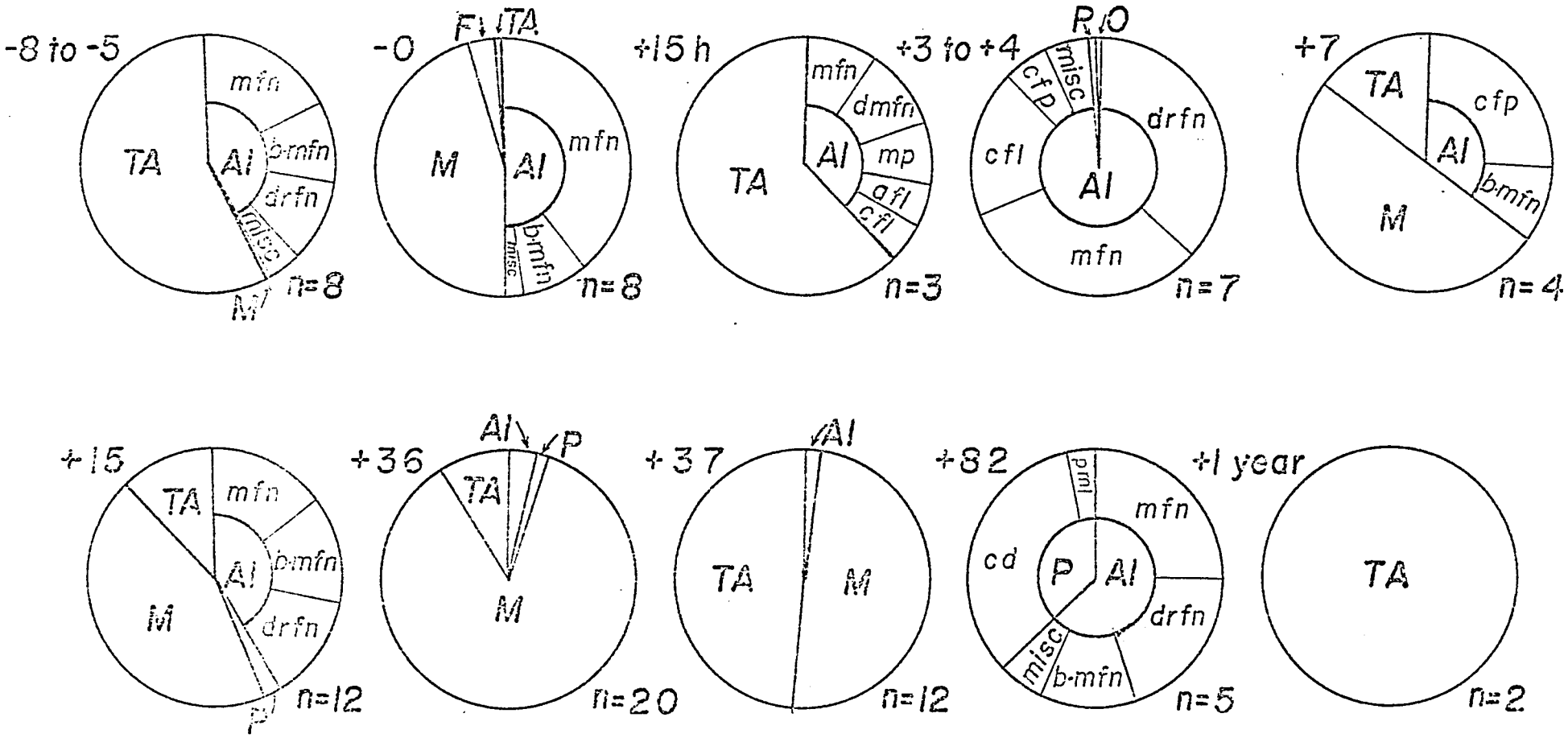

Fig. 10. Contributions of various food items to the diet of smallmouth bass in Lac Tassel. AI-aquatic insects (afl-alderfly larvae, b-mfn-burrowing mayfly nymphs, cfl-caddisfly larvae, cfp-caddisfly pupae, dmfn-damselfly nymphs, drfn-dragonfly nymphs, mfn-mayfly nymphs, mp-midge pupae, misc.-miscellaneous), P-planktonic organisms (cd-cladocerans, pml-phantom midge larvae), M-minnows, F-frogs, TA-terrestrial arthropods, n = number of fish sampled, -8, +3 etc. - days before or after treatment.

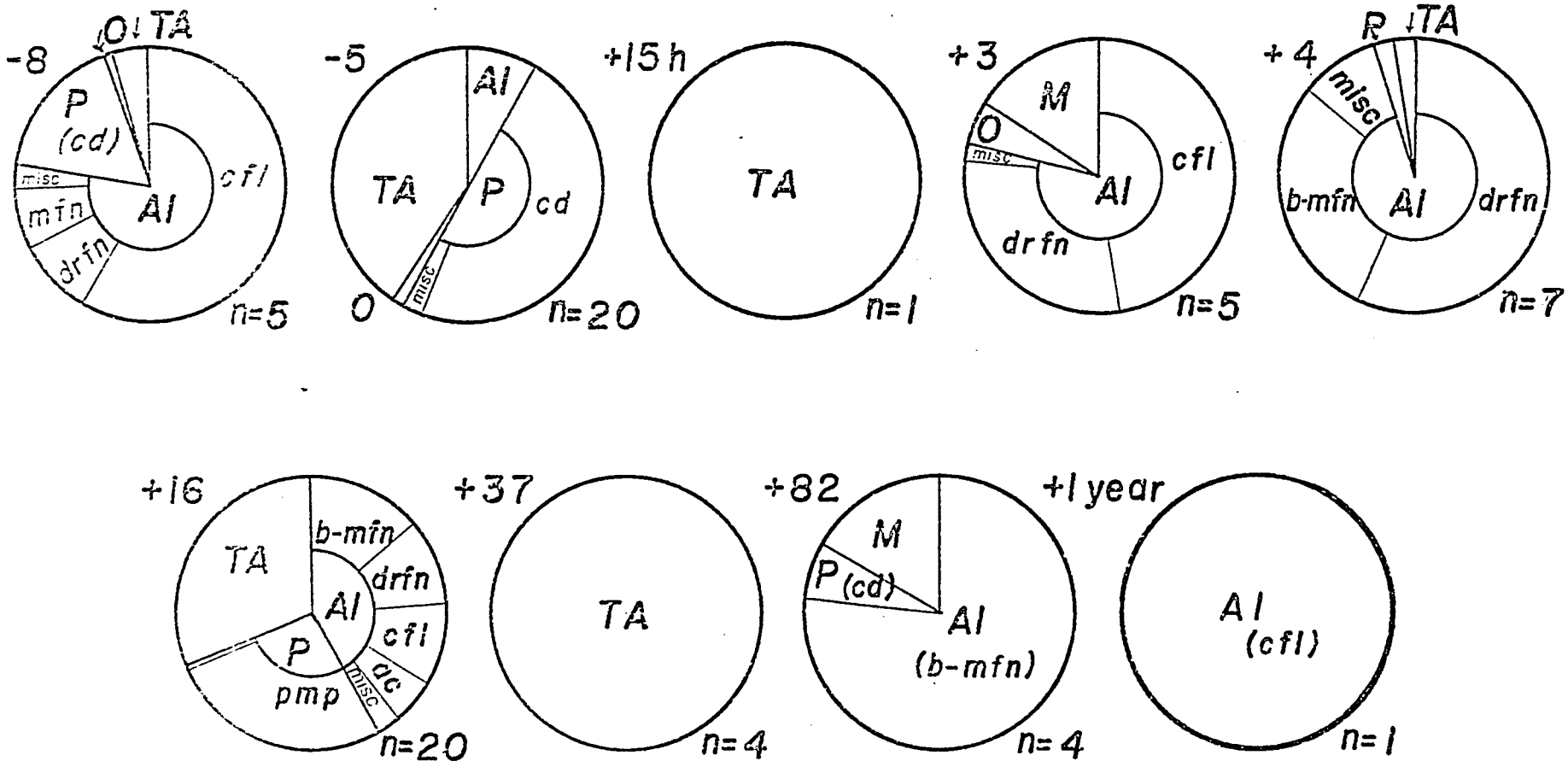

Fig. 11. Contributions of various food items to the diet of fallfish in Lac Tassel. AI-aquatic insects (ac-aquatic beetles, b-mfn-burrowing mayfly nymphs, cfl-caddisfly larvae, drfn-dragonfly nymphs, mfn-mayfly nymphs, misc.-miscellaneous), P-planktonic organisms (cd-cladocerans, pmp-phantom midge pupae, misc.-miscellaneous), O-other aquatic invertebrates, M-minnows, TA-terrestrial arthropods, n = number of fish sampled, -8, +3 etc. - days before or after treatment.

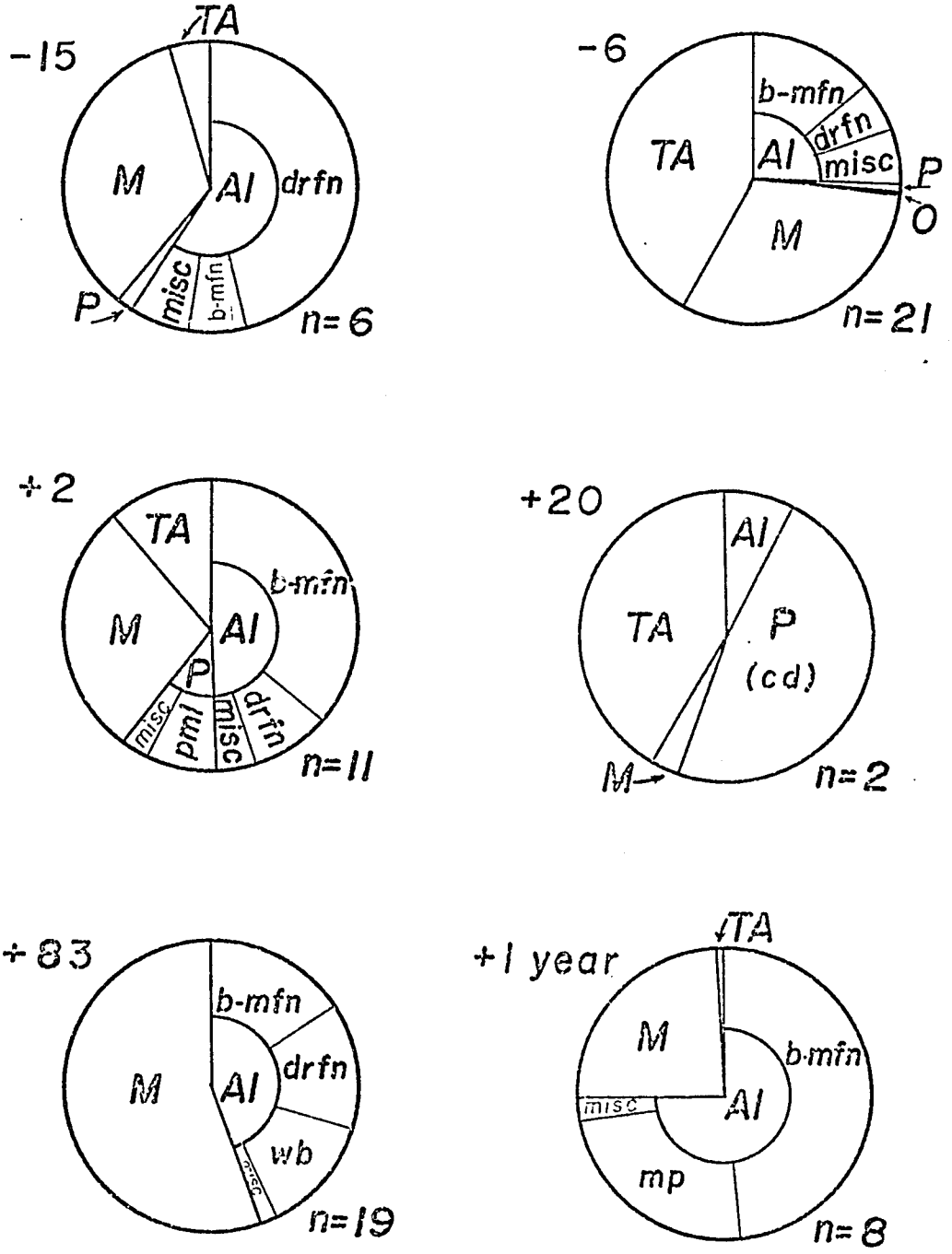

Fig. 12. Contributions of various food items to the diet of brook trout in Lac Herman. AI-aquatic insects (b-mfn-burrowing mayfly nymphs, drfn-dragonfly nymphs, mp-midge pupae, wb-water boatmen, misc.-miscellaneous), P-planktonic organisms (pml-phantom midge larvae, misc.-miscellaneous), O-other aquatic invertebrates, M-minnows, TA-terrestrial arthropods, n = number of fish sampled, -15, +2 etc. - number of days before or after treatment.

Feeding activity among brook trout slowly declined throughout the summer as seen by changes in the occurrence of empty stomach contents. The contribution of cladocerans to the diet of brook trout increased in late May, peaked in mid-June and fell to nil in August. Aside from this, brook trout fed on a fairly steady diet of minnows and aquatic insects with occasional large input of flying insects.

Brown bullheads in Lac Tassel and Lac Herman fed on similar diets predominated by a large variety of aquatic insects with some input of other aquatic invertebrates, particularly amphipods (Fig. 13, Appendix, Tables 19 to 24). Caddisfly larvae and pupae did not occur in bullhead stomachs in either lake during mid to late summer, but other aquatic insect groups and amphipods were generally present in varying numbers throughout the study period. Some bullheads in Lac Tassel fed on blackfly larvae and fish eggs from the inlet stream in mid-May of 1975.

The diet of yellow perch in Lac Tassel consisted primarily of planktonic organisms (both cladocerans and phantom midge larvae and pupae), aquatic insects and minnows, principally smallmouth bass fry (Fig. 14, Appendix, Tables 25 to 27). Cladocerans fell off greatly in occurrence and contribution to the volume of food in perch stomachs following treatment and then gradually regained importance throughout the summer. Phantom midge larvae and pupae were particularly important in perch diets during the periods when cladocerans were not found in the stomachs. Smallmouth bass fry were quite extensively fed on by perch in mid-June. The drop in the importance of cladocerans in the diets of fish in Lac Tassel after treatment was also seen in the small number of common shiners sampled for analysis of their digestive tract contents (Appendix, Table 28). Following treatment shiners fed primarily

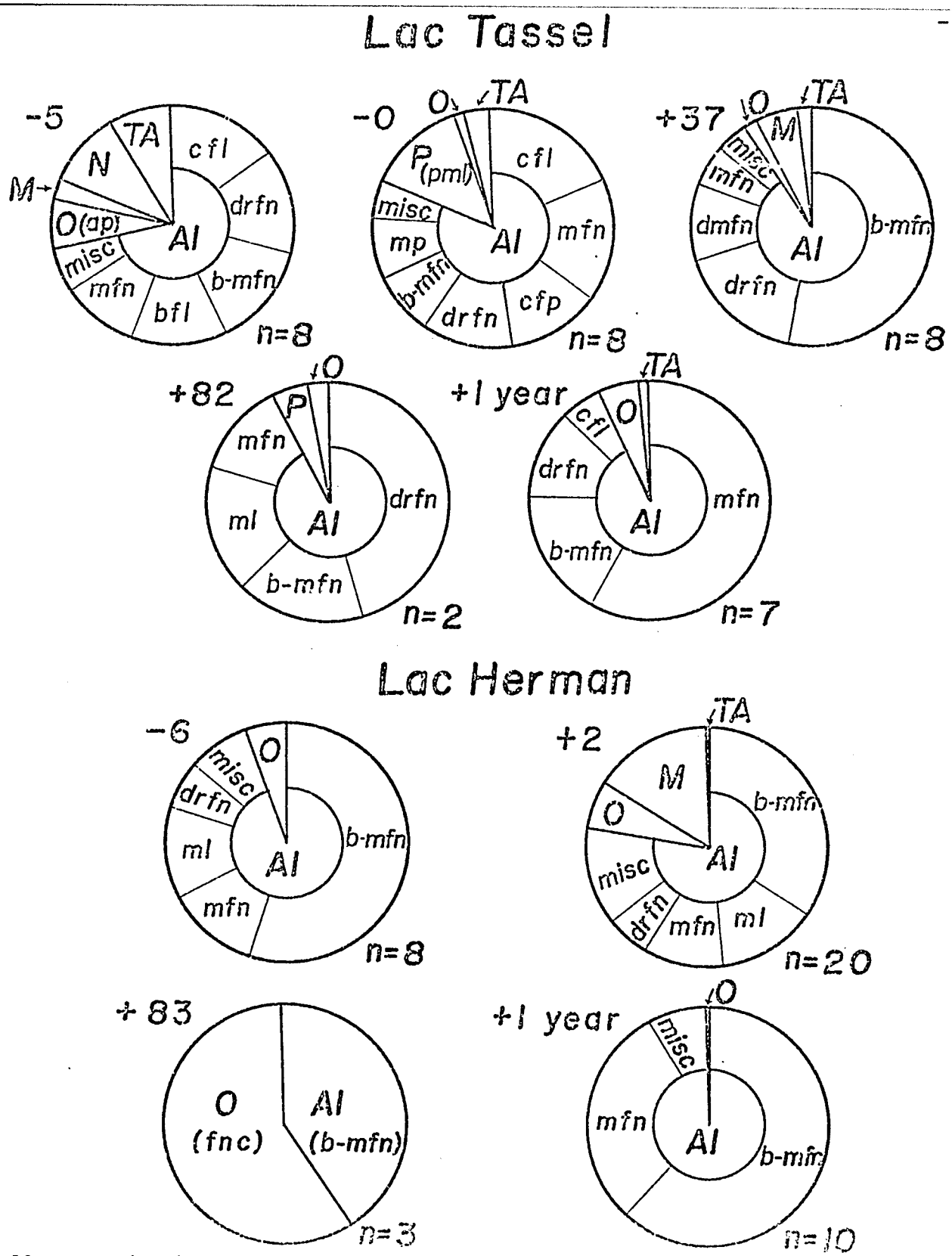

Fig. 13. Contributions of various food items to the diet of brown bullheads in the study lakes. AI-aquatic insects (bfl-blackfly larvae, b-mfn-burrowing mayfly nymphs, cfl-caddisfly larvae, cfp-caddisfly pupae, dmfn-damselfly nymphs, drfn-dragonfly nymphs, mfn-mayfly nymphs, ml-midge larvae, mp-midge pupae, misc.-miscellaneous), P-planktonic organisms (pml-phantom midge larvae), O-other aquatic invertebrates (ap-amphipods, fnc-fingernail clams), M-minnows, N-newts, TA-terrestrial arthropods, n = number of fish sampled, -5, +37 etc. days before or after treatment.

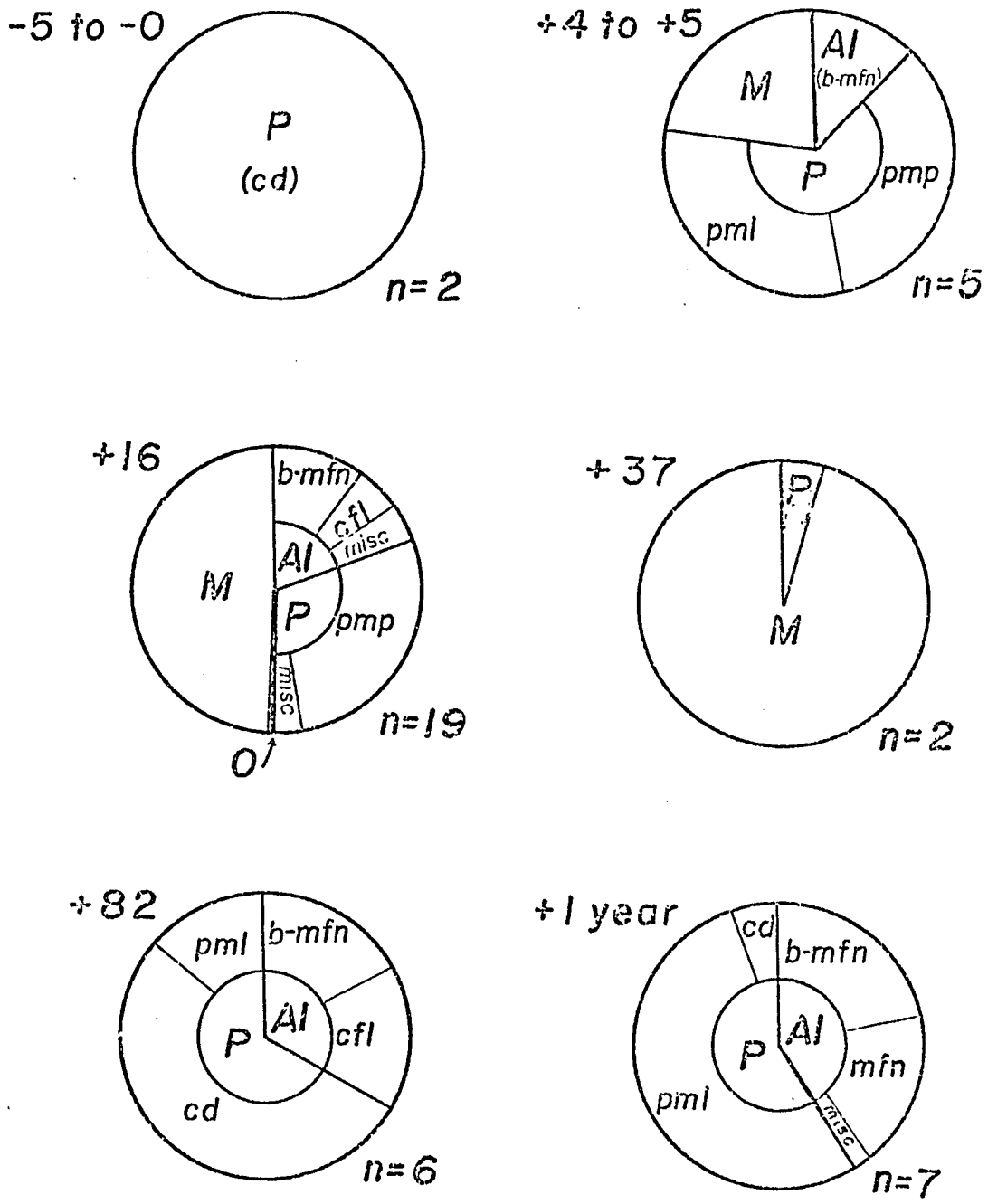

Fig. 14. Contribution of various food items to the diet of yellow perch in Lac Tassel. AI-aquatic insects (b-mfn-burrowing mayfly nymphs, cfl-caddisfly larvae, mfn-mayfly nymphs, misc.-miscellaneous), P-planktonic organisms (cd-cladocerans, pml-phantom midge larvae, pmp-phantom midge pupae, misc.-miscellaneous), O-other aquatic invertebrates, M-minnows, n = number of fish sampled, - 5, +4 etc. - days before or after treatment.

on phantom midge larvae and pupae.

Mean condition coefficients ($K = \frac{10^5 \times \text{weight in grams}}{(\text{length in mm})^3}$) were calculated for three different size classes of white suckers from Lac Tassel and Lac Herman (Table 18). For both lakes, general trends in changes in relative condition were apparent which applied to suckers of all size classes. Condition coefficients decreased to various extents (3.7 to 14.7%) during the last week of May in both lakes. Suckers in Lac Tassel continued to lose condition over the first two weeks of June, except for small suckers in which condtion increased slightly (3.1%). During this same period, all sizes of suckers in Lac Herman increased in condition by relatively large extents (8.4 to 21.5%). Suckers in both lakes increased in condition between mid-June and August with similar gains being recorded for similar sized groups of fish. The net change in condition coefficients over the summer was almost identical for large suckers in the two lakes (an increase of about 9%). Medium-sized suckers in Lac Tassel showed a net decrease of 2.1% whereas the same group had a net increase of 3.8% in the untreated lake. Small suckers in Lac Tassel showed a net decrease in condition over the summer of 4.4%. No comparable calculation can be made for small suckers in Lac Herman because of their absence from the early May sample, but this group showed strong gains in condition between late May and August.

Fallfish in Lac Tassel showed a similar trend in changes in condition as seen in suckers, up until July (Table 19). Their condition coefficients decreased in late May and the first half of June but then increased strongly by early July. Between July and August they lost condition again. Insufficient or incomplete samples of other fish species prevented any meaningful evaluation of changes in their condition.

Table 18

Condition coefficients (K) of different size classes* of white suckers from Lac Tassel and Lac Herman, May 1975 to May 1976

Lac Tassel

		23 May 1975	1 June 1975	13 June 1975
>250 mm	K value	1.111 ± 0.069 (10)	1.070 ± 0.075 (18)	1.039 ± 0.049 (13)
	% change	-	-3.7%	-2.9%
200 mm to 250 mm	K value	1.164 ± 0.081 (26)	1.081 ± 0.068 (28)	1.014 ± 0.074 (14)
	% change	-	-7.1%	-6.2%
<250 mm	K value	1.207 ± 0.088 (13)	1.043 ± 0.067 (8)	1.075 ± 0.044 (8)
	% change	-	-13.6%	+3.1%
		4 July 1975	19 Aug.1975	18 May 1976
>250 mm	K value	1.089 ± 0.059 (5)	1.210 ± 0.132 (7)	1.182 ± 0.106 (7)
	% change	+4.8%	+11.1%	-2.3%
200 mm to 250 mm	K value	1.090 ± 0.041 (5)	1.140 ± 0.056 (10)	1.147 ± 0.075 (4)
	% change	+7.5%	+4.6%	+0.6%
<250 mm	K value	1.139 ± 0.070 (10)	1.154 ± 0.069 (4)	1.090 ± 0.071 (9)
	% change	+6.0%	+1.3%	-5.5%

* Total length

Number of fish in each sample is given in parenthesis.

Table 18 (Cont'd)

Lac Herman

		22 May 1975	30 May 1975	17 June 1975
>250 mm	K value	1.170 ± 0.035 (4)	0.998 ± 0.105 (3)	1.108 (1)
	% change	-	-14.7%	+11.0%
200 mm to 250 mm	K value	1.144 ± 0.096 (15)	1.065 ± 0.076 (17)	1.154 ± 0.040 (3)
	% change	-	-6.9%	+8.4%
<250 mm	K value	-	0.971 ± 0.233 (22)	1.180 ± 0.082 (11)
	% change	-	-	+21.5%

		20 Aug. 1975	17 May 1976
>250 mm	K value	1.277 (1)	1.260 ± 0.006 (3)
	% change	+15.3%	-1.3%
200 mm to 250 mm	K value	1.188 ± 0.037 (2)	1.021 ± 0.122 (16)
	% change	+2.9%	-14.0%
<250 mm	K value	1.257 ± 0.009 (4)	1.029 ± 0.117 (6)
	% change	+6.5%	-18.1%

Number of fish in each sample is given in parenthesis.

Table 19

Condition coefficients of fallfish from Lac Tassel, 23 May to 19 August 1975

Date	Number of fish in sample	Condition coefficient (% Change)
23 May	42	1.083 ± 0.074
1 June	7	1.035 ± 0.036 (-4.4%)
13 June	20	1.003 ± 0.075 (-3.1%)
4 July	3	1.285 ± 0.088 (+28.1%)
19 August	4	1.165 ± 0.119 (-9.3%)

4. Observations on fish and aquatic invertebrates

Considerable mortality occurred among the fish caged at the surface of Lac Tassel to study residue accumulation and persistence. All the white suckers (29) and bullheads (11) held in cages died within 24 hours of treatment of the lake, except for those sampled live for residue analysis over this period. Ten suckers and one bullhead had died in cages over two days before treatment. Thirteen of twenty-one caged bass died over an eight day period after treatment with four bass dying in four days of caging prior to fenitrothion application. Fallfish survival in cages was good until two days after treatment when the last five caged individuals all died.

No indications of mortality or abnormal behavior were observed among native fish populations during scuba dives 30 hours and two weeks after treatment. Three bass nests containing fry in various stages of development appeared unaffected 30 hours after spray application, and the behavior of their guarding males was normal. Large numbers of free swimming fry were observed in the vicinity of these nests two weeks later.

The only observation made of aquatic invertebrate mortality in Lac Tassel was the finding, 30 hours after treatment, of a number of dead small dragonfly nymphs in shallow (1m and less) areas along portions of the lake's shoreline. One apparently healthy large dragonfly nymph was seen at the same time. At this and other times normal appearance and behavior was noted among planarians, water mites, freshwater clams, mayfly nymphs, beetle larvae and darters. Cast off mayfly nymph exuvia were observed in some numbers on the bottom 30 hours after treatment, and adult mayfly activity at the surface of the lake at dusk of this day was very noticeable.

B. Laboratory Bioassays.

The static bioassays with fish were run for periods of up to 336 hours (2 weeks) or until significant mortality began to occur among control groups. Ten percent mortality or less occurred among low dosage groups of golden shiners, white suckers and brown bullheads over 336 hours, indicating that the incipient LC50 value (concentration lethal to 50 percent of the individuals on long exposure (Sprague, 1969)) for these groups was higher than the lowest dosages tested (> 1 mg/ℓ). Mortality among the lowest dosage groups of pumpkinseeds had reached 60 percent after 336 hours while no mortality had occurred in the control groups, indicating that the incipient LC50 value for pumpkinseeds is less than 1 mg/ℓ. Substantial mortality occurred between 96 and 336 hours in the control groups of brook trout and basses, making it impossible to draw conclusions as to whether the incipient LC50 value was approached.

The time-response results of the bioassays were fitted to a probit plane equation involving the two independent variables log time (t) and log dose (x) to yield an equation,

$$\text{Response (in probits)} = A + Bt + Cx.$$

The equation was estimated by a maximum likelihood procedure based on the method of Fletcher and Powell (1963), taking into account the number of subjects per dose level and the observed number of subjects responding at 3, 6, 12, 24, 36, 48, 72 and 96 hours at each dose level.

LC50 values for 24, 48, 72 and 96 hours for each fish species, as calculated from the probit plane equations derived, are presented in Table 20. The range of LC50's for the species tested was quite small, with the most suceptible species (brook trout) only about two and a half

times as sensitive as the least sensitive species (brown bullhead and golden shiner). Smallmouth bass fry and yearling largemouth bass were very close in their susceptibility to fenitrothion. They were both about one and a half times as sensitive as pumpkinseeds, the other centrarchid species tested.

Table 20

LC50's of fenitrothion (mg/ℓ) to various fish species determined from static bioassays

	24h	48h	72h	96h
Brook trout	2.2	1.6	1.4	1.2
Golden shiner	4.9	3.9	3.3	3.0
White sucker	3.6	2.7	2.2	2.0
Brown bullhead	5.4	3.7	2.9	2.5
Pumpkinseed	4.9	3.4	2.8	2.4
Smallmouth bass (fry)	2.9	1.9	1.4	1.2
Largemouth bass	3.2	2.2	1.7	1.5

IV. DISCUSSION

A. Deposit and Dynamics of Fenitrothion in Lake Waters and Fauna

The measured deposit of spray products onto the surface of Lac Tassel accounts for less than half of the emitted dosage. Although deposits of this percentage of emitted material are considered good in forest stands, they seem low for the large flat surface presented by the lake, particularly in light of the excellent weather conditions at the time of treatment. The factor probably responsible for this apparent discrepancy was the difference in temperature between the lake's surface waters (about 20°C) and the air above it (2.2°C). This resulted in rising currents of moist air heated by the warmth of the lake interfering with deposit of spray products.

Spray products reaching the lake's surface rapidly dispersed throughout the epilimnion (surface to 2m) within the first hour. Penetration through the thermocline was somewhat slower but still occurred rapidly, with complete dispersion of fenitrothion through the top 4 metres of the lake occurring within 12 hours. Relatively small amounts of fenitrothion reached the deeper portions of the lake, probably because of the relatively slow rate of mixing between the epilimnion and hypolimnion and within the hypolimnion itself (Hutchinson, 1957). These patterns of disperion of insecticide residues are of great significance in terms of the effects the insecticide has on lake fauna. The rapid dilution of initially high concentrations at the surface would limit the probability and length of exposure of any organism to these relatively high and potentially hazardous concentrations. On the other hand, complete mixing of residues within the epilimnion exposes a greater number and variety of organisms to the insecticide than if it

remained concentrated at the surface. This is probably of greatest significance to benthic organisms confined to the littoral zone. Zooplankton and fish would still not be exposed to these levels of insecticide if their normal habitat were the deep portions of the lake or if they were able to detect and avoid fenitrothion in shallower waters by retreating below the thermocline. The rather low (10 µg/ℓ) threshold value at which goldfish detected and avoided fenitrothion in the laboratory (Scherer, 1975) suggests that it may be feasible that some native fish species could partially avoid exposure to the insecticide in this way.

Once fenitrothion residues had reached their maximum dispersion with the lake waters, they persisted at close to these levels for various periods, with different rates of disappearance at different depths. The major factors affecting the disappearance were breakdown to metabolites, continued dispersion within the lake and addition of residues washed into the lake by rainfall and runoff. Residues declined fastest below the hypolimnion, probably due to the combined effects of breakdown, slow dispersion throughout the hypolimnion and adsorption into bottom sediments. Persistence at the surface was somewhat erratic, probably due to horizontal movement of residues across the surface by wind and waves (suggested by differences in residues found at the surface deep and shoreline stations), and input of residues from rainfall and runoff 64 and 94 hours after treatment. Faster rates of breakdown by photodecomposition by sunlight (Lockhart *et al*, 1973) presumably occurred at the surface than in deeper waters. Fenitrothion residues appear to be most stable and persist longest in the epilimnetic waters just above the thermocline. This suggests that the greatest hazard posed by the fenitrothion residues would be to bottom fauna and fish confined to the epilimnion.

Conflicting results with respect to long term persistence of fenitrothion residues in water were found between pre-spray water samples from both study lakes and water samples from Lac Tassel collected a year after treatment. Both lakes contained residues between 0.16 and 0.18 µg/ℓ of mostly fenitrooxon when sampled prior to treatment in 1975, even though the last time fenitrothion spraying took place in their vicinity appears to have been during the 1974 Quebec spruce budworm control program. In 1976, Lac Tassel waters contained only trace to 0.03 µg/ℓ fenitrothion with no detectable quantities of fenitrooxon being found. These residues were highest in the deeper waters, even though the lake was only slightly stratified. The variation from year to year may be due to differing water chemistry parameters in the lakes over the winters of 1974-75 and 1975-76. Early spring samples suggest that oxygen depletion may have been more severe in the study lakes in the winter of 1974-75 than 1975-76.

The fenitrothion residues accumulated by caged and wild fish in Lac Tassel are similar to those found in caged and wild fish in streams within fenitrothion treated areas in Manitoba (Lockhart *et al*, 1973), Newfoundland (Hatfield and Riche, 1970) and Maine (Marancik, 1976). They demonstrate the rapid accumulation by fish of residues many times higher than in surrounding water. Similar accumulation of fenitrothion residues by anuran larvae has been demonstrated in forest ponds (Lyons *et al*, 1976). The relative level of residues accumulated is distinctly different for different species of fish, and this seems to be true both for fish of different species caged in the same location and fish moving freely in the lakes. This suggests that the accumulation of fenitrothion residues by different species of fish is more dependent on differences in metabolic rate or tissue composition than on differences in habitat preference. Bottom feeding

species such as white suckers and brown bullheads accumulated as much fenitrothion as smallmouth bass and fallfish, which fed on the surface to a much greater extent. Since all the fish in the lake appeared to be feeding in the epilimnion of the lake at the time of treatment, they probably were all exposed to similar concentrations of fenitrothion. The only exception noted was the smallmouth bass exposed to and affected by concentrated residues at the surface within minutes of treatment. The hazard of exposure of surface feeding species of fish to this type of concentrated residue is increased by the presence of distressed flying and terrestrial insects knocked down onto the surface.

The significance of the fenitrothion levels accumulated in fish is difficult to determine. Since no distress or mortality was noted among "wild" fish, with the exception already noted, these fenitrothion levels do not appear to constitute a serious hazard to fish survival. Mortality among caged fish suggests that those levels of fenitrothion do constitute a significant stress factor which can lead to mortality when combined with caging and high temperature stress. Salmonids accumulating residue levels close to those found in this study have not suffered effects on brain acetylcholinesterase activity or serum chemistry (Lockhart *et al*, 1973). The rapid disappearance of residues from all fish species with the possible exception of white suckers suggests that long term effects are unlikely to be found.

Freshwater clams accumulate relatively small residue levels depsite their filter-feeding existence. This is notably different from the dramatic accumulation of the persistent organochlorine insecticides which has been found in bivalve molluscs (Butler, 1969).

B. Effects of Fenitrothion on Populations of Fish Food Organisms in Lakes

Even the highest fenitrothion residues found in Lac Tassel after treatment were below reported 24 hour LC50 values for all but the most sensitive aquatic invertebrates (McLeese, 1976). Residues of these levels have, however, been shown to cause considerable disturbance among benthic invertebrates in streams (Eidt, 1975). Lakes generally constitute more stable ecosystems than streams as they are far less subject to extreme short term physical, chemical and temperature fluctuations, and this might moderate both impact on and recovery of invertebrate populations.

Comparison between changes in cladoceran populations in the treated and control lake suggest that some short term depression of cladoceran populations related to the fenitrothion treatment occurred in Lac Tassel. The differences may, however, simply reflect natural differences in the cladoceran faunas of the two lakes as the increases in cladoceran numbers in Lac Herman at the time when populations were depressed in Lac Tassel was almost entirely due to increases in *Bosmina*, a genus never represented by more than a single individual in plankton catches from the deep station at Lac Tassel. *Bosmina* were present in large numbers at the shoreline station of Lac Tassel before treatment but disappeared completely after treatment, suggesting that the differences could also be due to a selective effect on this genus of cladoceran.

Changes in abundance of the larger genera *Daphnia* and *Holopedium* in the two lakes showed no apparent differences attributable to fenitrothion treatment. Copepod populations in Lacs Tassel and Herman followed similar patterns of abundance, showing that they were not affected by the fenitrothion treatment.

The relative stability of total benthic organisms sampled per Ekman grab sample from Lac Tassel over the study period shows that the insecticide treatment did not greatly affect benthic organisms in general. Comparison with populations in the control lake suggest that dragonfly nymphs, amphipods and possibly marl beetle larvae were selectively affected, with some indications that recovery of these groups was quite slow. Unfortunately, Ekman grab samples do not provide a very suitable method of measuring populations of larger, widely scattered or highly mobile benthic invertebrates as the numbers sampled per unit area are very low while the standard deviation among groups of samples are often as high as 200 to 300 percent for groups of benthic organisms present at low densities. Some method of visual counts along a grid system or even population assessment using a mark-recapture system such as used for measuring crayfish populations in lakes (Emery, 1975) might be more suitable for measuring impact on important large fish food items such as dragonfly nymphs.

No effects on emerging insect populations were apparent from emergence trap collections from the study lakes. Toxicology studies have demonstrated that pupal stages of insects are generally much less susceptible to insecticide poisoning than larval stages, due to their quiescent, non-feeding habit, and this may be true among aquatic insects which undergo complete metamorphosis.

C. Effects of Fenitrothion on the Diet and Condition of Fish in Lakes

Severe effects of the chlorinated hydrocarbon insecticide DDT on fish food organisms in New Brunswick streams in the 1950's, resulted in dramatic changes in the food consumed by young Atlantic salmon (Keenleyside, 1967). Reductions of the aquatic insect populations on which salmon had been feeding resulted in a change in diet towards midge larvae recolonizing the streams and snails, worms and fish, previously unimportant as salmon food items. This kind of change in the diet of fish can adversely affect their condition and growth through insufficient food being available, less nutritional value being represented in the sources of food turned to, or more energy being expended in procuring the new food items.

There were few indications that the fenitrothion treatment caused significant changes in the diets of fish in Lac Tassel. The contribution of cladocerans to the diets of white suckers, fallfish and yellow perch did appear to decline during the period when cladoceran populations were depressed in the lake. Aquatic insects consistently made up a large proportion of the stomach contents of white suckers and brown bullheads over the summer following treatment, and none of the major aquatic insect food items were consistently absent following the treatment. The insecticide application had a short lasting effect of increasing the availability of terrestrial arthropods to surface feeding smallmouth bass and fallfish, but their utilization of this food supply was simply opportunistic feeding and not a lasting deviation from their normal diet. There is some indication that the fenitrothion treatment made some of the larger aquatic insects susceptible to fish predation for a short period by increasing their movements in response to the

irritating effects of the insecticide. This has often been seen in streams where insect drift increases after an insecticide application and fish feed on the disturbed insects in the drift.

MacDonald and Penney (1968) found that salmon parr populations in a fenitrothion treated and an untreated stream showed similar increases in their average condition factor over an eight week period. In this study white suckers over 250 mm in total length in the two lakes had a similar net change in mean condition coefficient over the summer, while smaller white suckers appeared to increase in condition to a greater extent in the untreated lake. No definitive conclusions can be made on the effects of the fenitrothion treatment on fish condition because of small sample sizes and large standard deviations within samples. The limited observations made on nesting smallmouth bass indicated that reproduction of this species occurred successfully and the newly hatched fry survived the period of greatest fenitrothion residues in their environment.

D. Toxicity of Fenitrothion to Different Fish Species

Bioassays with different fish species have shown that there is a tendency for sensitivity to a pesticide to follow family lines (Walker *et al*, 1964). Macek and McAllister (1970) tested twelve species of fish against nine insecticides and found that susceptibility was generally similar within systematic groups, with Salmonidae being the most susceptible of the families tested and Ictaluridae and Cyprinidae being the least susceptible. Identical results were found in the fenitrothion bioassays conducted, even though different species were used than in the Macek and McAllister study. The salmonid (brook trout) was the most sensitive species while the ictalurid (brown bullhead) and cyprinid (golden shiner) were the least sensitive. The two species of *Micropterus* tested were found to be very similar in their response to fenitrothion, even though individuals of very different size were tested. This suggests that the closer the systematic relationship, the closer the susceptiblity to fenitrothion.

The toxicity of fenitrothion to cyprinids and ictalurids as compared to the three centrarchids tested fall within the range of 1:1 to 2:1 found by Macek and McAllister. They related the low range of susceptibilities of different fish families to phosphorothioate insecticides in general to the structure of the organophosphorus molecule which is released during phosphorylation of cholinesterase. All organophosphorus insecticides such as fenitrothion having a substituted phenyl moiety as a leaving group appear to exhibit a small range of toxicities to different fish species.

V. GENERAL DISCUSSION AND CONCLUSIONS

Fenitrothion applied at dosages registered for forest insect control does not appear to present a serious hazard to native fish populations in lakes exposed to aerial applications. Insecticide deposit on lakes from early morning or late evening applications is limited by air currents rising from the surface of the lake, provided that surface waters are warmer than air temperatures. Concentrations of fenitrothion in lake waters are unlikely to exceed suggested 'safe levels' of 0.1 to 0.05 of the incipient LC50 (Sprague, 1971). Maximum fenitrothion concentrations measured in lake waters from the application of twice the normal dosage applied in forest pest control operations were 21.6 µg/ℓ, while incipient LC50 values for most fish species appear to be close to or greater than 1 mg/ℓ.

Individual fish may suffer acute or sublethal effects if they come into contact with concentrated fenitrothion residues at the lake's surface shortly after they enter the lake. This hazard may be increased if the insecticide is carried in a solvent oil which holds it in a surface film or if fish are drawn to the surface to feed on knocked down flying insects. Fenitrothion applied as an emulsion in water rapidly disperses throughout lake waters and fish frequenting different habitats within the lake are all exposed to it and rapidly accumulate residues many times higher than found in water. Fenitrothion applied as an oil formulation would probably remain concentrated near the surface and would be expected to be accumulated to a greater extent by fish feeding in shallow water or at the surface than by bottom feeding species.

The application of 420g fenitrothion/ha to Lac Tassel had little effect on populations of fish food organisms or the diet of native fish species, with the possible exception of numbers of cladocerans and their contribution to the diets of white suckers, fallfish and yellow perch. The impact of severe reductions of zooplankton populations by insecticides in lakes would be most serious in terms of reduced survival and growth of juvenile fish totally dependent on these tiny organisms as the only suitable food source available.

Many aspects of insecticides in lakes require further study to broaden our understanding of possible effects and permit sound decision making concerning their use. Some suggested areas for focusing future investigations are implications of the type of formulation used on the fate and biological effects of insecticides, the role of lake sediments in the storage and persistence of insecticides, effects on large, shallow dwelling invertebrate fish food organisms such as dragonfly nymphs and crayfish, effects on the juvenile life stages of fish species reproducing in the early spring and long term persistence of insecticides in lake ecosystems.

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APPENDIX

Diets of fish in Lac Tassel and Lac Herman

May 1975 to May 1976

Table 1

Fish sampled for stomach content analysis from Lac Tassel

White suckers

Date	May 23 (-5)	June 1 (+4)	June 13 (+16)
Number of fish sampled	20	20	20
Capture method	Gill Net	Gill Net	Gill Net
Mean total length (mm)	238.6	258.1	241.6
Mean fork length (mm)	220.8	239.6	227.0
Mean preserved weight (g)	157.9	201.3	150.0
Sex ratio (males:females)	17:3	15:5	14:6
Date	July 4 (+37)	Aug. 19 (+82)	18 May 1976 (+1 year)
Number of fish sampled	20	20	20
Capture method	Gill Net	Gill Net	Gill Net
Mean total length (mm)	221.9	239.4	264.3
Mean fork length (mm)	207.6	225.3	246.8
Mean preserved weight (g)	138.7	175.2	221.8
Sex ratio (males:females)	18:2	14:6	7:3

Smallmouth bass

Date	May 20-23 (-8 to -5)	May 28 (+0)	May 28 (+15 hours)
Number of fish sampled	8	8	3
Capture method	Angling	Trap Net	Angling
Mean total length (mm)	269.2	244.5	344.6
Mean fork length (mm)	256.6	233.5	317.3
Sex ratio (males:females:immatures	5:3:0	1:5:2	2:1

Table 1 (Cont'd.)

Smallmouth bass (Cont'd.)

Date	May 31-June 1 (+3 to +4)	June 4 (+7)	June 12 (+15)	July 3 (+36)
Number of fish sampled	7	4	12	20
Capture method	Angling	Angling	Angling (9) Gill Net (3)	Angling
Mean total length (mm)	205.0	176.5	231.6	284.4
Mean fork length (mm)	196.8	168.0	220.6	270.8
Sex ratio (males:females:immatures)	4:2:1	0:1:3	7:5:0	17:3:0

Date	July 4 (+37)	Aug. 19 (+82)	18-30 May, 1976 (+1 year)	
Number of fish sampled	12	5	2	
Capture method	Gill Net (7) Trap Net (5)	Gill Net	Angling (1) Gill Net (1)	
Mean total length (mm)	208.7	160.8	247.5	
Mean fork length (mm)	200.5	153.2	241.0	
Sex ratio (males:females:immatures)	12:0:0	4:0:1	2:0:0	

Brown bullheads

Date	May 23 (-5)	May 28 (-0)	July 4 (+37)	Aug. 19 (+82)	18 May, 1976 (+1 year)
Number of fish sampled	8	8	8	2	7
Capture method	Gill Net	Trap Net	Gill Net (5) Trap Net (3)	Gill Net	Gill Net
Mean total length (mm)	205.6	190.1	186.6	159.5	205.6
Mean preserved weight (g)	129.1	108.8	94.7	51.8	131.6
Sex ratio (males:females:immatures)	4:4:0	3:3:2	5:3:0	1:1:0	3:4:0

Table 1 (Cont'd.)

Yellow Perch

Date	May 23-28 (-5 to -0)	June 1-2 (+4 to +5)	June 13 (+16)
Number of fish sampled	2	5	19
Capture method	Gill Net (1) Trap Net (1)	Gill Net (4) Trap Net (1)	Gill Net
Mean total length (mm)	217.5	180.8	208.9
Mean fork length (mm)	208.0	173.2	199.8
Mean weight (g)	110.8	62.2	101.9
Date	July 4 (+37)	Aug. 19 (+82)	18 May, 1976 (+1 year)
Number of fish sampled	2	6	7
Capture method	Gill Net	Gill Net	Gill Net
Mean total length (mm)	230.0	195.2	143.3
Mean fork length (mm)	221.0	187.5	138.1
Mean weight (g)	124.5	80.3	42.3

Common Shiners

Date	May 23 (-5)	May 30 (+2)	June 13 (+16)
Number of fish sampled	2	1	2
Capture method	Gill Net	Trap Net	Gill Net
Mean total length (mm)	162.5	198.0	160.5
Mean fork length (mm)	148.0	183.0	147.5
Mean weight (g)	63.0	130.5	61.5
Sex ratio (males:females)	2:0	1:0	1:1

Table 1 (Cont'd.)

Fallfish

Date	May 20 (-8)	May 23 (-5)	May 28 (+15 hours)
Number of fish sampled	5	20	1
Capture method	Angling	Gill Net	Angling
Mean total length (mm)	261.8	231.1	268.0
Mean fork length (mm)	238.6	208.4	246.0
Mean preserved weight (g)	-	136.2	-
Sex ratio (males:females)	2:3	8:12	1:0
Date	May 31 (+3)	June 1 (+4)	June 13 (+16)
Number of fish sampled	5	7	20
Capture method	Angling	Gill Net	Gill Net
Mean total length (mm)	233.6	227.9	215.5
Mean fork length (mm)	210.6	205.7	196.3
Mean preserved weight (g)	-	125.6	105.5
Sex ratio (males:females)	5:0	4:3	13:7
Date	July 4 (+37)	Aug. 19 (+82)	18 May 1976 (+1 year)
Number of fish sampled	4	4	1
Capture method	Angling (1) Gill Net (3)	Gill Net	Gill Net
Mean total length (mm)	261.8	252.5	260.0
Mean fork length (mm)	239.3	231.8	240.0
Mean preserved weight (g)	184.5	185.6	238.0
Sex ratio (males:females)	4:0	1:3	0:1

Table 2

Fish sampled for stomach content analysis from Lac Herman

White Suckers

Date	May 22 (-6)	May 30 (+2)	June 17 (+20)
Number of fish sampled	19	20	15
Colletion method	Gill Net	Gill Net	Gill Net
Mean total length (mm)	248.5	221.0	193.4
Mean fork length (mm)	230.3	206.9	181.1
Mean preserved weight (g)	184.2	122.9	90.9
Sex ratio (males:females)	7:12	13:7	7:8

Date	Aug. 20 (+83)	17 May, 1976 (+1 year)
Number of fish sampled	7	20
Colletion method	Gill Net	Gill Net
Mean total length (mm)	206.1	235.8
Mean fork length (mm)	192.4	219.4
Mean preserved weight (g)	116.3	154.0
Sex ratio (males:females)	2:5	6:14

Brook Trout

Date	May 13 (-15)	May 22 (-6)	May 30 (+2)
Number of fish sampled	6	21	11
Collection method	Angling	Gill Net	Gill Net
Mean total length (mm)	312.8	276.6	267.0
Mean fork length (mm)	299.8	263.8	254.8
Sex ratio (males:females:immatures)	1:5:0	10:10:1	4:7:0

Table 2 (Cont'd.)

Brook Trout (Cont'd.)

Date	June 17 (+20)	Aug. 20 (+83)	17 May, 1976 (+1 year)	
Number of fish sampled	2	19	8	
Collection method	Gill Net	Gill Net	Gill Net	
Mean total length (mm)	213.5	228.6	330.0	
Mean fork length (mm)	206.0	217.8	317.6	
Sex ratio (males:females:immatures)	1:1:0	14:5:0	2:4:2	
Brown bullheads				
Date	May 22 (-6)	May 30 (+2)	Aug. 20 (+83)	17 May 1976 (+1 year)
Number of fish sampled	8	20	3	10
Collection method	Gill Net	Gill Net	Gill Net	Gill Net
Mean total length (mm)	125.0	135.4	144.3	156.6
Mean preserved weight (g)	30.7	35.5	36.8	48.8
Sex ratio (males:females:immatures)	1:3:4	14:6:0	3:0:0	5:5:5

Table 3

Food items found in fish stomachs from Lac Tassel and Lac Herman

Food group	Common Name	Comments
Aquatic insects	Alderfly larvae	Megaloptera:Sialidae (*Sialis* sp.)
	Backswimmers	Hemiptera:Notonectidae
	Beetles	Coleoptera:various families
	Beetle larvae	Coleoptera:primarily Elmidae
	Blackfly larvae	Diptera:Simuliidae (from streams entering lakes)
	Burrowing mayfly nymphs	Ephemeroptera:Ephemeridae
	Caddisfly larvae	Trichoptera-various families
	Caddisfly pupae	" " "
	Caterpillars	Lepidoptera:Pyralidae
	Damselfly nymphs	Odonata:Zygoptera
	Dragonfly nymphs	Odonata:Gomphidae and Libellulidae
	Fishfly larvae	Megaloptera:Corydalidae
	Mayfly nymphs	Ephemeroptera:Baetidae and Heptageniidae
	Midge larvae	Diptera:Chironomidae and some Heleidae (Culicoides sp.)
	Midge pupae	" "
	Spongilla-fly larvae	Neuroptera:Sisyridae
	Water boatmen	Hemiptera:Corixidae
	Water striders	Hemiptera:Gerridae
Planktonic organisms	Cladocerans	Crustacea-Cladocera
	Copepods	Crustacea-Copepoda
	Ostracods	Crustacea-Ostracoda
	Phantom midge larvae	Insecta-Diptera:Culicidae (*Chaoborus* sp.)
	Phantom midge pupae	" " " "

Table 3 (Cont'd.)

Food group	Common name	Comments
Other aquatic invertebrates	Amphipods	Crustacea-Amphipoda
	Fingernail clams	Pelecypoda-Sphaeriidae
	Isopods	Crustacea-Isopoda
	Leeches	Hirudinea
	Oligochaetes	Oligochaeta
	Snails	Gastropoda
	Water mites	Arachnida-Hydracarina
Fish eggs	Probably white sucker eggs	
Minnows	Includes small white suckers and perch as well as cyprinids	
Frogs	Probably green frogs. Rana clamitans	
Newts	Spotted newts. Triturus viridescens	
Terrestrial arthropods	Beetles	Coleoptera:various families
	Dragonflies	Odonata:Anisoptera
	Flying ants	Hymenoptera:Formicidae
	Midges	Diptera:various families
	Spiders	Arachnida
	Unidentified flying insects	Include Diptera, Trichoptera, Ephemeroptera etc.
	Unidentified terrestrial insects	Include Hemiptera, larval Lepidoptera etc.

Notes on appendix Tables 4 to 28.

Mean volume of stomach contents - Mean of all fish in sample including those with empty stomachs

Mean percent of the volume contributed by various food items - only fish with some food in their stomach are included in calculating these values. The % contribution to volume of each food item in an individual fish's stomach is determined for all fish in the sample with some food in their stomach. For each food item, the % contributions to volume for each fish stomach in which that food item occurs are then summed and the total is taken as a percentage of the possible total contribution (the number of fish with food in their stomachs X 100%). This means that a midge larva contributing 100% of the volume of the stomach contents of one fish ends up with the same value as a 5 cm minnow contributing 100% of the volume of another fish's stomach contents.

Mean numbers of various food items in stomachs in which they occurred - Only fish with the food item in question in their stomachs are included in taking the mean

Example
Fish 1 Six snails (0.2 ml) One minnow (0.6 ml)
Fish 2 Four snails (0.1 ml)
Fish 3 Empty

Mean volume of stomach contents: $\frac{0.8 + 0.1}{3} = 0.3$ ml

Mean percent of the volume contributed by:

Snails $\frac{25\% + 100\%}{2 \times 100\%} = 62.5\%$

Minnows $\frac{80\%}{2 \times 100\%} = 37.5\%$

Mean numbers in stomachs in which they occur:

Snails $\frac{6 + 4}{2} = 5$

Minnows $\frac{1}{1} = 1$

Table 4

Percent occurrence of various food items in white sucker digestive tracts from Lac Tassel, 23 May, 1975 to 18 May, 1976

Number of days before or after treatment	-5	+4	+16	+37	+82	+1 year
No food present	10	0	20	5	5	0
Aquatic insects						
Alderfly larvae	10	5	10	0	5	0
Beetles	25	5	5	30	5	0
Beetle larvae	55	15	20	35	15	10
Burrowing mayfly nymphs	10	15	10	5	5	20
Caddisfly larvae	75	65	25	40	50	20
Caddisfly pupae	0	5	0	0	0	0
Damselfly nymphs	0	0	0	0	15	10
Dragonfly nymphs	20	30	10	5	65	0
Mayfly nymphs	20	35	10	25	5	10
Midge larvae	85	90	80	85	65	20
Midge pupae	55	30	35	10	15	0
Unidentifiable	0	0	0	0	0	10
Planktonic organisms						
Cladocerans	25	55	5	35	95	100
Copepods	0	0	25	5	0	10
Ostracods	0	0	5	0	0	0
Phantom midge larvae	20	10	5	0	0	10
Other aquatic invertebrates						
Amphipods	30	0	10	50	30	10
Fingernail clams	0	10	0	0	0	0
Snails	20	15	25	35	40	0
Water mites	5	25	15	25	5	0
Fish eggs	0	0	0	0	0	10
Flying insects	0	0	0	0	5	0

Table 5

Mean percent of the volume of white sucker digestive tract contents contributed by various food items, Lac Tassel, 23 May, 1975 to 18 May, 1976

Number of days before or after treatment	-5	+4	+16	+37	+82	+1 year
Aquatic insects						
Alderfly larvae	0.6	0.2	1.9	0.0	0.5	0.0
Beetles	3.4	0.8	0.6	4.7	0.3	0.0
Beetle larvae	6.6	1.5	4.1	8.9	1.6	0.5
Burrowing mayfly nymphs	0.8	2.8	2.2	0.5	0.3	4.2
Caddisfly larvae	21.9	17.0	3.8	7.9	11.8	1.0
Caddisfly pupae	0.0	0.8	0.0	0.0	0.0	0.0
Damselfly nymphs	0.0	0.0	0.0	0.0	1.3	0.3
Dragonfly nymphs	4.2	6.5	4.1	1.0	27.1	0.0
Mayfly nymphs	5.0	4.2	1.2	3.9	0.3	0.5
Midge larvae	22.5	26.2	55.9	38.7	10.3	4.9
Midge pupae	8.6	2.2	4.1	0.8	0.5	0.3
Unidentifiable	0.0	0.0	0.0	0.0	0.0	0.3
Plantonic organisms						
Cladocerans	14.7	32.8	5.9	14.7	37.9	78.4
Copepods	0.0	0.0	7.8	0.3	0.0	3.9
Ostracods	0.0	0.0	0.6	0.0	0.0	0.0
Phantom midge larvae	5.6	0.5	0.0	0.0	0.0	4.7
Other aquatic invertebrates						
Amphipods	3.6	0.0	2.8	11.8	2.1	0.2
Fingernail clams	0.0	0.5	0.0	0.0	0.0	0.0
Snails	1.2	1.8	4.4	4.5	5.0	0.5
Water mites	0.3	2.2	1.2	2.1	0.5	0.0
Fish eggs	0.0	0.0	0.0	0.0	0.0	0.3
Flying insects	0.0	0.0	0.0	0.0	0.5	0.0

Table 6

Mean numbers of various food items in white sucker digestive tracts in which they occurred,

Lac Tassel, 23 May, 1976 to 18 May, 1977

Number of days before or after treatment	-5	+4	+16	+37	+82	+1 year
Aquatic insects						
Alderfly larvae	1	1	1½	-	3	-
Beetles	4	5	6	2	4	-
Beetle larvae	4	2	5	6	9	10
Burrowing mayfly nymphs	1	2	1½	2	2	1
Caddisfly larvae	6	9	1	3	∿12	4
Caddisfly pupae	-	4	-	-	-	-
Damselfly nymphs	-	-	-	-	1	2
Dragonfly nymphs	3	3	1	3	5	6
Mayfly nymphs	4	1½	1	1	1	-
Midge larvae	∿30	∿29	∿30	∿28	∿30	∿17
Midge pupae	5	1	1	1½	1	-
Unidentifiable		-	-	-	-	1
Planktonic organisms						
Cladocerans	100's	∿1000	1000's	100's	∿1000	∿1000
Copepods	-	-	100's	∿100	-	∿1000
Ostracods	-	-	50	-	-	-
Phantom midge larvae	∿20	1	1	-	-	∿300
Other aquatic invertebrates						
Amphipods	∿6	-	4	16	10	5
Fingernail clams	-	1½	-	-	-	-
Snails	1½	3	5	4	11	-
Water mites	2	2	1	1	1	-
Fish eggs	-	-	-	-	-	10
Flying insects	-	-	-	-	3	-

Table 7

Percent occurrence of various food items in white sucker digestive tracts from Lac Herman, 22 May, 1975 to 17 May, 1976

Number of days before or after treatment of Lac Tassel	-6	+2	+20	+83	+1 year
No food present	0	20	7	14	15
Aquatic insects					
Alderfly larvae	16	0	0	14	0
Beetles	0	5	0	0	0
Beetle larvae	0	5	0	14	5
Burrowing mayfly nymphs	58	30	33	43	30
Caddisfly larvae	42	30	13	43	10
Caddisfly pupae	0	5	0	0	0
Dameslfly nymphs	0	5	0	0	5
Dragonfly nymphs	10	15	7	0	5
Mayfly nymphs	0	5	7	14	10
Midge larvae	90	70	53	71	50
Midge pupae	16	30	27	14	55
Water boatmen	5	0	0	0	0
Planktonic organisms					
Cladocerans	5	20	64	0	25
Phantom midge larvae	0	5	0	0	5
Phantom midge pupae	0	0	0	14	0
Other aquatic invertebrates					
Amphipods	5	0	0	0	5
Fingernail clams	0	0	7	29	0
Oligochaetes	10	0	0	0	0
Snails	32	0	0	0	0
Water mites	5	5	0	0	0

Table 8

Mean percent of the volume of white sucker digestive tract contents contributed by various food items, Lac Herman, 22 May, 1975 to 17 May, 1976.

Number of days before or after treatment of Lac Tassel	-6	+2	+20	+83	+1 year
Aquatic insects					
Alderfly larvae	0.6	0.0	0.0	2.5	0.0
Beetles	0.0	0.3	0.0	0.0	0.0
Beetle larvae	0.0	0.3	0.0	5.0	0.3
Burrowing mayfly nymphs	25.5	9.4	17.5	46.7	11.5
Caddisfly larvae	16.0	13.1	3.2	20.8	7.9
Caddisfly pupae	0.0	1.2	0.0	0.0	0.0
Damselfly nymphs	0.0	2.5	0.0	0.0	0.3
Dragonfly nymphs	1.3	4.1	1.1	0.0	2.0
Mayfly nymphs	0.0	1.6	0.7	0.8	4.1
Midge larvae	28.7	29.4	17.8	16.7	12.4
Midge pupae	10.8	17.5	1.8	4.2	42.0
Water boatmen	0.1	0.0	0.0	0.0	0.0
Planktonic organisms					
Cladocerans	<0.1	17.2	57.5	0.0	15.9
Phantom midge larvae	0.0	0.3	0.0	0.0	0.6
Phantom midge pupae	0.0	0.0	0.0	0.8	0.0
Other aquatic invertebrates					
Amphipods	0.5	0.0	0.0	0.0	0.3
Fingernail clams	0.0	0.0	0.4	2.5	0.0
Oligochaetes	5.8	0.0	0.0	0.0	0.0
Snails	8.4	0.0	0.0	0.0	0.0
Water mites	2.1	3.1	0.0	0.0	0.0

Table 9

Mean numbers of various food items in white sucker digestive tracts in which they occurred, Lac Herman, 22 May, 1975 to 17 May, 1976

Number of days before or after treatment of Lac Tassel	-6	+2	+20	+83	+1 year
Aquatic insects					
Alderfly larvae	1	-	-	2	-
Beetles	-	1	-	-	-
Beetle larvae	-	2	-	7	1
Burrowing mayfly nymphs	5	3	4	~18	3
Caddisfly larvae	9	3	7	6	7
Caddisfly pupae	-	3	-	-	-
Damselfly nymphs	-	4	-	-	1
Dragonfly nymphs	1	2	2	-	3
Mayfly nymphs	-	10	1	1	6
Midge larvae	~40	~25	~45	9	~17
Midge pupae	~40	~20	1	4	~20
Water boatmen	1	-	-	-	-
Plankton organisms					
Cladocerans	1	100's	1000's	-	100's
Phantom midge larvae	-	10	-	-	1
Phantom midge pupae	-	-	-	1	-
Other aquatic invertebrates					
Amphipods	1	-	-	-	6
Fingernail clams	-	-	2	2½	-
Oligochaetes	1½	-	-	-	-
Snails	14	-	-	-	-
Water mites	2	2	-	-	-

Table 10

Percent occurrence of various food items in smallmouth bass stomachs from Lac Tassel
20 May, 1975 to 30 May, 1976

Number of days before or after treatment	-8 to -5	-0	+15 hours	+3 to +4	+7	+15	+36	+37	+82	+1 year
No food present	12	25	33	0	50	17	55	50	0	50
Aquatic insects										
Alderfly larvae	12	0	33	0	0	0	0	0	20	0
Beetles	0	0	0	0	0	0	0	8	0	0
Beetle larvae	0	0	0	0	0	0	0	0	20	0
Burrowing mayfly nymphs	12	12	0	14	25	33	10	8	40	0
Caddisfly larvae	12	0	33	86	0	0	0	0	0	0
Caddisfly pupae	0	0	0	14	25	0	0	0	0	0
Damselfly nymphs	0	0	33	29	0	0	0	0	0	0
Dragonfly nymphs	12	0	0	71	0	25	0	0	20	0
Mayfly nymphs	38	38	67	71	0	33	0	0	40	0
Midge larvae	0	12	0	43	0	8	0	0	0	0
Midge pupae	0	0	67	14	0	0	0	0	0	0
Planktonic organisms										
Cladocerans	0	0	0	0	0	0	0	0	40	0
Phantom midge larvae	0	0	0	14	0	0	0	0	20	0
Phantom midge pupae	0	0	0	0	0	8	5	0	0	0
Other aquatic invertebrates										
Snails	0	0	0	0	0	8	0	0	0	0
Water mites	0	0	0	14	0	0	0	0	0	0
Minnows	12	38	0	0	25	42	40	33	0	0
Frogs	0	12	0	0	0	0	0	0	0	0
Terrestrial and flying insects										
Beetles	0	12	33	0	0	8	0	0	0	0
Dragonflies	0	0	0	0	0	8	5	17	0	0
Midges	0	0	0	0	25	8	0	0	0	0
Unidentified flying insects	12	0	67	0	0	17	5	17	0	50
Unidentified terrestrial insects	38	0	0	0	0	0	0	0	0	0

Table 11

Mean percent of the volume of smallmouth bass stomach contents contributed by various food items, Lac Tassel, 20 May, 1975 to 30 May, 1976

Number of days before or after treatment	-8 to -5	-0	+15 hours	+3 to +4	+7	+15	+36	+37	+83	+1 year
Mean volume of stomach contents (ml)	0.30	2.40	0.80	0.44	0.10	0.65	1.03	0.51	0.26	0.10
Aquatic insects										
Alderfly larvae	2.9	0.0	5.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Beetles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
Beetle larvae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0
Burrowing mayfly nymphs	10.0	8.3	0.0	1.4	10.0	13.5	3.3	0.0	12.0	0.0
Caddisfly larvae	0.7	0.0	5.0	18.6	0.0	0.0	0.0	0.0	0.0	0.0
Caddisfly pupae	0.0	0.0	0.0	5.7	25.0	0.0	0.0	0.0	0.0	0.0
Damselfly nymphs	0.0	0.0	10.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0
Dragonfly nymphs	10.0	0.0	0.0	36.4	0.0	11.8	0.0	0.8	20.0	0.0
Mayfly nymphs	18.6	40.0	10.0	31.4	0.0	14.8	0.0	0.0	24.0	0.0
Midge larvae	0.0	1.7	0.0	0.7	0.0	1.0	0.0	0.0	0.0	0.0
Midge pupae	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Planktonic organisms										
Cladocerans	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.0	0.0
Phantom midge larvae	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	4.0	0.0
Phantom midge pupae	0.0	0.0	0.0	0.0	0.0	2.0	1.1	0.0	0.0	0.0
Other aquatic invertebrates										
Snails	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Water mites	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Minnows	0.7	45.8	0.0	0.0	50.0	44.5	86.7	49.2	0.0	0.0
Frogs	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terrestrial and flying insects										
Beetles	0.0	0.8	2.5	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Dragonflies	0.0	0.0	0.0	0.0	0.0	6.0	5.6	33.3	0.0	0.0
Midges	0.0	0.0	0.0	0.0	15.0	0.5	0.0	0.0	0.0	0.0
Unidentified flying insects	14.3	0.0	60.0	0.0	0.0	4.5	3.3	15.8	0.0	100.0
Unidentified terrestrial insects	42.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 12

Mean numbers of various food items in smallmouth bass stomachs in which they occurred, Lac Tassel, 20 May, 1975 to 30 May, 1976

Number of days before or after treatment	-8 to -5	-0	+15 hours	+3 to +4	+7	+15	+36	+37	+83	+1 year
Aquatic insects										
Alderfly larvae	1	-	1	-	-	-	-	-	1	-
Beetles	-	-	-	-	-	-	-	1	-	-
Beetle larvae	-	-	-	-	-	-	-	-	1	-
Burrowing mayfly nymphs	1	1	-	1	1	2	1	-	1	-
Caddisfly larvae	2	-	3	6	-	-	-	-	-	-
Caddisfly pupae	-	-	-	1	1	-	-	-	-	-
Damselfly nymphs	-	-	3	1½	-	-	-	-	-	-
Dragonfly nymphs	1	-	-	3	-	1	-	1	2	-
Mayfly nymphs	2	1	2	4	-	1	-	-	2½	-
Midge larvae	-	1	-	2	-	2	-	-	-	-
Midge pupae	-	-	2	1	-	-	-	-	-	-
Planktonic organisms										
Cladocerans	-	-	-	-	-	-	-	-	∿100	-
Phantom midge larvae	-	-	-	4	-	-	-	-	7	-
Phantom midge pupae	-	-	-	-	-	1	5	-	-	-
Other aquatic invertebrates										
Snails	-	-	-	-	-	1	-	-	-	-
Water mites	-	-	-	100's	-	-	-	-	-	-
Minnows	1	1	-	-	1	3	2	6	-	-
Frogs	-	1	-	-	-	-	-	-	-	-
Terrestrial and flying insects										
Beetles	-	1	1	-	-	1	-	-	-	-
Dragonflies	-	-	-	-	-	1	1	1	-	-
Midges	-	-	-	-	2	1	-	-	-	-
Unidentified flying insects	1	-	12	-	-	2	2	3	-	1
Unidentified terrestrial insects	1	-	-	-	-	-	-	-	-	-

Table 13

Percent occurrence of various food items in fallfish digestive tracts form Lac Tassel, 20 May, 1975 to 18 May, 1976

Number of days before or after treatment	-8	-5	+15 hours	+3	+4	+16	+37	+82	+1 year
No food present	0	5	0	0	43	40	50	25	0
Aquatic insects									
Alderfly larvae	0	5	0	0	0	0	0	0	0
Beetles	0	0	0	0	14	0	0	0	0
Burrowing mayfly nymphs	0	0	0	0	43	20	0	75	0
Caddisfly larvae	80	5	0	80	79	15	0	0	100
Damselfly nymphs	20	0	0	0	0	0	0	0	0
Dragonfly nymphs	40	5	0	40	43	10	0	0	0
Mayfly nymphs	20	10	0	20	14	5	0	0	0
Midge larvae	20	10	0	0	0	5	0	0	0
Midge pupae	0	0	0	0	14	10	0	0	0
Unidentifiable remains	0	5	0	0	0	0	0	0	0
Planktonic Organisms									
Cladocerans	20	55	0	0	14	0	0	25	0
Phantom midge larvae	0	10	0	0	0	5	0	0	0
Phantom midge pupae	0	0	0	0	0	20	0	0	0
Other aquatic invertebrates									
Snails	0	5	0	0	0	0	0	0	0
Water mites	20	0	0	40	0	0	0	0	0
Minnows	0	0	0	20	0	0	0	25	0
Terrestrial arthropods									
Beetles	0	20	100	0	0	10	0	0	0
Flying ants	20	35	0	0	0	5	0	0	0
Midges	20	0	100	0	0	5	0	0	0
Spiders	20	0	100	0	0	0	0	0	0
Unidentified flying insects	0	45	100	0	14	30	50	0	0
Unidentified terrestrial insects	0	0	100	0	0	0	0	0	0

Table 14

Mean percent of the volume of fallfish digestive tract contents contributed by various food items, Lac Tassel, 20 May, 1975 to 18 May, 1976

Number of days before or after treatment	-8	-5	+15 hours	+3	+4	+16	+37	+82	+1 year
Mean volume of digestive tract contents (ml)	2.58	1.50	3.50	0.60	0.80	0.80	1.95	0.30	0.20
Aquatic insects									
Alderfly larvae	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beetles	0.0	0.0	0.0	0.0	1.3	5.4	0.0	0.0	0.0
Burrowing mayfly nymphs	0.0	0.0	0.0	0.0	28.8	14.2	0.0	76.7	0.0
Caddisfly larvae	58.0	0.3	0.0	48.0	3.8	7.0	0.0	0.0	100.0
Damselfly nymphs	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dragonfly nymphs	9.0	4.2	0.0	29.0	57.5	10.0	0.0	0.0	0.0
Mayfly nymphs	7.0	2.1	0.0	2.0	1.3	0.8	0.0	0.0	0.0
Midge larvae	0.5	<0.1	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
Midge pupae	0.0	0.0	0.0	0.0	2.5	4.4	0.0	0.0	0.0
Unidentifiable remains	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Planktonic organisms									
Cladocerans	18.0	48.9	0.0	0.0	2.5	0.0	0.0	6.7	0.0
Phantom midge larvae	0.0	1.3	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Phantom midge pupae	0.0	0.0	0.0	0.0	0.0	27.0	0.0	0.0	0.0
Other aquatic invertebrates									
Snails	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water mites	0.5	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0
Minnows	0.0	0.0	0.0	16.0	0.0	0.0	0.0	16.6	0.0
Terrestrial arthropods									
Beetles	0.0	4.2	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Flying ants	1.5	14.5	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Midges	0.5	0.0	3.0	0.0	0.0	2.5	0.0	0.0	0.0
Spiders	2.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified flying insects	0.0	22.1	85.0	0.0	2.5	28.0	100	0.0	0.0
Unidentified terrestrial insects	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 15

Mean numbers of various food items in fallfish digestive tracts in which they occurred, Lac Tassel, 20 May, 1975 to 18 May, 1976.

Number of days before or after treatment	-8	-5	+15 hours	+3	+4	+16	+37	+82	+1 year
Aquatic insects									
Alderfly larvae	-	1	-	-	-	-	-	-	-
Beetles	-	-	-	-	2	-	-	-	-
Burrowing mayfly nymphs	-	-	-	-	4	2	-	2	-
Caddisfly larvae	17	1	-	6	3	3	-	-	2
Damselfly nymphs	1	-	-	-	-	-	-	-	-
Dragonfly nymphs	1	2	-	8	7	3	-	-	-
Mayfly nymphs	3	1½	-	1	1	1	-	-	-
Midge larvae	1	1	-	-	-	1	-	-	-
Midge pupae	-	-	-	-	5	3	-	-	-
Planktonic organisms									
Cladocerans	1000's	1000's	-	-	∿20	-	-	100's	-
Phantom midge larvae	-	∿15	-	-	-	1	-	-	-
Phantom midge pupae	-	-	-	-	-	∿55	-	-	-
Other aquatic invertebrates									
Snails	-	5	-	-	-	-	-	-	-
Water mites	1	-	-	2	-	-	-	-	-
Minnows	-	-	-	1	-	-	-	1	-
Terrestrial arthropods									
Beetles	-	3	3	-	-	2	-	-	-
Flying ants	1	∿8	-	-	-	4	-	-	-
Midges	1	-	∿15	-	-	5	-	-	-
Spiders	1	-	1	-	-	-	-	-	-
Unidentified flying insects	-	∿35	∿75	-	2	∿15	∿20	-	-
Unidentified terrestrial insects	-	-	∿15	-	-	-	-	-	-

Table 16

Percent occurrence of various food items in brook trout stomachs from Lac Herman

13 May, 1975 to 17 May, 1976

Number of days before or after treatment of Lac Tassel	-15	-6	+2	+20	+83	+1 year
No food present	0	10	0	0	63	0
Aquatic insects						
Alderfly larvae	0	14	0	0	0	25
Backswimmers	0	5	0	0	0	0
Burrowing mayfly nymphs	17	29	54	50	5	75
Caddisfly larvae	17	5	0	0	0	0
Damselfly nymphs	17	0	0	0	0	0
Dragonfly nymphs	83	14	9	0	5	0
Fishfly larvae	0	0	0	0	0	12
Mayfly nymphs	17	5	0	0	0	0
Midge larvae	0	10	45	0	0	0
Midge pupae	67	24	18	50	0	25
Water boatmen	17	14	0	0	5	0
Water striders	0	0	0	0	5	0
Planktonic organisms						
Cladocerans	16	5	18	50	0	0
Phantom midge larvae	0	10	27	0	0	0
Other aquatic invertebrates						
Amphipods	17	5	0	0	0	0
Snails	0	5	0	0	0	0
Minnows	67	38	45	50	21	38
Terrestrial arthropods						
Beetles	33	52	18	0	0	12
Flying ants	0	63	0	0	0	0
Spiders	0	0	9	0	0	0
Unidentified flying insects	0	0	9	50	0	0
Unidentified terrestrial insects	17	5	9	0	0	0

Table 17

Mean percent of the volume of brook trout stomach contents contributed by various food items, Lac Herman, 13 May, 1975 to 17 May, 1976

Number of days before or after treatment of Lac Tassel	-15	-6	+2	+20	+83	+1 year
Mean volume of stomach contents (ml)	1.70	1.46	1.52	1.15	0.19	6.05
Aquatic insects						
Alderfly larvae	0.0	1.8	0.0	0.0	0.0	0.9
Backswimmers	0.0	2.6	0.0	0.0	0.0	0.0
Burrowing mayfly nymphs	5.8	13.9	35.9	7.5	14.3	49.1
Caddisfly larvae	3.3	0.2	0.0	0.0	0.0	0.0
Damselfly nymphs	0.8	0.0	0.0	0.0	0.0	0.0
Dragonfly nymphs	45.8	5.5	9.1	0.0	14.3	0.0
Fishfly larvae	0.0	0.0	0.0	0.0	0.0	0.6
Mayfly nymphs	0.8	0.3	0.0	0.0	0.0	0.0
Midge larvae	0.0	0.3	2.1	0.0	0.0	0.0
Midge pupae	1.7	0.6	1.8	<0.1	0.0	24.4
Water boatmen	0.4	0.2	0.0	0.0	14.3	0.0
Water strider	0.0	0.0	0.0	0.0	1.4	0.0
Planktonic organisms						
Cladocerans	1.7	0.2	3.1	47.5	0.0	0.0
Phantom midge larvae	0.0	0.5	8.4	0.0	0.0	0.0
Other aquatic invertebrates						
Amphipods	<0.1	<0.1	0.0	0.0	0.0	0.0
Snails	0.0	0.1	0.0	0.0	0.0	0.0
Minnows	35.0	31.2	28.2	2.5	55.7	24.4
Terrestrial arthropods						
Beetles	3.8	13.4	8.2	0.0	0.0	0.6
Flying ants	0.0	28.8	0.0	0.0	0.0	0.0
Spiders	0.0	0.0	0.4	0.0	0.0	0.0
Unidentified flying insects	0.0	0.0	0.9	42.5	0.0	0.0
Unidentified terrestrial insects	0.8	0.1	1.8	0.0	0.0	0.0

Table 18

Mean numbers of various food items in brook trout stomachs in which they occurred, Lac Herman, 13 May, 1975 to 17 May, 1976

Number of days before or after treatment of Lac Tassel	-15	-6	+2	+20	+83	+1 year
Aquatic insects						
Alderfly larvae	-	1	-	-	-	2½
Backswimmers	-	1	-	-	-	-
Burrowing mayfly nymphs	2	3	6	1	1	20
Caddisfly larvae	1	1	-	-	-	-
Damselfly nymphs	1	-	-	-	-	-
Dragonfly nymphs	2	2	1	-	1	-
Fishfly larvae	-	-	-	-	-	1
Mayfly nymphs	1	3	-	-	-	-
Midge larvae	-	∿20	3	-	-	-
Midge pupae	2	3	2	1	-	45
Water boatmen	2	1	-	-	1	-
Water striders	-	-	-	-	2	-
Planktonic organisms						
Cladocerans	∿50	∿100	∿100	1000's	-	-
Phantom midge larvae	-	∿35	∿50	-	-	-
Other aquatic invertebrates						
Amphipods	1	1	-	-	-	-
Snails	-	1	-	-	-	-
Minnows	1	3	2	1	5	6
Terrestrial arthropods						
Beetles	1	5	1½	-	-	1
Flying ants	-	∿10	-	-	-	-
Spiders	-	-	1	-	-	-
Unidentified flying insects	-	-	2	6	-	-
Unidentified terrestrial insects	1	1	2	-	-	-

Table 19

Percent occurrence of various food items in brown bullhead stomachs from Lac Tassel, 23 May, 1975 to 18 May, 1976

Number of days before or after treatment	-5	-0	+37	+82	+1 year
No food present	25	25	12	0	14
Aquatic insects					
Alderfly larvae	12	0	0	0	14
Beetle larvae	12	0	0	0	14
Blackfly larvae	38	0	0	0	0
Burrowing mayfly nymphs	62	62	0	0	43
Caddisfly pupae	0	50	0	0	0
Caterpillars	12	0	0	0	0
Damselfly nymphs	12	12	12	0	0
Dragonfly nymphs	62	38	38	100	28
Mayfly nymphs	62	62	25	50	86
Midge larvae	50	62	12	100	28
Midge pupae	12	25	38	0	0
Spongilla fly larvae	0	12	0	0	0
Plantonic organisms					
Cladocerans	0	0	0	100	0
Planton midge larvae	0	62	0	0	0
Other aquatic invertebrates					
Amphipods	62	25	12	50	43
Leeches	0	0	0	0	28
Minnows	0	0	25	0	0
Fish eggs	12	0	0	0	0
Newts	12	0	0	0	0
Terrestrial arthropods					
Spiders	0	12	0	0	0
Unidentified terrestrial insects	25	12	12	0	14

Table 20

Mean percent of the volume of brown bullhead stomach contents contributed by various food items, Lac Tassel, 23 May, 1975 to 18 May, 1976

Number of days before or after treatment	-5	-0	+37	+82	+1 year
Mean volume of stomach contents (ml)	1.53	0.61	0.42	0.10	1.57
Aquatic insects					
Alderfly larvae	0.2	0.0	0.0	0.0	0.4
Beetle larvae	0.3	0.0	0.0	0.0	0.4
Blackfly larvae	12.5	0.0	0.0	0.0	0.0
Burrowing mayfly nymphs	13.7	8.3	53.6	17.5	17.1
Caddisfly larvae	14.5	18.3	0.0	0.0	5.0
Caddisfly pupae	0.0	12.5	0.0	0.0	0.0
Caterpillars	0.7	0.0	0.0	0.0	0.0
Damselfly nymphs	0.5	1.2	10.0	0.0	0.0
Dragonfly nymphs	14.2	11.7	16.4	45.0	11.7
Mayfly nymphs	10.8	16.7	5.7	12.5	58.3
Midge larvae	4.2	3.2	0.7	17.5	0.9
Midge pupae	0.3	8.3	3.6	0.0	0.0
Spongilla fly larvae	0.0	1.2	0.0	0.0	0.0
Planktonic organisms					
Cladocerans	0.0	0.0	0.0	5.0	0.0
Phantom midge larvae	0.0	13.7	0.0	0.0	0.0
Other aquatic invertebrates					
Amphipods	6.5	1.5	1.4	2.5	2.1
Leeches	0.0	0.0	0.0	0.0	3.3
Minnows	0.0	0.0	6.4	0.0	0.0
Fish eggs	2.5	0.0	0.0	0.0	0.0
Newts	10.8	0.0	0.0	0.0	0.0
Terrestrial arthropods					
Spiders	0.0	0.8	0.0	0.0	0.0
Unidentified terrestrial insects	8.3	2.5	2.1	0.0	0.8

Table 21

Mean numbers of various food items in brown bullhead stomachs in which they occurred, Lac Tassel, 23 May, 1975 to 18 May, 1976

Number of days before or after treatment	-5	-0	+37	+82	+1 year
Aquatic insects					
Alderfly larvae	1	-	-	-	1
Beetle larvae	1	-	-	-	1
Blackfly larvae	∿300	-	-	-	-
Burrowing mayfly nymphs	2	2	2	1	4
Caddisfly larvae	4	2	-	-	2
Caddisfly pupae	-	2	-	-	-
Caterpillars	2	-	-	-	-
Damselfly nymphs	1	1	3	-	-
Dragonfly nymphs	1	2	1	2	2
Mayfly nymphs	4	3	2	1	17
Midge larvae	9	3	1	5	2
Midge pupae	5	4	2	-	-
Spongilla fly larvae	-	1	-	-	-
Planktonic organism					
Cladocerans	-	-	-	∿20	-
Phantom midge larvae	-	3	-	-	-
Other aquatic invertebrates					
Amphipods	3	2	5	1	3
Leeches	-	-	-	-	1
Minnows	-	-	1	-	-
Fish eggs	∿30	-	-	-	-
Newts	3	-	-	-	-
Terrestrial arthropods					
Spiders	-	1	-	-	-
Unidentified terrestrial insects	1	1	1	-	1

Table 22

Percent occurrence of various food items in brown bullhead stomachs from Lac Herman, 22 May, 1975 to 17 May, 1976

Number of days before or after treatment of Lac Tassel	-6	+2	+83	+1 year
No food present	0	15	33	10
Aquatic insects				
Alderfly larvae	0	15	0	30
Beetle larvae	25	5	0	0
Burrowing mayfly nymphs	62	45	33	70
Caddisfly larvae	25	15	0	30
Caddisfly pupae	0	10	0	0
Damselfly nymphs	12	15	0	0
Dragonfly nymphs	12	10	0	10
Mayfly nymphs	62	30	0	60
Midge larvae	62	45	0	20
Midge pupae	0	20	0	10
Other aquatic invertebrates				
Amphipods	12	30	0	10
Fingernail clams	0	5	67	0
Isopods	0	5	0	0
Minnows	0	15	0	0
Flying insects	0	5	0	0

Table 23

Mean percent of the volume of brown bullhead stomach contents contributed by various food items,

Lac Herman, 22 May, 1975 to 17 May, 1976

Number of days before or after treatment of Lac Tassel	-6	+2	+83	+1 year
Mean volume of stomach contents (ml)	0.18	0.68	0.03	0.62
Aquatic insects				
Alderfly larvae	0.0	2.9	0.0	1.2
Beetle larvae	2.5	0.6	0.0	0.0
Burrowing mayfly nymphs	55.0	34.4	40.0	63.3
Caddisfly larvae	3.8	2.4	0.0	2.6
Caddisfly pupae	0.0	1.2	0.0	0.0
Damselfly nymphs	1.9	4.7	0.0	0.0
Dragonfly nymphs	6.2	5.9	0.0	1.7
Mayfly nymphs	12.8	10.6	0.0	29.2
Midge larvae	12.8	13.9	0.0	1.1
Midge pupae	0.0	1.2	0.0	0.3
Other aquatic invertebrates				
Amphipods	5.0	3.5	0.0	0.6
Fingernail clams	0.0	0.9	60.0	0.0
Isopods	0.0	1.8	0.0	0.0
Minnows	0.0	15.9	0.0	0.0
Flying insects	0.0	0.3	0.0	0.0

Table 24

Mean numbers of various food items in brown bullhead stomachs in which they occurred, Lac Herman, 22 May, 1975 to 17 May, 1976

Number of days before or after treatment of Lac Tassel	-6	+2	+83	+1 year
Aquatic insects				
Alderfly larvae	-	1	-	1
Beetle larvae	2	1	-	-
Burrowing mayfly nymphs	2	3	1	7
Caddisfly larvae	2	2	-	1
Caddisfly pupae	-	1	-	-
Damselfly nymphs	1	1	-	-
Dragonfly nymphs	1	1	-	1
Mayfly nymphs	2	4	-	2
Midge larvae	6	3	-	1
Midge pupae	-	2	-	1
Other aquatic invertebrates				
Amphipods	3	2	-	1
Fingernail clams	-	15	-	-
Isopods	-	1	1	-
Minnows	-	2	-	-
Flying insects	-	1	-	-

Table 25

Percent occurrence of various food items in yellow perch stomachs from Lac Tassel, 23 May, 1975 to 18 May, 1976

Number of days before or after treatment	-5 to -0	+4 to +5	+16	+37	+82	+1 year
No food present	50	20	10	50	50	29
Aquatic insects						
Burrowing mayfly nymphs	0	20	16	0	17	29
Caddisfly larvae	0	0	5	0	17	0
Dragonfly nymphs	0	0	5	0	0	0
Mayfly nymphs	0	0	0	0	0	29
Midge larvae	0	20	10	0	0	14
Midge pupae	0	0	5	0	0	14
Plantonic organisms						
Cladocerans	50	0	16	50	50	29
Phantom midge larvae	0	80	21	0	17	43
Phantom midge pupae	0	80	79	0	0	0
Other aquatic invertebrates						
Amphipods	0	0	5	0	0	0
Minnows						
Smallmouth bass fry	0	0	63	50	0	0
Unidentified minnows	0	20	0	0	0	0

Table 26

Mean percent of the volume of yellow perch stomach contents contributed by various food items

Lac Tassel, 23 May, 1975 to 18 May, 1976

Number of days before or after treatment	-5 to -0	+4 to +5	+16	+37	+82	+1 year
Mean volume of stomach contents (ml)	0.05	0.24	0.54	0.10	0.05	0.96
Aquatic insects						
Burrowing mayfly nymphs	0.0	12.5	11.2	0.0	16.7	21.0
Caddisfly larvae	0.0	0.0	5.3	0.0	13.3	0.0
Dragonfly nymphs	0.0	0.0	2.9	0.0	0.0	0.0
Mayfly nymphs	0.0	0.0	0.0	0.0	0.0	18.0
Midge larvae	0.0	0.2	0.3	0.0	0.0	1.0
Midge pupae	0.0	0.0	0.2	0.0	0.0	1.0
Plantonic organism						
Cladocerans	100.0	0.0	0.7	5.0	56.7	5.0
Phantom midge larvae	0.0	30.4	1.9	0.0	13.3	54.0
Phantom midge pupae	0.0	34.4	27.8	0.0	0.0	0.0
Other aquatic invertebrates						
Amphipods	0.0	0.0	0.6	0.0	0.0	0.0
Minnows						
Smallmouth bass fry	0.0	0.0	49.1	95.0	0.0	0.0
Unidentified minnows	0.0	22.5	0.0	0.0	0.0	0.0

Table 27

Mean numbers of various food items in yellow perch stomachs in which they occurred, Lac Tassel, 23 May, 1975 to 18 May, 1976

Number of days before or after treatment	-5 to -0	+4 to +5	+16	+37	+82	+1 year
Aquatic insects						
Burrowing mayfly nymphs	-	3	1	-	2	1
Caddisfly larvae	-	-	5	-	4	-
Dragonfly nymphs	-	-	1	-	-	-
Mayfly nymphs	-	-	-	-	-	3½
Midge larvae	-	1	2	-	-	1
Midge pupae	-	-	1	-	-	7
Planktonic organisms						
Cladocerans	∿20	-	∿20	∿20	∿35	∿250
Phantom midge larvae	-	6	∿17	-	4	∿230
Phantom midge pupae	-	∿14	∿37	-	-	-
Other aquatic invertebrates						
Amphipods	-	-	1	-	-	-
Minnows						
Smallmouth bass fry	-	-	8	1	-	-
Unidentified minnows	-	1	-	-	-	-

Table 28

Food items found in common shiner digestive tracts from Lac Tassel, 23 May to 13 June, 1975.

Number of days before or after treatment	-5	+2	+16
Percent occurrence of:			
Burrowing mayfly nymphs	0	0	50
Cladocerans	100	100	0
Phantom midge larvae	50	100	0
Phantom midge pupae	0	100	100
Unidentified flying insects	0	0	100
Unidentified terrestrial insects	50	0	0
Mean volume of digestive tract contents (ml)	0.90	1.00	0.25
Mean percent volume contributed by:			
Burrowing mayfly nymphs	0.0	0.0	5.0
Cladocerans	60.0	5.0	0.0
Phantom midge larvae	37.5	45.0	0.0
Phantom midge pupae	0.0	45.0	65.0
Unidentified flying insects	0.0	0.0	30.0
Unidentified terrestrial insects	2.5	0.0	0.0
Mean numbers per digestive tract presented in of:			
Burrowing mayfly nymphs	-	-	1
Cladocerans	∿100	∿20	-
Phantom midge larvae	∿40	∿40	-
Phantom midge pupae	-	∿30	∿10
Unidentified flying insects	-	-	3½
Unidentified terrestrial insects	2	-	-