Archives

A STUDY OF THE DISTRIBUTION, PERSISTENCE AND BIOLOGICAL EFFECTS OF FENITROTHION APPLIED TO A SMALL LAKE IN AN OIL FORMULATION

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ABSTRACT

Treatment of a small lake with 140 g fenitrothion/ha had little overall impact on lake biota. Little pesticide reached the deeper parts of the lake and persistence in surface waters was approximately one week. Fish caged at the surface accumulated moderate quantities of fenitrothion without apparent effects, and fish below the thermocline accumulated little more than trace amounts. Surface populations of zooplankton and phantom midge larvae, *Chaoborus sp.*, were depressed for a short period. No substantial impact was found on benthic invertebrates, emerging insects or amphibians in the lake.

RESUME

Le traitement d'un petit lac avec 140 g de fenitrothion/ha eut une influence générale trés minime sur la vie animale. Peu de pesticide a atteint les profondeurs du lac et la persistance dans les eaux de surface ne dura qu'environ une semaine. Les poissons dans des cages à la surface ont accumulé quelque quantité de fenitrothion sans effets apparents et les poissons au-dessous de la thermocline n'absorbèrent que des traces du produit. Les populations en surface de zooplancton et de larves de *Chaoborus* sp., furent affaiblies pendant une courte période. Aucun effet substantiel ne fut observé sur les invertébrés de fond, les insectes émergents ou les Amphibiens du lac.

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1. INTRODUCTION

In the course of the operational treatment of millions of acres of Quebec forests with the insecticide fenitrothion in 1973, several reports of fish mortalities and reduction of angling success in lakes within treated areas were received. Some of these incidents were investigated and subsequently reported on (Kingsbury 1973). In the course of these investigations, the difficulties of trying to evaluate the effects of such a short lived insecticide, several days after it had entered a lake, became apparent. The relationship of residues found in fish, invertebrates, sediments and lake water several days after treatment to the initial or maximum concentrations of insecticide present could only be guessed at, with a minimum of supporting laboratory and field studies to which reference could be made.

Studies of the effects of insecticides introduced into aquatic ecosystems by forest pest control programs have almost exclusively dealt with effects on the fauna of forest streams or rivers. The effects and fate of insecticides in lakes have been almost completely ignored. The recent use of large aircraft flying several hundred feet above the forest canopy and depositing insecticides over a wide swath width has increased the risk of introducing insecticides into lakes, especially in Quebec where thousands of lakes of all sizes are located in the midst of commercially valuable, pest infested forest regions. In light of the trend towards more extensive use of these large aircraft to disperse chemical insecticides to control damage caused by the current spruce budworm, *Choristoneura fumiferana* Clemens, outbreak over eastern North America, this study was initiated to learn more

about the ecological effects, physical distribution and chemical persistence of insecticides introduced into small lakes.

2. MATERIALS AND METHODS

2.1 Study site and treatment procedures

The study was carried out in Gib Lake, located in Pontefract Township, Pontiac County, about 15 km north of Fort Coulonge, Quebec (Fig. 1). The lake is small (19.4 ha) but deep (maximum depth 23 m) with the bottom falling off rather sharply from the shoreline except at the south end of the lake, where a fairly large shallow area is present behind two large beaver dams across the stream leaving the lake (Fig. 2). Just beyond these beaver dams is a waterfall about 15 m high, and this has effectively blocked the movement of fish into the lake with the result that there are no native fish populations in the lake. The lake does support a rich and diverse aquatic invertebrate fauna and a large population of spotted newts, *Triturus viridescens*.

The nature of the bottom of the lake changes rapidly with depth. The shoreline and shallow border of the lake consist of a hard bottom of coarse and fine sand and gravel with a considerable amount of wood debris littered about. There are a few areas with considerable growth of rooted aquatic plants, particularly along the west shoreline of the lake. Starting between the depths of 5 and 6 m, a thick layer of fine silt covers the bottom of the lake. This thick silt is found in all the deeper portions of the lake but its nature varies from being fine enough to easily run through a fine meshed screen bottomed bucket to a coarser silt interwoven

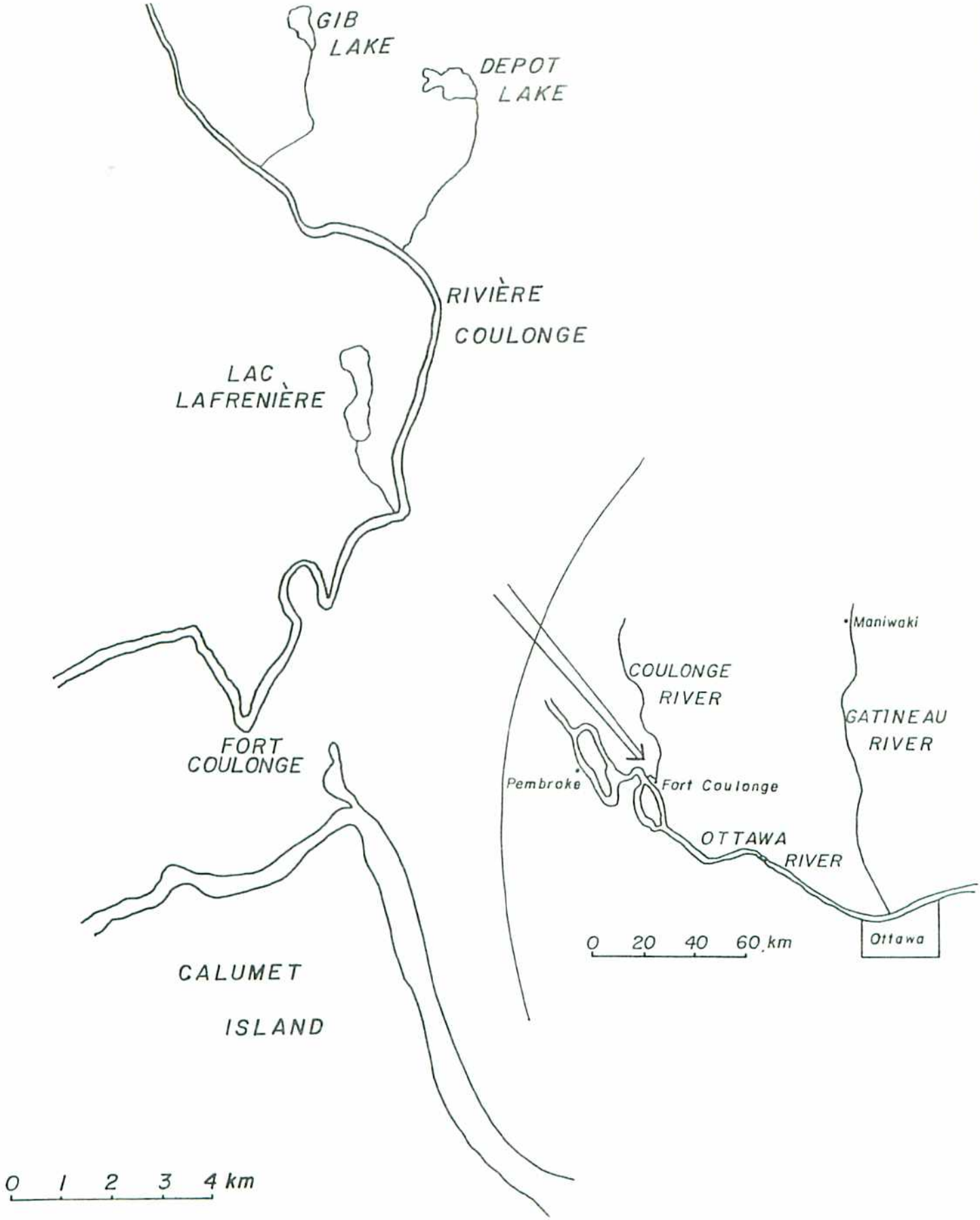

Fig. 1. Location of the study site at Gib Lake, Quebec.

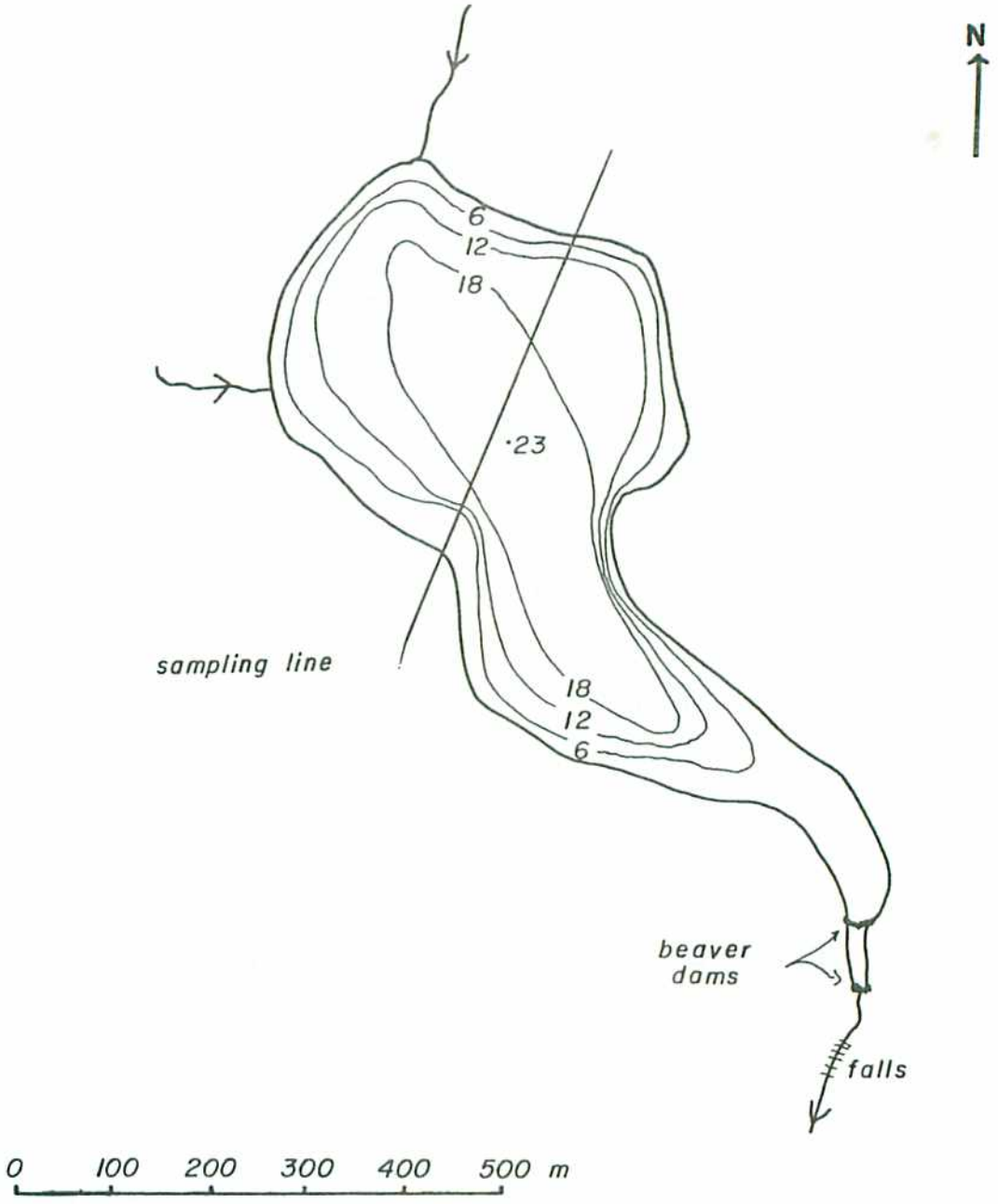

Fig. 2. Depth contours (in metres), Gib Lake, Quebec. Details of the sampling line are given in Fig. 3.

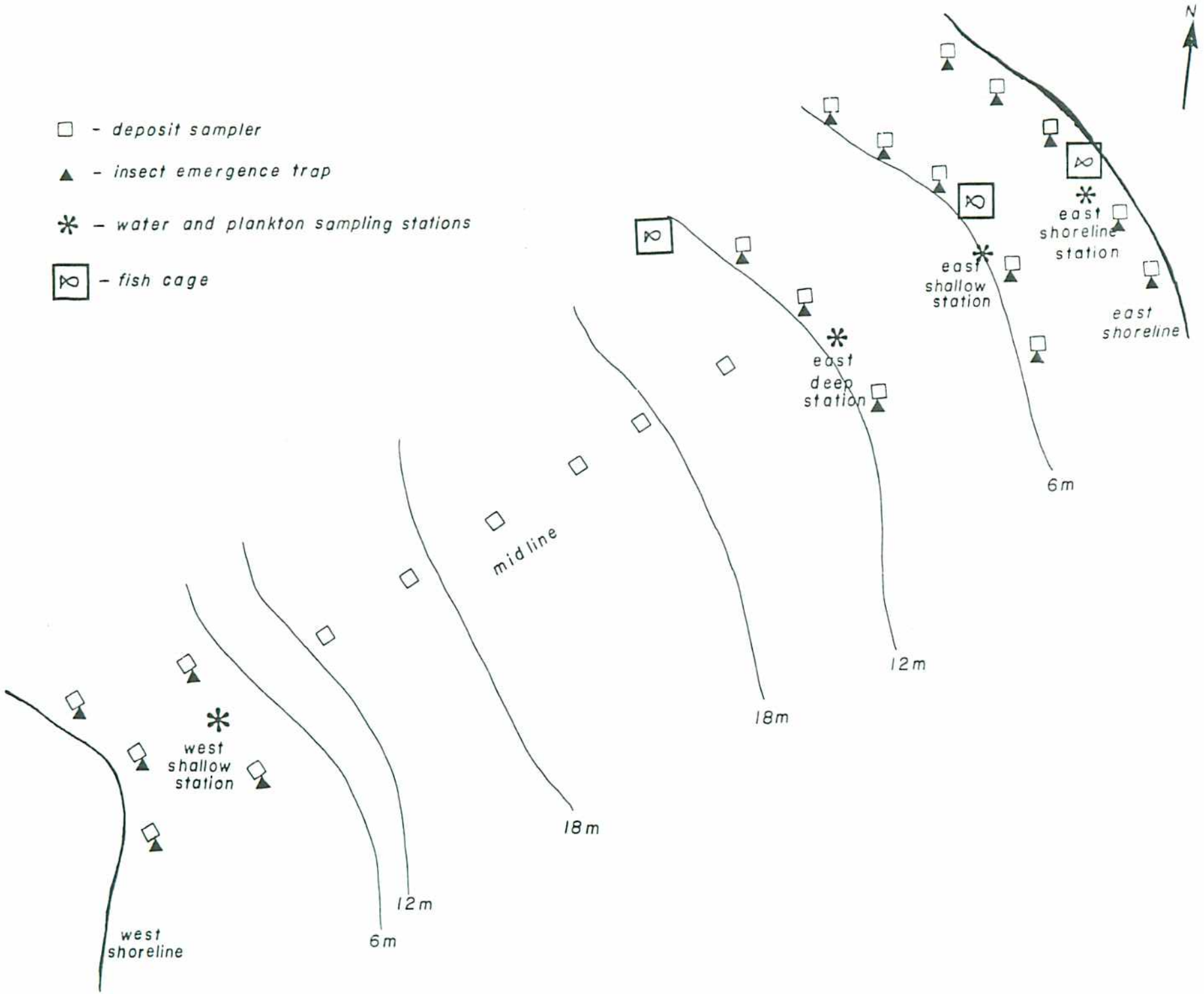

Fig. 3. Sampling stations in Gib Lake. The centre portion of the lake has been greatly contracted.

with matted filamentous vegetal matter.

Biological and insecticide residue sampling in Gib Lake was carried out along a line of stations running across the lake perpendicular to the lake's north-south orientation (Fig. 3). Shoreline, shallow and deep stations on the east side of the lake were marked by a line of insect emergence traps suspended from styrofoam floats permanently moored to concrete anchors. Similar shoreline and shallow stations were laid out on the west side of the lake but on a shallow, flat-bottomed ledge projecting from the shoreline out to a large rock. A line of floats across the middle of the lake from east to west stations completed the sampling design.

Temperature profiles of the lake were taken throughout the study using a thermistor with a submersible temperature probe[1]. Basic water 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 (Fig. 4).

Fenitrothion was applied to Gib Lake at 0930 hours on 19 June, 1974 by a Cessna 185 aircraft fitted with a Micronair® spray emission system (Fig. 5). Technical fenitrothion was dissolved in Arotex® 3470[4], a solvent oil, and a small quantity of Automate dye was added to this spray mixture to facilitate deposit measurement. The nominal application rate

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

[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.

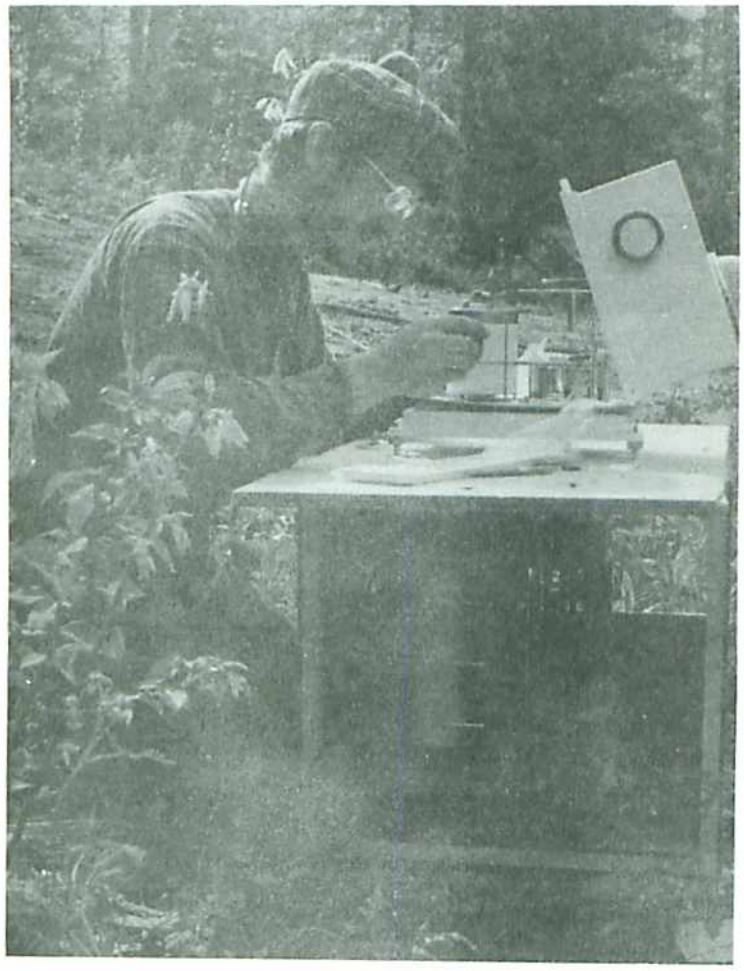


Fig. 4. Portable meteorological equipment on location at Gib Lake for recording solar radiation (top) and temperature, humidity and barometric pressure (bottom).

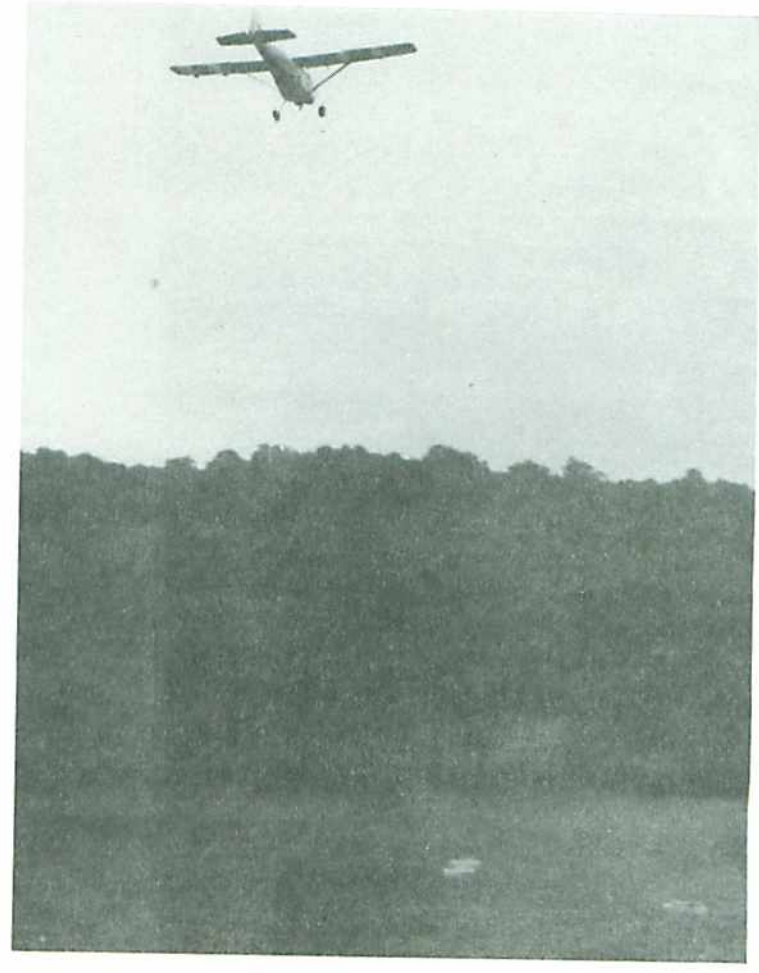


Fig. 5. Cessna 185 treating Gib Lake with fenitrothion.

was 0.140 kg fenitrothion/ha (2 oz/acre) applied in 1.46 ℓ/ha (20 fl. oz/acre) of formulated spray mixture.

2.2 Insecticide deposit and residue analysis

Spray deposit on the surface of Gib lake was measured by setting out deposit samplers on styrofoam floats (Fig. 6). Each sampler consisted of two aluminum pans 13 x 17 cm and a 10 x 10 cm Kromekote card. 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 toluene 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).

Water samples for GLC analysis of fenitrothion residues were collected at intervals from the surface and various depths at four stations in Gib Lake (Table 1). Water samples from below the surface were collected with a Kemmer water sampler and poured into glass jars previously rinsed with acetone. The Kemmer bottle was submerged in the closed position and opened underwater, in order to avoid introducing fenitrothion present in

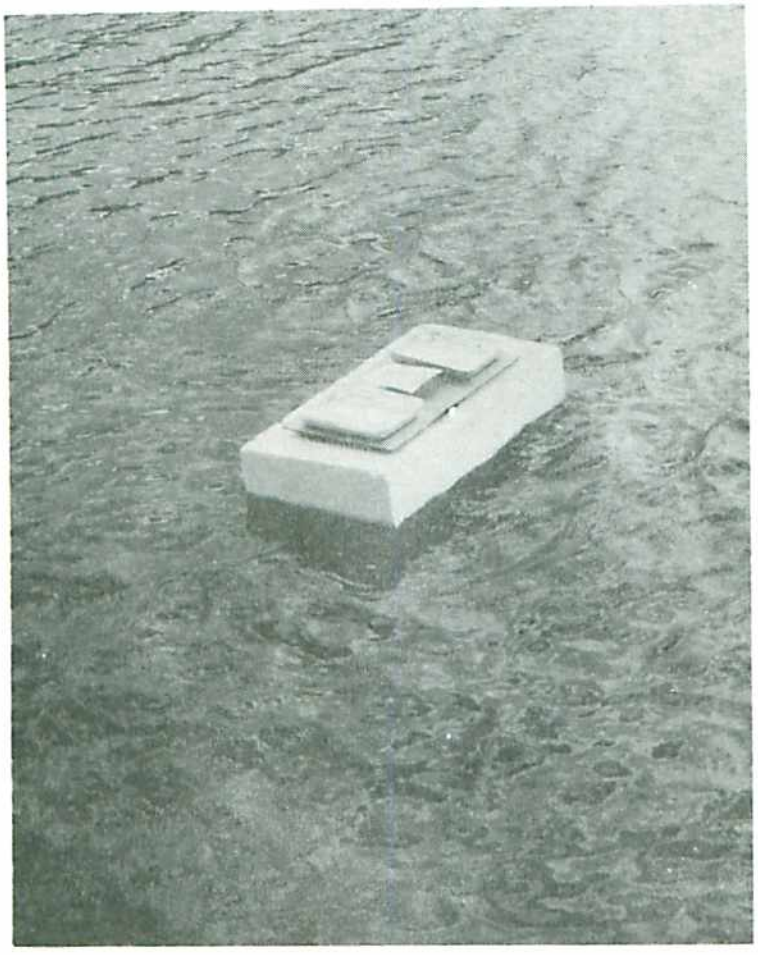


Fig. 6. Deposit sampler set out on the surface of Gib Lake.

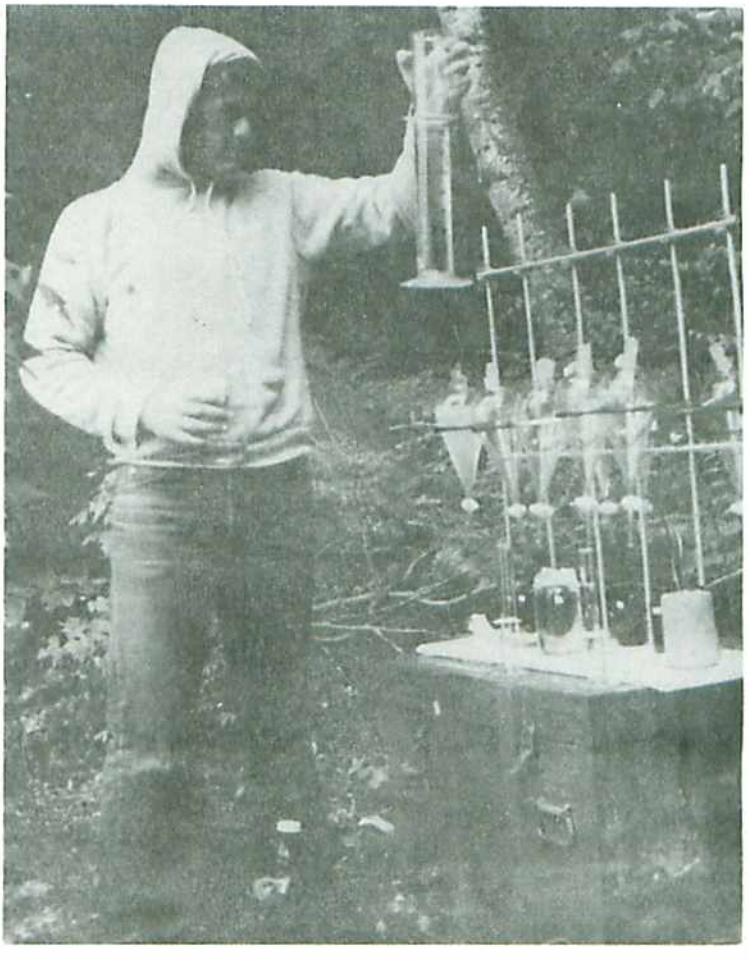


Fig. 7. Extracting fenitrothion residues from water samples in the field.

Table 1

Water samples for GLC analysis collected from Gib Lake, Quebec, 1974

Date	Time relative to treatment	Sampling Sites							
		East Shorline	East Shallow		East Deep			West Shallow	
		Surface	Surface	4m	Surface	6m	10m	Surface	1.5m
18 June	Prespray	X	X	X	X	X	X	X	
19 June	+½ hour	X*			X			X*	
	+4 hours	X	X	X	X	X	X	X	X
	+9 hours	X	X	X	X	X	X	X	X
20 June	+25 hours	X	X	X	X	X	X	X	X
	+34 hours	X	X	X	X	X	X	X	X
21 June	+50 hours	X	X	X	X	X	X	X	X
	+60 hours	X	X	X	X	X	X	X	X
22 June	+71 hours	X	X	X	X	X	X	X	X
25 June	+6 days	X*	X	X	X	X	X	X*	X
28 June	+9 days	X	X	X	X	X	X	X	X
3 July	+2 weeks	X	X	X	X	X	X	X	X
10 July	+3 weeks	X	X	X	X	X	X	X	X

* duplicate samples taken for independent analysis by two agencies.

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 (Fig. 7) 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 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.

On two occasions duplicate water samples were collected for independent analysis by the chemists of the Forest Pest Management Institute (Ottawa) and Quebec Service de Protection de l'Environnment. The latter agency also analyzed sediment samples collected with an Ekman grab from the east shallow and deep stations of Gib Lake three, six and fifteen days after treatment, using the extraction and analysis technique outlined by St. Jean (1975).

Prior to the treatment of Gib Lake, hatchery raised brook trout, *Salvelinus fontinalis* Mitchill, were placed in cages set in three places along the east shore of the lake: right at the shoreline and extending above the surface, right on the bottom (4.5 m) at the shallow station and floating 3 m off the bottom at a depth of 10 m at the deep station.

Fish were removed from the various cages at intervals for GLC analysis of fenitrothion residues (Table 2). Fish from the shallow cage were removed from the cage underwater by chasing them through a small opening into a plastic bag (Fig. 8). One end of the cage was made of a bag of netting which was pushed in towards the other end of the cage by one diver, to direct the fish towards the opening. The second diver placed a plastic bag over the opening and waited for a fish to enter it. He then grabbed the neck of the bag to trap the fish inside it, closed the opening on the cage and tied a knot in the end of the plastic bag to seal the fish off from exposure to the surface waters during the diver's ascent. Fish from the deep cage were sampled by raising the cage to the surface and removing the fish there; so they were not protected from exposure to surface waters while being sampled. In addition to the caged brook trout, spotted newts were collected from the lake for GLC analysis by capturing them in minnow traps baited with bread.

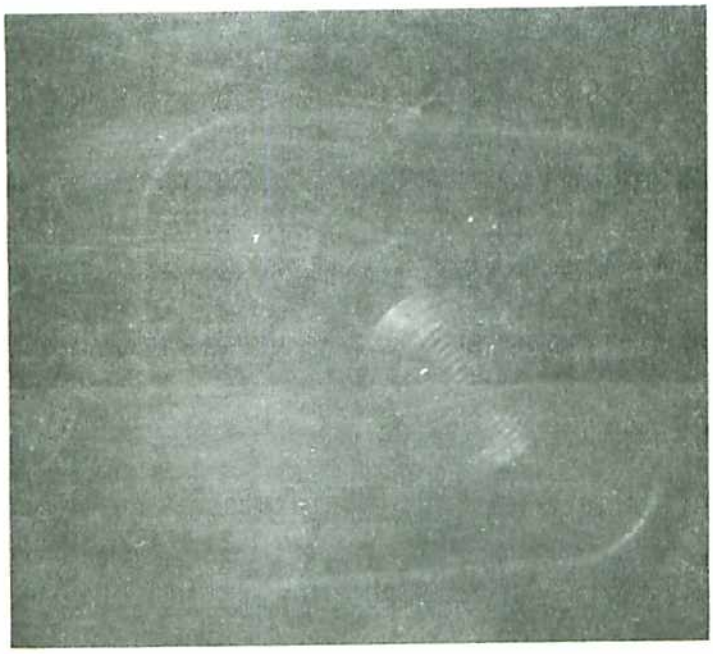
Individual fish and pooled newt samples (2 to 6 individuals) were weighed and fenitrothion and its metabolites extracted from them in 200 mℓ of pesticide grade ethyl acetate in a Sorvall-Omni-Mixer (5 min. at speed 6). The extract was filtered through a sharkskin filter paper and washed with an additional 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 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

Table 2

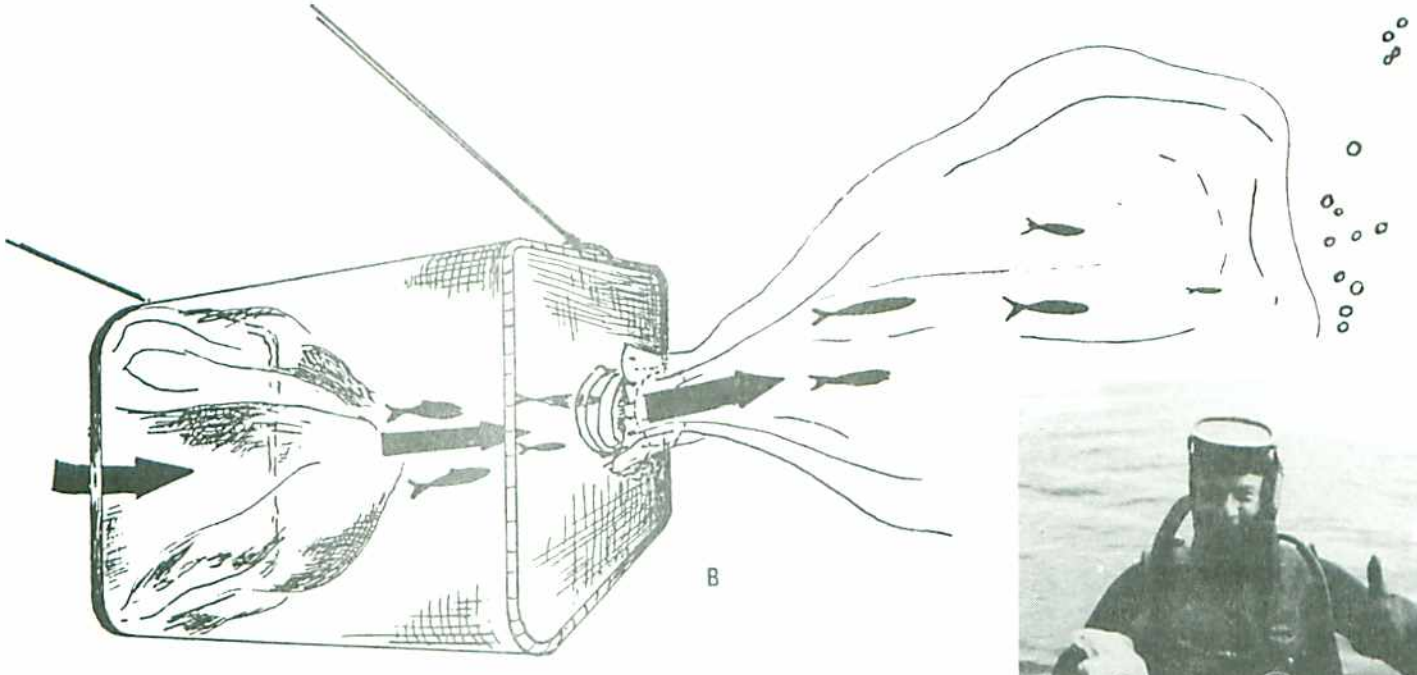
Fish and newts sampled from Gib Lake, Quebec for GLC determination of fenitrothion residues, 1974.

Date	Time relative to treatment	Brook trout from cages			Newts
		Shoreline cage	Shallow cage	Deep Cage	
18 June	Prespray	X			
19 June	+ 6 hours	X	X	X	
19 June	+12 hours	X			
20 June	+24 hours	X		X	
20 June	+33 hours	X	X	X	
21 June	+48 hours	X		X	
21 June	+58 hours	X	X	X	
22 June	+72 hours	X	X	X	X
25 June	+ 6 days	X	X	X	X
28 June	+ 9 days	X	X	X	X
4 July	+ 2 weeks	X	X*		X
10 July	+ 3 weeks	X	X		
19 July	+ 4 weeks	X	X		

* cage raised to the surface to remove fish from this point on.



A



B

C

Fig. 8. Cage for sampling fish underwater to prevent exposure to insecticide residues on the surface: A - Cage in position on the lake bottom, B - Diagram illustrating how fish are herded into a plastic bag, C - Diver with fish brought to the surface sealed in a plastic bag.

layers of anhydrous sodium sulfate, then eluted with 100 mℓ for GLC analysis.

GLC analysis at the Forest Pest Management Institute (Ottawa) were 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 its metabolite, fenitrooxon. Gas chromatographs were standardized with freshly prepared solutions of analytical grade samples obtained from the Sumitomo Chemical Company, Japan.

2.3 Biological sampling

Zooplankton populations in Gib Lake 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 samplers were taken from the surface at the east shoreline station, from the surface and bottom (4 m) at the east shallow station and from the surface, midwater (6 m) and bottom (10 to 12 m) at the east deep station. All zooplankton samples were preserved with formaldehyde and later counted and identified in the laboratory by placing them in a grided dish under a dissecting microscope.

Bottom fauna populations were sampled with an Ekman grab (Ekman 1911) which sampled 232 cm^2 of bottom. From three to five samples were taken at each of the east shallow, east deep, west shallow and west shoreline stations on each sampling date. The same portion of shoreline was sampled each time and an effort was made to sample the same range of

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)

depths, however this proved to be very difficult at the east stations because of the rather sharp angle at which the bottom dropped off from the shoreline. All bottom samples were preserved with formaldehyde in the field in their entirety, and the 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 Gib Lake were sampled with submerged emergence traps (Flannagan and Lawler 1972) suspended from styrofoam floats. A clear plastic cone directed nymphs and pupae swimming towards the surface to emerge into a small mason jar partially filled with air (Fig. 9). After emerging into the jar, adult insects were trapped until they could be removed, identified to order and counted, usually on a daily basis. Five lines of emergence traps were set running parallel to the shores of Gib Lake: five traps along the east shoreline, five further out at the east shallow station, three at the east deep station, three along the west shoreline and two at the west shallow station.

In order to confirm the complete absence of fish in Gib Lake, two trap nets and five minnow traps were set around the shoreline of the lake. No fish were caught, but the minnow traps, which were baited with bread, caught large numbers of newts and aquatic invertebrates, so they were set and checked throughout the study period to give an indication of possible impact on these organisms. Skin and scuba diving observations were made on newt, tadpole and aquatic invertebrate populations and searches of the bottom for dead or distressed organisms were carried out

Fig. 9. Submerged insect emergence trap suspended beneath the surface of Gib Lake. The plastic cone has been well coated with water boatmen or backswimmer eggs.

following treatment of the lake.

Through the co-operation of the Clinical Enzymology Unit of the Environmental Health Directorate, Health and Welfare Canada, brain cholinesterase measurements were made on some of the brook trout sampled from cages in the lake. The heads of these fish were cut off and frozen on dry ice in the field and sent to the co-operating laboratory in a frozen state. Usually two heads were sampled and packaged together at each sampling interval. In the laboratory, the brains were excised *in toto* from the frozen heads, with the two brains packaged together being combined as one sample. Five brains sampled prior to treatment were processed individually to provide a range of normal brain cholinesterase activity.

Samples were weighed and homogenized with buffer and brain cholinesterase activity was measured by the procedure of Hestrin (1949). Acetylcholine and hydroxylamine were used, and incubation of brain homogenate with substrate was twenty minutes. The value of millimoles of acetylcholine hydrolyzed was read from a standard curve, multiplied by three and divided by the milligrams of brain in the volume of homogenate used, giving values of acetylcholinesterase activity in units of milligrams of acetylcholine hydrolyzed per milligram of fish brain per hour of incubation.

RESULTS

3.1 Limnological and meteorological conditions

Gib Lake exhibited weak thermal stratification in late May and early June, 1974, which became more pronounced towards the end of the month (Fig. 10). At the time the lake was treated the epilimnion extended from the surface to 3 metres with a gradual thermocline between this depth and the upper limits of the hypolimnion (between 7 and 8 metres). The limits of the epilimnion and hypolimnion remained much the same throughout July with the thermocline between them becoming increasingly steeper. Dissolved oxygen levels in the lake were steady throughout the study period (Table 4) and remained around saturation levels in the epilimnion and thermocline and somewhat lower in the hypolimnion. The lakes epilimnetic waters became more alkaline over the study period while the hypolimnetic waters remained close to neutral pH.

Weather data around the treatment date are presented in Table 5. Moderate to heavy rain fell 18, 28, 47, and 54 hours after the lake was treated, followed by a period of clear dry days. The lake was treated under marginal spray conditions as the temperature was high (20°C), and relative humidity was 85% but rapidly falling. Low lying clouds prevented treatment of the lake earlier in the morning when conditions were better for maximum spray deposit. The wind was negligible at the time treatment began, but moderate to strong winds from the southwest began blowing shortly after treatment was finished and persisted over much of the afternoon.

3.2 Distribution and persistence of fenitrothion residues

Measurement of the deposit of emitted spray products onto samplers set out on Gib Lake show that only a small proportion reached

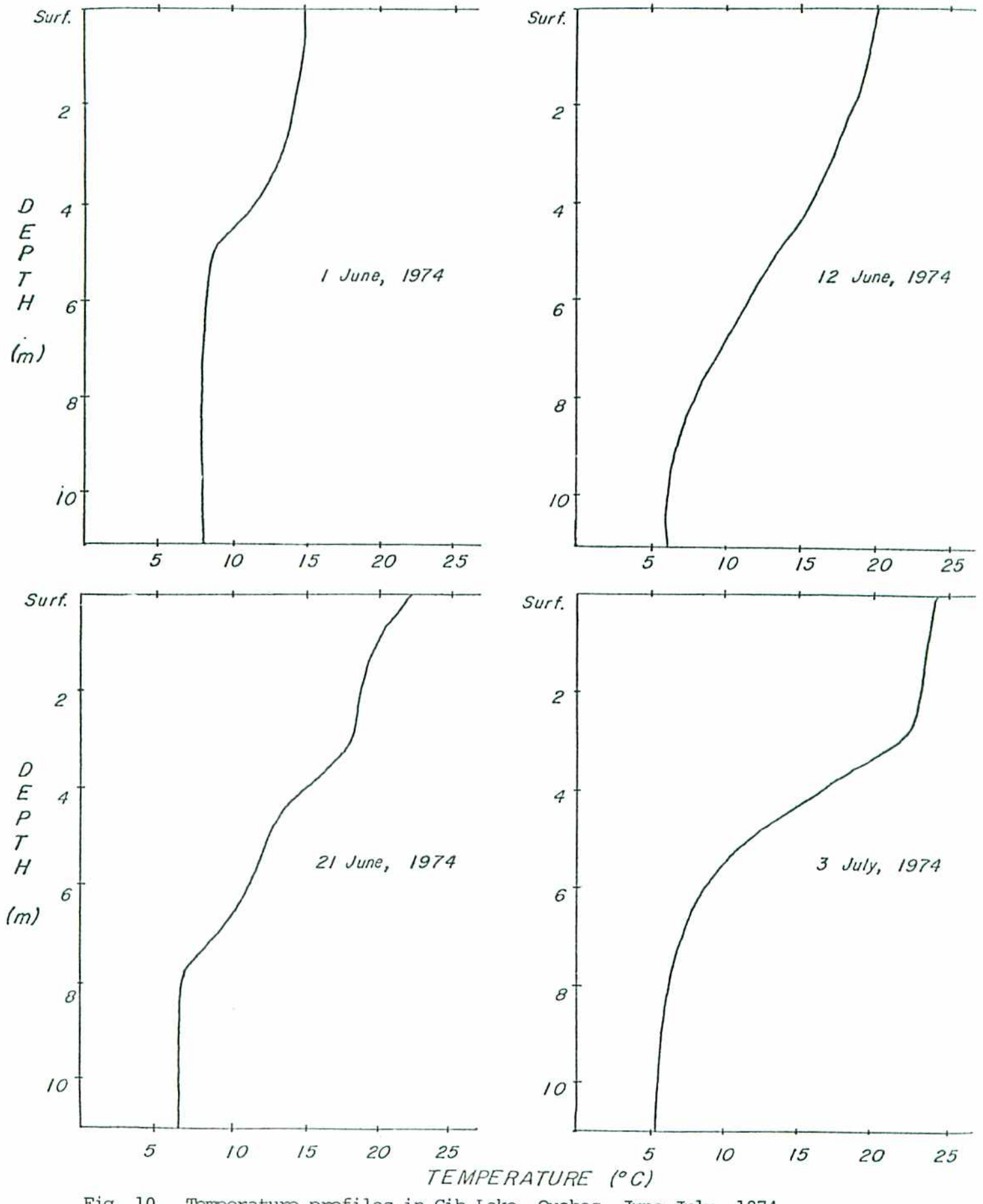


Fig. 10. Temperature profiles in Gib Lake, Quebec, June-July, 1974.

Table 4

Water chemistry parameters at various depths of Gib Lake, Quebec,
21 May to 19 June, 1974

		May 21	June 1	June 12	June 21	July 3	July 10	July 19
Surface	Temp (°C)	12	15	20	22	24	24	22
	0^2 (ppm)	11	10	10	9	9	8	9
	pH	7.7	7.8	8.0	8.0	8.2	8.5	8.3
	Alkalinity (gpg CaC03*)	4	4	4	4	4	4	4
	Hardness (gpg CaC03)	5	5	5	5	5	5	5
6 m	Temp (°C)	7	8	11	11	11.5	10	11.5
	0^2 (ppm)	10	11	12	12	12	11	12
	pH	7.4	7.3	7.6	7.5	7.6	7.5	8.0
10 m	Temp (°C)	6	8	6	7	5.3	5.5	5.5
	0^2 (ppm)	8	8	8	9	7	7	8
	pH	7.0	7.0	7.0	7.0	6.8	7.0	6.7
	Alkalinity (gpg CaC03)	4	4	4	4	4	4	4
	Hardness (gpg CaC03)	5	5	5	5	5.5	5	5

* grains per gallon calcium carbonate.

Table 5

Weather data from Gib Lake, Quebec, 31 May to 3 July, 1974.

Date	Temperature (°C)			Atmospheric pressure (millibars of (Hg)		Rainfall (cm)	Solar radiation (cal/cm^2)
	High	Low	4-h Mean	High	Low		
May 31	21.1	8.3	15.6	1008	993	1.32	--
June 1	25.6	7.8	16.5	1011	1001	0.02	705.6
June 2	26.7	5.0	16.6	1012	1010	0.96	584.6
June 3	26.7	10.6	17.2	1013	1010	0.02	645.2
June 4	25.0	7.8	18.2	--	--	0.00	504.0
June 5	32.2	15.6	23.0	--	--	0.02	625.0
June 6	28.9	13.9	21.6	--	--	0.00	625.0
June 7	28.9	14.4	21.4	--	--	0.00	604.8
June 8	28.9	15.6	21.6	--	--	0.00	403.2
June 9	28.3	17.8	22.1	1008	998	0.00	--
June 10	33.3	18.9	23.4	998	992	1.24	--
June 11	20.0	8.9	15.3	1002	992	0.05	--
June 12	18.9	7.2	12.7	1002	999	0.00	--
June 13	23.3	8.9	14.6	1008	1002	0.28	483.8
June 14	25.6	7.2	14.7	1010	1008	0.00	625.0
June 15	23.3	10.0	17.6	1008	1001	0.46	322.6
June 16	20.0	16.1	17.9	1002	1000	1.22	161.3
June 17	22.8	12.2	16.8	1002	998	0.76	438.8
June 18	15.6	8.9	13.0	1008	1002	0.30	201.6
June 19	26.7	11.1	17.8	1009	1003	0.00	463.7
June 20	26.7	13.9	19.6	1004	1000	0.94	463.7
June 21	27.8	12.8	17.1	1000	993	0.76	443.5
June 22	23.3	11.1	16.8	1002	994	0.00	524.2
June 23	23.3	10.0	16.0	1008	1002	0.00	483.8
June 24	25.6	10.6	17.3	1010	1008	0.00	423.4
June 25	28.9	12.8	20.2	1011	1009	0.00	544.3
June 26	27.8	12.2	17.5	1014	1011	0.13	504.0
June 27	30.0	10.0	18.4	--	--	0.00	665.3
June 28	30.6	10.6	20.2	1018	1012	0.00	604.8
June 29	20.0	14.4	17.2	1012	1002	0.20	141.1
June 30	26.7	15.6	19.2	1002	993	0.30	322.6
July 1	28.9	11.1	19.7	1002	995	0.00	524.2
July 2	27.2	16.7	21.8	1003	1002	0.00	362.9
July 3	31.7	17.2	23.4	1008	1002	0.99	383.0

the lake's surface (Table 6). Results from the three methods of deposit assessment show reasonably close agreement in the overall estimate of deposit (6.6 to 10.1% of emitted material) and in the distribution of deposit across the lake, with the exception of one very low value given by GLC analysis for the west shoreline station. Deposit along both east and west shores of the lake was somewhat higher than the mean deposit over the centre portion of the lake.

Peak fenitrothion concentrations (3.80 to 5.80 µg/ℓ) were found in the east shoreline surface waters of Gib Lake a half hour after treatment (Table 7). Surface waters at other stations were much lower in fenitrothion content (0.83 to 1.22 µg/ℓ) at the same time. A pink foam was noticeable along the east shore of the lake twenty minutes after treatment (Fig. 11), suggesting that spray products were concentrated there by wind action. No foam was found along the west (leeward) shore at this time.

Four hours after treatment, surface waters across the lake contained similar small quantities of fenitrothion (0.52 to 0.83 µg/ℓ). These residues slowly disappeared over the period of a week with no detectable residues found after this point in water samples. Small quantities of fenitrothion penetrated to the bottom (1.5 m) of the west station by late afternoon of the treatment date nine hours after treatment. Fenitrothion levels at this depth, from this point on, were almost identical to those found in surface waters, indicating complete mixing of fenitrothion within the epilimnion from within a short time after treatment until the disappearance of detectable residues. Fenitrothion was found in only trace amounts below the epilimnion, first

Table 6

Deposit of emitted spray products on the surface of Gib Lake, 19 June, 1974

	Method of measuring deposit					
	GLC analysis		Computerized spot counting		Colorimetric analysis***	
	g/ha AI deposited*	% deposit	ℓ/ha deposited**	%deposit	ℓ/ha deposited**	% deposit
East Shoreline	9.1	6.5	0.131	9.0	0.110	7.5
East Shallow	8.4	6.0	0.189	12.9	0.131	9.0
East Deep	12.3	8.8	0.178	12.2	0.146	10.0
Midline	6.3	4.5	0.056	3.8	0.036	2.5
West Shallow	18.3	13.1	0.240	16.4	0.219	15.0
West Shoreline	0.5	0.04	0.102	7.0	0.146	10.0
Mean	9.2	6.6	0.149	10.1	0.131	9.0

* 140 g/ha AI emitted
** 1.46 ℓ/ha emitted
*** values given represent minimum deposit due to loss of second decimal place in original readout (oz/acre) through improper calibration of the colorimeter.

Table 7

Fenitrothion residues* in µg/ℓ (ppb) in Gib Lake, Quebec,
18 June to 10 July, 1974

Time relative to treatment	Pre-Spray	+ ½h	+ 4h	+ 9h	+ 25h	+ 34h	+ 50h	+ 60h	+ 71h	+ 6 days	+ 9 days	+ 2 wks	+ 3 wks
East Shoreline Station													
Surface	N.D.	3.70 5.80	0.52	0.64	0.52	0.34	0.46	0.22	0.20	0.16 0.14	N.D	N.D	N.D.
East Shallow Station													
Surface	N.D.		0.57	0.68	0.57	0.28	0.22	0.25	0.30	0.19	N.D.	N.D.	N.D.
Bottom (4 m)	N.D.		T	N.D.	T	N.D.	N.D.	N.D.	T	T	N.D.	N.D.	N.D.
East Deep Station													
Surface	N.D.	0.83	0.83	0.60	0.52	0.21	0.34	0.20	0.30	T	N.D	N.D.	N.D.
Mid (6 m)	N.D.		T	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Bottom (10 m)	N.D.		T	T	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
West Station													
Surface	N.D.	1.22 0.19	0.64	0.40	0.34	0.40	0.40	0.20	0.27	0.19 0.25	N.D.	N.D.	N.D.
Bottom (1.5 m)			N.D.	0.44	0.62	0.46	0.46	0.22	0.20	0.19	N.D.	N.D.	N.D.

T - Traces (< 0.15 µg/ℓ) N.D. - not detected

* water samples did not contain any detectable (> 0.45 µg/ℓ) fenitrooxon residues.

( ) figures in brackets give values arrived at independently on duplicate samples by chemists of the Chemical Control Research Institute (top) and Québec Services de Protection de l'Environnement (bottom).

Fig. 11. Foam present along the east shore of Gib Lake twenty minutes ater treatment. The foam was tinted pink from the dye present in the spray formulation.

right after treatment at 4.6 and 10 m and later shortly before complete disappearance of fenitrothion from the lake waters at the 4 m depth only. This indicates two different ways in which the insecticide penetrated into the deeper portions of the lake--an initial "sinking" effect and a slower mixing in from surface waters. No detectable fenitrooxon residues (<0.45 µg/ℓ) were found in any of the water samples taken. Reasonably close agreement was found between the levels of fenitrothion present in duplicate water samples analyzed independently by the two co-operating agencies.

Small quantities of fenitrothion were found in sediments collected from Gib Lake (Table 8). Three days after treatment fenitrothion was found in measurable quantities (0.5 to 0.7 µg/kg) in the single shallow sample and one of the two deep samples taken. Trace amounts of fenitrothion were found in one of the two deep samples collected six days after treatment and in both the shallow samples collected fifteen days post-spray. Some of the apparent scatter in the occurance of residues with time and depth may be due to the poor suitability of the Ekman grab as a sampler for obtaining sediment samples for pesticide residue analysis from lakes with soft, silty bottoms. The grab sinks deep into this type of bottom and brings up large quantities of buried sediment which may dilute or totally mask pesticide residues in the thin surface layer of sediments where they are most likely to accumulate (and probably have the greatest impact on biological communities).

Caged brook trout in the shoreline cage at the surface of Gib Lake rapidly accumulated insecticide following treatment to peak whole body residue levels of about 0.2 µg/g within the first twelve

Table 8

Fenitrothion residues* in the sediments** of Gib Lake, Quebec, 22 June to 4 July, 1974

Days after treatment	Station (depth)	Fenitrothion*
+3	East shallow (6.1 m)	0.7
	East deep (12.8 m)	N.D.
	East deep (14.6 m)	0.5
+6	East shallow (6.1 m)	N.D.
	East deep (11.0 m)	N.D.
	East deep (13.4 m)	T
+15	East shallow (6.1 m)	T
	East shallow (6.4 m)	T
	East deep (11.9 m)	N.D.
	East deep (12.5 m)	N.D.

* fenitrothion residues are expressed as µg/kg (ppb) dry weight.

** no fenitrooxon was detected in any sediment sampled.

T - trace (<0.5 µg/kg).

N.D. - not detected.

hours following treatment (Table 9). These decreased rapidly at first and then more gradually, with small quantities of fenitrothion still present in fish when sampling was discontinued four weeks after treatment. Fenitrooxon was only found in greater than trace amounts over the first two and a half days following treatment, suggesting faster metabolism or breakdown of this metabolite than of the parent compound. The fish caged on the bottom at the shallow station and sampled without being exposed to surface waters never accumulated more than just over trace quantities of fenitrothion, but these were again found up to four weeks after treatment. Brook trout caged near the bottom at the deep station and raised to the surface unprotected when being sampled, accumulated somewhat higher residues than fish sampled from the shallow cage, but still far lower levels than fish caged at the surface. Newts trapped in the lake three days to two weeks after treatment contained residues somewhat lower but much closer to those found in the brook trout held at the shoreline.

3.3 Changes in biological populations

Plankton trap catches in Gib Lake (Appendix A - Tables I to III) were dominated throughout the study period by cladocerans of the genera *Bosmina* and *Daphnia*, calanoid and cyclopoid copepods, rotifers of the genera *Kellicottia* and *Keratella* and phantom midge larvae (Diptera: Culicidae, *Chaoborus*). Immediately following the fenitrothion treatment a short lived decline in cladoceran numbers was evident at the shoreline station, while little change was evident at the shallow station and a considerable increase occurred at the deep station (Fig. 12). Much the same pattern was found for copepod numbers captured at the three stations

Table 9

Fenitrothion and fenitrooxon residues* in fish and newts from Gib Lake, Quebec
18 June to 19 July, 1974.

Time relative to treatment	Brook trout from cages					Newts
	Shoreline cage			Shallow cage	Deep cage	
	Fen	Fenox**	Total	Fen	Fen	Fen
Prespray	N.D.	N.D.	N.D.	-	-	-
6 hours	0.128	0.066	0.194	0.002	0.008	-
+ 12 hours	0.158	0.044	0.202	-	-	-
+ 24 hours	0.046	0.042	0.088	-	0.004	-
+ 33 hours	0.038	0.036	0.074	N.D.	0.004	-
+ 48 hours	0.042	T	0.042	-	0.002	-
+ 58 hours	0.036	0.022	0.058	0.002	T	-
+ 72 hours	0.042	T	0.042	T	N.D.	0.014
+ 6 days	0.028	N.D.	0.028	T	0.004	0.016
+ 9 days	0.024	N.D.	0.024	N.D.	0.002	0.030
+ 2 weeks	0.014	N.D.	0.014	0.002	-	N.D.
+ 3 weeks	T	N.D.	T	0.002	-	-
+ 4 weeks	0.012	T	0.012	0.002	-	-

* expressed in µg/g (ppm)
N.D. = not detected.
T = Traces (<0.002 µg/g fenitrothion, <0.006 µg/g fenitrooxon.)

** fenitrooxon was only found in brook trout from shoreline cage.

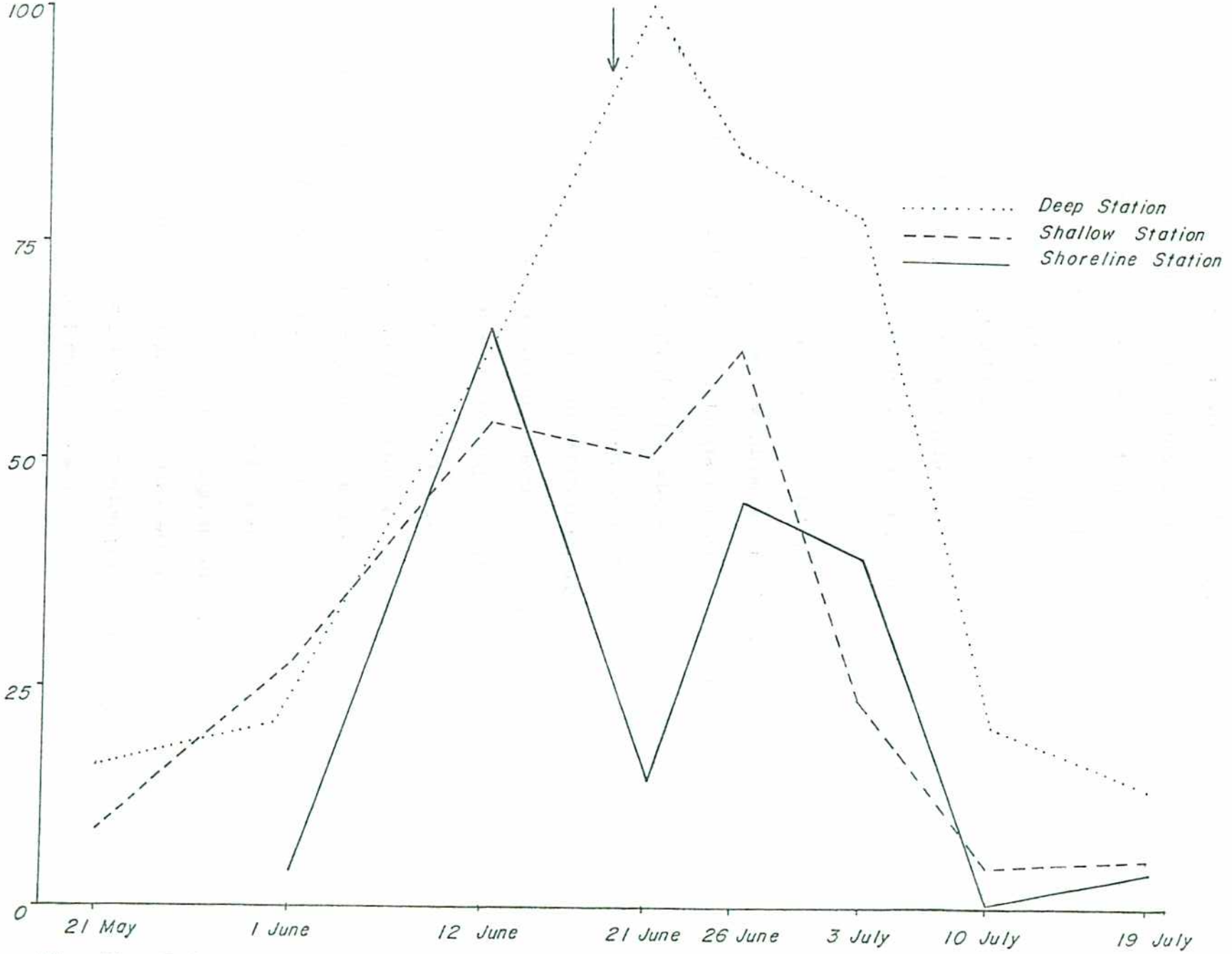


Fig. 12. Cladoceran catches in Gib Lake, 1974. Arrow denotes fenitrothion treatment.

(Fig. 13). The number of rotifers caught at all three stations decreased sharply immediately after treatment but quickly returned to greater than pre-treatment levels at all but the shoreline station, where a lesser increase occurred (Fig. 14). Pooling samples by depth (surface *vs.* subsurface) rather than by station clearly indicated that the decreases in numbers observed were due to the effects on zooplankton organisms at the surface of the lake (Table 10). Particularly noticeable is the complete disappearance of phantom midge larvae from the surface waters of the lake following treatment.

Zooplankton populations at all three stations fell to low levels by the third week of July as would be expected in an oligotrophic lake in mid-summer when strong thermal stratification blocks the recycling of nutrients to the surface waters and reduced primary production leads to declines in the populations of zooplankters.

Bottom fauna populations in Gib Lake (Appendix B, Tables I to IV) were predominated by midge larvae (Diptera:Chironomidae) and amphipods (Amphipoda). Mean numbers of both of these groups found in Ekman grab samples at the west shoreline and shallow stations declined following treatment (Fig. 15), but the standard deviations associated with pre-spray means were 70 to 80% of the mean values, indicating that considerable variability in numbers collected by this sampling method could be expected. No substantial decline was evident in numbers of other aquatic insects or aquatic invertebrate groups. Very large fluctuations in numbers of organisms sampled from the east shallow and deep station are clearly related to samples being collected from different depths and bottom types on different occasions. This was confirmed by scuba observations which

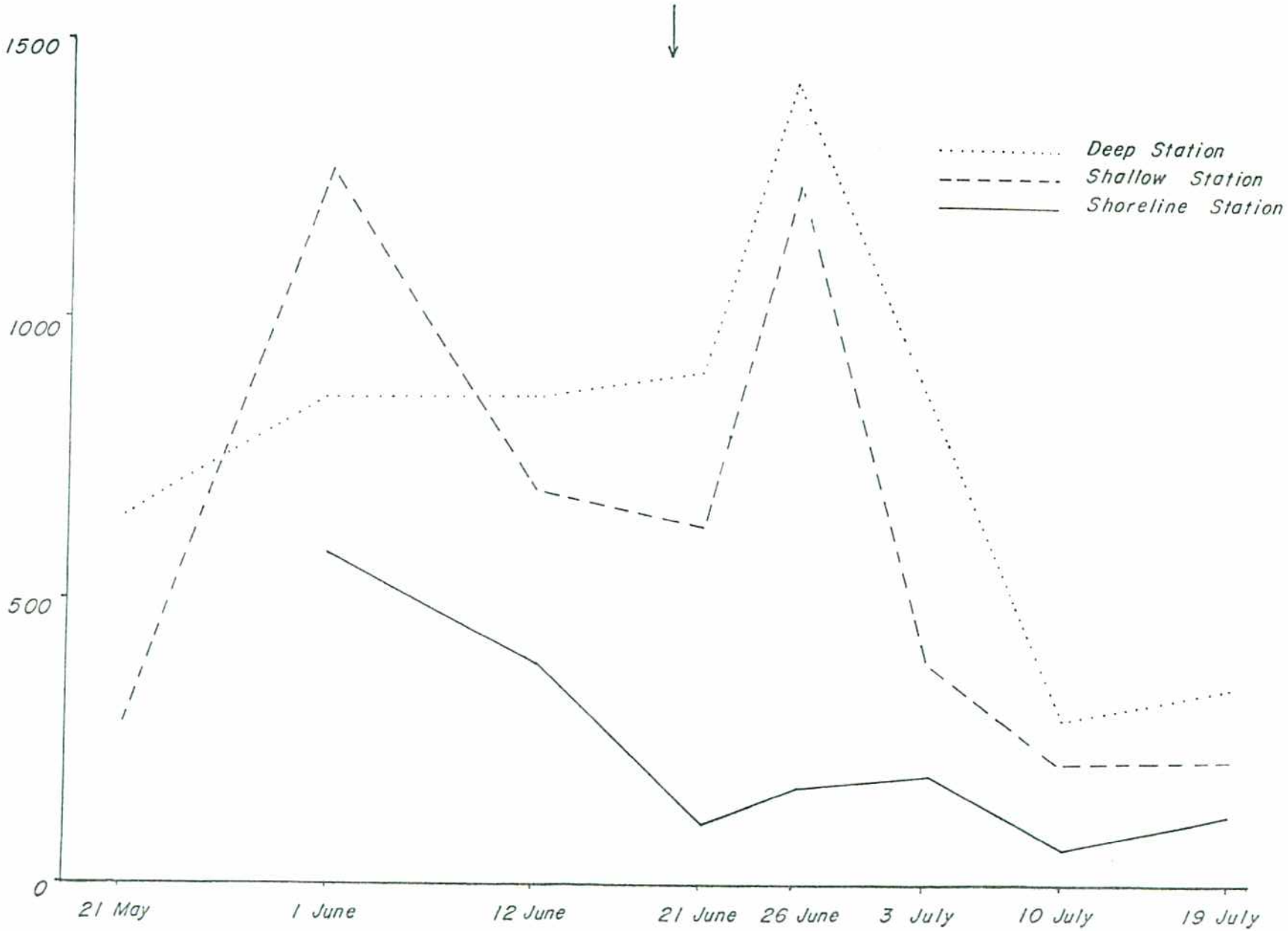


Fig. 13. Copepod catches in Gib Lake, 1974. Arrow denotes fenitrothion treatment.

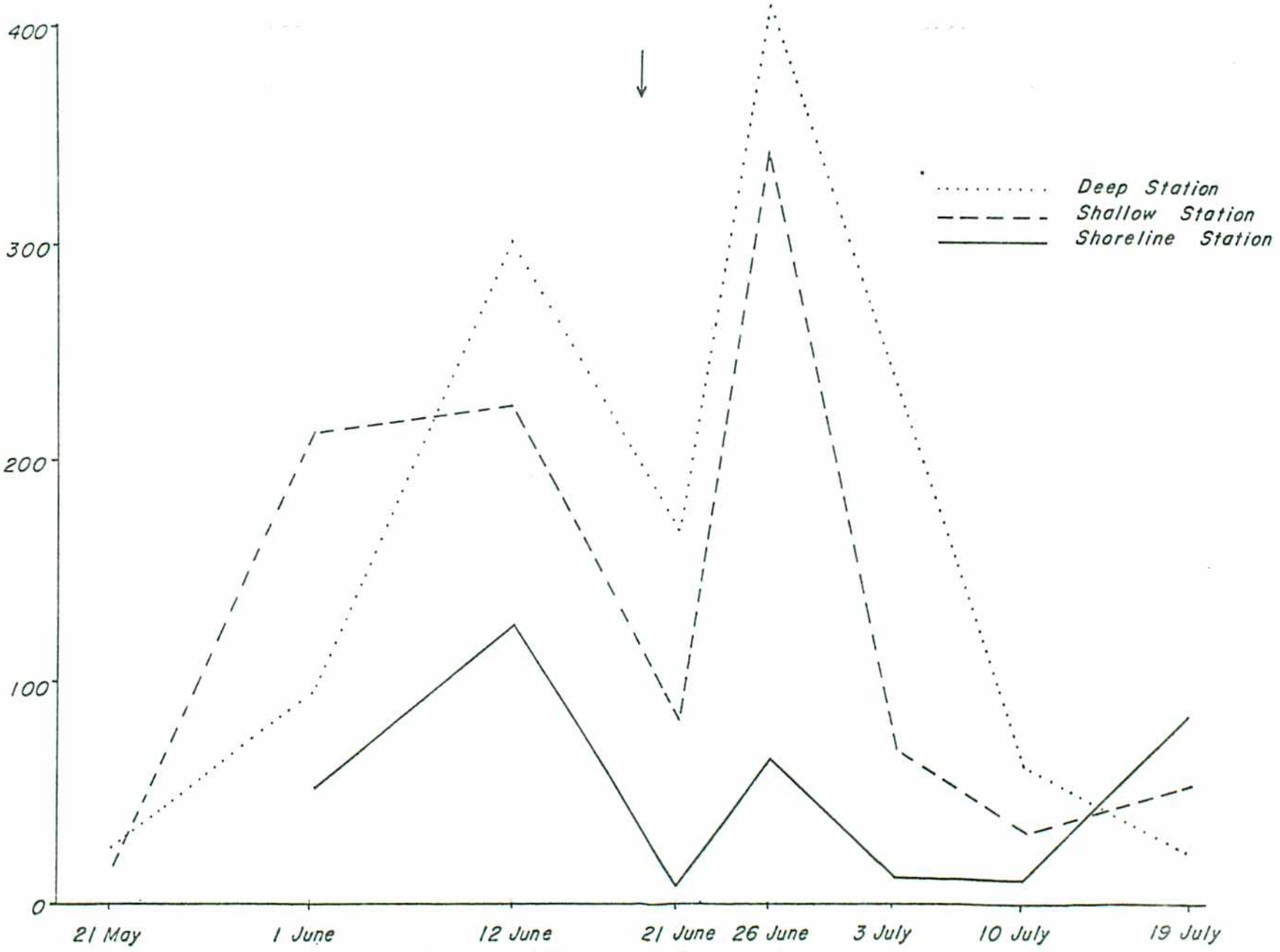


Fig. 14. Rotifer catches in Gib Lake, 1974. Arrow denotes fenitrothion treatment.

Table 10

Mean number of planktonic organisms/sample from surface and sub-surface samples
Gib Lake, Quebec, 21 May to 19 July, 1974

Number of days before or after treatment	-29	-18	-7	+2	+7	+14	+21	+30
Cladocera								
Surface	4	14	25	23	32	10	1	0
Sub-surface	5	2	14	27	17	23	7	6
Copepoda								
Surface	206	512	289	171	578	257	59	58
Sub-surface	178	232	238	348	310	166	112	132
Rotifera								
Surface	8	89	105	24	190	68	10	10
Sub-surface	8	12	71	62	61	34	21	14
Chaoborus larvae								
Surface	1.5	0.3	15.3	0	0	0	0	0
Sub-surface	2	0.7	3.7	24.7	10.3	0	6	1

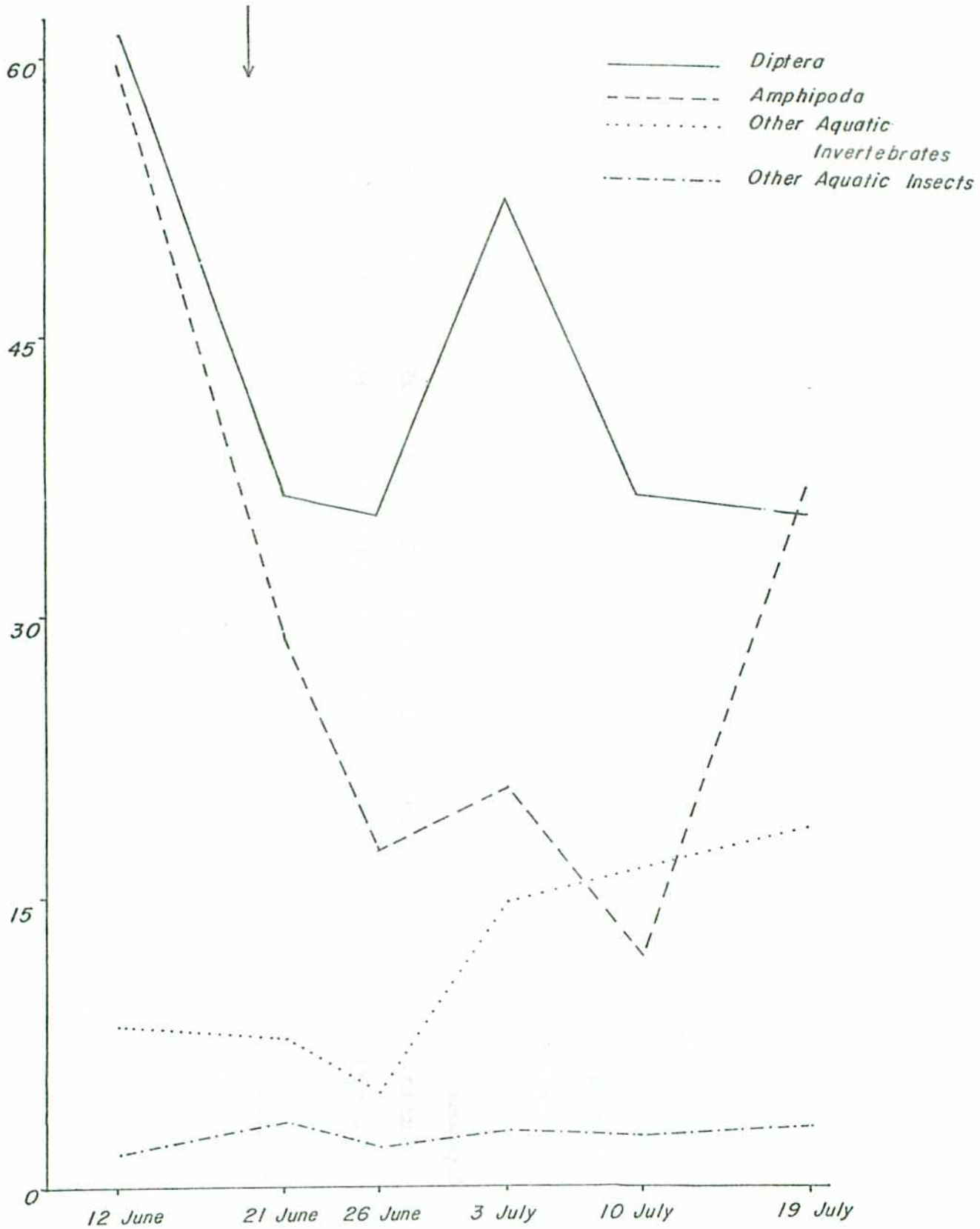


Fig. 15. Benthic organisms collected in Ekman grab samples from the west shoreline and shallow stations in Gib Lake, 1974.

showed that a sharp change in bottom type from coarse sand and gravel to thick silt occurred between the depths of 5 and 6 m along the east shoreline. The only samples collected from the east deep station which contained any number of aquatic invertebrates to speak of were the ones taken at shallower depths where the silt contained a thick mat of fibrous vegetal matter.

Emergence trap catches at the surface of Gib Lake consisted primarily of midges (Diptera:Chironomidae), but mayflies (Ephemeroptera), caddisflies (Trichoptera) and damselflies (Odonata:Zygoptera) were also caught in small numbers (Table 11). The treatment did not have an immediate effect on insect emergence, with the catch over the first twenty-four hours post-spray second in size only to the day immediately before treatment. Total emergence trap catches over the next two weeks were somewhat lower than pre-treatment catches, but the catches at the various stations consistently fell within the range of pre-spray catches at the same station. Mayflies and caddisflies began to consistently show up in emergence traps about four days after treatment and were caught right up to the end of the trapping period.

Minnow traps set in Gib Lake caught large numbers of newts, a few bullfrog tadpoles, one water snake and a large assortment of aquatic invertebrates. Fifty newts were captured over eight days, trapped prior to treatment; while forty-two newts were captured in eight trapping days after treatment. Large numbers of dragonfly nymphs (Odonata:Anisoptera), caddisfly larvae (Trichoptera) and leeches (Hirudinea) were caught in the minnow traps before and after treatment, as were smaller numbers of predacious diving beetles (Coleoptera:Dytiscidae). Scuba observations after treatment of the lake did not reveal any dead or distressed

Table 11

Mean numbers of emerging insects caught/trap/day at the surface of Gib Lake, Quebec. 12 June to 3 July, 1974.

Days before or after treatment of the lake	-7	-6 to -5	-4	-3 to -2	-1	+0	+1	+2	+3 to +5	+6	+7 to +8	+9 to +13	+14
East shoreline	8.2	11.5	4.0	7.5	9.4	13.2	7.2	7.2	6.2	3.8	4.7	4.6	7.8
East shallow	0.0	0.0	0.0	0.3	1.0	1.0	0.4	0.2	0.1	0.2	0.2	0.4	0.2
East deep	-	0.8	0.0	0.0	0.0	0.0	0.7	0.3	0.0	1.0	0.0	0.1	0.3
West shallow	-	0.0	1.5	1.2	4.0	3.0	4.0	3.0	1.7	1.5	1.2	1.4	5.0
West shoreline	-	9.5	14.0	6.3	10.7	6.7	3.7	5.0	9.0	7.3	6.7	6.0	8.7
Total	-	21.8	19.5	15.3	25.1	23.9	16.0	15.7	17.0	13.8	12.8	12.5	22.0
All stations													
Midges	4.12	4.50	2.54	3.31	5.53	6.31	3.06	3.28	3.18	2.50	2.42	2.42	3.94
Mayflies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.17	0.14	0.04	0.17
Caddisflies	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.04	0.00	0.06	0.08	0.17
Damselflies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.01	0.00
Total	4.12	4.50	2.54	3.31	5.41	6.31	3.06	3.28	3.44	2.67	2.62	2.55	4.28

organisms in the lake. Observations were made of amphipods, newts, bullfrog tadpoles, water mites (Hydracarina), dragonfly nymphs, damselfly nymphs, caddisfly larvae, leeches, water tigers (predacious diving beetle larvae), water boatmen (Hemiptera:Corixidae) and backswimmers (Hemiptera: Notonectidae) apparently unaffected by the treatment. Several large snapping turtles were also observed in the lake, and one which was drowned in the trap net was found to have been feeding heavily on the abundant supply of amphipods. A large female was observed laying her eggs about 50 m from the lake two weeks after treatment.

The results of the brain acetylcholinesterase activity determinations (Table 12) show no evident pattern which could be used to suggest an effect or lack of effect of the treatment on this enzyme. Large discrepancies in values, even among the prespray samples, suggest that a problem in the sampling, storage or analysis of samples made it impossible to obtain meaningful results. The most likely source of error is suggested to be not being able to preserve the enzyme intact by simply freezing whole fish heads on dry ice in the field and later excising the brain. Better results have subsequently been obtained by another worker by rapidly excising the brain in the field and freezing it instantly using liquid nitrogen (Marancik 1976).

Table 12

Brain acetylcholinesterase activity values* for brook trout sampled from Gib Lake, Quebec. 18 June to 19 July, 1974.

Time relative to treatment	Shoreline cage	Shallow cage	Deep cage
Prespray	(1.3**, 3.2**, 5.8, 6.7 for five individual fish sampled before being put in cages).		
+ 6 hours	7.0	9.4	7.0
+ 12 hours	2.5	-	-
+ 24 hours	2.7	3.1	5.3
+ 33 hours	3.1	10.7**	11.0**
+ 48 hours	8.4	-	5.8
+ 58 hours	4.2	4.3	5.7
+ 72 hours	5.3	7.3	4.7
+ 6 days	2.8	7.1	3.3
+ 9 days	1.9	2.1	5.4
+ 2 weeks	4.9	-	-
+ 3 weeks	3.4	5.7	-
+ 4 weeks	6.9	6.9	-

* expressed as millimoles acetylcholine hydrolyzed per milligram fish brain per hour incubated.
** values reported as dubious as solutions appeared opalescent.

4. DISCUSSION AND CONCLUSIONS

The results of the biological and chemical sampling in Gib Lake clearly demonstrate the importance of the factors controlling movement of insecticides into and within lake waters, and the effects the pesticide will have on biological communities. Uneven deposit of insecticide across the surface of a lake can result in initial concentration of insecticide in surface water being much higher in some places than in others (in the case of this limited study, by a factor of as great as 7). This can be compounded by the effects of wind and waves concentrating the surface film of insecticide in oil along windward shorelines. Areas of concentrated insecticide on the surface appear to be short lived, with rapid dilution occurring due to movement of the pesticide throughout the epilimnetic waters. The themocline of a stratified lake appears to be an effective barrier against penetration of insecticide applied in oil into the deeper regions of lakes. Some insecticide does appear to reach even the deepest portions of the lake very shortly after application and this is suggested to be due to physical association of the pesticide with particles (e.g. dirt) in the emitted formulation or from the surface of the lake which sink and carry attached pesticide down with them.

The importance of the manner in which the insecticide moves into and within the lake are clearly shown by the differences in the accumulation of residues by fish and impact on zooplankton seen at different depths. By becoming more familiar with the movement of insecticides in lakes and applying this to a knowledge of the distribution and movements of limnetic

populations, potential hazards to lake communities could be predicted and indicator organisms could be selected for monitoring the degree of impact in scattered lakes within large areas treated operationally. Plankton communities in general and phantom midge larvae populations in particular would seem to be suitable for this purpose, at least with respect to fenitrothion. Cladocerans and Culicidae larvae have been shown to be rather sensitive to this insecticide (Flannagan 1973), and their presence throughout the different compartments of lake waters make them suitable groups for studying impacts in lakes.

The overall impact of the application of 140 g fenitrothion/ha to the surface of Gib Lake was small. Effects on zooplankton were limited to surface waters and populations were back to pre-spray levels very quickly. No substantial impact on benthic invertebrates or emerging insects could be documented. Only fish caged at the surface were exposed to more than trace amounts of fenitrothion, and they were not significantly affected by the residues they accumulated. Disappearance of fenitrothion from the lake waters was rapid although residues persisted longer in fish.

5. ACKNOWLEDGEMENTS

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APPENDIX "A"

PLANKTON TRAP CATCHES

IN GIB LAKE, 1974

TABLE A-I

Plankton Trap Catches* at the east shoreline Station in Gib Lake, Quebec
1 June to 19 July, 1974

Number of days before or after treatment	-18	-7	+2	+7	+14	+21	+30
Bosmina	2	40	14	45	33	-	1
Daphnia	2	2	-	-	2	-	1
Diaphanosoma	-	3	-	1	-	-	2
Polyphemus	-	19	-	-	-	-	-
Simocephalus	-	-	-	-	4	-	-
Total Cladocera	4	64	14	46	39	-	4
Calanoid Copepods	83	294	49	72	115	48	87
Cyclopoid Copepods	12	5	14	35	14	-	3
Nauplii	495	101	53	68	63	18	41
Total Copepoda	590	400	116	175	192	66	131
Asplanchna	-	1	-	-	-	-	-
Kellicottia	41	99	4	65	11	8	83
Keratella	9	26	4	-	-	2	1
Total Rotifera	50	126	8	65	11	10	84
Chaoborus larvae	-	14	-	-	-	-	-

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

TABLE A-II

Plankton Trap Catches* at the east shallow station in Gib Lake, Quebec
21 May to 19 July, 1977

Number of days before or after treatment	-29			-18			-7			+2			+7			+14			+21			+30		
	Surf	4m	Tot	Surf	4m	Tot	Surf	4m	Tot	Surf	4m	Tot	Surf	4m	Tot	Surf	4m	Tot	Surf	4m	Tot	Surf	4m	Tot
Bosmina	4	4	8	12	-	12	30	8	38	18	9	27	38	12	50	-	-	-	-	-	-	-	2	2
Daphnia	-	-	-	14	1	15	-	9	9	1	-	1	-	6	6	2	-	2	-	-	-	-	-	-
Diaphanosoma	-	-	-	-	-	-	4	3	7	-	22	22	2	4	6	18	-	18	2	1	3	-	-	-
Leptodora	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	1
Simocephalus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	2	2
Total Cladocera	4	4	8	26	1	27	34	20	54	19	31	50	40	22	62	22	-	22	3	1	4	-	5	5
Calanoid Copepods	81	33	114	220	56	276	295	183	478	51	402	453	554	390	944	181	160	341	38	103	141	80	107	187
Cyclopoid Copepods	8	-	8	64	13	77	20	12	32	37	-	37	-	10	10	-	-	-	-	16	16	-	-	-
Nauplii	131	37	168	662	250	912	99	99	198	89	60	149	172	114	286	41	19	60	10	52	62	16	19	35
Total Copepoda	220	70	290	946	319	1265	414	294	708	177	462	639	726	514	1240	220	179	401	48	171	219	96	126	222
Kellicottia	13	1	14	160	32	192	118	80	198	21	38	59	278	44	322	25	31	56	7	21	28	9	43	52
Keratella	3	-	3	18	-	18	15	14	29	6	21	27	4	18	22	3	10	13	2	4	-	-	-	-
Total Rotifera	16	1	17	178	32	210	133	94	227	27	59	86	282	62	344	28	41	69	9	23	32	9	43	52
Chaoborus larvae	-	1	1	-	2	2	18	11	29	-	61	61	-	6	6	-	-	-	-	18	18	-	-	-

* from single 12ℓ Shindler-Patalas Plankton Trap samples.

TABLE A-III

Plankton Trap Catches* at the east deep station in Gib Lake, Quebec
21 May to 19 July, 1974

Number of days before or after treatment	-29				-18				-7				+2			
	Surf	6m	12m	Tot	Surf	6m	12m	Tot	Surf	6m	12m	Tot	Surf	6m	11m	Tot
Bosmina	1	-	-	1	-	-	-	-	27	4	1	32	49	5	7	61
Daphnia	3	8	3	14	16	1	3	20	8	16	1	25	-	27	11	38
Diaphanosoma	-	-	-	-	-	-	-	-	5	-	-	5	2	-	-	2
Simocephalus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Cladocera	4	8	3	15	16	1	3	20	40	20	2	62	51	32	18	101
Calanoid Copepoda	15	21	12	48	106	12	10	128	342	135	57	534	239	104	121	464
Cyclopoid Copepoda	4	20	2	26	26	69	11	106	19	32	23	74	-	9	41	50
Nauplii	173	205	205	583	459	132	45	636	91	143	30	264	96	87	220	403
Total Copepoda	192	246	219	657	591	213	66	870	452	310	110	872	335	200	382	917
Kellicottia	-	9	5	14	89	5	-	94	151	71	26	248	39	24	65	128
Keratella	-	-	10		10	-	-	-	31	12	11	54	6	7	30	43
Total Rotifera	-	9	15	24	89	5	-	94	182	83	37	302	45	31	95	171
Chaoborus larvae	3	4	1	8	1	-	-	1	14	-	-	14	-	3	10	13

* from single 12ℓ Shindler-Patalas Plankton Trap samples.

TABLE A-III (Cont'd)

Number of days before or after treatment	+7				+14				+21				+30			
	Surf	6m	11m	Tot	Surf	6m	11m	Tot	Surf	6m	10m	Tot	Surf	6m	10m	Tot
Bosmina	56	3	-	59	9	-	-	9	-	-	-	-	-	-	1	1
Daphnia	-	15	10	25	-	5	39	44	-	7	7	14	-	-	5	5
Diaphanosoma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	7
Simocephalus	-	-	-	-	-	-	24	24	-	-	6	6	-	-	-	-
Total Cladocera	56	18	10	84	9	5	63	77	0	7	13	20	-	-	13	13
Calanoid Copepoda	756	189	25	970	406	70	90	566	107	54	39	200	68	3	97	168
Cyclopoid Copepoda	16	-	1	17	28	-	4	32	6	-	-	6	2	-	4	6
Nauplii	1008	287	128	1423	550	145	175	870	130	76	89	295	79	6	265	350
Kellicottia	272	23	93	388	172	45	15	232	21	5	26	52	20	-	-	20
Keratella	16	4	2	22	3	2	-	5	-	-	8	8	2	-	-	2
Total Rotifera	288	27	95	410	175	47	15	237	21	5	34	60	22	-	-	22
Chaoborus larvae	-	25	-	25	-	-	-	-	-	-	-	-	-	-	3	3

APPENDIX "B"

BOTTOM FAUNA POPULATIONS IN GIB LAKE, 1974

TABLE B-I

Benthic organisms* collected in Ekman grab samples
from the west shoreline station, Gib Lake, Quebec
12 June to 19 July, 1974

Number of days before or after treatment	-7	+2	+7	+14	+21	+30
Number of samples	5	3	3	3	3	3
Mean depth sampled (m)	1.7	1.8	1.8	1.5	1.8	1.5
Ephemeroptera	0.6 ± 0.9	1.0 ± 1.0	0.7 ± 0.6	1.0 ± 1.7	1.3 ± 1.5	-
Odonata	-	-	-	-	-	0.3 ± 0.6
Hemiptera	-	0.3 ± 0.6	-	-	-	-
Neuroptera	0.4 ± 0.9	-	0.3 ± 0.6	0.7 ± 1.1	0.7 ± 1.1	0.7 ± 0.6
Trichoptera	1.0 ± 1.2	1.0 ± 1.0	0.3 ± 0.6	2.7 ± 2.9	3.7 ± 4.0	4.3 ± 3.2
Lepidoptera	-	0.3 ± 0.6	-	-	-	-
Coleoptera	-	-	-	-	-	0.3 ± 0.6
Diptera:Culicidae	-	-	-	1.7 ± 1.5	0.3 ± 0.6	-
:Chironomidae	83.2 ± 67.9	49.7 ± 19.1	49.7 ± 36.9	92.3 ± 47.1	68.3 ± 29.3	68.0 ± 22.3
:Heleidae	3.6 ± 1.7	7.0 ± 4.6	2.7 ± 3.0	1.7 ± 0.6	2.0 ± 1.7	1.3 ± 1.5
Nematoda	-	-	0.3 ± 0.6	-	-	-
Oligochaeta	3.0 ± 2.4	2.3 ± 1.5	6.0 ± 2.6	3.0 ± 2.0	2.0 ± 3.5	2.3 ± 0.6
Hirudinea	0.2 ± 0.4	-	0.3 ± 0.6	-	-	-
Amphipoda	78.4 ± 54.8	43.3 ± 21.5	20.7 ± 6.0	26.0 ± 6.1	19.7 ± 13.6	53.0 ± 5.3
Hydracarina	0.2 ± 0.4	-	-	-	-	0.3 ± 0.6
Mollusca:Gastropoda	0.4 ± 0.9	-	-	1.3 ± 1.1	0.3 ± 0.6	0.3 ± 0.6
:Sphaeriidae	4.2 ± 6.3	0.7 ± 1.1	2.3 ± 4.0	19.3 ± 9.6	19.7 ± 5.5	33.3 ± 13.2
Total	175.2 ± 77.2	105.7 ± 18.8	83.3 ± 32.0	149.7 ± 66.4	118.0 ± 32.2	164.3 ± 10.0

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

TABLE B-II

Benthic organisms* collected in Ekman grab samples
from the west shallow station, Gib Lake, Quebec
12 June to 19 July, 1974

Number of days before or after treatment	-7	+2	+7	+14	+21	+30
Number of samples	3	3	3	3	3	3
Mean depth sampled (m)	1.7	1.4	1.7	1.4	1.4	2.0
Ephemeroptera	0.7 ± 1.1	2.0 ± 3.5	-	0.3 ± 0.6	-	0.3 ± 0.6
Odonata	0.3 ± 0.6	3.0 ± 1.0	3.0 ± 1.0	1.0 ± 1.0	-	0.3 ± 0.6
Neuroptera	-	-	-	-	-	0.3 ± 0.6
Trichoptera	0.3 ± 0.6	-	-	0.3 ± 0.6	-	-
Diptera:Culicidae	0.3 ± 0.6	-	-	-	-	-
:Chironomidae	21.0 ± 7.5	18.0 ± 7.0	19.7 ± 4.2	11.3 ± 11.7	4.0 ± 3.6	3.3 ± 2.1
Oligochaeta	1.7 ± 2.1	8.3 ± 7.6	4.7 ± 1.1	3.3 ± 0.6	0.3 ± 0.6	0.3 ± 0.6
Hirudinea	0.7 ± 0.6	0.3 ± 0.6	-	-	-	-
Amphipoda	31.3 ± 14.2	16.3 ± 7.0	15.7 ± 13.3	17.3 ± 10.6	6.0 ± 6.0	22.0 ± 16.4
Mollusca:Gastropoda	0.7 ± 0.6	2.0 ± 1.0	1.0 ± 0.0	1.7 ± 1.1	1.0 ± 0.0	1.0 ± 1.0
:Sphaeriidae	6.7 ± 7.6	2.3 ± 2.3	0.7 ± 0.6	2.3 ± 4.0	-	1.3 ± 2.3
Total	63.7 ± 25.6	52.3 ± 9.1	44.7 ± 17.0	37.7 ± 26.1	11.3 ± 5.8	29.0 ± 20.1

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

TABLE B-III

Benthic organisms* collected in Ekman grab samples
rom the east shallow station, Gib Lake, Quebec
21 May to 10 July, 1974

Number of days before and after treatment	-29	-18	-7	+2	+7	+14	+21
Number of samples	3	4	5	3	3	3	3
Mean depth sampled (m)	5.4	5.8	4.4	6.0	4.9	6.3	5.6
Ephemeroptera	0.3 ± 0.6	-	1.2 ± 1.3	0.3 ± 0.6	0.3 ± 0.6	-	-
Odonata	0.3 ± 0.6	-	0.2 ± 0.4	-	-	-	-
Hemiptera	0.3 ± 0.6	-	-	-	-	-	-
Neuroptera	0.3 ± 0.6	-	2.2 ± 0.0	-	0.3 ± 0.6	0.3 ± 0.6	0.3 ± 0.6
Diptera:Culicidae	0.3 ± 0.6	-	0.2 ± 0.4	-	-	-	-
:Chironomidae	7.3 ± 1.5	-	3.4 ± 2.1	-	3.0 ± 2.6	-	0.7 ± 0.6
:Heleidae	-	-	0.4 ± 0.9	-	-	-	-
Oligochaeta	2.3 ± 1.1	1.2 ± 2.5	0.4 ± 0.9	-	1.3 ± 2.3	-	-
Hirudinea	-	-	0.2 ± 0.4	-	-	-	-
Amphipoda	0.7 ± 0.6	0.8 ± 1.0	4.4 ± 2.3	0.7 ± 0.6	105.3 ± 18.8	-	16.7 ± 13.6
Hydracarina	0.3 ± 0.6	-	-	-	-	-	-
Mollusca:Sphaeriidae	3.0 ± 2.0	-	-	-	-	-	0.3 ± 0.6
Total	15.3 ± 4.6	2.0 ± 3.4	12.6 ± 4.5	1.0 ± 1.0	110.3 ± 23.1	0.3 ± 0.6	18.0 ± 13.8

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

TABLE B-IV

Benthic organisms* collected in Ekman grab samples
from the east deep station, Gib Lake, Quebec
1 June to 10 July, 1974

Number of days before or after treatment	-18	-7	+2	+7	+14	+21
Number of samples	4	3	3	3	3	3
Mean depth sampled (m)	14.9	8.2	12.2	14.6	12.5	8.5
Odonata	-	-	-	-	-	0.7 ± 1.1
Diptera:Chironomidae	-	-	0.3 ± 0.6	-	-	-
Oligochaeta	-	0.7 ± 0.6	-	-	-	-
Amphipoda	-	0.7 ± 0.6	-	-	-	5.7 ± 8.1
Mollusca:Sphaeriidae	-	5.3 ± 5.8	-	-	-	-
Total	-	6.7 ± 5.4	0.3 ± 0.6	-	-	6.3 ± 9.3

* expressed as mean number and standard deviation found in the indicated number of 232 cm^2 Ekman grab samplers.