EFFECTS OF FENITROTHION AND PHOSPHAMIDON ON STREAM BENTHOS - 1975

by

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FREDERICTON, NEW BRUNSWICK

INFORMATION REPORT M-X-65

CANADIAN FORESTRY SERVICE

DEPARTMENT OF THE ENVIRONMENT

August, 1976

Effects of Fenitrothion and Phosphamidon on Benthos in the Nashwaak Project Study Streams in 1975

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ABSTRACT

The results of streamwater analysis after forest spraying suggested high but unverified concentrations of fenitrothion for 18 h or more. There was no kill and little or no effect on drift of benthic invertebrates. Eleven to 18 days later, in the same streams, phosphamidon, detectable for 3 days at concentrations up to 17 ppb, had no effect.

RESUME

L'analyse de certains ruisseaux après pulvérisation aérienne de la forêt a indiqué des concentrations élevées (mais non vérifiées) de fénitrothion pendant 18 heures ou plus. On n'a enregistré aucune mortalité ni aucun effet sur la dérive des invertébrés benthiques. Dans les mêmes ruisseaux, 11 à 18 jours plus tard, des concentrations de phosphamidon de jusqu'à 17 parties par milliard et perceptibles durant 3 jours ne produisirent aucun effet.

INTRODUCTION

In a previous report (Eidt 1975a), the effects of fenitrothion in 1973 on the benthic invertebrates of the study streams of the Nashwaak Experimental Watershed Project (Anon 1976) were described in detail. In the two seasons since, the effects of the spruce budworm spray program have been monitored to further elucidate the relationship between the concentration and persistence of insecticide in stream water and the effect on benthic invertebrates. The evaluation of the effects on benthos of experimental clear-cutting and fertilization treatments of the Nashwaak Project could be seriously handicapped by unaccounted benthos kills.

The 1973 spray program, using fenitrothion at 210 g/ha, resulted in some kill of aquatic insects, especially of stonefly larvae in Narrows Mountain Brook, but there was no detectable depletion of benthos, even at the generic level (Eidt 1975a). In the 1974 spray program, fenitrothion applied at the same rate resulted in lower concentrations of insecticide in the water; it disappeared rapidly and no kill occurred (Eidt 1975b). This report describes the monitoring program in the same streams in 1975.

Relevant literature was reviewed in my two earlier papers. An exception is the National Research Council review on the effects of the use of fenitrothion on environmental quality (National Research Council 1973) which recommends further investigation of the partitioning and persistence of fenitrothion in aquatic sediments. This is important in streams because Eidt (1975a) gave evidence that stream benthos within the substrate is safer than that near the substrate surface or in drift.

The experimental streams were described in the earlier papers (Eidt 1975a,b). This work was a part of the Nashwaak Experimental Watershed Project (Anon 1976), a cooperative study of environmental impacts of forestry practices involving Environment Canada, the University of New Brunswick, the New Brunswick Departments of Natural Resources and Environment, and the St. Anne Nackawic Pulp and Paper Co. Ltd.

METHODS

The study area was sprayed with fenitrothion at the rate of 174 g (a.i.)/ha followed by phosphamidon at the rate of 174 g (a.i.)/ha, both in aqueous emulsion. The fenitrothion formulation was 150 parts of technical fenitrothion, 50 parts of the emulsifier Atlox 3409F, and 20 parts of a solvent oil CFTX107 Aerotex 3470. Technical fenitrothion varied from 95 to 97% active ingredient but was mixed with water on the basis of an average of 97%. Thus the amount of active ingredient emitted varied slightly. The phosphamidon was 92% active ingredient and required no further additives to mix with water.

Narrows Mountain Brook was in spray block 558 (Fig. 1), which was sprayed with fenitrothion the evening of 3 June. The same area (renamed block 1258) was sprayed with phosphamidon the morning of 11 June (Table 1). Hayden Brook was in block 573 (Fig. 1), which was sprayed with fenitrothion the morning of 4 June and with phosphamidon (block 1273) the morning of 22 June (Table 2). Lake Brook was in block 572 (Fig. 1), which was sprayed with fenitrothion immediately after block 573 the morning of 4 June and with phosphamidon (block 1272) immediately after block 1273 the morning of 22 June (Table 3).

Water samples were collected from each stream before spraying and about 1, 4, 10, 24, and 36 h, and 2, 3, and 5 days after spraying. Within an hour after each sample was collected, 1 ℓ of sample water and 50 ml of chloroform were shaken in a separatory funnel for 30 min. The chloroform containing the insecticide was separated and the water fraction was discarded. All further traces of water were removed with anhydrous sodium sulphate, the chloroform was filtered to remove sodium sulphate, and the residue was rinsed with 5 ml of chloroform. The samples were sealed in amber bottles with aluminum-lined screw caps, wrapped in aluminum foil, and shipped to Dr. K.M.S. Sundaram for analysis. Each sample was analysed for fenitrothion and the *cis*- and *trans*-isomers of phosphamidon using gas-liquid chromatography. The procedure is less sensitive than for samples containing only one of the insecticides because their retention times are similar, but the level of sensitivity was adequate. The method of collection and analysis was fundamentally the same as that used in 1973 and 1974 (Eidt 1975a, b).

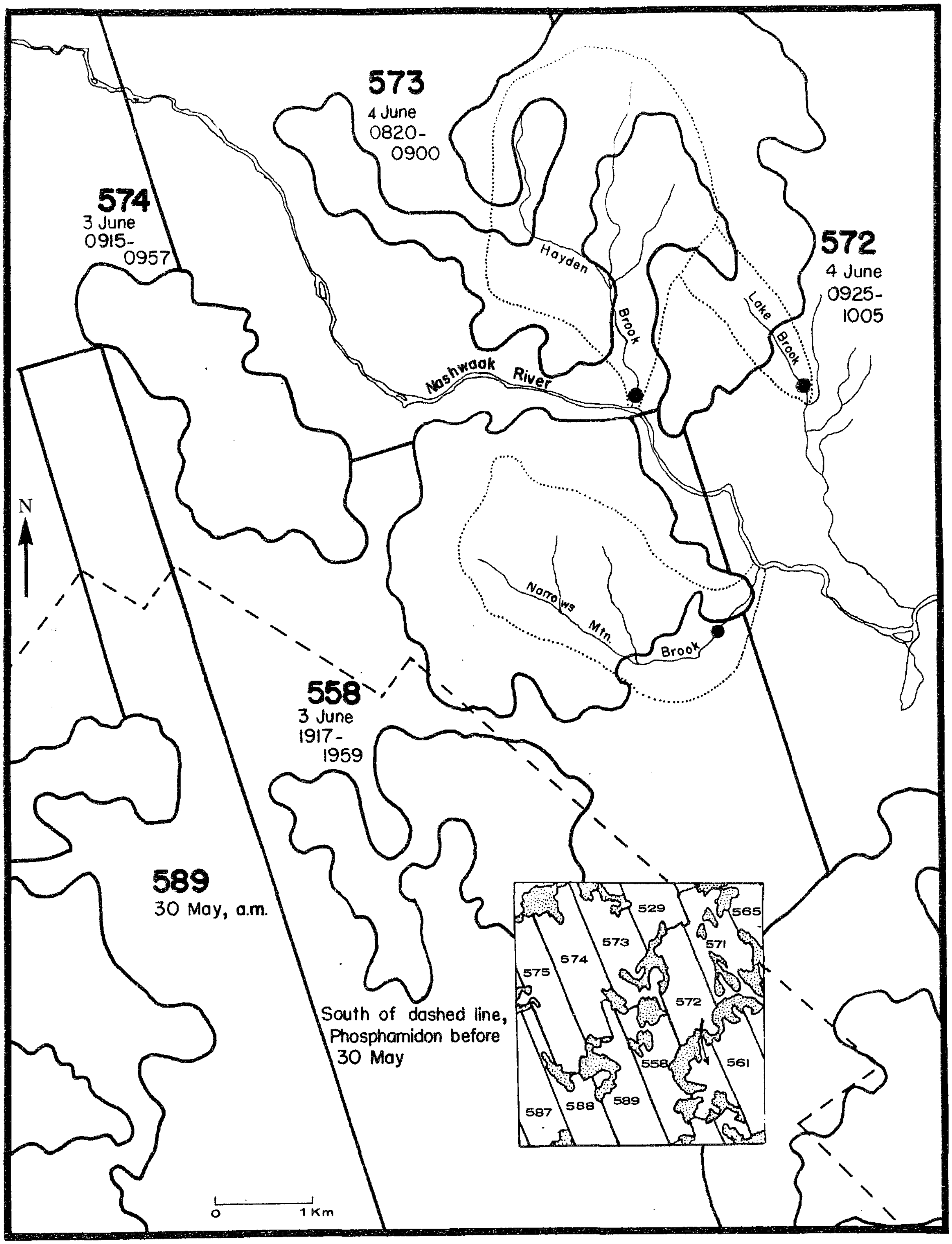

Fig. 1. Study area showing spray block boundaries, heavy lines; unsprayed areas not susceptible to spruce budworm, irregular areas enclosed by heavy lines; watersheds, dotted lines; and sample stations, dots. Inset: neighbouring spray blocks.

The methods for insect drift collection and analysis were the same as those used in 1974 (Eidt 1975b). The interval between samples was increased to 4 h; two of six daily samples were taken during the dark period. Sample splitting, to reduce the amount of laboratory analysis, was achieved by simply reducing the duration of net sets when drift was abundant.

RESULTS AND DISCUSSION

Increases in drift occurred on 7 June in Narrows Mountain Brook, on 9 and 10 June in Lake Brook (Fig. 2) and to a lesser extent on both 7 and 9 June in Hayden Brook (Fig. 3). These increases were due to an increase in discharge that occurred on all three brooks the night of 6-7 June (Fig. 4). Drift sampling was suspended from 2300 h on 7 June to 1100 h on 9 June because of spate conditions. In general, the amount of daily drift declined over the sample period, which is consistent with results in 1973 and 1974, and reflects normal seasonal decline. A slight increase in the number of organisms in Hayden Brook drift samples taken at 2300 h on 4 June and at 0300 h on 5 June suggests a possible effect from fenitrothion sprays that were applied to block 558 the evening of 3 June and to block 573 the morning of 4 June (Fig. 5). No similar increases occurred in Lake and Narrows Mountain brooks (Fig. 6). There were no increases that could be associated with the phosphamidon sprays on 11 and 22 June. There were no unusual numbers of dead aquatic animals in any of the drift samples. Many dead terrestrial insects, including spruce budworm larvae, were found following each spray, and especially in Lake Brook drift following the phosphamidon spray of 22 June.

Variations in drift can not only be associated with changes in stream discharge but also with water temperature. However, during rainy weather average stream temperature drops and the amplitude of daily fluctuations decreases (Fig. 7). At the same time, discharge, which is known to affect drift, increases. The water temperature changes are probably not responsible for variations in drift (Waters 1972), nor are the changes in daily water temperature fluctuations.

The concentrations of fenitrothion in the streamwater were apparently high at times, but cannot be verified. For example, at 1850 h on 3 June a sample from Narrows Mountain Brook contained 47 ppb (μg/ℓ). At the rate of 174 g/ha, 27% of the spray would have to reach the stream to give that concentration. According to the estimations of Eidt and Sundaram (1975) this is much higher than expected. Furthermore, the area had not yet been sprayed on 3 June and the sprayed area nearest to the sample station was block 574, the southern extremity of which was 6.5 km to the west. The wind was from the southwest at 8-11 km/h when block 574 was sprayed about 13 h earlier. Even allowing for wide errors in estimation of wind speed and direction, spray drifting 6 km would disperse considerably, and it is difficult to accept a figure of 47 ppb.

Other unusually high concentrations were recorded: in Narrows Mountain Brook (Table 1) 3 and 4 June after block 558 was sprayed; in Hayden Brook (Table 2) 3 and 4 June before block 573 was sprayed and the late evening of 5 June more than 35 h after any fenitrothion spraying had been done within 10 km or more; and similarly in Lake Brook (Table 3) 3 and 4 June before block 572 was sprayed and the late evening of 4 June over 10 h after block 572 or any other neighbouring block was sprayed.

The appearance of insecticide in places distant from those sprayed is not surprising, but at such high concentrations for such durations, a substantial kill of benthos should have occurred. Previous experience (Eidt 1973, Banks 1973, and H.A. Hall[1], unpublished reports) has demonstrated that benthos kills occur at much lower concentrations than these. Intensive monitoring in 1975 failed to detect a kill and at most a slight increase in living drift may have occurred in one stream. There was only one obvious difference between 1973, when a kill occurred with a observed fenitrothion peak of 5.25 ppb (Eidt 1975a), and 1975 when no kill occurred at much higher concentrations. Sampling was earlier in 1975 and the water temperature (9-13°C) averaged about 3.5°C lower. The lower temperature would not decrease the degradation rate of fenitrothion appreciably. The lower metabolic rate of the invertebrates might afford them some protection but hardly enough to explain the discrepancy between the apparent concentrations of the insecticide and

[1]Environmental Protection Service, Environment Canada, Halifax, N.S.

the lack of biologcal effects. On the other hand, Cairns *et al* (1975) rightly points out that the interactions between temperature and toxicity of organophosphorous insecticides may be very complex and conclusions and generalizations are unjustified.

Phosphamidon was found in low concentrations in Narrows Mountain Brook (Table 1) at various times after block 1258, containing the stream, and neighbouring blocks were sprayed. In Hayden Brook (Table 2) low concentrations, drift from elsewhere, were found occasionally before spraying, and as expected, rose quickly after the spray, then declined exponentially. In Lake Brook (Table 3) no phosphamidon was detected before spraying, the concentration rose quickly when block 1272 was sprayed, and declined exponentially over the next 3 days. It was expected that phosphamidon would have no effect on the benthos. Grant (1967), measuring benthos drift and insect emergence, found no effect on benthos in two streams sprayed with phosphamidon at ½ lb/ac (556 g/ha) and at 1 lb/ac (1112 g/ha). He did not determine the concentration of insecticide in the water, but the streams were deliberately sprayed and a tracer dye showed that phosphamidon entered the water.

CONCLUSIONS

Fenitrothion entered the waters of Hayden, Narrows Mountain, and Lake brooks but apparently high concentrations could not be verified. There was no effect on benthos, with the possible exception of a slight increase in living drift in Hayden Brook during the night of 4-5 June following sprays applied the previous morning.

Phosphamidon entered the waters of Hayden, Narrows Mountain, and Lake brooks and peak concentrations of 7, 1.5, and 16 ppb were recorded. There was no effect on benthos.

ACKNOWLEDGMENTS

The cooperation of Forest Protection Ltd., who applied the sprays, is gratefully acknowledged. Data on stream discharge for Narrows Mountain and Hayden brooks were provided by the Water Survey of Canada. Water samples were analysed for fenitrothion and for the *trans*- and *cis*-isomers of phosphamidon by Dr. K.M.S. Sundaram, Chemical Control Research Institute, Canadian Forestry Service, Ottawa, who also reviewed the manuscript. The constructive criticism of Dr. P.E.K. Symons, Fisheries and Marine Service, St. Andrews, New Brunswick, is gratefully acknowledged.

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Table 1. Spray schedule and insecticide concentrations in Narrows Mountain Brook. 0 = none detected, T = < 1 ppb

June date	Time*	Fenitrothion (ppb)	Phosphamidon (ppb) *Trans*	*Cis*
1	1540	0	0	0
3	0915-0957	Sprayed block 574		
	1850	47	0	0
	1917-1959	Sprayed block 558		
	2055	7	0	0
	2345	7	0	0
4	0745	29	0	0
	0820-0900	Sprayed block 573		
	0925-1005	Sprayed block 572		
	1058	5	0	0
	1405	2	0	0
	2015	3	0	0
5	0955	4	0	0
	2220	2	0	0
6	1010	4	0	0
7	1010	2	0	0
9	1030	1	0	0
11	0530		Began east 3/4 block 1258	
	0645	1	0	0
	0705		Ended spraying	
	0735-0915		Sprayed west 1/4 block 1258 and east 1/2 block 1289	
	1230	1	0	0
	1750	1	0	0
12	0910	T	0	0
	1914	1	0	0
13	0730	1	0	1.5
22	0635		Began block 1273	
	0640	T	0	0
	0716		Ended spraying	
	0736-0822		Sprayed block 1272	
	0850	T	T	T
	0940	T	T	1
	1240	T	T	T
	1840	1	0	0
23	0840	T	0	0
	2040	T	0	0
24	0840	T	0	T
25	0900	T	0	0

*Atlantic Daylight Time.

Table 2. Spray schedule and insecticide concentrations in Hayden Brook. 0 = none detected, T = < 1 ppb

			Phosphamidon (ppb)	
June date	Time	Fenitrothion (ppb)	*Trans*	*Cis*
1	1500	T	0	0
3	0915-0957	Sprayed block 574		
	1840	5	0	T
	1917-1959	Sprayed block 558		
	2050	3	0	0
	2340	3	0	0
4	0750	8	0	0
	0820-0900	Sprayed block 573		
	0925-1005	Sprayed block 572		
	1100	4	T	2
	1355	1	T	1
	2010	1	T	1
5	0950	2	T	1
	2210	15	0	0
6	1004	T	0	0
7	1000	T	0	T
9	1030	T	0	0
22	0635	T	0	T
	0635-0716		Sprayed block 1273	
	0736-0822		Sprayed block 1272	
	0845	T	2	5
	0935	T	1	3
	1230	T	1	2
	1835	T	T	T
23	0830	T	T	T
	2040	T	T	T
24	0835	0	0	0
25	0900	0	0	0

*Atlantic Daylight Time.

Table 3. Spray schedule and insecticide concentrations in Lake Brook. 0 = none detected, T = < 1 ppb

June date	Time*	Fenitrothion (ppb)	Phosphamidon (ppb) *Trans*	*Cis*
1	1620	T	0	0
3	0915-0957	Sprayed block 574		
	1850	14	0	0
	1917-1959	Sprayed block 558		
	2050	9	0	0
	2355	12	0	0
4	0800	8	0	0
	0820-0900	Sprayed block 573		
	0925-1005	Sprayed block 572		
	1058	16	0	0
	1400	8	0	0
	2012	38	0	0
5	1010	2	0	0
	2215	1	0	0
6	1010	T	0	0
7	1030	1	0	0
9	1030	T	0	0
22	0635		Began block 1273	
	0640	0	0	0
	0716		Ended spraying	
	0736		Began block 1272	
	0812	0	3	9
	0822		Ended spraying	
	0945	T	4	12
	1215	T	4	13
	1845	T	3	6
23	0815	T	T	1
	2015	1	T	1
24	0803	1	T	1
25	0930	T	T	T

*Atlantic Daylight Time.

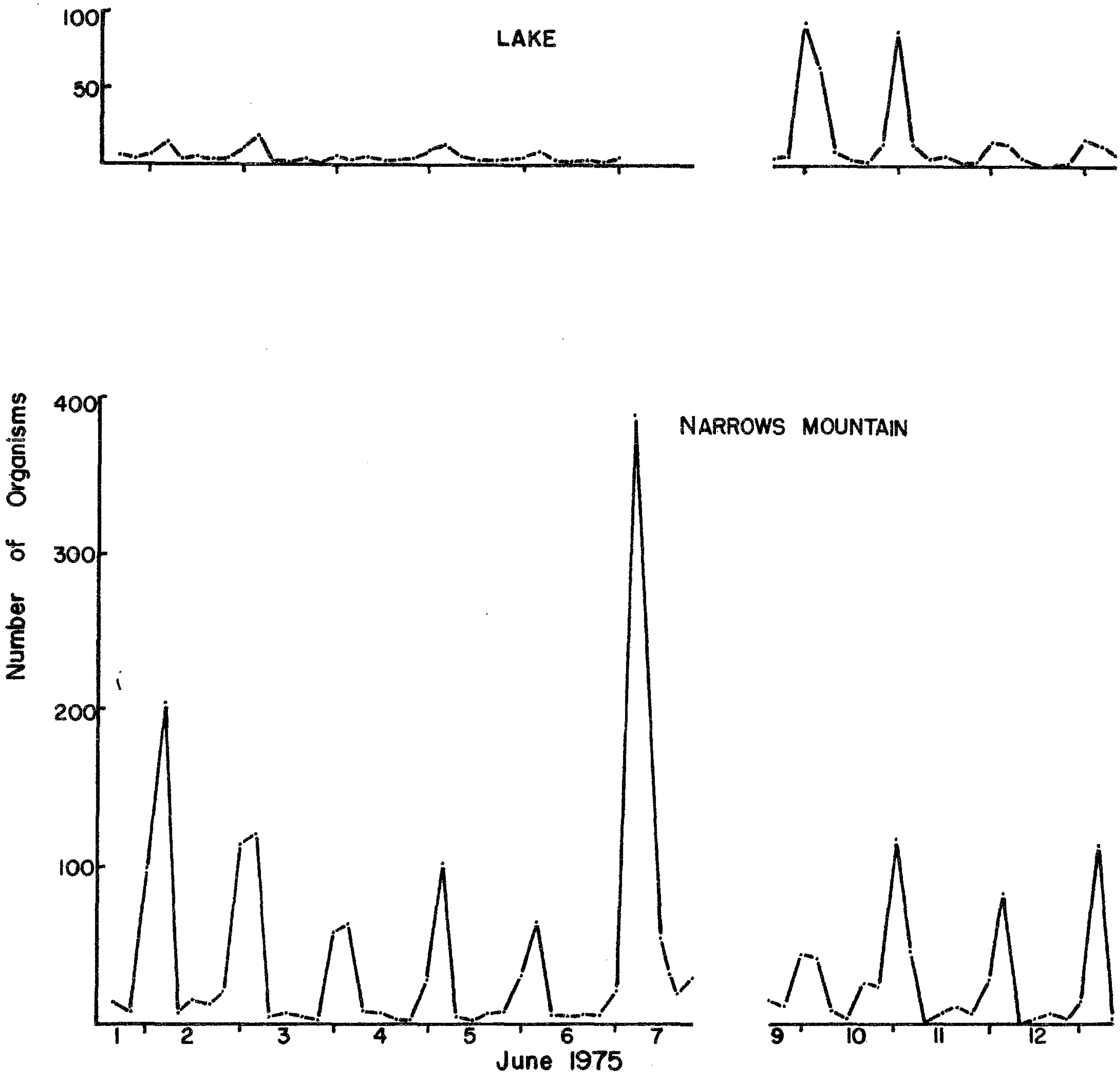

Fig. 2. Fifteen-minute drift catches at 4-hr intervals. Above: Lake Brook. Below: Narrows Mountain Brook.

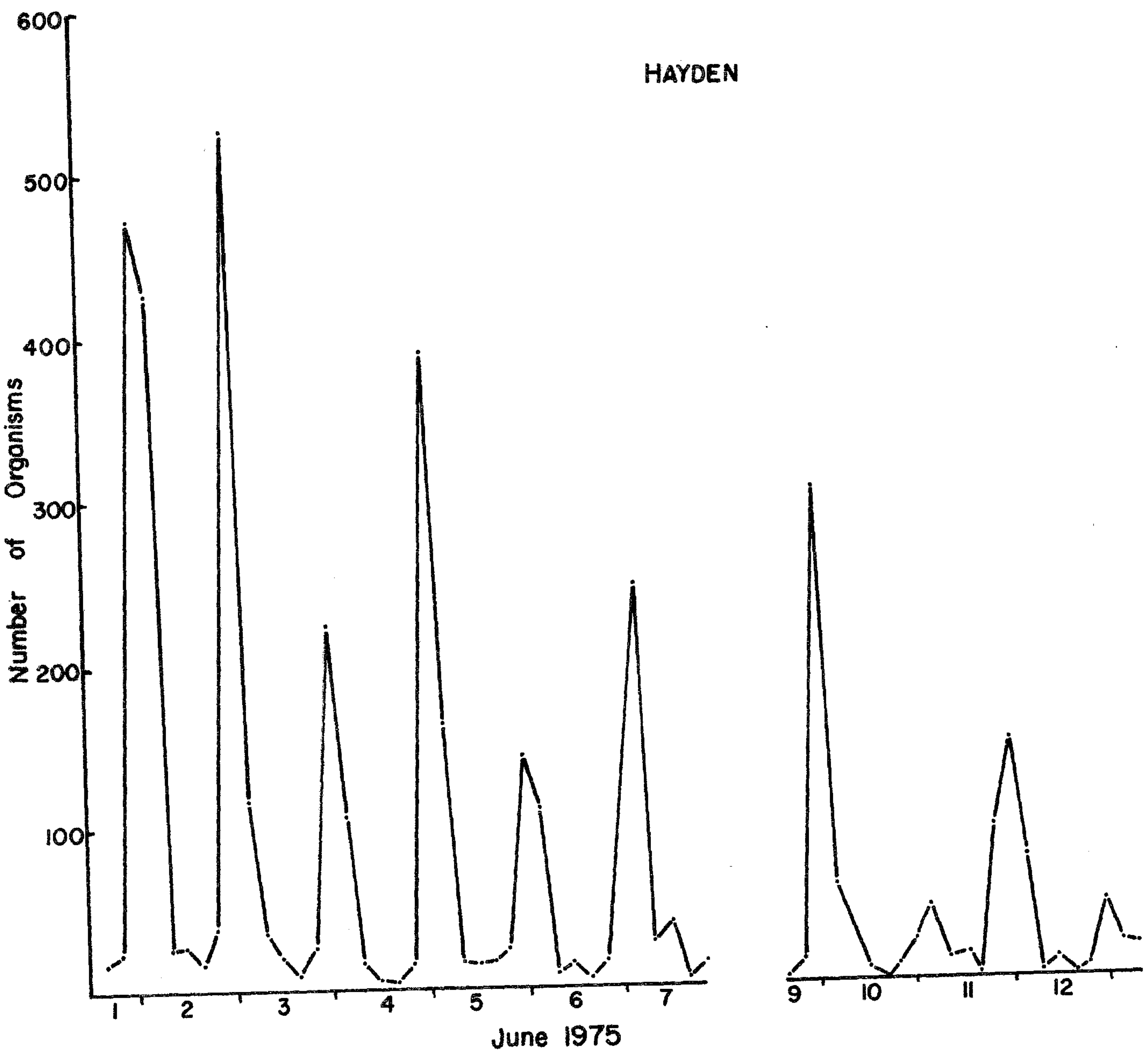

Fig. 3. Fifteen-minute drift catches at 4-hr intervals on Hayden Brook.

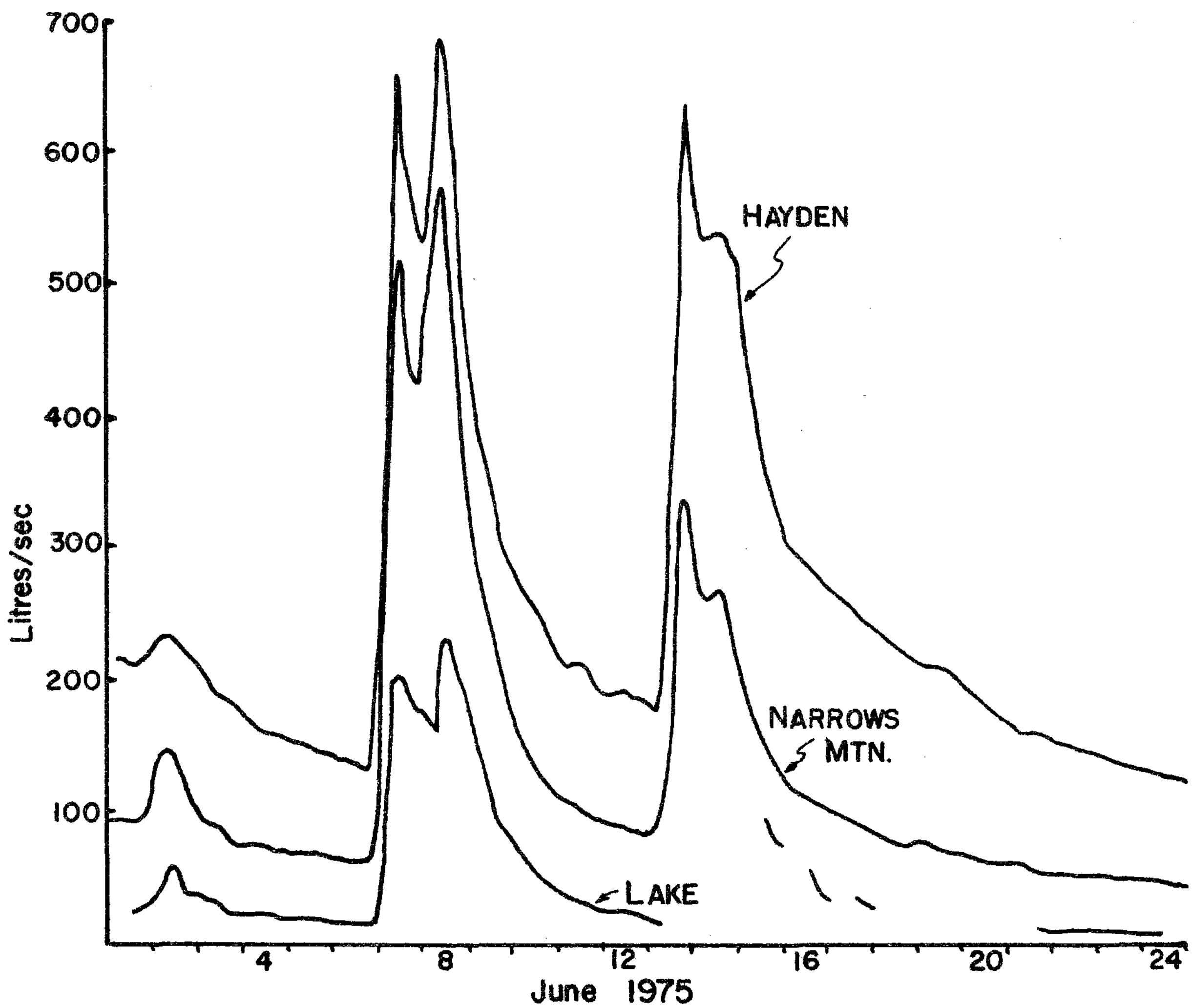

Fig. 4. Stream discharge of Hayden, Narrows Mountain and Lake brooks.

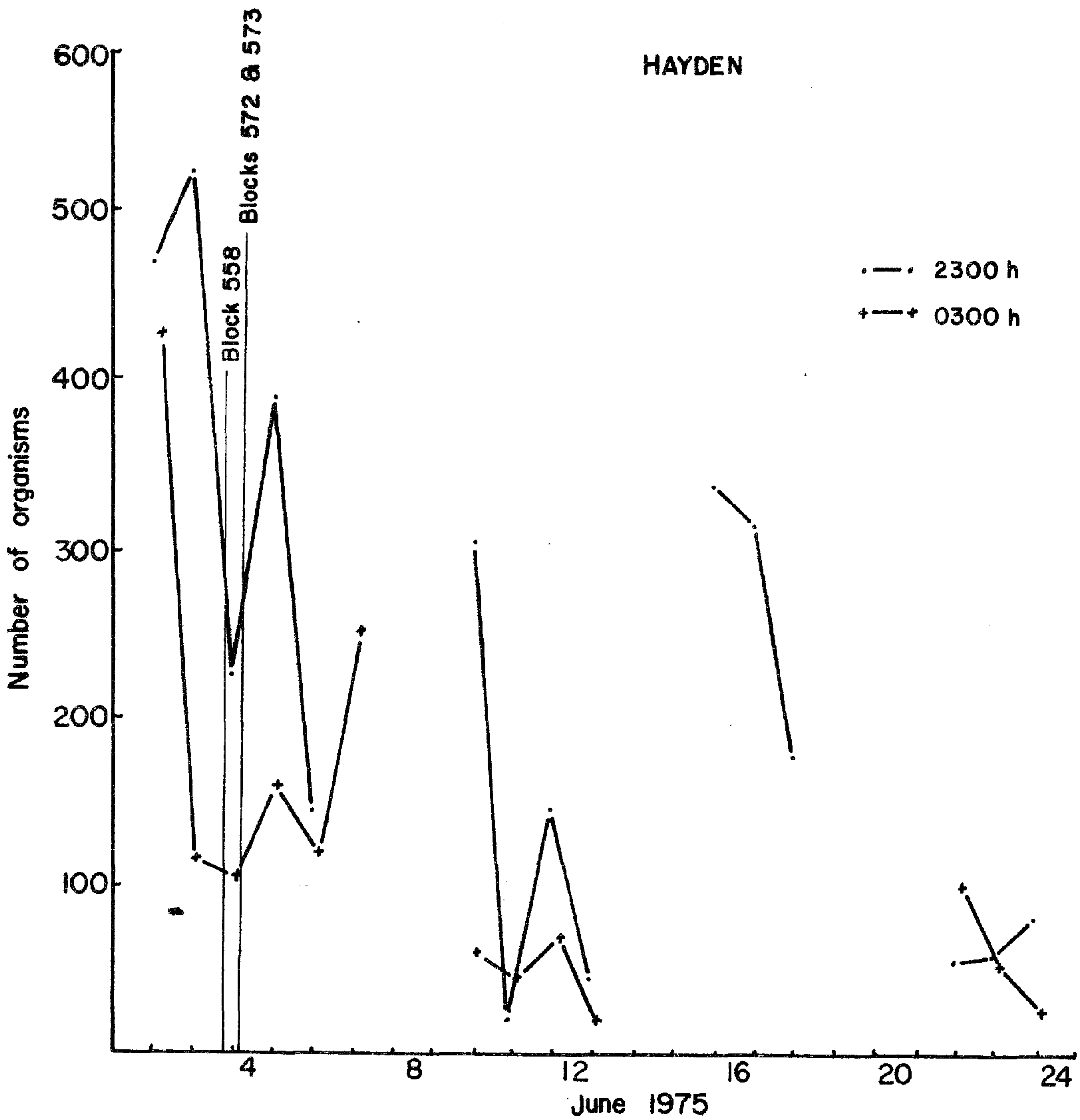

Fig. 5. Nighttime, 15-min. drift catches from Hayden Brook.

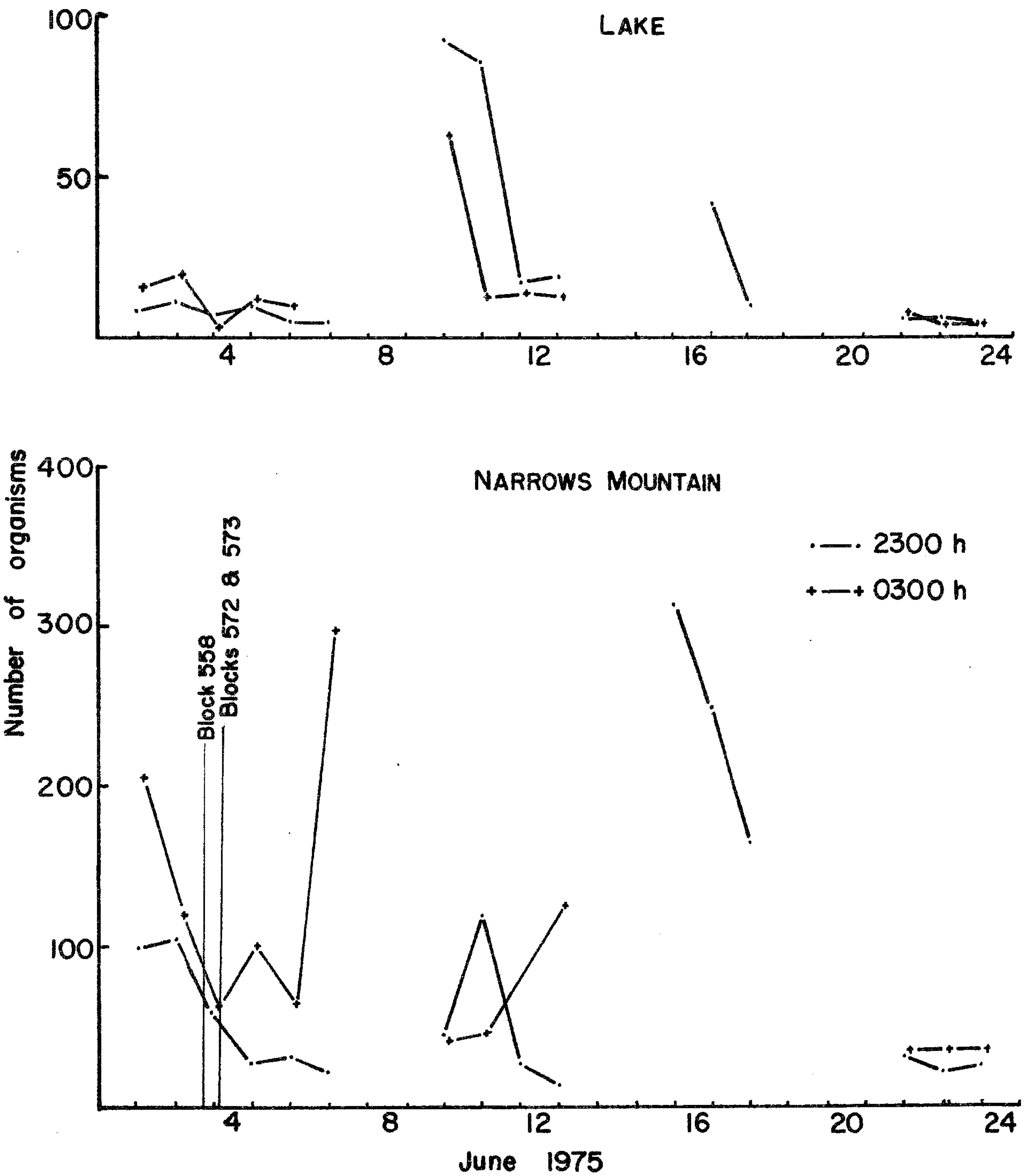

Fig. 6. Nighttime, 15-min. drift catches. Above: Lake Brook. Below: Narrows Mountain Brook.

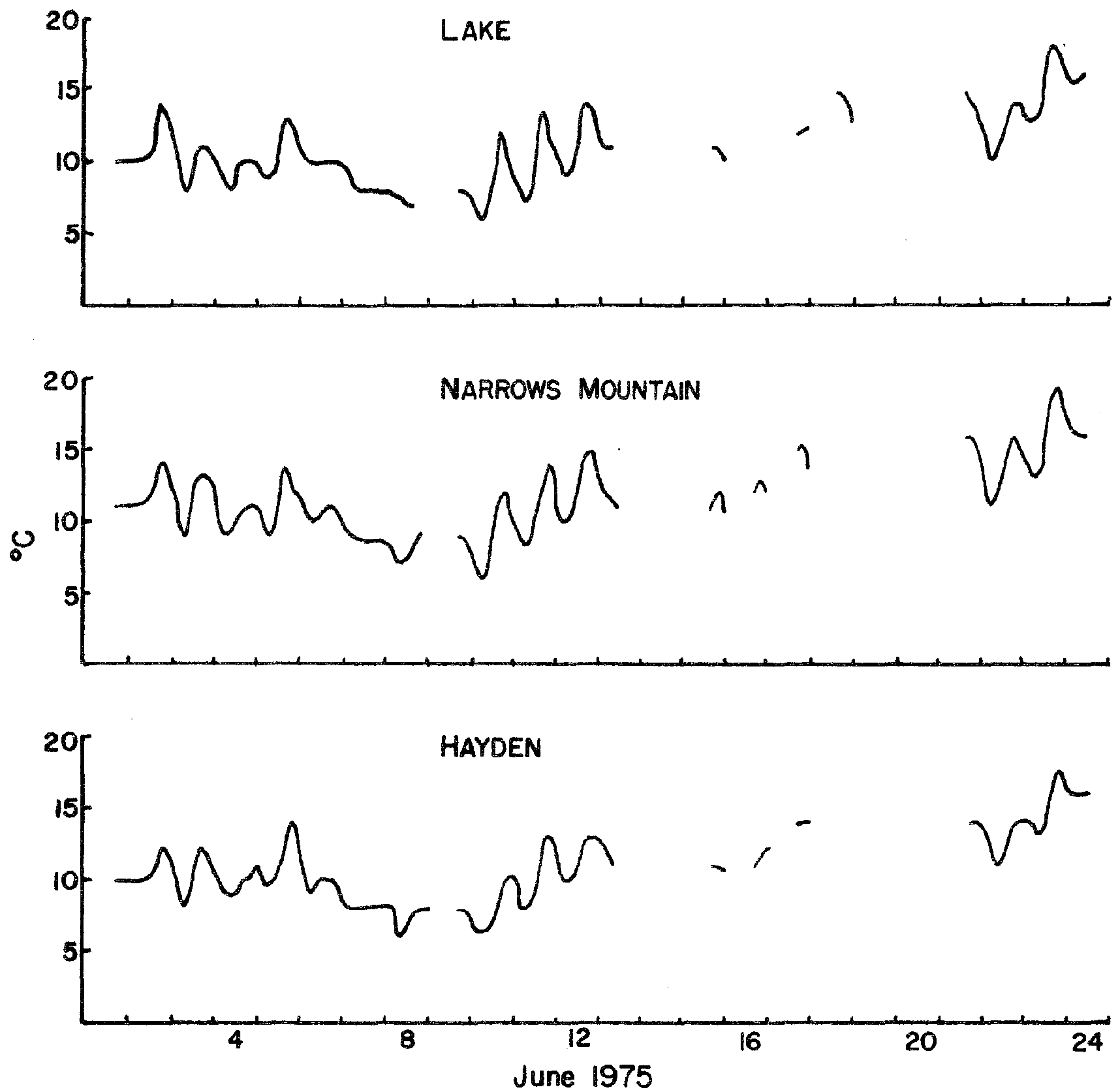

Fig. 7. Water temperatures plotted from 4-hourly readings in Lake (top), Narrows Mountain (centre), and Hayden (bottom) brooks.