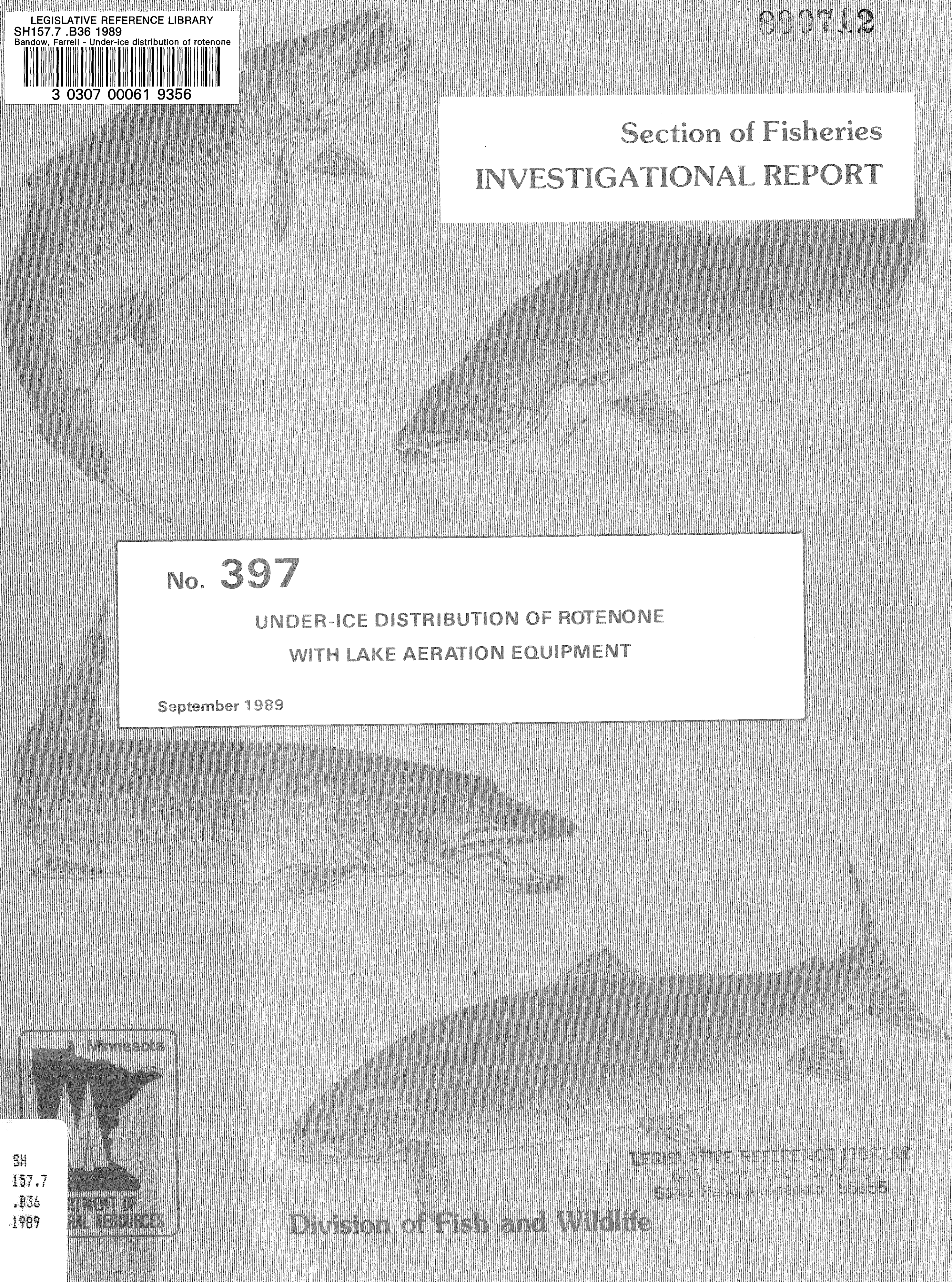

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UNDER-ICE DISTRIBUTION OF ROTENONE WITH LAKE AERATION EQUIPMENT

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UNDER-ICE DISTRIBUTION OF ROTENONE

WITH LAKE AERATION EQUIPMENT[1]

by

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ABSTRACT

The ability of subsurface bubbler aeration systems to distribute rotenone beneath ice cover was evaluated in a 3.5 ha drainable pond in 1987 and a 26.5 ha lake in 1988. In the pond, a 0.25 hp compressor and single diffuser accomplished near uniform horizontal distribution of rotenone near target concentration (50 ppb) within 2 wk after the January application. In the main body of the lake, near uniform horizontal distribution near target concentration (75 ppb) with a 0.5 hp compressor and single diffuser took 3-4 wk. In an area of the lake separated from the aeration site by an island, it took 1-2 wk longer. Rotenone was distributed vertically throughout the water column, but both basins lacked sufficient depth (approximately 2 m maximum) to provide good indication of vertical distribution potential.

Rotenone remained relatively stable near target level for several weeks following treatments and then plummeted toward extinction after warm weather removed snow cover. Sunlight apparently was a major contributor to the sudden plunges in rotenone concentration, indicating that snow cover is probably essential for under-ice treatments that target resistant species. Black bullhead (*Ictalurus melas*) populations suffered severe mortality, but some individuals survived both treatments. Only a few fish carcasses littered the shoreline of the urban lake after ice-out, and no public outcry occurred.

INTRODUCTION

Nongame species dominating fish communities in shallow Minnesota lakes frequently reduce water quality, interfere with angling for traditional game fish, or reduce production and impede fingerling harvest in walleye nursery lakes. Conventional methods for controlling undesirable fish species are costly or ineffective. Circulation of fish toxicants under ice with winter aeration equipment has the potential to reduce these problems.

Bubbler aeration systems for winterkill prevention have been installed in approximately 100 Minnesota prairie lakes since 1974. Game fish management efforts in these lakes frequently produce disappointing results. Efforts to eradicate or substantially reduce numbers of winterkill resistant species such as black bullhead (*Ictalurus melas*) or carp (*Cyprinus carpio*) by not operating aeration equipment will usually fail and contribute to community imbalance by eliminating game fish.

Fisheries managers have nearly abandoned efforts to remove nongame fish with traps and seines because they are not cost-effective. The procedure has not improved game fish populations except in rare instances or when removal was extensive and continual (Ricker and Gottschalk 1940; Rawson and Elsey 1950; Rose and Moen 1952; Moyle and Clothier 1959; Scidmore and Woods 1961).

Application of toxicants is a proven and popular means of altering fish communities, but high cost limits its use. Results of a late fall treatment in Michigan suggested that the relatively high stability of rotenone in ice-covered lakes would permit reduction in conventional application rates and that the need for dead fish disposal could be reduced or eliminated (Spitler 1986).

Convection generated by disruption of thermal stratification and cooling of the water column of lakes by aeration equipment offers a means of easily and cheaply distributing fish toxicant in winter. Monitoring of temperature and dissolved oxygen profiles in the water column of ice-covered Minnesota lakes with bubbler aeration systems showed extensive horizontal circulation (Bandow 1986) at apparently much faster rates than the naturally occurring 10-20 m/d described for a northwestern Wisconsin lake and two Canadian arctic lakes (Likens and Hasler 1962; Welch and Bergmann 1985).

Winter conditions offer additional opportunities to reduce treatment costs. By January, the ice layer reduces lake volume substantially, and many adjacent refuge areas for fish freeze out. Under-ice distribution of fish toxicant with aeration equipment could allow substantial increase in the scope of Minnesota's lake reclamation program without additional cost.

This investigation was conducted to evaluate speed and uniformity of under-ice circulation generated by bubbler aeration equipment, persistence of rotenone in winter, and potential for economically eradicating resistant fish species with winter rotenone applications.

METHODS

Pond Experiments, 1987

Experiments with fluorescent dye and rotenone were conducted in Pond 11, a drainable pond at the Minnesota Department of Natural Resources Waterville Fisheries Headquarters. Pond 11, when full, has a surface area of 3.5 ha, a maximum depth of 2.1 m and a mean depth of 1.4 m.

In Autumn 1986, 231 kg of black bullhead and 11 adult carp were released in the pond. The bullheads ranged from age 0 to approximately 400 g adults.

A subsurface bubbler aeration system was installed at the deep end of Pond 11 at a depth of 1.7 m. It consisted of an onshore, 0.25 hp oilless air compressor that delivered 108 L of air/min (manufacturer's description) through a 13 mm I.D. tube to a single, offshore diffuser.

Rhodamine B fluorescent dye was released in the water column on 7 January 1987, 40 min after operation of the aeration system began. The dye was pumped beneath the ice at station 9, 145 m from the aeration site (Fig. 1). Target concentration was 100 ppb. Because of leakage, the pond had a maximum depth of 1.9 m at time of treatment. Mean depth was 1.3 m.

A 2.5% (confirmed by assay) synergised rotenone formulation was pumped beneath the ice 2-3 m from open water at the aeration site of Pond 11 on 20 January. Target concentration was 50 ppb rotenone (2 ppm of formulation). At the time of the rotenone treatment, maximum pond depth was 1.8 m, and mean depth was 1.2 m. Total alkalinity was 211 mg/L as $CaCO_3$ (pH 4.6 endpoint), and pH was 7.6. The aeration system ran continuously until 9 February.

Sixteen sample stations were established on Pond 11 (Fig. 1). Sampling for rhodamine B dye analysis was conducted at 1-3 day intervals for a 12 d period following treatment. Sampling for rotenone analysis, beginning 2 d after the 20 January treatment, was conducted at approximately weekly intervals through 3 March. Bioassays were conducted beyond ice-out by continually confining five carp and five black bullhead in live cages at station 12. Dissolved oxygen and temperature profiles were measured irregularly throughout winter at stations 4, 6, 9, 12, and 15.

<u>Holy Name Lake Demonstration Project, 1988</u>

In January 1988, a reclamation project with rotenone was conducted on Holy Name Lake, an urban lake in Hennepin Co., Minnesota. Holy Name Lake covered 26.5 ha, with a maximum depth of 2.0 m and mean depth of 1.4 m. Total

STATION 4 - AERATION AND ROTENONE APPLICATION SITE

STATION 9 - RHODAMINE B DYE APPLICATION SITE

STATION 12 - BIOASSAY SITE

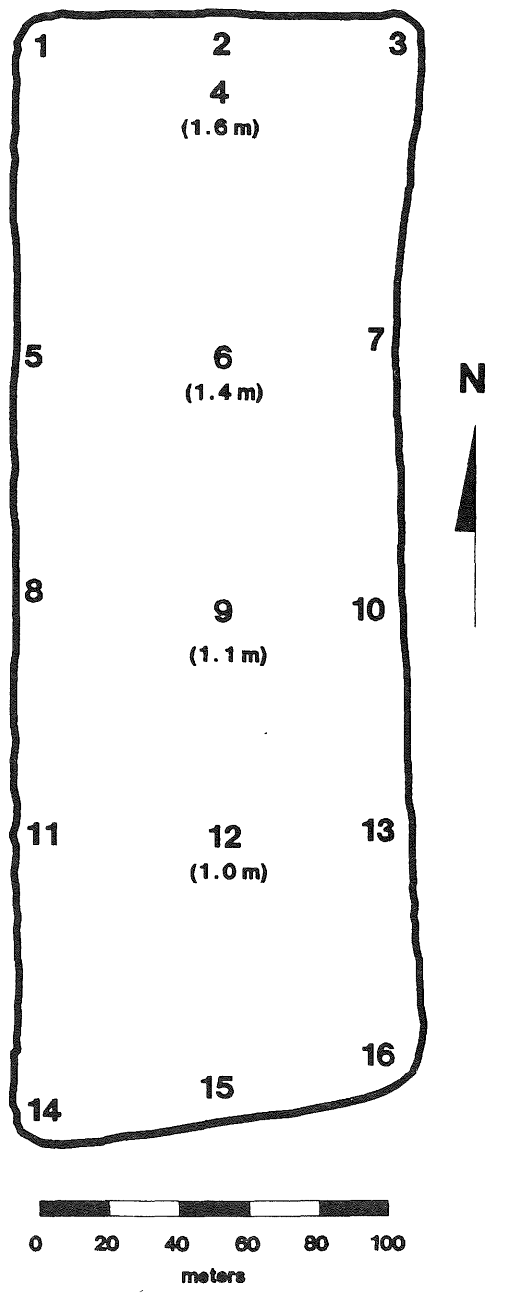

Figure 1. Treatment sites and sample station locations on Pond 11, 1987. Station depths on 20 January in parentheses.

alkalinity was 147 mg/L as $CaCO_3$ (pH 4.6 endpoint), and pH was 7.1. A 1984 netting survey indicated that small bullheads, primarily black bullhead, strongly dominated the fish community of Holy Name Lake (Table 1).

The subsurface bubbler aeration system used to distribute rotenone consisted of an onshore, 0.5 hp oilless air compressor that delivered 204 L of air/min (manufacturer's description) through a 13 mm ID tube to a single, offshore diffuser. The diffuser was at maximum lake depth of 2.0 m.

On 14 January 1988, the contents of four 208 L drums labeled 2.5% synergised rotenone were pumped beneath the ice in Holy Name lake 12-15 m from the open water at the aeration site (Fig. 2). A 12 volt pump dispensed the liquid. Target concentration of rotenone in the water column was 78 ppb (3.1 ppm of formulation). Two formulation assays of a composite sample of the chemical yielded 2.7 and 2.8% rotenone. These values would increase target concentration to 84 and 87 ppb, respectively. The aeration system operated from 11 January to 17 February.

Eleven sample stations were established on Holy Name Lake (Fig. 2). Sampling for rotenone analysis, beginning 5 d after the 14 January treatment, was conducted weekly through 22 March. Dissolved oxygen and temperature profiles at stations 5 and 9 were measured on most of the same occasions.

Table 1. Catch per unit effort of fish in Holy Name Lake by overnight gill net and trap net sets, July 1984.[a] The gill net was 76.2 m long with mesh graded 1.9-5.1 cm square measure. Trap net mesh was 1.9 cm square measure. Number of net sets in parentheses.

	Gill net (1)		Trap net (4)	
	Mean no. per lift	Mean wt. per fish (g)	Mean no. per lift	Mean wt. per fish (g)
Northern pike *Esox lucius*	2	885	1	431
Black bullhead *Ictalurus melas*	144	57	184	45
Brown bullhead *Ictalurus nebulosus*	10	95	23	73
Bluegill *Lepomis macrochirus*	3	106	63	110
White crappie *Pomoxis annularis*	12	113	19	102
Black crappie *Pomoxis nigromaculatus*	19	86	37	123
Largemouth bass *Micropterus salmoides*	1	318	1	287
Hybrid sunfish	--	--	tr[b]	227

[a] Data from Minnesota Department of Natural Resources lake survey files.

[b] Less than 0.5

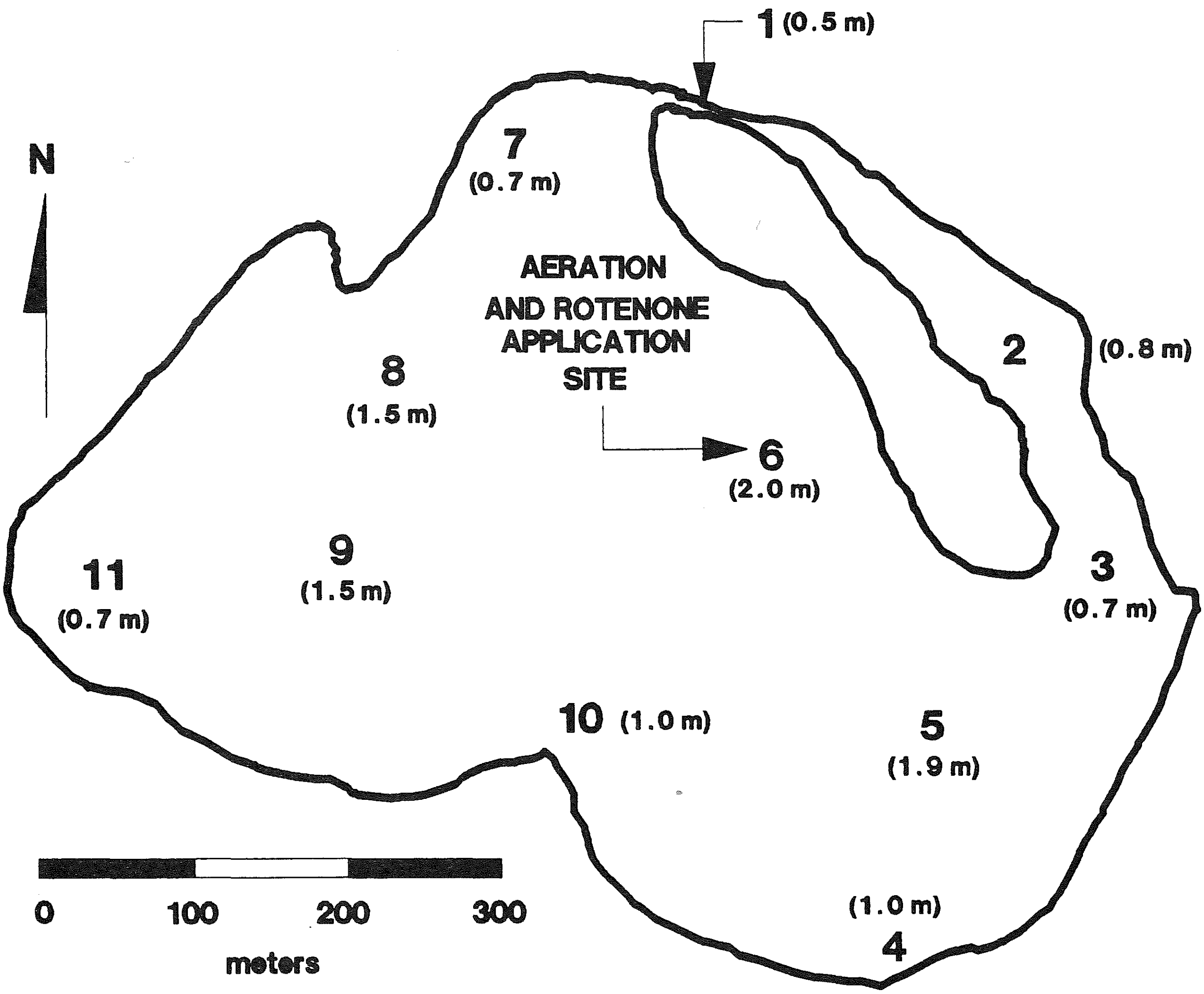

Figure 2. Treatment site and sample station locations on Holy Name Lake, 1988. Station depths in parentheses.

Analytical Procedures

Rotenone concentrations were analyzed by gas chromatography of rotenone concentrate extracted with methylene chloride (Delfel 1973). Results were confirmed using liquid chromatography on two occasions. Variability of gas chromatography results was evaluated once. Three analyses of a composite lake sample yielded 54, 49, and 52 ppb rotenone (SD = 2.5 ppb). Chloroform was added to water samples in the field, and they were transported in cold and darkness.

Rhodamine B fluorescent dye concentrations in Pond 11 were measured with a filter fluorometer. An instrument calibration curve was made using prepared dye solutions in the range of 5 to 150 ppb.

Dissolved oxygen and temperature profiles were measured with a combination temperature compensating polarographic sensor ($\pm$ 0.1 mg/L oxygen) and thermistor ($\pm$ 0.5 C). Individual measurements were at 0.25 or 0.5 m depth intervals depending upon oxygen and temperature gradients. Ice thickness at sample stations was measured to the nearest centimeter from the under surface of the ice layer to the top of the unfrozen water column. Maximum and minimum snow depths near sample stations were measured to the nearest centimeter by probing at several locations within an approximate 10 m radius of sample holes. Snow depth is expressed as the midpoint of the recorded range.

RESULTS

Pond 11

Rhodamine dye moved 145 m from the application point (station 9) to the aeration site within 2 d after the 7 January pond application (Fig. 1 and 3). It gradually spread throughout the pond, finally reaching station 16 at the southeast corner between 9 and 12 d after treatment. Mid-depth concentrations became increasingly uniform throughout the pond during the 12 d analysis period, and the mean continually increased but failed to reach the 100 ppb target concentration. The highest individual concentration recorded at any time was 89 ppb at station 6 on 19 January.

The dye was well distributed vertically throughout the water column, and although it frequently lacked uniformity, no consistent surface to bottom pattern was evident (Table 2). Dye analysis was discontinued after 19 January because of the forthcoming rotenone treatment and discovery that rotenone influenced fluorometer readings.

Though rotenone appeared to be well distributed horizontally in Pond 11 within a week of the 20 January treatment, the mean mid-depth concentration on 27 January was 54% above the 50 ppb target concentration indicating that mixing was incomplete (Fig. 4). By 3 February, 14 d after treatment, mid-depth concentrations had declined to near target level where they remained for at least 2 wk before plummeting to about 50% of target by 23 February.

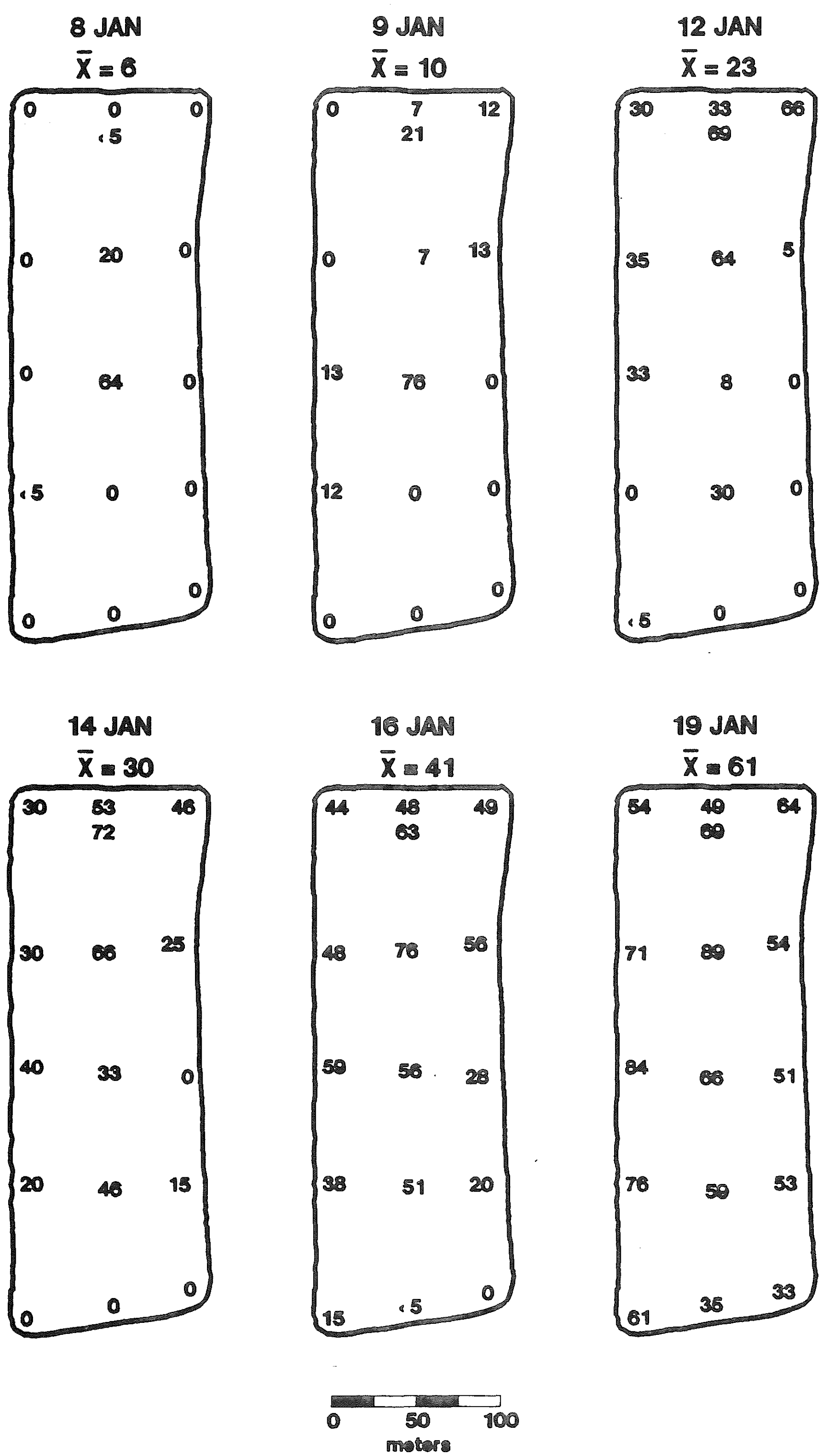

Figure 3. Rhodamine B dye concentrations (ppb) at mid-depth in the water column of Pond 11 following the 7 January application.

Table 2. Vertical distribution of rhodamine B dye in the water column of pond 11. Treatment date was 7 January 1987.

	Unfrozen water column depth[a] on 9 Jan. (m)	Dye concentration (ppb)				
		9 Jan.	12 Jan.	14 Jan.	16 Jan.	19 Jan.
Station 6	1.3					
Surface		13	30	54	69	67
Mid-depth		7	64	66	76	89
Bottom		12	56	66	67	67
Station 9	0.9					
Surface		44	5	28	56	72
Mid-depth		76	8	33	56	66
Bottom		143	21	44	58	54
Station 12	0.8					
Surface		--	--	--	--	71
Mid-depth		0	30	46	51	59
Bottom		--	--	--	--	51

[a] Depth declined at a rate of approximately 1 cm/d.

Vertical distribution of rotenone was nearly uniform at station 2 where, on 17 February, surface, mid-depth and bottom concentrations were 48, 51 and 54 ppb, respectively. The unfrozen water column depth at station 2, the area of maximum pond depth, was 1.5 m.

Rotenone circulated faster than the dye even though less heat was available in the water column by the time of the rotenone application. The volume-weighted mean pond temperature declined from 2.6 to 1.6 C between the dye and rotenone application dates.

At least three circumstances, however, could have contributed to faster rotenone distribution. Rotenone was injected at the aeration site while dye was released 145 m away, and it moved that distance to the aeration site before spreading to any large degree to other areas of the pond. A relatively large area at the aeration site was ice free and exposed to the atmosphere when rotenone was applied while the aeration system had been operating only about 40 min when dye was applied. A major factor was probably the difference in ambient air temperatures during the week following each application (Table 3). Lower air temperatures following the rotenone treatment more rapidly cooled water at the aeration site and thus should have had greater influence on convective water movement.

As expected, carp succumbed to the rotenone faster than black bullhead, and the period of lethal toxicity was longer for carp (Table 4). All carp caged in the pond through 17 February, 28 d after the rotenone treatment, died. All black bullhead caged through 2 February, 13 d after treatment, died. Mid-depth rotenone concentrations at the bioassay site were 109, 68 and 61 ppb on 22 January, 27 January and 3 February, respectively. Thus, caged fish were subjected to concentrations above the 50 ppb target level during earlier bioassays.

Table 3. Daily maximum and minimum air temperature recordings at pond 11. Dye was applied on 7 January and rotenone on 20 January.

Date Recorded	Temperature (C) Maximum	Minimum
January 8	- 1	-10
9	- 1	-11
10	0	-11
11	- 3	-10
12	3	- 6
13	6	- 4
14	8	- 4
January 21	- 5	-13
22	1	-15
23	-11	-26
24	-17	-25
25	- 8	-19
26	- 9	-16
27	- 2	-11

Seventeen adult black bullhead were recovered alive on 19 March when the pond was drained, a 1-2% survival. None of the several hundred age 0 black bullhead nor any of the 11 carp survived. Most dead fish were exposed on shore after ice-out.

Holy Name Lake

The rotenone application at Holy Name Lake took a total of 5 man-hours beginning with arrival of the crew at the lake. The entire operation of setting up, rotenone application, cleanup and reloading equipment on vehicles took about 1.5 h. Two people dispensed 833 L of rotenone

Table 4. Results of bioassays in Pond 11 with five carp and five black bullhead. Evaluation continued through 17 March, 9 d after ice-out. Rotenone treatment date was 20 January.

	Date assay began	Evaluation
Carp:	20 Jan.	All dead within 4 d.
	4 Feb.	All dead within 5 d.
	9 Feb.	Three dead within 4 d; two dead in 4-8 d.
	17 Feb.	Four dead within 4 d; one dead in 10-13 d.
	23 Feb.	Three dead within 4 d; one dead in 4-7 d; one alive on 17 Mar.
	2 Mar.	Two dead and three alive on 17 Mar.
Black bullhead:	20 Jan.	All appeared dead in 6 d and were removed from the pond and placed in an indoor raceway where they revived but eventually died.
	26 Jan.	All appeared dead in 7 d and were placed in a raceway where one revived but eventually died.
	2 Feb.	All dead in 9-25 d.
	11 Feb.	Four dead in 16-19 d; one alive on 17 Mar.
	2 Mar.	One dead and four alive on 17 Mar.

beneath the ice in approximately 30 min. Cleanup involved 4 workers and included rinsing four empty rotenone drums three times each.

Rotenone was distributed throughout Holy Name Lake within 5 d of treatment, but concentrations were well below the 78 ppb target level at most sample stations (Fig. 2 and 5). Concentrations exceeded target at most stations within 19 d, and only stations 2 (on the opposite side of the island) and 11 (the most distant station from the treatment site) were substantially below target. Station 2 reached target concentration within 39 d. The rotenone concentration at station 11 was 87% of target within 26 d and remained near that level for a time before it finally surpassed target concentration between 39 and 47 d after treatment. Rotenone disappeared rapidly from the water column in March after warm weather removed snow cover.

Rotenone was well distributed vertically but lacked uniformity at station 5 on 22 February. Samples from the surface, mid-depth and bottom contained 105, 89, and 72 ppb rotenone, respectively.

Some black bullheads survived the treatment. Two 76 m experimental gill nets fished 3 d each 3 wk after ice-out did not catch any fish, but a lake survey crew in August caught two black bullheads in an overnight gill net set and 15 in four trap net sets. Presumably, no other species survived.

The few fish carcasses that surfaced after ice-out did not create a problem, and cleanup was not required. Holy Name Lake is in an urban area, and no public outcry

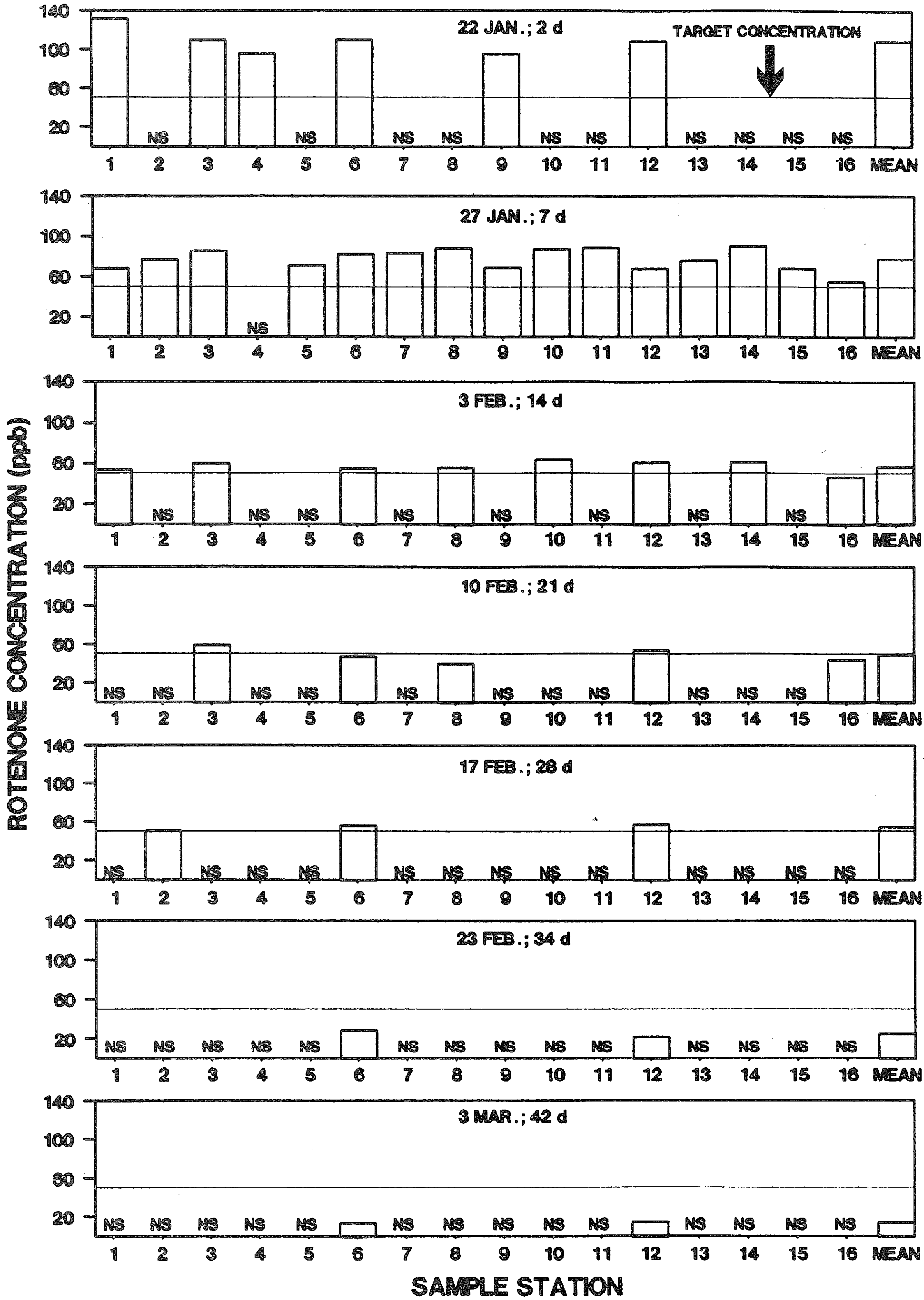

Figure 4. Rotenone concentrations at mid-depth in the water column of Pond 11. Treatment date was 20 January 1987. NS - not sampled.

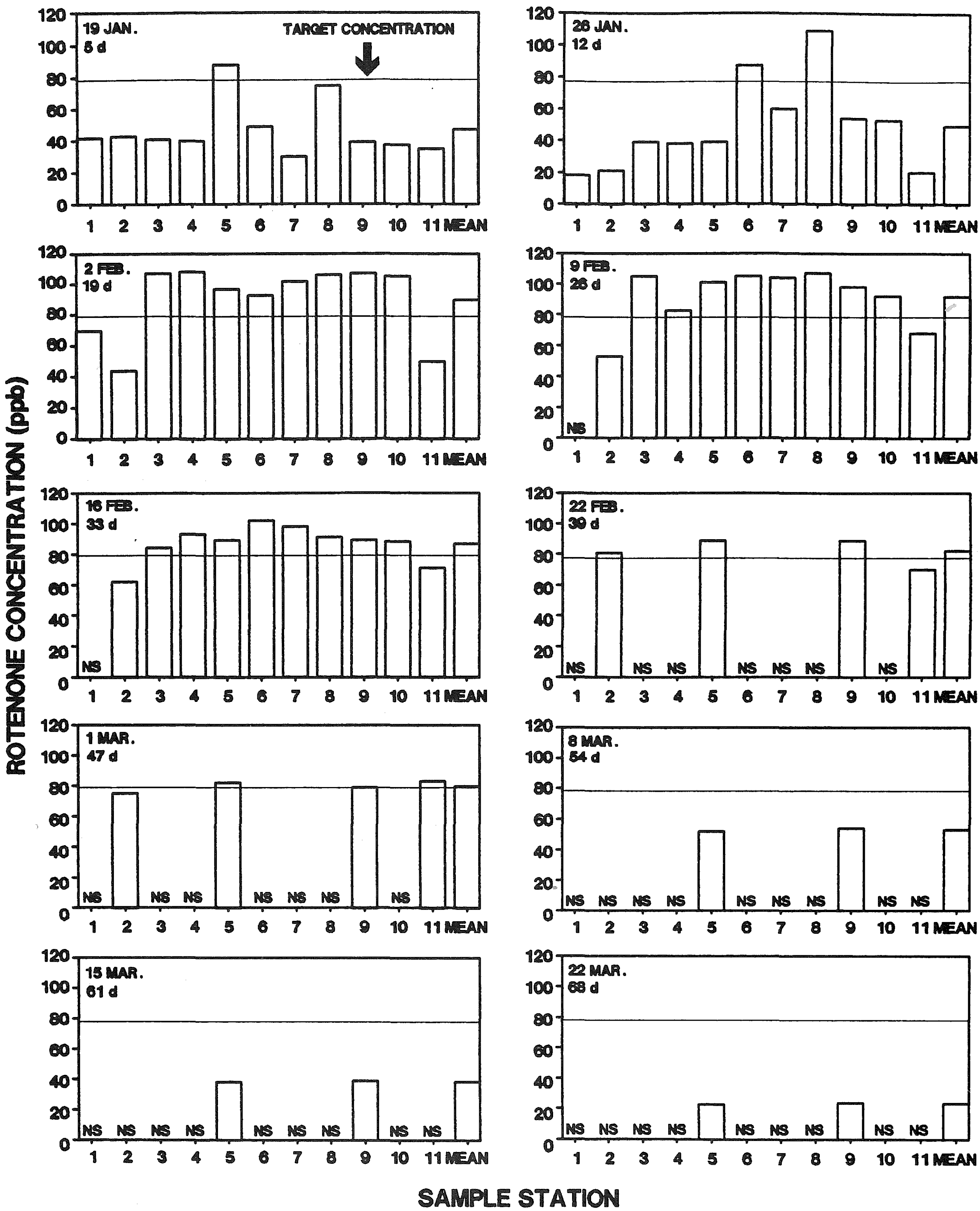

Figure 5. Rotenone concentrations at mid-depth in the water column of Holy Name Lake. Treatment date was 14 January 1988. NS - not sampled.

occurred. The lake was examined on 4 April, the day after ice cover disappeared. No carcasses were observed floating offshore, and while a few small groups of fish were washed up near shore, odor was not a problem. No dead fish were seen on 25 April.

DISCUSSION

Rotenone was distributed horizontally throughout Pond 11 and Holy Name Lake within a few days, and near uniformity was achieved within time frames of 2 wk in Pond 11 and about a month in most of Holy Name Lake. A part of the lake separated from the aeration site by the island required 1-2 wk longer. The initial movement of fluorescent dye from the remote release point in Pond 11 was mostly toward the aeration site (Fig. 3) indicating that direct release of chemical in remote or obstructed areas in effort to expedite distribution may actually slow the process of achieving uniformity.

Rotenone and dye were well distributed vertically in the water column, although uniformity was sometimes lacking. Both water bodies lacked sufficient depth to provide good indication of vertical distribution potential, but it is believed that adequate vertical distribution will be achieved if complete disruption of thermal stratification is accomplished in an area of maximum lake depth.

The time required to achieve target concentration will vary from treatment to treatment depending upon lake morphology, ambient air temperatures, and equipment capacity and placement. Odor of the chemical formulation was detectable in water when rotenone concentrations were as low as 20 ppb and will provide some indication of distribution if treatment rates are above detection level. On-site bioassays with target fish or direct water analysis will be required to determine with certainty when adequate distribution is attained. Post (1955) describes a simple field method for adequately measuring rotenone concentrations.

Ice formation will reduce treatment costs by important amounts (Fig. 6). Mean ice thickness on Holy Name Lake at time of treatment was 34 cm. With a mean depth of 1.4 m, lake volume, and thus rotenone cost, was reduced by 23.5%.

Fish in Holy Name Lake and Pond 11 were subjected to stresses besides rotenone toxicity. Maximum dissolved oxygen concentrations of <1 mg/L in Holy Name Lake during most of the period of high rotenone toxicity undoubtedly inflicted additional stress. The odor of hydrogen sulfide was present at all sample stations. Maximum oxygen concentrations in Pond 11 in January were near 2 mg/L, and although bioassay fish caged in the pond a week before treatment did not appear distressed, the effect of rotenone could have been augmented.

Black bullhead populations in Pond 11 and Holy Name Lake suffered severe mortality but were not totally

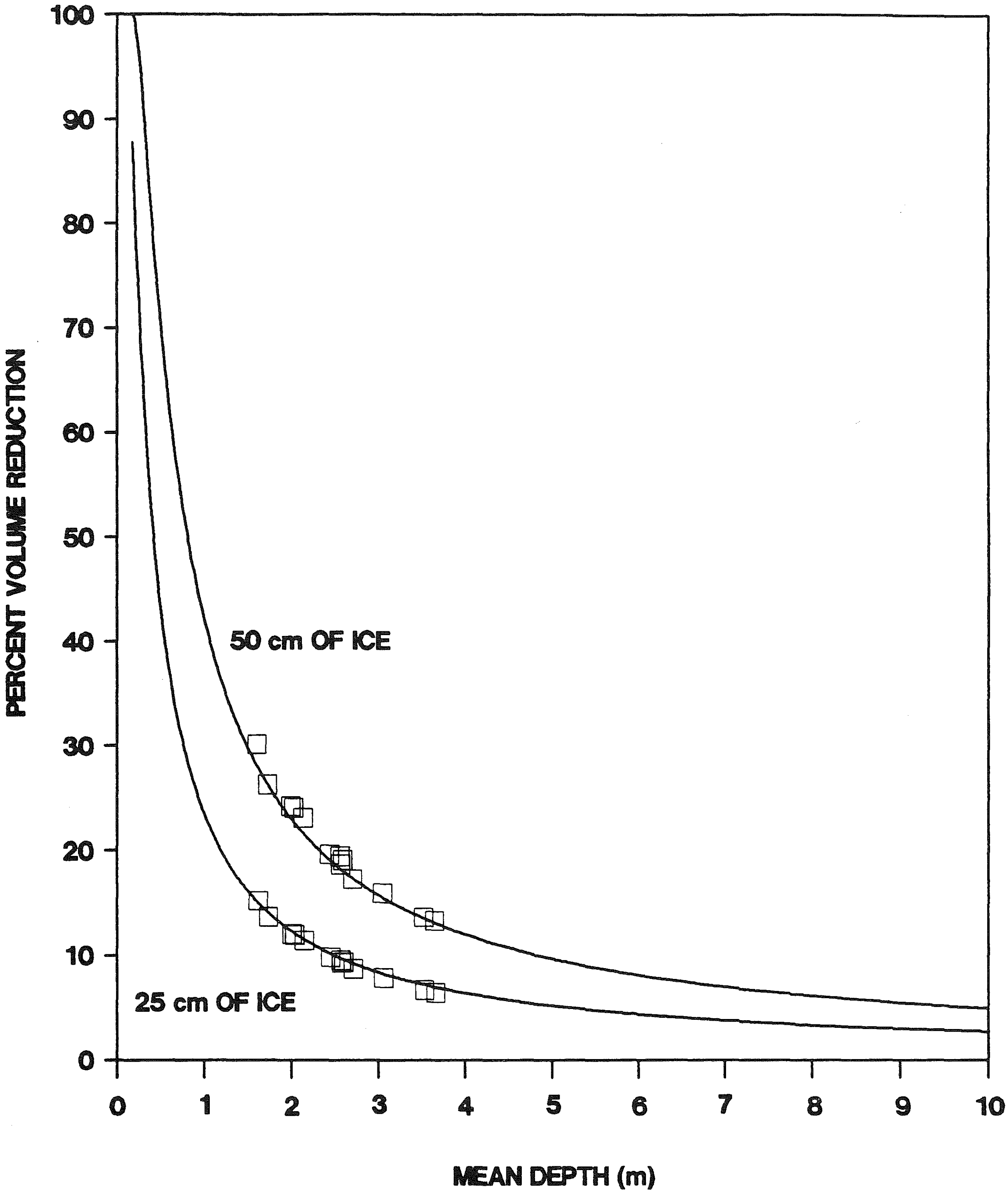

Figure 6. Percent reduction of lake volume due to surface ice formation. Lines generated from hypothetical cone shaped basins. Symbols from morphometry of 13 southern Minnesota prairie lakes that were treated as series of cone frustums.

eradicated in either case. The treatments are not considered failures, however, because severe reduction of the population is all that is realistically expected from a conventional summer or fall rotenone treatment that targets black bullhead. A substantial kill provides opportunity to establish predators and slow recovery of the bullhead population.

Too few fish carcasses surfaced after ice-out to create a problem at Holy Name Lake. Despite it being an urban lake with developed shoreline, no public outcry occurred. Conversely, many carcasses were exposed on shore after ice-out on Pond 11. Pond 11, however, is small and shallow and not typical of lakes that would be candidates for lake reclamation. Some fish carcasses may have been exposed because of pond leakage causing water line withdrawal along the relatively steep sloped basin, and wind was probably a major factor in the small, shallow pond. Leakage had reduced mean depth to less than 1 m by the time ice cover disappeared. Spitler (1986) reported that too few carcasses surfaced to be a problem after ice-out in a 122 ha Michigan Lake that was treated at time of freezeup.

Rotenone concentrations in late winter plummeted well below target concentration in Pond 11 and Holy Name Lake following periods of relative stability near target levels. The concentration declined 74% in 14 d in Pond 11 (Fig. 7) and 71% in 21 d in Holy Name Lake (Fig. 8). A combination

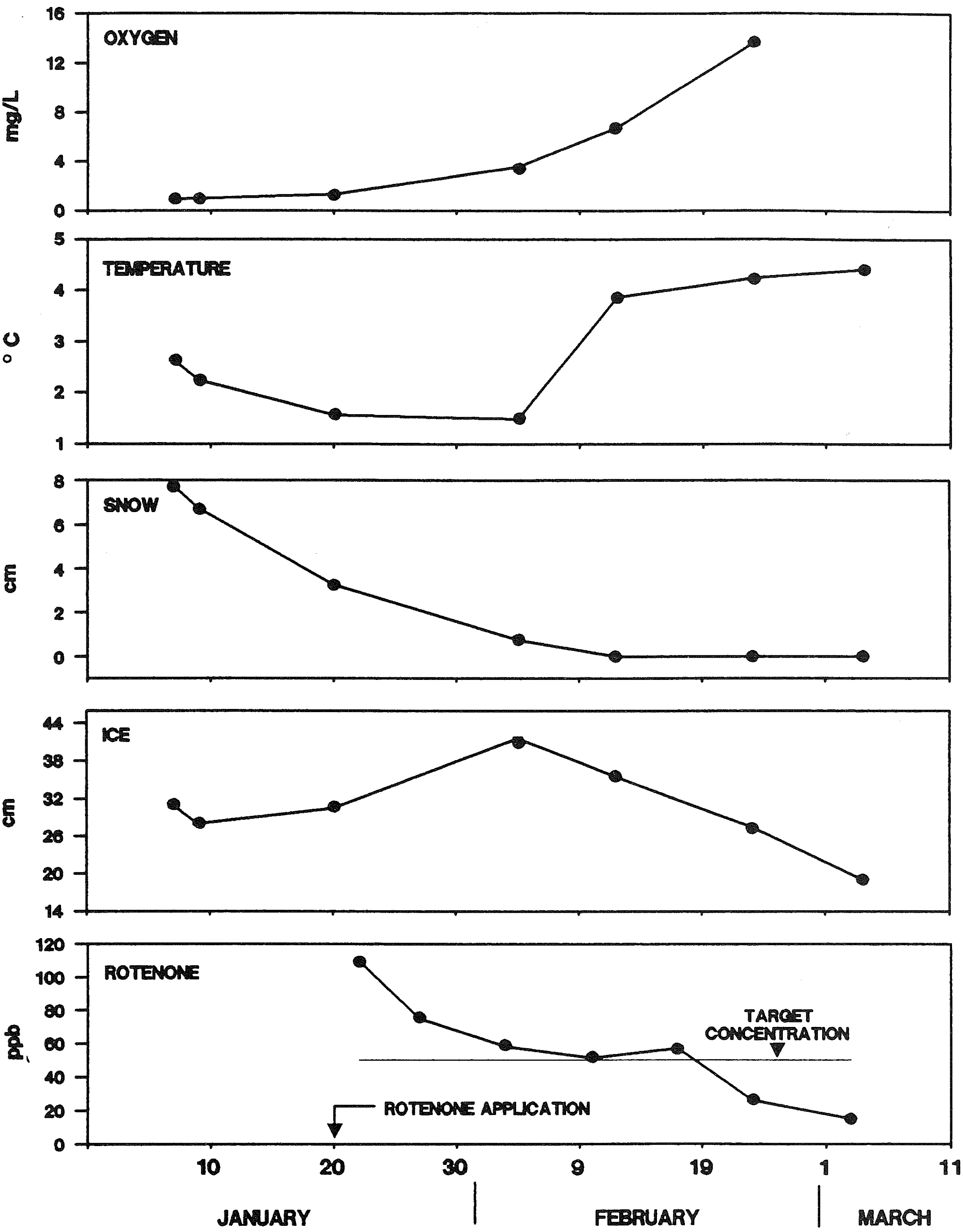

Figure 7. Pond 11, 1987. Mid-depth rotenone concentrations, ice thickness and mid-points of snow depth ranges at stations 6 and 12 combined. Volume-weighted mean pond temperatures and volume-weighted mean pond dissolved oxygen concentrations.

of weather related factors probably caused these abrupt changes. Thawing air temperatures that removed snow cover and reduced ice thickness preceded them in both cases. Dilution from snow melt was not much of a factor and dilution from ice melt, at best, in the event that it was rotenone free, could not account for more than 15-20% of the sudden rotenone breakdown in either basin.

Temperature and dissolved oxygen rose sharply following snow melt in pond and lake. Infiltration of melted snow and surface ice could perhaps account for the moderate rise of dissolved oxygen in Holy Name Lake, but the soaring oxygen concentration in Pond 11 indicates substantial light penetration. Dramatic temperature increases in both basins undoubtedly reflects, at least in part, warming of the water column through light penetration.

A positive correlation between temperature and rotenone decomposition rate has been established (Cahn et al. 1945; Post 1958; Marking and Bills 1976; Engstrom-Heg and Colesante 1979; Gilderhus et al. 1986; Gilderhus et al. 1988) and light intensity strongly influences rotenone decomposition (Gunther 1943; Subba Rao and Pollard 1951; Engstrom-Heg and Colesante 1979).

The latter authors provided equations for rotenone degradation in dark hypolimnetic waters and lighted surface waters at various temperatures. The equation for lighted surface waters, derived from data of Post (1958), reasonably

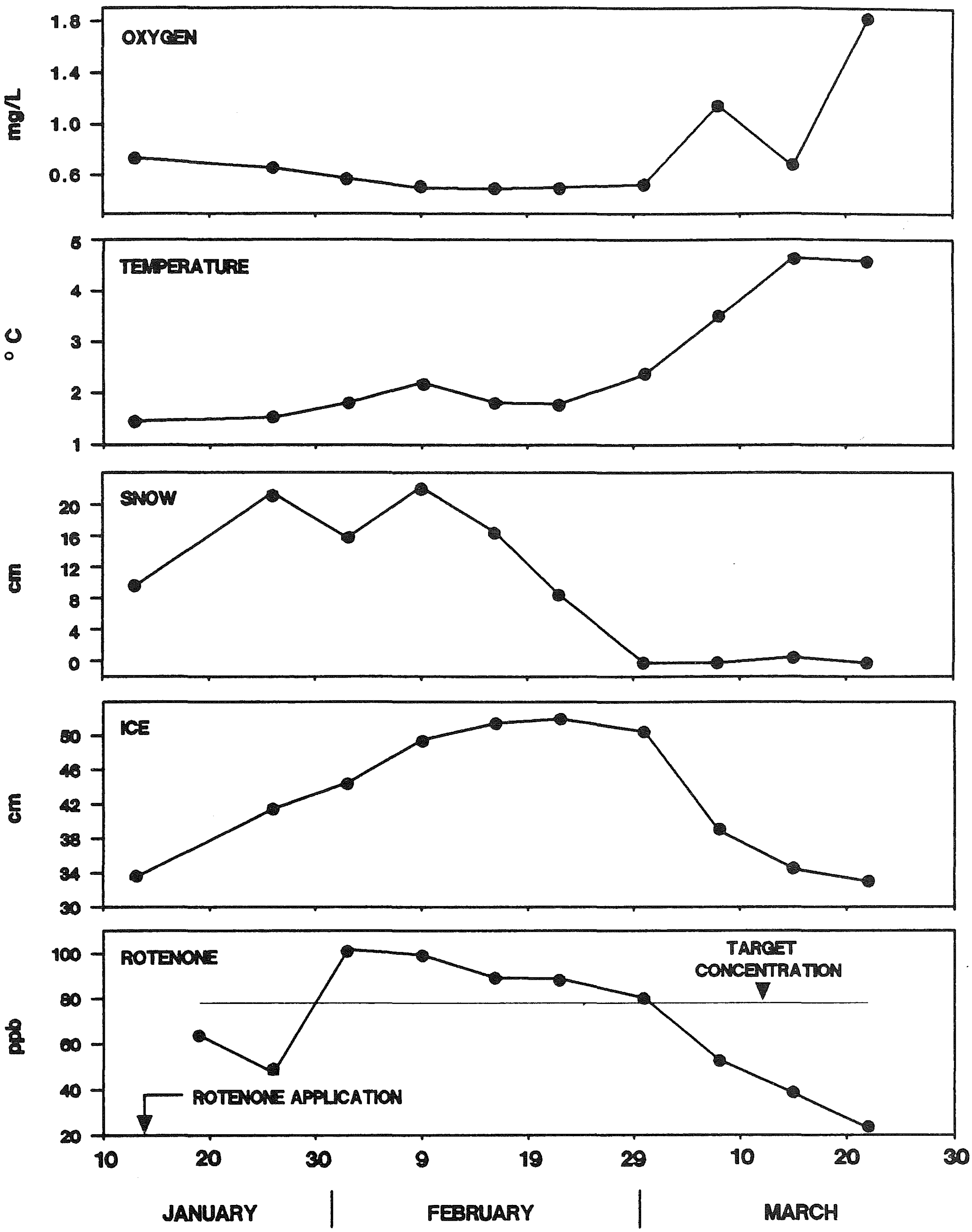

Figure 8. Holy Name Lake, 1988. Mid-depth rotenone concentrations, ice thickness and mid-points of snow depth ranges at stations 5 and 9 combined. Volume-weighted mean lake temperatures and volume-weighted mean lake dissolved oxygen concentrations.

predicts the abrupt declines in rotenone concentrations in Pond 11 and Holy Name Lake. Application of the equation, however, to under-ice conditions is an extrapolation as, 7 C was the low end of the temperature range in Post's experiments. It is evident, however, that absence of light is important to under-ice stability of rotenone and that snow cover is probably essential for success of under-ice rotenone treatments that target resistant fish species.

The relatively high stability of rotenone beneath a snow-covered lake permits use of reduced application rates to achieve satisfactory results as compared with conventional open-water treatments. A high application rate of 78 ppb was used in Holy Name Lake, however, in an attempt to eradicate the black bullhead. The lower 50 ppb rate applied in Pond 11 achieved similar results. Spitler (1986) used a synergised rotenone formulation (percent rotenone unspecified) at half the 2 ppm rate commonly used for open-water treatments in Michigan and reported a successful kill in a lake that was treated in late fall when seasonal ice cover was beginning to form. Black bullhead did not inhabit the lake.

A major disadvantage of a winter treatment as compared to a late summer or fall treatment in a lake to be managed for game fish can be preclusion of restocking with game fish the same fall when juvenile fish are most readily and economically available. This, however, will not be a problem with walleye nursery lakes that are stocked with fry in spring and used to rear fingerlings through summer. Winter carry-over of undesirable fish in these lakes reduces their effectiveness. A year or two without severe winterkill frequently renders them useless. A portable generator and small bubbler aeration system could be used to distribute toxicant and economically restore original walleye production capabilities to many of these shallow lakes. Rotenone toxicity should not be a problem by the time walleye fry are available, because detoxification occurs rapidly following disappearance of snow cover.

MANAGEMENT IMPLICATIONS

Under-ice rotenone distribution with bubbler aeration equipment offers five important, cost-saving advantages over conventional summer or fall treatments:

1) Chemical application is done quickly and easily.
2) Reduced lake volume due to surface ice formation substantially lowers the amount of chemical needed to attain target concentration.
3) Cold temperatures and lack of sunlight penetration into the water column of snow-covered lakes greatly increase rotenone stability. This permits lower treatment concentrations to achieve the same results as conventional summer or fall treatments.
4) Many shallow inlets, outlets, and adjoining sloughs that would provide refuge for target fish and require

special attention during conventional treatments will be frozen out.

5) The large and unpleasant task of dead fish disposal following rotenone treatment near populated areas will be greatly reduced or eliminated.

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