FREEZE-OUT OF NUTRIENTS FROM LAKE ICE

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The development of a lake ice cover may cause nutrients to become concentrated immediately below the black ice as a result of freeze-out (Adams 1976, Grøterud 1978). A slow rate of freezing gives rise to black ice with low nutrient content, while rapidly formed black ice has a higher nutrient content (Pounder 1969). Nutrient freeze-out is one of the factors which plays a role in under-ice primary production.

The difficulties of collecting water samples beneath an ice cover are evident. Cutting a hole in the ice, for example, results in an upwelling of water due to hydrostatic pressure caused by the weight of the snow cover. Thus any nutrient concentration gradients which may have existed beneath the ice are immediately destroyed. Furthermore, a number of holes would be necessary in order to study nutrient freeze-out under a developing ice cover. Wolfe (1979) designed two sampling devices to collect water samples from beneath ice but met with limited success. One device involved filling a 10 cm diameter tube frozen into the ice cover with oil to a depth below the expected maximal downward growth of black ice. To collect a water sample, a 1.3 cm diameter metal sampling tube containing a length of tygon tubing was inserted through the oil seal. The tygon tubing was forced out into the water column and a sample drawn off using a small pump. This device is quite complex and would not necessarily sample at the black ice/water interface. The second method tried by Wolfe was to drill a hole to a point 3-4 cm above the black ice/water interface and then force a metal tube through the remaining black ice and draw off water flooding into the tube. A new hole is required for each sampling occasion and slushing would appear to be a problem.

It became evident that a simple in situ sampling method is required so that water samples can be collected with minimal disturbance to the ice cover and water beneath. It was decided to try and modify the sampling system devised by Jones and Stuart (1973) and Jones (1980) for this purpose. Essentially it involves collecting water samples with evacuated rubber stoppered test tubes (Vacutainers) with the aid of sleeved double-end hypodermic needles. A needle is inserted into a Vacutainer prior to sampling and when the rubber sleeve covering the exposed end of the needle is mechanically depressed, the tube fills.

To sample beneath the ice cover, a rectangular plexiglas box was constructed. The wall thickness was 9 mm and the outer dimensions of the box were 12 x 28 x 80 cm. A series of alternating holes, each hole 1.2 cm in diameter, was drilled down one side of the box. A second piece of plexiglas (8 x 80 cm) was drilled in the same way. A strip of rubber (8 x 80 cm) was glued onto the outer wall of the box over the holes and the piece of plexiglas fixed on top of the rubber with screws. One end of the box was sealed shut with plexiglas and the other end covered with a lid insulated with styrofoam.

When local ice conditions had formed a safe working surface, the sample box was frozen into the ice cover of Dummer Lake (43° 22'N and 78° 6'W). This was achieved by clearing a hole through the ice cover and by forcing the plexiglas box down into the water with a weight suspended from its bottom (Fig. 1). The weight also kept the box in a vertical position in the water column. To collect a water sample from beneath the ice, a hand held 10 ml Vacutainer with a needle inserted through the stopper was lowered to the required

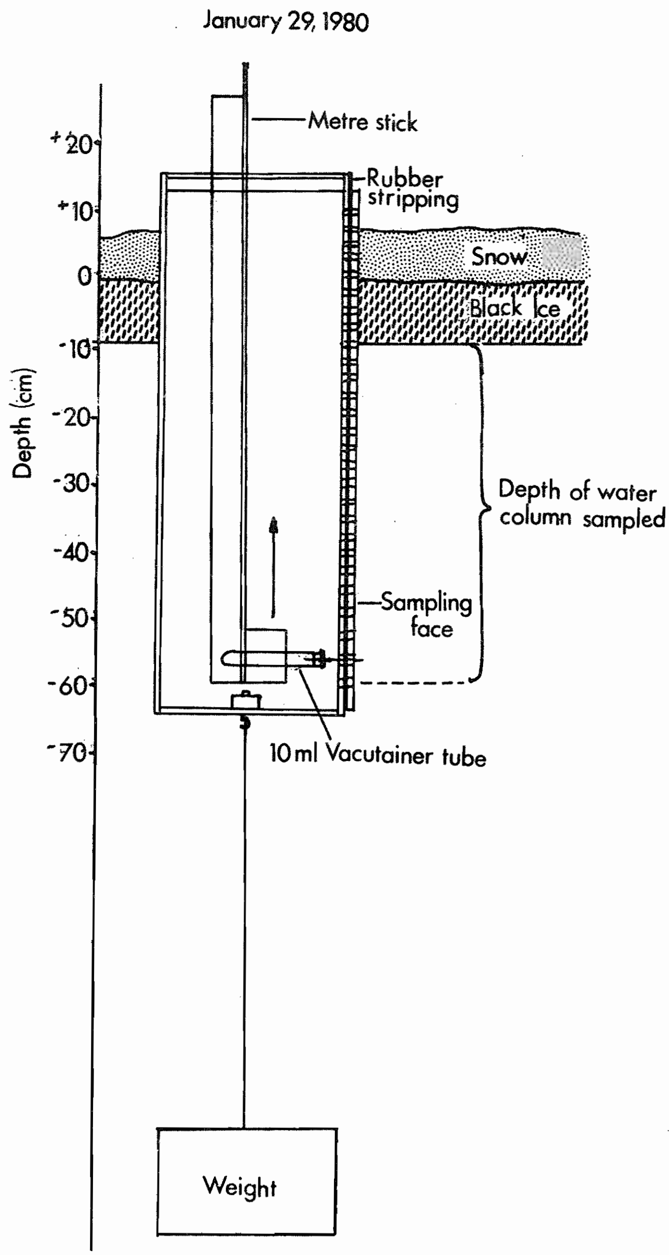

Fig. 1. Sampling box frozen into the lake ice cover.

depth as measured with a metre stick. The sleeved needle was pushed through the hole against the rubber seal causing the needle to enter the water column and the tube to fill with water. In this way a sequential depth series of water samples was collected. To facilitate sample collection near the bottom of the plexiglas box a block of wood on the end of a longer piece of wood was drilled to hold a Vacutainer tube. A metre stick attached to the long piece of wood was used to indicate the sampling depth. Pieces of styrofoam were placed inside the box to inhibit freezing of water around the box below the black ice/water interface.

Just prior to the spring ice breakup the box was removed in an ice block. There was no evidence of water having seaped up the outside of the box. Black ice had developed uniformly around the box with very little extension of freezing down the outside beneath the black ice/water interface. It seems likely that more efficient insulation would have prevented this ice collar formation.

Concentration profiles of the major cations, calcium, potassium and magnesium beneath the ice cover of Dummer Lake on January 29 and March 18, 1980 are illustrated in Fig. 2.

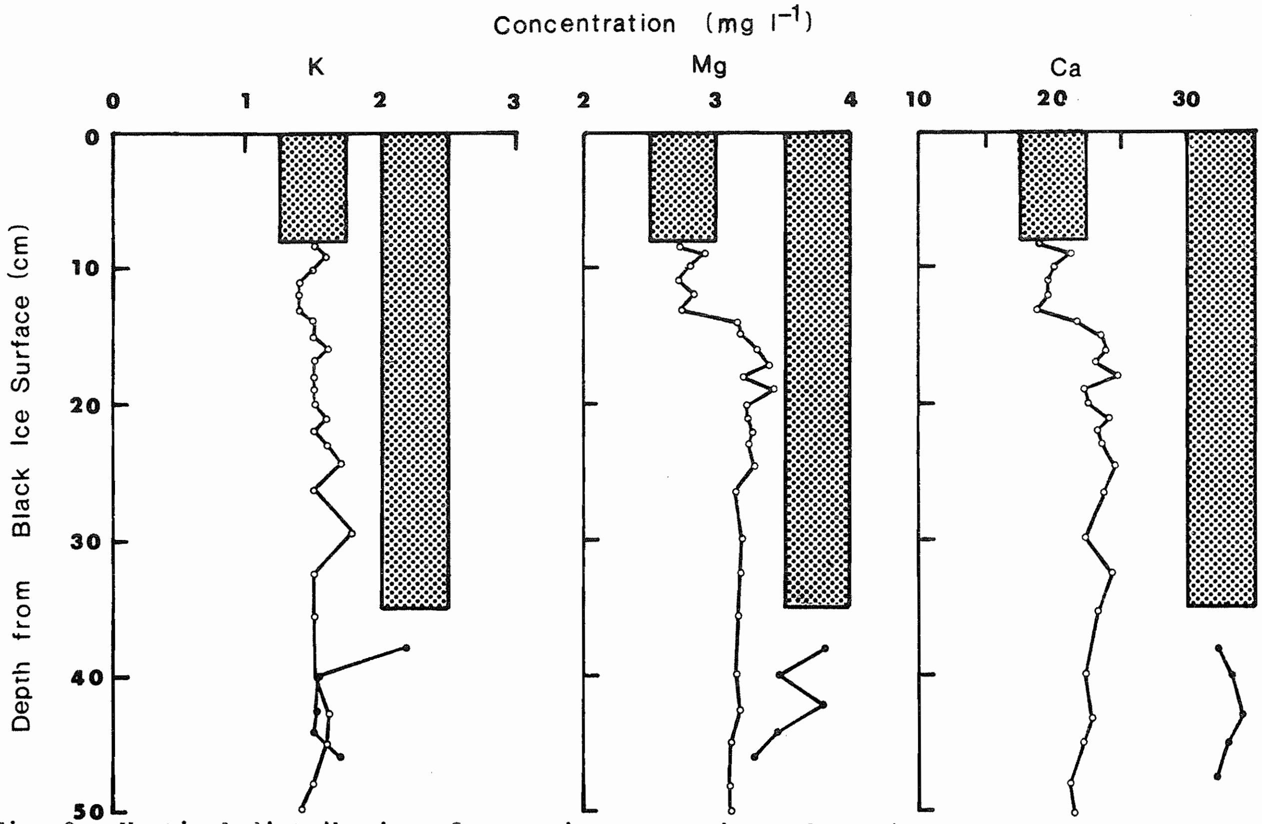

Fig. 2. Vertical distribution of potassium, magnesium and calcium beneath the black ice in Dummer Lake. black ice, January 29, 1980, March 18, 1980.

These preliminary results suggest that the sampling method described above is a suitable way to collect water samples from beneath a developing ice cover. Further evaluation of this method will continue next winter.

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