J. Great Lakes Res. 14(3):372–376
Internat. Assoc. Great Lakes Res., 1988

NOTE

OPERATIONS FOR AN UNDER-ICE ECOLOGY PROGRAM

S. J. Bolsenga, H. A. Vanderploeg, M. A. Quigley, G. L. Fahnenstiel
National Oceanic and Atmospheric Administration
Great Lakes Environmental Research Laboratory
2205 Commonwealth Blvd.
Ann Arbor, Michigan 48105-1593

ABSTRACT. A pilot program tested the feasibility of conducting a study on the under-ice ecology of the Great Lakes. The east arm of Grand Traverse Bay, in the lower peninsula of Michigan, was chosen as the test area. The project was conducted in three phases; (1) a pre-ice cruise (open water), (2) an under-ice phase, and (3) a post-ice cruise (open water). Overall, an under-ice ecology program that could produce sound scientific results was found to be feasible. However, to be successful, detailed planning is essential and careful attention must be given to operational safety, proper winter clothing, and scientific coordination.
ADDITIONAL INDEX WORDS: Ice cover, lake ice.

INTRODUCTION

Information on the population dynamics of plants and animals living under the ice of the Great Lakes is largely non-existent. A pilot program that tested the merit and feasibility of studying under-ice biological processes seemed an appropriate first step toward large scale assessment of the effect of ice cover on the ecology. The program was conducted on the East Arm of Grand Traverse Bay, Lake Michigan, in three phases: a pre-ice cruise (15 January 1986), an under-ice phase (5–10 March 1986), and a post-ice cruise (15 & 17 April 1986). The need for information on wintertime ecological processes prompted us to provide this description of the operations for others who might conduct similar studies. Papers on the biological and physical results are planned.

PRE-ICE CRUISE

Scientific Goals

Scientific goals involved: 1) Collecting water (Fig. 1, Site A) to determine photosynthetic end products and the photosynthesis vs. light intensity relationship for evaluation of the physiological condition of the phytoplankton; 2) Collecting depth profiles of chlorophyll and algal concentration to determine the distribution of zooplankton food at a representative deep station (Fig. 1, Site A) and at other stations (Fig. 1, Sites B & C) to provide an idea of spatial variability; 3) Obtaining live *Diaptomus* for experiments of feeding on natural seston and determining *Diaptomus* lipid concentrations (Fig. 1, Site A); (4) Determining vertical distribution of zooplankton at three locations in the bay (Fig. 1, Sites A–C) to estimate zooplankton concentration and spatial variability.

Site Logistics

Major concerns of the pre-ice cruise included launching a vessel in the presence of shore ice and safety on the water under winter conditions. The field party consisted of a boat operator, technician and two scientists. "Mustang" survival suits were worn by all party members and insulated rubber gloves were used by members collecting the samples. A variety of footwear was used by the party, but well insulated, waterproof boots were best suited for the operation. The vessel was a 21-foot, aluminum-hulled launch equipped with twin outboard motors. A kerosene heater warmed the canvas-covered cabin. Shore ice, 30–60 cm thick, was present between the slip areas in the marina (Fig. 1, Location D). The boat and trailer were backed onto the ice in one of the slips until the truck wheels were at the ice-ground edge (Fig. 2).

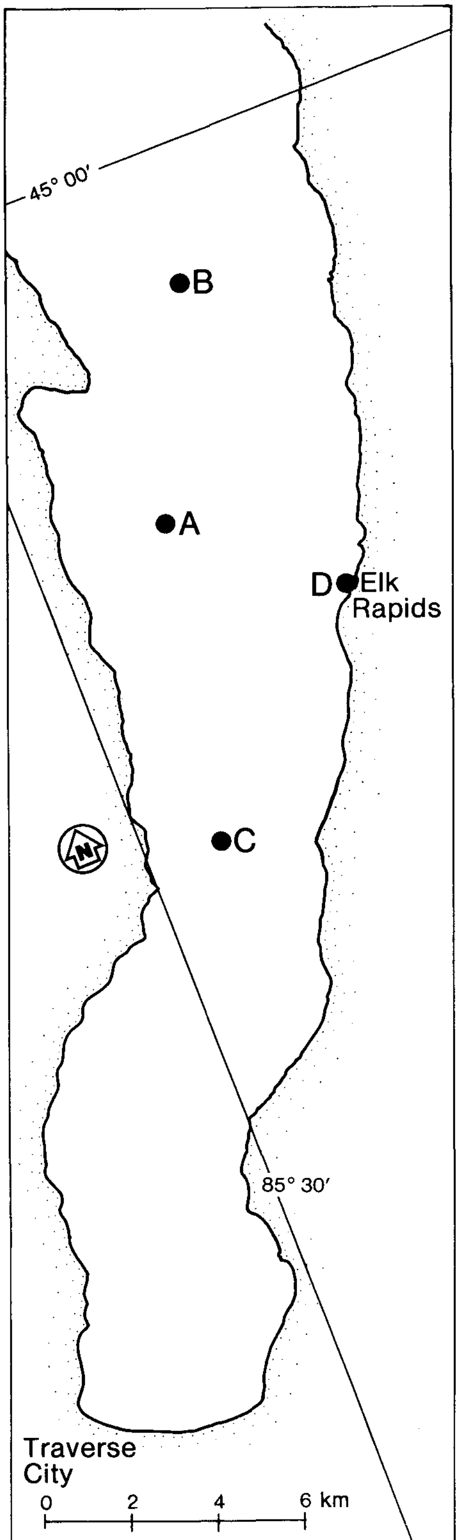

FIG. 1. Sites for the under-ice ecology pilot program.

FIG. 2. Launching the boat during the pre-ice cruise.

The trailer and boat were then moved by hand to the ice-water edge for launching.

During early morning preparations, the temperature was about -9°C, and the windspeed about 3.5 m/sec. In the bay, waves were initially less than 0.5 m. The Loran navigation system became inoperable due to a faulty battery pack, and our location (Fig. 1, Site A) could only be defined by visual sighting of landmarks, a chart, and depth sounder. Water samples were collected, using a standard Van Dorn bottle and a hand-operated winch. Live zooplankton were collected with vertical net tows. The contents of the plankton bucket were added to lake water for transport to the laboratory. During sampling, rapidly deteriorating weather conditions made it difficult to keep our position at Site A. After the first net tow, the waves reached a maximum of slightly over 1.0 m. The temperature was about -6°C, and the winds were gusting to over 10 m/sec. Net tows took approximately 15 minutes to complete using the davit (80 m depth), and only two tows were possible before we felt it prudent to return to shore. Due to the poor weather conditions, goals 2 and 4 were only partially attempted since only one site was occupied.

On the return trip, waves made travel difficult and boat speed was kept low to avoid excessive spray freezing onto the hull and deck areas. Retrieving the boat was accomplished without difficulty or damage: it was nosed up to the ice surface and the engine power increased significantly, causing it to slide-up onto the ice (Fig. 3). The engine casings self-drained immediately.

FIG. 3. The boat immediately after completion of the pre-ice cruise. Note extensive icing on the windshield.

We encountered no major safety problems during the pre-ice phase although lack of attention to certain details could have been potentially dangerous. For example, even though the boat used was small, a larger vessel was not moved from its winter berth in southern Lake Michigan due to concern about superstructure icing. Cold weather fortunately did not cause water to freeze within the outboard motor casings although this was a concern before engine warmup and after shutdown. During sampling, spray on the bow, deck, and windshield (primarily due to the cathedral-type hull design) froze making it difficult to walk and see. Steering the boat was a problem due to freezing wash in the transom area. The steering never failed, but was balky. A deep-V, metal-hulled boat with an inboard engine would have minimized spray and eliminated transom wash, but would be less stable on-station and draining water from the engines would have been a problem. One alternative would be a larger vessel equipped for ice operations (such as an icebreaking tug).

Performance of the survival suits was excellent, and all persons aboard remained relatively warm, although the suits were covered with ice by the time the sampling had been completed. Dry-type survival suits were also available in case of a serious boat accident. The "stiffness" of the suits limited mobility and was often uncomfortable after a long work period. Adequate cold weather footwear, such as insulated waterproof boots, is essential.

UNDER-ICE PHASE

Scientific Goals

Scientific goals were substantially the same as those of the pre-ice phase with the addition of the following: 1) Measure radiation transmittance through ice in the photosynthetically active range; 2) observe changes in the surface of the ice to characterize the reflectance of the ice cover for subsequent modeling of the radiation transmittance through the ice; 3) observe ice thickness and stratigraphy spatially and temporally for the radiation studies, project planning, and safety; and 4) collect Ponar grab samples of sediment at predetermined depths from the shore, near Site D to Site A (Fig. 1).

Site Logistics

We proceeded with the under ice phase after about 20 cm of ice was measured on the open bay in early March. Ice formation during this year was about normal for Grand Traverse Bay (Assel *et al.* 1983). During the week of the under-ice work, every type of winter weather was observed (above and below freezing temperatures, snow, blowing snow, rain and fog). Temperatures ranged from −22 to +10°C and windspeeds from calm to 20 m/sec gusts.

The field party consisted of three scientists (phytoplankton/zooplankton, benthos, radiation) and one technician. "Mustang" survival suits were worn. Equipment included: a snowmobile, open and closed/heated sleds, depth finder, Loran C, power auger, chain saw, and hydraulic winch on a sled. Usually, holes were cut with an 8-inch power ice auger and chain saw. Shallow cuts were made in the ice, to avoid water swamping the chain saw motor. A reciprocating saw would have caused fewer icing and oil and gas contamination problems, but one was not available.

Four holes were cut for the phytoplankton/zooplankton sampling (Site A, Fig. 1). Contamination by chain saw oil and gasoline was tolerated because those samples were preserved. The holes were covered with white styrofoam to prevent excessive light from entering the water. On the last day of the under-ice phase, a hole was cut through the ice at Site A (Fig. 1) using only hand tools for the live phytoplankton and zooplankton samples to be used in physiological experiments. Three replicate benthos samples were collected at five sites without problems. However, due to somewhat irregular bottom topography, considerable time was spent in locating sites at the exact depths required.

The sampling equipment worked well. Benthos samples could be collected even in marginal weather conditions, but other types of data collection required better conditions. The vertical net and the Schindler trap net were sprayed with warm tap water (stored in insulated picnic jugs) to rinse zooplankton into the collection buckets and into widemouth polyethelene bottles for preservation. This prevented the rinse water from freezing on the nets. We also left the drain valves of the Van Dorn bottles open to prevent freezing.

Improvements in some of the operational equipment and procedures would be desirable. We originally planned to conduct the net tows and Schindler trap data collections at 6-hour intervals throughout the day and night to determine the extent of vertical migration. However, night measurements were eliminated for safety purposes. Since rain and fog were common during the latter portion of the field program and since the ice cover was dynamic with small leads opening and closing periodically, any measurements after dark would have necessitated illumination of the site and assurance of a safe path to the site. Arrangements were made to have incandescent lighting at the site during work periods and a gas lantern to illuminate the site when it was not occupied for navigation purposes, but no travel route markers were available. Since the site (Site A, Fig. 1) was over 4 km offshore and since fog, snow, blowing snow, and rain were common, route markers or Loran C units on the transport vehicles as well as bright headlights on the vehicles were considered essential for night operations. The safest option would be to cancel night operations when visibility is poor or if ice stability is at all questionable.

The dynamic nature of ice cover in many areas of the Great Lakes can be a major problem. Experience in ice operations of at least some party members is essential to avoid problems with safety. In the Grand Traverse Bay area, for example, a thick, full ice cover can be transported from the bay to the open lake in a short period by strong southerly winds. Although leads were present during this study, weather conditions were not likely to produce extensive open-water areas and none occurred. The field party leader must thus be aware of current and future weather conditions. Many areas of the Great Lakes, particularly those away from bays and harbors, are simply not safe for on-the-ice field parties. Helicopters can be used for sampling in offshore areas, where extensive open water is present, during ice decay, or where ice movement is expected. However, in some of those situations, whether or not such samples represent "cold-weather-open-water" samples or under-the-ice samples is open to question and would depend on the amount of open water versus ice present. Also, some sampling, including that described here, requires an extensive amount of time on the ice, making the use of a helicopter infeasible.

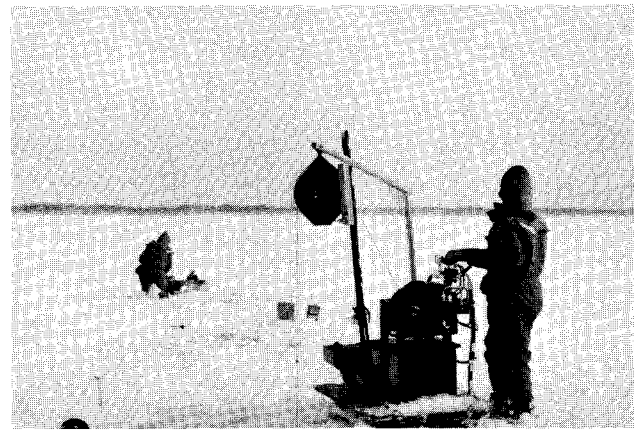

FIG. 4. A typical sampling site.

Positioning units (such as Loran C, radio direction finders, or satellite navigation systems) should be located on the transport vehicles. Station position changes should be recorded by all transport vehicles and by a shore station. In addition, sufficient time should be allotted for "laydays" so that personnel do not feel pressed to complete a task in a short period of time under extremely unfavorable or unsafe weather conditions, and to allow for equipment maintainance.

The winch was mounted on a small sled with only two runners (Fig. 4). It was difficult to move the unit from site to site, and the sled also bogged down in nearshore areas that had become laden with slush and water after mild weather. Large sleds with wide runners are recommended to reduce ground pressure; for some situations, mounting equipment, such as the winch, on wheels (e.g., Lawson *et al.* 1986, Brockett and Lawson 1985) would be most desirable. Small wheeled vehicles for personnel transport as well as towing equipment seemed to be more desirable than snowmobiles where snow depths are not excessive. Only one ice transport vehicle was available for much of this program. An additional vehicle would have facilitated transport of people and equipment and provided additional operational safety. A radio-equipped person on shore, with a dedicated vehicle, who could be summoned in case of emergency, is advisable.

Early morning meetings contributed to efficient operations due to rapidly changing weather conditions and resulting variable scientific progress. Simplicity in operational and sampling procedures was extremely advantageous in the hostile conditions. Primary and contingent sampling plans, if weather or ice conditions prove unfavorable, are recommended.

POST-ICE CRUISE

Scientific Goals

The goals of this portion of the program repeated those of the pre-ice cruise and all were achieved.

Site Logistics

The cruise took place in mid-April after a late ice breakup. Time of the cruise in relation to ice breakup was planned to represent true open-water rather than near-under-ice conditions. During the first day of the cruise, air temperatures averaged about 3.3°C, light snow was falling during most of the period, and windspeed varied from calm to 4 m/sec. The field party consisted of two scientists and a boat operator/technician. The power winch used during the under-ice phase was mounted in the boat in place of the davit used during the pre-ice cruise. Due to a poor weather forecast for the next day, we decided to complete the entire zooplankton-phytoplankton sampling operation in 1 day followed by a maintenance day with benthos sampling the third day. A primary and alternate cruise plan had been prepared for the phytoplankton-zooplankton collecting.

At the first station (Fig. 1, Site B), metered net tows and water samples were taken using the same equipment as in the under-ice phase. Water temperatures were measured with a thermometer inserted in the Van Dorn bottle. The boat then proceeded to the next station (Fig. 1, Site C) where the same measurements were taken. At the third station (Fig. 1, Site A), zooplankton were collected from four depth intervals and water samples were taken at 10 levels. The operation was started at 0730 and completed before dark at about 1730 hrs. Weather conditions were not favorable, but they were also not severe. Waves were only about 0.5 m. Nevertheless, stamina of the party was a factor. Transport of the live samples to the laboratory should also be considered during such a prolonged sampling period. In this case, the live samples were transported early the next morning. Benthos samples were collected on a subsequent day without problems. Seas were calm, air temperatures were over 10°C, and the sites occupied during the ice phase were easily located.

SUMMARY

An under-ice ecology pilot program was undertaken, but logistics problems were encountered in both operations and data collection. Significant experience was gained in both areas to make future programs of this type more efficient and scientifically productive. Planning with attention to details and simplicity, adequate cold-weather gear, sufficient time to conduct the experiments under adverse weather conditions, attention to safety equipment and operating procedures, and coordination of the various scientific phases are key items in the success of such programs.

ACKNOWLEDGMENTS

We wish to acknowledge the field assistance of D. V. Morse and W. R. Burns of GLERL. F. H. Don and an unidentified reviewer made many useful comments on the manuscript. GLERL contribution No. 569.

REFERENCES

Assel, R. A., Quinn, F. H., Leshkevich, G. A., and Bolsenga, S. J. 1983. *Great Lakes ice atlas.* National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan.

Brockett, B. E., and Lawson, D. E. 1985. *Prototype drill for core sampling fine-grained perenially frozen ground.* CRREL Report 85-1, Cold Regions Research and Engineering Laboratory, Hanover, N.H.

Lawson, D. E., Chacho, Jr., E. F., Brockett, B. E., Wuebben, J. L., Collins, C. M., Arcone, S. A., and Delaney, A. J. 1986. *Morphology, hydraulics, and sediment transport of an ice covered river.* CRREL Report 86-11, Cold Regions and Engineering Laboratory, Hanover, N.H.