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HABITAT PREFERENCE AND MOVEMENT OF NORTHERN PIKE DURING FALL AND EARLY WINTER IN POTATO LAKE, WASHBURN COUNTY

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ABSTRACT

Because northern pike are often difficult to sample alive during periods of the year other than the spring spawning run, we monitored the habitat preference and movement of northern pike with radio telemetry during fall and early winter 1984. This knowledge is important for developing capture methods for pike during non-spawning periods. We surgically implanted radio transmitters into 4 northern pike (18.8-25.9 inches) and monitored the pike from 1 October through 23 December 1984 during periods of open water and ice cover. We investigated depth and habitat preferences, and daily movement patterns. Pike preferred areas with aquatic macrophytes at depths of 5-10 ft, and their activity areas were generally less than 11 acres. Nontypical movements suggested responses to prey availability and to weather factors. Hourly monitoring during periods of ice cover suggests that pike are generally inactive. Movement consisted of sporadic displacements that were greatest during daylight hours. At the end of the study, we used angling to recover transmitters, which demonstrated the high vulnerability of northern pike when their location can be closely determined by telemetry.

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INTRODUCTION

During the spring spawning period, fyke nets are used to collect data on northern pike (Esox lucius). During non-spawning periods, gill nets have been used successfully. Both methods have drawbacks. Fyke netting limits the seasonal study of such things as food habits; gill nets may kill the fish. We need a technique that can safely sample northern pike at any time of the year.

An important factor in the design of sampling procedures is knowledge of habitat preferences and behavior of northern pike. Northern pike have long been considered sedentary predators occupying restricted home ranges (Ivanova 1969, Malinin 1969, Nursall 1973, Diana 1980). Diana et al. (1977) and Diana (1980), however, observed that although pike are generally inactive and associated with aquatic vegetation, they can also move extensively. More recently, Chapman and Mackay (1984) suggested that pike are more versatile in habitat use than we previously thought. They observed pike traveling long distances quickly and using nonvegetated areas for periods exceeding 10 days.

In this study, we used radio telemetry to determine the movement and preferred habitats of adult northern pike in Potato Lake during fall and early winter 1984. We divided the work into 2 time segments: In the first (1 October through 23 November), depth and habitat preferences were studied; in the second (4-5 December and 12-13 December), daily movement patterns were observed. After the end of the study (21 and 23 December), we determined the vulnerability of radio-tagged fish to angling.

STUDY AREA

Potato Lake is a hard water, drainage lake of 220 acres at the headwaters of Potato Creek, Washburn County. Maximum depth is 22 ft and the methyl purple alkalinity is 95 ppm (Sather and Busch 1976). Surface water temperatures during the summer reach 77 F and the lake does not thermally stratify. Myriophyllum sp. and Potamogeton robbinsii are the primary submersed macrophytes in 36% of the lake down to 11 ft (Fig. 1). Wild rice (Zizania sp.) at the southern end constitutes most of the emersed vegetation present. Discontinuous beds of bulrush (Scirpus sp.) ring the north and east margins of the lake. Emersed vegetation covers 8% of the surface while 56% of the bottom is unvegetated.

Northern pike is the dominant predatory game fish followed by largemouth bass (Micropterus salmoides). Seventeen other game and forage fish species inhabit Potato Lake (Append. Table 5).

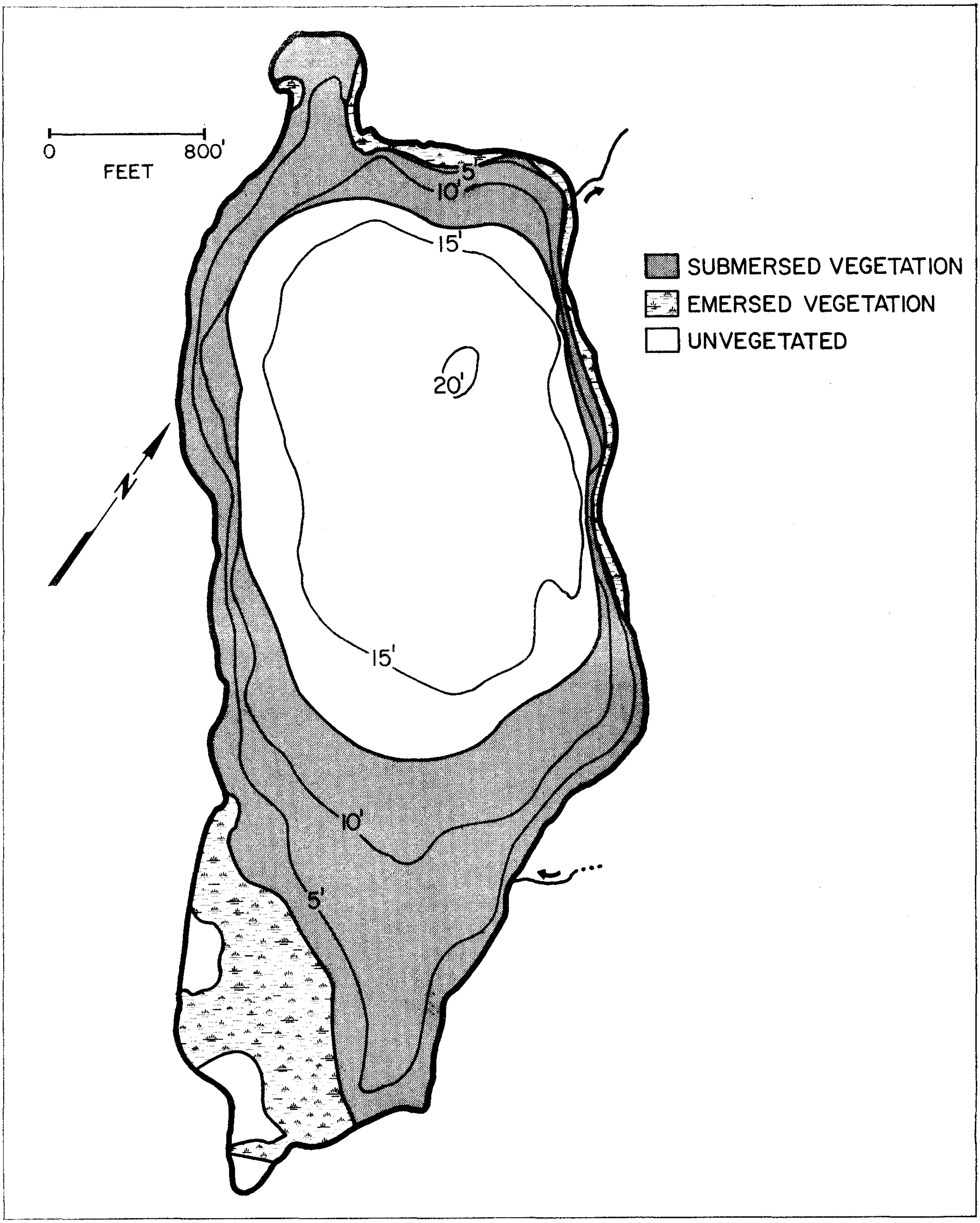

FIGURE 1. Depth contours and vegetated areas of Potato Lake, Washburn County.

METHODS

TAGGING

We electroshocked 4 northern pike, ranging from 18.8-25.9 inches in total length, on 26 September 1984 and held them in a holding net overnight (Table 1). The following morning radio transmitters were surgically implanted in the body cavities (as in Crossman 1977). We used nonbleeding (non-dissolvable) sutures to close the incision, after which 2 ml of terramycin in a distilled water solution was injected into the body cavity to reduce the chance of infection. Pike were released into the lake at the shoreline immediately after they recovered from surgery (15-20 min).

Implanted transmitters averaged 1.4 inches in length (including loop antenna), weighed 6.9 g in air, and had a minimum life expectancy of 90 days. They operated on a frequency of 50.239-50.381 MHz. We estimated signal range to be 150-300 ft, with the greater signal range occurring in late fall and early winter, after most aquatic vegetation had senesced and settled.

TABLE 1. Growth of radio monitored northern pike in Potato Lake, 1984.

Radio No.	Sex	Total Length (inches) 27 Sep	21-23 Dec	Increase
1	F	21.6	22.1	0.5
2	F	22.7	23.5	0.8
3	M	18.8	18.9	0.1
4*	F	25.9	-	-

* Radio transmitter failed on 23 November.

TRACKING

We began monitoring the radio-tagged northern pike on 1 October 1984 and continued this activity intermittently for 84 days through 23 December 1984. Telemetry data were separated into 3 chronological segments for analysis:

1) from 1 October to 23 November, to determine depth and habitat preferences, 2) 4-5 December and 12-13 December, to determine daily movement patterns, and 3) 21 and 23 December, to determine vulnerability of radio-tagged fish to angling.

1 October-23 November

We located the pike during the open water period from a boat by using a hand-held loop antenna. The boat was maneuvered close enough to a pike so that the transmitter signal became omnidirectional. Volume of the receiver was then reduced to pinpoint the pike's location. We noted habitat characteristics and plotted the pike's location on a lake map by using visual landmarks along with lake map depth contour lines. Depths greater than 11 ft were considered without vegetation. During the first study segment, we tried to locate fish at least twice weekly (7:00 a.m.-4:00 p.m.); however, the time intervals between successive locations of a fish ranged from 1-12 days, depending on our ability to locate a particular fish and the formation of ice.

4-5 and 12-13 December

We determined daily movement patterns during ice covered periods by monitoring fish for 1-hour intervals for 24 (4-5 December) and 36 hours (12-13 December). Radio-tagged northern pike were located by either tracking on foot or on a 3-wheel all-terrain-cycle (ATC). When we used the ATC, we kept it at least 100 ft from the most recent observation point, a precaution we later found to be unnecessary. Specific location was determined and recorded as during the earlier period. Fish locations were marked by placing wooden net floats on the ice labelled with the transmitter frequency and the time of location. During night tracking, a cyalume fluorescent stick was placed into an upright net float at the most recent location. The cyalume stick could be seen from approximately 200 ft away and it facilitated nighttime tracking. At the end of an observation period, the depth and distance between fish locations were recorded with a tape measure, and the direction taken by the fish was determined with a hand-held compass. We considered gross movements between contact periods as linear distances between 2 successive locations.

21 and 23 December

Determining the vulnerability of radio-tagged pike during an ice covered period involved angling for the 3 fish still carrying actively transmitting radios. One of the 4 transmitters implanted failed on 23 November after 54 days. The 3 remaining active transmitters were recovered on 21 and 23 December. The fish were recovered using traditional ice fishing techniques. Tip-ups, a jig, and hook and bobber set-up were baited with minnows.

DATA COLLECTION, ANALYSIS, AND CONVERSIONS

We mapped vegetation zones by using a Raytheon DE-719B depth recorder and we determined the area of specific habitats and pike activity areas by using an Apple IIe computer and a digitizing pad (Houston Ins. HIPAD). All other parameters were determined manually. Chi-square analysis was used to determine if the pike used habitats (depth, bottom type) at a higher frequency than would be expected on the basis of actual area occupied by each habitat type. Depth was grouped into 5 intervals (0-3 ft, >3-5 ft, >5-10 ft, >10-15 ft, >15 ft) by using lake map contours. Bottom type was separated into vegetated and nonvegetated areas.

We converted fork length (Grimm 1981) and standard length (Chapman and Mackay 1984) of pike to total length measurements using Mann's conversions (Mann 1976). Metric units reported by authors were converted to English to facilitate comparison.

RESULTS AND DISCUSSION

HABITAT PREFERENCE AND ACTIVITY AREAS

Radio-monitored northern pike preferred habitats with aquatic macrophytes at depths of $\geq$5-10 ft from 1 October to 23 November. Radioed fish were found in and near vegetation on 91% of all fixes and at depths of $\geq$5-10 ft on 61% (Table 2). Occurrences of pike in these habitats were both significantly different than would be expected if habitat was randomly chosen (Depth $\chi^2 = 92.2$, $P<0.001$; vegetation $\chi^2 = 46.8$, $P<0.001$).

Activity areas for the pike ranged from 3.3-10.9 acres during the 39 days preceding ice formation (1 October-9 November). However, during the period of ice formation (12-20 November), behavior of the pike changed and their ranges extended as pike departed from vegetated into deeper unvegetated areas. On 12 November, ice covered 90% of the lake (surface water temperature, 37 F) and tracking was impossible except for 1 fish that could be located from the boat landing. Strong southeasterly winds on 13-14 November reopened the lake, allowing tracking by boat on 15 November (surface water temperature 36 F). Two of 3 pike (Nos. 3 and 4), which had remained near the north shore at depths ranging from 4-13 ft since tracking was initiated, had moved to unvegetated areas at depths of 22 and 18 ft, respectively (Fig. 2). The third pike (No. 1) near the north shore moved to a depth of 12 ft. Pike No. 2 in the southern portion of the lake remained within the zone it had previously occupied. On 18 November, ice covered the lake again, following 3 days of strong north winds, and by 20 November, 3 inches of ice had formed, allowing us to track on foot. Two of the 3 north shore pike (Nos. 1 and 4) had returned to littoral areas that they had formerly occupied, while the third (No. 3) was moving in that direction (from a depth of 22-16 ft on 15 November). Pike No. 2 from the south end of the lake had moved 2,300 ft from its previous location on 15 November (water depth of 10 ft) to an unvegetated area at a depth of 20 ft (Fig. 2). On 21 and 23 November (3-inch ice cover), all 4 pike had returned to littoral areas in zones that they had previously occupied. Pike No. 2 returned to its original area, a displacement of 2,300 ft in 1 day (Fig. 2).

Northern pike activity in Potato Lake suggests that a combination of biotic and abiotic factors influence habitat selection and movement. Depth preference may be dependent on the presence of rooted macrophytes that were found to depths of 11 ft. Grimm (1981) suggested that density of pike (less than 17.0 inches) in 4 European lakes was positively associated with the amount of aquatic vegetation. Chapman and Mackay (1984) also found that northern pike in Seibert Lake, Alberta, Canada were associated with aquatic vegetation, but also noted that pike left areas of aquatic vegetation for periods of up to 10 days. Chapman and Mackay studied large pike (greater than 29.0 inches) and suggested that they may be more versatile than smaller fish in their movement from one habitat to another. Northern pike monitored in Potato Lake were of intermediate size (18.8-25.9 inches) compared to those in the European and Canadian studies, but still were associated with vegetated areas for most of the contacts.

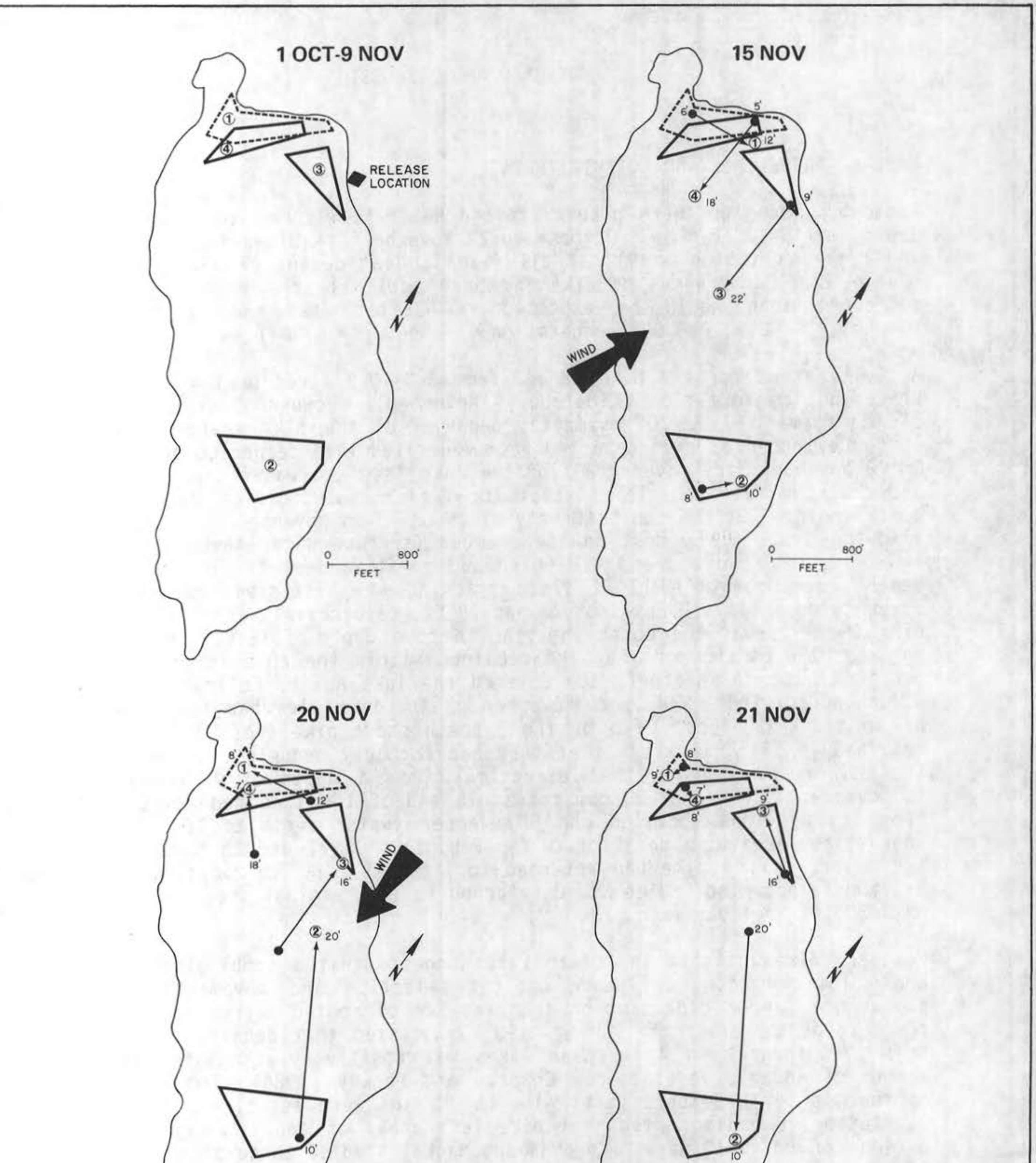

FIGURE 2. Activity areas and movement (small arrows) of northern pike in Potato Lake. Large arrows represent wind direction. Polygons represent previously occupied areas.

TABLE 2. The observed and expected frequency of habitat use for northern pike in Potato Lake, 1 October-23 November, 1984 (n = 54).

Parameter	Expected Frequency*	Observed Frequency
Depth (ft)		
0-3	8 (15)**	0 -
> 3-5	4 (7)	9 (17)
> 5-10	9 (17)	33 (61)
> 10-15	16 (30)	8 (15)
> 15	17 (31)	4 (7)
Vegetation		
Unvegetated	30 (56)	5 (9)
Vegetated	24 (44)	49 (91)

*If each habitat had been occupied on a random basis.
**Percent in parentheses.

Prey availability may also be a factor in determining preferred habitats. Malinin (1969) and Bregazzi and Kennedy (1980) suggested that pike movement is dictated by the distribution of prey species, and Makowecki (1973) stated that in many lakes the littoral zone often has the greatest number of prey items compared to other areas of the lake. In Potato Lake, the density of forage fishes available is assumed to be higher in littoral areas, which could partly account for the association of pike with these habitats.

The sporadic behavior observed during the initial freeze-up stage appears to have resulted from abiotic factors. Strong southerly winds (Table 3) may have forced colder surface waters to the north end of Potato Lake, causing pike to retreat to deeper (possibly warmer) areas, but may not have had this effect on the pike located at the southern end of the lake. When strong northerly winds persisted 3 days before freeze-up, the pike in the southern portion moved to deeper water and the pike along the northern portion of the lake returned to their original areas within the littoral zone. Chapman and Mackay (1984) found that pike selected habitats farther from shore on windy days in May-June possibly because of wind-created turbidity in shallow areas. The movement of pike in Potato Lake to greater depths may also demonstrate the effect of weather on habitat choice. Unfortunately, detailed water temperature information was not collected and closer monitoring of radioed pike during ice formation was not possible, hence this hypothesis cannot be substantiated.

TABLE 3. Wind and temperature data for 12-21 November, 1984.*

Date	Percent of Lake Ice Covered	Wind Direction	24-hour Peak Velocity (mph)	Temp (F) Air Min	Temp (F) Air Avg	Temp (F) Surface Water
12 Nov	90	SSE	15	18	29	37
13	0	SE	29	27	36	
14		SSE	35	39	42	
15		NW	46	17	29	36
16		WNW	29	13	23	
17		NNE	19	20	28	
18	100	N	17	13	20	
19		N	19	13	21	
20		SE	14	7	19	
21		SSE	29	14	25	

* Wind and air temperature information provided by Rice Lake Municipal Airport, Rice Lake, Wis.

DAILY ACTIVITY PATTERNS

Pike activity under ice cover was greatest during daylight hours and decreased substantially after sunset (4:30 p.m.) during both 24- and 36-hour observation periods (Fig. 3,4). During daylight hours (7:00 a.m.-4:30 p.m.), the pike frequently moved from their previous position (92% of the observations, n = 87), while movement occurred on 41% of the observations during hours of darkness (4:30 p.m.-7:00 a.m.). The mean total gross movement (total linear distance) for individual pike during daylight hours was 1,276 ft and ranged from 216-3,245 ft, while the mean for hours of darkness was 168 ft and ranged from 0-374 ft.

Movement rates (distance traveled/time) during the daylight period were also greater than those during darkness (day = 2.3 ft/min; night = 0.2 ft/min). Diana (1980) estimated mean swimming velocity for pike at 45 ft/min for periods when pike were continuously moving. Diana also noted that pike only turn occasionally and therefore assumed linear movement. If pike in Potato Lake swam at a similar velocity and on a linear course, a fish would have been actively swimming for a mean time of only 2.2 min each hour during the day, and less than 1 min of each hour during the night. Even the maximum rate we observed (15.8 ft/min) indicates that the pike was active only 35% (21 min) of the hour period between observations. These data suggest that pike are relatively inactive during most of a 24-hour period in terms of time actually spent swimming. However, the high frequency with which pike move from prior locations suggests that relocations to another area are common during diurnal periods, and occasional during nocturnal periods. Our data agree with Diana (1980), who found pike in Lac Ste. Anne, Alberta, to be almost completely inactive at night, and inactive 81% of the day (sunrise to sunset) during the period of ice cover.

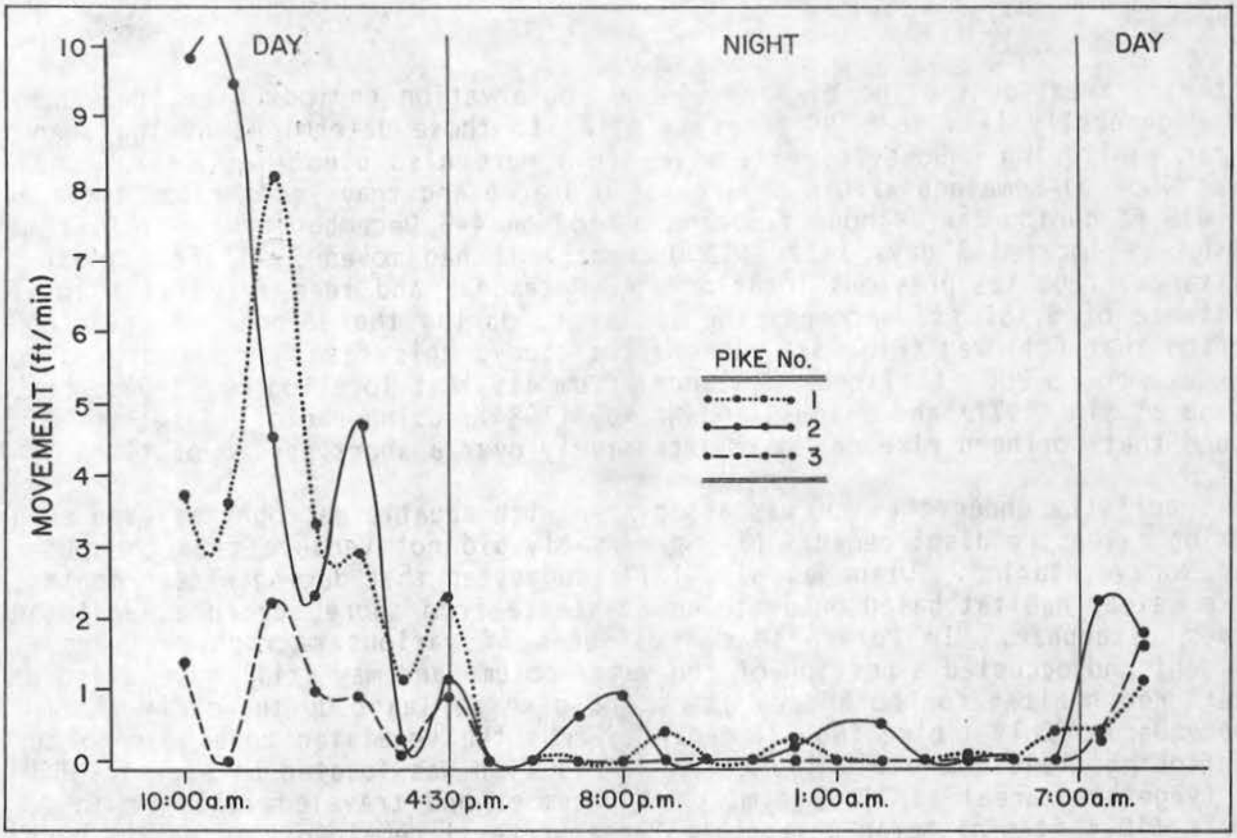

FIGURE 3. Movement rate of 3 northern pike in Potato Lake, 4-5 December 1984 (24 hours).

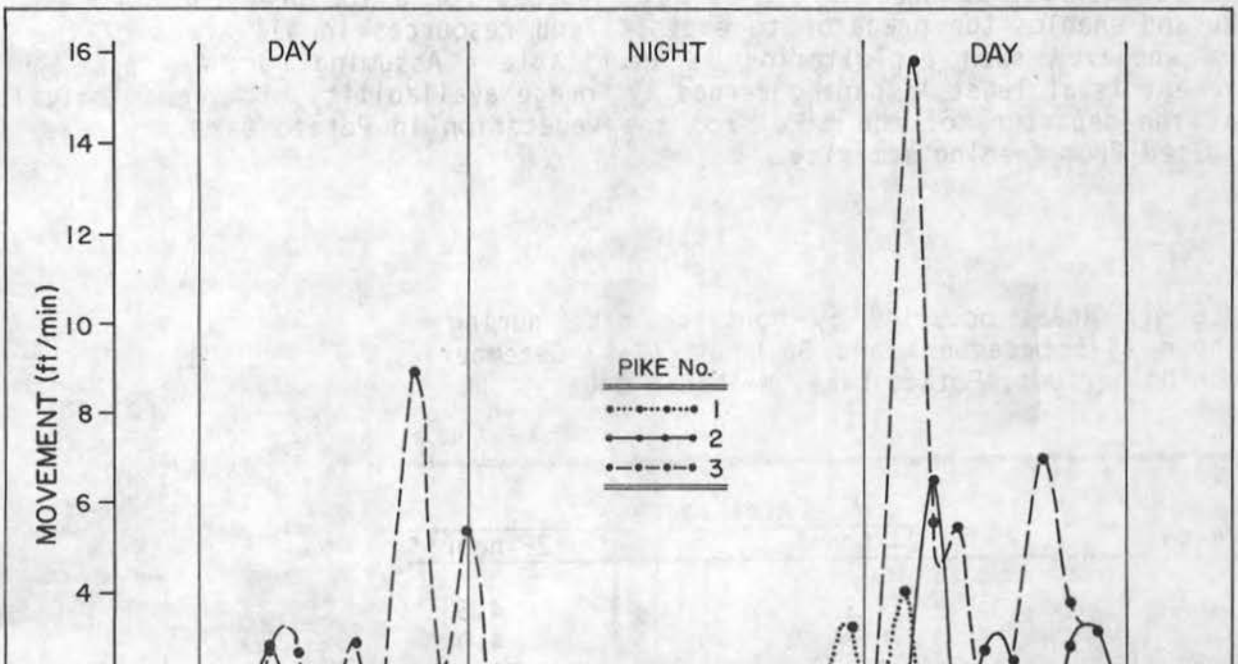

FIGURE 4. Movement rate of 3 northern pike in Potato Lake, 12-13 December 1984 (36 hours).

Activity areas during the 24- and 36-hour observation periods with ice cover were generally less than 11 acres, similar to those determined during open water monitoring. However, extensive areas were also used (Table 4). One pike (No. 3) remained within an area of 0.3 acre and traveled a total distance of 613 ft during the 24-hour tracking period on 4-5 December. When this same fish was located 7 days later (12 December) it had moved 3,400 ft (linear distance) from its previous location on 5 December, and then traveled a total distance of 5,157 ft, encompassing 70 acres, during the 36-hour observation period that followed (Fig. 5). To end the study, this fish was recaptured on 23 December 3,200 ft (linear distance) from its last location on 13 December. Diana et al. (1977) and Chapman and Mackay (1984), using radio telemetry, also found that northern pike can move extensively over a short period of time.

Most activity under the ice was associated with aquatic macrophytes, and even during extensive displacements pike presumably did not venture from the outer edge of vegetation. Diana et al. (1977) suggested that during winter months, pike select habitat based on depth and distance from shore, because vegetated zones disappear. In Potato Lake, residuals of various macrophytes were evident and occupied a portion of the water column and may still have acted as preferred habitat for both prey items and pike at least during early winter (December). Only 1 pike (No. 2) departed from the vegetated zones during our monitoring while there was ice cover. This fish was located at a depth of 9 ft (vegetated area) at 10:00 a.m. on 4 December and traveled 1,253 ft in 2 hours (10.4 ft/min) to an unvegetated area where it remained through the night until the following day (9:00 a.m.), at which time tracking was terminated. When located 7 days later (12 December) this fish had returned to a vegetated area it previously occupied (Fig. 6). Chapman and Mackay (1984) suggested that versatility in habitat use is advantageous for a top predator such as pike and enables the predator to exploit food resources in all areas of the lake whenever such exploitation is profitable. Assuming northern pike movement is at least in part governed by forage availability, it seems logical that the departure of the pike from the vegetation in Potato Lake may have resulted from feeding activity.

TABLE 4. Areas occupied by northern pike during 24-hour (4-5 December) and 36-hour (12-13 December) tracking periods, Potato Lake, Washburn County.

	Area (acres)	
Pike No.	24-hour*	36-hour**
1	1.9	4.5
2	10.7	4.0
3	0.3	70.0

*Includes 9 daylight and 14 night locations.
**Includes 20 daylight and 16 night locations.

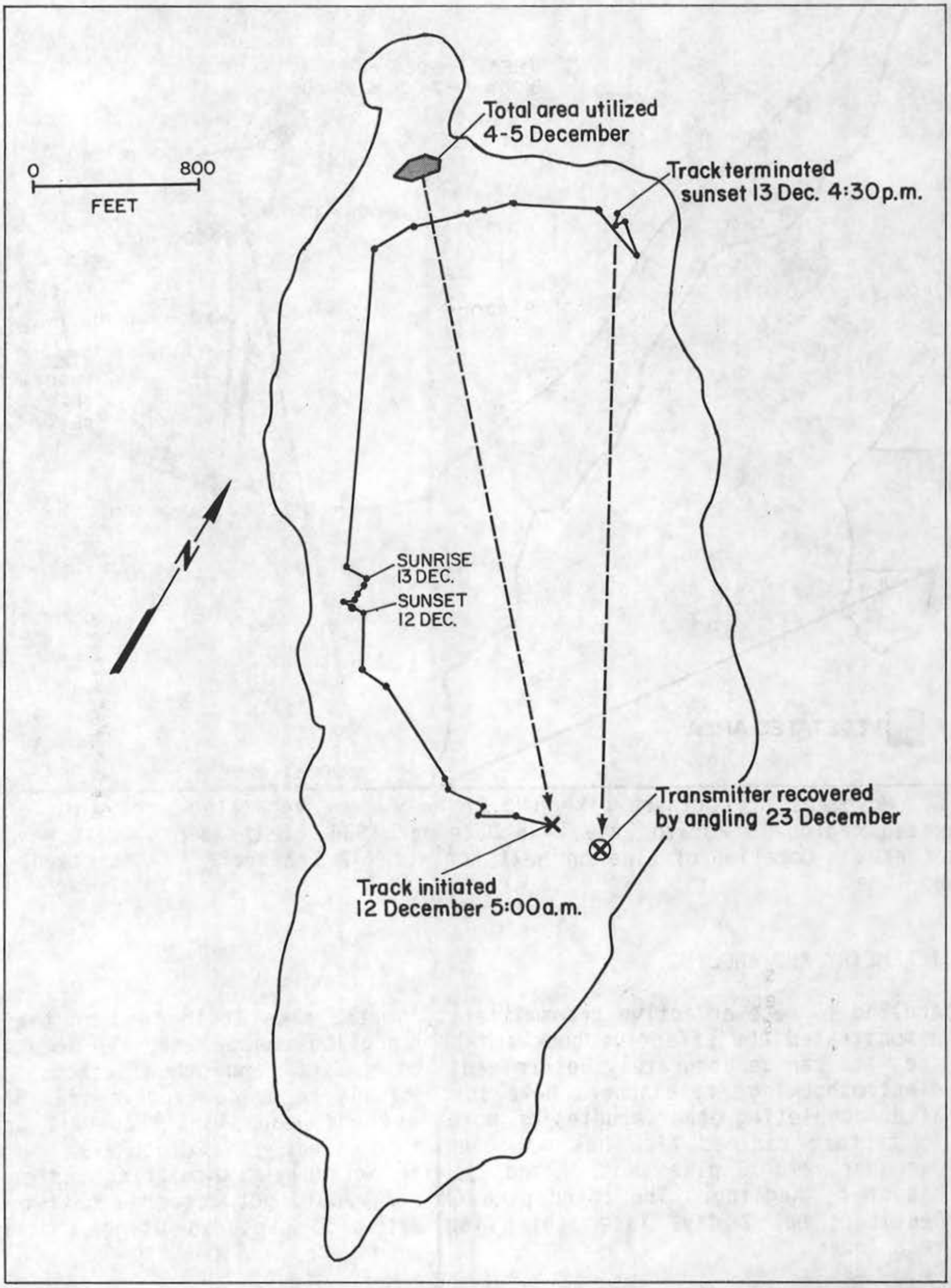

FIGURE 5. Movement of northern pike (No. 3) in Potato Lake during 4-23 December. Solid line represents monitoring during 36-hour tracking period. Dashed lines represent movement from 5-12 December and 13-23 December.

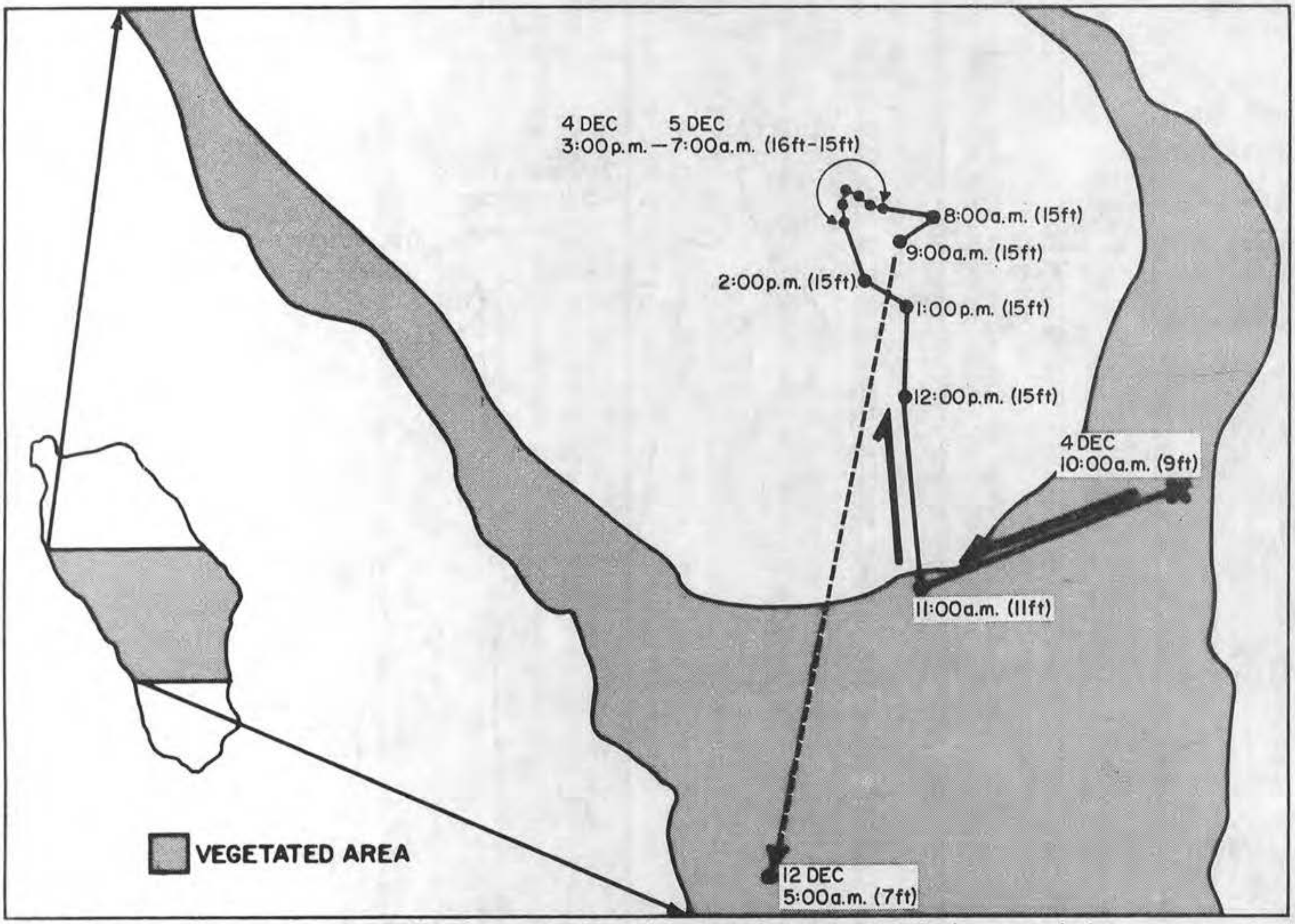

FIGURE 6. Movement of northern pike (No.2) away from vegetated area into nonvegetated region in Potato Lake, 4-5 December 1984. Water depth is shown in parentheses. Location of pike on next contact (12 December) is indicated by dashed line.

TELEMETRY AND ANGLING

Angling to recover active transmitters from the pike at the end of the study demonstrated how effective hook-and-line angling can be when the location of the fish can be accurately determined. Using SCUBA and other methods such as electroshocking, researchers have successfully recovered active transmitters after completing other studies of both live and dead fish. However, angling to capture radioed fish has not been documented. In Potato Lake on 21 December, 2 of 3 pike (Nos. 1 and 2) with actively transmitting radios were caught by angling. The third pike (No. 3) would not accept a bait on 21 December, but 2 days later this fish was also captured using similar techniques.

Two traditional ice fishing techniques were tested and both proved successful in capture of these pike. The initial strategy was to locate the signal and set up several tip-ups near the fish location (within 12-15 ft). This method was successful on the first pike. As tip-ups were being set, pike movement was monitored and followed to within 3 ft of a tip-up. When the pike was directly below the tip-up, the bait was taken and the flag tripped.

Monitoring was continued as the pike took 15 ft of line before stopping. The attempt to set the hook was unsuccessful and the pike moved out of the area (approximately 100-150 ft) into 8-10 ft of water for 30-45 min before returning to the area where it previously bit. The pike once again bit on a shiner baited tip-up and this time was caught.

The second angling technique used on the remaining 2 pike was more direct as 8-inch diameter holes were opened directly above the presumed fish location in 8-9 ft of water. The first of these pike accepted a jig (with minnow) within 10 sec after it was placed into the water. The second pike did not respond to either jig or live shiner for 30 min, even though the radio signal indicated that the pike was in the immediate area. Two days later another attempt was made and on this occasion the pike struck a jig (with minnow) within 10 sec of being placed into the water, but was not hooked. Relocating the transmitter signal indicated that the pike had moved 10 ft and had become stationary. After a new hole was opened at this location, the pike struck a live minnow immediately and this time was caught and the transmitter recovered.

The relative ease with which northern pike with transmitters were recovered demonstrated the high vulnerability of radio-tagged fish to angling. Because of this vulnerability and the possible misuse of radio transmitters, the Wisconsin Department of Natural Resources promulgated Statute NR 20.07, which states that no person may use a telemetry device attached or implanted in fish to aid in fishing.

The use of this procedure by fisheries personnel demonstrated the accuracy that can be achieved in locating fish, which in Potato Lake under ice cover was conservatively estimated to be within 3-6 ft, based on our results in capturing the radio-tagged pike.

Capture of the radio-tagged fish at the end of the study permitted observations on the effects of fish tagging. Inspection of the 3 recovered pike indicated that the external sutures (non-dissolvable) were intact and the incision had healed with no evidence of infection. Internally, radio tags were partly encapsuled by connective tissue, a defensive reaction of the pike's body to a foreign object. No other internal abnormalities were noted.

The use of an ice bar or auger to open holes in 3-5 inches of ice did not appear either to incite pike in 7-9 ft of water to leave the immediate area or to prevent them from feeding. Also, the 2 northern pike that were not hooked the first time they took the bait did not become wary and attempted to feed again shortly.

SUMMARY

1. Northern pike preferred habitats associated with aquatic macrophytes at depths of 5-10 ft from 1 October to 23 December in Potato Lake.

2. Strong association of pike with vegetated areas may have been related to presumed higher density of prey items in littoral zones.

3. Nontypical movement of pike away from and back to vegetated areas during freeze-up may have resulted from cold water temperatures caused by strong winds.

4. Activity areas of pike were generally up to 11 acres in periods of both open water and ice cover, but the pike also moved extensively.

5. Daily movement under the ice declined substantially after sunset (4:30 p.m.) and increased again at sunrise (7:00 a.m.).

6. Movement rates suggest that pike are generally inactive during diurnal periods in terms of time actually spent swimming; however, relocations are common.

7. The use of angling to recover active transmitters demonstrated the ease with which a specific fish in a known location can be caught, and provides support for Wisconsin Statute NR 20.07, which prohibits use of telemetry for sport fishing purposes.

APPENDIX TABLE 5. Fish species in Potato Lake, Washburn County, 1984.

Common Name	Scientific Name
Brook trout	*Salvelinus fontinalis*
Northern pike	*Esox lucius*
Golden shiner	*Notemigonus crysoleucas*
Common shiner	*Notropis cornutus*
Spottail shiner	*Notropis hudsonius*
Bluntnose minnow	*Pimephales notatus*
White sucker	*Catostomus commersoni*
Black bullhead	*Ictalurus melas*
Yellow bullhead	*Ictalurus natalis*
Brown bullhead	*Ictalurus nebulosus*
Rock bass	*Ambloplites rupestris*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Largemouth bass	*Micropterus salmoides*
Black crappie	*Pomoxis nigromaculatus*
Iowa darter	*Etheostoma exile*
Johnny darter	*Etheostoma nigrum*
Yellow perch	*Perca flavescens*
Walleye	*Stizostedion vitreum*

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