FISHERIES SESSION

WINTER MOVEMENT OF FLORIDA AND NORTHERN LARGEMOUTH BASS NEAR A HEATED EFFLUENT[1]

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Abstract: Winter home ranges and movements of northern and Florida largemouth bass *(Micropterus salmoides salmoides* and *M. s. floridanus)* in a heated cove of Boomer Lake, Oklahoma, were estimated by using ultrasonic telemetry. Within the heated cove, individuals of both subspecies (3 northern, 2 Florida) occupied home ranges that appeared to be related to the distribution of heated water, cover, current, depth, and food. Other fish of both subspecies left the heated cove and did not return. No periodic migrations into or out of the heated cove were observed, although tagged bass frequently moved among several limited areas of cover within the cove. No clear behavioral differences between subspecies were found that might explain the lower over-winter survival of Florida largemouth bass in Boomer Lake, but it appeared that mortality was not due solely to low temperature.

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Although the successful introduction of Florida largemouth bass into California (Bottroff and Lembeck 1978) prompted experimental introductions into many areas, this subspecies has not always survived well where winter water temperatures fall below those present in its native range (Chew 1975). If Florida largemouth bass, having evolved in a subtropical environment, are more warm-stenothermal than the northern subspecies, as suggested by Rieger and Summerfelt (1978), the Florida subspecies might survive in colder climates if stocked in areas of reservoirs warmed by power plant effluents. Although the introduction of an exotic may be evaluated by studying its growth and survival, the reasons for success or failure are not evident. However, suitability of the new environment might be apparent from the details of an organism's behavior there (Winter 1977).

Our study was designed to compare the winter movements of ultrasonically tagged Florida and northern largemouth bass in a small heated reservoir. Our objectives were to (1) ascertain differences in movement between the subspecies that might help explain the lower overwinter survival of Florida largemouth bass in Boomer Lake (Rieger and Summerfelt 1978, Nieman and Clady 1979), (2) estimate winter home range, the area over which an individual fish's movements are normally confined (Burt 1943, Hayne 1949), and (3) determine factors that influenced the area and shape of a home range, and movements within it.

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STUDY AREA

Boomer Lake (Fig. 1-A), located in the City of Stillwater, Payne County, Oklahoma, is a shallow, turbid, windswept reservoir with a surface area of 102 hectares, a shoreline length of 13.8 km, and mean and maximum depths of 3.0 and 7.6 m (Craven and Brown 1970). Little shoreline cover is present except in the narrow upper end. Boomer Lake Power Station supplies 9 to 23 megawatts of electricity per hour to the City of Stillwater and uses 76 to 103 m^3 of cooling water per minute. Water is withdrawn through a deep intake near the dam and is returned to a small cove on the southwest side of the lake through a 305-m concrete flume. Water is typically heated 4 to 6.5 ° C as it passes through the plant (Rieger 1976). Surface isotherms (Fig. 1-B) and vertical temperature profiles (unpublished data) indicate that heated water is usually confined to the effluent cove in winter by prevailing northerly winds and a long shallow point at the mouth of the cove; temperature increases were rarely detectable 50 m outside the cove. Heated water circulates within the cove as an ill-defined surface stream that overrides deeper water, which is at or near ambient temperature. Cover is provided by several brush piles and by large boulders used to disrupt the effluent (Fig. 1-B).

METHODS

Ultrasonic tags (K-Dan Systems Inc.[4], Tucson, AZ) were 60 mm long, 16 mm in diameter, and weighed 8 g in water. The tags had a life-span of 12 to 14 months and were identified by tag-specific pulse intervals (seconds/10 pulses). Tags were implanted in the coelom of fish 250 to 330 mm long, using the procedures of Hart and Summerfelt (1975). No data were collected for at least 24 hours after release because of possible erratic post-operative behavior (Warden and Lorio 1975, Winter 1977, Prince and Maughan 1978).

Receiving gear consisted of a Smith-Root, Inc.[4] (Vancouver, WA) TA-25 or K-Dan Systems receiver and a Smith-Root SR-70-H hydrophone. On 2 or 3 days per week from late December 1977 to early March 1978, weather permitting, fish were located by triangulation and the time of day and water temperature profile at each location noted. On each day, searching continued until all fish were located or until the entire ice-free portion of the lake was covered. During one 24-hr period in early February, locations of all fish were continuously determined at approximately 15-min intervals.

Locations in the effluent cove and main lake were plotted on maps gridded with squares representing 16 m^2 and 400 m^2, respectively. These scales reflected relative tracking and mapping precision, so that error from these sources was small compared with the total movement or area of a home range. We estimated the shape of home ranges by using the maximum-area polygon method described by Odum and Kuenzler (1955) and modified by Winter (1977). Area of home ranges was calculated by hand in a fashion analogous to Winter's (1977) computerized method.

RESULTS

Ultrasonic transmitters were implanted in 5 northern and 5 Florida largemouth bass collected by electrofishing in the effluent cove over a 10-day period beginning in late December. However, 3 of the fish moved into ambient areas under the ice sheet over the main lake and were never recaptured or located. One Florida largemouth bass died or shed the tag in early February and was omitted from further consideration. One northern largemouth bass (NX; Table 1, Fig. 2) could not be positively identified as either N3 or N4 because the tag's pulse interval changed. The other member of this pair was released at the effluent and was never relocated. Consequently, home ranges were determined for only 5

[4]Reference to trade names does not imply government endorsement of commercial products.

Table 1. Descriptions, locations, and home ranges of largemouth bass implanted with ultrasonic transmitters in Boomer Lake, December 1977 to March 1978.

Subspecies of largemouth bass and identification no.		Length (mm)	Weight (g)	Monitored (days)	No. of locations determined: Different days	No. of locations determined: Total times	Estimated home range (ha)
Northern							
N1		330	>500	65	21	43	0.25
N2		279	300	59	11	32	0.44
	N3	287	390				
NX[1]				28	9	11	0.20
	N4	270	260				
Florida							
F1		320	430	51	14	41	0.47
F2		315	425	55	10	21	0.07

[1]Bass NX could not be positively identified as either N3 or N4 because the tag's pulse interval changed.

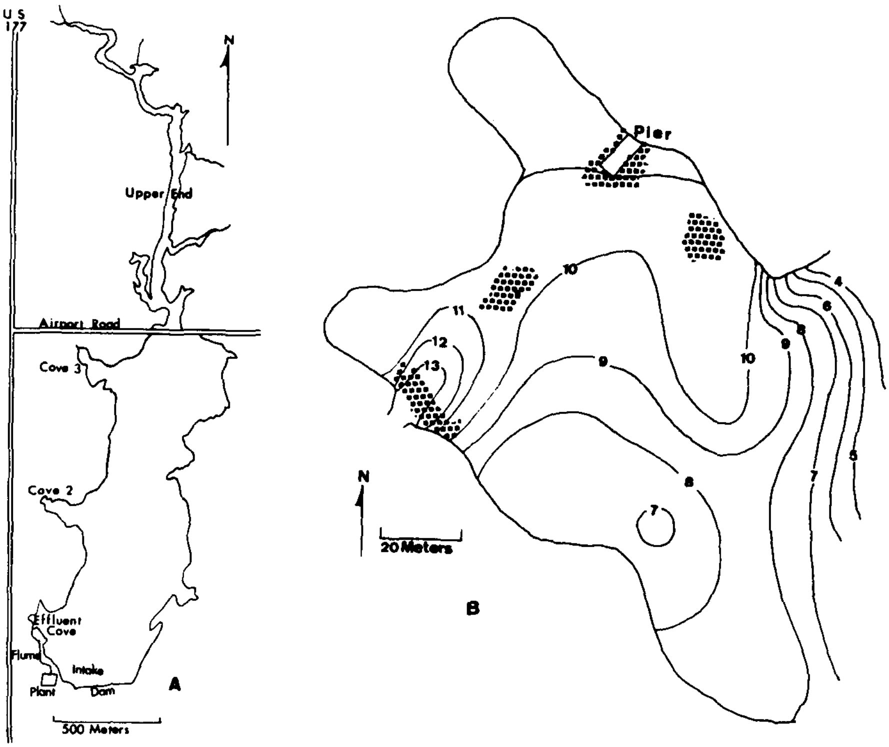

Fig. 1. Boomer Lake (A) and effluent cove (B) with representative surface isotherms (3°C) in mid-winter and areas of cover (stipled).

bass, 3 of the northern (N1, N2, NX) and 2 of the Florida form (F1, F2). Winter ranges of N1 and N2 were confined to the effluent cove. Both remained in cover for long periods, but N2 was more active, as shown by the greater number of locations occupied by it in various areas (Fig. 2). Fish NX, the only one to move far from the effluent cove and then return, was first located near the mouth of cove 2 (Fig. 1-A). Inclusion of this location would increase the home range from 0.20 to 1.72 hectares.

The home ranges of both Florida largemouth bass in the effluent cove were roughly similar to those of northern largemouth bass (Fig. 2). Although F2 typically moved to areas of cover that other tagged bass also used, the estimate of the area of its range while in the effluent cove may have been too low. In early February F2 moved to the dam where ambient temperature was 4° C. Although this movement appeared to be a shift in home range, inclusion of this location would increase the estimated home range from 0.07 to 2.2 hectares. After release, Fl moved just outside the cove where ambient water temperature was 7° C, but returned to the cove after the onset of cold weather. When in the cove, both Florida largemouth bass were most often located near the mouth of the effluent.

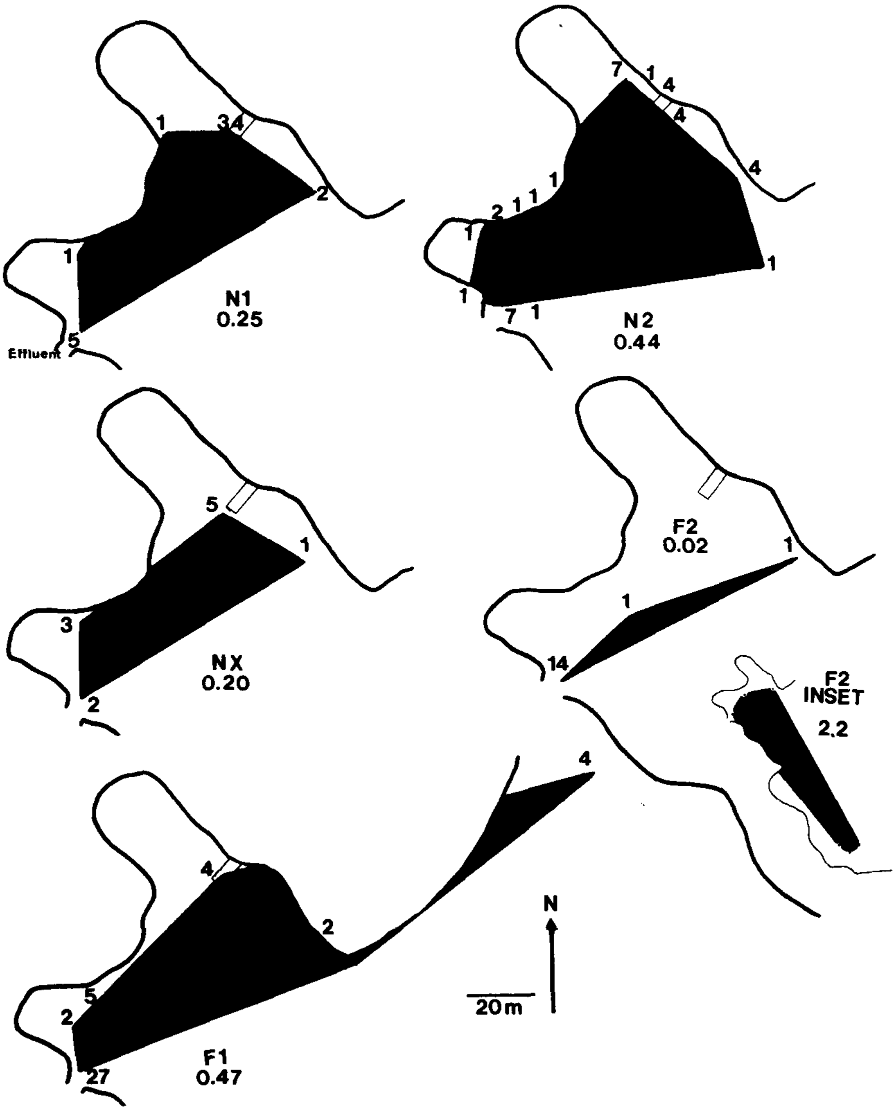

Fig. 2. Home range maps of Florida (F) and northern (N) largemouth bass. Numerals below the fish identification number indicate the area of the home range (shaded) in hectares. Numerals near the edge of the home range represent number of observations at each site. Map of home range of fish NX does not include early locations outside the effluent cove. Inset in the map for fish F2 depicts shape and size of range if locations near the dam are included.

Although we searched both mornings and afternoons and over one 24-hour period, no short-term excursions from the effluent cove were detected. Movements within the cove were from one area of cover to another. When bass were not moving they were usually found directly in cover.

DISCUSSION

Telemetry can provide more frequent observations and also eliminate the bias from gear avoidance and disturbance of fish associated with conventional tag-recapture studies of movement. However, telemetric studies can also be biased if transmitters affect behavior. Although trauma from capture, surgery, and possible infection can be minimized by careful technique, the presence of a transmitter may still affect behavior, particularly if a fish is small in relation to the size of the transmitter. Nevertheless, transmitters have been successfully implanted into white crappie *(Pomoxis annularis)* just large enough to accept them (Rumancik 1977). Inasmuch as a study by Gallepp and Magnuson (1972) showed that bluegill *(Lepomis macrochirus)* compensated for additional masses up to 2 percent of body weight within 24 hours, the largemouth bass probably were able to adjust similarly.

All largemouth bass for which home ranges were estimated showed no signs of being adversely affected by the transmitter. Several were recaptured by electrofishing (N1, N2, Fl) or caught by a fisherman (F2). Freshly ingested food was found in their stomachs and N1(a female) was sexually mature when recaptured in the spring. In late February, fish Fl was found dead after receiving a fresh, severe wound of unknown origin across the back. Previous observations on this bass were considered reliable because the surgical incision had been healing normally. Because tagged largemouth bass fed and moved about in an apparently normal manner and appeared to be in good condition when recaptured, we concluded that largemouth bass 270 mm or longer could be successfully implanted with the transmitters used in this study.

In Boomer Lake, some individuals of both subspecies had home ranges in the heated cove, whereas others left the heated area and did not return. Under these circumstances, warm-stenothermal Florida largemouth bass may not survive as well as northern largemouth bass because both subspecies used unheated areas in winter. Florida largemouth bass survived exposure to 4-7° C water for periods up to several weeks, however, and it did not appear that their distribution was limited by thermal loading. Concurrent studies of G. Wright (personal communication) in recently constructed and unheated Dripping Springs Lake, Oklahoma, determined that the overwinter survival of Florida largemouth bass was as high or higher than that of northern largemouth bass, despite prolonged low temperatures in that lake. Although Florida largemouth bass may have preferred the warmer water in Boomer Lake, as suggested by the large number of times they were located near the effluent mouth and by the higher catch rates (seining and electrofishing) reported for this subspecies in heated areas (Nieman 1978, Rieger and Summerfelt 1978), it appears that other factors—probably food, predators, and currents—operate independently and synergistically with each other and with temperature to influence the use of the effluent (Neill and Magnuson 1974, Dupont 1976).

Temperature has been considered the primary factor governing the use of thermal effluents by fishes (Neill and Magnuson 1974). Unfortunately, vertical heterogeneity of temperature in the effluent cove prevented determination of the exact temperature at which a fish was living. The shapes of the home ranges of largemouth bass in the effluent cove also appeared to be related to the distribution of cover and depth. Depth appeared to be important because largemouth bass never occupied the shallow flats ($<$ 1 m deep) near the shore of the cove. However, it was impossible to determine which factors most influenced the size and shape of home ranges because the distribution of heated water, current, cover, and deeper water overlapped considerably. Winter (1977) and Warden and Lorio (1975) found that home ranges of largemouth bass always contained cover. Largemouth bass in the present study occupied areas of cover for extended periods.

Dupont (1976) reported that high forage abundance near the thermal outfall in Par Pond, South Carolina, may have attracted largemouth bass to the effluent. Also, Prince and Maughan (1979) found that largemouth bass were apparently attracted to submerged reefs in Smith Mountain Lake, Virginia, by high densities of forage. Mississippi silversides *(Menidia audens)* concentrated in high numbers at the Boomer Lake outfall (Nieman 1978) and the combination of high prey abundance and elevated temperatures may have contributed directly to the common occurrence of recently consumed fish in stomachs of largemouth bass during the winter. Surface feeding activity was frequently observed in the heated plume, and movements to the effluent by tagged largemouth bass may have been forays in search of food.

Home ranges of largemouth bass in Boomer Lake in winter were about the size of primary areas occupied by largemouth bass in Mary Lake, Minnesota, in summer (Winter 1977). Warden and Lorio (1975) observed that largemouth bass were stationary from November to January in Loakfoma Lake, Mississippi, probably because lower metabolic rates in winter reduced activity and size of the home range. Areas of home ranges of largemouth bass in Boomer Lake were not measured in spring and summer, but the recapture of N1 about 600 m from the effluent cove in April suggests that ranges expanded as ambient water temperatures increased. Prince and Maughan (1979) found that movement of largemouth bass in a Virginia reservoir was much greater during spring and fall than during winter.

Areas of home ranges of largemouth bass reported here and elsewhere (Warden and Lorio 1975, Dupont 1976, Winter 1977) vary greatly. Maps presented by Dupont (1976) show that largemouth bass moved about in areas in Par Pond that often exceeded 100 hectares. This variation in home range size in different bodies of water may represent unique adaptations to particular environments and demonstrates plasticity within the species. As more telemetry studies on largemouth bass are completed it should be possible to describe in greater detail the relation between environmental factors and formation of home ranges.

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