Distribution and Habitat Selection of Telemetered Northern and Florida Largemouth bass in 2 Small Texas Impoundments

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Abstract: Twelve adult fish, three each of northern and Florida largemouth bass (*Micropterus salmoides* and *M. s. floridanus*) in each of 2 approximately 2-ha impoundments were implanted with ultrasonic transmitters and located over a period of 1 year to determine if distributional differences existed between the subspecies and to determine what factors might be responsible for any observed differences. Home range was beween 0.37 and 1.11 ha for all individuals. Average home range sizes were similar between subspecies and ponds. However, Florida bass generally made intensive use of small areas (i.e., usually <0.2 ha) within their home ranges while northern bass locations were more evenly distributed throughout their home ranges. Activity centers, within home ranges, rarely overlapped those of other tagged fish and seasonal shifts in their location were not apparent. Selection of water depths and type of cover was similar for both subspecies and reflected availability within the ponds. No consistent relationship was found between fish location and water temperature, dissolved oxygen or weather conditions. Except for the difference in size of intensively-utilized area, subspecies differences were less pronounced than differences between ponds. Differences between ponds appeared to be related to differences in water clarity, cover and forage availability.

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Fishery management programs have resulted in widespread introduction of Florida largemouth bass (hereafter referred to as FLMB) into established populations of northern largemouth bass (hereafter referred to as NLMB). Research in Texas and elsewhere has focused on subspecific differences, especially in anatomy, growth, and other physiological characteristics. Where the 2 subspecies coexist, behavioral differences become particularly important to fishery management as the differences impact intergradation, habitat partitioning, and harvest.

This telemetry study was designed to compare intra-habitat distribution of coexisting FLMB and NLMB in 2 ponds and thereby to determine whether habitat partitioning occurred. Of the several previous telemetry studies of largemouth bass, only Neiman and Clady (1982) investigated coexisting stocks of the 2 subspecies. Their study, concerned with winter distribution of the subspecies in a thermal outfall in Oklahoma, indicated no clear behavioral differences. However, subspecific differences in catchability (Zolcynski and Davies 1976, Rieger and Summerfelt 1978) indicate the existence of behavioral differences that may be related to distribution of the subspecies within impoundments. Largemouth bass distribution appears to be affected by cover, depth, and distance offshore as well as by food and water temperature (Winter 1977, Prince and Maughan 1979). For these reasons, our study used ponds which provided FLMB and NLMB with a variety of choices in types of cover, water depths and distances offshore. Also, we determined the location of the fish for a period of about 1 year, making possible a description of seasonal variation in distribution.

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Methods

Two adjacent small impoundments, 1.6 and 1.7 ha in surface area, were used for this study from August 1981 through July 1982. These ponds were located in Falls County, Texas, in the blackland prairie section of the Brazos River drainage basin. Each pond had well-established populations of both largemouth bass subspecies, marked FLMB adults having been introduced in 1979. However, the 2 ponds differed in bottom topography and water quality. The upper pond, the smaller and older (built ca. 1930) of the 2, was representative of the shallow basin-shaped watershed pond common throughout Texas; in contrast, the lower pond, built in 1978 specifically to favor bass production, had many deep holes, shoals and shallow cuts in the banks. Maximum depths of the upper and lower ponds were 2.5 m and 5.5 m, respectively.

The upper pond had a substrate of organic and inorganic sediment and was relatively turbid (mean annual secchi disc transparency of 92 cm); the lower pond had a hard clay bottom and remained clear (mean annual secchi disc transparency of 135 cm). Submerged vegetation was controlled in the upper pond, and a plankton bloom was normal during most of the year. No such control occurred in the lower pond and submerged vegetation, primarily *Chara* sp., extended to the 2.0 m depth contour for most of the year.

Table 1. Total length of fish, area of home ranges in hectares and adjusted area after omitting obvious excursions, and number of locations made during the study.

Pond	Subspecies	Fish	TL (mm)	Maximum area (ha)	Adjusted area (ha)	Number of locations
Upper	Florida	81.0F	378	0.86	0.44	27
		86.0F	347	1.10	0.65	28
		110.1F	355	0.37	0.14	25
		mean		0.78	0.41	
	Northern	92.0N	436	1.00	1.00	26
		100.7N	417	1.11	1.11	27
		106.9N	502	0.83	0.52	27
		mean		0.98	0.88	
	Both	mean		0.88	0.65	
Lower	Florida	76.3F	397	0.40	0.20	27
		83.9F[a]	349	0.43	0.43	20
		103.7F	350	0.93	0.93	29
		mean		0.59	0.52	
	Northern	72.7N	497	0.92	0.92	25
		88.4N	417	0.97	0.97	25
		94.8N	523	—	—	0
		mean		0.94	0.94	
	Both	mean		0.73	0.69	

[a]*Fish 83.9F was removed 3 months prior to termination of the experiment.*

Cover in the 2 ponds differed greatly. About 40% of the upper pond's shoreline had cut or fallen trees extending into the water. In contrast, the lower pond was almost devoid of such shoreline structure. Aquatic macrophytes and Christmas tree reefs were established near shore and in open water in order to provide cover. A more detailed description of the study area can be found in Betsill (1983).

Twelve adult fish, 3 each of the Florida and northern subspecies were collected from each of the ponds in August 1981, by angling and electrofishing. The range of lengths was 347–523 mm (Table 1), with FLMB average lengths slightly smaller than NLMB. Transmitters were implanted into the body cavity using surgical techniques described by Harvey et al. (1984). The time from capture to release (at the capture site) ranged from 18 to 45 minutes (mean of 26 minutes). Surgery averaged 7 minutes per fish. Temperature-sensitive ultrasonic transmitters (D. L. Brumbaugh, 2618 W. Calle Tonala, Tucson, AZ) measured 15 mm × 60 mm and weighed about 8 g in water. Each transmitter produced a signal with a frequency unique to that transmitter. Individual transmitters were identified with the use of directional hydrophones and a direct conversion ultrasonic receiver. Each fish was designated according to its frequency followed by N or F, indicating subspecies.

Attempts were made to obtain 1 telemetry location per fish at intervals of approximately 10 days for 1 year. Six permanent buoys were established in each of the ponds. All locations were made during daylight hours by triangulation from 2 boats positioned at 2 permanent buoys at which strong signals were received and good angles occurred for triangulation. These buoys also served as stations for collection of environmental data. Bearings on the maximum signal strength were taken by means of sighting compasses.

Whenever possible, we determined if the target fish was moving or stationary. A moving fish was considered one for which the direction of the signal changed over the 1 to 5 minute observation period with respect to at least one of the observers; variation in signal strength was not considered a reliable means of detecting movement. Chi-square tests were used to compare the proportions of observations categorized as "stationary" versus "moving."

After all fish within a pond had been located on a given visit, environmental data were collected. Secchi disc transparency, surface pH and temperature and dissolved oxygen profiles (0.5-m intervals) were taken at 1 to 4 stations in each pond: Weather conditions, such as cloud cover and wind direction, were noted on each sampling date.

For each fish, chronologically linked fixes (CLF) over the entire study period were plotted on a depth-contour map of the pond. Individual fixes which fell immediately outside the boundaries of the pond were arbitrarily placed at the nearest point within the pond 1 m offshore. The CLF were used to determine location of home ranges and to detect seasonal shifts in distribution; distance between successive CLF provided a measure of variation in fish location over approximately 10-day intervals (= "ranging"). The minimum area convex polygon method (Odum and Kuenzler 1955) was used to estimate home range size. An adjusted home range size estimate was calculated by omitting apparent excursions and then using the minimum area convex polygon method on the remaining CLF points. Two sample t-tests were used to compare home range size between ponds and subspecies.

Parameters of habitat selection—distance offshore, water depth and association with cover—also were estimated from the CLF plots. A fish was considered to be associated with cover if it was within 5.0 m of fallen trees, reefs, weed beds, or piers.

Results and Discussion

General

Tracking began immediately after tagging but data collected prior to 26 August 1981 in the lower pond and 20 September 1981 in the upper pond were excluded from analysis to discount any effects of tagging trauma. Sampling continued through late July 1982, when the transmitters began to fail.

On any sampling date we could expect to locate all fish in the upper pond. Aquatic vegetation in the lower pond made location of fish there considerably more difficult. The NLMB were consistently harder to find than FLMB in the lower pond. The number of locations per fish ranged from 25 to 29 (Table 1).

Ten of the 12 telemetered fish survived the entire study. One fish, 94.8N, ceased movement in October 1981, and was considered to have died or shed the transmitter. The transmitter could not be retrieved, so to avoid bias associated with behavior of dying fish as described by Manns (1981), data for this fish were discarded. Another fish, 83.9F, was removed by fishermen in late April 1982. Data collected up to that time were considered valid.

Although transmitters were temperature-calibrated immediately prior to implantation, temperature data from the transmitters were too often inconsistent with the temperature profiles. Because calibration of the transmitters changed over time and transmitters were not recovered for recalibration at the end of the study, only data derived from temperature profiles were used.

Home Range, Activity Centers, and Ranging

Morphology of home range varied among individuals, but home range size was between 0.37 and 1.11 ha for all individuals (Table 1). This was consistent with reports of summer home ranges between 0.3 and 1.4 hectares for NLMB in a 22.6-ha lake in Minnesota (Winter 1977) and in bayous and canals in southern Louisiana (Doerzbacher 1980). However, home ranges in our study were generally larger than winter home ranges of NLMB and FLMB in a power-plant cooling reservoir in Oklahoma (Nieman and Clady 1982). Chappell (1974) suggested that home range size is positively correlated with size and age of fish. However, within the relatively narrow range of total lengths of fish in this study, there was no discernible relationship between fish size and home range size.

Average home range sizes for fish in upper and lower ponds were 0.88 and 0.73 ha, respectively. These values were not statistically different ($P > 0.05$), nor were sizes of adjusted home ranges significantly different ($P > 0.05$).

Average home range size for FLMB was 80% and 63% that the northern subspecies in the upper and lower ponds, respectively. Although these values were not statistically different, the CLF strongly suggest that the subspecies did differ in area of the ponds utilized.

The minimum area convex polygon method of home range estimation does not indicate areas of intense use, but CLF (Figs. 1, 2), developed to show locations of fish throughout the study period, indicate that the FLMB generally occupied small areas, usually <0.2 ha. Excursions were documented from these activity centers but the location of the activity center persisted throughout the study. NLMB were more likely to have multiple activity centers and correspondingly larger mean distances between consecutive locations (Fig. 3). Even though the ranges of the mean distances overlap considerably, consistency of the differences in the means indicates that over the study period FLMB ranged less than NLMB in both ponds. This phenomenon, due to its implicatons for sampling and management of largemouth bass populations, warrants further investigation.

Seasonal shifts in home range locations, as suggested by Winter (1977), were not apparent for any of the fish in this study. Within ponds, seasonal trends in ranging were similar for both subspecies (Fig. 3). In the lower pond, ranging by each subspecies peaked in fall and was lowest in spring and summer. In the upper pond, NLMB ranged more in spring and summer; FLMB ranged more in winter,

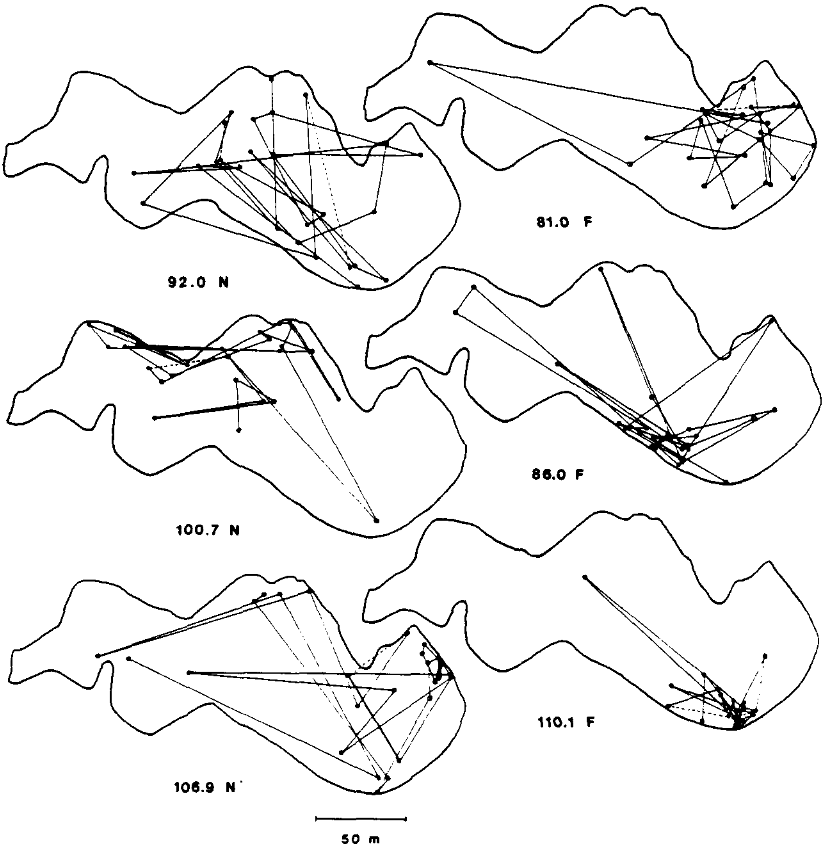

Figure 1. Chronologically linked fixes for the 3 FLMB and 3 NLMB in the upper pond. Dashed lines connect fixes separated by more than 14 days.

spring and summer. Whereas there was a decrease in ranging during winter by NLMB, FLMB increased the mean distance between consecutive locations over that during the fall. This discrepancy can be accounted for by the fact that during the winter FLMB in the upper pond moved to deeper water offshore, while NLMB generally remained in shallow water.

Seasonal trends in ranging of the fish were not similar between ponds. In the upper pond, ranging generally increased as the seasons progressed from fall to summer while in the lower pond ranging decreased over the same time period. This suggests that seasonal patterns of ranging are influenced more by the characteristics of the habitat than by subspecies.

Although home ranges of tagged fish overlapped considerably, visual inspection of location fixes indicated that activity centers of the tagged fish rarely overlapped spatially or temporally. However, physical characteristics of activity centers

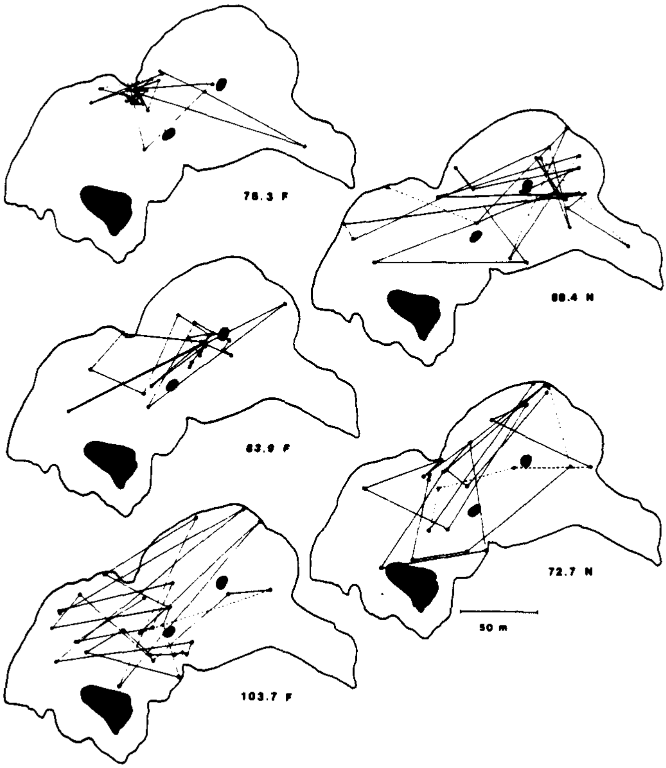

Figure 2. Chronologically linked fixes for the 3 FLMB and 2 NLMB in the lower pond. Dashed lines connect fixes separated by more than 14 days.

were similar for all fish in a pond. In the upper pond these centers were generally associated with fallen and cut trees along the shoreline. Activity centers in the lower pond were associated with artificial reefs, small islands, and shoals. Use of activity centers apparently did not reflect seasonal changes in distribution except when fish were spawning and certain fish, presumably males on nests, formed new activity centers for up to 4 weeks.

No consistent relationship existed between water temperature and distance between consecutive fixes. Average epilimnetic water temperature seldom differed by more than 1° C between ponds; therefore, temperature was less important than differences in morphometry and cover in accounting for between-pond differences in ranging of fish.

Surface dissolved oxygen in the upper pond fell below 6.0 mg/liter on 8 of 10 sampling dates between 3 April and 15 July 1982,and dropped below 5.0 mg/liter on 1 date. Three NLMB and 2 FLMB made excursions or shifted their activity centers to areas with higher oxygen levels on the latter date but most had returned

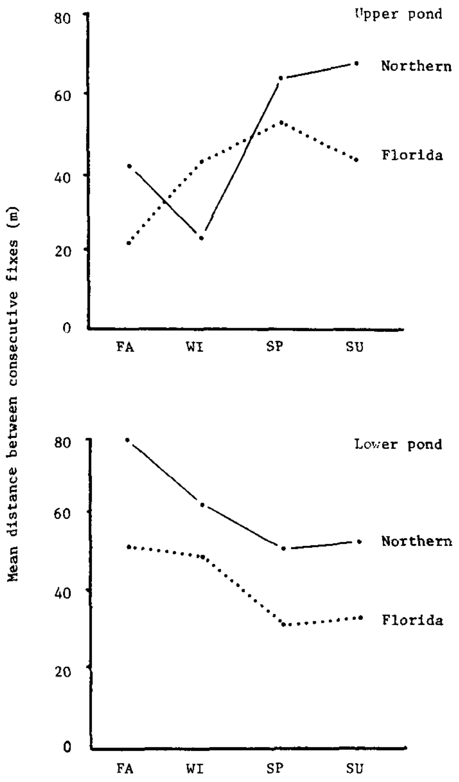

Figure 3. Seasonal mean distances between consecutive fixes (m) for fish in each pond.

to their original activity centers by the next sampling date, even though oxygen levels were still below 6.0 mg/liter. This type of behavior was not seen at levels above 6.0 mg/liter. However, the distribution of these fixes could not be distinguished as being non-random, and the data should be considered only suggestive of avoidance behavior at low dissolved oxygen.

The number of locations for which fish were stationary was not significantly different between subspecies or ponds. No relationship was found between wind direction or cloud cover and whether fish were moving.

Water Depth and Distance Offshore

Over the entire study period, utilization of various water depths by largemouth bass generally followed availability of depths (Fig. 4). In the upper pond, fish showed a preference for water <1.0 m deep which probably reflects the fact that most of the cover was within the 1.0-m contour. In the lower pond, where cover (other than aquatic vegetation) primarily occurred at depths between 1.0 m and 3.0 m, there was no attraction to water shallower than 1.0 m. During much of the year, depths of <1.0 m were far inside the extensive weedbeds.

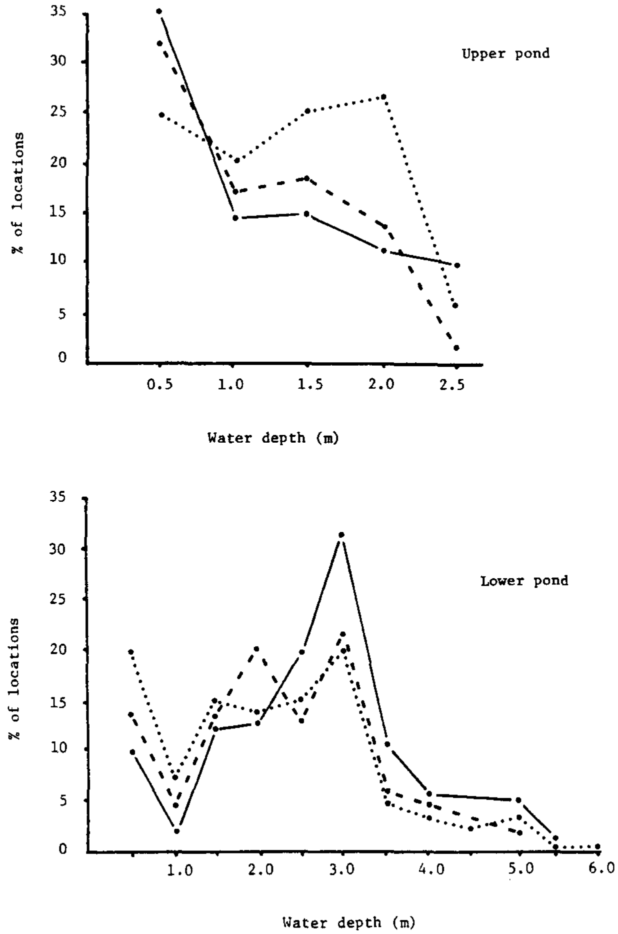

Figure 4. Distribution of water depth of fish locations in each pond. The solid line represents FLMB and the dashed line represents NLMB. The dotted line shows the distribution of available depths.

In this study, movement to deeper water during winter, as reported by Lewis and Flickinger (1967) and Prince and Maughan (1979), was evident for some fish. In the upper pond, the 3 FLMB and 1 NLMB moved to deeper water in winter. The other 2 NLMB remained in shallow water. In the lower pond, FLMB showed no change in depth distribution during winter while NLMB rarely occupied shallow water. Movement to deeper water in the lower pond was first noticed at a water temperature of 15° C, whereas similar movements in the shallow upper pond were not apparent until water temperatures were below 7.5° C. Fish which moved into deeper water had returned to their prior range before water temperature rose to 15°

Table 2. Percent of total observations in various habitat types.

	N	% in shoreline brush	% in open water reefs	% in vegetation	% in cover	% in open water
Upper pond						
FLMB	80	49	5	3	57	43
NLMB	80	53	6	4	63	37
Lower pond						
FLMB	77	8	22	25	55	45
NLMB	50	4	18	44	66	34

C. Except during winter, mean distance offshore was similar for both subspecies in both ponds.

Use of Cover

Approximately 33% of the upper pond surface area was within 5 m of some form of cover. Fallen trees along the shore were by far the most abundant form of cover, followed by small brush piles in open water. Emergent vegetation was probably too dense to provide suitable cover for the fish. Fish of both subspecies used areas of cover more than they did areas devoid of cover (Table 2). NLMB had a slightly higher percentage of locations associated with cover than did FLMB.

Results were similar for the lower pond, where 56% of the surface area was within 5 m of cover. As in the upper pond, NLMB had a slightly higher percent occurrence in cover than did FLMB; weed beds (the most prevalent form of cover) were used more than any other form.

The relative use of cover in the 2 ponds again points out the effects on behavior of difference between the ponds. In the upper pond, overall use of cover was extremely disproportionate (approximately 60% association with 33% of the pond's area). In contrast, largemouth bass in the lower pond used cover and open water in almost the same proportions as these habitat types occurred. These differences may be related to differences in composition of the cover, but may also have been related to other factors such as water clarity and food availability.

Forage Availability and Water Clarity

Forage availability and water clarity may have played an important role in determining the distribution of fish in our study. Electrofishing (unpubl. data) indicated that bluegill (*Lepomis macrochirus*) was the most abundant forage species in the study ponds. Condition of largemouth bass was higher in the upper pond ($K_{TL} = 1.41$) than lower pond ($K_{TL} = 1.30$) during the study period. Size distributions of bluegill indicated that more forage was available in the upper pond than in the lower pond. Consequently, fish in the upper pond may have ranged less than fish in the lower pond (eg., Savitz et al. 1983), especially during summer when small bluegill are present. However, if water clarity is also considered ranging might be decreased during periods of high water clarity since fish should be more successful at locating forage. Data presented in Figure 3 show that for the lower pond during summer, when water clarity and demand for food were greatest, fish ranged less than when water clarity was low. Similarly, ranging increased in the upper pond during spring and summer when water clarity was reduced.

Interacting Factors in Largemouth Bass Distribution

It is obvious that the factors discussed thus far were not acting independently to affect distribution of fish, nor are they the only factors involved. Instead, a wide range of environmental parameters, working together, determined distribution within a body of water.

Results of this study indicated that cover (availability and type), subspecies, morphology of the impoundment, and probably forage availability were the major factors which interacted to produce the observed distribution of fish in these 2 impoundments. In contrast, temperature and dissolved oxygen levels had minimial or, more likely, indirect effects on distribution. Water temperature is known to affect such physiological responses of largemouth bass as feeding and intiation of spawning activity (Coutant 1975) and in this manner indirectly affects behavior and distribution. However, the only change in distribution which we directly related to water temperture was the movement of some fish to deeper water during the coldest part of winter.

Cover was apparently most important in determining distribution of fish in these ponds. Cover near shore was apparently preferred to that offshore and particularly affected selection of activity centers. It is not known whether cover was used because it provided shade, or concentrated forage fish, or for a combination of factors. It is this relationship of cover to fish that may hold the key to differences seen between subspecies in this study.

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