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LONG RANGE MOVEMENT AND HOMING BY LARGEMOUTH BASS (*MICROPTERUS SALMOIDES*) IN A THERMALLY ALTERED RESERVOIR.—Par Pond is an 1,120 hectare cooling reservoir for a nuclear production reactor, located near Aiken, S.C. Water temperatures in the reservoir vary seasonally and with changes in reactor power levels. Mean maximum temperatures at the heated end of Par Pond (Fig. 1) generally exceed those in ambient areas by about 10 C. Bass taken from thermally altered portions of the reservoir differ in consumption of food items (Bennett and Gibbons, 1971), densities of infection by acanthocephalan parasites (Eure and Esch, 1974), incidence of infection by *Epistylis* sp. and *Aeromonas hydrophila* (the causative agents of red-sore disease, Esch et al., 1976) and body condition. The implication of these studies is that movement of bass between heated and non-heated portions of the reservoir is not extensive and that individuals usually remain within a prescribed area of the lake.

Previous mark-recapture studies in Par Pond, provide evidence for long-range movement in some instances and restricted home ranges in others. For example, Gibbons and Bennett (1973) examined movement between an area adjacent to the inflow of thermal effluent and another area in an ambient temperature location approximately 6 km distant. Of 3,000 bass tagged and released, 95 were recaptured. Five had moved from the thermal to the ambient temperature location and five others had moved from the ambient to the thermal location; each of the other 85 was recaptured at the site of its initial capture. Dupont (1976) observed long distance movement (up to 12 km) by several Par Pond bass in which sonic tags were placed. He indicated that movement was apparently influenced by reactor operations.

The apparent dichotomy of results regarding long-range movement of bass in Par Pond, coupled with an interest in assessing the phenomenon of home range in a thermally altered reservoir suggested the need for additional mark-recapture studies. It was also felt that such an investigation would permit us to either confirm or reject implicit assumptions concerning restricted bass movement in Par Pond in previous studies.

Materials and methods.—From September, 1974 through August, 1975 more than 2,000 largemouth bass, *Micropterus salmoides,* were captured by electrofishing in Par Pond. Approximately equal numbers were taken in heated (HOT-HD, -BB, -OB and -GB; Fig. 1) and ambient areas (COLD-NC, -SS, -CD, -KB, -LL and -DL). Variability in sample sizes at different sites is primarily due to differential time and effort given to electrofishing rather than to disproportionate local densities or amount of surface area sampled. All bass were weighed and total and standard lengths were taken. Fish were marked with a number, color-coded, Peterson tag and released. Bass from HOT-HD, -BB and -OB were released at Site I; bass from COLD-CD were released at Site II; bass from COLD-NC were released at Site III. All other bass were released at the site of capture.

Results.—Of 2,100 bass caught, tagged and released, 188 (8.9%) were recaptured (Table 1); 100 of the recaptures were from thermal sites. Most of the bass from the thermal areas were tagged at HOT-HD ($N = 575$) and released at Site I; 48 (83%) were recaptured at HOT-HD while six (10%) had moved to HOT-BB. Two others were recaptured at HOT-OB, the thermal location across open water from the release site. One had moved down the heated arm to HOT-GB and a single individual from HOT-HD was subsequently recaptured out of the heated portion of the lake. Of the bass tagged in HOT-BB, released at Site I, and subsequently recaptured, 11 (73%) returned to HOT-BB; the others had moved in the other direction from Site I and were caught at HOT-HD. Of the 214 bass caught at HOT-OB and released across the lake at Site I, 25 were recaptured; 14 (56%) returned to HOT-OB, 10 (40%) were caught at HOT-HD and one at HOT-BB. Thus, of 100 recaptures of bass originally tagged and released in heated areas, one (1%) was subsequently recaptured in an ambient location and 99 (99%) were recaptured in heated areas. Furthermore, the majority (75%) returned to the specific site of initial capture, despite being released at a central location.

Of 88 recaptured bass originally caught and tagged at ambient sites, eight (9%) had moved to thermal locations. Of 29 recaptures from COLD-NC, 24 (83%) returned to the same site while four were recaptured at HOT-HD. One had moved to another ambient temperature site, COLD-CD, more than 6 km away. Of the 28 bass tagged at COLD-CD and subsequently recaptured, 24 (86%) were at COLD-CD; one was caught later at COLD-SS and one at HOT-HD. At COLD-SS ($N = 125$), 14 (78%) of 18 recaptures were from the same site; two others had moved to other ambient temperature locations, while two were later caught at HOT-HD. Bass tagged at all other ambient sites were recaptured at the same locations.

A total of 13 (7%) of 188 recaptured bass had moved between nonadjacent collecting sites which were at least 1,600 m apart. Of these, three moved between ambient locations, one moved from a heated to an ambient site and eight moved from ambient to thermal areas (Table 1). The mean total length of bass which had moved long distances was 44 cm; that of bass which were recaptured at the sites of original capture was significantly lower, 39 cm.

Double recaptures were made on 15 bass; 11 were at the original site of capture each time, whereas four had made minor moves to adjacent locations within the heated area. The two triple recaptures had moved long distances (>1,600 m), and then returned to the site of original capture. One moved a distance of 12 km from COLD-NC to HOT-HD between 15 April and 5 June 1975, and was recaptured at COLD-NC on 21 July 1975.

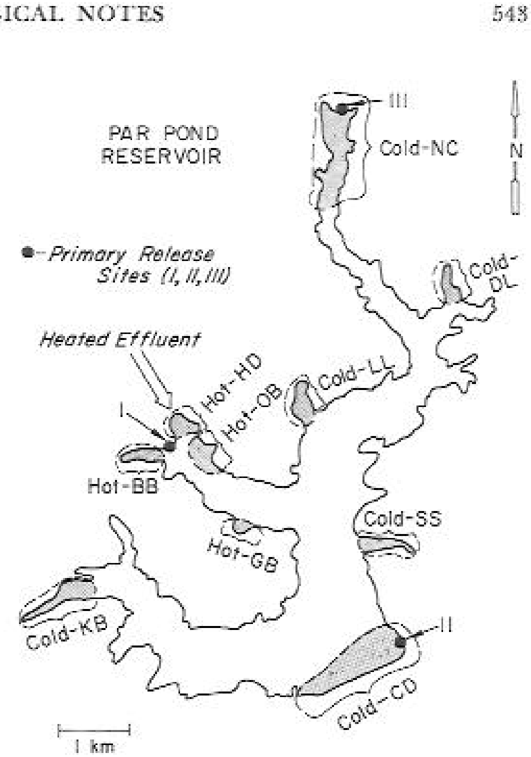

Fig. 1. Map of the Par Pond Reservoir showing collecting sites. Heated sampling sites in the reservoir are HOT-HD, HOT-BB, HOT-OB and HOT-GB; ambient locations include COLD-LL, COLD-NC, COLD-DL, COLD-SS, COLD-CD and COLD-KB. Release sites are marked I, II and III. The shaded areas represent approximate limits for the collecting sites.

Discussion.—The present study supports the findings of others (Hulse and Miller, 1958; Dequine and Hall, 1949; Moody, 1960; McCann and Carlander, 1970) who report that largemouth bass are capable of moving long distances. However, our data suggest that long distance movement by largemouth bass in Par Pond is exceptional rather than characteristic and occurs with greater frequency among larger individuals. Movement between thermal and ambient locations occurred, but infrequently. Furthermore, recorded movement was more frequent from ambient to thermal locations than from heated to ambient. This may explain the contrasting conclusions (Clugston, 1973; Gibbons and Bennett, 1973; Dupont, 1976) about the frequency of long distance movement in Par Pond. A fish of substantial

TABLE 1. NUMBERS AND LOCATIONS OF ORIGINAL CAPTURES AND RECAPTURES OF LARGEMOUTH BASS (*Micropterus salmoides*) FROM A SOUTH CAROLINA RESERVOIR RECEIVING THERMAL EFFLUENT FROM A NUCLEAR REACTOR. See Fig. 1 for locations of code designations. Hot—indicates location in thermal region; Cold—indicates ambient temperature site.

Code designation for capture location	Number captured	Number recaptured	Number recaptured at orig. site	Number recaptured in same temperature region	Number recaptured in different temperature region
HOT—HD*	575	58	48	9	1
HOT—OB*	214	25	14	11	0
HOT—BB*	199	15	11	4	0
HOT—GB	27	2	0	2	0
Total	1015	100	73	26	1
COLD—NC**	333	29	24	1	4
COLD—CD***	331	28	24	2	2
COLD—SS	145	18	14	2	2
COLD—KB	137	11	11	0	0
COLD—LL	68	1	0	1	0
COLD—DL	44	1	1	0	0
COLD—JB	27	0	0	0	0
Total	1085	88	74	6	8

* These bass were released at Site I (Fig. 1).
** These bass were released at Site II (Fig. 1).
*** These bass were released at Site III (Fig. 1).
All other bass were released at the location of initial capture.

size must be used for surgical implantation of sonic equipment in the abdomen. We suggest, therefore, that selection bias for large individuals results in the use of fish which would be more likely to move long distances. Until sonic equipment can be miniaturized further, interpretations of the results from such studies must be cautiously considered.

Displacing bass from their home ranges by releasing at a central location, did not influence the probability of their return to the original capture site except when the release point and the original capture site were separated by open water. Individuals captured at HOT-HD or HOT-BB and released at Site I, had a choice of moving either direction yet more than 80% of those recaptured had returned to their site of original capture. The presence of deep, open water between the release point and the original site of capture appeared to lower the likelihood that bass would return. Thus, only 56% of the bass caught initially at HOT-OB and released at Site I, were subsequently recaptured at HOT-OB. However, 40% were recaptured at HOT-HD which is enroute to HOT-OB, as if a fish were following the shoreline.

A significant aspect of this study relates to earlier (Eure and Esch, 1974) and current work (Esch et al., 1976) attempting to show differences in parasitism between bass from thermal versus ambient locations. These investigations were based on the assumption that exchange of individuals between points within the lake is not extensive, especially between thermal and ambient locations. Results of the present study confirm this assumption.

Yardley et al., 1974, reported that allelic frequencies for selected loci in Par Pond bass did not vary throughout the reservoir. This implies a panmictic population with genetic exchange between areas. Results of the present study do not refute this conclusion as the low percentage of long range migrations observed would permit a level of genetic mixing sufficient to maintain allelic frequencies if strong selective forces are not in operation. Thus, Par Pond probably harbors subpopulations which genetically overlap extensively with those in adjacent areas and partially with other more distant areas of the lake.

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