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DIFFERENTIAL SEASONAL MIGRATION OF THE CRAYFISH, ORCONECTES VIRILIS (HAGEN), IN MARL LAKES [1]

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Abstract

A differential seasonal migration of Orconectes virilis was observed during the summer in West Lost Lake, Otsego County, Michigan, in an earlier study during 1962 and 1963. The present additional observations on O. virilis, during three summers and in three lakes, confirm this migration. Evidence from other areas suggests this movement is a general phenomenon of the species throughout its range. An explanation for seasonal migration is proposed.

Introduction

Many recent observations have been made on the movement of crayfish in streams and ditches (Henry, 1951; Black, 1963; Momot, 1966; Mobberly and Pfrimmer, 1967; Merkle, 1969). Others, Bovbjerg (1956) and Mobberly and Owens (1966), made laboratory

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observations on the relationship between movement and density. These studies were not of sufficient duration to relate the seasonal pattern of movement; none allude to the movement of crayfish in lakes.

Movement of Orconectes virilis in a lake was reported recently by Momot (1967). A differential seasonal migration was noted between May and August in West Lost Lake, Otsego County, Michigan. Our objective is to confirm the validity of this migration as a general phenomenon of the species throughout its range. We have therefore extended our observations of Orconectes virilis to three growing seasons in three lakes. Also, indirect evidence of seasonal movement is presented from other areas of its range. An explanation for this behavior is offered.

Materials and methods

Crayfish were caught in common cylindrical wire minnow traps baited with pieces of fish. Traps were lifted and rebaited every 24 hours. After being processed (sexed, counted, etc.) crayfish were released in the center of the lake.

Camougis and Hichar (1959) demonstrated that O. virilis moved randomly about a pond. Bovbjerg (1953) showed that the extremely aggressive behavior of O. virilis could be duplicated in the laboratory. Based on his laboratory experiments, Bovbjerg (1964) concluded that crayfish dispersal is density related, i.e.,

the rate of dispersal per unit time from a point of release is greatest at the point of greatest density. Therefore, by releasing crayfish at the center of the lake, we feel the crayfish moved in a random manner and were sampled randomly by stationary traps. In 1966, traps in each lake were distributed as follows: seven set at 1.5 m (range: shore--2.2 m), seven at 3 m (range: 2.2-3.8 m), seven at 6.1 m (range: 5.3-6.9 m), eight at 7.6 m (range: 6.9-8.4 m), and six at 9.1 m (range: 8.4-9.9 m). In 1967 and 1968 we set nine in shallow water, nine at 3 m, nine at 6.1 m, four at 7.6 m, and four at 9.1 m.

All lake basins exhibited radial symmetry to a great extent (Fig. 1). The bathymetric distribution of crayfish is assessed on the basis of a trapping index for each of five depth intervals represented as five concentric bands. The bands, as measured by planimeter, are actually lake surface projections of the bottom being trapped. From the area measurements of these bands, a ratio was assigned to each using the 8.4-9.9 band as unity (see the 9.1 m contour). Assuming the trap catch to be a measure of relative abundance, the product of the catch per trap times (x) the band area ratio is an index of the abundance of crayfish in each band of the lake. For example, 790 female crayfish were captured by seven traps in the 5.3-6.9 (6.1-m) band in West Lost Lake during June 23 through July 7, 1966. The catch per trap is 112.8 (790/7) and, as the ratio for the 5.3-6.9 band is 1.07, the trapping index becomes 120.7 (112.8 x 1.07). The traps were selective for crayfish over

24 mm in cephalothorax length, and did not include young-of-the-year (Momot, 1967).

Study area

The field work was conducted from May 1966 to September 1968 on three limestone sink lakes at the Pigeon River Fisheries Research Station in Otsego County, Michigan. North Twin, South Twin and West Lost lakes are small in area, close to one another, and are generally similar in chemical and physical characteristics. Tanner (1960) described their limnological features in detail. They are symmetrical in outline, water surfaces are 12 to 18 m below the surrounding terrain, and the lakes have steep slopes. The lakes range in area from 1.5 to 1.9 ha (3.5-4.7 acres) and have average depths of 7.3 to 8.5 m (24-28 feet). The shoal areas comprise 11.0 to 15.3% of the total bottom. The predominant soil types are sand in the shoal area and outward to a depth of 3 m, fibrous peat out to 6 m, and pulpy peat in the deepest part.

Logs are abundant in the littoral areas. The logs are marl-incrusted in West Lost Lake. Aquatic vegetation is very limited and consists mainly of the yellow water lily, Nuphar variegatum Engelm.

Results

During 1962-1963, Momot (1967) observed the bathymetric distribution of crayfish in West Lost Lake from May 11 to August 12. He concluded that a gradual shift in bathymetric distribution of female crayfish occurred between June and August. During May and June most crayfish were found at depths of less than 3 m. At that time females with eggs and yearlings stayed in shallow water (0-1.5 m). Yearlings remained in shallow water until the middle of July and then gradually moved to deeper water. Migration to deeper water started earliest for adult females; by August most females were at 6.1 m or deeper, being particularly abundant at 7.6 m. By contrast, yearlings frequented the shallower water, relatively few were found in water deeper than 6.1 m.

Information gathered on the bathymetric distribution of crayfish in three lakes in 1966, 1967, and 1968, showed a seasonal migration of females in all lakes. During early summer, adult females in all lakes generally were most plentiful in the shallow water, less abundant at increasing depths, and negligible at 9.1 m (Table 1 and Fig. 2). We did not record the catch of males during this period as our primary concern was to obtain estimates of the female breeding populations. Momot (1967), however, showed the bathymetric distribution of adult males in West Lost Lake to be similar to females in the early summer of 1963. By about midsummer

a shift had occurred in the bathymetric distribution of females in all lakes for the three years. There was a common movement of females toward deeper water, being more pronounced in some lakes and in certain years than in others. In particular, the proportion of females found in the two deepest zones increased.

The bathymetric distribution of males for this period in all lakes for the years 1966-1968, resembled that for females during early summer (Table 1). Thus, it would appear that the depth distribution of males is uniform throughout most of the summer.

For more extensive observations of the bathymetric distribution of crayfish, trapping was extended into the fall, 1966 (Table 2). The catch of crayfish in autumn was considerably less than that for midsummer. The catch depends largely on the movement of crayfish and at lower water temperatures, movement decreases; below 10 C locomotor activity falls very rapidly. Table 2 shows that in all lakes relatively few females inhabited the shoal areas, most remained in the deeper waters (6.1-9.1 m). Males were more evenly distributed than females, especially in West Lost and North Twin lakes. It is not known if females remain in deep water throughout the winter. Normally, in late April when ice cover disappears, berried females appear near shore.

Discussion and conclusions

Aiken (1965) and Threinen (1958) have commented on the occurrence of unusual sex ratios in samples of Orconectes virilis from lakes. Aiken (1965) sampled New Hampshire ponds and lakes, in excess of 300 acres, with standard baited wire minnow traps. In his statewide collection he found a sex ratio of about 4:1 in favor of males. From one lake he had 7 females out of 1,479 crayfish. Very little trapping was done at depths beyond 6 m. Threinen (1958) observed the commercial harvest of Orconectes virilis in northwestern Wisconsin. Crayfish were captured in cylindrical wire traps similar to the type used by Aiken and us. Trapping is permitted from June 15 to March 1. The catch from nine representative waters totaled 250,000 individuals. The harvest consisted almost exclusively of males. The percentage of females in the catch never exceeded 7.3% of the total. Most of the trapping was done in less than 1 m of water and never in more than 3 m. The differential seasonal migration of female Orconectes virilis noted in the Michigan lakes seems to be a general phenomenon which also occurs in Wisconsin and New Hampshire and probably throughout its range.

It was hypothesized earlier (Momot, 1967) that the migration of females to deeper water followed the maturity molt of yearlings, and the molt to the reproductive form in males, and might be

associated with maturation of the gonads. Aiken (1968) has shown in an Alberta stream, that between late summer and fall, mature Orconectes virilis move out of shallow water, females preceding males, with the exodus being completed by the end of October. He concluded that seasonal movements associated with the reproductive cycle contributed to overwinter survival of adult crayfish in Albertan rivers. According to Aiken (1969) gonadal maturation may be related to water temperature. This migration of females is associated with gonadal maturation in our lakes; its survival value for this species in rivers is indirect.

Presumably, the species evolved in rivers rather than lakes. Since the species is distinctly northern in its distribution, the severe winter conditions would eliminate a species that did not migrate to deeper waters, especially since Aiken (1968) showed that Orconectes virilis exhibited no specific physiological or behavioral response to winter conditions. It would be interesting to study a southern species to test this hypothesis.

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Table 1.--Seasonal bathymetric distribution of crayfish in three limestone sink lakes during 1966, 1967, and 1968

Data presented as trapping index: catch/trap x ratio for area (band) trapped

Lake, and dates	Sex	Depth, in meters					Total catch
		1.5	3.0	6.1	7.6	9.1	
North Twin							
6/22-7/2/66	♀	161.8	75.4	65.2	18.6	6.5	1,860
7/28-8/10/66	♀	14.6	10.0	21.8	71.1	17.2	922
	♂	306.3	204.2	169.8	134.7	10.5	5,005
6/20-7/7/67	♀	151.9	66.1	37.7	8.5	0.0	1,830
8/1-8/9/67	♀	18.9	10.5	13.4	21.8	11.5	443
	♂	228.2	131.9	118.2	42.8	7.2	3,681
6/21-7/2/68	♀	110.5	68.2	68.5	15.4	0.2	1,877
7/30-8/9/68	♀	64.8	26.8	53.8	38.5	38.8	1,351
	♂	436.6	249.2	242.6	62.2	37.8	7,160
South Twin							
6/22/-7/7/66	♀	37.3	27.6	50.4	8.7	3.8	966
7/27-8/12/66	♀	6.6	4.6	13.1	21.2	13.7	406
	♂	138.5	108.2	288.7	196.4	47.8	5,584
6/20-7/7/67	♀	57.0	33.4	37.6	5.8	0.0	1,327
8/1-8/9/67	♀	3.2	2.4	2.6	0.9	10.0	129
	♂	115.6	88.3	167.6	74.0	39.8	4,079
6/21-7/5/68	♀	86.5	42.2	67.0	33.6	4.2	2,072
7/30-8/9/68	♀	27.8	19.6	99.0	65.8	58.8	1,759
	♂	413.2	309.8	782.7	571.0	241.5	17,253
West Lost							
6/23-7/7/66	♀	152.3	102.6	120.7	14.1	8.5	2,245
7/27-8/8/66	♀	66.5	31.8	88.9	63.0	54.0	1,885
	♂	451.2	239.4	357.2	186.6	147.7	8,111
6/20-7/7/67	♀	212.5	104.4	114.6	22.7	6.2	3,074
8/1-8/9/67	♀	22.1	8.3	15.4	14.3	24.2	470
	♂	348.3	187.0	238.0	91.1	99.2	6,163
6/21-7/5/68	♀	122.4	64.6	49.0	11.3	3.0	1,655
7/31-8/9/68	♀	22.8	12.7	16.3	11.3	7.8	440
	♂	207.6	139.6	168.8	128.8	42.8	4,364

Table 2. --Distribution of adult crayfish in three limestone sink lakes during fall, 1966

Data presented as trapping index: catch/trap x ratio for **area** (band) trapped

Lake, and date	Sex	Depth, in meters				Total catch
		1.5	3.0	6.1	9.1	
North Twin						
10/7, 14	♀	0.5	1.9	5.8	7.7	45
	♂	49.6	48.0	82.4	51.3	615
South Twin						
10/7, 12, 14	♀	0.0	0.2	2.4	2.7	15
	♂	35.0	43.3	100.8	97.0	863
West Lost						
10/7, 11	♀	5.6	1.4	7.5	7.3	58
	♂	54.9	34.6	46.8	47.0	465

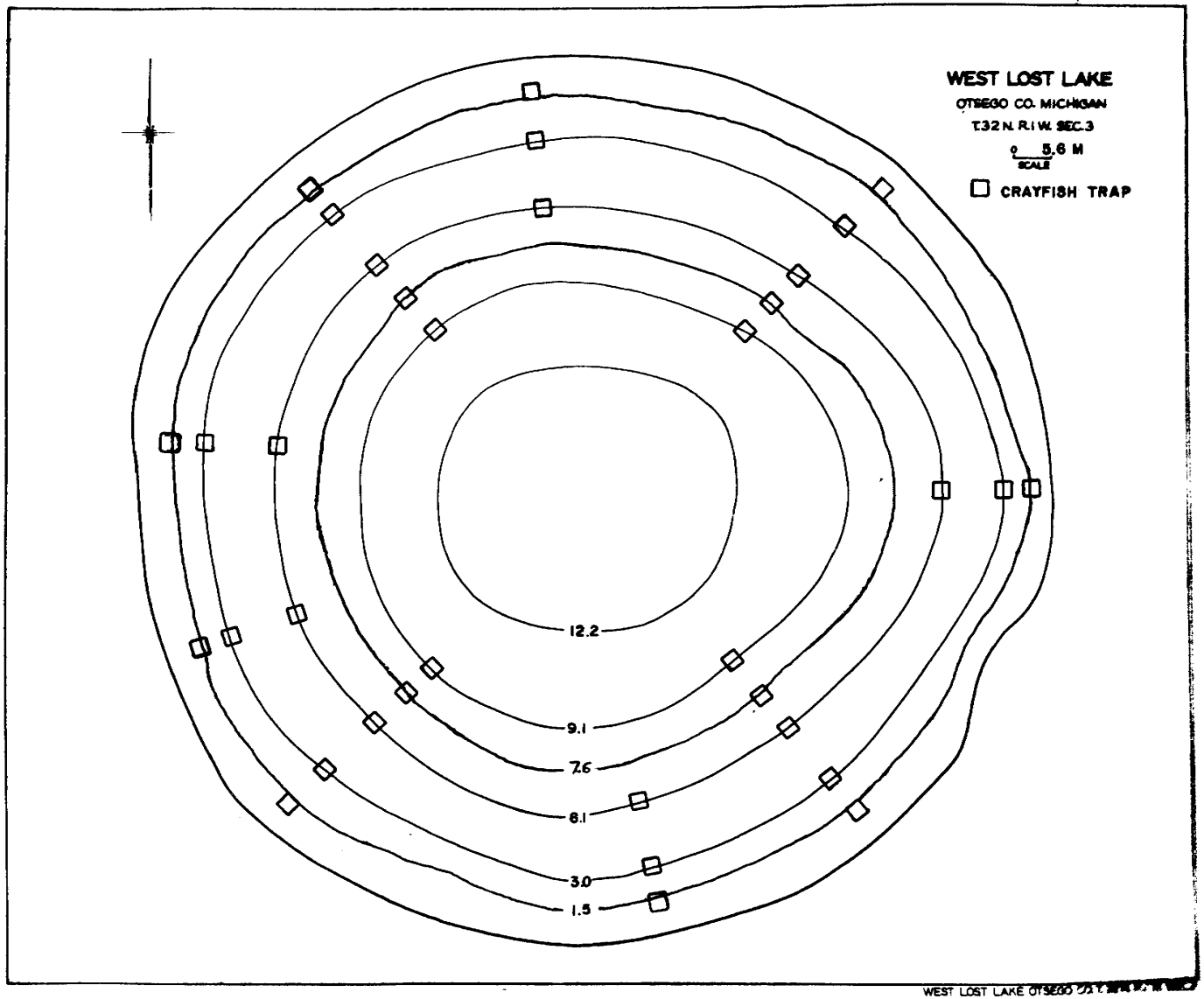

Figure 1.--Hydrographic map of West Lost Lake, showing general pattern of traps for 1967 and 1968. Contours shown are depths in meters.

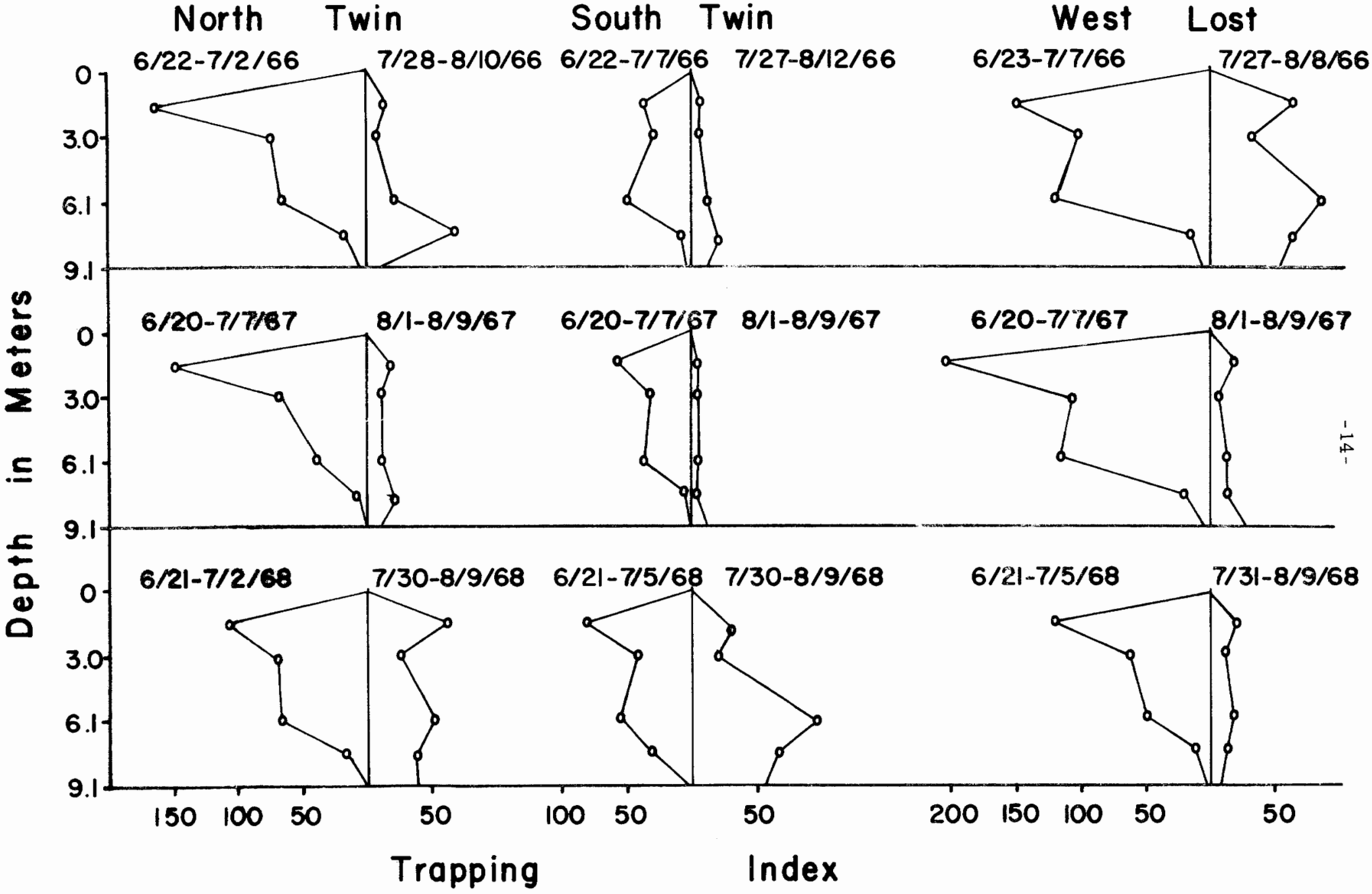

Figure 2. --Seasonal bathymetric distribution of female crayfish in three lakes during 3 years. The abundance of animals at various depth intervals is presented as a trapping index.