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Comparison of Condition Index (K) of Spot (*Leiostomus xanthurus*) from the Elizabeth and York Rivers, Virginia[1]

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ABSTRACT

Condition Index (K) was measured on spot, *Leiostomus xanthurus* from the York (control) and Elizabeth rivers (Experimental-polluted) in 1983-1985. Condition indices for the two populations were regressed against seasonal temperature at the time of capture. Between 6.0 and 19.0 C the Condition Index of the two populations rises in synchrony. Above 19.0 C the Elizabeth River Condition Index continues to rise, and the York begins to drop. Above 26 C the York drops to levels approaching those of winter, and the Elizabeth continues to rise to the highest levels measured. It is hypothesized that this disparity is caused by high population densities of constantly recruiting juvenile polychaete worms in the Elizabeth sediments which are a major food source for the spot, and which provide sufficient nutrition to the fish to keep pace with high metabolic energy requirements. This large forage source, while supportive of high summer metabolism, is a potential pathway for enhanced sediment-fish pollutant transfer.

INTRODUCTION

This study compares the Condition Index (K) of young-of-the-year spot (*Leiostomus xanthurus*) from the Elizabeth and York rivers, Virginia through several seasonal cycles between 1983 and 1985. Condition Index (K) is defined here as a coefficient that depicts the degree of "plumpness" or health of a fish (Moyle & Cech 1988). Young-of-the-year spot were chosen for three reasons: 1) retrospective data were available; 2) spot have been shown to be susceptible to Elizabeth River pollutants (Huggett et al, 1984; Hargis et al, 1984; Hargis and Colvocoresses, 1986; Hargis and Zwerner, 1988a; Plummer, 1988); 3) and young-of-the-year spot (75-135mm FL) have body proportions unaffected by allometric growth or spawning (Austin, unpublished data).

The Elizabeth River (Figure 1), which flows into the James River just west of Norfolk, Virginia is a sub-estuary of the Chesapeake Bay; and is reported to be the most polluted estuary in Virginia (Huggett et al, 1984; Hargis et al, 1984). Numerous military, industrial, and municipal outfalls are the main sources of the pollution. In one notable case, a fire in a creosote plant in the late 1940's resulted in the accidental discharge of large quantities of creosote which are still visibly detectable today. Polynuclear aromatic hydrocarbons (PAH's), one of the results of the fire,

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2 Christopher's School, Richmond, VA and VIMS Virginia Governor's School, July, 1988

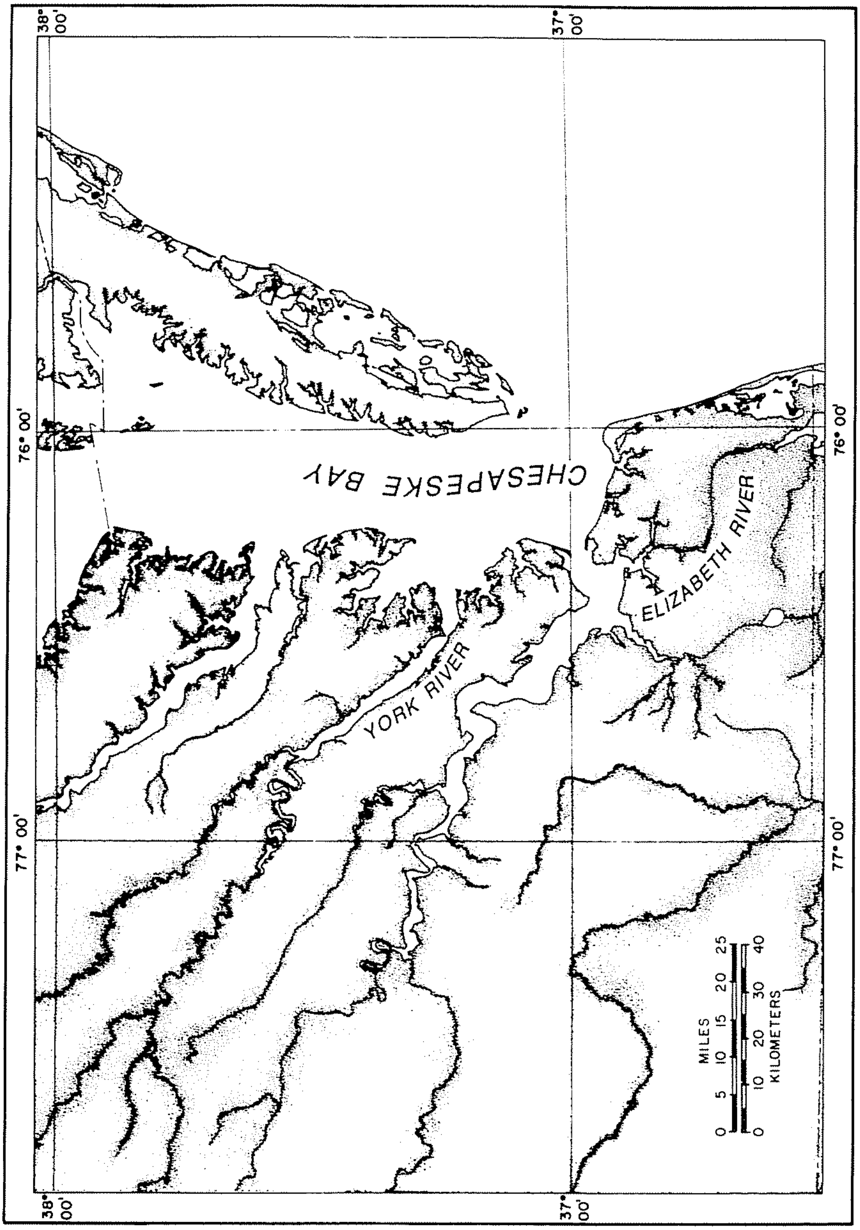

FIGURE 1. Map of tidewater Virginia showing the locations of the Elizabeth and York rivers.

and the creosote contamination that accompanied and preceded it; as well as activities at nearby petroleum transfer and storage facilities, continue at toxic levels in Elizabeth River sediments (Huggett et al, 1984). Young-of-the-year spot are normal year-round benthophagus residents of the Elizabeth.

The York River (Figure 1), on the other hand, located between the James and Rappahannock rivers is considered to be one of Virginia's "least" PAH-impacted riverine systems (Weeks et al, 1989). While the York is deeper than the Elizabeth, the gross physical-chemical environments of the two rivers are similar and one would expect fish populations to be similar. As such, one would also expect that the Condition Indices of spot would be similar in the two rivers sites. Conversely, considering the impacted Elizabeth sediments, and the benthophagus feeding habits of spot, one would expect the York River fish to be "healthier".

METHODS AND MATERIALS

Spot were taken using a 10 m semi-balloon otter trawl in both the York and Elizabeth rivers (Table 1). The sampling was conducted in connection with a bioassay project which was conducted from May to January during 1984, 1985, and 1986 (see for example, Hargis, et al 1984 and Hargis and Colvocoresses 1986). There were 32 cruises during this nine month period. All specimens were measured to the nearest 0.1 mm fork length)FL) with a measuring board, and weighted to the nearest 0.1g with a triple beam balance at sea. Generally, at least 16 samples per river were available for each cruise period.

Bottom temperature data were recorded to the nearest 0.1 C at each station at the time of collection. In a few instances however, temperature data were not measured. In these instances data were taken from the VIMS pier temperature records (York River kilometer 10) and extrapolated to the Elizabeth River since past VIMS investigators have shown there are direct liner relationships (Blaylock, 1984; Hsieh, 1979) in temperature between the VIMS pier and other Virginia estuaries.

Length and weight data were entered into the VIMS PRIME 990 and the Condition Index computed. Later, the indices and concurrent temperature data were loaded into a PC, and SAS graph was used to compute the regression coefficients and to plot Condition Index against temperature. The graphics software package plots a "best" fit to any X/Y data using a quadratic function and includes computations of r and p values when the graph is generated.

Condition Index was calculated based on the relation $K = W/L^b$

where K = Condition Index

W = Weight (g)

L = Fork Length (mm)

b is the slope of the regression line of W on L (Royce, 1972; Moyle and Cech, 1988). For spot, b was found to be 3.2.

The quadratic function was in the form

$$Y = a + bx + cx^2$$

TABLE 1. Condition Index, Temperature, and Date of Capture for Spot (Leiostomus xanthurus) collected from the Elizabeth and York rivers, Virginia; November, 1983 October, 1986.

River	Mean Condition Index (K)	Temperature (°C)	Date of Capture
York	4.55	8.5	23 Nov., 1983
York	4.55	8.5	2 Aug.
Elizabeth	4.68	8.0	8 Mar., 1984
Elizabeth	5.05	15.7	22 May
York	5.13	19.4	6 Jun.
Elizabeth	5.06	26.1	13 Jul.
Elizabeth	4.86	26.3	30 Jul.
Elizabeth	5.26	26.3	1 Aug.
Elizabeth	5.28	26.8	14 Aug.
Elizabeth	5.29	27.6	14 Aug.
Elizabeth	4.95	26.8	29 Aug.
York	4.46	27.1	29 Aug.
Elizabeth	5.38	22.4	18 Sept.
Elizabeth	5.34	22.4	18 Sept.
Elizabeth	5.28	22.4	18 Sept.
York	5.20	18.5	15 Oct.
York	4.96	18.5	15 Oct.
Elizabeth	4.20	16.2	7 Nov.
Elizabeth	4.40	14.5	12 Nov.
Elizabeth	4.69	8.5	16 Dec.
Elizabeth	4.75	21.8	16 May, 1985
York	4.31	21.5	20 Jun.
York	4.86	26.5	18 Jul.
York	4.50	27.0	24 Jul.
York	4.61	27.2	30 Jul.
Elizabeth	5.03	28.0	13 Aug.
York	4.87	22.9	28 Aug.
Elizabeth	4.81	18.9	22 Oct.
York	4.67	11.2	4 Dec.
York	4.56	11.2	4 Dec.
York	4.77	11.2	4 Dec.
Elizabeth	4.24	8.5	16 Dec.
Elizabeth	4.69	8.5	16 Dec.
Elizabeth	4.36	3.5	17 Jan., 1986
York	4.69	22.5	30 Sep.
York	5.18	17.9	7 Oct.
Elizabeth	4.93	17.9	7 Oct.
Elizabeth	4.73	17.9	8 Oct.

K values were computed for each fish, then averaged for all fish collected on each cruise. A typical sample was between six and 20 fish. Mean K values were regressed and plotted against water temperature for the date of capture.

RESULTS

The maximum Condition Index for the York River was 5.2 reached at 18.5 C (Table 1). Minima were reached at 6.0 C (K=4.6), and again at 27.0 C (K=4.5). The maximum for the Elizabeth was 5.4 at 22.4 C, dropping slightly to 5.2 when 26-28.0 C. The seasonal minimum was 4.4 at 3.5 C.

The coefficients of determination (r^2) for K regressed on temperature were 0.52 for Elizabeth River ($p=0.0009$) and 0.42 for York River ($p=0.0304$) (Table 2). Spot in the Elizabeth and York rivers have similar Condition Indices between 8.0 and 20.0 C (Figure 2). At 20.0 C the regression lines intersect. From 22.0 to 28.0 C, late summer, the York values drop to almost the same level or less than at 8.0-10.0 C (winter - early spring). Over the same temperature interval, the Elizabeth River index continues to increase; and above the 26.0-28.0 C mark the two rivers are separated by almost one half (4.5-5.0) Condition Index unit.

DISCUSSION

Normally when compared to temperature, the Condition Index for poikilotherms shows the following seasonal pattern: fish are "thinnest" in cold temperatures, reach maximum "plumpness" at spring and fall temperatures, and during the hottest part of the summer drop down to almost as thin as they are in winter (Lagler, Bardach and Miller, 1962). Spot in the York River follow this normal pattern as evidenced by a low Condition Index in winter, rising in spring and early summer, and falling again during late summer (Figure 2).

The drop in K during the winter is normally due to the loss of food sources, reduced metabolism and physical activity. Fish achieve a balance between nutritional intake and metabolic rate during spring and fall. The subsequent summer drop in K is due to either on or a combination of factors: 1) available forage not providing sufficient nutrition to keep up with basal metabolic demands; 2) elevated ambient summer temperatures exacerbating environmental stresses; or 3) hypoxic or even anoxic conditions. Fish metabolism doubles with every 10 C increase in temperature (Lagler, Bardach, and Miller, 1962); consequently the metabolism of Chesapeake Bay spot is as much as four to six times higher in summer than in winter.

The Elizabeth River followed an atypical pattern for Condition Index versus temperature compared to the York River. Rather than getting thinner in the hottest months, Elizabeth River spot became more robust in summer than during either spring or fall. Considering that the metabolic rate doubles for every 10.0 C increase, and that the Condition Index for fish normally drops during the warmest months when metabolic requirements exceed food supply, leads us to speculate that the food supply for young-of-the-year spot in the Elizabeth must be unlimited and consistent through time. Juvenile polychaetes (Spionids, Nephthyids, and Maldinids), a primary food source for juvenile spot, are extremely abundant year-round in the Elizabeth River (Diaz and Schaffner, personal communication, VIMS) and recruit throughout the summer season. These polychaetes, in the absence of competition in the polluted sediments, have been found to produce

TABLE 2. Analysis of Variance and Quadratic Regression for Condition Index vs Temperature for the Elizabeth and York rivers, Virginia: November, 1983-October, 1986.

River	Sum of Squares	Mean Square	F value	R-square	Prob>F
Elizabeth	1.41278	0.70639	10.310	0.52	0.0009
York	0.45205	0.22602	4.623	0.42	0.0304

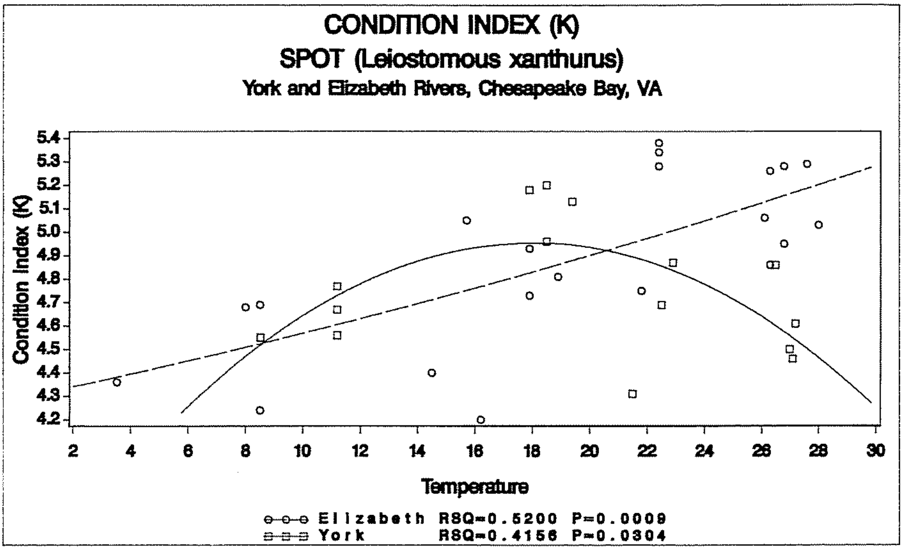

FIGURE 2. Temperature versus Condition Index (K) for spot, (Leiostomusxanthurus) Collected in the Elizabeth and York rivers, Virginia:November, 1983-October, 1986.

enormous populations which provide continuing abundant forage for the young-of-the-year spot even during "high metabolism" summer periods.

The unusually high Condition Indices for Elizabeth River spot during the warmer months suggest successful foraging. We speculate that the intimate contact between invertebrates and sediment, and the subsequent ingestion by spot could provide a rapid means of uptake of PAH's as well as other toxic material from the sediment. The higher Condition Index levels measured are probably a transient phenomenon since the subsequent incidence of cataracts, fin erosion, and lesions documented in the Elizabeth have been shown to produce chronic disease effects

(Hargis et al, 1984; Hargis and Colvocoresses, 1986; Hargis and Zwerner, 1988a and b, and Hargis and Zwerner, 1989).

CONCLUSIONS

1. The Condition Index versus temperature comparison of York River spot follows a normal, seasonal pattern.
2. The Condition Index versus temperature comparison of Elizabeth River spot follows a pattern of increasing Condition Index throughout the temperature range.
3. The increase in Condition Index in the Elizabeth River at high temperatures may be due to the unlimited availability of recently recruited benthic forage.
4. This rapid foraging, while supportive of high summer metabolism, is also a potential means of rapid sediment-fish pollutant transfer.

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