Differential Relations of Age-0 Black Crappie and Yellow Perch to Climatological Variables in a Natural Lake

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ABSTRACT

To better understand recruitment processes of black crappie Pomoxis nigromaculatus and yellow perch Perca flavescens in natural lakes, we sampled age-0 fishes during late summer-early fall 1988-1995 in Brant Lake, South Dakota, with a bottom trawl. Age-0 black crappie catch per unit effort (CPUE) was only >5.0/min when yellow perch CPUE was <0.1/min. Age-0 yellow perch CPUE was only >0.1/min when black crappie CPUE was <5.0/min. We also found that the CPUE for both species was relatively low compared to other South Dakota waters and concluded that the relation between black crappie and yellow perch was probably not simply interspecific competition. Therefore, we assessed climatological variables to help explain this relation. In general, crappie CPUE was negatively correlated with precipitation and positively correlated with mean daily temperature difference and mean wind speed. Conversely, CPUE for perch was positively correlated with precipitation and negatively correlated with mean daily temperature difference and mean wind speed. Although these are not necessarily cause-and-effect relations, age-0 yellow perch were most abundant during years with more precipitation, less wind and less variation in daily temperatures in Brant Lake, whereas age-0 black crappie were most abundant during years with less precipitation, more wind and greater daily variation in temperature.

INTRODUCTION

The recruitment process is an important component of fisheries that is not always well understood. Guy and Willis (1995) found that recruitment of black crappie Pomoxis nigromaculatus was more consistent in impoundments, but less consistent in natural lakes (i.e., missing year classes were common along with increased variability in year-class strength). To better understand reasons for differences in black crappie recruitment, an understanding of recruitment processes in individual water bodies for each water type is needed.

Although complete failure of yellow perch Perca flavescens year classes is not as common as for black crappie, large fluctuations in yellow perch year-class strength are typical (Koonce et al. 1977, Weber and Les 1982, Newsome and Aalto 1987, Mills et al. 1989). Lott et al. (1996) studied yellow perch populations in different types of South Dakota natural lakes. They found that yellow perch recruitment was more consistent in deep natural lakes with high shoreline development that contained submerged aquatic macrophytes than in shallow natural lakes with low shoreline development and little or no aquatic vegetation.

To clarify these findings on black crappie and yellow perch recruitment in natural lakes, we monitored age-0 relative abundance of both species during late summer-early fall, 1988-1995, in a South Dakota natural lake. Age-0 relative abundance of both species was then related to climatological variables throughout the same time span.

METHODS

Brant Lake is a 405-ha natural lake in eastern South Dakota. The lake has a shoreline development index of 1.2, a mean depth of 3.4 m, a maximum depth of 4.3 m, a morphoedaphic index of 191, <1% aquatic macrophyte coverage (primarily cattails Typha spp.), and does not thermally stratify during the summer. The watershed is primarily agricultural land, of which 93% is crop land and 7% is pasture (Koth 1981).

Bottom trawling was conducted annually on Brant Lake during mid-August to early October (Table 1). The trawl had a 4.87-m headrope, weighted footrope with mudrollers, and 0.45- X 0.60-m otter boards. The netting consisted of 19-mm mesh (bar measure) wings tapered to 13-mm mesh in the cod end. The cod liner had 6.3-mm mesh. The trawl was towed 24.4 m behind the boat at approximately 1.4 m/s. All sampling was conducted at night beginning shortly after dusk. Six 4-min trawls were made at fixed sites on one to three different nights each year (Table 1). All age-0 black crappie and yellow perch were counted. Mean catch per unit effort (CPUE) values were calculated for both species each year using the catches from all trawls that year.

Meteorological data for temperature, precipitation, and wind were obtained from the nearest National Oceanic and Atmospheric Administration monitoring station (Sioux Falls, South Dakota; approximately 40 km from Brant Lake).

The CPUE (mean number/min of trawling) data were not normally distributed and a logarithmic transformation did not normalize the data. The CPUE data were ranked to ensure that each year had equal influence in our analyses and Spearman rank correlations were used to describe relations between CPUE of each species with climatological variables.

RESULTS

Age-0 black crappie CPUE was only >5.0/min when yellow perch CPUE was <0.1/min (Table 1). Age-0 yellow perch CPUE was only >0.1/min when black crappie CPUE was <5.0/min. The CPUE values for both species were relatively low compared to other South Dakota waters, especially for yellow perch (Lucchesi 1994). Thus, the relation between black crappie and yellow perch was probably not simply due to interspecific competition. Therefore, we assessed relations between climatological variables and CPUE of age-0 black crappie and yellow perch.

The CPUE values of age-0 black crappie and yellow perch were differentially (i.e., had opposite slopes) correlated with several climatological

Table 1. Sampling dates (Aug=August, Sep=September, Oct=October) and number (N) of bottom trawl hauls made for calculating mean (± SE) catch per unit effort (CPUE; number/min) of age-0 black crappie (BLC) and age-0 yellow perch (YEP) collected in Brant Lake, South Dakota.

Year	Dates	N	BLC CPUE	YEP CPUE
1988	Sep 9, 22; Oct 4	18	79.5 ± 10.4	0.01 ± 0.01
1989	Sep 14, 25; Oct 11	18	8.8 ± 1.9	0.04 ± 0.03
1990	Aug 28; Sep 18, 27	18	12.4 ± 2.4	0.00 ± 0.00
1991	Aug 14	6	0.6 ± 0.2	0.25 ± 0.20
1992	Aug 26; Sep 28	12	0.2 ± 0.1	0.10 ± 0.04
1993	Sep 7, 22	12	0.6 ± 0.2	0.77 ± 0.26
1994	Aug 11, 22; Sep 5	18	1.3 ± 0.3	0.36 ± 0.13
1995	Aug 10; Sep 5	12	3.8 ± 1.1	1.00 ± 0.30

variables (Table 2). Although not all correlations were statistically significant at α=0.05, there were consistent trends. For example, all correlations of black crappie CPUE with mean daily temperature difference and mean wind speed were positive, while all correlations of yellow perch CPUE with mean daily temperature difference and mean wind speed were negative. All correlations between crappie CPUE and precipitation were negative, whereas all correlations between perch and precipitation were positive.

Black crappie CPUE was significantly ($\underline{P} \leq 0.05$) and inversely correlated with precipitation annually, during summer (i.e., June-August), and during ice-free period prior to sampling (i.e., April-August; Table 2). Yellow perch CPUE was significantly ($\underline{P} \leq 0.05$) and positively correlated with precipitation annually and during ice-free period prior to sampling (Table 2).

We expected to find significant relations between mean temperature and CPUE for both species; however, the only significant correlation was between black crappie CPUE and mean temperature during summer ($\underline{r}$=0.71, $\underline{P}$=0.05). However, differences between high and low temperatures did correlate significantly with CPUE for both species. Black crappie CPUE was significantly ($\underline{P} \leq 0.05$) and positively correlated with mean daily temperature difference annually, during summer, and during ice-free period prior to sampling (Table 2). Yellow perch CPUE was significantly ($\underline{P} \leq 0.05$) and negatively correlated with mean daily temperature difference annually, during spring, and during ice-free period prior to sampling (Table 2).

Black crappie CPUE was significantly ($\underline{P} \leq 0.05$) and positively correlated with annual mean wind speed (Table 2). Yellow perch CPUE was significantly ($\underline{P} \leq 0.05$) and negatively correlated with mean wind speed annually and during spring (Table 2).

Age-0 yellow perch CPUE was higher during years with more precipitation, less temperature variation and less wind. Age-0 black crappie CPUE was higher during years with less precipitation, greater daily variation in temperature and more wind.

Table 2. Spearman rank correlation coefficients for catch per unit effort (number/min caught in a bottom trawl) of age-0 black crappie (BLC) and age-0 yellow perch (YEP) with climatological variables [precipitation (cm), mean daily temperature difference (Temp diff; maximum daily temperature - minimum daily temperature; °C), and mean wind speed (km/hr)] annually and by season in Brant Lake, South Dakota, 1988-1995. The probabilities of obtaining a larger correlation coefficient are provided under the correlation coefficients.

	Precipitation		Temp diff		Wind speed	
	BLC	YEP	BLC	YEP	BLC	YEP
Annual	-0.833 0.01	0.691 0.06	0.779 0.03	-0.862 0.006	0.850 0.008	-0.719 0.04
April - June	-0.310 0.46	0.548 0.16	0.643 0.09	-0.714 0.05	0.503 0.20	-0.731 0.04
July - August	-0.881 0.004	0.691 0.06	0.952 0.0003	-0.595 0.12	0.524 0.18	-0.476 0.23
April - August	-0.738 0.04	0.786 0.02	0.786 0.02	-0.810 0.01	0.619 0.10	-0.643 0.09

DISCUSSION

In reservoirs, white crappie P. annularis year-class strength and crappie (black and white crappies combined) year-class strength were reported to be positively related to water level (Beam 1983, Ploskey 1986, McDonough and Buchanan 1991, Mitzner 1991). However, black crappie may not respond to increased water levels as do white crappie. In addition, it is clear that increased water level is not sufficient in itself to ensure strong year classes; the duration of the increase is as important as the extent of the increase (Ploskey 1986). The water level in Brant Lake decreased during dry years, but water level was quite similar during wet and very wet years because water flowed out of the lake when water level was high. Over the eight years of this study, water level fluctuated approximately 1.5 m. Thus, it is difficult to evaluate effects of water level or water flow-through on abundance of age-0 fishes in Brant Lake.

Yellow perch commonly spawn on inundated woody debris (Weber and Les 1982). During years with more precipitation, yellow perch in Brant Lake may benefit from newly flooded woody debris during spawning. The water level commonly receded below the outlet level during summer and fall, leaving woody debris exposed. In the spring, the woody debris most often was newly inundated by snow melt or spring precipitation. Thus, the positive relation between age-0 yellow perch and precipitation may be partially explained by small (e.g., ≤ 1 m) increases in water level. Additionally, strong winds during early spring that displace yellow perch egg masses can negatively affect relative abundance of age-0 yellow perch (Clady and Hutchinson 1975, Kallemeyn 1987) and may explain the inverse relation between yellow perch CPUE and mean wind speed during spring..

Although these differential correlations between age-0 black crappie and age-0 yellow perch CPUE with climatological variables are not necessarily cause and effect, we believe that these findings warrant further investigation into the effects of climate on the abundance of age-0 fishes in natural lakes. Also, inverse relations between age-0 black crappie and yellow perch, if widespread in natural lakes, would be important knowledge for fishery biologists working on such systems.

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