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NORTHERN PIKE (*ESOX LUCIUS*) POPULATION CHARACTERISTICS AND RELATIONS TO RECRUITMENT IN HACKBERRY LAKE, NEBRASKA

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ABSTRACT

Knowledge of the population structure of northern pike (*Esox lucius*), an important recreational and top-level piscivore, is essential to Nebraska Sandhill lakes management. We collected a sample of adult northern pike from Hackberry Lake in June and July of 2004. Proportional stock density (PSD) was 98 (95% CI = ± 3) and relative stock density of preferred-length fish (RSD-P) was 40 (95% CI = ± 9). Northern pike were aged using sagittal otoliths, and fish from the 1993 to the 2002 year classes were present in our population sample. Age-frequency histograms revealed relatively consistent recruitment of northern pike, as no missing year classes were detected, but year-class strength was variable among years. Examination of mean length at age suggested that growth was rapid in the first two years and slowed thereafter but was faster than populations in other locations, perhaps because this population is near the edge of the geographical range for this species. Year-class strength of northern pike was negatively related to spring wind speed and was curvilinearly related to spring air temperature. The strongest year classes occurred in years with relatively moderate air temperatures and lower wind speeds. This research provided useful information regarding northern pike population characteristics and recruitment in one Sandhill lake.

† † †

The northern pike (*Esox lucius*) is an important recreational fish in North America, including the Nebraska Sandhills region which is near the southwestern boundary of the range for this species (Crossman 1996). An understanding of the population structure of northern pike is essential for management of Sandhill lakes. As a top-level piscivore, northern pike may exert substantial influence on a fishery through predation (Anderson and Shupp 1986, DeBates et al. 2003, Margenau 1995, Paukert and Willis 2003, Paukert et al. 2003).

Northern pike typically require adequate flooded vegetation for spawning activity and subsequent recruitment (Casselman and Lewis 1996). Northern pike year-class strength has been positively correlated with air temperature (Kipling and Frost 1970, Casselman and Lewis 1996) and water levels (Casselman and Lewis 1996). Casselman and Lewis (1996) found that depth of nursery habitat was positively correlated with fish size and age in the Great Lakes Basin. Water temperature and level may affect vegetation growth and cover, thus indirectly affecting recruitment. In addition, optimum growth for age-0 northern pike occurs at 22° -23° C (Casselman and Lewis 1996) while optimal temperature is slightly lower (19° C) for subadults and adults (Casselman 1978). Year-to-year climatic variability may affect lake habitats, and slow growth and reduced size structure can result in lakes with high recruitment rates (Diana 1987).

The goal of this study was to describe northern pike population characteristics in Hackberry Lake, Nebraska. Specific objectives were to quantify size and age structure, growth rates, and recruitment patterns. We also explored potential climatological influences on year-class strength by examining relationships with temperature, precipitation, wind speed, and winter severity.

STUDY SITE

Northern pike were obtained from Hackberry Lake, a Nebraska Sandhill lake located in Cherry County in north-central Nebraska. This lake is large (275 ha), shallow (1.5 m mean depth, 2.1 m maximum depth), and moderately vegetated (38% coverage, Paukert and Willis 2000). The fish community consisted primarily of common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), northern pike, and black bullhead (*Ameiurus melas*). A complete description of the lake physicochemical characteristics can be found in Paukert and Willis (2000).

Angling regulations for northern pike included a three fish daily bag limit and maximum size limit of 71 cm (i.e. all fish $\geq$ 71 cm must immediately be returned to the lake), which has been in place since 1993. Finally, the lake was chemically renovated (e.g. rotenone) following this study (in September 2004) to remove an abundant common carp population.

METHODS

Northern pike were collected using four overnight experimental gill net sets in June and July of 2004. Experimental gill nets were of two different sizes. One net size was 36-m long with five 7.6-m panels of 1.9-, 2.5-, 3.8-, 5.1-, and 6.4-cm bar mesh. The other net used was 43-m long with six 7.6-m panels of 1.9-, 2.5-, 3.8-, 5.1-, 6.4-, and 7.6-cm bar mesh. Collected fish were placed on ice and returned to the laboratory for further processing.

Total length (TL; mm) and weight (g) were recorded from each specimen prior to removal of sagittal otoliths for aging. Some northern pike were damaged due to predation by snapping turtles (*Chelydra serpentina*) while in the gill nets; lengths and/or weights were not recorded from these individuals although otoliths were removed when possible. Although scales and cleithra have been used in the past to age northern pike (Casselman 1990, Laine et al. 1991), the use of otoliths has gained recent favor over many other bony structures to age fish (Secor et al. 1995, Casselman 1987). Sagittal otoliths were removed, polished, and dried. Otoliths were mounted in epoxy and sectioned through the focus using an Isomet low-speed saw. Several sections were mounted on a slide to ensure that annuli were not missed. Annuli were counted by two independent readers and disagreements were resolved by reading in concert.

Length- and age-frequency histograms were generated to describe size and age structure of northern pike. Size structure was further indexed using proportional stock density (PSD; the percentage of 35 cm and larger fish that also exceeded 53 cm) and relative stock density of preferred-length fish (RSD-P; the percentage of 35 cm and larger fish that also exceeded 71 cm; Gabelhouse 1984). Northern pike growth was described as mean length by cohort at time of capture.

A catch-curve analysis (Ricker 1975) was computed by regressing the $\log_e$ of number-at-age as a function of age for ages 2-11. Residuals produced from the catch-curve analysis were used to index year-class strength (Maceina 1997). Positive residuals represented relative strong year classes while negative residuals represented relative weak year classes. Bi-variate relationships between year-class strength (i.e. residual) and selected climatological variables (i.e. temperature, precipitation, wind, and winter severity) that corresponded with key time periods in northern pike spawning, larval, and juvenile stages were explored by conducting correlation analyses. Climatological data were obtained from the National Oceanic and Atmospheric Administration weather station in Valentine, Nebraska, located approximately 32 km from Hackberry Lake and operated by the National Weather Service. Climate variables examined were mean daily air temperature (°C), cumulative daily precipitation, mean daily wind speed (km/h), and winter severity (cumulative number of days where temperature was $\leq 0°$ C) in the first winter for an age-0 northern pike. Statistical analyses were conducted using the Statistical Analysis System (SAS 2000). Statistical significance was set *a priori* at $\alpha = 0.10$ because this was an exploratory study with a low number of observation (*i.e.* year-classes).

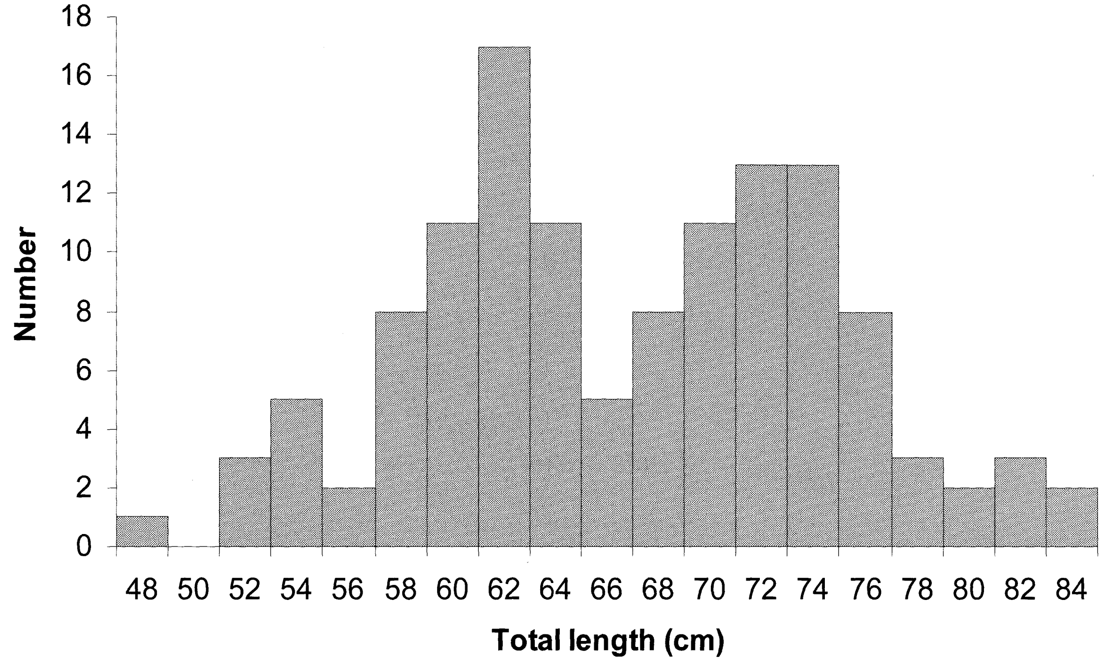

Figure 1. Length frequency for northern pike sampled from Hackberry Lake, Nebraska in June and July 2004.

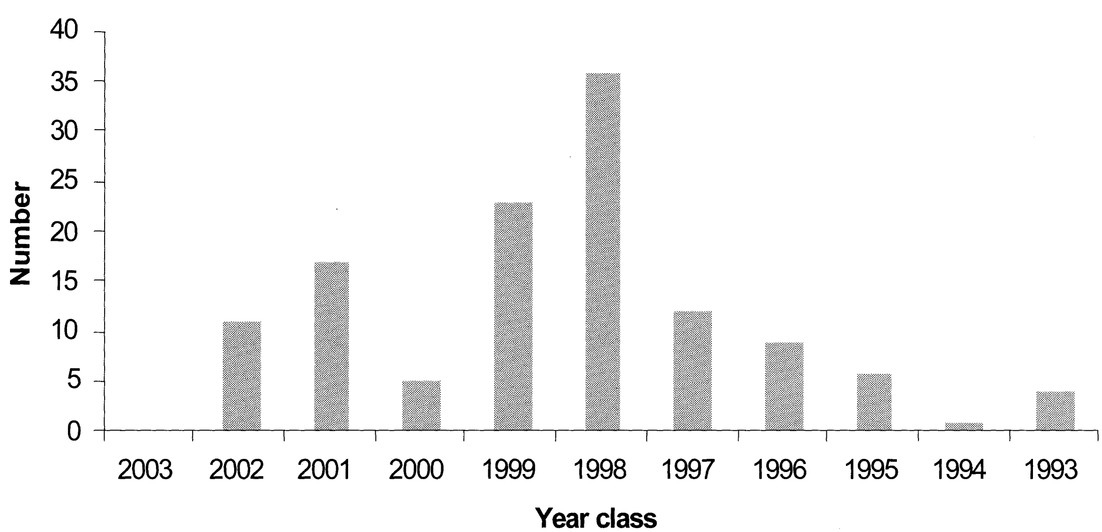

Figure 2. Age frequency for northern pike sampled from Hackberry Lake, Nebraska in July 2004.

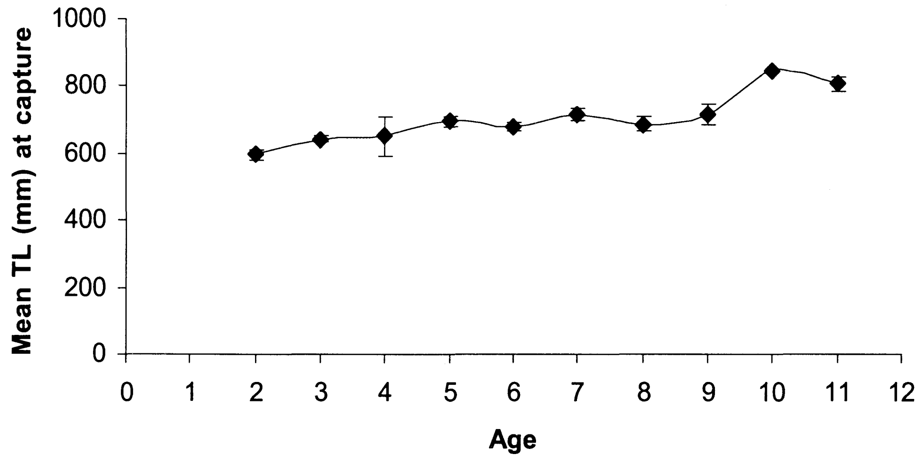

Figure 3. Mean observed total length (± SE) at time of capture by cohort for northern pike in Hackberry Lake, Nebraska in 2004.

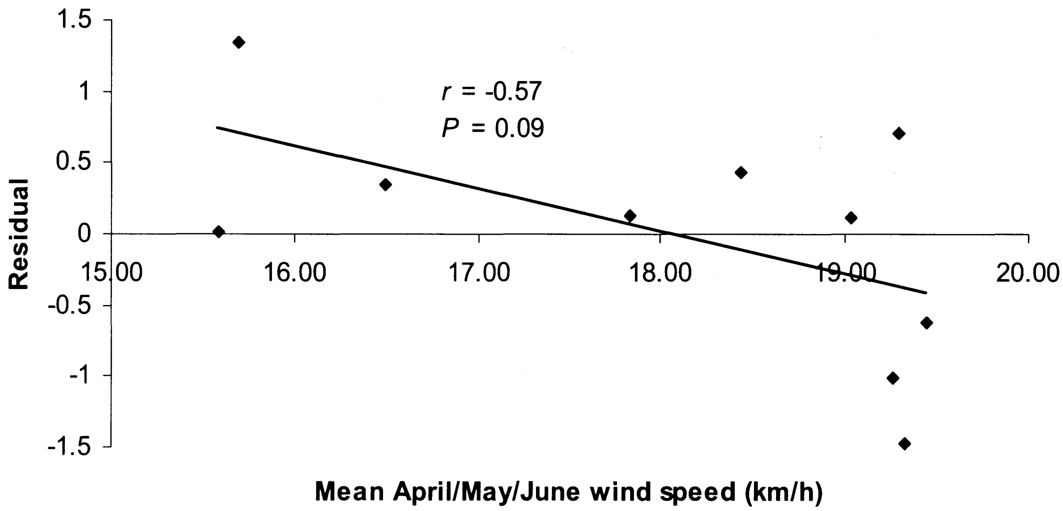

Figure 4. Plot of mean cumulative wind speed (km/h) for April, May, and June as a function of year-class strength (i.e., residual) for northern pike from Hackberry Lake, Nebraska.

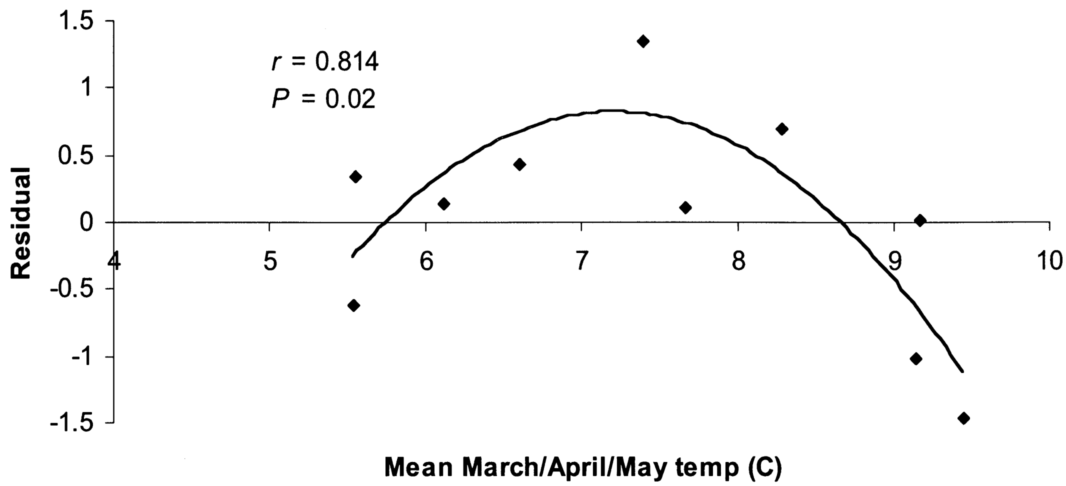

Figure 5. Plot of mean cumulative air temperature for March, April, and May as a function of year class strength (i.e., residual) for northern pike from Hackberry Lake, Nebraska.

RESULTS

A total of 139 northern pike was collected from Hackberry Lake between 16 June and 16 July 2004. Total length ranged from 490 mm to 860 mm with a mean of 679 mm (Fig. 1). Proportional stock density was 98 (95% CI = ± 3) and RSD-P was 40 (95% CI = ± 9) indicating a population dominated by larger individuals. One memorable-length (TL ≥ 86 cm) and no trophy-length (TL ≥ 112 cm; Gabelhouse 1984) northern pike were collected.

Ages ranged from 2 to 11, years corresponding to the 2002-1993 year classes (Fig. 2). Age-1 northern pike (2003 year class) were absent from our sample; however, those may not have been sampled effectively with our gill nets. Northern pike exhibited relatively consistent recruitment from 1993 to 2002, as no missing year-classes were detected. However, year class strength was variable as indicated by the erratic pattern in the age-frequency histogram (Fig. 2). The 2000-2002 year classes were weaker than expected in comparison with the more abundant, older age groups.

Growth was rapid through the first two years but slowed thereafter (Fig. 3). The mean length for age-3 fish (i.e., approximately 3.5 years of age) was 644 mm (SE = ± 10) while the mean length was 677 mm (SE = ± 12) for age-6 fish.

Mean combined wind speed for April, May, and June was negatively correlated with northern pike year-class strength (r = -0.57, P = 0.09; Fig. 4) while various measures of annual precipitation were not correlated with year-class strength. Combined March, April, and May mean daily air temperature and year-class strength were curvilinearly related (r = 0.81, P = 0.02; Fig. 5). Winter severity (cumulative number of days ≤ 0° C) was not significantly correlated with year-class strength (r = -0.40, P = 0.26).

DISCUSSION

The Hackberry Lake northern pike population had faster early growth rates (ages 2-4) than most populations in North America and Europe (Willis 1989; Neumann et al. 1994; Margenau et al. 1998). Paukert and Willis (2003) reported similar growth of northern pike in a study of 30 Sandhill lakes. Out of the 139 northern pike sampled in Hackberry Lake, only one memorable length and no trophy length fish were collected, suggesting that northern pike at the southern boundary of their natural geographic range may not attain large sizes due to physiological environmental limitations. Neumann et al. (1994) found that northern pike growth in Lake Thompson, South Dakota, was restricted during the high water temperature periods of summer.

The high observed PSD and RSD-P are indicative of a northern pike population dominated by larger individuals. The maximum size limit (71 cm) for anglers likely contributed to the observed size structure. The angling restrictions were established to protect larger northern pike that may control common carp recruitment through predation, Sammons et al. (1994) found that northern pike in a

South Dakota lake preyed on common carp in midsummer and winter. Our gill net sizes may not have captured smaller (i.e. age 1) northern pike effectively, as no substock size (TL < 350 mm; Gabelhouse 1984) fish were captured. Neumann and Willis (1994) caught no northern pike <340 mm in a South Dakota lake in a 25-mm (bar measure) gill net; the smallest gill net mesh size used in our study was 19 mm. Thus, we likely did not catch small (i.e., TL < 350 mm) northern pike because fish were not fully recruited to the gear. The Hackberry northern pike population exhibited relatively consistent but still variable recruitment. Paukert and Willis (2003) also reported variable northern pike recruitment, but missing year classes were rare. They suggested that among-lake variability in recruitment patterns might be attributable to lake-specific factors.

Northern pike year-class strength was curvilinearly related to mean combined March, April, and May air temperature, corresponding to the time period when northern pike are spawning, hatching, and entering their juvenile life stages. Because northern pike in our study lake are near the southwestern edge of their natural geographical range (Crossman 1996), warmer years may depress recruitment. Previous research has found positive relationships between temperature and recruitment but most of these studies occurred at more northerly latitudes (Kipling and Frost 1970; Casselman and Lewis 1996). Although water levels have been cited as important for spawning and nursery habitats (Casselman and Lewis 1996), thereby potentially affecting year class strength, precipitation was not related to year-class strength in Hackberry Lake over the range of years in our study. We suspect that the abundance of aquatic vegetation for spawning habitat in Sandhill lakes provided adequate resources for northern pike recruitment in most lakes. Mean combined wind speed for April, May, and June was weakly correlated with northern pike year-class strength. Wind has been reported to affect recruitment of other fishes through physical destruction of eggs, transport of eggs to unfavorable locations, and sedimentation on eggs. Hassler (1970) reported that higher mortality was associated with wind-induced siltation of embryos. Some combination of wind-related factors is likely to detrimentally affect northern pike recruitment in Hackberry Lake.

Finally, although winter severity has been implicated in high overwinter mortality of other fishes (Oliver et al. 1979; Adams et al. 1982; Miranda and Hubbard 1994), we found no evidence that recruitment of northern pike in Hackberry Lake was affected by severity of winter.

This research provides detailed information on a northern pike population in one Sandhill lake. However, we recommend further research in other lakes to fully understand the recruitment patterns of northern pike in Nebraska Sandhill lakes.

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