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Fine scale habitat use by age-1 stocked muskellunge and wild northern pike in an upper St. Lawrence River bay

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ABSTRACT

Radio telemetry of stocked muskellunge ($n = 6$) and wild northern pike ($n = 6$) was used to track late summer and fall movements from a common release point in a known shared nursery bay to test the hypothesis that age-1 northern pike and stocked muskellunge segregate and have different habitat affinities. Water depth, temperature, substrate and aquatic vegetation variables were estimated for each muskellunge ($n = 103$) and northern pike ($n = 131$) position and nested ANOVA comparisons by species indicated differences in habitat use. Muskellunge exhibited a greater displacement from the release point and used habitat in shallower water depths (mean = 0.85 m, SE = 0.10) than northern pike (mean = 1.45 m, SE = 0.08). Both principal components analysis (PCA) and principal components ordination (PCO) were used to interpret underlying gradients relative to fish positions in two-dimensional space. Our analysis indicated that a separation of age-1 northern pike and muskellunge occurred 7 d post-release. This first principal component explained 48% of the variation in habitat use. Northern pike locations were associated with deeper habitats that generally had softer silt substrates and dense submersed vegetation. Muskellunge locations post-acclimation showed greater association with shallower habitats containing firmer sandy and clay substrates and emergent vegetation. The observed differences in habitat use suggest that fine-scale ecological separation occurred between these stocked muskellunge and wild northern pike, but small sample sizes and potential for individual variation limit extension of these conclusions. Further research is needed to determine if these patterns exist between larger samples of fishes over a greater range of habitats.

Introduction

Stocking of muskellunge (*Esox masquinongy*) is a common management action used to sustain populations. Stocking large fingerlings and yearlings has been demonstrated to enhance survival (Kapuscinski et al., 2007; Margenau, 1992), which has led to rearing larger individuals in hatchery management systems (Kerr, 2011; Kerr and Lasenby, 2001). Despite these intensive management efforts, few studies have examined the distribution or habitat use of stocked sub-adult muskellunge (Hanson and Margenau, 1992; Wagner and Wahl, 2007, 2011) and their potential for overlap with sympatric esocids such as northern pike (*E. lucius*).

Ecological separation between wild northern pike and muskellunge has been proposed to explain their coexistence in the St. Lawrence (Osterburg, 1985) and Niagara (Harrison and Hadley, 1978) rivers, but more recent studies demonstrated that muskellunge and northern pike overlap at fine spatial scales in the St. Lawrence River during spawning and nursery periods (Cooper et al., 2008; Farrell, 2001; Farrell et al., 1996, 2007; Murry and Farrell, 2007). Whether these segregation patterns hold for stocked and older age-1 muskellunge is not understood, but northern pike grow larger than muskellunge through age-1 and diets can overlap (Farrell, 1998), so northern pike could be in direct competition with muskellunge for forage (Inskip, 1986). Therefore, we sought to characterize habitat use of age-1 stocked muskellunge and wild northern pike to determine if significant overlap occurs to address the potential for their interaction. We used radio telemetry of age-1 pond-reared muskellunge and wild northern pike (both progeny of wild fish from the St. Lawrence River) to test if distributions and habitat use overlapped or were segregated.

Material and methods

Radio telemetry

Progeny of wild St. Lawrence River muskellunge were pond-reared for 13 months prior to radio-implantation at the New York State Oneida Lake Fish Hatchery. On 12 September 1995, 2.19 g Lotek™ radio

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transmitters were surgically implanted into six age-1 muskellunge with a mean total length (TL) of 314.5 mm (SD = 27) and weight of 154.2 g (SD = 28.2). On 15 September, six age-1 northern pike with a mean TL of 391.5 mm (SD = 8.7) and weight of 291.3 g (SD = 43.8) were captured by electrofishing in Flynn Bay, Clayton New York, and were surgically implanted with radio transmitters (Table 1). Tag weight was only 0.8% (SD = 0.1) of body weight for northern pike and 1.5% (SD = 0.2) for muskellunge. All fishes had internal loop antennae (Hanson and Margenau, 1992). The radio transmitters, with independent frequencies ranging from 50.172 to 50.362 MHz, had an expected battery life of 60 d. Both muskellunge and northern pike were held in rearing tanks for recovery until they were released at a common location in the center of Flynn Bay on 18 September.

Movements and habitat characterization

Northern pike and musellunge were tracked with an ATS receiver from 18 September to 13 November using a boat mounted Yagi directional antenna and a hand-held antenna. Radio locations were made daily within Flynn Bay for the first week and then every 3–5 d thereafter. All radio locations were plotted on a scaled map (1:2400) and were determined using triangulation with landmarks and shoreline features. Distance traveled by each fish was measured between points plotted on a map (1:2400) for locations on each consecutive date. Flynn Bay (44.253251°N–76.136121°E) is a diverse habitat within a coastal embayment off Grindstone Island (74 ha open water) in the Thousand Islands region of the St. Lawrence River. The bay contains large sand bars and rocky shoals at its mouth and its interior contains substrates ranging from silty organic sediments to clay with eroding banks and hard substrates with scattered boulders. Shoreline and patches of offshore vegetation are dominated by cattail *Typha* spp., and bulrush (*Schoenoplectus tabernaemontani*). Floating-leaved and submersed aquatic vegetation is similarly diverse with over 18 species present (Farrell, 1991) and the site contains a headwater drowned river mouth tributary dominated by *Typha* spp. with upslope wet-meadow habitats dominated by sedges *Carex* spp., with *Typha* spp. encroachment (Cooper et al., 2008).

Water depth, surface and bottom temperature, substrate type (sand, silt, clay, organic), vegetation species and percent total coverage were recorded at each radiolocation site as measures of habitat. An Onset™ recording thermograph recorded temperature (°C) every 2 h at Flynn Bay from 18 September to 18 November. Aquatic vegetation was separated into morphological categories including emergent, submersed, mat-forming algae, and floating-leaved. The species composition in each category and total percent coverage of plants was used to index the relative importance of vegetation to the presence of the fish. Similarly, the presence (1) or absence (0) of silt, sand, clay and organic matter was recorded and used as an index of substrate at the location of individual fish. Water depth (m) and the temperature (°C) differential between the surface and bottom (TDIFF) were also recorded to determine potential influence of thermal habitat differences.

Data analysis

A nested Analysis of Variance (ANOVA) was used for each habitat variable to quantify differences in the microhabitats occupied by age-1 stocked muskellunge and wild northern pike (Freund et al., 1986). Because the analysis was unbalanced, the least squares means (adjusted) and standard errors were used to quantify average values for each species. Simple Pearson correlation coefficients were used to explore linear relationships among water column, substrate and vegetation variables. Because our data spanned a significant duration of time, averages were obtained for each variable by fish, which yielded a data set with $n = 12$ fish and $v = 10$ variables.

Principal components analysis (PCA) was performed on the correlation matrix for the variables as a means of identifying and interpreting gradients along which fish positions could be mapped (Pielou, 1984). When the number of variables is large relative to *N*, however, principal coordinates ordination (PCO) is generally more efficient (Green, 1979). PCO operates on an $n \times n$ similarity matrix (Jackson et al., 1989) instead of a $v \times v$ correlation matrix (in this case). Both methods were used so we could interpret underlying gradients and construct an ordination of fish in two-dimensional space. For the PCO, Gower's general similarity coefficient was used because of its ability to handle different data types (i.e., species frequency data, multi-state and continuous variables; Gower, 1987; Minchin, 1987).

To allow for acclimation and demonstrate the use of specific habitats by individual fish, we broke the data set into observations made within the first 7 d of release from the center of the bay (Ordination 1, acclimation) to represent the stocking displacement similar to Wagner and Wahl (2007), and those observations greater than or equal to 7 d (Ordination 2, post-acclimation). The division was based on the temporal pattern of initial distances moved that decreased around September 24 and therefore ordination 2 was assumed to represent habitat selection. Ordinations were overlaid with vectors showing the displacement of fish in two-dimensional space over time.

Results

Radio telemetry

Northern pike were observed at more locations ($n = 131$) and for more days at large than stocked muskellunge ($n = 103$), because of

Table 1
Summary of radiotracking results for age-1 northern pike ($n = 6$) and stocked muskellunge ($n = 6$) released in Flynn Bay, Grindstone Island, Clayton, New York, on 18 September 1995. Total length (mm) and weight (g) were measured at the date of release.

Frequency	Size (TL/WT)	Locations (n)	Dates at large	Distance moved (m)	Temperature range (°C)	Comment
Northern Pike						
50.172	400/305	22	9/18–11/13	1342	16.6–3.7	Alive
50.192	396/298	22	9/18–11/13	1083	16.6–3.7	Alive
50.222	379/276	21	9/18–11/13	1609	16.2–3.6	Alive
50.252	384/242	22	9/18–11/13	1311	16.7–3.4	Dead
50.292	400/367	22	9/18–11/13	921	16.6–3.7	Alive
50.302	390/260	22	9/18–11/13	1904	17.0–4.9	Alive
Muskellunge						
50.181	299/132	21	9/18–11/6	1984	16.5–5.9	Died[a]
50.202	296/137	19	9/18–10/30	574	16.7–6.2	Lost signal
50.211	337/144	22	9/18–11/13	2428	16.5–2.8	Alive
50.262	325/200	11	9/18–30	925	16.7–18.9	Died[a]
50.282	280/134	8	9/18–27	1524	16.9–16.2	Died[a]
50.362	350/178	22	9/18–11/13	2300	15.9–4.6	Alive

[a] Tag recovered.

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