Summer Habitat Use by Introduced Smallmouth Bass in an Oligotrophic Adirondack Lake

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Abstract

Non-native smallmouth bass became established in 1951 in Little Moose Lake, an oligotrophic Adirondack lake. Salmonids dominated the littoral zone at the time. Snorkel surveys, from late June through early August 1997, were used to determine the distribution and abundance of fish in the littoral zone. Transects were established on four habitat types: sand, wood (submerged trees), rock covered by silt (particles < 2 mm), and clean cobble (particles >64 mm). Non-native smallmouth bass were the most common fish species observed over the transects. Counts of adult smallmouth bass (*Micropterus dolomieu*) were greater than pumpkinseed (*Lepomis gibbosus*) and salmonids. Average lengths of bass were different between habitat types indicating size class segregation among the habitats in the littoral zone. Adult bass (>50 mm) were only observed on wood and cobble habitats. Nearly all bass >300 mm were observed on wood habitats. Young-of-year bass (<50 mm) were only observed on sand and silted rock. Only two brook trout (*Salvelinus fontinalis*) and three rainbow trout (*Oncorhynchus mykiss*) were observed; however, water temperature (range 21 °C to 24 °C) may have limited their presence. We conclude that non-native smallmouth bass dominate the littoral zone of this Adirondack lake during the summer.

Introduction

Use of the littoral zone in lakes by fish species varies seasonally (Gelwick and Matthews 1990), and can depend on the presence or absence of forage (Hall and Werner 1977), life history stage (Werner et al. 1983a), and trophic position (Werner et al. 1983b). Native fish species within the littoral zone in most lakes appear to have co-evolved to reduce competition for food and space resources (e.g., Seehausen and Bouton 1997). Non-native fish species, because of a lack of co-adaptation, can directly compete for food and space, disrupt native fish species distribution and cause shifts in resource partitioning (Moyle et al. 1986).

The effects of introduced fish have been documented in North America and throughout the world (Courtenay and Kohler 1986, Moyle et al. 1986). Non-native fish species have been shown to compete for limited resources including food and habitat (e.g., Larson and Moore 1985), be predators of native species (e.g., Crowder 1980), transmit disease (e.g., Goede 1986), alter habitat (e.g., Forester and Lawrence 1978), and hybridize with native fish species (Krueger and May 1991).

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Intentional and accidental introductions of non-native fishes to the upland waters of the Adirondack region of New York State are believed to have been detrimental to native fish species (George 1980, Smith 1985). Smallmouth bass (*Micropterus dolomieu*), yellow perch (*Perca flavescens*), northern pike (*Esox lucius*), and largemouth bass (*M. salmoides*) are examples of non-native species now well-established in many Adirondack waters (George 1980). Competition for available resources and predation by these non-native fishes can limit trout biomass in Adirondack waters (Flick and Webster 1992) and Canadian shield lakes (Fraser 1978).

Non-native smallmouth bass were first observed in 1951 in Little Moose Lake, an oligotrophic upland Adirondack lake. This species likely gained entry through invasion via the outlet connection with the South Branch of the Moose River or by an unauthorized introduction (Webster 1954a). Prior to the establishment of smallmouth bass, brook trout (*Salvelinus fontinalis*), introduced landlocked Atlantic salmon (*Salmo salar*), pumpkinseed (*Lepomis gibbosus*), and creek chubs (*Semotilus atromaculatus*) were abundant in the littoral zone of the lake (Webster 1952). Smallmouth bass could be both a predator on and competitor with salmonids and other native fishes in Little Moose Lake.

The purpose of this study was to determine habitat use by fish species in the littoral zone of Little Moose Lake from late June through early August. The study objectives were (1) to describe the relative abundance of fish species in the littoral zone and (2) to compare the relative abundance of individual fish species within and among three littoral zone habitat types.

Study Site

The study was conducted from 20 June to 7 August 1997 in the East Bay of Little Moose Lake, Herkimer County near Old Forge, New York (43°37'N,74°55'W). Little Moose Lake is a 271 ha oligotrophic lake with a mean depth of 15 m and maximum depth of 39 m. The lake has six first order tributaries and the watershed is predominately forested. During the study, water temperature ranged from 21° to 24° C, dissolved oxygen concentrations ranged from 8.4 to 9.4 ppm, pH ranged from 6.8 to 7.2 at the surface and Secchi depths ranged from 6 m to 9 m.

The fish community of Little Moose Lake consists of eleven native fish species and four introduced species (Table 1). Native lake trout (*Salvelinus namaycush*) and non-native smallmouth bass are abundant. Other salmonids include native brook trout, and introduced landlocked Atlantic salmon and rainbow trout (*Oncorhynchus mykiss*).

Methods and Materials

Four predominant littoral zone habitat types were identified as strata for recording of fish observations. These habitat types were woody material (submerged trees), sand, silted rock (covered with particles < 2 mm) and clean cobble (particles >64 mm). Two transects each were established on woody material and sand; one transect was established on each of the two rock substrates.

The rectangular 4x30 m transects for snorkel surveys were established in 2 m of water and delineated with nylon rope, which was anchored at each

Table 1. Fish species list for Little Moose Lake.

Common name	Scientific name	Origin	Introduction
Family Salmonidae			
Brook trout	*Salvelinus fontinalis*	Native	
Lake trout	*Salvelinus namaycush*	Native	
Landlocked Atlantic salmon	*Salmo salar*	Introduced	1894
Rainbow trout	*Oncorhynchus mykiss*	Introduced	1961
Round whitefish	*Prosopium cylindraceum*	Native	
Family Centrarchidae			
Pumpkinseed	Lepomis gibbosus	Native	
Smallmouth bass	*Micropterus dolomieu*	Introduced	1951
Family Cyprinidae			
Common shiner	*Luxilus cornutus*	Native	
Creek chub	*Semotilus atromaculatus*	Native	
Blacknose dace	*Rhinichthys atratulus*	Native	
Family Catostomidae			
White sucker	*Catostomus commersoni*	Native	
Family Osmeridae			
Rainbow smelt	*Osmerus mordax*	Introduced	1975
Family Ictaluridae			
Brown bullhead	*Ameiurus nebulosus*	Native	
Family Cottidae			
Slimy sculpin	*Cottus cognatus*	Native	
Family Umbridae			
Central mudminnow	*Umbra limi*	Native	

corner. Transects were limited to 4 m widths based on water clarity to ensure all fish would be visible. Habitat within each transect was mapped in mid June to note large rocks, trees, and other major features.

Length estimates of fish within the transects were made by visual comparison to reference markers anchored to the bottom with a brick. The markers were painted alternately red and white at 50 mm increments and placed at the start and mid-point of the transect. Fish size was estimated to the nearest 50 mm.

Observational sampling by snorkeling took place from late June through early August (27 June - 7 August). Fish were counted by species, total lengths were estimated, and their locations were mapped during thirteen surveys on each of the six transects. Precautions were taken to not disturb the fish within a transect during boat landing and water entry for snorkeling. Weather conditions, time of day, water temperature (surface and at 2 m), and Secchi depth were recorded on each day of sampling.

One-way analysis of variance ($p \leq 0.05$) was used to detect differences in

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indicated that smallmouth bass counts were higher (mean = 6.4, 95% CI = ±2.2) than pumpkinseed (mean = 0.9, 95% CI = ±0.5) and salmonid counts (mean = 0.1, 95% CI = ±0.2), while pumpkinseed and salmonid counts were not different from each other (Figure 1). Only five salmonids (two brook trout and three rainbow trout) were observed.

Smallmouth bass ranging from 20 mm to 450 mm in length were observed during snorkeling observations. However, bass < 50 mm were never observed on the same transect with bass > 50 mm (Table 3). Counts of bass in the 0-50 mm size class were estimated; therefore, only counts of bass greater than 50 mm were used in data analysis below.

Length distributions of bass were different between wood and cobble habitats ($p<0.001$) (Table 3). The mean length of bass over cobble was 169 mm (n=258, 95% CI = ±4.4) which was smaller than the mean size over wood of 214 mm (n=242, 95% CI = ±9.6). Only one bass >300 mm was observed over the cobble habitat while 39 bass of this size were observed over the wood habitat.

Differences in counts of smallmouth bass existed among the six transects ($p=0.001$) (Table 2). Fisher pairwise comparisons indicated that smallmouth bass counts were greater over cobble (mean = 19.8, 95% CI = ±7.7) than over the two wood transects -- wood transect 1 (mean = 7.5, 95% CI = ±2.1) or wood transect 2 (mean = 11.2, 95% CI = ±3.9) (Figure 2). No bass > 50 mm were observed over the sand or silted rock transects.

Bass fry (<50 mm, presumed to be young-of-year) were first present over the sand transects on July 7 and were observed over the same areas through the end of July. Fry were observed over the silted rock from July 16 until the end of the study.

Pumpkinseed were observed only over wood and cobble (Table 2) and differed among the six transects ($p = 0.001$). Of these observations, 87% were made on one of the two wood transects. Fisher pairwise comparisons indicated that mean counts of pumpkinseed on wood transect 2 (mean = 4.9, 95% CI = ± 1.9) were greater than mean counts over all other transects.

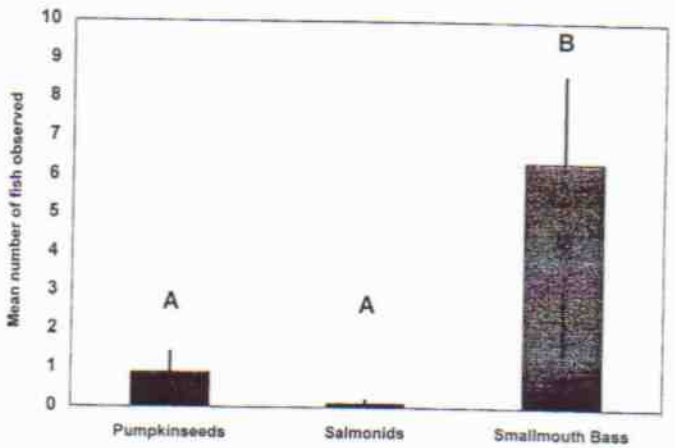

Figure 1. Mean number of fish, by species, observed from June to August 1997. Error bars represent 95% confidence intervals. Bars with similar letters were not different from each other using a Fisher pairwise comparison ($p<0.05$).

Discussion

Non-native smallmouth bass was the most abundant fish species occupying the littoral zone of Little Moose Lake during the summer. The abundance of bass observed suggests that numerically this species dominates the littoral zone habitat. This observation contrasts sharply from Webster (1952) who listed brook trout, landlocked salmon, pumpkinseed, and creek chub as the predominant littoral zone species. All known size classes of bass in Little Moose Lake were present in littoral zone habitats during this study.

Spatial segregation of smallmouth bass by size class occurred among habitat types in Little Moose Lake. No fish > 50 mm were observed on sand and silted rock habitats, while all fish < 50 mm were only observed on these two structureless habitat types. Age 0 smallmouth bass used the tributaries of Cayuga Lake and were segregated from older bass (Webster 1954b). In the Buffalo River, Arkansas, young-of-year smallmouth bass used shallow water habitats with structure and were segregated from older bass (Walters and Wilson 1996). We hypothesize that small bass used areas of structureless habitat to segregate from older bass in Little Moose Lake, possibly to avoid cannibalism.

The highest numbers of smallmouth bass >50 mm were found in areas of wind-blown rocky shoreline of granite cobbles and boulders. Bass from 50 mm to 300 mm were most abundant on this habitat type while few larger (>300 mm) bass were observed. Previous studies suggest that lake dwelling smallmouth bass prefer habitat characterized by clean rock or gravel substrate, abundant cover (e.g., boulders or fallen trees), and abundant forage (Webster 1954b, Emery 1973, Coble 1975, Johnson and Hale 1977). Further, Munther (1970) suggested a positive relationship between numbers of crayfish and bass over a broken rock substrate. Similar areas of rock substrate within Little Moose Lake can support populations of crayfish, Ephemeroptera, and Odonata.

Smallmouth bass from 50 mm to 300 mm were also abundant in areas of woody cover, while fish > 300 mm were only observed in these areas. In previous studies, smallmouth bass used areas of woody cover as residence areas (Hubert and Lackey 1980, Emery 1973). Smallmouth bass association

Table 3. Length frequency distribution of smallmouth bass observed over the six transects sampled from June to August 1997. *Estimates of fish numbers were made for the smallest size class (0-49 mm).

	Length Interval (mm)										
Transect	0-49*	50-99	100-149	150-199	200-249	250-299	300-349	350-399	400-449	>450	Total
Sand 1	526	0	0	0	0	0	0	0	0	0	526
Sand 2	120	0	0	0	0	0	0	0	0	0	120
Wood 1	0	1	5	16	53	9	5	6	0	2	97
Wood 2	0	1	10	36	52	20	9	8	3	6	145
Silted rock	430	0	0	0	0	0	0	0	0	0	430
Cobble	0	0	16	150	73	18	1	0	0	0	258

with cover was shown to be more important than water temperature in laboratory experiments (Bevelhimer 1996). Larger bass may prefer woody habitats over other littoral zone habitats in Little Moose Lake.

Most pumpkinseeds were observed over woody habitat. However, only one of the two wood transects had concentrations of pumpkinseed. Other than physical location, no readily discernible differences existed between the two transects. Although counts of pumpkinseed were different, counts of bass were not different between woody transects. Pumpkinseed are dependent on cover for predator avoidance and feeding (Werner et al. 1983b, Savino and Stein 1982).

The few salmonids observed in the littoral zone could have been caused by water temperatures (21-24 °C) that were not ideal for these species. The optimal temperature range for brook trout is 14-16 °C (Coutant 1977), while rainbow trout thrive in lakes with temperatures of 21 °C or lower (Scott and Crossman 1973). The critical thermal maxima for brook and rainbow trout was 29 °C when acclimatized to 20 °C (Lee and Rinne 1980). Temperatures in the littoral zone during this study were not optimal but could be considered in the marginal range.

Exotic species introductions often lead to declines of native littoral zone fishes and alter lake-wide fish community structure. Martin and Fry (1972) reported a decline in the brook trout fishery of Lake Opeongo, Ontario, Canada after smallmouth bass were introduced. Similarly, Catt (1949) described the reduction in numbers of brook trout, whitefish, and landlocked Atlantic salmon in lakes Chiputniticook and Magaguadavic, New Brunswick, Canada after smallmouth bass introduction. In Maine, brook trout populations have declined in most waters where smallmouth bass have been introduced or become abundant (K. Warner, Maine Dept. of Inland Fisheries,

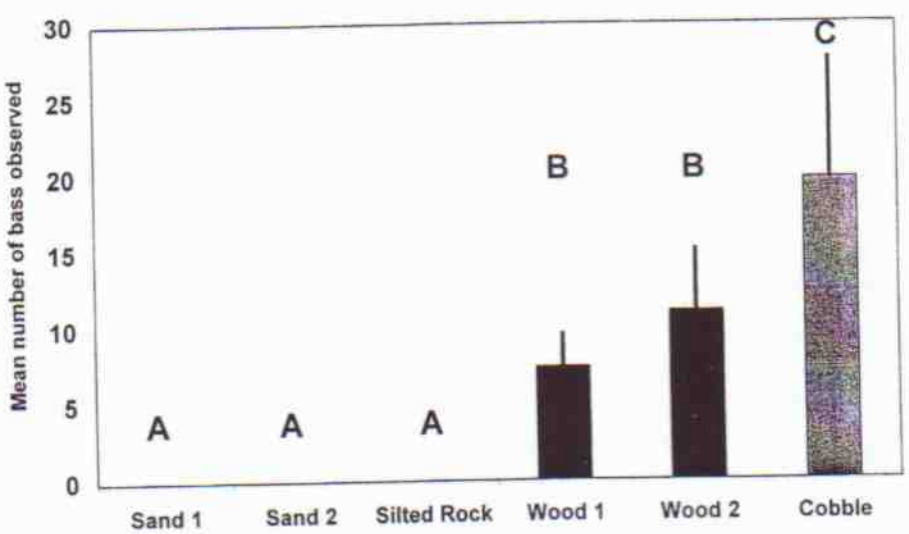

Figure 2. Mean number of smallmouth bass, by habitat type, observed from June to August 1997. Error bars represent 95% confidence intervals. Bars with similar letters were not different from each other using a Fisher pairwise comparison ($p<0.05$).

personal communication), especially in those waters considered marginal for trout (Watson 1955). Several studies have documented the occurrence of salmonids in the diets of smallmouth bass (Pflug and Pauly 1984, Gray and Rondorf 1986, Rieman et al. 1991, Poe et al. 1991). The predation on salmonids by bass and loss of salmonid fisheries suggest that smallmouth bass are detrimental to salmonid populations across North America. The virtual absence of salmonids in the littoral zone of Little Moose Lake provides further evidence of this negative interaction.

Little Moose Lake historically supported important landlocked Atlantic salmon and native brook trout fisheries that have declined since smallmouth bass became established. Warner (1952) cites smallmouth bass as a possible predator of salmon in Little Moose Lake; however, competition for space and habitat could also be important processes that have limited salmonid populations. The establishment of smallmouth bass as the dominant littoral zone fish species coincided with declines in salmonid and native fish populations in Little Moose Lake. We conclude that introduced smallmouth bass have likely exerted sufficient competitive and predatory pressures to alter the native fish community in Little Moose Lake.

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