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Quantifying Differences in Habitat Use Between Anglers and Large Bluegills

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ABSTRACT We compared the habitat use of large (≥200 mm) bluegills (*Lepomis macrochirus)* to the locations of anglers targeting bluegills in a South Dakota glacial lake to determine whether habitat use was similar between anglers and bluegills. Eighty-five bluegills (mean total length = 213 mm) collected in September 2002 and May 2003 were affixed with external radio transmitters and subsequently relocated three to four times per week from October 2002 through October 2003. Bluegill angler locations were recorded during bluegill tracking sessions and roving creel surveys. Habitat variables (water depth, vegetation density and height, and substrate type) were measured lake-wide during August and October 2003. Water depth and vegetation in summer habitat did not differ between anglers and bluegills. Bluegill used areas that were shallower and more heavily vegetated than winter anglers. Anglers used softer substrates than bluegills during both seasons, especially summer. Based on these results, it is possible that summer anglers have the potential to impact bluegill populations more than winter anglers in lakes where sufficient vegetation exists to provide winter refuge from exploitation.

KEY WORDS anglers, bluegill, habitat use, radio telemetry

Angling for bluegill (*Lepomis macrochirus*) is a popular recreational activity (USDOI 2006) due in part to their widespread distribution and susceptibility to inexpensive and simple angling techniques, but recreational angling may have substantial effects on bluegill populations. Goedde and Coble (1981), Guy and Willis (1990), and Beard and Kampa (1999) documented changes to bluegill size structure and age frequencies due in part to angling mortality. Anglers are size selective, targeting large (≥200 mm) individuals in a population (Coble 1988, Beard and Kampa 1999), but high exploitation can have negative impacts on the size structure of bluegill populations (Beard and Essington 2000). Size selective exploitation also may cause bluegill populations to "stunt" by reducing the age of sexual maturity (Drake et al. 1997, Ehlinger et al. 1997, Jennings et al. 1997, Beard and Essington 2000, Aday et al. 2003). This may indirectly reduce growth, increase recruitment, and increase natural mortality due to increased intraspecific competition (Coble 1988).

Since the 1980s, it has become increasingly common for fisheries managers to manipulate harvest regulations to improve panfish population size structure (Coble 1988). These efforts have resulted in varied success due to biological and sociological reasons. Fishing mortality may have less influence on *Lepomis* abundance and size structure than natural mortality and growth rates (Crawford and Allen 2006, Sammons and Maceina 2008, Hoxmeier and Wahl 2009). Anglers also play a role in the success of panfish regulations. Restrictive regulations can increase bluegill size structure but often at a cost of reduced yield and harvest (Paukert et al. 2002, Crawford and Allen 2006, Sammons and Maceina 2008). Anglers may increase the number of fishing trips taken if bluegill size structure increased, potentially counteracting any improvement in bluegill size structure caused by new regulations (Reed and Parsons 1999, Crawford and Allen 2006). Paukert et al. (2002) suggested that some anglers would accept minimum size limits to improve bluegill size structure only if other nearby lakes provide fish for harvest.

Harvest rates are directly influenced by the angler's ability to locate and catch fish, and fish may use similar or different habitat than that of anglers. While more likely to occur with small bluegills, large bluegills can select for specific habitat features. In a shallow Nebraska lake, large male bluegills seasonally selected emergent vegetation, while females showed no preference (Paukert and Willis 2002). However, no studies have quantified the characteristics of the areas that anglers use and compared those with those of bluegill to determine whether overlap exists. Our objective was to compare the habitat used by bluegill anglers to that used by large (≥200 mm) bluegills to examine whether anglers use similar habitat across seasons as large bluegills.

STUDY AREA

Enemy Swim Lake is a mesotrophic 870-ha glacial lake located in Day County, South Dakota, with mean depth of 5.0 m, a maximum depth of 8.5 m, and Secchi depths frequently exceeding 2.5 m (Stueven and Stewart 1996). Blackwell (2001) reported steep bottom contours common in the main lake basin and gentle slopes in the smaller arms and sheltered bays.

The Enemy Swim Lake fishery has historically been managed for walleye (*Sander vitreus*), northern pike (*Esox lucius*),

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smallmouth bass (*Micropterus dolomieu*), and largemouth bass (*M. salmoides*; Blackwell 2001). In the mid-1990s, the population size and structure of bluegills improved (Blackwell 2005), providing an increasingly popular fishery. A substantial increase in summer angling effort and bluegill catch and harvest occurred in 1998, and a winter bluegill fishery developed (Blackwell 2005). Increases in angling effort and concerns over maintaining bluegill population size structure led the South Dakota Department of Game, Fish and Parks (SDGFP) to implement a regulation change in 2002 similar to other panfish fisheries in the region. These regulations included reducing the daily bag limit from 25 to 10 and instituting a 'no high-grading' rule; these limits were in place during the course of this study and were increased to 15 in 2011.

METHODS

Bluegill Locations

We collected large bluegills from Enemy Swim Lake with the SDGFP using standard 19-mm bar mesh trap nets in September 2002 and May 2003. Bluegills were measured, weighed, and affixed with external radio transmitters (Model PD-2, Holohil Systems, Ltd., Ontario, Canada) prior to immediate release. Transmitter-bearing bluegills were located three to four times per week from 7 October 2002 through 18 October 2003 with an 'H'-style antenna (Winter 1996) by boat, ATV, or snowmobile. We used a random number generator to select travel direction, start location (five pre-determined points on the lake), and start time for each tracking event. A fish was assumed to be directly below the vessel or vehicle when the transmitter signal was equal in strength in all directions. The position was recorded on a Trimble GeoExplorer III GPS (Trimble Navigation Limited, Tempe, AZ, USA). Bluegill mortality or transmitter loss was assumed only if a transmitter signal ceased movement over multiple tracking events, and the frequency was removed from future tracking. Attempts were made to recover transmitters that ceased movement, but recovered transmitters were not reused. Bluegill locations were downloaded and categorized into one of five seasons: winter (ice cover), spring (period post-ice with warming air/water temperatures without evidence of spawning behavior), spawn (evidence of spawning behavior), summer (period of high, stable temperatures), and fall (period pre-ice with cooling temperatures).

Angler Locations

During bluegill tracking events, boat- and ice-based anglers were interviewed or observed to determine the species being targeted; locations of these anglers were recorded using a handheld GPS unit. A SDGFP roving creel survey also was used during portions of this study to collect additional information regarding angling and harvest. When conducting roving creel surveys, creel clerks also recorded locations of bluegill anglers on a handheld GPS unit. Additional locations of anglers targeting bluegill were collected during mobile telemetry surveys. Angler locations were organized into the same seasonal categories as described for bluegill tracking.

Habitat Assessment

We assessed habitat in Enemy Swim Lake to examine the habitat characteristics associated with bluegill and angler locations. Habitat was surveyed during 12–16 May (spring/post-ice), 4–14 August (summer; interrupted by bad weather and substrate collections), and 20–24 October (fall/pre-ice) 2003 to address seasonal changes to habitat. Habitat sample locations were randomly selected using ArcInfo and ArcView 3.2 (ESRI, Redlands, CA, USA). A 50-m × 50-m grid was superimposed on Enemy Swim Lake using ArcInfo, and a point was placed at the center of each cell, generating a total of 3,491 points for sampling locations. Seven hundred sampling locations were randomly selected for each survey period; no locations were selected more than once. Water depth (m), vegetation density, and vegetation height were measured at each site using an underwater camera with depth sensor (Aqua-Vu DT-60, Nature Vision, Inc., Brainerd, MN, USA). Vegetation densities were assigned into classes based on stem densities: dense (stems <5 cm apart), moderate (stems 5–15 cm apart), sparse (stems >15 cm apart), and no vegetation. Substrate samples were collected using a petite ponar dredge (232 cm^2) during August sampling and classified using a modified Wentworth scale (Cummins 1962, Stukel 2003). Habitat point data were interpolated using ArcMap (ESRI) to generate raster-based (3-m × 3-m cells) maps of habitat characteristics associated with bluegill and angler locations. As we did not assess habitat through-ice, we used habitat data from the fall/pre-ice survey to represent habitat during winter. We assumed that a category of vegetation density or height would senesce relative to the other categories, with areas having the most dense vegetation pre-ice having the highest density under-ice. We used analysis of variance ($\alpha = 0.05$) to test for seasonal differences in habitat use by bluegills and bluegill anglers.

RESULTS

Enemy Swim Lake substrate was dominated by silt, muck (1:1 silt and sand), and sand (93.6%) but gravel (5%), pebble (1.1%), and isolated detritus and cobble substrates (<1%) were also present (Fig. 1). Aquatic macrophytes were present in 37% (summer), 31% (fall), and 24% (spring) of the lake area, with emergent vegetation limited to less than 1% of the lake.

A total of 85 (40 in September 2002 and 45 in May 2003) bluegills (total length [TL] = 213 mm, SE = 11.4; weight = 240 g, SE = 45.5) were affixed with external transmitters and

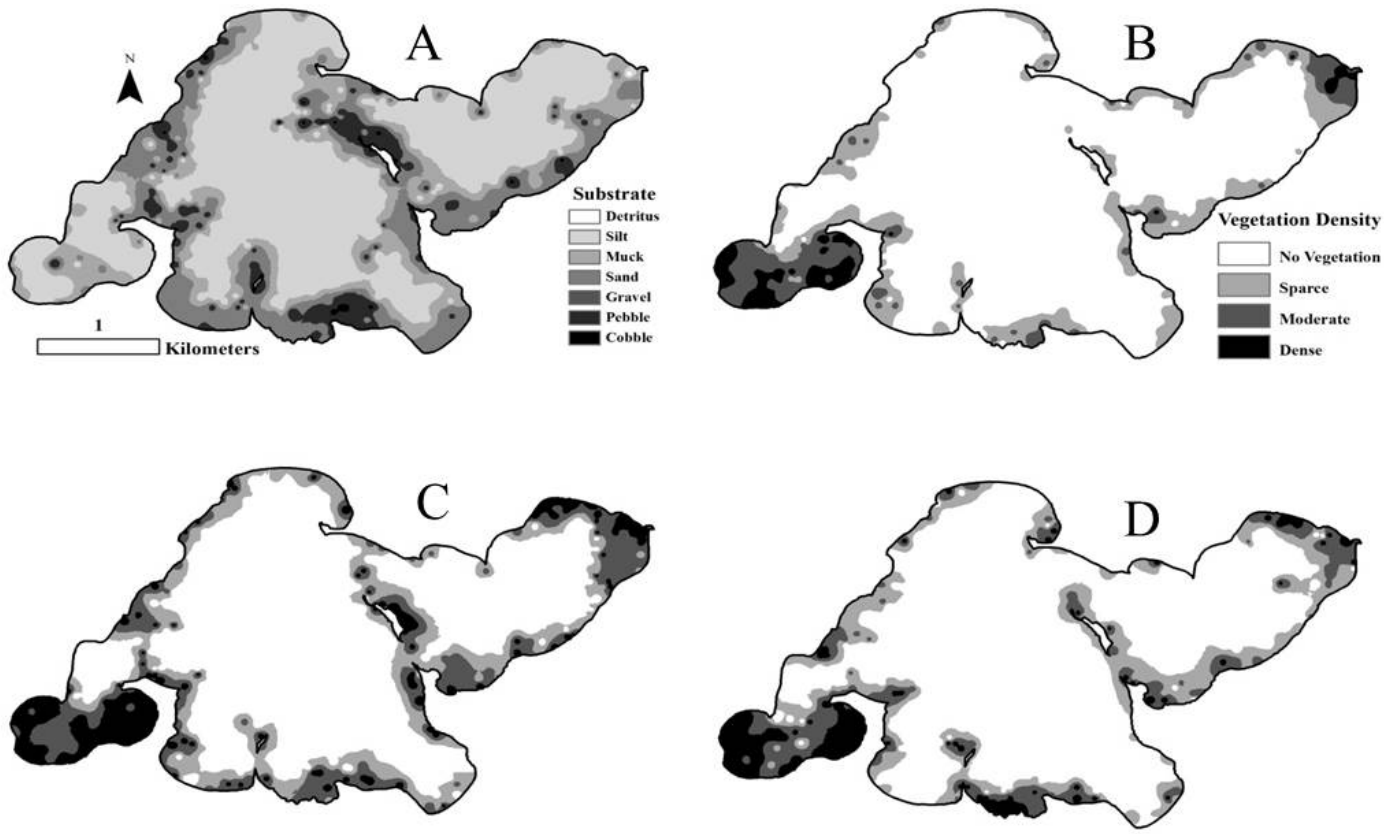

Figure 1. Distribution of substrate types (A) and vegetation density in spring (B), summer (C), and fall (D) in Enemy Swim Lake, South Dakota, USA, 2003.

released. The number of bluegill tracked, and number of bluegill and angler locations recorded, varied across seasons (Table 1). This variability was due to signal interference (i.e., static from motorboats and powerlines), weather, weakening transmitter batteries, and fish mortality/ transmitter loss. Anglers targeted bluegills seasonally, with few locations during fall, spring, or during the spawn. We limited our comparison of habitat use to winter and summer because of the lack of angler locations during other seasons.

Bluegills and anglers were concentrated in shallow, vegetated bays and nearshore areas during most of the winter (Fig. 2A). Church Bay, located at the western end of the Enemy Swim Lake, was heavily utilized by both bluegills and anglers during winter months. Most bluegill locations in the deeper basin of the lake were during late winter as temperatures started warming and ice began to melt. During the summer, bluegills and anglers used nearshore areas distributed throughout the lake (Fig. 2B).

We found bluegills and anglers used different habitat, particularly during winter. Winter anglers fished deeper water ($F_{1, 737}$ = 78.37, $P \leq 0.001$) with shorter ($F_{1, 737}$ = 25.07, $P \leq$ 0.001), less dense ($F_{1, 737}$ = 27.56, $P \leq 0.001$) vegetation than bluegills (Fig. 3A–C). Winter bluegills used softer substrates than anglers ($F_{1, 737}$ = 13.97, $P \leq 0.001$; Fig. 3D), although both used mainly silty substrates. During summer, bluegills used harder substrates than anglers ($F_{1, 137}$ = 12.85, $P \leq$ 0.001). Bluegills and anglers used habitat with similar depths and vegetation in the summer.

DISCUSSION

At the lake scale, anglers appear to use similar areas as large (≥200 mm) bluegills during both winter and summer. Anglers and bluegills concentrated in Church Bay during winter, and both used nearshore areas during the summer, suggesting that bluegill anglers are adept at locating their target species. However, habitat use differs within these areas, particularly during winter. The bluegills in our study used shallow, vegetated habitat during the winter. Bluegill consume zooplankton, benthic, and epiphytic macroinvertebrates, and are influenced by fish size, availability of prey, competition, and season (Mittelbach 1981, Harris et al. 1999, Rakocinski et al. 2000, Olson et al. 2003, Brenden and Murphey 2004). Use of habitat with aquatic vegetation suggests winter bluegills feed on epiphytic macroinvertebrates (Schramm and Jirka 1989). In Enemy Swim Lake, Church Bay

Table 1. Seasonal bluegill and angler location data from Enemy Swim Lake, South Dakota, USA, 2002–2003. Winter locations were collected during the period of ice cover, December 2002 through March 2003. Fall locations were collected in 2002 and 2003. Locations for other seasons were collected in 2003.

Season	# Bluegill tracked	Total bluegill locations	Total angler locations
Winter	24	591	148
Spring	42	101	2
Spawn	43	315	8
Summer	15	76	63
Fall	48	542	0

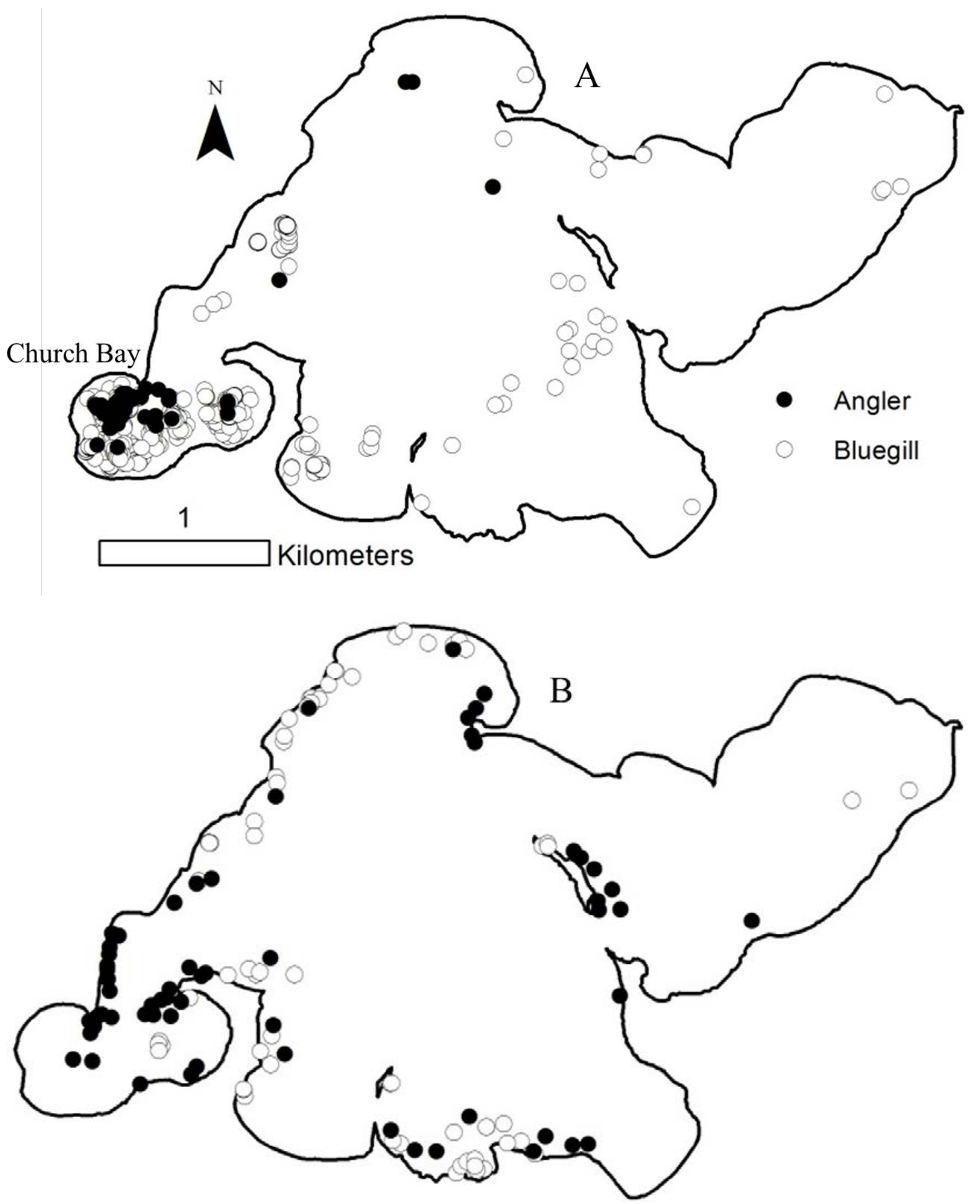

Figure 2. Angler (●) and bluegill (○) locations during winter 2002–2003 (A) and summer 2003 (B) in Enemy Swim Lake, South Dakota, USA.

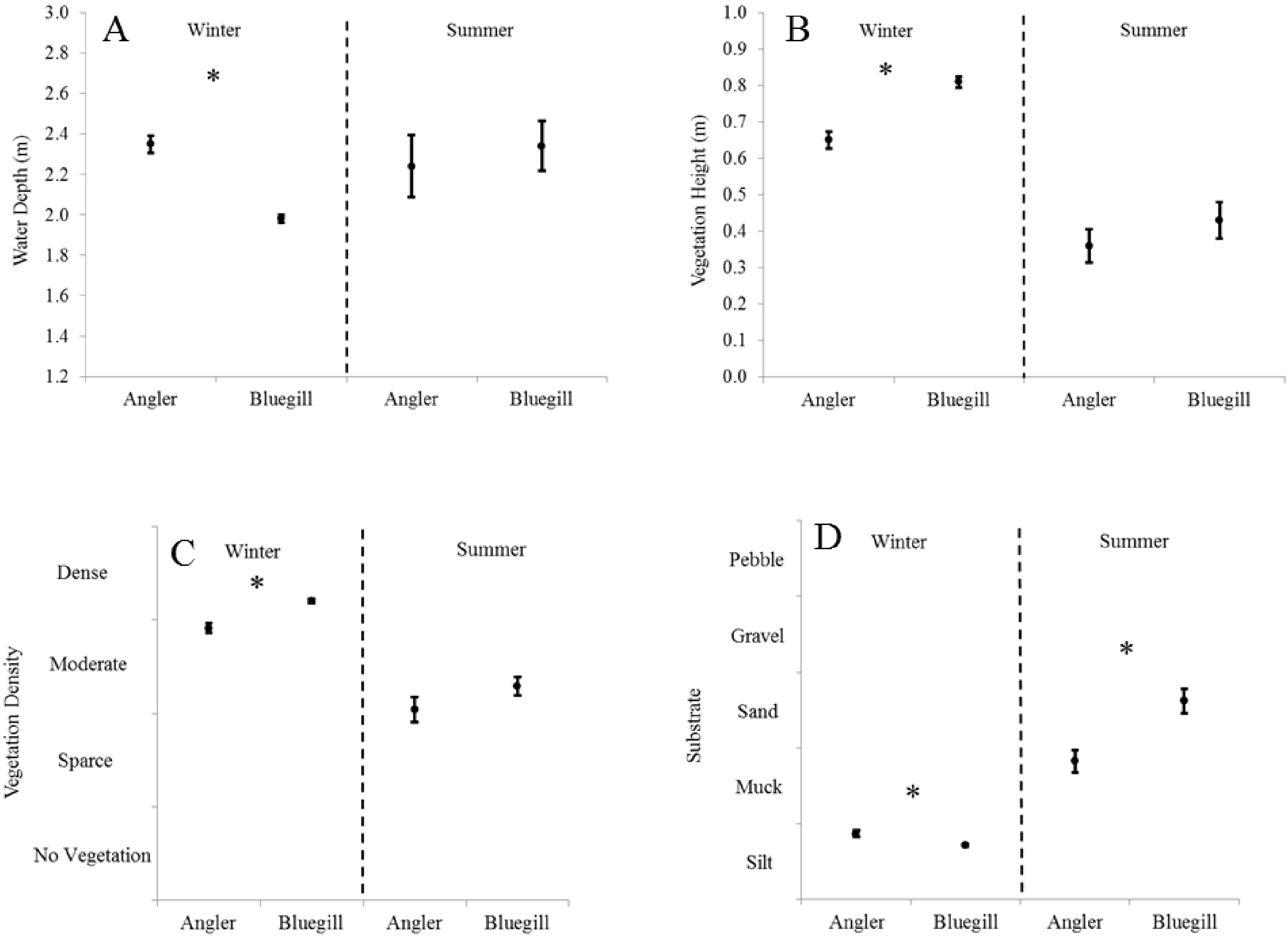

Figure 3. Mean water depth (A), vegetation height (B), vegetation density (C), and substrate type (D) in habitat used by bluegills and bluegill anglers in Enemy Swim Lake, South Dakota, USA, during Winter 2002–2003 and Summer 2003. Winter water depth and vegetation data were collected during October 2003; summer depth and vegetation data and all substrate data were collected during August 2003. Error bars represent the standard error of the mean; statistical differences from ANOVA testing ($\alpha = 0.05$) are indicated with an asterisk (*).

contains the largest area of aquatic vegetation and may represent the best feeding habitat for large bluegills during winter.

In contrast, larger bluegills used deeper water and less vegetated areas in summer compared to winter. Large bluegills, whose size make them relatively free from predation risk, have been shown to utilize open water habitats for feeding on zooplankton during summer months when zooplankton densities are high (Mittelbach 1981). Paukert and Willis (2002) found that large bluegills used open water and vegetated habitats in similar proportions during late summer. However, their study lake had similar densities of zooplankton and benthic macroinvertebrates in both open water and vegetation, making foraging profitable in both habitats (Paukert and Willis 2000). In Enemy Swim Lake, summer dispersal may reflect a diet shift to zooplankton or benthic invertebrates, or it may reflect increased vegetation growth in other portions of the lake providing additional substrate for feeding on epiphytic invertebrates.

Anglers also used different habitats depending on the season. Whittaker et al. (2006) suggested that angler habitat use is influenced by both social and biophysical factors. Winter bluegill anglers who typically use small baits on light fishing lines may be limited to fishing in areas with sparser vegetation because it is too difficult to fish in dense vegetation. Summer anglers may be located in softer substrates, but open water allows anglers to cast horizontally, rather than fishing vertically as required when ice fishing. With firmer substrates being closer to shore in Enemy Swim Lake, it is possible that summer anglers may be presenting their baits in substrates similar to those used by bluegills. Factors affecting how anglers select fishing locations were not addressed in this study. Social factors, such as tradition, locations of other anglers, and level of angling technology (i.e. using sonar, mapping software, etc.), likely play as important a role in selecting angling habitat as the vegetative structure.

Interestingly, habitat used by anglers and bluegills were more similar during summer than winter. Winter use of highly vegetated habitats by bluegills may inadvertently create a refuge from angling. Thus, anglers may have less of an impact on bluegill size structure through harvest during this season. In contrast, Blackwell (2005) reported that bluegill harvest rates during this study were higher in the summer compared to winter, which suggests summer anglers may be better at locating and utilizing large bluegill habitat. Therefore, anglers may have a greater impact on bluegill size structure during this period.

MANAGEMENT IMPLICATIONS

Differences in winter habitat use by large bluegills and anglers likely reduce the impacts of harvest and regulations on population dynamics by providing bluegills a natural refuge from angling mortality. Winter anglers appear limited in their ability to exploit bluegill populations where aquatic macrophytes are abundant, making regulations based on reducing exploitation to maintain or increase bluegill size structure less likely to be successful. However, similarities in use of summer habitat suggest that anglers may affect bluegill population dynamics sufficiently to warrant the use of regulations to maintain or increase bluegill size structure. When considering enacting regulations to manage bluegill population size structure, managers should take all available physical, biological, and social data in to account. Habitat availability, population dynamics, harvest and effort data, and angler patterns and behavior each may play a role in the effectiveness of regulations.

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