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Winter Habitat Use by Adult Largemouth Bass in the Pend Oreille River, Idaho

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Abstract.—We evaluated the behavior and use of overwintering habitat of adult largemouth bass *Micropterus salmoides* in the Pend Oreille River, Idaho, using radiotelemetry after increases in winter water levels. Largemouth bass tagged in late summer remained in backwaters until the initiation of the fall drawdown, when they moved to deeper shoreline areas. As water temperatures declined further, all but 1 of the 19 largemouth bass tagged throughout a 44.2-km-long section of river migrated to one of two overwintering areas. Once there, largemouth bass either showed no movement or migrated freely between the two overwintering areas. The overwintering areas were adjacent to the river, had an abundance of aquatic macrophytes, were more than 1 m deep, and had zero water velocity. Higher winter lake levels of 0.6 m did not attract wintering largemouth bass to backwaters. We hypothesized that habitat in overwintering areas was preferred because water temperatures there were several degrees warmer than in shallow backwaters.

Lowering of water levels during winter is common in many impounded river complexes to maximize power generation and prevent spring flooding. These practices, however, can adversely affect off-channel overwintering habitats for many riverine fishes (Greenbank 1956; Sheehan et al. 1990; Pitlo 1992; Raibley et al. 1997). Winter survival of centrarchid fishes in riverine environments has been linked to accessibility and quality of backwater habitat (Greenbank 1956; Hatch 1991; Carlson 1992; Pitlo 1992). Winter drawdowns can directly influence winter habitat through dewatering and exposing off-channel areas, thereby forcing fish to seek alternative winter habitat or overwinter in the main river channel (Pitlo 1992). Indirect effects of winter drawdown are related to a reduction in water depth. Shallow backwaters are especially susceptible to oxygen depletion during periods of extensive snow and ice cover (Mathias and Barica 1980) and can often reach temperatures near 0°C. Large or untimely fluctuations in water level during the winter may also trap fish wintering in backwaters and lead to fish kills (Greenbank 1956).

We conducted a radiotelemetry study to evaluate the winter behavior and habitat selection of largemouth bass *Micropterus salmoides* in the Pend Oreille River, Idaho, under reduced winter drawdown conditions. Previous winter drawdown conditions severely limited fish access to side channels and backwaters.

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Study Area

The Pend Oreille River begins at the outlet of Lake Pend Oreille in northern Idaho at an elevation of 628.5 m (2061 ft) above mean sea level (Figure 1). The study area was the upper portion of the river, extending from the natural outlet of Lake Pend Oreille at the U.S. Highway 95 Bridge near Sandpoint, Idaho, 44.2 km downstream to Albeni Falls Dam. This section of river is operated as a run-of-the-river reservoir, with flows ranging seasonally from 617 to 2,044 m^3 (11,200–73,000 ft^3/s). At full pool, the surface area is 3,887 ha, the maximum depth is 48.5 m, and the average depth is 7.1 m (DuPont 1994). About 161 km of the shoreline, including sloughs and islands, has a gentle to moderate slope made up mostly of fine sediments (<4 mm), whereas about 16 km of shoreline is riprap. Aquatic macrophytes, mainly *Potamogeton* spp. and *Myriophyllum sibiricum*, are abundant along the shoreline in many areas (Wagner 2000).

Six major backwaters occur in this section of the Pend Oreille River: Riley Creek Slough (Rkm 18.2), Hoodoo Creek Slough (Rkm 19.0), Tanner Creek Slough (Rkm 21.7), Cocolalla Slough (Rkm 23.2), Morton Slough (Rkm 25.4), and Gypsy Bay (Rkm 31.6; Figure 1). These areas are isolated from main river currents and have relatively shallow water depths (from 2.0 m to 3.8 m), with heavy growths of aquatic macrophytes. Prevalent fishes in these backwaters include largemouth bass, black crappie *Pomoxis nigromaculatus*, and pumpkinseed *Lepomis gibbosus* (DuPont 1994).

Waters upstream of Albeni Falls Dam are drawn

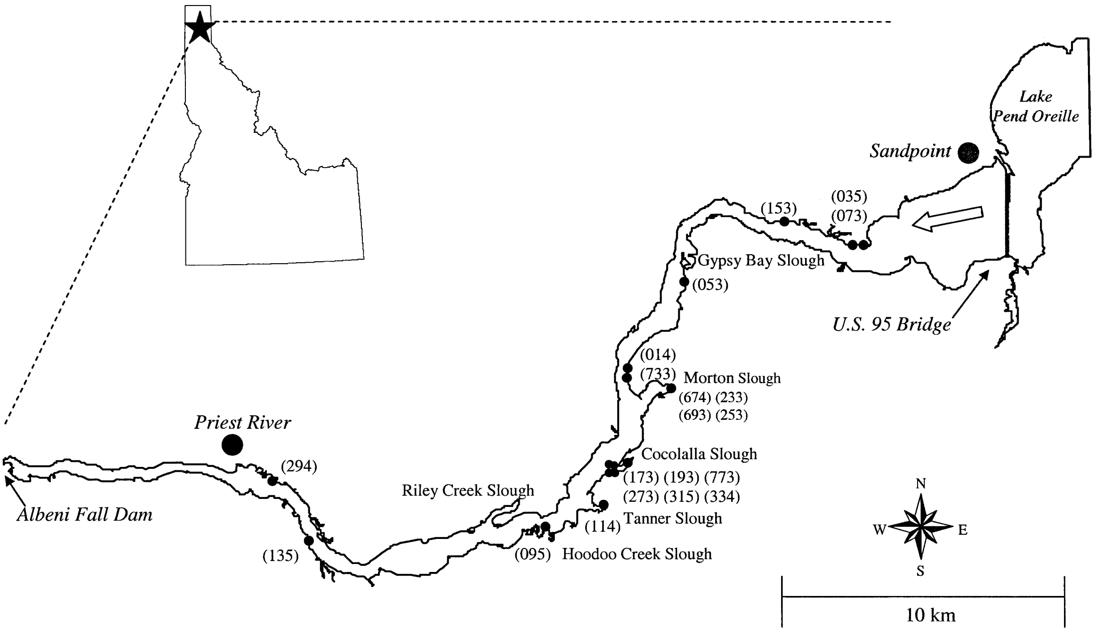

FIGURE 1.—Study area map of the Pend Oreille River, Idaho, including the six primary backwater areas and initial capture locations of 20 radio-tagged largemouth bass collected from 29 August to 19 October 1999.

down annually from late fall to early spring for flood control and winter generation of electrical power (Dice 1983). Traditionally, winter water levels are reduced by 3.5 m or to a lake elevation of 625.0 m (2,050 ft); during 1999, however, the maximum winter drawdown was reduced to 2.9 m or to a lake elevation of 625.6 m (2,052 ft). Drawdown began on 19 September and continued through 3 November 1999, at a mean removal rate of about 4.5 cm/d. Under the 2.9-m drawdown regime, only Morton Slough maintained water depths near 1.5 m. Spring refill began on 5 May and reached full pool on 15 June 2000, at a mean fill rate of about 5.3 cm/d.

Methods

Winter movement patterns and habitat use were determined from 20 adult largemouth bass that had been implanted with radio tags. Fish were captured from 29 August through 19 October 1999 by means of boat electrofishing and angling. Selected fish were anesthetized (MS-222), measured for total length (mm), weighed (g), and surgically implanted with 17 × 40 mm (17 g dry weight) radio transmitters (model 5902; Advanced Telemetry Systems, Inc., Isanti, Minnesota) by techniques similar to those described by Ross and Kliner (1982) and Hart and Summerfelt (1975). Each transmitter was equipped with a braided wire antenna and coated with clear waterproof epoxy resin. Transmitters contained 3.0 V lithium batteries with 300-d longevities; each was operated on a unique frequency between 151 and 152 MHz. After surgery, largemouth bass were tagged with serially numbered Floy© tags for external identification, returned to a holding tank until recovery (usually 10–20 min), and then released at the site where they had been captured.

Each fish was located at least once every 2 weeks through June of 2000, after a 7-d acclimation period (Guy et al. 1992). The general vicinity of radio-tagged fish was located by using a boat equipped with a fixed signal receiver (model FM 1470; Advanced Telemetry System), and a four-element 1.2-m yagi antenna. A handheld directional antenna was then used to determine a definitive location (<2 m). Fish locations were recorded in Universal Transverse Mercator (UTM) coordinates, determined with a global positioning unit (GPS) with an external antenna (Trimble Geoexplorer II). Date, time of day, water temperature (°C), total depth (m), velocity (cm/s), dissolved oxygen concentration (mg/L), turbidity (NTU), distance to nearest shore, and cover type also were recorded at each contact point. Location and habitat data were downloaded to a computer, differentially corrected, and imported into ArcView v.3.2 for analysis (ESRI 1997).

Habitats available to largemouth bass under winter drawdown conditions were determined from maps describing water depth, velocity, and presence or absence of aquatic macrophytes. Changes in river depth were determined with a digitized bathymetric map obtained from the U.S. Geological Survey (USGS 1996). During December 1999 and January 2000 we measured water velocities at 0.5 m below the water surface, middepth (0.6 of total depth), and 0.5 m above the bottom along 1-km spaced transects, using a Swoffer current meter at four predetermined points (two pelagic and two littoral) along each river transect and from all existing backwaters. Data recorded at each point were given a reference coordinate (UTM) by using GPS and were recorded as attribute data. Distribution of aquatic vegetation was determined from visual observations made from a boat during calm sunny days under low pool conditions. The perimeter of aquatic vegetation patches was recorded by using GPS. All habitat data were imported into ArcInfo v.7.2.1 and ArcView v. 3.2 for spatial analysis (ESRI 1997).

Mean daily water elevation during the study period was obtained from the U.S. Army Corps of Engineers from readings at the Hope recording station on Lake Pend Oreille. Water temperature was recorded hourly at two permanent stations (main river channel and backwater; Figure 1) with use of three temperature loggers (model RTM 2000; Ryan Instruments, Inc., Redmond, Washington) suspended at bottom, middepth, and surface positions.

The minimum distance of winter migration was calculated for each radio-tagged fish as the minimum linear distance between the locations of initial capture and overwintering area (Animal Movement extension in ArcView; ESRI 1997).

Observations of habitat use and availability were divided among seven habitat categories, based on water depth, presence or absence of aquatic macrophytes, and orientation to the main river channel. Areas that remained wetted after the winter drawdown had been completed and maintained water velocity <1 cm/s were deemed available to overwintering largemouth bass (Winter and Ross 1982). These categories included: vegetated–shallow depth (0–1 m), open water–shallow depth, vegetated–medium depth (1–3 m), open water–medium depth, vegetated–deep depth (3–5 m), open water–deep depth, and backwaters (open water and vegetated, 0–1.5 m). Habitat maps representing river depth, water velocity, and aquatic vegetation were produced in raster model format by using ArcInfo and ArcView (ESRI 1997). We generated a composite map by logically overlaying the three habitat maps (water depth, velocity, and vegetation) and a shoreline reference map and used this to determine the availability of each habitat category within the study area. We used a 5×5 m pixel size to increase map resolution. Largemouth bass use of each habitat category was evaluated by overlaying a map of fish locations on the composite map that delineated each habitat category. For each fish, the number of observations within each habitat category was then enumerated to derive habitat use.

Compositional analysis was used to test whether largemouth bass selected overwintering habitat categories in proportion to their availability (Aebischer et al. 1993). Only fish contacts between November and mid-March were used to determine winter habitat selection. All calculations were performed with Resource Selection v.1 (Leban 1999).

Results

Three hundred-eighty one locations were detected for 19 radio-tagged largemouth bass from 2 October 1999–2 June 2000 (Table 1; Figure 1). No signals were received from one largemouth bass (no. 073) and we assumed that radio tag was defective. The mean number of observations was 20/fish (range, 14–26), and fish were tracked over an average of 246 d (range, 170–276). We observed no emigration of fish outside the study area.

Movement of largemouth bass to overwintering areas coincided with drawdown. Locations in September and mid-October indicated that largemouth bass moved from backwater habitat to shoreline areas along the main river channel but remained in the general vicinity of where they had been tagged. Movement toward overwintering areas and away from initial capture locations began in late-October as water temperatures in the main river channel decreased to below 10°C, and winter drawdown was near completion (Figure 2). Some fish traveled from 10 (nos. 035 and 153) to 16 km (no.294) and generally followed the shoreline in areas of lowest water velocity. On 4 November 1999, 18 of 19 (95%) largemouth bass were located in one of two primary wintering areas (PWA; Figure 3). The upper PWA (49.3 ha) was located along the shoreline immediately downriver of Gypsy Bay; the lower PWA (52.9 ha) extended from the mouth of Morton Slough downriver to Tanner Creek Slough (Figure 1). Both areas had zero water velocity, a gentle sloping bottom with a mean water column depth of 2 m, and dense

TABLE 1.—Summary of radio-tagged largemouth bass in the Pend Oreille River, Idaho, during August 1999 through June 2000.

Fish code Number	Total Length (mm)	Weight (kg)	Study dates[a]	Number of locations	Distance traveled[a] (km)
035	471	2.20	29 Aug 1999–16 Apr 2000	20	8.4
095	495	2.52	29 Aug 1999–2 Jun 2000	22	3.8
073	500	2.20	29 Aug 1999[b]	2	
114	405	1.00	2 Sep 1999–31 May 2000	26	0.8
135	434	1.17	3 Sep 1999–31 May 2000	16	2.2
153	465	1.74	5 Sep 1999–2 Jun 2000	26	10.5
193	396	1.00	17 Sep 1999–16 Apr 2000[c]	19	1.5
173	393	0.80	17 Sep 1999–29 Apr 2000	18	1.3
253	412	1.05	18 Sep 1999–29 Apr 2000	20	1.2
233	400	1.03	18 Sep 1999—31 May 2000	21	1.3
273	372	0.77	2 Oct 1999–31 May 2000	20	1.5
315	398	0.97	3 Oct 1999–29 Apr 2000	18	1.0
294	485	1.79	3 Oct 1999–31 May 2000	19	15.9
693	356	0.69	7 Oct 1999–31 May 2000	21	1.3
674	365	0.69	7 Oct 1999–25 Mar 2000[c]	17	1.4
334	470	1.56	7 Oct 1999–31 May 2000	20	0.9
773	365	0.71	8 Oct 1999–2 Jun 2000	24	0.8
014	475	2.13	9 Oct 1999–2 Jun 2000	21	1.0
733	505	2.16	9 Oct 1999–31 May 2000	19	1.1
053	488	1.93	19 Oct 1999–13 Mar 2000	14	4.8

[a] From implantation of transmitter to overwinter area.
[b] Signal was never received after release.
[c] Fish was harvested by anglers.

aquatic macrophyte growth. Of the 18 largemouth bass that wintered in these areas, all but 1 remained until early spring. In mid-January, one fish (no. 053) moved out of the upper PWA and was located upriver 4.8 km along the south shoreline, where it remained until spring refill. The one experimental fish (no. 135) that overwintered outside the PWA complex was located along the south shoreline at

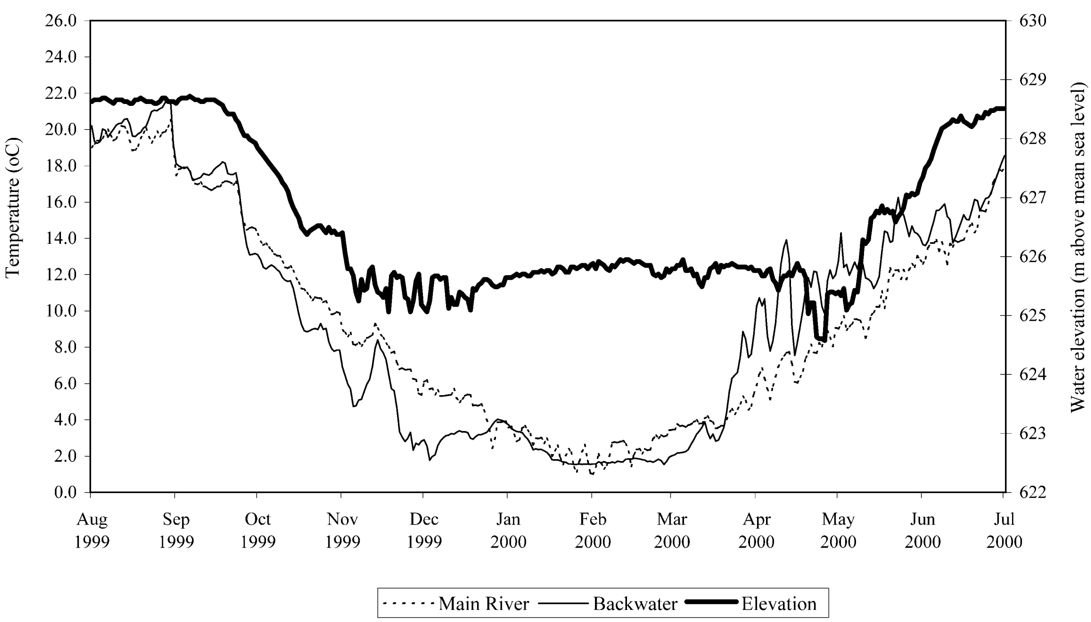

FIGURE 2.—Mean daily water temperatures and water surface elevation from August 1999 to June 2000 in the Pend Oreille River, Idaho.

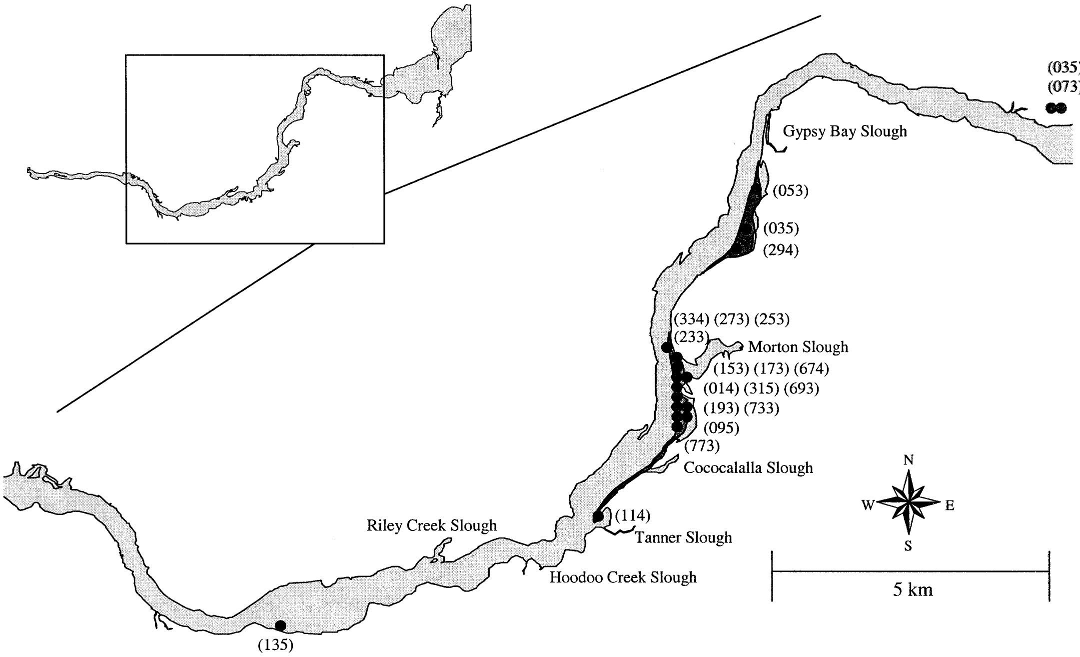

FIGURE 3.—Locations of radio-tagged largemouth bass in the Pend Oreille River, Idaho, on 4 November 2000 under 2.9-m winter draw-down conditions. Shaded areas indicate primary wintering areas (PWA) from November 1999 to March 2000.

Rkm 13.5, where it remained for the duration of winter in similar habitat to the PWA.

Two general trends of largemouth movement were seen once fish had moved into the overwintering areas. One group ($n = 9$) remained relatively sedentary near the mouth of Morton Slough in an area of less than 15 ha, especially after the water temperature decreased below 6°C in December. Others ($n = 9$) remained more active and moved from one wintering area to the other, even at water temperatures of 3°C.

In the wintering areas, largemouth bass were frequently located under ice from mid-December until early March but not in areas defined as backwaters. Temperature within the PWA differed from the top to the bottom by only 0.1–0.5°C; and dissolved oxygen exceeded 8.5 mg/L at all depths.

Movement away from the PWA began in mid-March, when water temperatures in the existing backwaters became warmer than in the main river (Figure 2). By 25 March 2000, all fish that overwintered in the upper and lower PWA were located in adjacent backwaters that had remained accessible after drawdown. Most fish ($n = 15$) were located in Morton Slough, but some were located in Cocolalla (no. 773) and Tanner Creek sloughs (no. 114). From March to April, mean water temperatures in backwaters increased from 7.5°C to 15°C, and remained between 3°C and 5°C warmer than the main river. During this period, all fish were located close to shore in waters less than 1 m deep and in no detectable cover. All radio-tagged fish that moved into backwaters in March remained in these areas until the initiation of spring refill in May.

During spring refill, the tagged largemouth bass redistributed throughout the study area but were typically located in re-inundated backwaters. Of the 12 fish we located after completion of the spring refill in June, 9 had returned to the areas where they were originally captured.

A drawdown of 2.9 m in the Pend Oreille River in fall 1999 reduced the total wetted surface area by about 11.3%, and exposed approximately 423 ha of shoreline. The most frequently occurring habitats available to largemouth bass were open water–medium depth (1–3 m; 52.9% of the available area) and vegetated–medium depth (23.5% of the available area; Table 2). Areas defined as vegetated–deep depth (3–5 m) accounted for the least amount of available habitat (1.4%).

Compositional analysis indicated that habitat

TABLE 2.—Relative abundance (%) of habitats available to tagged largemouth bass during the winter period of November through mid-March, Pend Oreille River, Idaho, 1999–2000.

Habitat type	Abbreviation	Habitat Availability
Vegetated, shallow depth (0–1 m)	VSD	5.3
Open water, shallow depth (0–1 m)	OWSD	5.9
Vegetated, medium depth (1–3 m)	VMD	23.5
Open water, medium depth (1–3 m)	OWMD	52.9
Vegetated, deep depth (3–5 m)	VDD	1.4
Open water, deep depth (3–5 m)	OWDD	3.7
Backwater	BW	7.3

use was nonrandom ($\chi^2 = 128.9$; df = 6; $P < 0.0001$); largemouth bass selected vegetated–medium depth habitat significantly more frequently than all other habitat types (Table 3). Vegetated–deep depth was ranked second in use and also was selected significantly more than other habitat types. We detected no difference in use among the remaining habitat types except for backwater habitat, which was selected significantly less often than all other habitat types except open water–shallow depth.

Discussion

Our results demonstrate the importance of specific wintering areas to 20 largemouth bass in the Pend Oreille River. From the beginning of November to mid-March, 95% of largemouth bass ($n = 19$) radio-tagged within a 30-km section of the reservoir were located in one of two small wintering areas (combined surface area 102.2 ha). These areas provided refuge from high water velocities and had relatively stable and warmer water temperatures, consistent with other findings of suitable winter habitat (Sheehan et al. 1990; Pitlo 1992). However, largemouth bass in the Pend Oreille River overwintered along the main river channel outside of existing backwaters. This is in contrast to other studies that suggest off-channel areas typically provide suitable habitat and attract high densities of fish during the winter in other northern riverine systems (Greenbank 1956; Sheehan et al. 1990; Pitlo 1992; Raibley et al. 1997).

Largemouth bass overwintering adjacent to the main river channel and outside of adjacent areas probably reflects the lack of suitable backwater habitat in the Pend Oreille River, despite the reduction in winter drawdown by 0.6 m. A drawdown of 2.9 m reduced the total surface of the Pend Oreille River by approximately 11% and exposed about 423 ha of shoreline. Exposed and nearly exposed areas consisted of shallow backwaters (<1 m deep) or sloughs located adjacent to the main river channel. Shallow backwaters cooled more rapidly in fall and stayed an average 3°C cooler than the main river channel until early January. Because largemouth bass thermally regulate (Cherry et al. 1975; Cincotta and Stauffer 1984; Crawshaw 1984), they seek areas providing the warmest available water to overwinter (Coutant 1975; Ross and Winter 1982; Sheehan et al. 1990; Pitlo 1992; Raibley et al. 1997). We believe the warmer littoral areas along the main river channel that had little to no water velocity probably served as alternative winter habitat to backwater areas under drawdown conditions.

The fact that we found all radio-tagged fish outside of adjacent backwaters suggests that essential habitat components were provided in primary overwintering areas. The ability to find suitable winter habitat can be critical to survival of largemouth bass in riverine environments at northern latitudes. For example, when low water levels denied access to suitable winter habitat in the upper Mississippi River, radio-tagged largemouth bass had severe winter mortality (Pitlo 1992). Similarly, largemouth bass populations declined when the Mississippi River backwater habitat was destroyed by sedimentation (Gent et al. 1995).

TABLE 3.—A ranking matrix for habitat selection of largemouth bass based on comparing the proportions of use and availability for each habitat type. Signs (+ or −) indicate selection for or against a given habitat; triple sign (+++ or −−−) indicate significant deviation at $P < 0.05$. Habitat type marks followed by a common letter are not significantly different ($P > 0.05$). See Table 2 for habitat abbreviations.

Habitat type	VSD	OWSD	VMD	OWMD	VDD	OWDD	BW	Rank
VSD		+	−−−	+	−−−	+	+++	3 x
OWSD	−		−−−	−	−−−	−	+	6 xw
VMD	+++	+++		+++	+++	+++	+++	1 z
OWMD	−	+	−−−		−	+	+++	4 x
VDD	+++	+++	−−−	+++		+++	+++	2 y
OWDD	−	+	−−−	−	−−−		+++	5 x
BW	−−−	−	−−−	−−−	−−−	−−−		7 w

The high concentration of tagged fish combined with the distance some fish traveled to reach preferred overwintering areas may reflect a general lack of available and suitable winter habitat under draw-down conditions. Within primary wintering areas, largemouth bass selected habitats containing aquatic vegetation at depths of 1–3 m. Based on our GIS analysis, these habitat characteristics were present in other sections of reservoir but were unoccupied by tagged fish; indeed, several fish bypassed these areas when migrating to the upper and lower PWA. Temperature, dissolved oxygen, and water velocity measurements from these areas throughout the winter indicated little difference from the PWA, which suggests that largemouth bass may have selected overwintering sites based on other habitat characteristics.

Strong affinity of largemouth bass to specific overwintering areas may be related to habitat size, aquatic macrophyte community, and site fidelity. While we found that other reservoir sections also contained aquatic vegetation at depths of 1–3 m, primary overwintering areas made up more than 50% of the total surface area. Species distribution and density of aquatic macrophytes also may be important characteristics of winter habitat. Macrophyte diversity is high and spatially heterogeneous (Wagner 2000). We do not know whether overwintering site selection was based on specific vegetation types or densities, although the importance of these habitat attributes have been mostly associated with summer feeding behavior (Savitz et al. 1983; Savitz and Thomas 1985; Rogers and Bergersen 1996). Largemouth bass have been shown to return to specific overwintering sites year after year (Carlson 1992; Pitlo 1992). Winter water levels in the Pend Oreille River remained approximately 0.5 m higher during the 3 years preceding this study, which dramatically increased littoral densities of aquatic macrophytes (Wagner 2000). This increase may explain the presence of preferred winter habitat in other river sections, but it might not have influenced overwintering site selection.

Water temperature appeared to influence movement of largemouth bass into and away from overwintering areas. In fall, largemouth bass exhibited a shift from backwater habitat into deeper shoreline areas, movements coinciding with cooler water temperatures. Fish remained outside of shallow backwaters until early spring, when water temperatures warmed and fish returned to those sites. Largemouth bass winter migrations have been characterized by fish shifting offshore during winter and returning when water temperatures warm in spring (Betsill et al. 1988; Woodward and Noble 1999). Access to warmer water temperatures in spring increases recruitment by allowing adult fish to begin spawning earlier; this leads to a longer growth period and an increased survival of age-0 largemouth bass (Bowles 1985; Hatch 1991; Pine et al. 2000).

An unreported finding for northerly regions was that some radio-tagged largemouth bass continued to move within overwintering areas. In other studies, largemouth bass were relatively sedentary during winter (Warden and Lorio 1975; Pitlo 1992), probably because of decreased metabolic activity at low water temperatures (Johnson and Charlton 1960; Crawshaw 1984). The reason for sustained activity by some largemouth bass in the Pend Oreille River is unclear. Although largemouth bass have been shown to move under low water temperatures to avoid areas with low dissolved oxygen levels (Sheehan et al. 1990; Gent et al. 1995; Raibley et al. 1997), the dissolved oxygen in both backwater and main river habitats in the Pend Oreille River remained greater than 8 mg/L throughout the winter, a concentration sufficient to provide nonstressful conditions to fish. Movement in response to predator–prey interactions is also unlikely, because feeding by largemouth bass is significantly reduced at water temperatures below 10°C (Crawshaw 1984). Persistent winter mobility may represent a mobile segment within some largemouth bass populations (Woodward and Noble 1999), although this behavior has been most commonly observed in intermediate size-classes (250–320 mm) and not during winter.

Managers need to be creative in providing wintering habitat for largemouth bass. Intuitively, we believed that higher winter water levels should increase suitable overwintering habitat for adult largemouth bass. In the Pend Oreille River, increasing water levels by 0.6 m did not make backwater habitat suitable for overwintering. Creation of deepwater refuge in a few select areas (e.g., identified preferred wintering areas) may be more cost-effective than large-scale dredging, while still effectively enhancing winter habitat. Deeper backwaters would minimize potential dissolved oxygen problems and provide more stable and warmer water temperatures. Well-designed backwaters could provide all suitable habitat attributes identified by Sheehan et al. (1990) for overwintering of many littoral fishes.

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