

The Use of Sanctuaries for Protecting Nesting Black Bass from Angling

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Abstract.—Catch-and-release angling for bass during the brood-guarding stage can induce premature nest abandonment by the male parent, resulting in loss of the brood to predation. Significant levels of angling-induced brood loss can cause a population-level decrease in reproductive success. If that decrease in reproductive success translates into a decrease in recruitment, the population density and/or size structure of the bass population may be affected negatively. To avoid these potential problems, managers in some parts of North America have implemented regulations designed to protect nesting male bass while they are spawning and guarding their young. The purpose of this study was to determine if Voluntary Bass Conservation Zones (areas within a lake that are closed voluntarily to all angling until the bass spawning season is over) could be used to protect these highly vulnerable bass from angling. Our results demonstrate first that with sufficient levels of advertisement and community enforcement, a Voluntary Bass Conservation Zone can both reduce levels of angling for nesting bass and increase the reproductive success of the bass population within the zone. They demonstrate second, however, that a Voluntary Bass Conservation Zone that is not properly enforced can actually decrease bass reproductive success by attracting unscrupulous anglers to bass spawning areas, thereby increasing levels of angling for nesting bass.

Introduction

Managers have known for many years that numerous fish populations are in serious decline (Murray et al. 1999). Largemouth bass *Micropterus salmoides* and smallmouth bass *M. dolomieu* in North America suffer the same fate as many fisheries around the world—valuable stocks are being subjected to high angling pressures and excessive harvest rates

(Paragamian 1982). This overfishing can lead to a reduction in the density of bass populations and changes in their population size structure, as well as a decrease in angling quality (Weithman and Anderson 1978). A decrease in angling quality is particularly problematic, because bass fisheries constitute arguably the most economically valuable recreational fishery in North America, attracting large numbers of nonresident anglers (Barnhart 1989; Weithman 1999).

In late spring, male bass move into the littoral zone of lakes, rivers, and streams and with their caudal fins fan out a shallow, bowl-like nest in the

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substrate. Once a nest has been constructed, females are courted, and spawning occurs shortly thereafter. After egg deposition is complete, the female leaves the area, while the male remains at the nest site to provide sole parental care for the developing young (Ridgway et al. 1989). This parental care, which includes fanning of eggs and defending the brood from potential predators, can continue for up to five weeks (Neves 1975) until the offspring have reached independence from the male parent (Ridgway 1988). Males defend their broods quite vigorously, and fish that venture too close are chased away with an aggressive display or an attack (Ridgway 1988). Because many fishing lures mimic various organisms that are potential brood predators, they are attacked just as ferociously, making male bass extremely vulnerable to angling while they are guarding their young. Philipp et al. (1997), for example, reported that over 70 percent of nesting bass struck a fishing lure cast near their nest.

If a nest-guarding male bass is angled and harvested, his brood is left completely defenseless, and predatory fish are able to consume the unprotected eggs or fry quickly (Neves 1975). If a nest-guarding male bass is angled and then released immediately, it is still removed from its nest for some finite amount of time, which, again, subjects his brood to predation risk (Kieffer et al. 1995; Philipp et al. 1997). Catch-and-release angling also causes additional physiological stress for nesting male bass, which can reduce their ability to defend offspring (Kieffer et al. 1995; Philipp et al. 1997; Cooke et al. 2000; Suski 2000). Brood predation and/or physiological stress can result in premature nest abandonment, and the concomitant loss of reproductive success for that male. Reduction in reproductive success for bass at a population scale likely reduces recruitment (Myers and Barrowman 1996; Ridgway and Shuter 1997; Svec 2000), which can decrease the quality of the bass fishery over time.

With the goal of ensuring the continued health of bass populations through protection from overharvest, managers have developed and implemented a variety of different regulations, including size limits, harvest limits, and gear restrictions (Krueger and Decker 1999; Noble and Jones 1999). These techniques are effective at protecting bass in some situations, but are ineffective at protecting bass from angling during the spawning and brood guarding stages. Restricting angler access to nesting bass, either temporally through the use of closed seasons or spatially through the use of no-fishing sanctuaries or reserves, is a regulatory strat-

egy that may provide the level of protection needed in some if not many circumstances. Throughout much of the province, Ontario employs a closed season for bass until the last Saturday in June (presumed to be when all spawning and nest-guarding activities are completed). Unfortunately, because of enforcement and compliance difficulties with this regulation (created because fishing seasons for other species are open at this time), illegal angling that targets nesting bass is extremely high in many if not most Ontario bass lakes (Philipp et al. 1997).

To provide additional protection for nesting bass, a new type of sanctuary is being tested experimentally on some lakes in Ontario. Voluntary Bass Conservation Zones (VBCZ's) are designated sections of a waterbody in which the local community encourages anglers to voluntarily eliminate all angling activities until the opening day of bass season (the last Saturday in June). Local residents help inform anglers of this request and encourage voluntary compliance. Although local residents have no legal authority to force compliance, theoretically they can act as persuasive advocates for angler participation, thereby actively deterring fishing inside a VBCZ. The overall goal of this study was to determine how effective Voluntary Bass Conservation Zones are at reducing levels of angling for nesting bass and at increasing the reproductive success of the bass in that population.

Methods

Study Sites

This study was carried out at three lakes in eastern Ontario, each one of which contained at least one VBCZ (i.e., an area where all angling activities prior to the last Saturday in June were discouraged). For the study, paired segments of shoreline with similar nesting habitats were selected; for each pair one segment was located inside a VBCZ (Test Site) and the second segment was located outside a VBCZ (Control Site). No effort was made to curtail ongoing angling activities within the Control Sites, and anglers were allowed to fish legally for species such as northern pike *Esox lucius* and black crappie *Pomoxis nigromaculatus*. The level of intervention to prevent angling within Test Sites varied among the study lakes.

One study lake was Lake Opinicon (44°31'N, 76°20'W), a shallow (mean depth = 4.5 m), mesotrophic lake (surface area = 787 ha) located on the Rideau Canal system in Eastern Ontario (Fig-

ure 1). A VBCZ located on the west shore of the lake adjacent to the Queen's University Biological Station (QUBS) was established on Lake Opinicon for three years (1990–1992). To promote compliance with the Lake Opinicon VBCZ, posters were placed at local bait shops and boat launches to inform and educate local anglers about the sanctuary and the harmful consequences of angling for nesting bass. In addition, floating signs and orange buoys were placed in the water 10 m from the shoreline at the sanctuary perimeter to dissuade anglers further from fishing inside the VBCZ. Any angler that was seen fishing near or inside the VBCZ prior to the onset of the bass season was approached by researchers at QUBS, informed of the conservation zone, and asked to refrain from all angling activities. The researchers were quite effective in obtaining cooperation and compliance. The VBCZ was

discontinued in 1993 and for several years following 1993 no effort was made to discourage angling activities inside or outside of the VBCZ. Following removal of the VBCZ, bass reproductive activities and hook-wounding rates were monitored for two additional years in both the Test and Control sites.

A second study lake was the East Basin of Loughborough Lake (44°27'W, 76°25'N), Frontenac County, Ontario (Figure 1). This large (surface area approximately 1,066 ha), shallow (mean depth approximately 2.1 m) basin contained a VBCZ in Battersea Bay that was established and monitored from 1996 to 1998. This VBCZ had highly visible signs placed on shore at all boundaries and at boat launches throughout the lake. Buoys or floating signs, however, were not used to further highlight the location of the VBCZ. Residents and cottage owners at the lake (and not QUBS researchers) en-

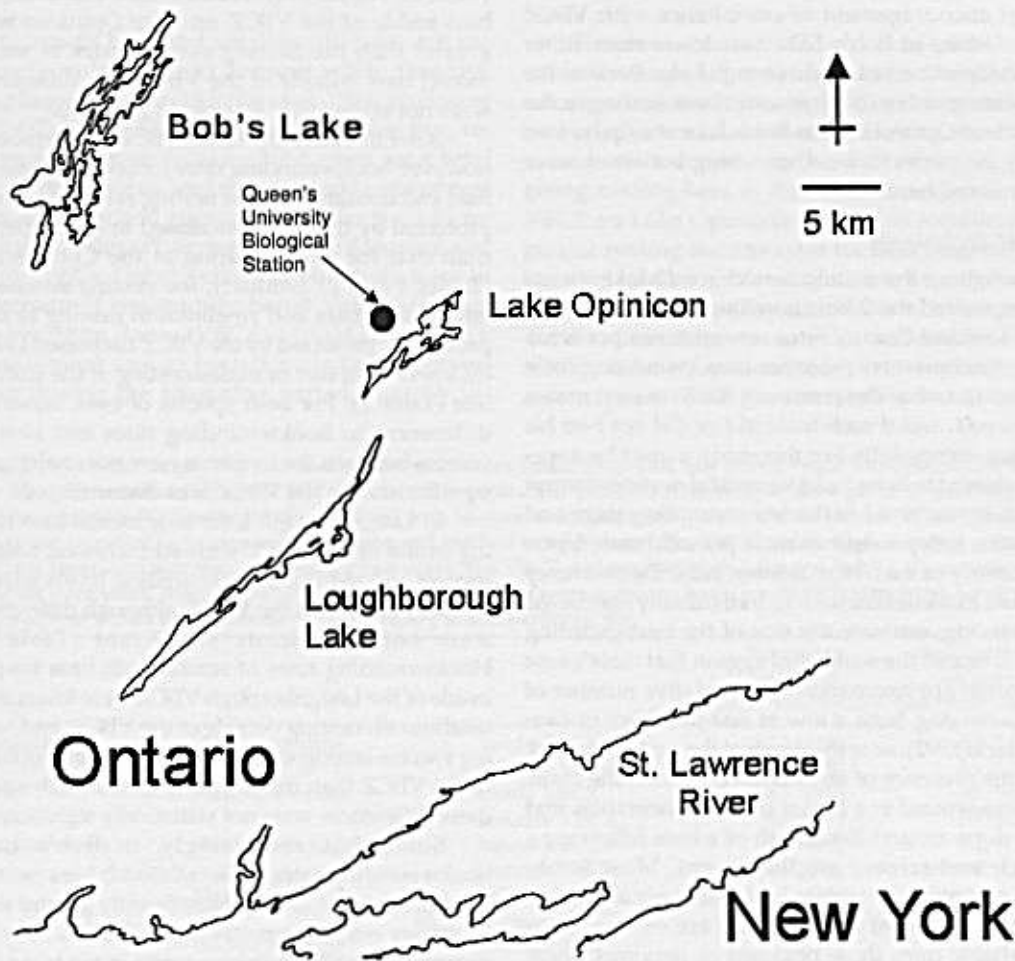


Figure 1. Location of study lakes and Queen's University Biological Station in Eastern Ontario.

couraged anglers to comply with voluntary no fishing regulations. In addition, resort owners were informed of the VBCZ and were encouraged to educate their guests about bass spawning behavior and the voluntary no-fishing strategy. Encouragement of angler compliance at Loughborough Lake was substantial, but less than at Lake Opinicon.

Bob's Lake (44°41'N, 76°35'W), which lies in Frontenac and Lanark Counties, Ontario, (Figure 1) was the site of the third VBCZ and was studied from 1996 to 1998. The VBCZ of this large (surface area approximately 2,451 ha), physically complex lake was divided into several parts that were spread across the lake. As a result, boundaries of these component VBCZ's were not as clearly delineated or effectively advertised as those at Loughborough Lake or Lake Opinicon; signs used were somewhat confusing and sparsely distributed. In addition, local encouragement of compliance with VBCZ regulations at Bob's Lake was lower than either Lake Opinicon or Loughborough Lake. Because the relative number of largemouth bass nesting in the Test and Control sites at Bob's lake was quite low, only smallmouth bass spawning activities were monitored here.

Field Techniques

Throughout the nesting period in each lake, swimmers visited the 2 km shoreline segments of both the Test and Control Sites several times per week to collect presence/absence data on nesting male bass, thereby determining how many males spawned, and if each male did or did not rear his young successfully. For this study, a male bass was considered to have had a successful nesting attempt if his fry survived to the free swimming stage and became independent of male parental care. Upon discovery of each new nesting bass, the swimmer would mark its nest with an individually numbered plastic tag, estimate the size of the nest-guarding male, record the number of eggs in that male's nest (a visual approximation of the relative number of eggs ranging from a low of one to a high of five; Kubacki 1992), note the depth of the nest, and check for the presence of any hookwounds on the male. A hookwound is a bruise or small laceration that develops around the mouth of a bass following a catch-and-release angling event. Most hookwounds typically remain visible for only about two weeks, so recent hookwounds are easily distinguishable from those obtained in previous years. The presence of a hookwound on a male bass was considered to be indicative of a recent catch-and-

release angling event.

Statistical Tests

To determine differences in nesting success and hookwounding rates for bass from the Test and Control Sites, contingency table analysis (χ^2) with a Yates correction for continuity was used (Zar 1996). The level of significance (α) for all tests was 0.05.

Results

Largemouth bass nesting inside of the VBCZ on Lake Opinicon showed significantly lower hookwounding rates and significantly greater nesting success than males nesting outside of it (Table 1). Similarly, smallmouth bass nesting inside of the VBCZ showed significantly lower hookwounding levels than smallmouth nesting outside the VBCZ (Table 2). The nesting success rates for smallmouth bass inside of the VBCZ on Lake Opinicon were greater than the nesting success rates of smallmouth bass outside of the VBCZ, but differences were not statistically significant (Table 2).

After the Lake Opinicon VBCZ was removed, however, hookwounding rates for both largemouth bass and smallmouth bass nesting at areas formerly protected by the VBCZ increased to levels greater than that for males nesting at the Control Site (Tables 1 and 2). Similarly, the nesting success of largemouth bass and smallmouth nesting at sites previously protected by the VBCZ decreased to levels lower than that of males nesting at the Control Site (Table 1). For both species of bass, however, differences in hookwounding rates and nesting success between the two sites were not statistically significant after the VBCZ was discontinued.

In Loughborough Lake largemouth bass nesting inside of the VBCZ showed increased nesting success and reduced hookwounding levels relative to males outside of the VBCZ, although differences were not statistically significant (Table 1). Hookwounding rates of smallmouth bass nesting inside of the Loughborough VBCZ were lower than smallmouth nesting outside of the VBCZ, and nesting success among smallmouth was greater outside of the VBCZ than inside (Table 2), although again, these differences were not statistically significant.

Somewhat surprisingly, in Bob's Lake hookwounding rates for smallmouth bass nesting inside of the VBCZ were significantly greater than for males nesting outside of the VBCZ. Nesting success for smallmouth bass males in the two sites, however, was identical (Table 2).

Table 1. Hookwounding levels and nesting success rates for largemouth bass that nested inside and outside of Voluntary Bass Conservation Zones (VBCZs). Data are expressed as per cent with sample sizes given in parentheses. Hookwounding is % of nesting males observed with hookwounds, and nesting success is the percent of nesting males that raised broods that became free-swimming and reached independence. The VBCZ on Lake Opinicon was enforced for three years, and was then removed for two years. The VBCZ on Loughborough Lake remained in place for three years. Asterisks indicate that hookwounding or nesting success levels inside of the sanctuary are significantly different from levels outside of the sanctuary at that particular site. Too few largemouth bass nested in Bob's Lake for inclusion.

Site			Sanctuary enforced (three year totals)	Sanctuary not enforced (two year totals)
Opinicon	Hookwounding	Inside VBCZ	6 (248) *	25 (118)
		Outside VBCZ	18 (256) *	22 (137)
	Nesting success	Inside VBCZ	63 (248) *	47 (118)
		Outside VBCZ	45 (256) *	49 (137)
Loughborough	Hookwounding	Inside VBCZ	32 (93)	N/A
		Outside VBCZ	44 (102)	N/A
	Nesting success	Inside VBCZ	46 (93)	N/A
		Outside VBCZ	38 (102)	N/A

Discussion

Largemouth bass and smallmouth bass are extremely vulnerable to angling while they are guarding their nests (Kieffer et al. 1995; Philipp et al. 1997; Suski 2000). Angling activities that remove a male bass from his nest, even for a brief period of time, can lead to increased levels of nest abandonment and concomitant reductions in recruitment rates (Philipp et al. 1997; Ridgway and Shuter 1997). The objectives of our study were to determine if community-based Voluntary Bass Conservation Zones (VBCZ's) could be used as a management tool to protect male bass from angling during the spawning period, thereby in-

creasing reproductive success at the population level.

The presence of a VBCZ on Lake Opinicon resulted in a significant decrease in hookwounding rates for both smallmouth bass and largemouth bass relative to a control area, indicating that there indeed was a decrease in the level of angling targeting nesting bass in that area. In response, the VBCZ on Lake Opinicon resulted in significantly greater nesting success rates for both largemouth bass and smallmouth bass relative to a control area. The reduction in angling activities and consequent increase in nesting success observed inside of the VBCZ on Lake Opinicon likely occurred because researchers at QUBS were very active in encourag-

Table 2. Hookwounding levels and nesting success rates for smallmouth bass that nested inside and outside of Voluntary Bass Conservation Zones (VBCZs). Data are expressed as per cent with sample sizes given in parentheses. Hookwounding is % of nesting males observed with hookwounds, and nesting success is the percent of nesting males that raised broods that became free-swimming and reached independence. The VBCZ on lake Opinicon was enforced for three years, and was then removed for two years. The VBCZ on Loughborough Lake and Bob's Lake remained in place for three years. Asterisks indicate that hookwounding or nesting success levels inside of the sanctuary are significantly different from levels outside of the sanctuary at that particular site.

Site			Sanctuary enforced (three year totals)	Sanctuary not enforced (two year totals)
Opinicon	Hookwounding	Inside VBCZ	12 (76) *	33 (54)
		Outside VBCZ	27 (99) *	26 (62)
	Nesting success	Inside VBCZ	62 (76)	50 (54)
		Outside VBCZ	46 (99)	70 (62)
Loughborough	Hookwounding	Inside VBCZ	45 (58)	N/A
		Outside VBCZ	49 (90)	N/A
	Nesting success	Inside VBCZ	45 (58)	N/A
		Outside VBCZ	48 (90)	N/A
Bob's	Hookwounding	Inside VBCZ	59 (117) *	N/A
		Outside VBCZ	41 (112) *	N/A
	Nesting success	Inside VBCZ	50 (117)	N/A
		Outside VBCZ	50 (112)	N/A

ing compliance with sanctuary regulations, adequate signs and buoys were in place to advertise the sanctuary, and public stakeholders in the vicinity of Lake Opinicon were in favor of additional protection for spawning bass. This conclusion is strengthened by the fact that after the VBCZ on Lake Opinicon was removed, the portion of the lake that was previously protected by the VBCZ suffered an increase in hookwounding rates and a decrease in nesting success relative to the control area.

The presence of a VBCZ without adequate enforcement, however, may actually impact a bass population negatively. At Bob's Lake, levels of hookwounding observed inside the VBCZ were actually greater than those observed outside of the VBCZ. By indicating to anglers the location of quality spawning areas through establishing VBCZ's and then failing to enforce compliance, quality bass spawning habitat appears to have been advertised and put at increased risk, rather than protected. The VBCZ in Loughborough Lake, a location that had levels of enforcement and advertisement intermediate to Lake Opinicon and Bob's Lake, provided some protection to nesting bass and increased nesting success somewhat relative to a control area, although results were not statistically significant. This result is intermediate to the results at Bob's Lake and Lake Opinicon.

The use of freshwater sanctuaries as a management tool was abandoned in many jurisdictions long ago because some managers did not see any change in catch-per-unit effort after a sanctuary was removed (Pelton 1948). In addition, many managers believed that a managed bass population could not only maintain itself, but might also begin to overpopulate a waterbody. Recently, attitudes concerning the stock-recruitment relationship and fisheries management in general have begun to change. Studies of marine ecosystems have shown that no-fishing reserves have the potential to decrease the likelihood of population collapses by protecting spawning individuals and/or by acting as source populations (Bohnsack 1996; Murray et al. 1999). Studies of freshwater conservation areas have shown that sanctuaries can extend the amount of time that fish are available to anglers and can increase angler success by raising catch per unit effort within a waterbody (Sztramko 1985; Barnhart 1989). Currently, some managers are stressing a precautionary, sustainable approach to the management of certain fisheries (Garcia 1994; Botsford et al. 1997; Charles 1998), not measuring the success of a management program simply by changes in the catch-per-unit effort of the target

species or the number of trophy fish caught (Krueger and Decker 1999). This new attitude towards fisheries management encourages managers to err on the side of caution by implementing conservative management actions at first, and then subsequently relaxing regulations if research demonstrates that stringent rules are not necessary (Garcia 1994).

By eliminating all angling within a VBCZ, a measurable portion of the spawning population of bass becomes protected from angling during the nest guarding stage. As a result, the likelihood of a male within the VBCZ raising a brood to independence increases. Because recruitment for many species is likely related to spawner abundance (Myers and Barrowman 1996), or more accurately, spawner reproductive success (Svec 2000), the added protection afforded male bass in a VBCZ would result in an increase in the production of bass within a waterbody.

The critical factor in determining the success of a VBCZ, however, appears to be the level of compliance by anglers, which appears directly related to the level of local enforcement. Members of a local community, such as guides and resort owners, often rely on quality fisheries for their livelihood. In fact, in the case of the VBCZ on Loughborough and Bob's Lakes, it is these local residents that initially approached the Ontario Ministry of Natural Resources requesting that programs to prevent a decline in bass populations be developed. The dependence of these stakeholders on the fishery for income, as well as for recreation, makes their involvement and cooperation in establishing partnerships between local interest groups and government agencies more likely (Amar et al. 1996; Charles 1998; Krueger and Decker 1999; Lucy and Davy 2000). In addition, enforcement by government agencies and legal authorities may not always be possible, making local 'watchdogs' more effective. For those lakes in which the level of local enforcement is not adequate, legislated No Fishing Zones may be required to guarantee some acceptable minimum level of successful bass reproduction.

Acknowledgments

We want to thank Mark Ferguson and Ross Cholmondeley of the Ontario Ministry of Natural Resources for establishing the VBCZ's at Bob's and Loughborough Lakes, the key motivation behind this entire study, as well as for their support and assistance whenever needed. We also thank the staff of the Queen's University Biology Station for

providing such excellent facilities from which to conduct this research project. We thank Julie Claussen, John Epifanio, Blake Konkle, Mike Ward, Jim Ludden, Jana Svec, David B.F. Philipp, and Anna Toline for providing assistance in the field collecting data, and Larry York for discussing with innumerable anglers the vast benefits of voluntarily complying with the VBCZ at Loughborough Lake.

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