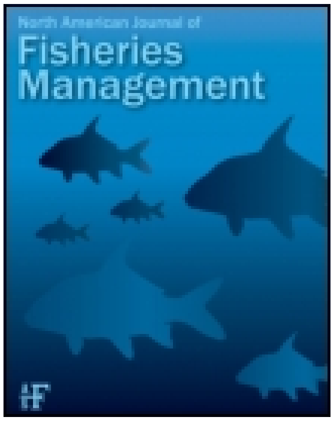

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Comment: Not all Biases are Created Equal—A Comment on the Snorkel Survey Bias Observed by Hessenauer et al. (2014)

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COMMENT

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In their recent paper, Hessenauer et al. (2014) address an important topic, the efficacy of snorkel surveys in detecting Largemouth Bass *Micropterus salmoides* nests. In their study they compared the observed numbers of reproductively successful and unsuccessful nests in the spring (identified via snorkel surveys) with the actual origin of young of the year collected in the fall as determined by genetic pedigree analysis. Based on that approach, the authors reported observational biases in two aspects of snorkel surveys: nest detection efficacy (where snorkelers missed 50% of the nests that produced young of the year) and nest success/failure determination (where snorkelers misclassified 40% of the nests as unsuccessful while genetic analysis indicated that those nests were actually successful in terms of raising broods to the swim-up stage). Because that study provided one of the few reports of nest or brood detection rates by snorkel surveys (see Shaw and Allen 2014), its findings are particularly relevant to other studies investigating black bass *Micropterus* spp. reproductive ecology. Unfortunately, the authors drew broad, generalized conclusions regarding bias in snorkel survey methods without acknowledging potentially important methodological differences among snorkel survey techniques. We wish to address some of the detection bias issues raised by Hessenauer et al. (2014) because we feel that the authors did not adequately acknowledge alternative sources of bias in their study and incorrectly cast aspersions on studies that in fact avoided or were unaffected by the biases identified by these authors.

ISSUE 1: OBSERVED NEST DETECTION BIAS

Clearly, the genetic pedigree analysis in the Hessenauer et al. (2014) study showed that the majority of young-of-the-year Largemouth Bass sampled at the end of the year were not spawned in one of the 33 nests detected by that research team, indicating a nest detection bias. The authors, however, chose to conclude that this same bias likely exists in other studies using snorkel surveys to locate nests, bringing into question the use of snorkel survey methods for nest detection in general. We believe that the poor rate of detection observed in the authors' study lake (Warner Lake, Michigan) in 2010 resulted from the specific technique used and the extent of macrophyte cover at nest sites.

Hessenauer et al. (2014) towed a snorkeler behind a boat in Warner Lake with one or two observers on the bow who visually searched for Largemouth Bass on nests. When an onboard observer noted a Largemouth Bass remaining stationary at a putative nest site, the snorkeler was directed to that location to investigate. By employing this technique, the detection of nests relied on the ability of above-water observers to find guarding male Largemouth Bass rather than that of underwater observers to find actual nests. Our experience during more than 30 years of locating black bass nests from Ontario to Florida has shown us that although the well-excavated nests of Smallmouth Bass *M. dolomieu* (at least in some lakes and streams) are often visible from a boat, the nests of Largemouth Bass, which are often unexcavated and simply located on top of undisturbed substrate (or vegetation such as *Elodea canadensis* or even woody debris) are much more difficult to locate from a boat. In addition, although some fish stay on their nests and continue to guard their broods as a boat approaches, many flee to deeper water well ahead of the boat's arrival at the nest. We would never consider using a boat to locate nests when the research question required locating all of the nests in a study lake. Nests with eggs or embryos in them, however, cannot swim away; hence the nests themselves should be the target for detection, and locating them is best accomplished through underwater observation.

In addition, a snorkeler's ability to locate black bass nests can vary widely across lake and river systems depending on the vegetation coverage, water clarity, depth, velocity, and other external conditions. The effectiveness of visual surveys in locating black bass nests, therefore, is highly site specific, and study sites must be carefully selected so that the environmental conditions are appropriate for the purpose of the study. Lakes that are even mildly turbid, have a high density of macrophytes, have large flat, shallow areas (as opposed to sharp declining shorelines with clear delineations between littoral and pelagic habitats), or other visibility issues are not good study sites for research questions that require complete sampling of the nests in a population. While Hessenauer et al. (2014) provide an analysis of the effect of macrophyte density on the detection of free-swimming fry, they provide no analysis of the effect of macrophytes on nest detection, nor do they provide any indication of the impact of turbidity on the detection of nests or free-swimming fry. The high macrophyte cover (median = 80%) and the potential for periods of poor visibility likely also contributed to the high rate of missed nests in Warner Lake. As a result, we speculate that Warner Lake itself was not a very good site for a study that required complete nest discovery utilizing boat observers.

Although Hessenauer et al. (2014) does show an inherently high bias with respect to Largemouth Bass nest detection, their conclusions only apply to the study methods they employed in Warner Lake; the more general conclusion that other techniques used in other systems share that high failure rate is absolutely unwarranted. Long-term studies on Smallmouth Bass reproductive ecology utilizing underwater observation to detect nests and determine nest success tell a very different story. Working in a connected lake–river system over a 6-year period, Barthel (2010) used underwater snorkeling methods to detect approximately 300 nests per year and collect more than 100 age-1 offspring per year, and using genetic identification of all nest-guarding males in a pedigree analysis matched offspring to observed nests. Contrary to Hessenauer et al. (2014), the Barthel (2010) study found no evidence of a contribution to year-classes from offspring originating from undiscovered nests. Likewise, studies in two different locations using experimental populations of Largemouth Bass (Parkos et al. 2011; Sutter et al. 2012) with similar genetic analysis of fathers and offspring also provided no indication of undetected nests. This point is further driven home by the recent paper by Shaw and Allen (2014), who used dual snorkelers swimming transects and calculated a nest detection rate (in a single pass) of >90%—considerably higher than in Hessenauer et al. (2014). These studies demonstrate a clear distinction between above-water and underwater methods for nest detection that Hessenauer et al. (2014) inexplicably failed to acknowledge. We argue that if one's research question requires finding all of the nests in a population the research team needs to employ good snorkel survey techniques and work in a study site that is conducive to good underwater observation (i.e., clear water with slight to moderate macrophyte density and well-defined shorelines and spawning areas).

ISSUE 2: ERROR IN NEST SUCCESS/FAILURE CLASSIFICATION

Hessenauer et al. (2014) reported that 40% of the surviving fall young of the year originated from nests that were classified by their snorkelers as unsuccessful and correctly concluded that there was a major bias to their nest success/failure classification system. Instead of introspectively assessing what might have caused that result during their 1-year, single-lake study, however, they concluded that this bias is likely present in all such studies. In any study assigning nest success, there are two ways that a nest could be misclassified. First, snorkelers may incorrectly classify a nest as failed if the nest-guarding male has indeed abandoned its brood prematurely or has been removed and a portion of those offspring somehow avoided predation or, once they became free swimming, joined another male's brood (i.e., creched). Second, snorkelers may incorrectly classify a nest as failed if the male and his brood left the nest (i.e., the brood was not abandoned) when the offspring became free swimming and moved away from the nest site between observations by the snorkeler. We believe that the first case—fry surviving independently of parental care or joining another brood—is fairly rare given that two other studies using genetic pedigree analysis to assess nest contributions did not detect any evidence of the survival of truly abandoned nests (Parkos et al. 2011; Sutter et al. 2012). Given that in the Hessenauer et al. (2014) study snorkelers only swam the site every 3–4 d, there was ample time between observations for embryos to develop into free swimming fry and move some (unknown) distance from the nest site; hence nests would have been scored as failures when they were in fact successful. The use of telemetry tags to track black bass engaged in parental care has revealed that when Largemouth Bass fry became free swimming the male and his offspring quickly left the nest area (Cooke et al. 2006) while Smallmouth Bass tended to guard their developing offspring at the nest site for longer periods (Scott et al. 1997; Cooke et al. 2006). Once again, the technique and study site need to be appropriate for the research question. If scoring nest success/failure is important to the research question, observations are required at least every 1–2 d.

RECOMMENDATIONS AND CONCLUSIONS

We entirely agree with Hessenauer et al. (2014) that future studies employing underwater observation of nesting black bass should account for nest detection bias when it may impact the research question and hypotheses being tested. Detection bias, however, may not be present or pertinent in every study, and therefore the existence of a bias in the Hessenauer et al. (2014) study should not automatically invalidate previous work, as these authors repeatedly state that it does. For example, the authors state that

> many studies have sought to evaluate the effects of anthropogenic disturbances, such as angling (e.g., Kieffer et al. 1995; Philipp et al. 1997; Suski et al. 2003) . . . on the nesting success of black bass species. These and other studies have made inferences about factors affecting black bass nesting dynamics based on observational methods that located and sometimes repeatedly observed nests through time. However, if a large but unknown number of nests were not located or if nest fate was incorrectly determined, the inferences made regarding habitat selection or the effects of factors important for nest success may be limited or incorrect to the extent that biased errors occurred.

In reality, neither of the two biases identified by Hessenauer et al. (2014) were even a factor in the studies they cite. The nests identified in those studies (i.e., Kieffer et al. 1995; Philipp et al. 1997; Suski et al. 2003) were a subsample of hundreds of nests (in various study lakes) that served as individual replicates in a set of manipulative experiments. None of those studies are invalidated by nest detection bias, as argued by Hessenauer et al. (2014), because locating all of the nests in the study lakes was never required by the experimental design of those studies. In addition, the determination of whether the male stayed at or abandoned a nest was made for a set period of time (e.g., 24–48 h after experimental manipulation). To evaluate abandonment, a snorkeler returned to a nest and determined whether the male was present, then looked directly in the nest to determine whether or not offspring were still present. Because all of the nests chosen had broods that were at the unhatched egg stage, it was developmentally impossible (reviewed in DeVries et al. 2009) for embryos to become free swimming and leave the nest within 24–48 h. The criticisms levied by Hessenauer et al. (2014), therefore, are in fact completely unfounded and misapplied.

To close, snorkel surveys are indeed an important tool in the study of black bass reproductive ecology and behavior, and we agree with Hessenauer et al. (2014) that some of these survey methods may have inherent detection biases that should be accounted for, especially in the planning phase. We disagree, however, that the biases detected by Hessenauer et al. (2014) devalue, confound, or invalidate the findings of previous or future work utilizing any variety of snorkel survey methodology. Rather, we view the authors' work as a clear example of the need to discuss the myriad factors that require consideration when using underwater survey techniques. A critical requirement for the use of underwater observation methods is to employ standardized training and to utilize highly competent teams of motivated observers with routine quality assurance and control measures to minimize the bias in nest detection and the assignment of success or failure. To minimize bias, observational studies of black bass reproductive ecology must incorporate experimental designs that account for the effects of environmental conditions, the behavioral characteristics of black bass species, and embryonic development schedules (which are temperature dependent) and include the rigorous training of observers. We urge researchers utilizing these methods to reduce the impact of any detection biases by implementing the principles we discussed above and to acknowledge the impact of these biases on their results.

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