Reproduction, Habitat Preference, and Year Class Strength of Smallmouth Bass (*Micropterus dolomieu*) in the Eel River near North Manchester, Indiana

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Abstract

The Eel River, located in north central Indiana, has been the subject of numerous fish surveys since a dramatic absence of smallmouth bass (*Micropterus dolomieu*) was documented in the early 1980's. While these surveys have provided important data, none have focused on a particular stream reach over multiple field seasons. Through the months of May and June 2006-2008, chemical, physical, and biological data were collected regarding the population, habitat, spawning, prey selectivity and year class strength of smallmouth bass (*Micropterus dolomieu*) in the Eel River near North Manchester, Indiana. Nest surveys were conducted weekly by snorkeling and/or by wading over a 2.5 km stream reach. Fish clearly preferred nest sites in back eddies where water velocities were less than 0.1 m/sec and water depths were between 30 and 40 cm. In 2006 and 2008 nesting success was poor with mean stream discharge of 31m^3/sec and 14.5 m^3/sec respectively. In 2007 there were twenty successful nests with a mean stream discharge of only 6.6 m^3/sec. The largest number of black fry produced in 2006 from any nest was 39 and the largest number of sac fry counted was only 139. In 2007 over 500 black fry were observed and over 1,500 sac fry were counted in at least one nest. There were no documented successful nests in 2008. The Zippin depletion method population was used to estimate the population of *M. dolomieu* each year of the study in a 500 m stream reach. In 2006 the population was estimated to be 116, 32 in 2007 and only 8 in 2008.

Introduction

The Eel River in northern Indiana flows southwest 110 miles from north of Fort Wayne in Allen County to the Wabash River near Logansport, Indiana (Kittaka, 2005). Approximately 80% of the 814 square mile watershed is devoted to agriculture (Braun 1993). The Eel River was once known as an outstanding smallmouth bass (*Micropterus dolomieu*) fishery and was a favorite destination for anglers from across the Midwest. However, in the 1970's the numbers of bass began to decline dramatically (Braun 1982). While there have been numerous fish surveys since this documented decline, there have been no long-term scientific investigations of one stream reach in the Eel River to understand the temporal and spatial parameters that may be responsible for unstable year-class strength of smallmouth bass. The purpose of this investigation was to examine smallmouth bass population dynamics as it relates to environmental and biological factors over a three year study period by examination of a 2.5 km reach of the Eel River near North Manchester, Indiana. The objectives include:

1. Quantify physical and chemical parameters
2. Quantify nesting success and year-class strength of smallmouth bass

Physical and chemical parameters are known to alter stream biotic community structure and function (Gammon 1992). For example, the effects of turbidity on fish behavior include avoidance and redistribution, as well as a change in activity and decreased foraging capabilities (Hartman 2003). In some cases suspended sediment has been shown to decrease size and survival of larval sight-feeding species (Newcombe 1996 and Sweeten 2002). Data also suggest that stream water velocity may be detrimental to Centrarchids during nesting (Simonson 1990). There are two distinct life stages for which current velocity is likely to have a catastrophic effect on smallmouth. The first is during the developmental stages in the nest and the second when the fry have dispersed from the nest (Simonson, 1990). Pflieger (1966) documented smallmouth bass nesting success in Little Saline Creek (Arkansas) as high as nearly 4,000 fry in one nest and fry numbers nearly 80,000 per stream mile. However a population estimation for the lower Eel River in 2002 concluded there to be 473.2 Smallmouth per mile, compared to the same study in 2000 having just 291.6 fish per mile with a similar catch per unit effort (CPUE) (Kittaka, 2005). These data suggest a significant difference in bass numbers from the Eel River to the Arkansas stream. Researchers have multiple hypotheses regarding the causation of how stream water quality has affected stream biota. However, stream ecosystems are dynamic and unfortunately there are no controls or sufficient historical data that provides clear evidence of stream quality prior to European settlement.

Materials and Methods

Spawning periods of smallmouth bass were quantified during May 1, 2008 through 30 June, 2008, on the 2.5 km study section of the Eel River located approximately 84 river kilometers from the river's confluence near Logansport, Indiana (Figure 2). Water chemistry was collected from three different sites in North Manchester daily: The Covered Bridge (most upstream), the Waste Water Treatment outlet, and the United States Geologic Survey (USGS) gage site (most downstream) (Figure 2). Dissolved oxygen (mg/L), conductivity, water temperature (°C), and air temperature (°C) measurements were taken once daily with handheld Hach meters at all three sites. In addition, a water sample was also taken once daily at the USGS gage site for the following chemical analysis: Total phosphorus (mg/L), nitrate levels (mg/L), turbidity (NTU), and total suspended solids (mg/L). Water samples were acidified and stored at 4.0 °C until analysis was performed. Before analysis samples were brought back to their original pH. Only during rain events, rainfall exceeding one inch per hour, would more than one water sample be collected for a day—in such rain events a water sample would be taken every six hours.

Smallmouth bass nesting activity was monitored daily once the water temperature reached 16° C within the study section; spawning surveys were conducted 3 times weekly. Once located, nests were marked in the field with orange flagging and with a handheld GPS. Measurements were taken on each nest including: depth, diameter, substrate, distance from shoreline, and distance from cover. An estimation of the number of eggs, hatching date and presences of black fry was also recorded. Nest species verification was determined by identification of the male guarding the nest. If no guarding male was present, eight to ten eggs were removed from the nest and taken back to the lab and cultured indicating the species of the nest. After the usual spawning period for the area (May 1 – June 30), several trips were taken to the most dense nest sites to insure the end to the spawning period.

On July 21, 2008, a three pass population estimation using a closed stream reach of smallmouth bass was performed. Smallmouth bass were collected using a Smith-Root Type IV pulse DC electrofishing boat starting downstream to upstream. Once a pass was completed, the SMB were processed. Processing included running the SMB through the P.I.T. (Passive Integrated Transponder) tag reader to view recaptures from previous years. Non-recaptured SMB received a P.I.T. tag placed alongside the dorsal fin within the dermal tissue. All SMB also had the following data: total length (mm), weight (lb), and finally removing the first two dorsal spines as close to the skin as possible for aging purposes.

Spines were taken back to the lab where they were placed in clay within the cap of a micro centrifuge test tube. Each spine was placed in the widest end (the end which was closest to the skin) sticking out of the clay. The tip of the micro test tube was then cut off and discarded. The remaining piece of the micro test tube was placed on the cap and the spine was positioned as vertical as possible within the tube. Epoxy was then mixed and placed within test tube embedding the spine. Once the epoxy dried, the plastic micro test tube was removed and only the spine surrounded by epoxy remained. A Buehler low speed isometric saw was used to make very then cuts of each spine (less than 1 mm thick). After a slice was cut, it was sanded and lightly covered in silicon oil. Finally, each slice was viewed under a microscope. A digital picture was taken and then examined through the program Sigma Scan to determine the age and growth of each fish. Like rings on a tree, annuli are left in the spine during the winter months where it is a time of slow or no growth. Longer distances between annuli also indicated a period of rapid growth.

The Index of Biotic Integrity (IBI) and the Habitat Evaluation Index (QHEI) were performed on five 500 meter segments of the 2.5 km stream reach. These indices were used to quantify differences in fish community structure and stream habitat within each of the 500 meter segments. The two indices were performed working upstream from the most downstream site (USGS gage) to the covered bridge (most upstream site). Fish for the IBI were collected using a Smith-Root 2.5 PPG tote barge electrofisher. QHEI measures the quality of the habitat comparing various types of physical parameters such as substrate type, amount of cover, and other stream habitat properties.

Results

The reproduction period of smallmouth bass was affected very differently over the three years of 2006-08. Sttream discharge as measured by the North Manchester USGS gage during the months of May and June 2006-2008 clearly demonstrate the dynamic nature of water moving through the stream channel (Figure 1). The years of 2006 and 2008 were relatively wet with a peak discharge of nearly 6,000 cubic feet per second (cfs) and over 3,000 cfs respectively.in 2006 andand ended comparatively dry. The second year, 2007, proved to be the driest of the three years documented. Finally, 2008 was the wettest reproduction period of the three years as seen by the peaks and valleys that the graph shows. The largest stream discharge for 2008 was 3,200 ft^3 (the highest peak), however what cannot be shown on this graph is a rain event in early 2008 in which the Eel River discharge reached over 8,000, twice.

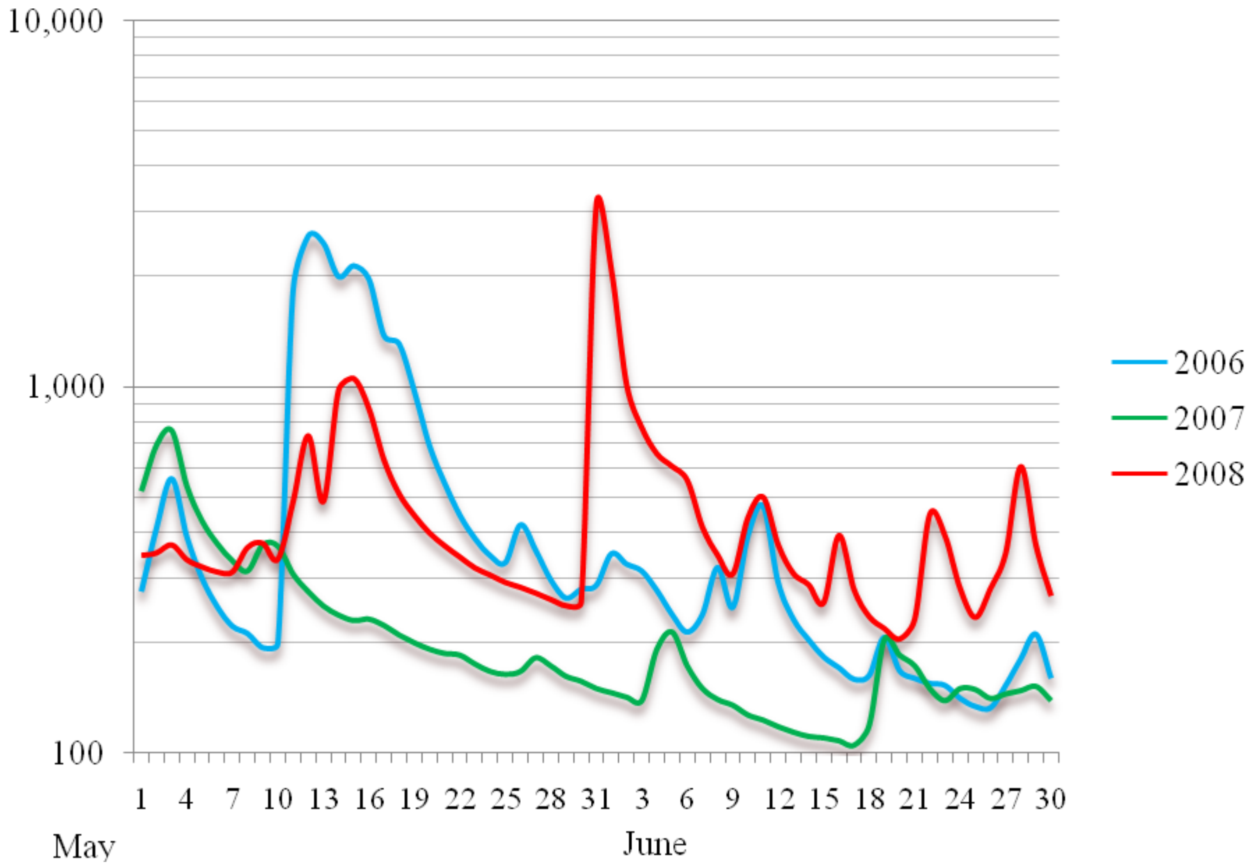

Figure 1. Stream discharge (Y-axis) in logarithmic scale (ft^3/second) at the USGS gage in North Manchester, Indiana for the Eel River from 1 May to 30 June in the years of 2006-2008

Throughout the three years, nesting smallmouth bass clearly preferred the outside of meanders, back eddies, and where stream velocity was the least (Figure 2). The preferred water depth for nests was 40 cm or less.

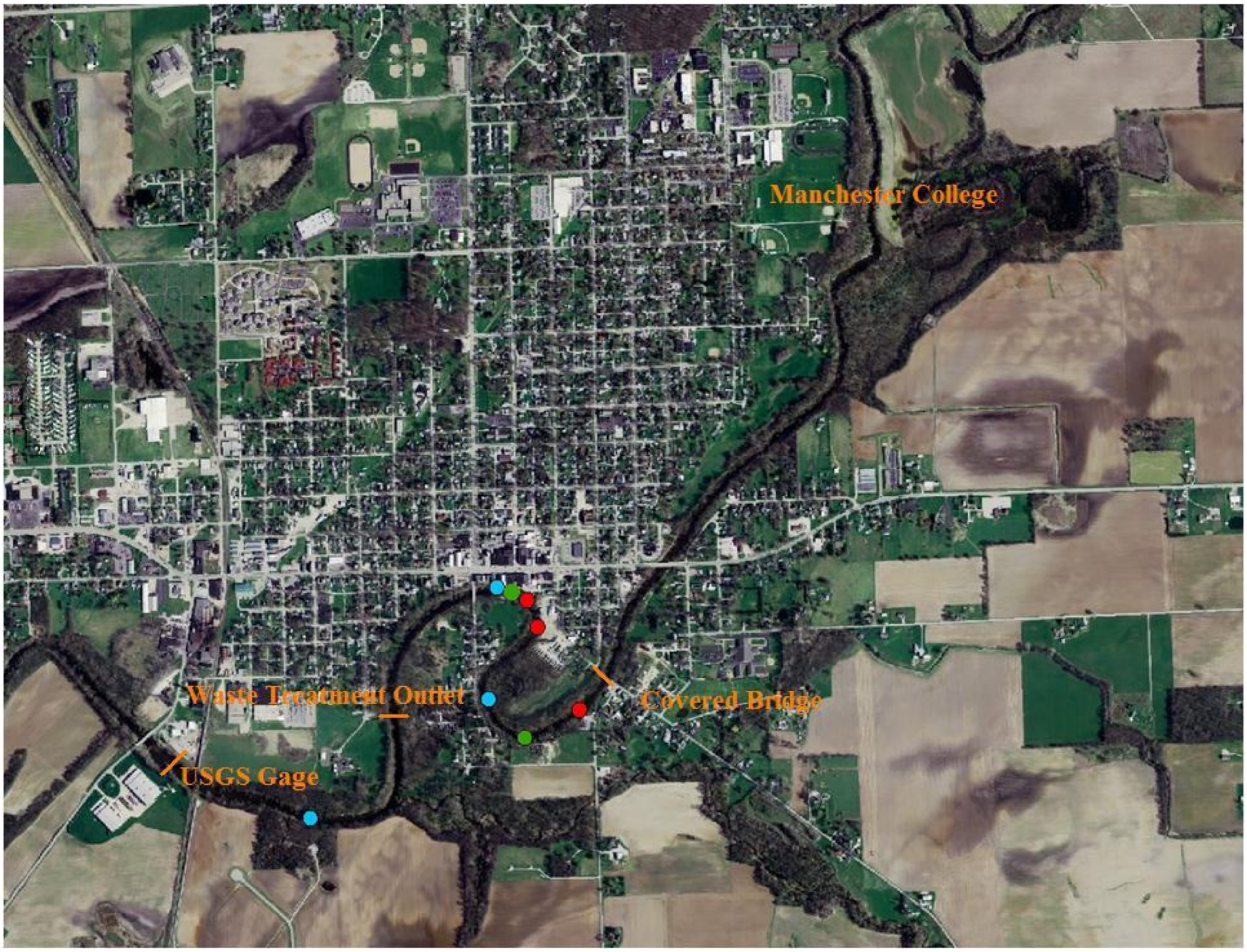

Figure 2. Frequent smallmouth bass nesting sites documented from 2006-2008 in North Manchester, IN within the 2.5 km study reach of the Eel River.

To further understand the relationship between stream discharge and the number of smallmouth nests the median discharge (m^3/sec) was compared to the nest data from 2006-2008 (Figure 3). The first year, 2006, as a moderately wet year and a comparatively moderate amount of nests (9) were documented. In 2007, the very dry reproduction season, there were a very large number of nests documented, sixteen (16). And lastly, 2008, which was a very wet year, there were zero (0) successful documented nests.

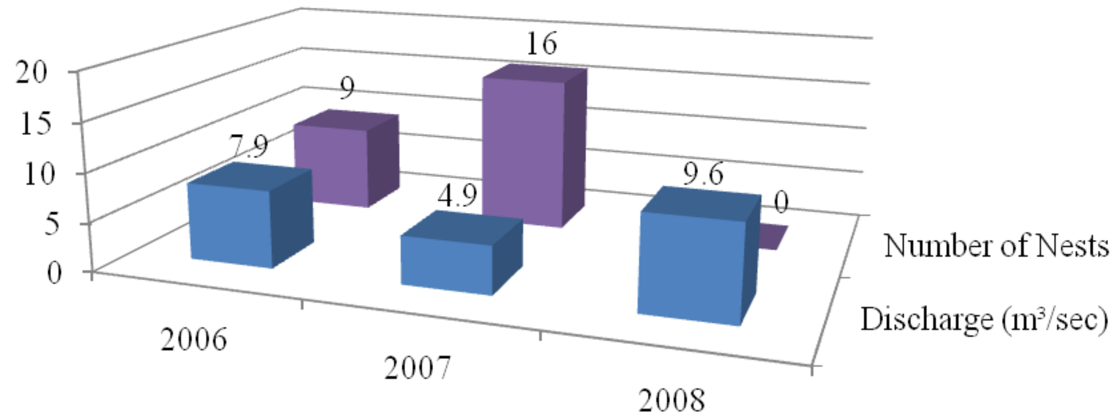

Figure 3. Comparison between the numbers of nesting sites found each year and the median discharge levels (m^3/sec) of each year.

Using the stomach contents of smallmouth black fry, their prey base was determined. Prey selectivity of smallmouth bass black fry from 2006-2008 suggest a clear preference for more diverse prey base during "dry" years. During 2006 and 2008 or "wet" years prey selectivity was limited to 3 species. However in 2007, the driest year, the prey selectivity was eight different types of prey (Figure 4).

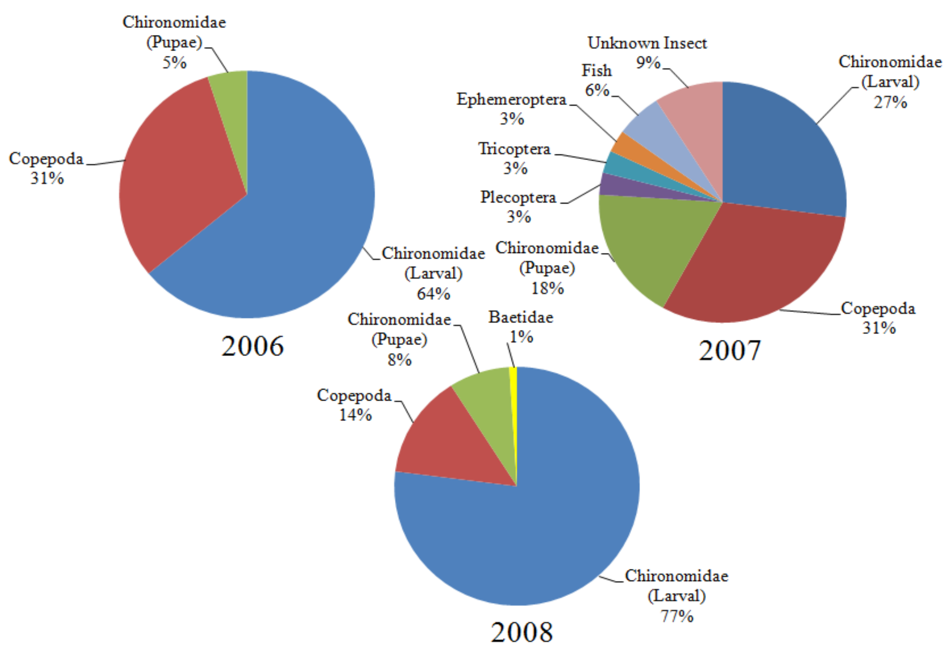

Figure 4. Prey selectivity of Smallmouth Bass black fry during 2006-2008.

The Qualitative Habitat Evaluation Index (QHEI) was completed in 2006 and 2008 starting at the USGS gaging site (most downstream) and continued upstream each 500 meters to the covered bridge (most upstream). The mean QHEI scores ranged from 55.5 at the most downstream site (USGS gage) to 71 for the most upstream site (covered bridge). The scores increased each 500 meters from the USGS gage (Figure 5).

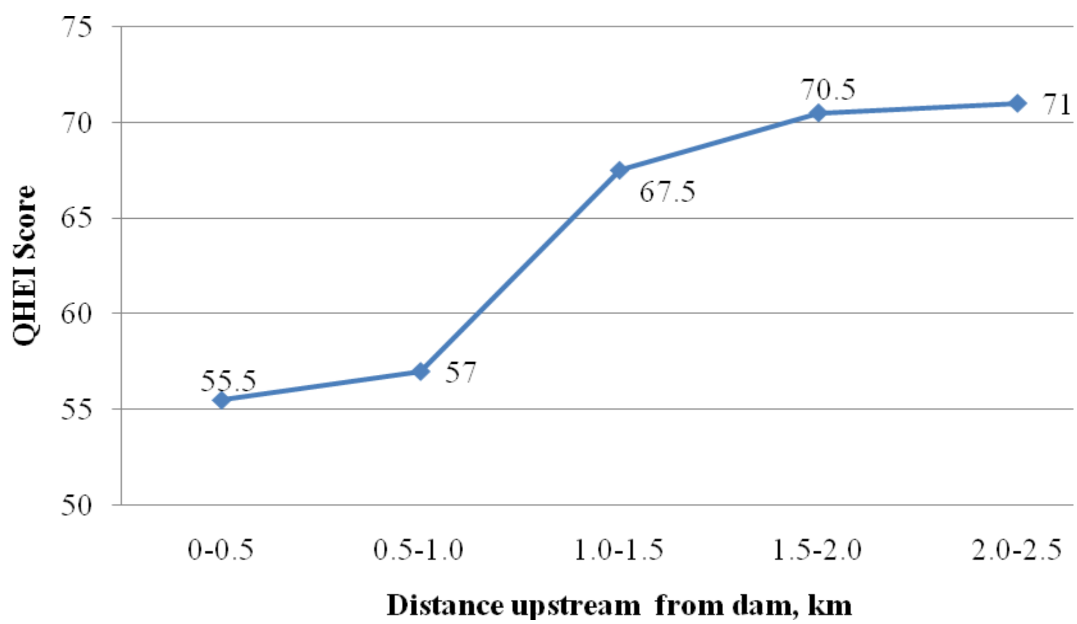

Figure 5. Mean Qualitative Habitat Evaluation Index (QHEI) scores from 2006-2008 on each of the half kilometer sections within the study reach moving upstream from the dam.

The second test done to measure the effect of the low-head dam on the stream was the Index of Biotic Integrity (IBI). The mean IBI scores from 2006-2008 throughout the five 500 meters sections of the study reach, starting at the USGS gage. Again, the lowest score (35) is found in the first 500 meters. After the first 500 meters, the scores are very close. However in the final 500 meters furthest upstream from the USGS gage the highest score (44) was found (Figure 6).

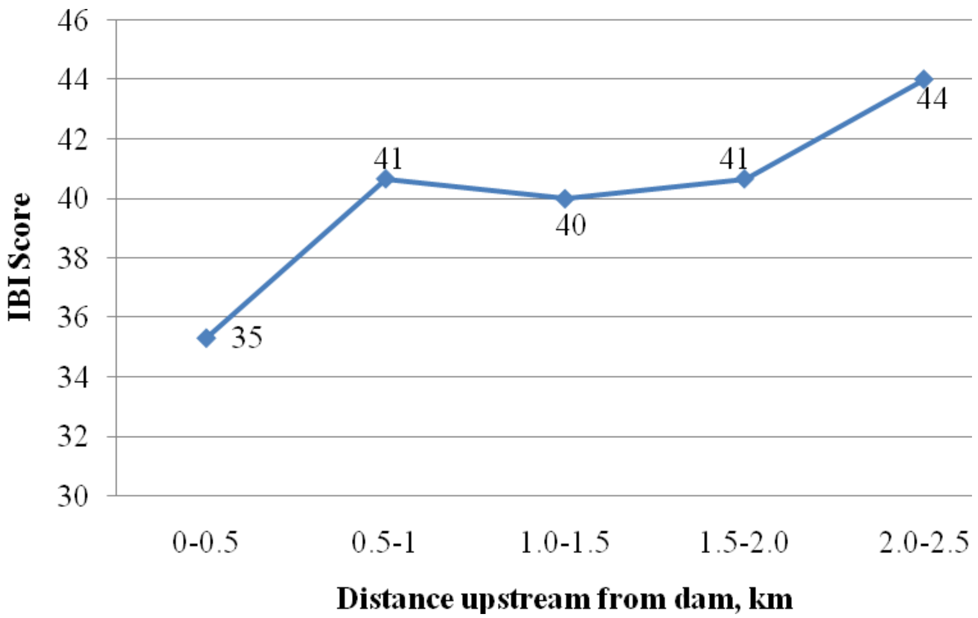

Figure 6. Mean Index of Biotic Integrity (IBI) scores from 2006-2008 on each of the half kilometer sections within the study reach moving upstream from the dam.

A population estimation was conducted during the 2006-2008 field seasons using the Zippin depletion method. There has been a steady decrease in the population estimate in the last three years as 2006 produced an estimate of 116 smallmouth bass per kilometer in the study reach. The number drastically fell in 2007 to 32 and in 2008 the lowest estimation was documented at only 8 smallmouth bass (Table 1).

Table 1. Summary of population estimation data from 2006-2008 using the Zippin Depletion three pass method on a closed system.

	Pass	SMB Captured	Population Estimate	Variance	Standard Error
2006	1-3	51	116	25.05	5.01
2007	1-3	15	32	1.76	1.33
2008	1-3	8	8	n/a	n/a

Using spines from the fish captured during the population estimation, each fish was aged to determine the year class in which they belonged to in order to quantify the amount of smallmouth bass found from each hatching year. Two wet years, 2004 and 2006, contain zero fish captured during the population estimate. 2002 was a moderately dry year, and the most abundant year class (28) captured during the three year study (Figure 7).

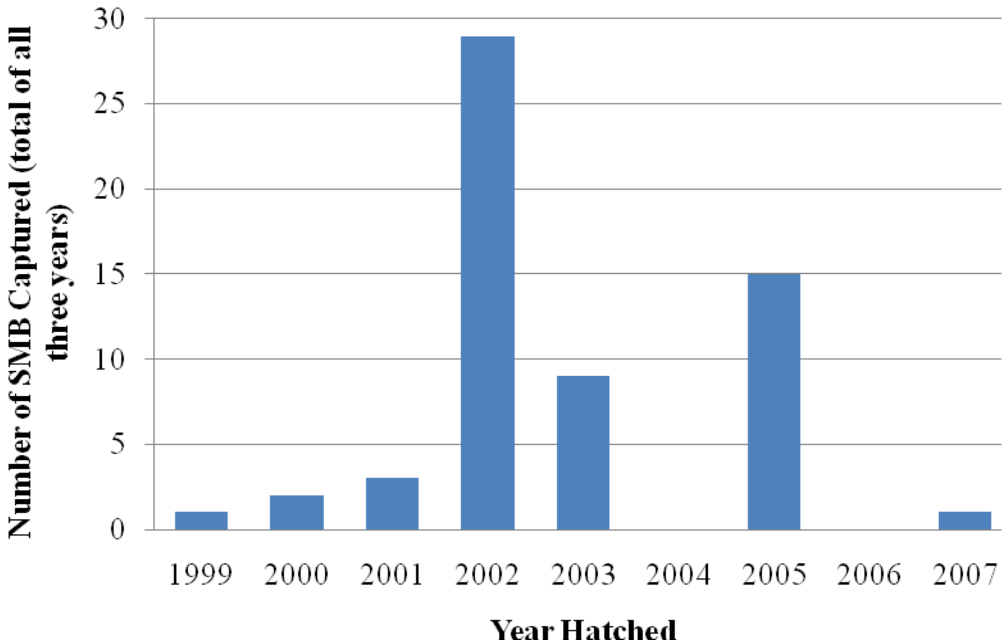

Figure 7. Comparison between SMB caught through population estimation from 2006-2008 and the year in which each SMB hatched.

Discussion

Data from the results suggests an apparent relationship between the discharge along with stream turbidity during the reproduction season in relation to unstable year classes of smallmouth bass in the Eel River. The year class of 2007 shows the most success during a period of relative dryness when compared to 2006 and 2008. During 2006, a moderately wet reproductive seasonal period, resulted in a fair amount of successful nests (9 nests). The reproductive season during 2008, a very wet year, however did not yield any successful smallmouth nesting sites (Figure 3). Coincidentally, 2008 also contained the largest median discharge level of any of the three years.

The changes from year to year from the amount of rainfall during reproduction leads to unstable year class strengths. From the aged spines taken every year, each fish was back-calculated in order to identify their hatching year. This data was collected and compared with other years on record to find further comparisons between rain amounts during the reproductive period of previous years. The most successful years as far as year class strength of Eel River smallmouth bass were found to be the 2002 and 2005 hatching years (Figure 7). Theses years correspond to dry seasons during reproduction. The lease successful years, in which no smallmouth bass were captured from, belong to the hatching years of 2004 and 2006. Not surprisingly these years corresponded to wet seasons during reproduction (Figure 7). It is also interesting to note the diversity of prey selectivity between wet and dry seasons for young of the year black fry (Figure 4). Further investigation into the lack of diverse prey for newly hatch black fry could help in aiding why wet seasons during the reproduction period lead to weak year class strengths.

The Eel River has shown effects from the local low-head dam, located just downstream from the USGS gage, in ways that may go unnoticed. The results of the QHEI and IBI scores (Figures 5 and 6) 2.5 km upstream from the dam are key indicators that even the smallest of dams can alter habitat for fishes. It is noticeable through the data that the habitat is altered more than the fish species present in a particular stretch of the stream. QHEI scores are low in the first kilometer from the dam, indicating that there is a loss of habitat and stream structure for fishes. This kilometer section contains stagnant water flow and is very sandy with very little woody debris. Moving upstream from the dam however there is much more woody debris and stream cover, as well as much larger substrate.

The IBI scores for the stream may be deceiving, however, as the lowest score is certainly closest to the dam, but four of the five scores fall under a “good” stream category and the highest score, nearest the covered bridge, was in the “very good” category for streams. This indicates that the Eel River is not as “dirty” as many think, and contains many pollution intolerant species.

In summary, smallmouth bass appear to prefer nesting areas of low stream velocity, such as back eddies and the outside of meanders. Increased rainfall will raise stream velocity considerably and smallmouth bass year class strength seems to be dependent on stream discharge. Also, IBI and QHEI scores seem to be affected by low-head dams. Scores appear to increase along with distance upstream from the dam. In order to improve scores, ways of improving fish passageways need to be investigated, including the removal of low-head dams. This will also attribute to the decrease in the nutrient and total suspended solid loads in the river. There are still many unanswered questions that could be addressed by long-term monitoring of this 2.5 km stream reach. The lack of long-term data prevents scientists from being able to quantify trends and patterns that may be manifested over years.

Acknowledgements

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