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QUALITY MANAGEMENT OF BLUEGILL: FACTORS AFFECTING POPULATION SIZE STRUCTURE

D.D. Aday, J.E. Claussen, J.H. Hoxmeier, D.M. Benjamin, T.W. Edison, D.H. Wahl, D.P. Philipp

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Division of Fisheries
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Executive Summary

This study contains four jobs, 101.1 Categorization of bluegill populations in Illinois impoundments, 101.2 Evaluation of bluegill life-history variation in Illinois impoundments, and 101.3 Pre- and post- regulation characterization of experimental study lakes, and 101.4, Analysis and reporting.

In past segments, we used existing creel and standardized sampling databases from project F-69-R, as well as input from all district biologists, to make assignments of study populations from Illinois to three categories based on adult size structure. Those categories were as follows: quality (populations with many/most adults > 180mm), stunted (populations with many/most adults <150mm) and intermediate (populations with a mixture of adult sizes). The final list for sampling included 60 lakes. These lakes were blocked by bluegill size structure (stunted or quality), by regions of the state (north, central, or south) and by lake size groups (small = < 100 acres, or large = > 100 acres). From these lakes, 32 were identified for an intensive management experiment (described in job 101.3). These lakes will be creeled at times during the management experiment to assess harvest levels in selected stunted and quality populations. In 1999, five lakes were re-creeled (Forbes, Pierce, Spring Lake North, Jacksonville, and Mingo), and 8 lakes were creeled for the first time (Glendale, Round, Homer, Pana, Paris, Hillsboro, McCleansboro, and Walton Park). Analysis of harvest data from these lakes has begun and will continue throughout the next segment. Current creel data are being analyzed to validate characterization of Illinois reservoirs.

Additional collection efforts were made during this segment on lakes with incomplete data to assess missing size classes. We removed otoliths for aging and measured lengths, weights, and maturity on the samples collected. We also continued sampling to update populations to assure accurate assessment of size- and age-

at-maturation. These results will be used to assess the ability of each of the four hypotheses to explain what shapes bluegill size structure in Illinois.

We continued monitoring and assessment of bluegill growth, reproductive characteristics, and age-at-maturation in response to management manipulations. These manipulations consisted of four treatments across 32 lakes (8 lakes per treatment): control, harvest regulation, predator stocking, and a combination of harvest regulation and predator stocking. Lakes have equal representation from regional, lake size, and bluegill size structure classifications. We examined important biotic and abiotic characteristics of the experimental lakes, such as prey resources, predation pressure, and lake-habitat characteristics. Selected experimental lakes were examined for correlations between bluegill growth (second-year growth and size at age 2), prey resources (inshore and offshore zooplankton abundance)and habitat characteristics (e.g., lake area, latitude, shoreline length). We found no correlations between inshore or offshore zooplankton abundance and bluegill second-year bluegill growth. We did find, however, a weak relationship between lake area and male age-at-maturation, which indicates that habitat variables may influence bluegill-population size structure. We also found significant differences in predator (largemouth bass) abundance between stunted and quality populations (i.e., predator abundance was higher in quality lakes) suggesting that certain biotic variables may help determine population size structure. We will continue to assess these biotic and abiotic variables following implementation of the experimental regulations to examine their effects on size structure of bluegill in study lakes. Also in 1999, we re-sampled seven experimental lakes to examine population size structure and age-at-maturation of bluegill. These data will be compared with original sampling data from these lakes to examine stability of these population metrics. Updating of the MANSIM (management simulations) model was also continued. It is clear, however, that it needs to be modified as additional population and creel data become available, and other models may need to be considered for appropriate examination of Illinois reservoirs. Angler survey data were also updated and analyzed to determine angler attitudes regarding experimental management regulations.

Job 101.1 Categorization of bluegill populations in Illinois impoundments.

OBJECTIVE

To use existing creel and standardized sampling databases to categorize bluegill populations based on adult size structure.

INTRODUCTION

Bluegill (*Lepomis macrochirus*), are viewed by many anglers as an important sportfish. In Illinois, as in many other states, the demand is growing for large, catchable sizes. With this growing pressure from anglers to produce a healthy bluegill fishery, it is critical to understand the factors that are driving population size structure, so that management biologists can make sound decisions.

Three major factors help shape a population's size structure: growth rate, longevity, and age at maturation. Factors that affect any one of these three components, therefore, can impact population size structure. Furthermore, growth trajectories for parental male bluegill (and most other fish as well) follow a pattern in which growth rates slow significantly following sexual maturation (Wootton 1985). Based on these principles, we have theorized (Jennings et al, 1997) that "stunted" bluegill populations, i.e., ones that consist of individuals that are all smaller on average than "normal" populations, can occur as a result of one (or a combination) of four hypothetical scenarios.

In the first scenario, the Overharvest Hypothesis, growth rates and sexual maturation schedules are typical of "normal" populations. Large individuals (typically, mature parental males) are not found in the population because when individuals reach some smaller size threshold, they are continually being removed through excessive overharvest. In addition, even in the face of this overharvest, growth rates and sexual maturation schedules remain unchanged. In support of this hypothesis Coble (1988) has shown that size-selective harvest can quickly reshape the size distribution of bluegill within a fished population.

In the second scenario, the Density-Dependent Growth Limitation Hypothesis, sexual maturation schedules are typical of "normal" populations, but in response to overly high bluegill densities (caused by any one of a number of factors, e.g., reduction in predation, increased competition, changes in habitat or water quality, etc.), early growth rates are diminished. In this scenario, large individuals are not produced in the population because the entire growth trajectory is slowed from birth. In a comparative study of reservoir bluegill populations (Belk and Hales 1993), it was proposed that differences in the resources available among habitats, including both food resources and refuges from predators such as largemouth bass, influenced growth rate. Similarly, Callahan et al. (1996) found growth of small bluegill across 14 reservoirs in Illinois was related to percent littoral zone. They proposed that fish in lakes with high percent littoral zone were experiencing high bluegill densities and, as a result, reduced density-dependent growth caused by a combination of predator avoidance behavior and feeding on suboptimal prey. Abiotic factors, such as latitude, also effected growth of large bluegill (Callahan et al. 1996).

In the third scenario, the Social Influence Hypothesis, early growth rates are typical of "normal" populations, but in response to some perturbation in the population (most likely some previous harvest of large individuals), parental males (and likely females) are maturing and reproducing at younger ages and smaller sizes. Because sexual maturation occurs at an earlier age (and size), the post-maturation depression of growth rate also occurs earlier. Thus, the size of mature males (and likely females) in the population is reduced. Although this relationship between male size/age structure and the onset of sexual maturation has been predicted from a theoretical standpoint (Reznick 1983, Stearns and Koella 1986), it has been tested in bluegill only recently (Jennings et al 1997).

In the fourth scenario, the Cuckolder Overproduction Hypothesis, growth rates and sexual maturation schedules are typical of "normal" populations, but in these populations a much greater percentage of males enter the cuckoldry rather than parental life history pathway. In this scenario, first, large individuals become rare because of some perturbation(s) (e.g., removal of large parental males). In response, fewer males delay maturation to become parental males, most males maturing early as cuckolders. Because the quantitative partitioning of males into the two life histories has only been determined for the bluegill population in Lake Opinicon, Ontario (Gross 1982, Philipp and Gross 1994), evidence for this scenario is lacking in Illinois.

Because sexual maturation and the expression of reproductive behaviors are energetically expensive, fish have most likely evolved to respond facultatively to social cues in a way that maximizes lifetime reproductive success (Stearns and Koella 1986, Jennings and Philipp 1992). Even though social control of reproductive behaviors has been demonstrated across a wide range of fish taxa (Robertson 1972, Borowsky 1978, Silverman 1978, Chapman et al. 1991, Fox and Keast 1991, Jennings 1991) we still do not know how these socially mediated shifts in life history might interact with density-dependent mechanisms to impact growth rates. In natural populations, undoubtedly, multiple confounding factors can complicate the assessment of the relative contribution and interaction of the different mechanisms involved (i.e., the four proposed hypotheses).

PROCEDURES

Initial efforts to categorize bluegill populations were made using existing creel and standardized sampling databases (Fisheries Analysis System, Bayley et al, 1993, Sobaski et al, 1995), available as part of Federal Aid Project F-69-R. Lakes in these databases are generally sampled each fall by IDNR management biologists using a variety of sampling gears (electrofishing, gillnets, trapnets, seining). Although we have so far been limited by the amount of recent data that has been entered into the FAS database, valuable length frequency information from creeled lakes was used for a preliminary evaluation of adult size structure in many potential lakes. These databases were supplemented with additional data collected on a number of lakes by Illinois Natural History Survey personnel.

Lakes were characterized from these databases as having a predominantly stunted adult population (<150mm), a quality adult population (>180mm), or some intermediate or mixed-size population. A meeting with regional and district biologists was used to select final criteria for choosing initial study lakes. Further input was solicited through a questionnaire to all regional and district biologists for suggestions on additional lakes, as well as comments on our preliminary list of proposed study lakes.

Further information on lake populations and angler activities was obtained from the creel survey data that was available for a number of our study lakes. Valuable angler and harvest data, as well as overall angling pressure, the proportion of anglers that target bluegill, and size of bluegill caught and harvested was used to assess further the size structure of bluegill in certain lakes for which there was data. Thirteen lakes included in the group of 32 study lakes were creeled in 1999, including eight lakes creeled for the first time.

Because creel survey data do not distinguish the sex of the fish, we used the following descriptor to classify quality versus stunted populations, Proportion of Quality Creeled Fish (PCF.180). For this calculation, the total number of fish caught ≥180mm was divided by the total number of fish caught.

To determine if there are seasonal differences in angling vulnerability among sexes, we analyzed bluegill being harvested from a selected subset of study lakes. Assessment of the sex, maturation, and size structure of harvested fish was conducted on three lakes (Walnut Point; Lake of the Woods; Ridge Lake). This was done by asking anglers to allow us to inspect fish and to take scale samples from bluegill that they were harvesting. The bluegill were divided into three categories based on date of harvest (pre-spawn, spawn, and post spawn). Fish caught from "ice out" until the day before fish were first observed on spawning beds were considered pre-spawn. Dates when bluegill were first observed on spawning beds were recorded for each of the three lakes and used as the onset of the spawning season. Fish were categorized as post spawn after male bluegill were no longer observed on spawning beds in each lake.

FINDINGS

Information from regional and district biologists through a questionnaire was combined with information from the creel survey and standardized sampling databases and from other INHS studies on lakes in the state. All potential study lakes were categorized to population size structure (stunted, quality, or intermediate). In addition, each lake was further classified based upon its location within Illinois: north, central, or south, and its size: large (>100 acres) or small (<100 acres). Based upon these three categories, a final list of 60 target lakes was produced (Table 1-1).

When available, creel data was used to assess fishing pressure and size of bluegill caught and harvested, and the Proportion of Quality Creeled Fish (PCF.180). We have included summary data for the 32 study lakes that will be used for the experimental regulation phase of the project (see Job 101.3) and the results are listed in Table 1-2a. Data collected between 3/15/99 and 6/15/99 were used to estimate proportion of anglers targeting bluegill, average weight of caught and harvested bluegill, and PCF.180. Estimated angler-hours per acre, and number and weight of caught and harvested bluegill in 1999 were not included in this report because the creel season was not yet completed at the time of this writing. Data collected in 1999 were used to update Table 1-2a whenever possible, while data from all study lakes creeled in 1999 are summarized in Table 1-2b.

Analysis of creel data shows that fishing pressure (angler-hours per acre) was not statistically different (0=.05) across lake size (large lakes versus small lakes), geographic region (northern lakes versus southern lakes), nor bluegill size (quality versus stunted) (Table 1-3). To assess the relative abundance of bluegill in these lakes, we compared catch and harvest data for both the number and kilograms of bluegill caught per hour. In all cases, quality lakes produced more bluegill than stunted ones in both number and weight, but no significant differences were seen for regional or lake size comparisons (Table 1-3). A comparison of the average size of fish between stunted and quality lakes showed that in quality lakes, larger fish were caught and harvested, but significant differences between regions or lake size were not observed (Table 1-3). Finally, there were significant differences in the size distribution of creeled fish (using the PCF.180 values) between stunted and quality populations, but no significant differences were found for comparisons between region or lake size (Table 1-3).

Seasonal differences in angling vulnerability among sexes were observed. Data revealed a heavy bias towards male harvest during the spawning season. During the pre and post-spawning periods, however, there was no consistent bias in the sex of the harvested fish (Table 1-4).

RECOMMENDATIONS

Additional harvest and population data from the FAS and creel databases for lakes in this project need to be collected and analyzed as those data become available. Creel surveys must continue on the 32 experimental lakes in the study. These surveys will be critical in evaluating the effects of bluegill regulations/manipulations on the fishery.

In addition, as back-logged FAS data are entered into the database, they should be analyzed and added to our information base on each study lake. These datasets should be kept current during the length of this project to follow population trends.

Job 101.2. Evaluation of bluegill life-history variation in Illinois impoundments.

OBJECTIVE

To determine the extent of variation in important bluegill life-history characteristics in selected impoundments throughout Illinois

INTRODUCTION

Before effective management strategies for increasing the size structure of "stunted" bluegill populations can be developed, we need a great deal more information about the factors controlling growth and maturation of bluegill. Competition has been shown to occur for sunfishes when high numbers of small fish are forced into refuges to avoid predation (Mittelbach 1984, 1986). The effect of this phenomenon on growth likely varies among reservoirs depending upon prey availability and predator densities. These density-dependent mechanisms also likely interact with harvest rates and bluegill social structure to determine population size structure.

Bluegill also exhibit complex reproductive behaviors (e.g., colonial nest construction, territorial defense, courtship of females, defense against brood predators). Furthermore, male bluegill exhibit alternative reproductive strategies, whereby some individuals mature precociously and become cuckolders at a younger age and a smaller size than their brothers, who delay maturation and become parental males (Gross 1980). The physiological changes and mating behaviors associated with reproduction require high energetic investment, and that energy is then unavailable for somatic growth (Claussen 1991, Fox and Keast 1991, Jennings 1991, Jennings and Philipp 1992). Although the impact of sexual maturation and spawning activities on the growth of *Lepomis* individuals is well established, little is known about how the size structure within a population affects age at maturation and the expression of reproductive behaviors. Earlier maturation and earlier behavioral investment in reproduction likely causes the growth trajectory of parental males to slow, thus reducing the overall size structure of a population (Jennings, et al. 1997). If we are to manage bluegill populations effectively, we need to understand how exploitation and/or various management activities alter these life-history characteristics. Only by understanding these complex interactions can the success of bluegill regulations and management strategies be predicted and effectively realized.

PROCEDURES

In the first phase of this project, boat electrofishing was used to sample 60 target populations (see Job 101.1, Table 1-1) between the months of May and July 1996 to determine bluegill abundance, size, age, sex, and maturation status. Sampling was conducted after bluegill spawning activity had clearly been initiated in each lake and before it ceased in mid-summer.

During sampling, type of habitat, weather conditions, secchi disk readings, water temperatures, and information on other species of fish found in the lake, e.g., number of sunfish hybrids and number of largemouth bass shocked were recorded. Electrofishing runs consisted of an initial run, in which all individuals of all sizes were collected. These preliminary runs usually were from 30 to 60 minutes in duration. Those bluegill were then measured quickly to determine the number of individuals in each of eight specified size classes (<50mm, 50-99mm, 100-149mm, 150-159mm, 160-169mm, 170-179mm, 180-189mm, >189mm). The goal was to obtain at least 50 individuals from each size class. An additional secondary run was then conducted in an attempt to supplement those size classes in which sample sizes were below 50. An additional sample of 30 individuals were also collected and separately wrapped and frozen for genetic analysis.

During summers of 1997 and 1998 additional samples were collected from many of the study lakes. District fisheries biologists and project personnel conducted sampling in an attempt to collect specific size classes from lakes that had missing or low numbers from the 1996 samples. In 1999, four additional lakes were sampled to increase sampled sizes in certain age/size classes.

To analyze the bluegill collected in each lake sampled, individuals were thawed and total length, weight, and sex determined. In addition, gonads were identified as to stage of development, and mature gonads weighed. Scales and otoliths were removed for age and growth analysis. We used these data to determine age-specific growth curves, age at maturation, and abundance of cuckolders.

All otoliths were read in whole view unless there was disagreement between two readers, or if crowding of annuli occurred. If so, the otolith was then sectioned by one of two methods: by either cracking the otolith in half and reading transverse section with fiber optic light or by mounting the mid-section on a slide and reading it with transmitted light.

To calculate a descriptor of the size structure that would distinguish quality from stunted populations, we devised the

Proportion of Quality Males (PQM.180). The PQM.180 for any given lake is calculated by dividing the number of mature males $\geq$180mm by the total number of mature males collected. The PQM.180 value provides a way to look at the degree at which a population is stunted or quality.

FINDINGS

All 60 of the target populations were electrofished in 1996 and additional samples were collected on selected lakes in 1997, 1998, and 1999. During this segment continued analysis of additional samples from the 60 target populations was conducted for total length, weight, sex, and maturity. In addition, ages of the sampled individuals have now been determined for all of the 60 populations.

We have included summary data for the additional samples taken in 1999 for four of the study lakes. These are: Lake of the Woods (Figure 2-1), Mingo (Figure 2-2), Spring Lake North (Figure 2-3), and Woods Lake (Figure 2-4). Each figure displays the size-at-age curve for the bluegill in each given lake. Average age at maturation (Z age) was calculated for each of the four populations as well (Table 2-1). The proportion of quality males (PQM.180) was calculated by determining the number of mature males over 180mm and dividing this by the total number of mature males collected (Table 2-1).

RECOMMENDATIONS

The 32 Experimental Lakes should be regularly sampled for bluegill size and age structure, prey resources, and predator populations throughout the next several years to assess the impacts of management manipulations (see Job 1.3). Bluegill sampling should include collection of fish for analysis of age, reproductive stage, and size. Additionally, fish of all life stages should be collected to examine growth rates at each stage. Prey populations, including inshore zooplankton, offshore zooplankton, and benthic invertebrates, should be sampled in each lake. Abundance of predators (especially largemouth bass) should be monitored as well.

In addition to the 32 experimental lakes, additional electrofishing collections on a few of the remaining 28 study lakes may be warranted to further understand their population size structures.

Job 101.3 Pre and post regulation characterization of experimental study lakes.

OBJECTIVE

To gather detailed baseline data on bluegill life-history characteristics as well as the biotic and abiotic variables that may affect bluegill recruitment, growth, and maturation in the chosen experimental study lakes.

INTRODUCTION

Four hypotheses have been proposed (introduction to Job 101.1) to explain the biological mechanisms causing "stunting" in bluegill populations (Jennings et. al. 1997). Those four hypotheses were explained in detail earlier in this report (introduction to Job 101.1). Determining the relative importance of each of these hypotheses in controlling the size structure of bluegill populations in Illinois is a major goal of this study. It may be that one hypothesis is the dominant mechanism in all lakes in the state. It is quite possible, however, that more than one mechanism will play some role (even within a single population), as lakes throughout the state exhibit tremendous variability in biotic and abiotic characteristics.

Four aspects of a species' growth curve determine the ultimate size structure of the adult population in a given waterbody: pre-maturation (larval/juvenile) growth rates, age at maturation, post-maturation (adult) growth rates, and longevity. These four facets are affected by a variety of factors within a waterbody. Age at maturation and longevity are directly affected by the social relationships among surviving adults and can, therefore, be greatly impacted by harvest. Both pre- and post-maturation growth rates are directly affected by density-dependent processes (i.e., slow growth rates are due to an overabundance of bluegill or underabundance of prey), that can cause a depression in growth rates at all bluegill life stages. Additionally, biotic (e.g., competition, predation) and abiotic (e.g., temperature, dissolved oxygen saturation) factors can also influence age at maturation and longevity. This study is designed to elucidate how these processes may act and interact to shape bluegill population size structure.

Results from Job 101.2 indicate the importance of age at maturation in determining size structure of bluegill populations throughout the state. Quality populations were characterized by a later age at maturity than stunted populations. Presumably, social influence of surviving mature adults (especially males) have an impact on age at maturation of juvenile bluegill in the population. It is important that we continue to collect mature and juvenile bluegill from study lakes to monitor size, maturity, and age over the next several years in response to the experimental management treatments.

Both pre- and post-maturation growth rates can be depressed by an overabundance of bluegill or an underabundance of prey. This density-dependent depression in growth rate can occur at any or all life stages of the bluegill. Larval bluegill feed offshore on zooplankton until they reach the juvenile stage, at which time they move inshore to avoid predation and feed on smaller zooplankton and invertebrates. Once the bluegill are large enough to avoid predation, they move offshore once again to feed on large zooplankton. Competition for food resources can occur at each of these life stages and could affect growth. In the

Density-Dependent Growth Limitation Hypothesis, growth rates are low due to an overabundance of bluegill. Identifying the importance of resource competition relative to other potential mechanisms causing stunting will be important for predicting the success of any management regulation. Because of the complex array of pathways through which stunting may occur, we need to examine mechanisms causing density-dependent growth at each life stage of bluegill populations, and monitor these changes in response to management manipulations such as harvest regulation and predator stocking.

An important goal of this study is to examine the impact of various management actions (e.g., harvest regulation, predator stocking) on bluegill growth rates and determine how each acts to improve size structure among stunted bluegill populations in Illinois. A variety of mechanisms may interact in combination to cause stunting. As a result it will be important to document changes in resource competition that may occur at each life stage, in response to any experimental regulation. For example, if slow growth in the offshore adult stage is contributing to stunting in a population, creel limits protecting this size of bluegill may have a negative effect. Conversely, if density-dependent slow growth is occurring during the juvenile stage, protecting adult bluegill might have a positive effect if coupled with a management strategy (e.g., predator stocking) that encourages removal of smaller individuals. Close investigation of prey resources (both abundance and diversity) available to each life stage, as well as predator abundance is necessary for understanding the way that density-dependent processes may shape population size structure. Additionally, other biotic and abiotic components of the experimental study lakes such as lake area and latitude, seasonality of prey availability, and female-bluegill fecundity may be important to larval and juvenile growth and adult maturation.

It is also important to understand whether population size structure and age-at-maturation of stunted populations can be altered through the addition of quality-sized mature males. We will conduct a large-male stocking experiment to determine the impacts on stunted populations. It will be important to identify and sample appropriate stunted and quality populations to examine reproductive ecology and behavior patterns prior to the addition of large male bluegill. After bluegill have been added, it will be important to monitor changes in response variables such as male reproductive success, and size- and age-at-maturation.

Because we are interested in effects of management manipulations on bluegill population size structure, it is important to understand angler attitudes towards and compliance with these regulations. It will be important to examine creel survey information to assess anglers' feelings about various management scenarios in the experimental lakes. In addition, compliance checklists completed by conservation officers can provide information about angler compliance with existing regulations. Clearly, management regulations will be unsuccessful without acceptance and compliance from the angling public. Understanding of these human dimensions aspects is a critical component of this investigation.

PROCEDURE

With the institution of an 8-inch minimum size limit and a 10-fish daily creel limit, the management experiment began in April,

1999. This experiment (described in detail in Claussen et al. 1999) involves monitoring 32 experimental lakes (Table 3 - 1) for changes in bluegill population size structure in response to various management manipulations (i.e., harvest regulations and predator stockings, separately and in combination). The primary activity in this job was examination and monitoring of bluegill population size structure, growth rates, and age-at-maturation, as well as prey availability, predator abundance, water quality, lake-habitat characteristics and other biotic and abiotic variables in these lakes to assess the impacts of experimental regulations. Secondarily, we continued modification and parameterization of a modeling program to predict impacts of experimental regulations, and continued analysis of extensive angler survey data to assess attitudes regarding various regulations. All 32 experimental lakes were sampled for bluegill (juvenile and adults) and largemouth bass (predators) abundance. In addition, prey resources (zooplankton and macroinvertebrates) were collected in 17 (8 stunted and 9 quality) of the 32 experimental lakes, and larval bluegill were collected in eight. We will continue to monitor these and other biotic and abiotic variables in the experimental lakes throughout the management experiment.

Monitoring of experimental lakes:

Three components of each study lake are important for current and continued monitoring: 1)bluegill population parameters (adult abundance, size structure, and age-at-maturation; larval and juvenile growth and abundance); 2) biotic variables (e.g., prey availability, predation); and 3) abiotic variables (e.g., temperature, lake productivity, lake-habitat characteristics). All 32 lakes were sampled in 1999 for predator abundance, adult bluegill abundance and size structure, and larval and juvenile bluegill abundance and growth rates. Prey availability was quantified in 17 of those lakes. Water quality analysis (chlorophyll *a*, phosphorous, temperature) was also measured in all experimental lakes. This represents the sampling protocol that we will continue to follow throughout the management experiment (i.e., all 32 lakes: predator abundance, bluegill size structure and abundance; 17 of those lakes: prey resources). Sampling began in May and continued monthly through October. In addition, seven lakes (4 quality and 3 stunted) were intensively re-sampled to examine bluegill population size structure and age-at-maturation (Table 3-2). This re-sampling was conducted to assess stability in growth and age-at-maturation of bluegill populations originally sampled in 1997-1998. Results from this subset of lakes will be important to assure stability of populations prior to and throughout the management experiment, and will allow us to attribute changes in response variables to the management manipulations rather than inherent variation in the populations.

Density-dependent mechanisms were examined in each of the study lakes to understand the role that they may play in causing stunting. We determined larval, juvenile, and adult bluegill abundance in experimental study lakes. Larval fish were collected from each offshore site by pushing an icthyoplankton net (0.5m diameter, 500 mm mesh) for 5 minutes. Volume of water filtered was calculated with a calibrated flow meter mounted inside the mouth of the net. Inshore bluegill density (primarily juveniles) was assessed by shoreline seining (6.7 x 1.2 m bag seine, 3.2 mm mesh) at four fixed sites within each lake. Effort was calculated as the length of the haul (nearest m). All fish were counted and a minimum of 50 individuals of each species collected were measured (total length in mm). Density (#/m of seine haul) was calculated for bluegill throughout the study period. Adult bluegill were collected by shoreline seining (6.7 x 1.2 m bag seine, 3.2 mm mesh) and electrofishing. In May, July, and September, up to 50 bluegill from three size classes (0-50mm, 51-100mm, 100+mm) were preserved from each lake for age (with scales and otoliths) and diet analysis. A final sample was collected in October from all 32 experimental lakes to examine population size structure.

Size-at-age was calculated for one- and two-year-old bluegill in selected experimental lakes. Second year growth was calculated by subtracting size at age 1 from size at age 2. Size at age 2 and second year growth were then correlated with zooplankton abundance and lake-habitat characteristics. We chose age-2 fish because all fish at this age were immature (except sneaker males, which were excluded from analysis). This allowed us to correlate pre-maturation growth and size characteristics with important biotic and abiotic characteristics of the study lakes.

Prey availability may interact with relative abundance of bluegill to affect growth at all life stages. It is important to determine if differences exist in prey abundance and availability among stunted and quality study lakes, and assess whether potential differences impact growth and maturity. Macroinvertebrates and zooplankton are important food items to larval, juvenile, and adult bluegill. In 17 of the experimental lakes, we determined the abundance of these food resources. To quantify zooplankton abundance, collections were taken using vertical tows with a 0.5 m diameter, 64 mm mesh zooplankton net at four inshore and four offshore sites (one tow per site). Zooplankton were preserved in a Lugols solution (4%) for later processing. Inshore macroinvertebrates were collected using a stovepipe sampler (20 cm diameter) at 6 sites (one sample per site) within each lake. Depth of each sample collection was measured. Samples were cleaned in a 250 mm mesh benthos bucket and preserved in a ethanol/rose bengal solution (70%) for processing.

Predator abundance may also influence bluegill size structure and may be important at each life stage. Largemouth bass, the primary predator in these centrarchid-dominated experimental lakes, can consume large numbers of larval and juvenile bluegill. In addition, bass may compete with bluegill for available resources at the larval and juvenile stage. To quantify largemouth bass abundance, fall electrofishing surveys were conducted on all experimental lakes.

We measured water transparency, dissolved oxygen, temperature, total dissolved phosphorous, and chlorophyll *a* on all 32 lakes. Water transparency was measured with a secchi disc. Temperature and dissolved oxygen profiles were measured at one meter intervals. Water samples were collected monthly with an integrated tube sampler for analysis of total phosphorous and chlorophyll *a*. Habitat characteristics (latitude, surface area(ha) mean depth(m), maximum depth(m), shoreline length (m) and shoreline development) were also recorded for most of the 32 lakes.

To assess compliance of anglers to the experimental regulations, compliance cards were given to conservation officers at all lakes with experimental regulations (Table 3-3). These cards were then completed by conservation officers each time they performed a bluegill regulation check on an experimental lake.

Six lakes were sampled throughout the summer to examine spawning behavior and age-at-maturation of male bluegill to determine appropriateness for the large-male addition experiment. Lakes were sampled to determine appropriate stunted, quality, and control populations for the experiment. We began to determine a sampling protocol to examine variables such as male reproductive success, colony success, duration of spawning season, and frequency of spawning events. We will continue to develop and modify this protocol once we have determined which lakes will be included in the experiment.

The MANSIM Model:

MANSIM is a model that is used to simulate effects of proposed management regulations on a population of bluegill. To use the MANSIM model, certain parameters specific to a population's growth rate, reproductive characteristics, and natural mortality rate are required to define the population of bluegill to be used in the simulation. Because many population-level characteristics are sex specific, these parameters are defined separately for males and females. The model also requires data pertaining to the fishery, such as number of anglers and fishing effort. Once all parameters are defined for a population, potential effects of management regulations (e.g., length and creel limits) on bluegill population size structure can be assessed. MANSIM simulates effects of those proposed regulations on the population size structure through time, providing information on age and length classes for each sex. There are many parameters that we still require before we can run the MANSIM model on Illinois populations. These include Von Bertalanffy growth, density-dependent growth functions, hooking mortality, catchability, and sex-specific vulnerability to harvest, among others. Therefore, we are continuing to assemble these data for input into the model. Once complete, we will use these simulations to predict the likely changes in bluegill population size structure in reservoirs throughout the state resulting from each management scenario.

Angler survey

Based on preliminary bluegill sampling that categorized lakes as quality or stunted, three lakes of each type were chosen for distribution of an angler survey (see Claussen et al. 1999). Lakes were chosen that were involved in an ongoing creel survey to provide estimates of fishing pressure and to determine the size of the angling population on a lake. Distribution of the angler survey began in early spring of 1998 and continued until June of 1999. Supplemental interviews were completed in the early part of 1999 to obtain adequate numbers of surveys for a 95 percent confidence level with precision within 10 percent, which required 81-95 surveys depending on the individual lake (Salant and Dillman 1994). All anglers that were able to read and write were asked to complete a survey, those who could not read or write had the survey read to them. Anglers that were too young to understand the questions were not included; these anglers were generally under the age of 10. Anglers at each lake were asked to fill out only one survey for the duration of the study year. Sampling was conducted on weekdays, holidays, and weekends in proportion to estimated fishing pressure. Distribution of the survey was done during both day and night, on all lakes experiencing fishing pressure. Trips to each lake were completed randomly throughout the year.

FINDINGS

Monitoring of Exeperimental Lakes:

Density-dependent growth and survival in bluegill could occur at all life stages. Combining density estimates of larval, juvenile, and adult bluegill with prey availability estimates of zooplankton, invertebrates, and other larval fish will help us determine at what life stage density-dependent growth and survival is occurring in Illinois reservoirs. Zooplankton and bluegill densities have been analyzed for 17 of the study lakes.

There was no statistically significant difference ($P > 0.05$) between stunted (mean = 45.88/m^3) and quality (mean = 2.45/m^3) populations in terms of larval fish densities (Figure 3-1). The lack of statistical significance is likely due to high variability in larval fish densities. In particular, larval fish density in Dolan Lake was an order of magnitude higher than all other stunted lakes. In contrast, juvenile bluegill abundances were significantly higher ($P = 0.03$) in quality (15.0/m shoreline) than in stunted (2.60 /m; Figure 3-2) populations. Continued analysis of all populations from multiple years will be necessary to control variance and increase likelihood of measuring differences between stunted and quality populations.

We examined the densities of inshore and offshore zooplankton in 17 experimental lakes. Offshore zooplankton densities were significantly higher ($P = 0.038$)in stunted (56.3 org/L) populations than in quality (39.0 org/L). Although not statistically significant ($P = 0.34$), the trend was similar for inshore zooplankton densities (stunted = 92.7; quality = 61.3; Figure 3-3).

Differences in zooplankton densities between stunted and quality populations did not translate into differences in measured growth characteristics of bluegill populations. There was no significant correlation ($P > 0.05$) between second-year growth rates and inshore or offshore zooplankton densities (Figure 3-4). In addition, size at age 2 of bluegill in all populations was not correlated ($P > 0.05$) with inshore or offshore zooplankton densities.

There were significant differences in predator (largemouth bass) populations among experimental lakes. Predator abundance in quality lakes(29.0 LMB/h) was significantly higher ($P = 0.03$) than in stunted lakes (12.0 LMB/h; Figure 3-5).

Productivity measures did not differ among experimental lakes. Analysis of chlorophyll *a* revealed no significant difference ($P = 0.85$) between stunted and quality lakes. In fact, means were nearly identical between the two treatment groups (stunted = 23.4 mg/L; quality = 22.3 mg/L). High primary productivity often relates to high larval fish abundance and faster growth through bottom-up trophic mechanisms. Lack of differences here may explain the lack of significant differences in larval fish abundance between stunted and quality populations.

Examination of lake-habitat characteristics for 13 (5 quality and 8 stunted) of the experimental study lakes revealed no significant correlations between bluegill growth and maturation parameters and habitat. The proportion of quality males (PQM) in each of the lakes was not correlated with any habitat characteristic ($P > 0.10$). However, both male Z age and female Z age were significantly correlated with shoreline length (P_{males} = 0.001, $P_{females}$ = .001) and shoreline development (P_{males} = 0.01, $P_{females}$ = 0.03). Examination of these data revealed that relationships were heavily influenced by Forbes Lake, which has considerably higher male and female z age, shoreline length, and shoreline development. Removal of this data point from the analysis results in the loss of significant correlations ($P >$ 0.01). Male z age was also significantly correlated with lake area ($P = 0.006$; Figure 3-6). Again, however, this was due to the strong influence of Forbes and Bloomington Lakes. Continued examination of all 32 experimental lakes should provide additional statistical power and the increased sample size necessary to determine the validity of these potential correlations.

The re-sampling of the seven lakes was conducted in late May and early June, 1999. We collected a minimum of 130 bluegill (across size classes) to re-examine population size structure, growth, and age-at-maturity (Table 3-2). We should complete analysis of these data during the next segment.

Complete data for the compliance cards was limited to seven lakes. Other experimental lakes either had low fishing pressure or infrequent compliance checks. Data from the seven compete lakes indicate high compliance of anglers with experimental management regulations. Percent compliance ranged from a low of 85.7% in Lake Bloomington to a high of 98.0% in Dolan Lake (Table 3-3).

Preliminary sampling of six lakes provided insight into variables necessary to examine during the large-male addition experiment. We determined that estimates of male reproductive success and data about spawning frequency and duration will be important to examine before and after addition of large males. Data from Bullfrog, Wampum, Kakusha, Hedge, and Jill lakes are being examined to determine suitability for this experiment. We are also locating additional populations to sample during the next segment.

MANSIM Model

It is apparent that many parameters necessary for simulation of management manipulations are different in Illinois reservoirs than those found in Wisconsin, where the model was initially developed. Many parameters vary considerably across study lakes, and others require additional data to calculate. Currently, parameters are being determined for each study lake so that simulations of management manipulations may be conducted.

Angler Survey

Based on data from the Illinois creel survey, target numbers of surveys were collected at all six of the study lakes in order to obtain a 95 percent confidence level. Response was greater than 97% for all of the six lakes and non-response bias was not considered a factor.

Angler response varied for the different regulations (Table 3-4). Response varied from strongly support to strongly oppose for all regulations. Anglers most strongly opposed a daily bag of 25 and no fishing zone for ½-lake year. Several regulations had the majority of the responses in the neutral category, including catch and release for the entire year, no fishing zones for 1/4 lake during the spawn, no fishing zones for 1/4 of the lake all year, no fishing zones for ½ of the lake during the spawn, 7-inch minimum size limit, and 8-inch minimum size limit. Anglers were strongly supportive of daily bag of 10 fish, 6-inch minimum size limit, and catch and release bluegill fishing during the spawning season.

Angler mean response varied within each major category of regulations. Within the catch and release category there was less support for catch and release for the entire year than for catch and release during the spawn. Lake closure was supported more during the spawning season than the entire year and closure of 1/4 of the lake was more popular than ½ lake closures. Daily bag limits of 10 fish were more popular than daily bag limits of 25. In the size limit category, 6 inches was more popular than 7 or 8 inches.

Anglers at stunted lakes were more likely to support regulations than those at quality lakes (Figure 3-7). Mean response values for all potential regulations were higher for stunted than for quality lakes (ANOVA df = 1,65; $P = 0.004$). Anglers were more supportive of a 25 fish bag limit in quality lakes than stunted populations, but were more supportive of all other regulations in stunted populations than quality (Figure 3-8).

Angler responses between stunted and quality lakes were similar for catch and release fishing for the entire year, no fishing zone for 1/4 of the lake all year, no fishing zone 1/4 of the lake during the spawn, daily bag of 10, daily bag of 25, and 7-inch size limit. In contrast, when comparing angler responses between stunted and quality lakes, we found differences among the other five categories of regulations (Tables 3-5 and 3-6). Catch and release fishing during the spawning season was strongly supported in stunted lakes, whereas anglers at quality lakes were more neutral. No fishing zones for ½ of the lake all year received neutral responses at stunted lakes but were opposed in quality lakes. The 6-inch and 8-inch minimum size limits were strongly supported categories for stunted lakes, but quality lakes supported the 6-inch size limit and were neutral towards the 8-inch size limit. The daily bag limit of 25 bluegill also differed between stunted and quality lakes, with the greatest percentage of anglers in stunted lakes strongly opposing the regulation while the majority of anglers in quality lakes were either supportive or neutral.

Anglers either strongly supported or supported (> 3.0) six of the 11 possible regulations (Table 3-7). Catch and release fishing for the spawning season had the greatest support with a mean score of 3.58. A high level of support was also shown for 6-inch minimum size limit and a 10-fish daily limit, with scores of 3.46 and 3.45 respectively. Size limits of 7 and 8 inches were supported with a mean of 3.24 for 8 inches and 3.19 for 7 inches. Response for no fishing zones for 1/4 of the lake during spawn and daily bag of 25 fish received more neutral scores of 3.03 and 2.98. Anglers were slightly opposed to catch and release fishing for the entire year and no fishing zones for 1/4 of the lake all year with scores of 2.87 and 2.83 respectively. No fishing zones for ½ of the lake were the most opposed with a mean score of 2.64 during the spawn and 2.52 for the entire year.

RECOMMENDATIONS

To determine the mechanisms causing stunting, we will need to examine lake characteristics as well as bluegill population size structure. It is important that we continue to monitor these factors (bluegill abundance, growth rates, and maturity, as well as other biotic and abiotic lake characteristics) in relation to the management manipulations. Understanding changes in these parameters will be important to examine in relation to any changes in bluegill size structure that might result from the management experiment. We should continue to monitor bluegill populations in the experimental and control lakes throughout the duration of the management experiment.

We will examine bluegill population parameters more intensively during this next segment. Specifically, we should examine adult abundances in each of the study lakes. We will also examine correlations between important biotic and abiotic variables and bluegill abundances at each life stage. We will continue to process and complete analysis of data from the resampling of the seven lakes that occurred during this segment. Additionally, after two years we will resample all 32 populations to assess any changes in growth, age-at-maturation, and size structure. This intensive sampling will provide insight into the temporal component of changes that may result from the management experiment.

To thoroughly examine the effects of prey availability at each life stage, we will continue to monitor prey resources in selected study lakes. More intensive analyses should focus on zooplankton assemblage and abundance to determine what impacts these differences may have on bluegill growth rates. Prey abundance will be combined with bluegill densities and size-at-age data to determine if density-dependent growth is occurring, and if so, at which stage. Sizes at each age should be examined for correlations between zooplankton densities as well as zooplankton assemblages. Macroinvertebrate densities and assemblages should be examined relative to bluegill population size structure and maturation. Pre- and post-maturation growth rates should also be examined in relation to prey abundance. Examining the remainder of the 32 experimental lakes should provide additional insight into the effects of prey availability on bluegill growth and maturity.

Preliminary analysis suggests that predator populations may be more important than lake productivity and prey resources in determining population size structure of bluegill. Predator abundances should continue to be monitored to determine the effects of predation on bluegill abundance and growth. By monitoring these variables before and after implementation of regulations we will be able to assess the cause of changes in age-at-maturation and growth rates that may result. Understanding the mechanisms causing changes in bluegill population size structure will be important in determining the future utility of these management options across a range of lakes.

High variability in prey and bluegill densities among the study lakes contributed to the lack of statistically significant relationships. Further analysis of the remainder of the study lakes should provide more insight into potential relationships between prey resources, predator densities, and bluegill abundance. Additionally, examination of prey resources relative to each life stage (i.e., both immature and mature fish) should provide additional evidence for or against density-dependent mechanisms in the study lakes. Further examination of lake-habitat characteristics on all study lakes should provide insight into the effects of important abiotic variables on bluegill growth and maturation. We will continue to analyze data on all experimental lakes to examine the importance of both biotic and abiotic variables to bluegill population size structure.

We will continue to process and analyze data from the compliance cards distributed by the conservation officers. We will need to collect additional data on populations with incomplete data sets (i.e., lakes where too few interviews with anglers were conducted). It will be important to continue to monitor changes in angler attitudes as the management experiment continues, and incorporate these data into future management recommendations.

Additional factors that may be important to age-at-maturation of adult bluegill will also be examined in the future. For example, gizzard shad densities may be an important factor in the lack of a relationship between primary productivity and larval fish abundance, given that they often act through middle-out trophic mechanisms (DeVries and Stein 1992). Other factors to consider include reproductive characteristics such as mean size of spawning males, number of spawns per season, and nesting behavior occurring in each study lake. Social influence of adult males on reproductive maturity of juvenile bluegill may need more thorough investigation. Specifically, the addition of large, mature males to stunted populations needs to be examined to determine whether social influence can alter size structure. To determine suitability for the large-male addition experiment, mating behavior, reproductive success, and spawning season data should be examined in selected lakes. Continued sampling should occur in the six lakes examined so far, and preliminary sampling should begin in other lakes that could potentially be included in this experiment. Specific sampling protocols should be developed and modified according to conditions in each population.

MANSIM Model:

The MANSIM model needs additional adjustment to simulate conditions found throughout Illinois reservoirs. Additionally, parameters necessary to run the model must be defined for each lake. Once the model is appropriately parameterized, we can simulate various regulation options and make predictions for test populations across the state. Because of continued problems with parameterization of the model and difficulties with population assessment (i.e., lack of sensitivity of the MANSIM model), we should begin to investigate alternative models that may better address the goals of this study. In addition, we will begin to consider development of a simulation model to predict not only changes due to management alternatives but also growth and reproductive characteristics of bluegill populations.

Angler Survey:

Survey results from six Illinois lakes showed that significant differences exist between lakes categorized as quality and stunted in angler attitudes towards regulations. Although overall means were different between stunted and quality lakes, responses to individual regulations were not. Our data should provide accurate information on angler attitudes throughout the state within a 5 percent margin of error.

Given angler response to potential regulations, some appear to be undesirable. No fishing zones for 1/2 or 1/4 of the lake for the entire year and no fishing zones for 1/2 of the lake during the spawn received negative responses. Catch-and-release bluegill fishing for the entire year was also not highly supported by anglers. Several regulations were neither supported nor opposed; these were no fishing zones for 1/4 of the lake during the spawn and a daily bag limit of 25 fish. Regulations that received the highest levels of angler support were catch-and-release bluegill fishing during the spawning season, 10 fish bag limits, and a 6-inch minimum size limit. These regulations would likely result in the greatest level of public support. The 7- and 8-inch size limits were not strongly opposed, but did not receive the level of acceptance that the 6-inch size limits received. Implementation of these regulations may require a greater degree of public education and enforcement to be effective.

During the next segment, we will finish analysis of angler survey data. Further analysis of the survey will focus on areas of angler avidity and angler demographics to help managers understand reasoning behind feelings about regulations. These analyses will help with identification of certain groups of anglers that may oppose regulations, as well as those groups that are likely to be highly supportive.

Job 101.4 Analysis and reporting.

OBJECTIVE

To prepare annual and final reports that provide guidelines for bluegill management in Illinois impoundments.

Relevant data were analyzed and reported in individual jobs of this report (see Job 101.1-101.3).

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Table 1-1. List of 60 study lakes chosen for bluegill population assessments and characterization. The list of lakes is organized by region (north, central, and south) and then split into categories based both on population size structure (quality populations = adults >180mm or stunted populations = adults <150mm) and lake size (large lakes are ≥ 100 acres and small lakes are < 100 acres). Names of counties follow each lake name.

NORTHERN LAKES

Quality/Large
- Tampier (Cook)
- Shabbona (Dekalb)
- Apple Canyon (Jo Davies)
- Busse - Main (Cook)
- Busse - South Pool (Cook)
- Holiday (Lasalle)

Quality/Small
- Botanical Garden (Cook)
- Johnson Sauk Trail (Henry)
- Kakushka (Lasalle)
- Baumann Park Lake (Winnebago)

Stunted/Large
- Pierce (Winnebago)
- George (Rock Island)
- Round (Lake)
- Long (Lake)

Stunted/Small
- Carleton (Whiteside)
- Sterling (Lake)
- Bullfrog (Cook)
- Wampum (Cook)
- Busse North (Cook)
- Le-Aqua-Na (Stephenson)
- Turner (Lake)
- Levings (Winnebago)

CENTRAL LAKES

Quality/Large
- Lincoln Trail (Clark)
- Mill Creek (Clark)
- Spring Lake South (Tazewell)
- Paradise (Coles)
- Bloomington (Mclean)

Quality/Small
- Woods Lake (Moultrie)
- Homer Lake (Champaign)
- Coles Co. Airport Lake (Coles)
- Beaver Dam Lake (Macoupin)
- Siloam Springs (Adams)
- Walnut Point (Douglas)

Stunted/Large
- Spring Lake North (Tazewell)
- Paris East (Edgar)
- Pana (Shelby)
- Mingo (Vermilion)
- Jacksonville (Morgan)
- Charleston (Coles)

Stunted/Small
- Lake of the Woods (Champaign)
- Oakland City Lake (Coles)
- Weldon Springs (Dewitt)
- Walton Park (Montgomery)
- Hillsboro Old City (Montgomery)

SOUTHERN LAKES

Quality/Large
- Mermet (Massac)
- Murphysboro (Jackson)
- Sam Parr (Jasper)
- East Fork (Richland)
- Dutchman (Johnson)

Quality/Small
- Red Hills (Lawrence)
- St. Elmo/South Lake (Fayette)
- Glendale (Pope)

Stunted/Large
- Jones (Saline)
- Forbes (Marion)
- Harrisburg (Saline)
- Sam Dale (Wayne)

Stunted/Small
- Dolan (Hamilton)
- One Horse Gap (Pope)
- Mcleansboro (Hamilton)
- Nellie (Fayette)

Table 1-2a. Creel data for the 32 study lakes, including the class (corrected if needed) of the lake population (Q = Quality, St = Stunted, N = North, S = South, L = Large, S = Small), the year last creeled, the percentage of anglers targeting bluegills, angler hours per acre, the number of bluegill caught and harvested per hour, the kilograms of bluegill caught and harvested per hour, the average weight of bluegills caught and harvested per hour, and the Proportion of Creeled Fish (PCF.180).

Class	Lake Name	Year of Creel	% BLG Intrvws	Angler Hrs/Acre	#/Hr Caught (Harvest)	KG/Hr Caught (Harvest)	Ave Wt (g) Caught (Harvest)	PCF.180
Q N L	Apple Canyon	NO DATA						NO DATA
Q N L	Bloomington	1996	2.0%	63	.312 (.140)	.026 (.016)	85.7 (112.1)	0.38
Q N L	Busse	1989	0.6%	451	.262 (.167)	.011 (.008)	46.1 (49.9)	0.01
Q N L	Spring Lake South	1996	31.8%	150	1.380 (.675)	.083 (.061)	61.1 (92.4)	0.19
Q N S	Kakusha	1998	17.6%	124	.135 (.095)	.012 (.009)	91.8 (105.8)	0.37
Q N S	Siloam Springs	1997	6.6%	416	.279 (.076)	.015 (.008)	55.0 (99.8)	0.15
Q N S	Walnut Point	1997	37.9%	199	.302 (.197)	.022 (.019)	62.9 (95.6)	0.23
Q N S	Woods Lake	NO DATA						NO DATA
Q S L	Forbes	1991	5.9%	117	.651 (.244)	.025 (.013)	36.3 (58.5)	0.02
Q S L	Lincoln Trail	1996	9.5%	112	.188 (.166)	.021 (.019)	111.5 (118.5)	0.60
Q S L	Mermet	1997	11.9%	81	.488 (.351)	.052 (.046)	108.4 (142.2)	0.48
Q S L	Murphysboro	1987	23.2%	198	.362 (.165)	.026 (.018)	70.2 (111.9)	0.25
Q S S	Glendale Lake	1999	3.7%		DATA NOT YET AVAILABLE		83.2 (84.3)	0.54
Q S S	Lake of the Woods	1998	5.0%	837	.732 (.136)	.023 (.005)	32.6 (39.8)	0.02
Q S S	Red Hills Lake	1994	18.1%	473	.612 (.278)	.049 (.030)	79.7 (104.3)	0.21
Q S S	Sam Parr	1997	16.6%	217	1.671 (1.020)	.112 (.094)	66.7 (94.4)	0.31
St N L	Pierce Lake	1993	2.3%	413	.088 (.021)	.003 (.002)	35.6 (81.1)	0.04
St N L	Round Lake	1999	2.4%		DATA NOT YET AVAILABLE		61.2 (81.5)A	0.25
St N L	Spring Lake North	1988	5.9%	32	.061 (.028)	.000 (.000)	64.5 (67.6)	0.14
St N L	Tampier	1998	3.2%	951	.118 (.022)	.003 (.001)	25.7 (46.9)	0.02
St N S	Bullfrog	1998	10.2%	111	.355 (.068)	.011 (.003)	32.1 (51.5)	0.01
St N S	Homer Lake	1999	4.6%		DATA NOT YET AVAILABLE		66.8 (86.2)	0.24
St N S	Le-Aqua-Na	1994	6.5%	742	.412 (.213)	.033 (.023)	73.2 (99.0)	0.27
St N S	Sterling	1989	0.8%	125	.006 (.002)	.000 (.000)	38.2 (61.0)	0.00
St S L	Jacksonville	1991	1.3%	61	.261 (.035)	.010 (.002)	43.0 (77.9)	0.07
St S L	Mingo	1988	3.9%	173	.202 (.114)	.012 (.009)	62.1 (76.4)	0.22
St S L	Pana Lake	1999	0.2%		DATA NOT YET AVAILABLE		35.9 (NO DATA)A	0.00
St S L	Paris	1999	13.0%		DATA NOT YET AVAILABLE		49.3 (59.9)	0.14
St S S	Dolan Lake	1998	5.2%	274	.399 (.242)	.017 (.013)	47.5 (65.6)	0.05
St S S	Hillsboro	1999	5.1%		DATA NOT YET AVAILABLE		52.6 (60.1)	0.07
St S S	McLeansboro	1999	9.2%		DATA NOT YET AVAILABLE		133.4 (157.4)A	0.50
St S S	Walton Park	1999	2.2%		DATA NOT YET AVAILABLE		47.4 (107.5)A	0.09

Notes

All 1999 data are based upon data collected from 3/15 to 6/15 only.

A - Sample size is less than 100

Table 1-2b. Preliminary creel data from study lakes in 1999. All estimates are based upon data collected from 3/15/99 to 6/15/99 only. Fishing effort and harvest rate estimates are not yet available.

Class	Lake Name	Year of Creel	% BLG Intrvws	Ave Wt (g) Caught (Harvest)	PCF.180
Q S L	Forbes	1999	7.0%	118.9 (137.3)	0.63
Q S S	Glendale Lake	1999	3.7%	83.2 (84.3)	0.54
St N L	Pierce Lake	1999	3.1%	35.5 (39.7)	0.04
St N L	Round Lake	1999	2.4%	61.2 (81.5)A	0.25
St N L	Spring Lake North	1999	26.3%	82.1 (83.4)	0.16
St N S	Homer Lake	1999	4.6%	66.8 (86.2)	0.24
St S L	Jacksonville	1999	0.3%	37.9 (43.5)A	0.05
St S L	Mingo	1999	7.5%	42.1 (46.7)	0.01
St S L	Pana Lake	1999	0.2%	35.9 (NO DATA)A	0.00
St S L	Paris	1999	13.0%	49.3 (59.9)	0.14
St S S	Hillsboro	1999	5.1%	52.6 (60.1)	0.07
St S S	McLeansboro	1999	9.2%	133.4 (157.4)A	0.50
St S S	Walton Park	1999	2.2%	47.4 (107.5)A	0.09

Notes

A - Sample size is less than 100

Table 1-3. Unpaired t-test analysis for comparisons of creel data components and regional differences (north and south), lake size differences (large and small), and population type differences (stunted and quality).

	REGION		LAKE SIZE		TYPE	
ANGLER HR/ACRE	Mean Diff.	83.2	Mean Diff.	-95.5	Mean Diff.	-73.2
	DF	20	DF	20	DF	20
	t-Value	0.74	t-Value	-0.85	t-Value	-0.64
	P-Value	0.47	P-Value	0.40	P-Value	0.53
# / HR CAUGHT	Mean Diff.	-0.28	Mean Diff.	-0.16	Mean Diff.	0.38
	DF	20	DF	20	DF	20
	t-Value	-1.63	t-Value	-0.89	t-Value	2.30
	P-Value	0.12	P-Value	0.39	P-Value	0.032
# / HR HARVEST	Mean Diff.	-0.19	Mean Diff.	-0.11	Mean Diff.	0.24
	DF	20	DF	20	DF	20
	t-Value	-1.7	t-Value	-0.95	t-Value	2.3
	P-Value	0.10	P-Value	0.35	P-Value	0.032
KG/HR CAUGHT	Mean Diff.	-0.02	Mean Diff.	-0.01	Mean Diff.	0.03
	DF	20	DF	20	DF	20
	t-Value	-1.66	t-Value	-0.85	t-Value	2.57
	P-Value	0.11	P-Value	0.41	P-Value	0.018
KG/HR HARVEST	Mean Diff.	-0.02	Mean Diff.	-0.01	Mean Diff.	0.03
	DF	20	DF	20	DF	20
	t-Value	-1.63	t-Value	-0.85	t-Value	2.37
	P-Value	0.12	P-Value	0.41	P-Value	0.028
AVE. WT. CAUGHT	Mean Diff.	-12.7	Mean Diff.	-0.74	Mean Diff.	24.3
	DF	28	DF	28	DF	28
	t-Value	-1.23	t-Value	-0.07	t-Value	2.54
	P-Value	0.23	P-Value	0.94	P-Value	0.017
AVE. WT. HARVES	Mean Diff.	-12.7	Mean Diff.	-4.2	Mean Diff.	26.5
	DF	27	DF	27	DF	27
	t-Value	-1.06	t-Value	-0.35	t-Value	2.39
	P-Value	0.30	P-Value	0.73	P-Value	0.024
PCF.180	Mean Diff.	-0.11	Mean Diff.	-0.02	Mean Diff.	0.22
	DF	28	DF	28	DF	28
	t-Value	-1.43	t-Value	-0.20	t-Value	3.46
	P-Value	0.16	P-Value	0.84	P-Value	0.002

Table 1-4. Sex ratio of angler harvested bluegill during pre-spawn and spawning seasons on three Illinois lakes.

WALNUT POINT

Pre-spawn Bluegill

	Male	Female	Unidentifiable
05-02-98	5	12	0
05-04-98	9	19	0
05-06-98	6	12	0
Total	20	43	0

Spawning Bluegill

	Male	Female	Unidentifiable
05-10-98	12	9	0
05-26-98	5	6	0
06-01-98	1	0	0
06-28-98	17	4	0
07-02-98	16	17	0
07-15-98	9	4	0
Total	61	41	0

Post-Spawn Bluegill

	Male	Female	Unidentifiable
09-12-98	10	9	0
01-16-99	8	10	0
Total	18	19	0

LAKE OF THE WOODS

Pre-spawn Bluegill

	Male	Female	Unidentifiable
05-08-98	0	3	0
05-09-98	9	7	0
05-10-98	3	4	0
Total	12	14	0

Spawning Bluegill

	Male	Female	Unidentifiable
05-15-98	3	4	0
05-17-98	12	2	0
05-19-98	5	4	0
06-06-98	11	3	0
06-16-98	4	3	2
06-23-98	7	3	2
07-03-98	6	2	4
Total	48	21	8

Post-Spawn Bluegill

	Male	Female	Unidentifiable
09-23-98	4	3	11
11-05-98	6	10	3
11-24-98	1	4	3
Total	11	17	17

Table 1-4 Continued

RIDGE LAKE

Pre-spawn Bluegill
*No data available Ridge Lake closed to fishing

Spawning Bluegill

	Male	Female	Unidentifiable
05-23-97	15	0	0
05-24-97	1	0	1
06-04-98	12	0	0
06-05-98	7	0	0
06-06-98	13	2	0
06-07-98	12	0	0
Total	60	2	1

Post-spawn Bluegill
*No data available Ridge Lake closed to fishing