Illinois Natural History Survey

Population Viability of Mottled Sculpin (*Cottus bairdi*) in Black Partridge Creek

Annual Progress Report (Winter 2001)

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607 E. Peabody Dr.
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Submitted to:
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Aquatic Ecology Report 01/01

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Background

The Illinois Department of Transportation has planned the construction of FAP Route 340, connecting Interstate Route 55 and Interstate Route 80. The upper end of the Black Partridge Creek watershed extends from near the proposed FAP Route 340/ I-55 interchange south to Lemont Road and I-55. The creek parallels the proposed road for approximately 1.7 miles before dissipating into wetlands north of the Des Plaines River. One species of potential concern in Black Partridge Creek is the mottled sculpin (*Cottus bairdi*). The mottled sculpin is only found in two locations in the Des Plaines drainage. In Illinois, it is common in a few tributaries of the Fox River, but extremely sporadic elsewhere. It is likely that these populations have been isolated from other sculpin populations for some time, and are relicts left behind in pockets of suitable habitat after the last glacial retreat. Sculpin are more typically found in higher gradient cold-water streams. Its occurrence in Black Partridge Creek is most likely due to the unique stream characteristics found within the Black Patridge Forest Preserve: high gradient and spring-fed water create a cool, clear, high gradient stream. This habitat is somewhat unique in Illinois, and may contain other species with limited occurrences within the state.

Reasons for Concern

The construction of roadways has the potential to increase run-off into the stream, which could increase sedimentation and increase the ratio of run-off/groundwater inputs. Both of these effects could potentially harm the sculpin, by 1) reducing the amount of cobble substrate they prefer, 2) decreasing their feeding efficiency, and/or 3) increasing stream temperatures. However, extensive development in the Black Partridge drainage basin may already have imposed these and other potentially negative effects on the population. Thus there is some belief that the sculpin population is already threatened, and, barring any recovery efforts, will become extinct regardless of whether the road is built or not. To assess both the current status of the sculpin population and the potential impacts of the roadway, some form of Population Viability Analysis (PVA) must be performed.

Population Viability Studies

A Population Viability Analysis (PVA) is broadly defined as the use of quantitative methods to predict the likely future status of a population or collection of populations of conservation concern (Morris et al. 1999). The foundation of most PVAs is a demographic model of the population of interest, frequently some form of life table analysis. The basic information needed for these models includes the population size structure, age-specific birth and death rates, etc. However, for real populations these factors are rarely constant. Habitat loss, environmental uncertainty, demographic stochasticity, genetic factors, etc. all interact to determine extinction probabilities for individual species (Soule 1987, cited in Meffe and Carroll 1994). More comprehensive PVA models incorporate additional factors such as these into their analyses. An important caveat to PVA analyses is that because they are based on limited data, they must be viewed as a tentative assessment of extinction risk, based upon current knowledge. They are not meant to be ironclad predictions, but rather serve as a guide to the range of possible fates for the populations (Morris et al. 1999).

Project Description

The main goal of the proposed project is to conduct a PVA of the sculpin population in Black Partridge Creek. The resulting analysis would allow for informed management decisions regarding the proposed highway extension, and provide a basis for assessing the impacts of future development on the sculpin population.

A PVA requires: life history information, population demographics, and in some cases genetic information. The current study is exploring only life history information and population demographics. Field work is being done to estimate existing population size/age structure. Sculpin populations are being estimated using both depletion estimates and direct sampling. Lab experiments will be done to determine the effects of turbidity and on sculpin foraging. The resulting information will be incorporated into two or more PVA computer programs, such as VORTEX and RAMAS/Metapop, to estimate survival probabilities of the population under a variety of scenarios. It should be noted that two years of population data is the bare minimum needed for a PVA, and thus the results of these models must be interpreted as tentative predictions. Based on the life history data, demographic information, and computer simulations, we will make an assessment of the viability of the sculpin population in Black Partridge Creek.

Work Completed in Year One

In the first year of the project, we have done extensive sampling to determine the distribution of the population, population size, and population size structure. We have also conducted a literature review to acquire some of the necessary life history information for the PVA models. Details about each of these portions of the project are described below.

Population Distribution

We conducted several sampling trips to simply look for sculpin along the length of Black Partridge Creek. We assumed that most of the sculpin would be found in the area of the stream within Black Partridge Forest preserve, due to the unique aspects of the stream at that location. We sampled upstream and downstream from the park until we consistently did not find any sculpin. We additionally sampled several large reaches upstream from the park, into the headwaters, to ensure that no sculpin were living upstream of that area. It appears that the sculpin are restricted to a relatively small stretch of the stream, approximately 1700ft. (518m) long (Map 1).

Population Size and Structure

Any single method of estimating a population will have error associated with it, thus we employed two different sampling techniques. For the first method we used a 5.38ft^2 (1/2m^2) benthic sampling device. The sampler frame is constructed out of PVC pipe, with ¼" netting sewn onto three sides and a lead-line attached to the bottom. The lead-line allows for a close seal over cobble substrate. The fourth side of the sampler is open, and a removable collecting bag can be placed into this opening (Figure 1). The sampler is placed on the substrate, and the area within the sampler disturbed in an upstream to downstream direction, herding any sculpin into the collecting bag. The bag can then be removed, and the captured fish measured and released.

We began sampling at the downstream edge of the sculpin's range. We established transects at 40ft (12m) intervals, unless there was some obstruction, in which case we would move upstream of the obstruction. Along each transect, we took three benthic samples, when possible. Occasionally the stream was only wide enough to allow for one or two samples. Sculpin in each sample were measured and their sex identified when possible. Males greater than 1.97–2.36in. (50-60mm) total length can be distinguished by the presence of genital papilla near their anus. After measurement, the fish were placed into a holding container until sampling at that transect was complete, after which they were released back into the stream. Sculpin have very small home ranges and typically move only small distances (Brown and Downherer 1982, Hill and Grossman 1987), thus it is extremely unlikely that fish would have swum upstream into the next transect area. We stopped sampling when we had done three transects without finding a single sculpin, resulting in a total of 44 transects. The average number of sculpin per sample was taken for a 5 transect reach, and multiplied by the total area for that reach to obtain a population estimate for that reach. The estimates for each reach were summed to obtain a population estimate for the entire stream.

The second sampling method employed was a three-pass removal estimate. Four reaches were sampled, each being approximately 200 feet long. Thus slightly less than half of the region with sculpin was sampled. Before sampling, block nets were placed at the upstream and downstream end of the sample reach. Three passes were then made through the section using a backpack electroshocker. After each pass, captured fish were placed into a holding container. After all three passes, fish were measured, sexed, and released back into the study section. Fish were released throughout the study section, and care was taken to return approximately the same number of small, medium, and large fish the same general area where they were captured. The resulting numbers were run through a program called CAPTURE, which estimates population sizes. We averaged all four estimates to obtain a mean sculpin density, and multiplied this by the total stream area to obtain an estimate for the entire stream.

We obtained two very different estimates with the separate sampling techniques (Table 1). The sampler estimated a total population size of 2,109 fish, while the removal method produced an estimate of only 926 fish (Figure 1). The benthic sampler method averaged 0.075 sculpin/ft^2 (0.81m^2), while the depletion method averaged 0.044 sculpin/ft^2 (0.47m^2). Other published densities of mottled sculpin range from 0.0009/ft^2 (0.0097/m^2) to 0.1236/ft^2 (1.33/m^2) (Anderson 1985), thus our estimates represent average densities for mottled sculpin. However, we believe both of our estimates to be fairly conservative, as both methods have problems that will lead to an underestimate of total fish density. For the benthic sampler, this bias is primarily for the smallest fish, as these fish have a greater probability of being able to slip under the collection net placed upon a rocky, uneven bottom. Electrofishing works by stunning the fish so that they may be collected. Sculpin, however, have no swim bladder, so those fish stunned under a rock or washed under a rock by the current will not be collected, leading to an underestimate for all size classes, and hence a lower total estimate.

The sculpin size distribution has two distinct peaks (Figure 3). The first of these represents this year's recruits. The second peak is composed of Age Class I+ fish. This size distribution is similar to other published distributions for mottled sculpin (Bailey 1952). During August, individuals <2.36in (60mm) were Age I, 2.36-3.11in (60-79mm) Age II, >3.11in (79mm) Age III+. Female mottled sculpin may start breeding when they reach a size of 2.36in. (60mm), and all fish 2.95in (75mm) and greater are reproductively active (Bailey 1952). Thus most of the fish in the second peak represent actively breeding individuals. The size structure appears to reflect a healthy population, but a second year of data is necessary before the PVA model can be run.

Literature Review

We gathered numerous papers on sculpin life history in order to produce a more informed and reliable PVA model. Several important pieces of information were obtained that will be incorporated into the PVA (Table 2). The most important of these is fecundity. This information could not be obtained from Black Partridge without killing and dissecting sculpin, which clearly is not an option. One aspect of fecundity is the age or size at which individuals begin breeding. For mottled sculpin, females begin breeding at 2.36in. (60mm) and all fish greater than 2.95in (75mm) are reproductively active (Bailey 1952). The other important factor is how many eggs are laid per female. This varies with size, with larger fish producing more eggs, and this variation will be incorporated into the PVA model.

We also used published studies of sculpin in a number of other streams to estimate the maximum sculpin density. This density is termed the "carrying capacity" of the population, and denotes the upper limit on population densities, beyond which there are not enough resources to support additional individuals. The maximum reported densities of mottled sculpin were $0.1236/ft^2$, and we used this number multiplied by the total area in the sculpin's range to determine the carrying capacity for Black Partridge Creek.

Literature information will also be used to make informed decisions about modeling other factors such as Allee effects, probability of catastrophes, etc.

Future Work: Year Two

Field Work

We will sample the population again several times in the upcoming year. We will also try to estimate timing of reproduction and average sizes of egg masses. We will also do additional sampling to determine what the main physical factors are which influence the limited distribution of sculpin in Black Partridge. We expect that the main factors influencing the sculpin's distribution will be temperature and flow. Data loggers have been place in the stream to obtain a yearly temperature profile for the stream, and we will measure flow rates at various places along the stream. We will combine this information with the already collected physical and chemical data for the stream to see if we can determine why the sculpin are restricted to the relatively small portion of Black Partridge.

Experimental Work

One of the main effects of roads on streams is to increase turbidity. Since sculpin are partially visually feeding fish, this may adversely affect their feeding efficiency and hence growth rates. Our experiment will measure feeding efficiencies and growth rates of mottled sculpin in artificial stream with low turbidity and high turbidity. (The mottled sculpin used will be collected from streams in southwestern Michigan.) These experiments will provide some insight into how run-off from the road may affect the sculpin population.

PVA Model

Once next summer's field work is completed, we will plug all the data into one or two PVA programs and use the information to predict the viability of mottled sculpin in Black Partridge Creek.

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Table 1: Results from three-pass removals of mottled sculpin in Black Partridge Creek. Removals were done using a backpack electroshocker, and represent numbers per 200ft. (60mm) stream reach.

Section	Pass	Total Sculpin	Age Class I	Age Class II	Age Class III
1	1	37	35	0	2
1	2	40	38	1	1
1	3	10	9	0	1
2	1	84	63	9	12
2	2	42	32	2	8
2	3	17	13	1	3
3	1	82	30	31	21
3	2	33	9	13	11
3	3	11	2	6	3
4	1	101	44	33	24
4	2	41	14	13	14
4	3	18	5	6	7

Table 2: Life History Information Necessary to Perform PVA

Parameter	Estimate	Source of Information
Age specific fecundity	Varies with size, with larger fish producing more eggs	Literature/ Field
Age specific survival	Need 2nd year of data	Field work
Sex ratio	50:50	Field work
Size at first reproduction	>2.36 inches (60mm)	Literature
Density dependence	Carrying capacity of 3,492 sculpin	Literature/ Field
Allee effects	Will estimate appropriate value from published work	Literature
Environmental stochasticity	Not modeled – need 3 years field data	NA
Demographic stochasticity	Yes/No option in model	NA
Probability of catastrophes	Will run model with various values	NA

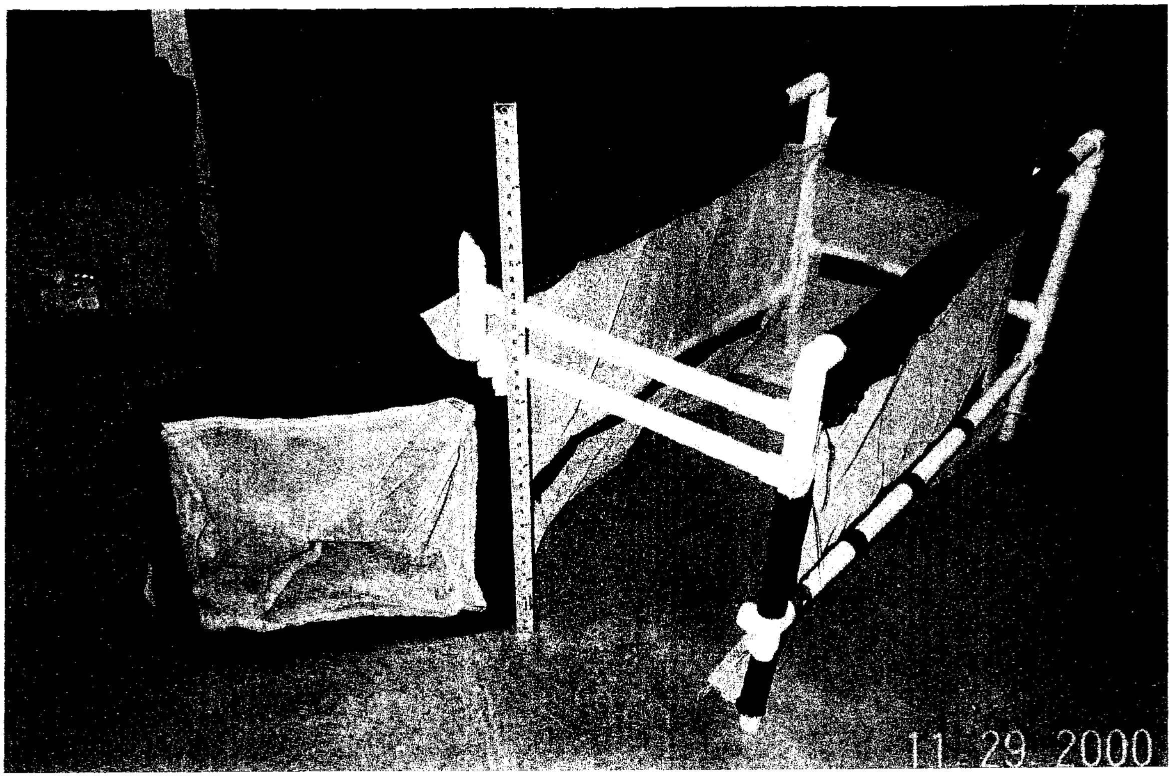


Figure 1: Benthic sampler used to estimate population size of mottled sculpin (*Cottus bairdi*) in Black Partridge Creek. The sampler is 5.38in^2 (1/2m^2) in area.

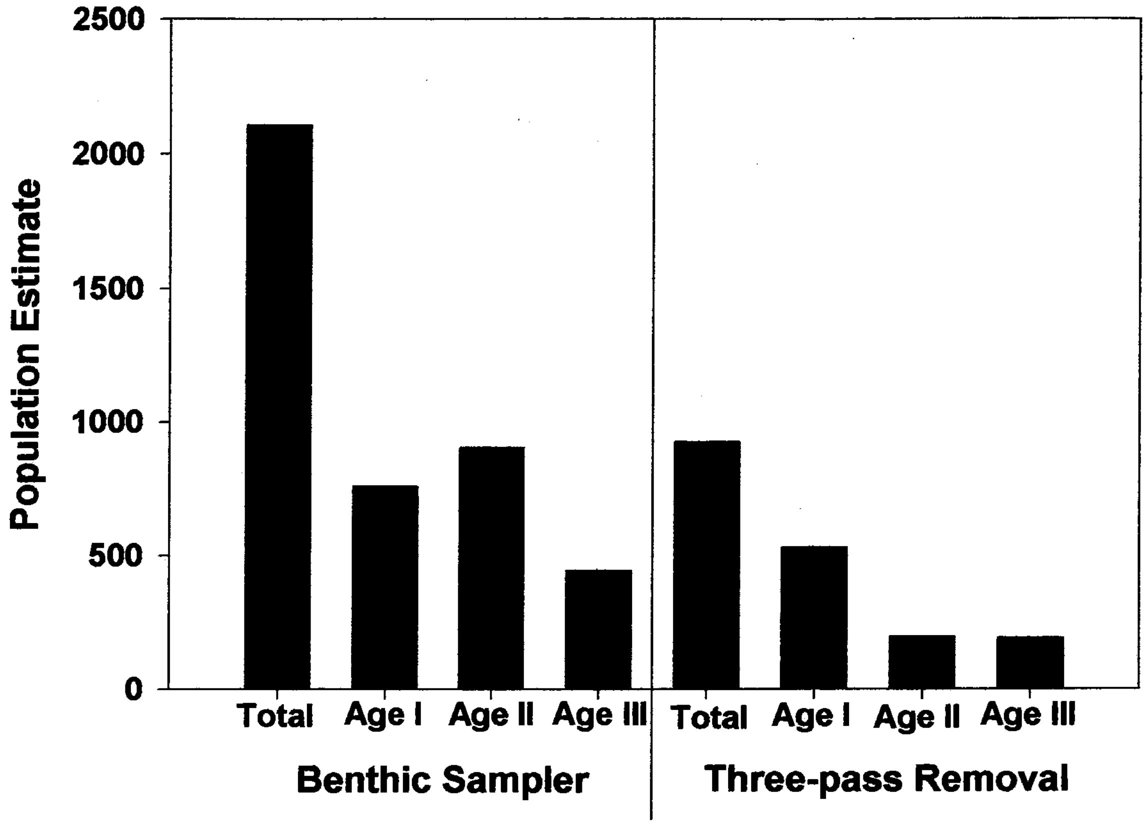


Figure 2: Population estimates for mottled sculpin in Black Partridge Creek. The estimates on the left were made using a 5.38in^2 (1/2m^2) benthic sampling device. Those on the right were obtained with a three-pass removal estimate. For the benthic sampler, the average number of sculpin per half-square meter were estimated per reach, and that number was multiplied by the total area to obtain the estimate. For the three-pass removal, four 200ft (60m) reaches were sampled and estimates obtained using the program CAPTURE. These four estimates were used to obtain an estimate for a typical reach, and this value was multiplied by the total area to obtain the final estimate.

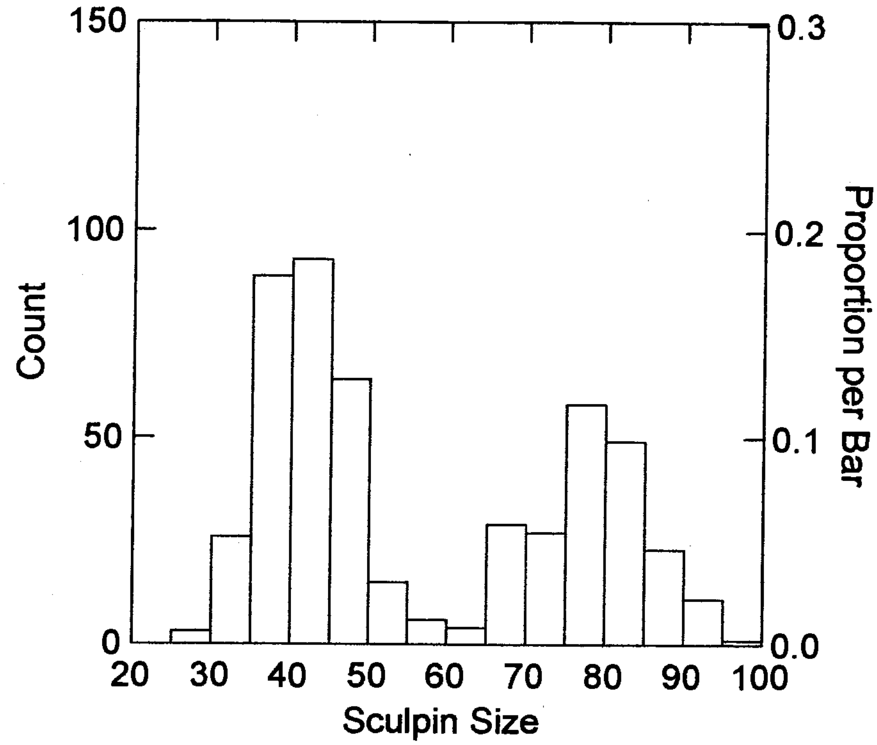
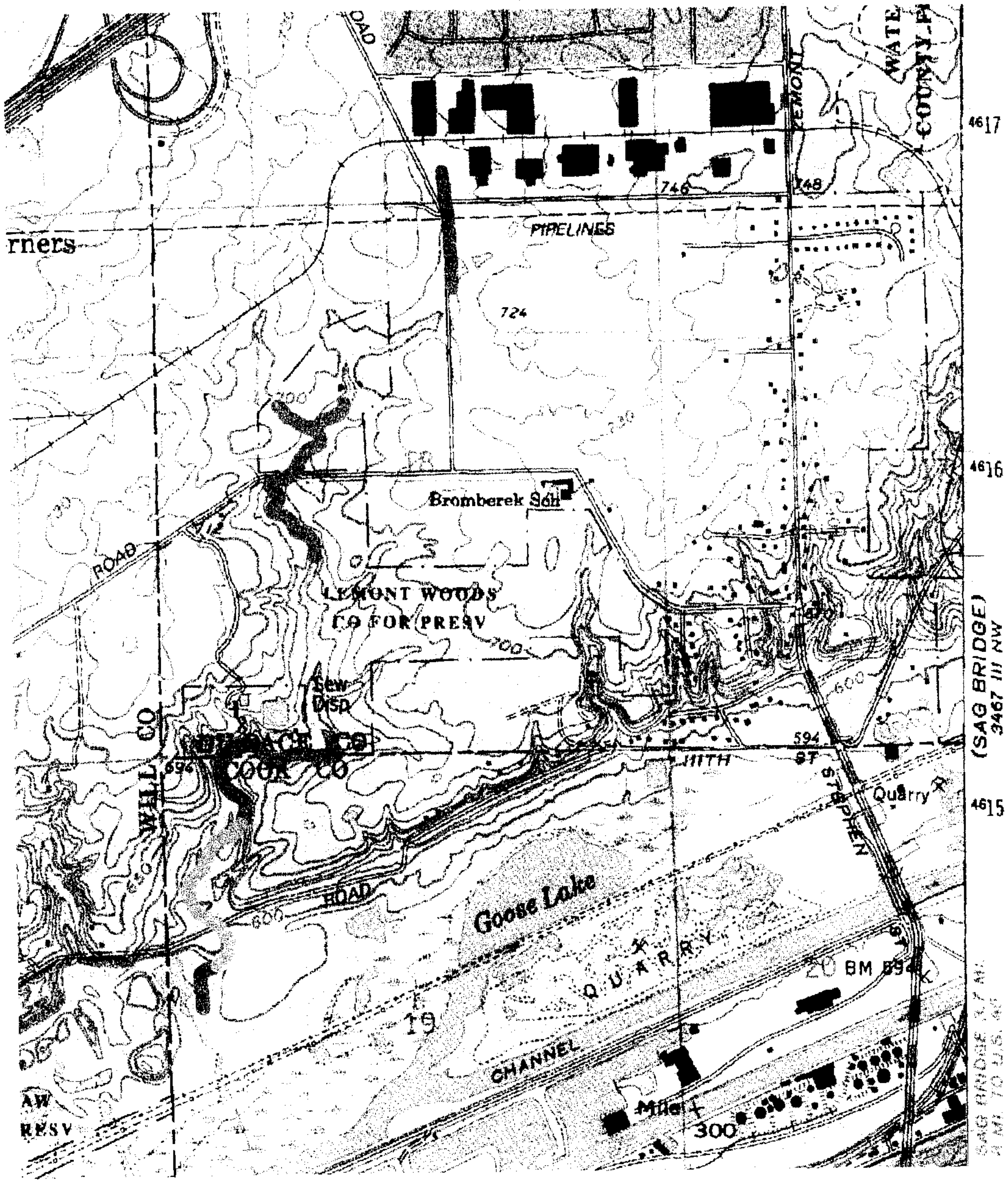
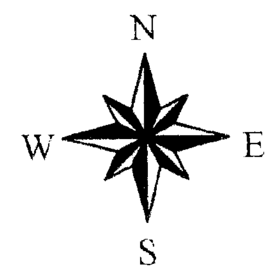


Figure 3: Size distribution of mottled sculpin (*Cottus bairdi*) in Black Partridge Creek. The first peak represents young of the year. The second peak represents individuals aged one year or greater. Samples were collected on August 2nd and 3rd, 2000.



Map 1: Area sampled in Black Partridge Creek. Dark blue shows areas where mottled sculpin were not found. Light blue shows areas where sculpin were found.

Areas with mottled sculpin
Areas without mottled sculpin
Streams



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