Diet overlap and habitat utilization of rainbow trout and juvenile walleye in Cooney Reservoir, Montana
by David Allan Venditti

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Diet overlap and habitat utilization were compared for rainbow trout (Oncorhynchus mykiss) and juvenile walleye (Stizostedion vitrevm) in Cooney Reservoir, Montana for the period between May and October, 1992. Additionally, walleye spawning activity was monitored in the reservoir and tributary creeks during April and May, 1993. Diet and habitat samples were taken twice monthly along randomly-selected 200 m transects over the three available substrates. Zooplankton tows were taken along the same transects 24 hours prior to fish sampling. Gastric lavage was used to remove stomach contents, and all fish were released. The proportion of fish collected over each substrate provided an estimate of habitat utilization. Rainbow trout were randomly distributed during all sampling periods, and fed almost exclusively on zooplankton.

Juvenile walleye selected for sand substrate and against the dam face through July, after which they were randomly distributed. Chironomids were the primary prey for juvenile walleye through June, but thereafter crayfish, fish, mayflies (Callibaetis spp.) and zooplankton dominated their diet. Diet overlap was not significant between the two. Walleye spawned in Red Lodge Creek, and several young-of-the-year walleye were collected from the reservoir. Apparent lack of natural walleye recruitment is hypothesized to be a result of a scarcity of copepods in the reservoir when walleye fry begin to feed.

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David Allan Venditti

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

12/1/94 — Robert G. White
Date — Chairperson, Graduate Committee

Approved for the Major Department

1 December 1994 — Robert E. Moore
Date — Head, Major Department

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12/12/94 — R L Brown
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ABSTRACT

Diet overlap and habitat utilization were compared for rainbow trout (*Oncorhynchus mykiss*) and juvenile walleye (*Stizostedion vitreum*) in Cooney Reservoir, Montana for the period between May and October, 1992. Additionally, walleye spawning activity was monitored in the reservoir and tributary creeks during April and May, 1993. Diet and habitat samples were taken twice monthly along randomly selected 200 m transects over the three available substrates. Zooplankton tows were taken along the same transects 24 hours prior to fish sampling. Gastric lavage was used to remove stomach contents, and all fish were released. The proportion of fish collected over each substrate provided an estimate of habitat utilization. Rainbow trout were randomly distributed during all sampling periods, and fed almost exclusively on zooplankton. Juvenile walleye selected for sand substrate and against the dam face through July, after which they were randomly distributed. Chironomids were the primary prey for juvenile walleye through June, but thereafter crayfish, fish, mayflies (*Callibaetis* spp.) and zooplankton dominated their diet. Diet overlap was not significant between the two. Walleye spawned in Red Lodge Creek, and several young-of-the-year walleye were collected from the reservoir. Apparent lack of natural walleye recruitment is hypothesized to be a result of a scarcity of copepods in the reservoir when walleye fry begin to feed.

INTRODUCTION

Walleye (*Stizostedion vitreum*) have become popular sport fish in Montana, and public pressure to introduce the species into historic trout reservoirs has become organized and vocal (Fredenberg 1983, Colby and Hunter 1989). However, due to negative impacts of walleye on trout populations elsewhere (McMillan 1984, Ellison 1991) the Montana Department of Fish, Wildlife and Parks (MDFWP) needs additional information on probable outcomes of walleye introductions before further introductions are made.

In their assessment of walleye introduction beyond their current range in Montana, Colby and Hunter (1989) recommend that each proposed introduction be evaluated on a case by case basis. They also recommend MDFWP take a conservative approach due to the few well documented cases of walleye introductions into salmonid waters.

Despite the poor history of success, Cooney Reservoir is an example of a system in which a strong trout fishery has been maintained after the establishment of a walleye population. A description of forage and habitat use by these species may provide fisheries managers a basis to better evaluate the suitability of walleye for introduction into other similar waters currently managed for trout.

Walleye introduction was first proposed by Marcuson (1980) and then by Fredenberg and Swedberg (1983) to provide a measure of biological control on the large white sucker (*Catostomus commersoni*) population in Cooney Reservoir. Biological control was opted for after attempts to chemically renovate the reservoir in 1958 and 1970 failed to eliminate suckers (Fredenberg and Swedberg 1983).

In 1984, 1 million walleye fry were introduced into the reservoir with subsequent stockings of 1 million fry in 1985 and 1986. Walleye stocking was then discontinued until 1990. Stocking was resumed after it became apparent walleye reproduction was not occurring or was extremely limited. Since 1990 walleye stocking has continued with 50,000 fry per year (MDFWP unpublished stocking records). Walleye stocked into Cooney Reservior were 3.6 cm in length, and stockings occurred in either May or June (MDFWP unpublished stocking records).

After walleye introduction, recruitment of young white suckers declined dramatically. In 1984, white suckers between 15.2 and 25.4 cm made up 49 % of the sucker sample. By 1988 only 3 % of suckers collected were less than 30.5 cm despite evidence of successful spawning (Fredenberg and

Poore 1989). Additionally, the average size of rainbow trout (*Oncorhynchus mykiss*) increased, and in 1988, the average size of rainbow trout was the largest since record keeping began in 1956. This was attributed to a combination of good growth, reduced stocking rates (approximately 100,000/yr down from 200,000/yr prior to walleye introduction) and an increase in the size of trout planted after walleye were introduced (Fredenberg and Poore 1989).

Prior to walleye introduction rainbow trout stocked were between 7.6 and 15.2 cm in length. After the walleye introduction trout have been planted at lengths between 10.1 and 24.4 cm to reduce walleye predation. Trout have been stocked at all times of the year, but most releases have taken place during the spring and summer months (MDFWP unpublished stocking records).

This study was undertaken to examine how rainbow trout and juvenile walleye partition the available food and habitat resources. Juvenile walleye (defined here as those from the 1990, 1991 and 1992 stockings) were the focus of this study for several reasons. First, there were a large number of young walleye present from the recent stockings. Secondly, it was felt the combination of little or no recruitment and angler harvest for 3 years had reduced the adult population below the level where it could sustain repeated gill net sampling. Finally, and most importantly, the potential for dietary overlap between walleye and rainbow trout would be greatest before young walleye become piscivorous.

The objectives of this study were to:

1. Assess the presence and/or extent of diet overlap between rainbow trout and juvenile walleye during the ice-free season by identifying and quantifying important food items in the diet of both species.

2. Monitor zooplankton density and composition throughout the ice-free season, and compare availability to the zooplankton composition in fish diets.

3. Examine habitat use of rainbow trout and juvenile walleye while using shallow-water feeding habitats.

An attempt was also made to locate walleye spawning areas. Particular emphasis was placed on the tributary streams because of unsubstantiated reports of walleye ascending them in early spring.

Field work for the diet, zooplankton and habitat utilization portions of this study was conducted between May and November 1992. Attempts to locate spawning walleye were made during April 1993, and an attempt to collect larval walleye was made in June 1993.

STUDY SITE DESCRIPTION

Cooney Reservoir is located in Carbon County, Montana approximately 22.5 km south of the city of Columbus. The reservoir was created in 1937 by placing an earthfill dam on Red Lodge Creek. The project was funded by the Public Works Administration and the Montana State Water Conservation Board (Fredenberg 1983) for flood control and to provide water for irrigation (Conklin and Harris 1974). Surface elevation at full pool is 1294 m (Conklin and Harris 1974), but irrigation demand and seasonal rainfall patterns frequently result in drawdowns of 6 m or more. The reservoir is approximately 315 ha in size (Conklin and Harris 1974) and has a maximum depth at full pool of about 19.5 m near the south end of the dam (personal observation).

Cooney Reservoir is fed by three tributary streams (Figure 1), which drain an area of approximately 509 km^2 (US Geological Survey 1991). Red Lodge and Willow Creeks are perennial and enter the northwest and southwest corners of the reservoir, respectively. Arms extending up these tributaries constitute approximately the upper third of the reservoir. Chapman Creek, a small, intermittent stream,

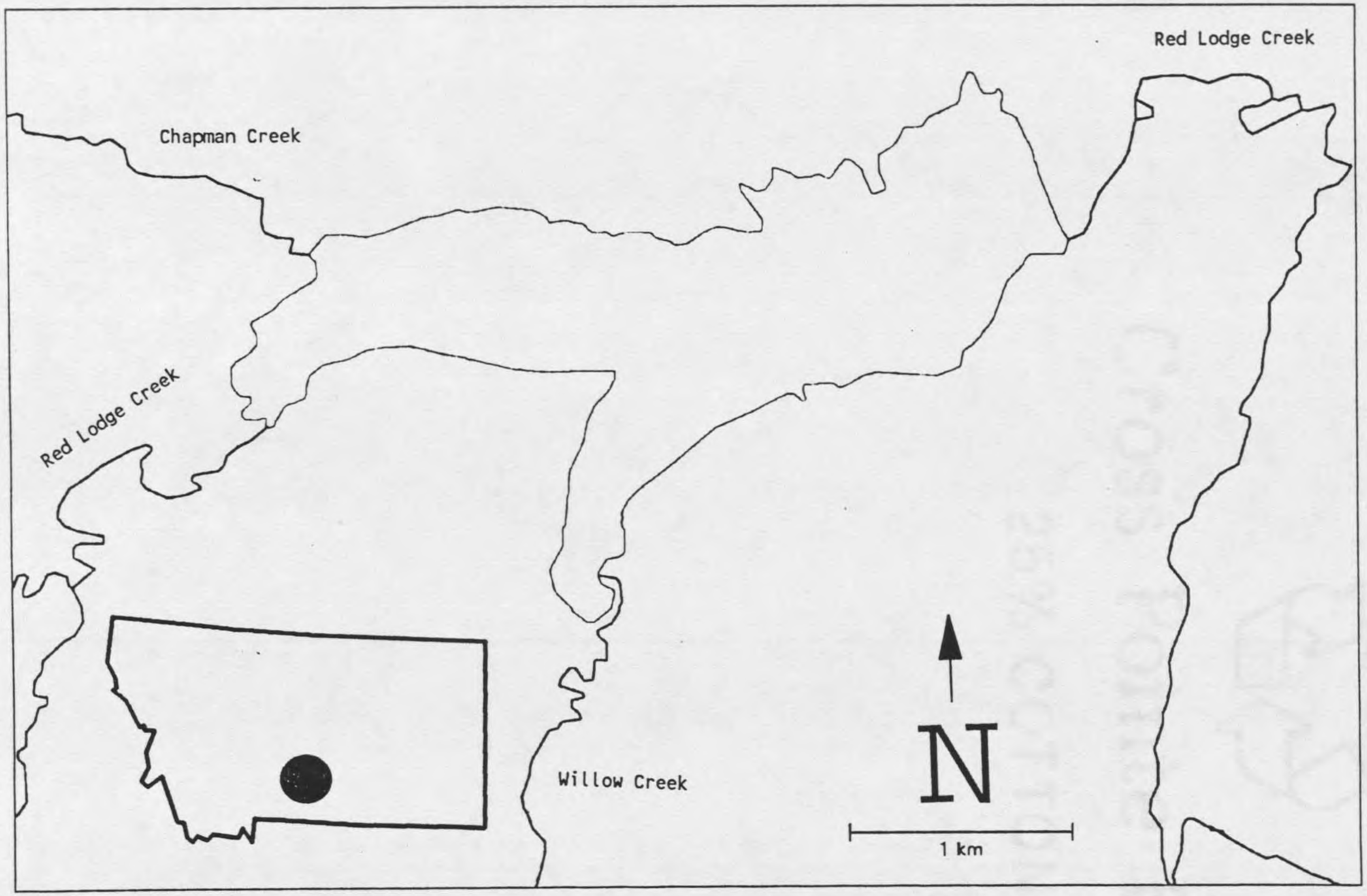

Figure 1. Location of Cooney Reservoir and major tributaries.

enters the reservoir from the north a short distance downlake from the mouth of Red Lodge Creek (Figure 1).

Despite having sufficient size and depth, Cooney Reservoir does not stratify. Frequent high winds appear to prevent the formation of a thermocline. However, water temperature remains tolerable for trout even during the warmest months.

Recreational use of the reservoir is extremely heavy, particularly during the summer months. Primary activities include fishing, water skiing, camping and picnicking. Much of this popularity can be attributed to the reservoir's proximity to Billings (77 km), ease of access and the quality of the facilities. Cooney Reservoir ranked 25th in the state for angling pressure between March 1991 and February 1992, with 20,009 angler days (McFarland in press).

METHODS

Sampling Effort and Distribution

Cooney Reservoir was sampled twice monthly during randomly selected weeks between May and October 1992, with two exceptions. Logistics prevented an early May sample and weather conditions only allowed a single sample in mid September. Sampling took place on three consecutive nights, and was stratified over the three substrates (habitats) present in the reservoir (sand, gravel and dam face) to facilitate the habitat utilization portion of the study. Zooplankton were collected on the first night as an estimate of forage availability, and fish were collected on the following nights for examination of food habits and habitat use.

Sampling Sites

Substrate Mapping

In the fall of 1991 irrigation demand severly drew the reservoir down, allowing for accurate mapping of the littoral substrates. Areas of sand and gravel substrates were identified by boating along the shoreline and plotting the substrate composition on a reservoir map.

Transect Locations

Thirteen 200 m transects were established around the reservoir based on the substrate composition. Six transects were located over sand, five over gravel and two along the face of the dam (Figure 2). Sand and gravel transects were spaced to distribute sampling effort around the entire perimeter of the reservoir. Transects located were at least 100 m from a different substrate type to minimize the possible effects caused by the transition zone between substrates.

Sampling Procedures

Transect Selection and Marking

One dam, two sand and two gravel transects were randomly selected for sampling prior to each collection date (Table 1). Transects were marked at each end by driving an iron rod into the ground near the water line. To facilitate their location after dark the rods were wrapped with reflective tape.

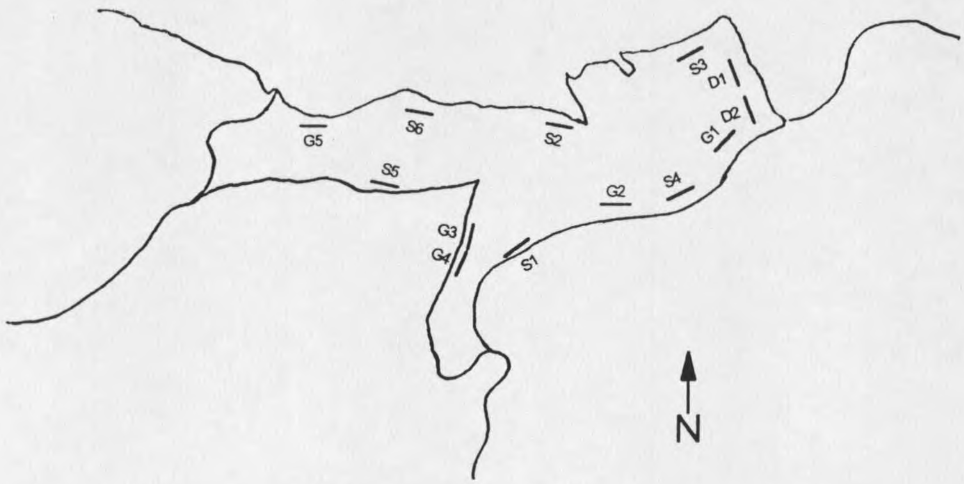

Figure 2. Location of transects sampled at Cooney Reservoir in 1992. D: dam face, S: sand, G: gravel.

Table 1. Sampling dates and transects sampled for forage availability and composition, walleye and rainbow trout food habits and habitat preference at Cooney Reservoir, Montana, 1992.

	Transects sampled and their substrate types		
Sample date	Sand	Gravel	Dam
May 26 - 28	S1,S2,S3	G1,G3	D2
June 8 - 10	S4,S5,S6	G4,G5	D1
June 23 - 25	S2,S4	G2,G4	D2
July 14 - 16	S2,S4	G1,G5	D2
July 21 - 23	S2,S6	G1,G4	D1
Aug. 18 - 20	S1,S6	G3,G5	D1
Aug. 28 - 30	S1,S3	G1,G3	D1
Sept. 4 - 6	S3,S5	G2,G4	D2
Oct. 9 - 11	S2,S6	G2,G5	D1
Oct. 23 - 25	S2,S3	G3,G4	D2

Zooplankton Collection

On the first evening of each sample date, zooplankton were collected using a 37 cm diameter net with a 500 μ mesh cod end at approximately 50 m intervals along each of the five 200 m transects selected for sampling. Sampling began approximately one half hour after sunset and continued until all 15 samples were taken. At the collection site the boat was anchored fore and aft, to prevent movement during the haul, in approximately 1 m of water. The net was attached to a 5 m length of rope, thrown overboard, allowed to sink slightly below the water surface, and retrieved. This procedure was then repeated off the other side of the boat to provide a single 10 m sample. The two samples were pooled, fixed in 95% ethyl alcohol, and later transferred to 70% ethyl alcohol (Pennak 1989).

Fish Collection

Fish were collected by electrofishing from water 0.15 to 2.0 m deep. Three transects were generally sampled on the first night of fish collection, and two on the second. All fish observed were netted, and held in a livewell until worked. Collection began approximately one half hour after sunset and continued until two or three transects had been sampled.

Electrofishing equipment used included multiple anodes suspended in a circular pattern from twin booms extending approximately 2.5 m in front of the boat. The aluminum hull of the boat acted as the cathode. Power was supplied by a portable 5000 W generator operating at 220 V, and a Smith Root Model VI-A Electrofisher was used to convert AC to 60 pulse per second DC. Current was maintained at 6 A while shocking.

Length and Weight Measurement

Immediately after a transect had been shocked, fish were lightly anesthetized in MS-222 to facilitate handling. All fish were identified to species, and measured to the nearest 1 mm fork length (FL). Walleye, rainbow trout, brown trout (*Salmo trutta*) and black crappie (*Pomoxis nigromaculatus*) were also weighed to the nearest 1.0 g on a mechanical balance.

Stomach Content Collection

We attempted to collect stomach contents from 10 walleye and 10 rainbow trout from each transect. In addition, stomach samples were taken from all brown trout and black crappie collected. If less than 10 walleye or rainbow trout were collected on the initial pass, sampling was continued within the transect until either 10 fish of each species were collected, or it became apparent further effort would be futile. When more than 10 fish of either species were collected, stomach contents were taken from the first 10 fish weighed and measured. Fish were then placed in a fresh water tank, and allowed to revive before being released. Fish having empty stomachs were noted as such, but were not counted toward the 10 fish sample for that transect.

Stomach contents were removed via gastric lavage, and flushed onto a 500 μ mesh sieve. Hyslop (1980) presents this as the preferred method, and Meehan and Miller (1978) found lavage to be both efficient and to have no effect on survival in salmonids. Samples containing only invertebrates were fixed in 95% ethyl alcohol and later transferred to 70% ethyl alcohol (Pennak 1989). Samples with fish remains were fixed in 10% formalin. After returning to the lab, these samples were rinsed with water for approximately 3 minutes before being transferred into 70% ethyl alcohol.

To check the efficiency of the lavage, 10 walleye, 10 rainbow trout and 4 black crappie were sacrificed after having their stomachs flushed.

Habitat Utilization

After the initial pass along the transect, all walleye and rainbow trout in the holding tank were counted. This number was used in the habitat use versus availability analysis.

Laboratory Procedures

Zooplankton Density and Composition

Zooplankton samples were poured into a petri dish for identification and enumeration under a dissecting microscope. Aquatic organisms were identified to either Family or Genus (Merritt and Cummins 1988, Pennak 1989), while terrestrial organisms were identified to Order (Borror and Delong 1954). A complete count was made of all non-zooplanktonic organisms. If a sample contained less than approximately 300 zooplankters the entire sample was placed on a counting wheel where all individuals were identified and counted. Samples with more than 300 organisms were diluted to a known volume. One milliliter aliquots were removed with a Hensen-Stempel pipette until at least 150 individuals were transferred, and all organisms were identified and enumerated on the counting wheel. The number of individuals within each taxonomic group in the original sample was then estimated using the ratio of the number in the subsample volume to the volume of the original sample. The accuracy of this procedure was verified by enumerating all zooplankton in five estimated samples. All estimates were within 5 % of the actual number (Appendix A).

Additionally, 50 or 100 *Daphnia* from each sample date were measured to the nearest 0.05 mm using an ocular micrometer fitted on the dissecting microscope. *D. pulex* were measured from the top of the carapace to the base of the posterior spine (Galbraith 1967, Bulkley 1970). One hundred *Daphnia* were measured from the May, June and July samples, but low variances (Table 2) justified reducing the number for the August, September and October samples.

Table 2. Variances associated with different numbers of *D. pulex* measured from zooplankton tows collected between May and October 1992 from Cooney Reservoir, Montana.

Sample date	Sample size	Mean length (mm)	Variance (mm)
5/26/92	100	1.281	0.072
6/8/92	100	1.269	0.062
6/23/92	100	1.386	0.080
7/14/92	100	1.438	0.136
7/21/92	101	1.269	0.068
8/18/92	90	1.369	0.070
8/28/92	50	1.404	0.045
9/14/92	50	1.506	0.068
10/9/92	50	1.430	0.090
10/23/92	50	1.412	0.111

Zooplankton Availability and Utilization

Availability was defined as the number of individuals from a particular taxonomic group per cubic meter of water, and was calculated using the formula:

$$A_i = N_i / 1.075$$

where A_i is the availability of food item (i), N_i is the number of food item (i) in the sample and 1.075 is the volume of water (m^3) sampled by a 0.37 m diameter net drawn through 10 m of water.

The mean size of *Daphnia* present in the plankton tows was compared to those in stomach samples using a two sample "*t*" test, with significance assumed at $P \leq 0.05$. Because zooplankter size in the tows differed significantly between sample dates (Appendix B), separate tests were run for each date.

Utilization was defined in two ways. Intrerspecific utilization was the proportion of each zooplankter in the fish diet, and intraspecific utilization was the difference between the mean size of each taxa in the diet and in the reservoir.

Stomach Content Analysis

Stomach samples were examined under a dissecting microscope. All non-zooplanktonic organisms were identified and counted. Zooplankters were either completely enumerated or their numbers were estimated using the procedure previously described. When intact *D. pulex* were present, an ocular micrometer was used to measure 10 individuals from each stomach to the nearest 0.05 mm as described above.

After being separated, each taxonomic group was weighed to the nearest 0.001 g on an electronic balance, and its volume measured by liquid displacement. Groups with volumes less than 1 mL were immersed in 9 mL of alcohol and measured to the nearest 0.01 mL. Larger samples were immersed in 50 mL of alcohol and measured to the nearest 0.1 mL. Weight and volume of crustacean zooplankton and insect samples less than 0.001 g and 0.01 mL, respectively, were estimated via regression (Appendix C).

Walleye, rainbow trout and black crappie diets were compared by graphing the average percent contribution by weight of each food group in each sample. Volumetric measurements were not used because they lacked the necessary accuracy for analysis of these small samples.

Numeric Analysis

Diet Overlap, Electivity and Importance Indices

Diet overlap was calculated using the equation proposed by Schoener (1970), and reported to be the most appropriate available by Wallace (1981) and Martin (1984). This measure is defined as:

$$\alpha = 1 - 0.5\ (\Sigma|px_i - py_i|)$$

where px_i is the proportion of food item (i) in the diet of species (x) and py_i is the proportion of food item (i) in the diet of species (y) (Wallace 1981).

Electivity was assessed with the Linear Food Selection Index (Strauss 1979). This index overcomes the shortcomings of the more widely used Index of Electivity (Ivlev 1961) in that its variance is defined in such a manner as to allow statistical comparisons between two calculated values or a calculated value and a null hypothesis (Strauss 1979). This index is defined as:

$$L = r_i - p_i$$

where r_i is the abundance of food item (i) in the gut and p_i is the abundance of food item (i) in the habitat (expressed as percentages) (Strauss 1979). Selection (positive or negative) was assumed for values greater than $|\pm 0.10|$ (Kohler and Ney 1982).

The importance of each food category was determined using the Absolute Importance Index (AI) and the Relative Importance Index (RI) (George and Hadley 1979). These indices are defined as:

$$AI = \%\ \text{frequency occurrence} + \%\ \text{total number} + \%\ \text{total weight}$$

$$RI = 100(AI/\Sigma AI).$$

These indices were chosen because they consider both size and number of prey simultaneously. Numerical analysis alone overestimates the importance of large numbers of small food items, which contribute relatively little to the total amount of food ingested (Wallace 1981). Analysis based solely on weight has been criticized for overemphasizing the importance of single, large food items (Hellawell and Able 1971, George and Hadley 1979).

Habitat Utilization

Habitat utilization for both species was determined for the entire study period. Walleye use was also determined for the time periods before and after a major diet shift. Use versus availability was calculated by the method described in Byers et al. (1984) using the computer program HABUSE. Statistical significance was assumed at $P \leq 0.05$.

Walleye Spawning Activity

Locating Walleye Spawning Areas

On April 16 - 18 and April 24 - 25, 1993, electrofishing and trap nets were used to locate walleye spawning areas. Effort was concentrated in the tributaries, but several main lake areas were also sampled. Main lake areas included the dam face, where walleye have attempted to spawn in the past (M Poore, MDFWP Fisheries Biologist personal communication), and other areas with suitable substrate and wave action.

On the nights of April 16 and 17 a trap net was placed in Red Lodge Creek in the pool below the first riffle, approximately 500 m upstream from the reservoir. The trap lead was pulled diagonally downstream to the opposite bank, effectively blocking the entire stream. An attempt was made to place a similar trap net in Willow Creek, but a large beaver (*Castor canadensis*) dam, approximately 100 m upstream from the reservoir, prevented upstream travel. A trap net was not placed below the beaver dam because of channel depth, substrate composition and the absence of appreciable flow this close to the reservoir. High flow made netting in Red Lodge Creek impossible on April 24 - 25.