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.

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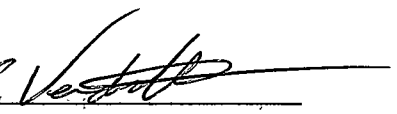
Signature 

Date 9/30/94

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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,

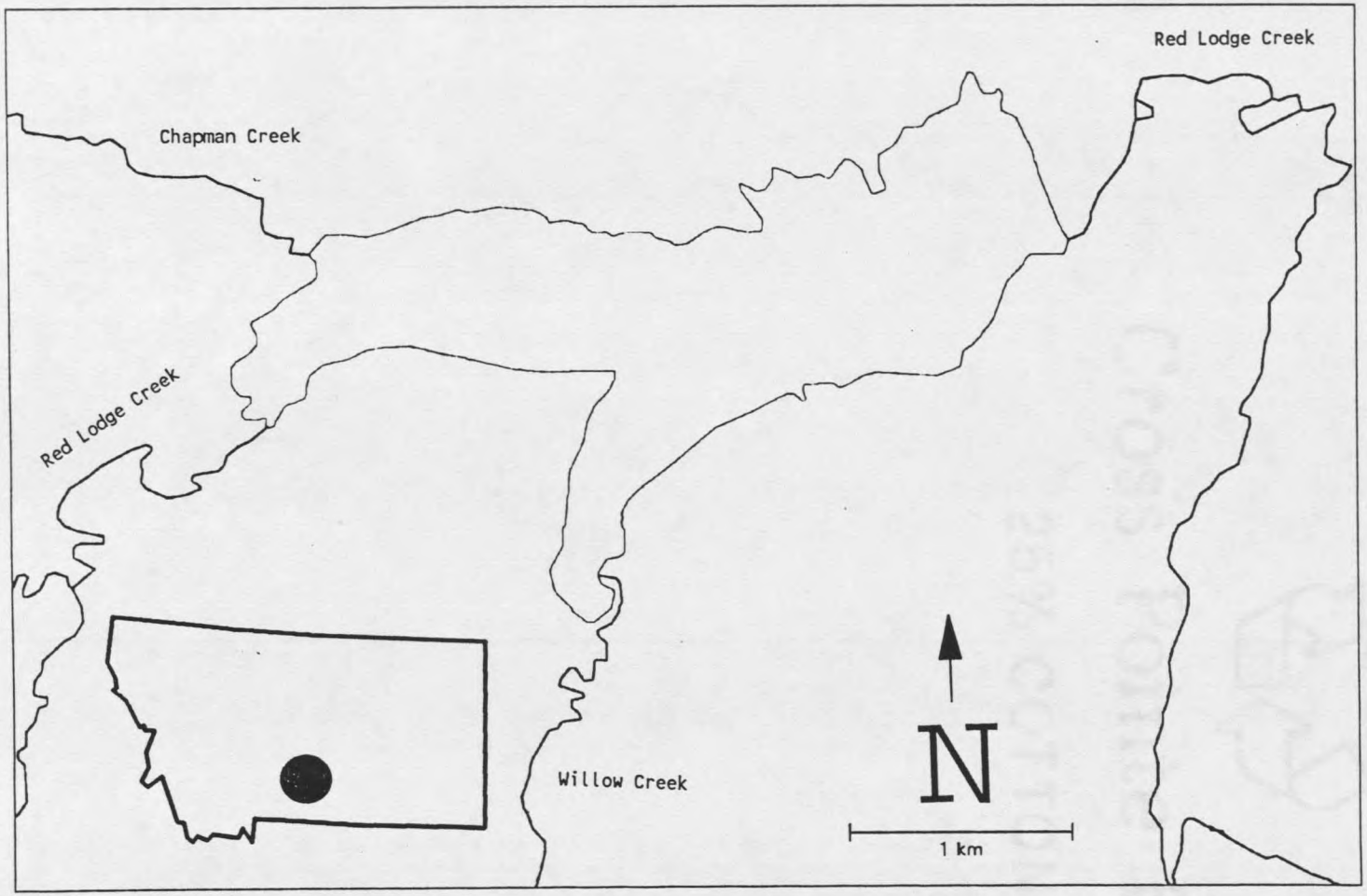

Figure 1. Location of Cooney Reservoir and major tributaries.

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.

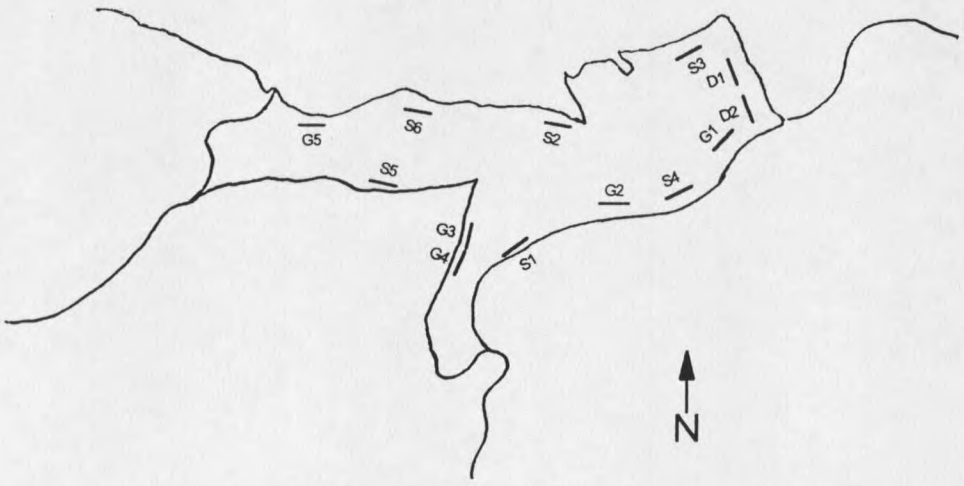

Figure 2. Location of transects sampled at Cooney Reservoir in 1992. D: dam face, S: sand, G: gravel.

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, electro-fishing 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.

The main lake areas and Red Lodge Creek were electrofished in an attempt to locate concentrations of ripe walleye during both sample periods. During the first period shocking on Red Lodge Creek was halted approximately 50 m below the trap net, but during the second period shocking continued to the upstream limit of boat travel.

Walleye collected during the spawning evaluation were measured to the nearest 1 mm FL and weighed to the nearest 1.0 g. Sex and spawning condition were also determined for adults. When a concentration of adult walleye was located, we returned the following day to search for walleye eggs. When concentrations were found in the main lake, the area was snorkeled to visually locate eggs. Because of high turbidity in Red Lodge Creek, substrate samples were collected with a 0.5 mm sieve and examined for eggs.

Egg Identification

Approximately 20 fish eggs collected from substrate samples in Red Lodge Creek were preserved in ethanol and returned to the lab. Additionally, eggs were removed from a white sucker present in Red Lodge Creek at the time of sampling. Characteristics described in Holland-Bartels et al. (1990) along with the eggs collected from the sucker were used to differentiate walleye and white sucker eggs.

Larval Fish Tows

Eight larval fish tows were made on June 1, 1993. The sampler consisted of two 0.5 m diameter frame nets with 500 μ mesh cod ends. After being suspended at the desired depth, the sampler was towed approximately 100 m behind the boat for 10 minutes. Five samples were taken at 1 m, two at 2 m and one at 2.5 m depth. Materials from both nets were combined to provide a single sample for that depth. Samples were preserved in 90 % ethyl alcohol.

Larval Fish Detection and Identification

Material from larval fish tows was examined with a hand lens to separate larval fish from zooplankters. A small amount of material was poured into an enamel pan, examined and any larval fish present were placed in 70% ethyl alcohol. This procedure was repeated until the entire sample had been examined.

RESULTS

Fish and Zooplankton Communities

Number, Length and Weight of Fish

Length and/or weight measurements were taken on 1,233 fish of seven species (Table 3, Figures 3 - 5). Rainbow trout were the most commonly collected species (n = 587), and had a mean length of 211 mm (range 122 - 395 mm). Visual inspection of rainbow trout length frequency (Figure 3), suggested the presence of three year classes in the reservoir. Also collected were 292 walleye, ranging from 90 - 566 mm (mean 204 mm). Length frequency of the walleye (Figure 4) indicate they were mainly fish from the past three stockings. Most walleye collected were between 160 and 260 mm, and only 11 were larger than 300 mm (Figure 4). White suckers (n = 316) represented the second most abundant species collected, and ranged in length from 188 - 480 mm (mean 281 mm) (Figure 5). In addition, 26 black crappie, 6 longnose suckers (*Catostomus catostomus*), 5 brown trout and 1 mountain whitefish (*Prosopium williamsoni*) were collected (Table 3).

Table 3. Number, mean length (sd), mean weight (sd) and ranges for fish species found in Cooney Reservoir, Montana in 1992. Values not available designated by N/A.

Species	Number collected	Mean length (mm)	Range (mm)	Mean weight (kg)	Range (kg)
Rainbow trout	587	211 (59.1)	122 - 395	0.2 (0.1)	0.02 - 0.72
Walleye	292	204 (55.4)	90 - 566	0.1 (0.2)	0.01 - 2.17
White sucker	316	281 (43.4)	188 - 480	N/A	N/A
Black crappie	26	119 (77.9)	33 - 228	0.1 (0.1)	0.002 - 0.21
Brown trout	5	232 (45.7)	175 - 275	0.2 (0.1)	0.06 - 0.23
Longnose sucker	6	184 (37.0)	132 - 230	N/A	N/A
Mountain whitefish	1	219 (N/A)	N/A	0.1 (N/A)	N/A

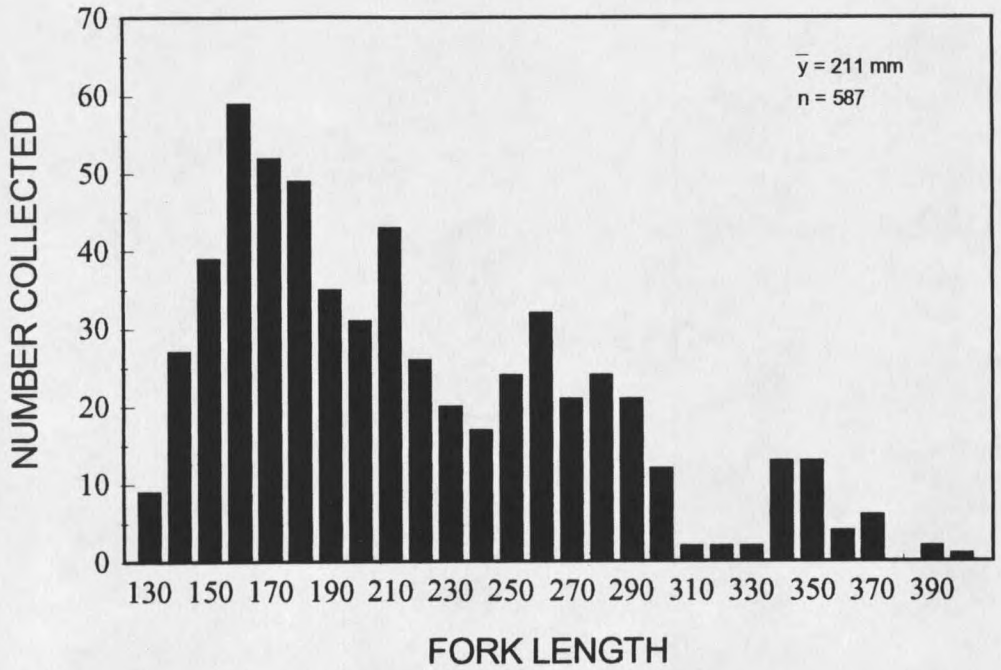

Figure 3. Length frequency of rainbow trout collected from Cooney Reservoir, Montana in 1992.

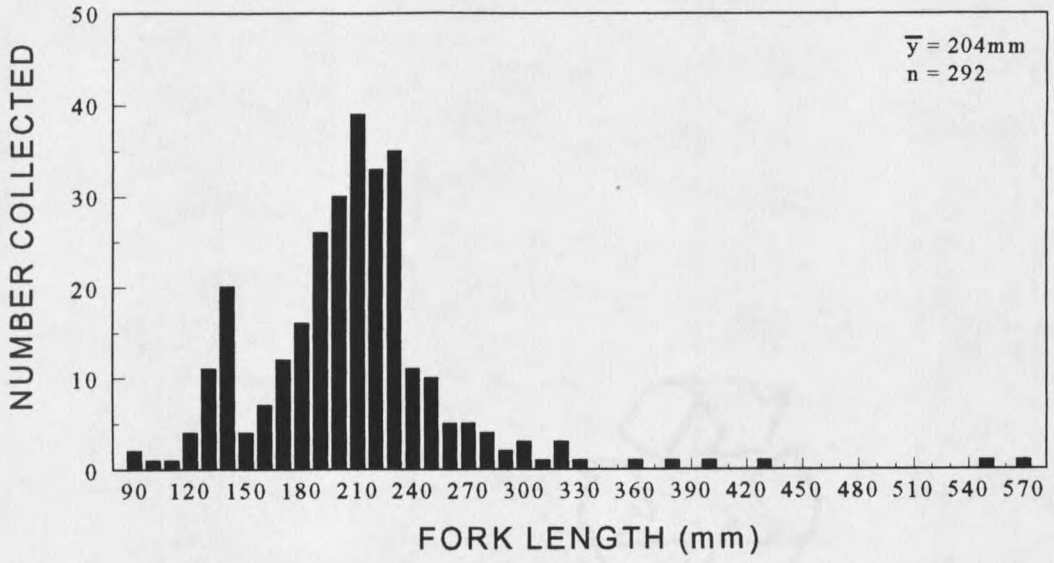

Figure 4. Length frequency of walleye collected from Cooney Reservoir, Montana in 1992.

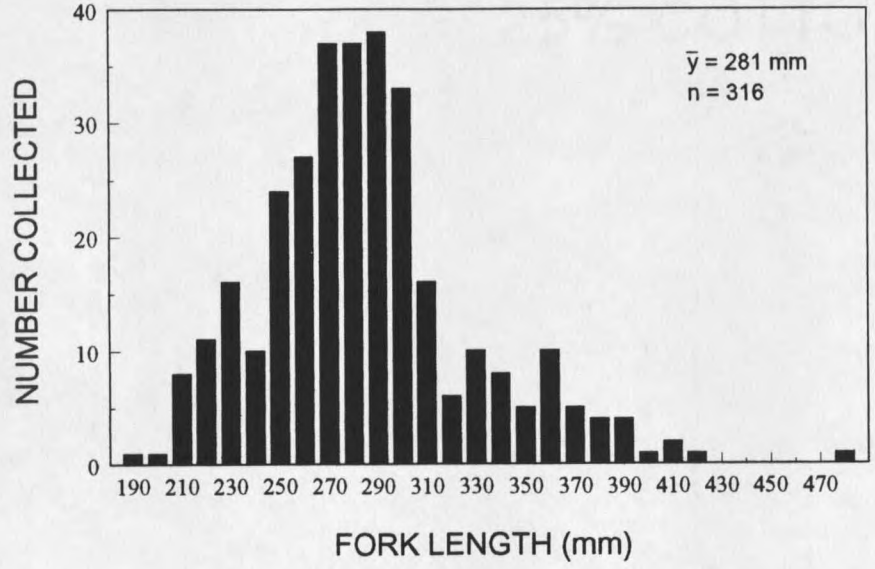

Figure 5. Length frequency of white suckers collected from Cooney Reservoir, Montana in 1992.

Zooplankton Composition and Density

Four zooplankton taxa were collected in Cooney Reservoir between April and November 1992. *Daphnia pulex* was the most abundant species in all samples, and ranged in density from approximately 53 to 908/m^3. Two other cladocerans, *Ceriodaphania laticaudata* and *Diaphanosoma brachyurum*, were also present in low densities, with *C. laticaudata* being more abundant. Both of these species reached their highest abundance late in the sampling period, after *D. pulex* density had declined (Table 4).

Copepods (*Cyclops* spp.) were the second most abundant zooplankter in all but the November 6, 1992 sample, when *C. laticaudata* was slightly more numerous. Copepod densities remained below 10/m^3 until July then increased. Copepod density peaked in September at 77.4/m^3 then declined slowly through the rest of the sample period.

Diet and Habitat Analysis

Lavage Efficiency

Gastric lavage was an effective means for removing stomach contents. Stomachs from 10 walleye (221-320 mm) and 4 black crappie (219-228 mm) sacrificed had been completely

Table 4. Zooplankton taxa, relative abundance (R.A.) and density (number/cubic meter) collected on 11 sampling dates between May and November 1992 at Cooney Reservoir Montana.

	Sample dates					
	5/26/92		6/8/92		6/23/92	
Taxa	R.A. %	Density	R.A. %	Density	R.A. %	Density
Daphnia pulix	99.8	587.0	99.3	908.2	97.4	207.1
Cyclops spp.	<0.01	0.6	<0.01	5.9	2.5	5.4
Ceriodaphnia laticaudata	<0.01	0.2	<0.01	0.1	0.0	0.0
Diaphanosoma brachyurum	0.0	0.0	0.0	0.0	0.0	0.0

	Sample dates							
	7/14/92		7/21/92		8/18/92		8/28/92	
Taxa	R.A. %	Density	R.A. %	Density	R.A. %	Density	R.A. %	Density
D. pulix	89.9	474.1	93.5	354.7	94.4	449.2	63:1	53.3
Cyclops spp.	10.1	53.2	6.5	24.8	5.5	26.3	36.7	30.9
C. Laticaudata	0.0	0.0	0.0	0.0	<0.01	0.3	0.2	0.2
D. brachyurum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	Sample dates							
	9/14/92		10/9/92		10/23/92		11/6/92	
Taxa	R.A. %	Density	R.A. %	Density	R.A. %	Density	R.A. %	Density
D. pulix	81.5	367.6	50.3	53.3	64.1	93.3	64.9	55.5
Cyclops spp.	17.2	77.4	41.1	43.6	32.2	46.8	17.0	14.5
C. laticaudata	0.7	3.2	4.8	5.1	3.3	4.8	17.8	15.2
D. brachyurum	0.6	2.9	3.8	4.0	0.3	0.5	0.4	0.4

evacuated. Stomachs of 10 trout (212-335 mm) had been fully evacuated, except for a single spider in one stomach.

Stomach Content Analysis

Analysis of 327 rainbow trout and 194 walleye stomachs showed the rainbow trout diet to be very consistent throughout the sample period, while walleye diet was variable, especially after July. Rainbow trout fed extensively on *D. pulex*, with chironomids (Order Diptera, Family Chironomidae) and various terrestrial insects making up smaller portions of their diet. Major food items in the walleye diet included chironomid larvae and pupae, mayfly nymphs (Order Ephemeroptera, Family Baetidae, *Callibaetis* spp.), crayfish (*Orconectes virilis*) and young-of-the-year (YOY) black crappie. Zooplankton (predominantly *D. pulex*) were generally present in walleye stomachs but only constituted a major portion of their diet in the September 5 - 6 and October 24 - 25 samples.

Of the four zooplankters present in the reservoir, only *D. pulex* and copepods were found in fish stomachs, with *D. pulex* being consumed in much higher numbers. The mean length of *D. pulex* in fish stomachs was significantly larger

($P < 0.05$) than *Daphina* collected in zooplankton tows (Figure 6) for all sampling dates.

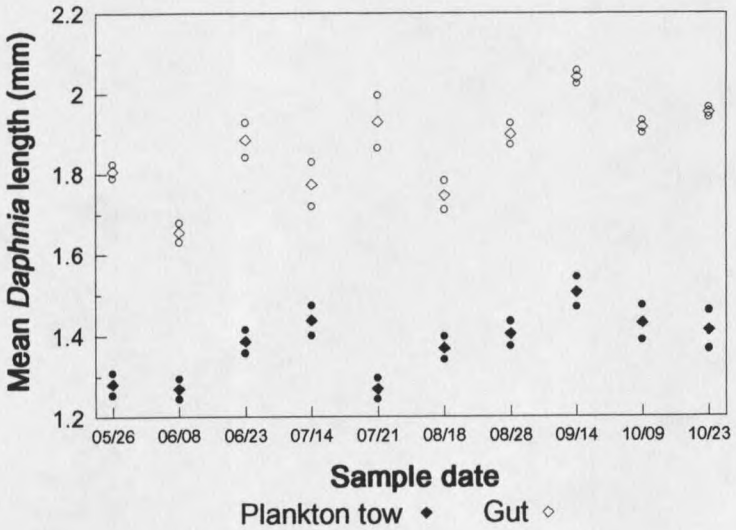

Figure 6. Average length (mm) and 95% CI of *D. pulex* in plankton tows compared to those from rainbow trout stomachs collected between May and October, 1992 from Cooney Reservoir, Montana.

On May 27 - 28, 1992, zooplankton was the dominant food of rainbow trout (n = 49; 129 - 378 mm FL), making up 68.4 % of their diet by weight (Figure 7). In addition, chironomid larvae and pupae and a small number of corixids were also consumed. Terrestrial insects (mainly Hymenoptera and Coleoptera) accounted for 8.5 % of the trout diet. The two walleye (120 - 128 mm FL) collected in this sample contained only chironomid larvae and pupae.

Rainbow trout diet (n = 18; 122 - 223 mm FL) on June 9 - 10, 1992 was 79 % zooplankton by weight. Chironomids and terrestrial insects were the second and third largest dietary components, respectively (Figure 8), with Hymenoptera and Coleoptera the most important terrestrial insects.

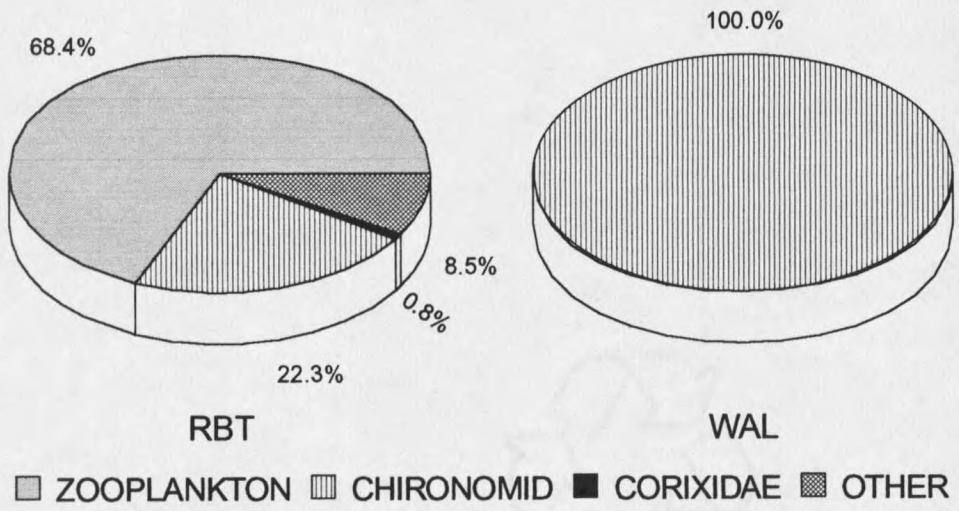

Figure 7. Average proportion by weight of food items in 49 rainbow trout (RBT) and 2 juvenile walleye (WAL) stomachs collected May 27 - 28, 1992, Cooney Reservoir, Montana.

Walleye diet on this sample date (n = 15; 126 - 203 mm FL) was more varied than the previous sample, but chironomids (larvae and pupae) were still the dominant food item, representing 69.9 % of their diet by weight (Figure 8). Other important food items included zooplankton, unidentified fish and *Callibaetis* spp. Fish were probably

more important than presented here, since bony parts were all that remained in some stomachs.

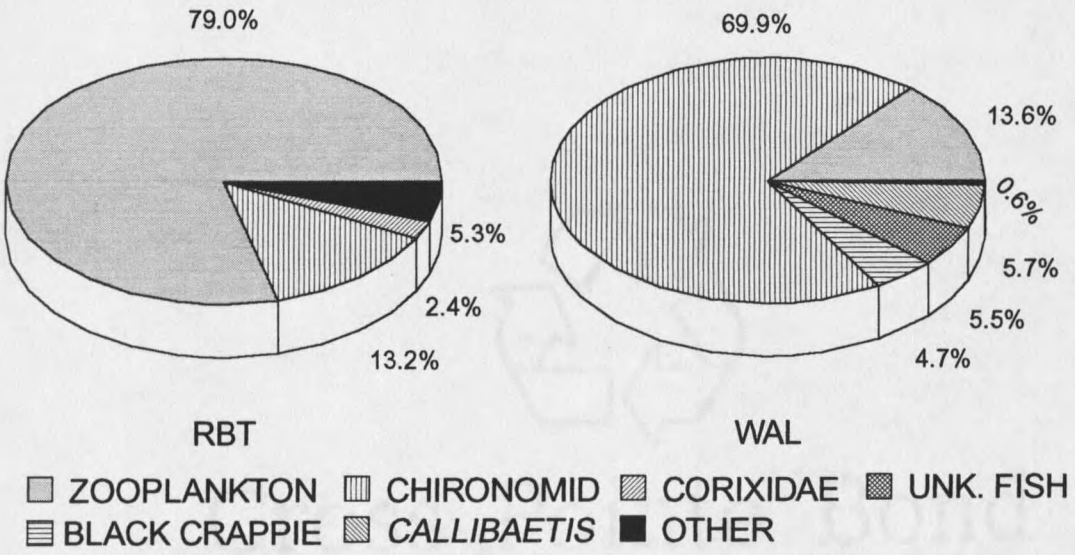

Figure 8. Average proportion by weight of food items in 18 rainbow trout (RBT) and 15 juvenile walleye (WAL) stomachs collected June 9 - 10, 1992, Cooney Reservoir, Montana.

On June 24 - 25, 1992, rainbow trout diet (n = 16; 133 - 260 mm FL) was more diverse than in earlier samples, but zooplankton remained the predominant food item (79.7 %). Other taxa consumed were chironomids, terrestrial insects, corixids, *Callibaetis* spp. and crayfish (Figure 9). Important terrestrial orders were Hymenoptera and Hemiptera.

In this sample, the walleye diet (n = 23; 126 - 203 mm FL) was dominated by chironomid larvae and pupae (46 %) and crayfish (32.6 %) (Figure 9). Zooplankton and juvenile suckers made up similar portions of the diet, and were

followed in importance by *Callibaetis* spp. (Figure 9). Several walleye stomachs contained small numbers of adult dipterans and one contained a dragonfly (Order Odonata *Lestes* spp.) nymph.

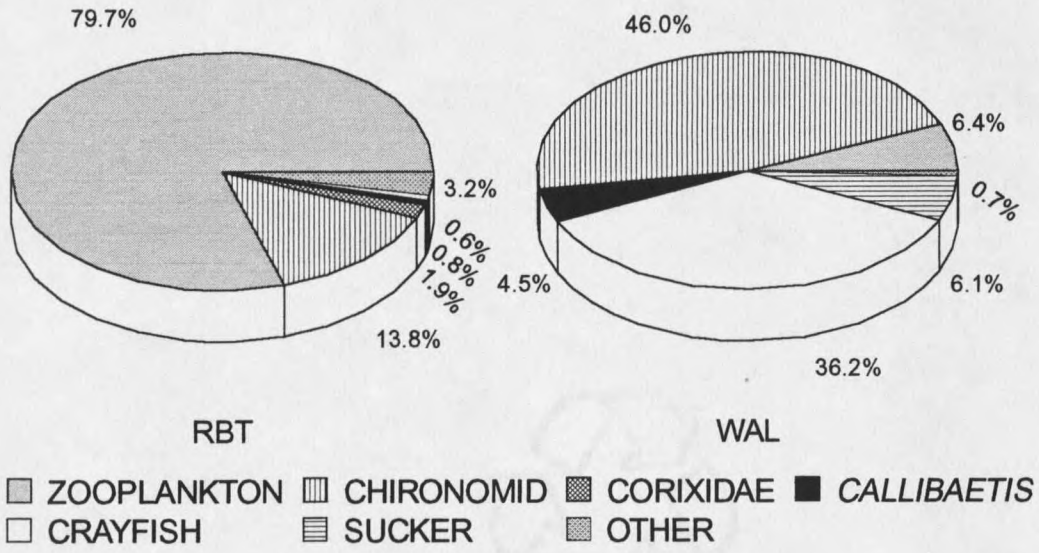

Figure 9. Average proportion by weight of food items in 16 rainbow trout (RBT) and 23 juvenile walleye (WAL) stomachs collected June 24 - 25, 1992, Cooney Reservoir, Montana.

No walleye were collected on the July 15 - 16 sample. Zooplankton was the major food item (66.7 %) in 31 rainbow trout stomachs (124 - 240 mm FL), with chironomids a distant second (Figure 10). Important terrestrial insects in this sample were Hemiptera and Hymenoptera. A few water mites (Hydracarina) were also present and were included with terrestrial insects in the "other" category.

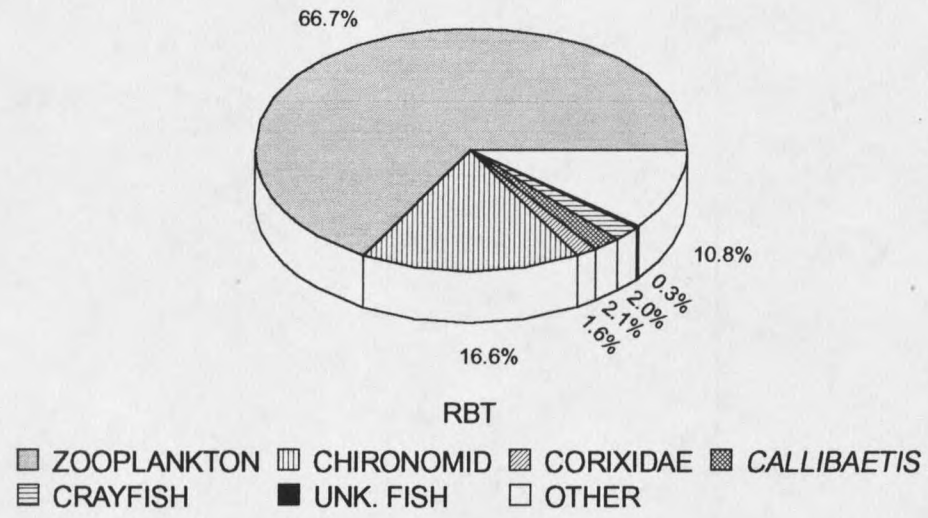

Figure 10. Average proportion by weight of food items in 31 rainbow trout (RBT) stomachs collected July 15 - 16, 1992, Cooney Reservoir, Montana.

Zooplankton made up 47.8 % of the rainbow trout diet by weight (n = 37; 124 - 317 mm FL) on July 22 - 23, and was the largest single dietary component, followed by chironomids (33.7 %). Individuals from the orders Hymenoptera and Hemiptera were important terrestrial insects in this sample (Figure 11).

Crayfish had become the dominant food of walleye (n = 33; 147 - 313 mm FL) comprising 43.9 % by weight, followed by chironomid larvae and pupae (35.5 %). Other taxa in the walleye diet were unidentified fish and *Callibaetis* spp. (Figure 11).

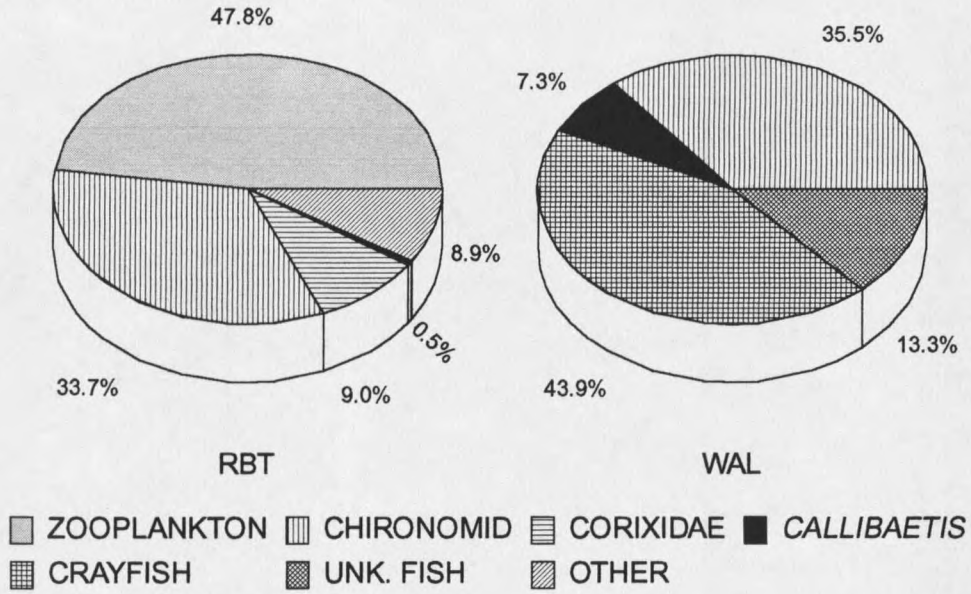

Figure 11. Average proportion by weight of food items in 37 rainbow trout and 33 juvenile walleye stomachs collected July 22 - 23, 1992, Cooney Reservoir, Montana.

The most important dietary component for rainbow trout on August 19 - 20, 1992 (n = 21; 166 - 367 mm FL) was zooplankton (48.8 %) and corixids (31.0 %) (Figure 12). This was the first sample in which chironomids were not the second largest component in the trout diet and represents a 22.8 % reduction in use from the previous sample.

The dominant food item in walleye stomachs (n = 45; 128 - 296 mm FL) during this sample period was YOY black crappie (63.1 %). The second and third most important taxa were *Callibaetis* spp. and crayfish, which were of almost equal importance. Chironomid consumption dropped to only 6 % of

the diet, a 29.5 % reduction in utilization from the previous sample (Figure 12).

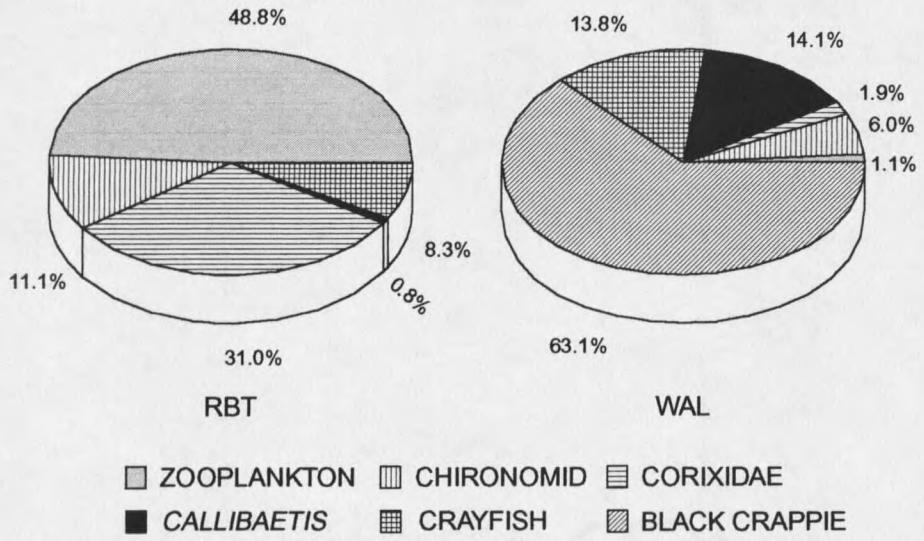

Figure 12. Average proportion by weight of food items in 21 rainbow trout (RBT) and 45 juvenile walleye stomachs (WAL) collected August 19 - 20, 1992, Cooney Reservoir, Montana.

In addition to walleye and rainbow trout, five adult black crappie were collected in this sample. Crappie diet was more similar to that of rainbow trout than to walleye. Zooplankton (mainly *D. pulex*) was the primary food item of crappie (50.1 %). Crayfish and YOY black crappie provided an additional 20.0 % each to the crappie diet (Figure 13).

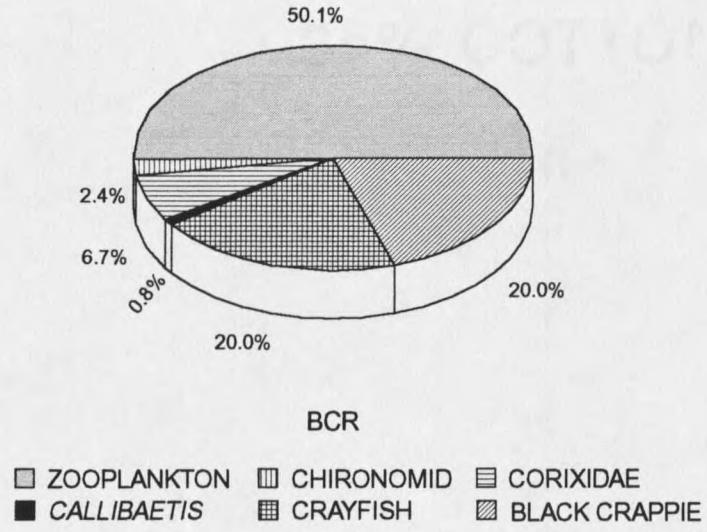

Figure 13. Average proportion by weight of food items in five black crappie (BCR) stomachs collected August 19 - 20, 1992, Cooney Reservoir, Montana.

As in previous samples, rainbow trout collected August 29 - 30, 1992 (n = 29; 135 - 363 mm FL) had fed predominantly on zooplankton. Chironomids were the second most utilized food item, but made up only 18.3 % of the diet. Corixids and terrestrial insects, mainly Hymenoptera, were of similar importance and provided slightly less than 10 % each (Figure 14).

The primary food item in the walleye diet (n = 43; 165 - 302 mm FL) was *Callibaetis* spp. (64.5 %). Chironomids and crayfish made up 11.2 % and 11.1 % of the diet, respectively. Black crappie, which were the major food item

in walleye stomachs from the previous sample, declined in importance from 63.1 to 9.5 % in this sample (Figure 14).

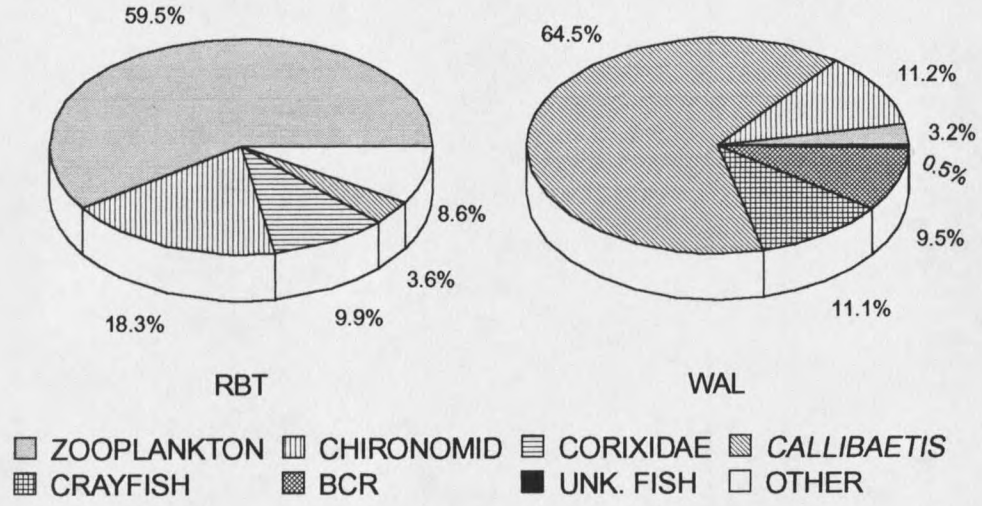

Figure 14. Average proportion by weight of food items in 29 rainbow trout (RBT) and 43 juvenile walleye (WAL) stomachs collected August 29 - 30, 1992, Cooney Reservoir, Montana.

Stomach contents of five adult black crappie collected in this sample, again more closely resembled those of rainbow trout than walleye. Zooplankton (67.7 %) was the major food of crappie, and crayfish were of secondary importance contributing 19.5 %. Chironomids, corixids and *Callibaetis* spp. were also present, but made up less than 13 % of the diet (Figure 15).

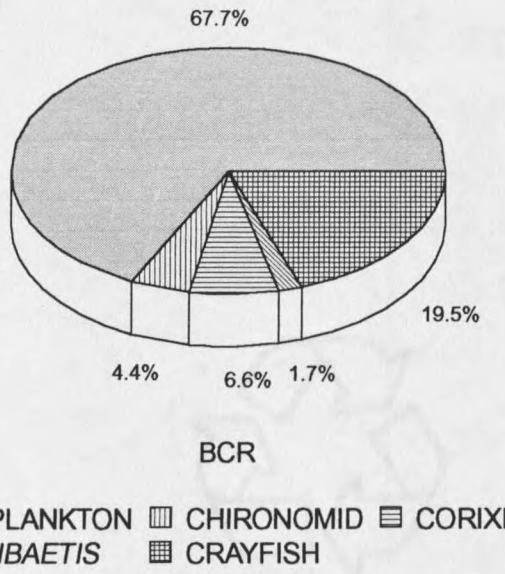

Figure 15. Average proportion by weight of food items in five black crappie (BCR) stomachs collected August 29 - 30, 1992, Cooney Reservoir, Montana.

Zooplankton increased in importance for rainbow trout (n = 34; 165 - 388 mm FL) in the September 5 - 6, 1992 sample, constituting 94.0 % of their diet. Three other taxa present in small amounts were chironomids, corixids and terrestrial insects (Figure 16).

The September 5 - 6, 1992 sample represents the only time zooplankton were the most important food source (36.8 %) in the walleye diet (n = 17; 116 - 293 mm FL). *Callibaetis* spp. and crayfish were also important, making up 25.4 and 22.6 % of the diet, respectively (Figure 16).

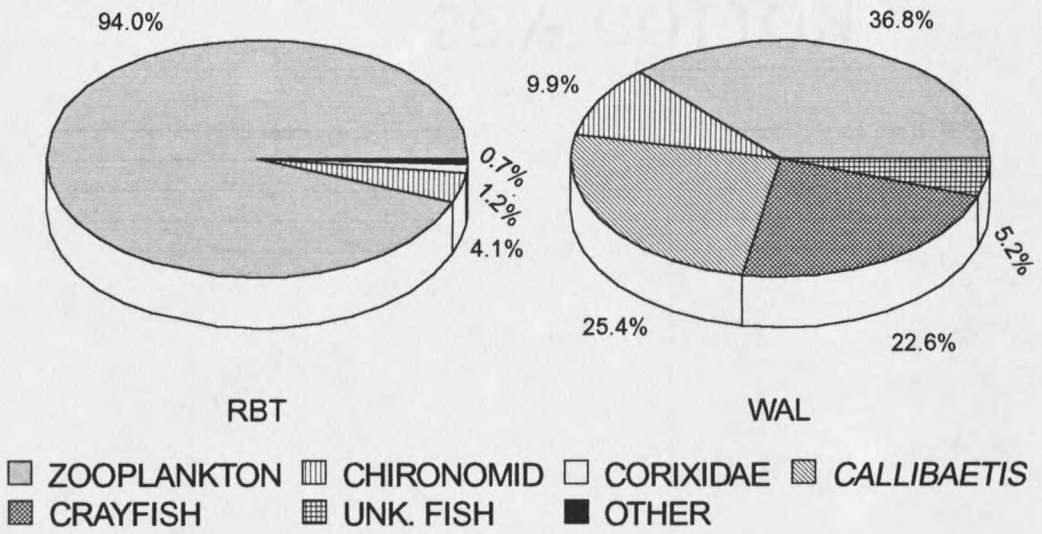

Figure 16. Average proportion by weight of food items in 34 rainbow trout (RBT) and 17 juvenile walleye (WAL) stomachs collected September 5 - 6, 1992, Cooney Reservoir, Montana.

Rainbow trout dependence on zooplankton (n = 44; 199 - 395 mm FL) was highest in the October 10 - 11, 1992 sample, making up 97.8 % of their diet (Figure 17). Terrestrial insects, from the orders Coleoptera, Hemiptera and Trichoptera, were next in importance, but accounted for only 1.2 % of the diet.

The primary food of walleye from the October 10 - 11, 1992 sample (n = 10; 90 - 266 mm FL) was *Callibaetis* spp. (67.4 %) (Figure 17). Two other groups, unidentified fish and zooplankton, were also major contributors at 18.0 and 13.1 %, respectively.

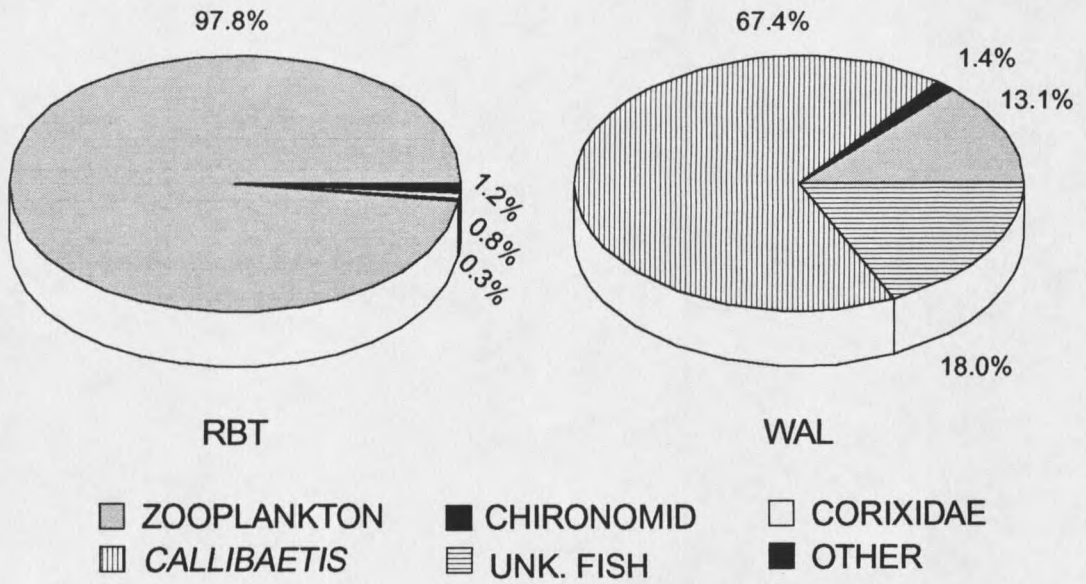

Figure 17. Average proportion by weight of food items in 44 rainbow trout (RBT) and 10 juvenile walleye (WAL) stomachs collected October 10 - 11, 1992, Cooney Reservoir, Montana.

In the October 24 - 25, 1992 sample, zooplankton again made up almost the entire rainbow trout (n = 48; 176 - 385 mm FL) diet (96.1 %). Also present in small quantities were crayfish, corixids and chironomids (Figure 18).

Walleye diet in this sample (n = 6; 90 - 250 mm FL) was almost evenly split between four food groups. Young suckers made up the largest portion of the diet (26.9 %) followed by *Callibaetis* spp., zooplankton and unidentified fish (Figure 18). The importance of the "other" food category (16.7 %) is overestimated since it represents the gut contents of a

single walleye, which contained almost 4.8 g of fish viscera.

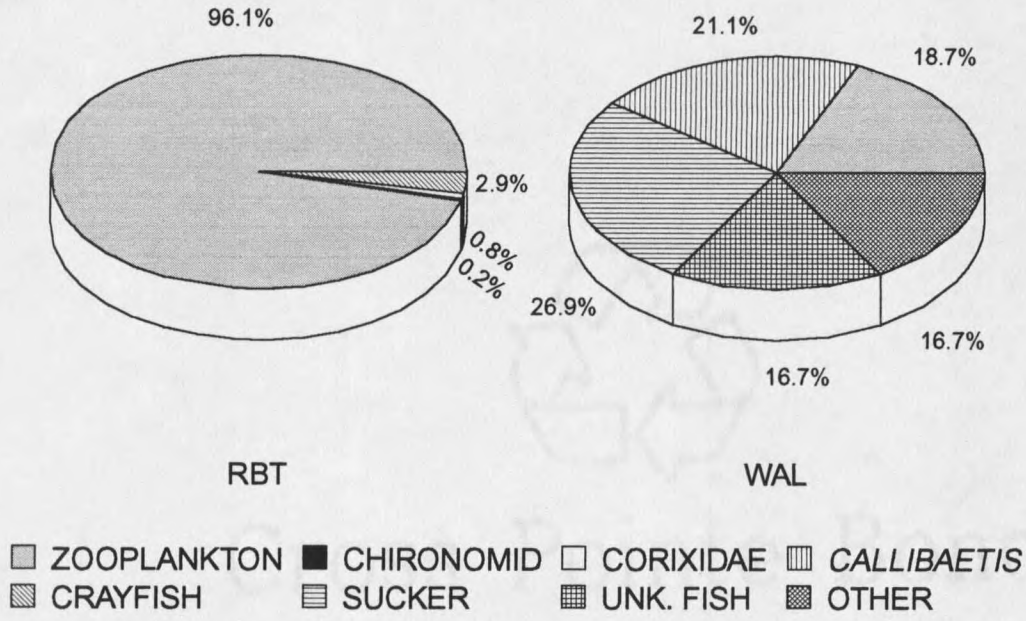

Figure 18. Average proportion by weight of food items in 48 rainbow trout (RBT) and 6 juvenile walleye (WAL) stomach collected October 24 - 25, 1992, Cooney Reservoir, Montana.

Diet Overlap, Electivity and Importance Indices

Diet overlap between rainbow trout and juvenile walleye, as measured by the Schoener Index, existed throughout the sample period, but at levels not considered "biologically significant". Significant overlap has been assumed for index values of 60 or greater (Zaret and Rand 1971, Mather 1977, Martin 1984, Glova and Sagar 1991). The mean index value of 30.1 was significantly less than 60

(t = 7.41 P < 0.0001). Overlap values ranged from 13.4 on October 9 - 11, 1992 to 41.0 on September 4 - 6, 1992 (Table 5).

Table 5. Schoener overlap index values for the diets of walleye (WAL) and rainbow trout (RBT); walleye and black crappie (BCR); and rainbow trout and black crappie collected in Cooney Reservoir, Montana between May and October, 1992.

Date	WAL / RBT	WAL / BCR	RBT / BCR
05/26/92	22.3		
06/08/92	27.1		
06/23/92	22.3		
07/21/92	34.4		
08/18/92	23.3	41.8	66.4
08/28/92	22.3	20.5	76.6
09/04/92	41.0		
10/09/92	13.4		
10/23/92	34.1		

Rainbow trout did not feed selectively until late in the sample period (Table 6). Rainbow trout consumed *D. pulex* and copepods in proportion to their availability through the August 18 sample. Electivity values for *Daphnia* increased sharply from + 0.05 to + 0.37 between August 18 and August 28, and remained greater than $|\pm 0.10|$ in subsequent samples. Although copepods reached their highest densities during this period (Table 4) they were selected against by rainbow trout.

Results from the Relative Importance Index (Table 7) were similar to those in the graphical analysis of diet (Figures 7 - 18). Zooplankton was the most important food for rainbow trout on all sampling dates, and was generally more than twice as important as the second ranking item. Important food items for walleye varied over time. Chironomids were the most important prey item in all samples through July, but later no category dominated consecutive samples.

Table 6. Rainbow trout electivity (SD) for zooplankters in Cooney Reservoir, Montana on 10 sampling dates between May and October, 1992.

	Rainbow trout electivity			
Date	*Daphnia*	Copepod	*Ceriodaphnia*	*Diaphanosoma*
05/26/92	+ 0.00 (0.0003)	- 0.00 (0.0003)	- 0.00 (0.0001)	--
06/08/92	+ 0.01 (0.0006)	- 0.01 (0.0006)	- 0.00 (0.0001)	--
06/23/92	+ 0.02 (0.0026)	- 0.02 (0.0026)	--	--
07/14/92	+ 0.09 (0.0034)	- 0.09 (0.0034)	--	--
07/21/92	+ 0.05 (0.0032)	- 0.05 (0.0032)	--	--
08/18/92	+ 0.05 (0.0025)	- 0.05 (0.0025)	- 0.00 (0.0001)	--
08/28/92	+ 0.37 (0.0131)	- 0.37 (0.0131)	- 0.00 (0.0013)	--
09/04/92	+ 0.18 (0.0045)	- 0.17 (0.0044)	- 0.00 (0.0008)	- 0.00 (0.0008)
10/09/92	+ 0.50 (0.0121)	- 0.41 (0.0119)	- 0.05 (0.0052)	- 0.04 (0.0046)
10/23/92	+ 0.36 (0.0099)	- 0.32 (0.0097)	- 0.03 (0.0037)	- 0.00 (0.0012)

Table 7. Relative Importance Index values for all prey groups found in rainbow trout (RBT) and walleye (WAL) stomachs collected from Cooney Reservoir, Montana between May and October, 1992. Food catagories not found in stomach samples designated by NF.

	Sample dates									
RBT prey	5/26	6/8	6/23	7/14	7/21	8/18	8/28	9/4	10/9	10/23
Zooplankton	56.7	57.4	60.2	58.3	46.9	48.9	44.1	62.4	79.4	82.1
Chironomid	27.6	22.6	24.8	21.1	30.1	16.7	24.0	19.0	5.5	7.7
Corixidae	4.2	6.8	8.5	3.4	12.1	24.7	15.2	7.8	5.7	5.5
Callibaetis	NF	NF	2.8	2.8	1.3	4.5	5.5	3.8	1.8	1.2
Crayfish	NF	NF	2.9	1.2	0.6	5.2	NF	NF	NF	3.4
Unk. fish	NF	NF	NF	0.8	NF	NF	NF	NF	NF	NF
Other	11.5	13.2	0.7	12.4	9.0	NF	11.1	7.0	7.6	NF

	Sample dates									
WAL prey	5/26	6/8	6/23	7/14*	7/21	8/18	8/28	9/4	10/9	10/23
Zooplankton	NF	26.4	13.6	--	1.7	1.6	6.9	43.2	21.0	24.9
Chironomid	100.0	54.4	36.2	--	36.7	13.1	11.7	12.2	4.2	NF
Corixidae	NF	NF	NF	--	NF	1.4	NF	NF	NF	NF
Callibaetis	NF	3.6	12.2	--	14.5	14.9	63.0	23.5	60.2	21.8
Crayfish	NF	NF	27.1	--	35.0	13.6	9.4	16.4	NF	NF
Crappie	NF	2.9	1.2	--	NF	50.9	7.4	NF	NF	NF
Sucker	NF	1.5	4.4	--	NF	NF	NF	NF	NF	23.3
Unk. fish	NF	5.7	2.1	--	12.2	2.3	0.9	4.6	14.6	15.0
Other	NF	5.5	3.2	--	NF	2.2	0.8	NF	NF	15.0

* No walleye collected in this sample

Habitat Utilization

When habitat utilization data for the entire sample period were pooled, only walleye displayed any significant habitat preference (Table 8). Walleye used sand and gravel substrates evenly, but selected against the dam face ($P < 0.001$). Rainbow trout used all three habitat types in proportion to their availability ($P = 0.7753$) (Table 8).

When the sample period was separated into early (May - July) and late (August - October) segments, to test if walleye habitat utilization changed along with their chironomid utilization, some additional habitat preferences became apparent.

During the early segment, while walleye were relying heavily on chironomids, they selected for areas of sand substrate ($P < 0.001$), avoided the dam face ($P < 0.001$), and neither selected for nor avoided gravel substrates ($P > 0.1$) (Table 9). During the late segment of the sample, after chironomid importance in the diet dropped, walleye began using all three habitat types equally ($P = 0.2299$) (Table 9).

Table 8. Habitat utilization of walleye and rainbow trout between May and October 1992 in Cooney Reservoir, Montana.

Species	Habitat	No. collected	Observed %	95 % CI	Expected %
Walleye	Sand	118	0.476	0.344 - 0.607	0.400
	Gravel	102	0.411	0.282 - 0.541	0.400
	Dam face	28*	0.113	0.030 - 0.196	0.200
Rainbow trout	Sand	170	0.413	0.355 - 0.471	0.400
	Gravel	165	0.400	0.343 - 0.548	0.400
	Dam face	77	0.187	0.141 - 0.233	0.200

* Statistically significant avoidance ($P < 0.001$)

Table 9. Habitat utilization of walleye between May and July (Early) and August and October, 1992 (Late) in Cooney Reservoir, Montana.

Period	Habitat	No. collected	Observed %	95 % CI	Expected %
Early	Sand	62#	0.620	0.419 - 0.821	0.400
	Gravel	35	0.350	0.152 - 0.548	0.400
	Dam face	3*	0.030	0.000 - 0.101	0.200
Late	Sand	54	0.375	0.278 - 0.472	0.400
	Gravel	67	0.465	0.366 - 0.565	0.400
	Dam face	23	0.160	0.087 - 0.233	0.200

Statistically significant selection ($P < 0.001$)
* Statistically significant avoidance ($P < 0.001$)

Walleye Spawning

Locating Walleye Spawning Areas

No concentrations of spawning walleye were found within the reservoir. Five ripe males were collected along one 50 m section of the southern shoreline, but no eggs were found when the area was snorkeled the following afternoon. Solitary ripe males were also collected from other locations around the reservoir, but these were generally small

individuals, with the exception of a single 520 mm male collected near the mouth of Chapman Creek.

There was extensive use of Red Lodge Creek by adults of both sexes (Tables 10 and 11). On April 17, 1993 electrofishing yielded five gravid females within the first 100 m of stream above the reservoir and three ripe and three gravid females between 100 and 800 m upstream. (Table 10).

Trap netting on the night of April 16, 1993 (Table 11) yielded six walleye, including one ripe female, one gravid female, three ripe males and one subadult. Also, 102 white suckers, three longnose suckers and two rainbow trout were collected.

Nine walleye were captured in a trap net on the night of April 17, 1993 (Table 11). These included two ripe males, one gravid female and six small individuals that were probably young males. Eighty-two white suckers, two longnose suckers and two rainbow trout were also trapped.

Electrofishing Red Lodge Creek on April 24 - 25, 1993 (Table 10) showed continued use by walleye, but no gravid females were found near the mouth. Shocking in the first 300 m upstream from the mouth resulted in the collection of only one ripe male. From 300 m upstream to the upper limit of boat travel 20 additional walleye, all ripe males, were collected. At least 10 additional walleye were seen in the

last 50 m of shocking, but escaped collection due to swift current and high turbidity. On both dates the largest concentrations of walleye were in riffle areas at or near the upper limit of boat travel.

Table 10. Number and mean length (range) of walleye collected by electrofishing in Red Lodge Creek in April, 1993 for assessment of walleye spawning activity in Cooney Reservoir.

Date	Gravid females	Mean length (range) mm	Ripe females	Mean length (range) mm	Ripe males	Mean length (range) mm
4/17/93	8	577 (380 - 617)	3	612 (602 - 624)	0	--
4/24/93	0	--	0	--	10	495 (279 - 556)
4/25/93	0	--	0	--	11	529 (504 - 565)

Table 11. Number and mean length (range) of walleye collected in trap nets in Red Lodge Creek April 16 - 18, 1993 for assessment of walleye spawning activity in Cooney Reservoir.

Date	Gravid females	Length mm	Ripe females	Length mm	Ripe Males	Mean length (range) mm	Sub-adults	Mean length (range) mm
4/16-17	1	498	1	610	3	507 (485 - 583)	1	286
4/17-18	1	495	0	--	2	430 (339 - 520)	6	280 (269 - 293)

Egg Identification

Eggs collected from Red Lodge Creek in April, 1993 were identified as walleye eggs based on color and oil globule characteristics as described in Holland-Bartles et al. (1990). Also, the mean size of 1.94 mm (range 1.6 - 2.2 mm) for the 15 eggs was well within the range of 1.8 - 2.1 mm

given in Holland-Bartles et al. (1990). Additional circumstantial evidence supporting this identification include a strong resemblance to eggs extruded from ripe walleye in the field, and the fact that no ripe white suckers (the only other numerically abundant species present in the stream) were collected by either electrofishing or trap netting.

Larval Fish Identification

Twenty larval walleye were collected in the eight tows made in June, 1993. Identification was based on the presence of an anterior oil globule and pigmentation patterns, which can differentiate walleye and white suckers (Holland-Bartels et al. 1990).

DISCUSSION

Reservoir Community

Length and Weight Measurement

The mean lengths of rainbow trout, walleye and white suckers collected in this study were smaller than those reported by Poore and Frazer (1990), probably due to differences in sample timing and gear used. This study was conducted over a longer time period, so rainbow trout measurements were affected by midsummer stockings of small (17.8 - 20.3 cm) trout. The MDFWP studies were conducted in early spring and fall, and consisted of fish stocked the previous year or which had several months to grow before being sampled. Gear bias was probably responsible for the differences in the size of walleye collected in the two studies. Electrofishing shallow areas proved ineffective for collecting adults, but well suited to collecting juveniles, which were the target of this study. Gill nets used by MDFWP appear more effective for sampling adult walleye than juveniles.

The introduction of walleye into Cooney Reservoir appears to be having the desired effect on the white sucker population. The proportion of white suckers less than 30 cm has been declining since 1987 (Fredenberg and Poore 1987, Fredenberg and Poore 1989, Poore and Frazer 1990). The smallest white sucker collected in this study was 188 mm, and was probably from the 1990 year class based on growth rates for these fish in Montana (Brown 1971). This implies white suckers have not recruited successfully since 1990. Walleye are believed responsible for this decline in the sucker population since suckers are spawning successfully (Poore and Frazer 1990). I also observed sucker fry along the shoreline during this study, and young suckers were present in walleye stomachs indicating a successful sucker spawn in 1992.

Zooplankton Composition and Density

The littoral zooplankton community is made up of just three cladoceran species and a single copepod genera and appears rather impoverished, especially with two of the three cladocerans found at very low densities. Pennak (1989) states that two or more cladoceran species of the same genus are usually found together in littoral areas, and copepod communities in littoral areas are also "richer" in

variety than the typical limnetic community, which is generally dominated by a single species of each order.

The littoral zooplankton community in Cooney Reservoir strongly resembles the "typical" limnetic community. At least two factors may be contributing to this. First, there is no littoral vegetation or other shoreline structure to provide shelter for near-shore species. Second, the frequent, strong winds may result in enough mixing to prevent the establishment of a littoral zooplankton community.

Diet and Habitat Analysis

Zooplankton Utilization

Zooplankton utilization by rainbow trout and juvenile walleye in Cooney Reservoir is probably associated with the size and abundance of available species. *D. pulex* was the largest, most abundant and most utilized zooplankter, with copepods ranking second in size, numbers and use. The other two cladoceran species were not found in stomach samples. Considering the low densities of *C. laticaudata* and *D. brachyurum* in the reservoir, a fish would rarely encounter them, and few of those encountered would be eaten by fish selectively feeding on larger zooplankters.

Size-selective feeding on zooplankton is well documented for many fish species. Young walleye have been shown to select for larger zooplankters as they grow (Mathias and Li 1982, Raisanen and Applegate 1983, Graham and Sprules 1992), which is believed to be a mechanism to maximize growth (Graham and Sprules 1992). Rainbow trout have also been shown to crop the largest available zooplankters (Wurtsbaugh et al. 1975). Size-selective zooplankton predation has also been described in largemouth bass (*Micropterus salmoides*) (Miller and Kramer 1971), blueback herring (*Alosa aestivalis*) (Davis and Foltz 1991), yellow perch (*Perca flavescens*), freshwater drum (*Aplodinotus grunniens*), black crappie (Schael et al. 1991) and many other fish species.

Diet Analysis

Results of the graphical and Relative Importance Index (RI) methods of diet analysis were similar. Concurrence was highest for food categories providing 10 % or more of the diet by weight. Similarity decreased with decreased utilization, and was especially poor for those providing less than 1 or 2 % of the bulk of the diet. This was expected due to the RI's inclusion of the frequency of occurrence and the percentage of the total number of prey

items consumed for each prey type. Reliance on numerical counts in dietary analysis has been recognized to overestimate the importance of frequently occurring small food items, which add little to the total caloric intake (Hyslop 1980, Wallace 1981).

Overestimation of the importance of lesser used food categories is an inherent characteristic of the RI. Despite this limitation it is still useful in diet analysis. Martin (1984) suggests using multiple indices whenever possible since none is without criticism. An advantage of the two methods used here is each avoids the criticisms of the other.

Percentage of the diet by weight was used in the graphical analysis because it was believed to be the most appropriate criterion of dietary importance measured, and the method Wallace (1980) found least objectional. The main criticism of this type of analysis is it overestimates the importance of a small number of large food items (Hellawell and Able 1971, George and Hadley 1979, Wallace 1981). However, the nature of the prey consumed by fish in this study minimized the effect of large food items. Every food item utilized throughout the study was either a small species (chironomids or *Callibaetis*) or was an early life

stage of larger species such as crayfish or YOY black crappie.

These two analyses agree on the items of major importance for both species in almost all samples. Both techniques identified the same food categories as being of primary and secondary importance to rainbow trout in all samples. On one occasion each, the items of primary and secondary, and secondary and tertiary importance for walleye were transposed. The difference between the two largest fractions of the walleye diet by weight was 8.4 % and 4.9 % on July 21 and October 9, respectively. On July 21 the transposed groups were chironomids and crayfish, and on October 9 the groups were zooplankton and unknown fish. In each case the RI placed greater importance on the smaller prey item which was found in greater numbers, but did not provide as much to the total bulk of the diet.

On October 23, walleye diet was almost evenly split between five categories, and there was no agreement on the order of the three most important groups. Because the diet was so evenly divided it is doubtful any two methods of analysis would result in agreement. However, when suckers and unknown fish were combined, both methods identify fish as the most important food item in the walleye diet.

Rainbow Trout Diet Composition

Most descriptions of rainbow trout diet in lentic systems indicate heavy reliance on insects (terrestrial and aquatic) and zooplankton, although other food items can be important in some cases. Rainbow trout diet in this study was very similar to that described by Tabor and Wurtsbaugh (1991) who found *Daphnia* spp. made up 99 and 96 % of the trout diet volume in two Utah reservoirs. In Castle Lake, California, rainbow trout diets have been shown to contain zooplankton, terrestrial insects and benthic organisms in the following percentages (by volume): 15, 15 and 70 % (Wurtsbaugh et al. 1975); and 33, 45 and 22 % (Swift 1970). In another Castle Lake study, Wales (1946) found zooplankton provided 23 % of the rainbow trout diet through age 2, but in older fish, utilization fell to less than 4 %.

In Arlee strain rainbow trout (the strain stocked into Cooney Reservoir), Hensler (1987) found *D. pulex to be* approximately twice as important as the second ranking food item (diptera pupae). The RI value of 32.3 reported by Hensler (1987) was lower than on any of my sample dates, but supports the assumption that zooplankton, specifically *Daphnia*, is the favored food of Arlee rainbow trout.

In contrast, Pflieger (1978) reported rainbow trout diet in Lake Taneycomo as nearly 90 % amphipods, and Joseph

(1976) found gastropods, amphipods and minnows important in a North Dakota lake. Reliance on these food items was probably due to a combination of availability and the fish being conditioned to eating them.

Walleye Diet Composition

The composition of juvenile walleye (90 - 322 mm) diet during this study resembled diets reported elsewhere in that it varied over time, and the dominant prey item changed often. Six different food items, chironomids, crayfish, YOY black crappie, *Callibaetis* spp., zooplankton and suckers dominated the walleye diet by weight (five according to the RI) over the 6 month sample period. In addition to fish, important food items in the diet of juvenile walleye in other studies have included mayflies (Mathias and Li 1982, Ritchie and Colby 1988), chironomids (Priegel 1969, Forney 1974, Bulkley et al. 1976, Fox 1989), frogs and amphipods (Joseph 1976). Fish were of much greater importance for all but the smallest walleye in these other studies compared to mine.

The general sequence of walleye prey choice begins with plankton then gradually changes to insects and finally progressively larger fishes. After beginning to feed, walleye fry less than 9 mm prey on diatoms (Hohn 1966) or

copepods and small cladocerans (Bulkley et al. 1976). Next, young walleye begin feeding selectively on copepods, and avoiding the larger *Daphnia* spp. until they reach 30 or 40 mm. At this size they begin to preferentially select *Daphnia* spp. and avoid copepods (Houde 1967, Raisanen and Applegate 1983, Graham and Spurles 1992, Jackson et al. 1992). Piscivory generally begins around 50 - 60 mm (Smith and Pycha 1960, Bulkley et al 1976, Walker and Applegate 1976, Jackson et al. 1992), but has been observed in walleye as small as 9 mm (Wunderlich 1985). Mathias and Li (1982) believe the onset of piscivory is more a function of the abundance of suitable sized prey fish and the abundance of alternate food sources than of walleye size.

Important food items in the juvenile walleye diet changed too frequently for accurate forage availability sampling but it appears they were feeding heavily on the most abundant food items present at the time. Young-of-the-year crappie were only observed in electrofishing collections during the times they were most abundant in the walleye diet, and small crayfish occurred in the diet at the time one would expect the young to first become available (Momot 1967). Lyons (1987) reports this type of prey switching in walleye based on the relative abundance of bluntnose minnows (*Pimiphales notatus*) and YOY yellow perch.

Knight et al. (1984) found walleye predation on various Lake Erie prey fish to be governed by seasonal availabilities.

Because of the lack of prey fish, Cooney Reservoir walleye appear to be relying on non-traditional food sources well past the size they would normally become piscivorous. Since walleye > 300 mm FL in this reservoir maintain their reliance on invertebrates, the effect of several annual stockings will lead to multiple year classes of walleye relying on invertebrates. This may have adverse future effects on the fishery if the invertebrates are unable to support this pressure. Possible overexploitation of this food supply, by young walleye, may lead to intraspecific competition, which could prove more important than interspecific concerns. In the future, walleye growth rates should be monitored. If growth does not remain acceptable, stocking rate and/or frequency may require adjustment to maintain the walleye fishery.

Diet Patterns

Two distinct patterns appear to have been present in rainbow trout and walleye diets in 1992. The first was the importance of zooplankton to trout, and the second involved chironomid utilization by both species. Zooplankton use is probably explained by trout focusing on an abundant, readily

available prey source, which they are apparently well suited for. The chironomid use pattern is not as easily explained. Through July chironomids were of either primary or secondary importance to both species, after which their utilization dropped off markedly. A similar pattern was described by Bulkley (1970) where yellow bass (*Morone mississippiensis*) preyed heavily upon chironomids between April and July, 1967, after which their importance declined drastically. The author did not provide an explanation, but noted that Mrachek and Bachmann (1967) did not detect any trends in chironomid abundance in the same lake the previous summer.

Diet Overlap

Diet overlap between rainbow trout (122 - 395 mm) and juvenile walleye (90 - 322 mm) does not appear to be a cause for concern. Overlap index values remained below the level of significance on every sample date indicating these two species are relying on essentially different forage bases.

Because there are no data on rainbow trout diet prior to walleye introduction, it is not known if rainbow trout have always been zooplanktivorous and walleye simply filled an empty niche, or if the present balance is a result of both species adopting foraging strategies which minimize

competition. However, work with Arlee strain rainbow trout by Hensler (1987) suggests Cooney Reservoir trout have probably always been zooplanktivorous.

The amount of overlap in the diets of black crappie and rainbow trout was significant. If the overlap on the two dates black crappie were collected is representative, diet overlap with black crappie could pose a greater threat to rainbow trout than overlap with juvenile walleye, if black crappie become abundant.

Habitat Utilization

Habitat utilization by both rainbow trout and walleye is consistent with their diets. Rainbow trout fed primarily on zooplankton, found throughout the water column, and would not be expected to be distributed in relation to substrate composition. Walleye, which relied heavily on benthic prey, selected feeding areas by substrate type during part of the year. Between May and July (when their reliance on chironomids was highest) walleye selected for areas of sand substrate and against the face of the dam. The interstitial spaces provided by large rocks along the face of the dam may have made chironomids more difficult to locate and capture than over a smooth sand bottom.

Habitat use by Cooney Reservoir walleye appears fairly typical, with sand and gravel substrates being commonly used. There are, however, some conflicting reports in the literature about the relative importance of these two habitat types. Holt et al. (1977) report locating radio-tagged walleye predominantly over sandy substrates, while Paragamian (1989) reported walleye to be associated with areas of gravel - cobble substrates. Paragamian (1989) observed walleye passing through areas of sand substrate but not remaining there. Schlagenhaft and Murphy (1985) also found walleye preferred rocky substrates, although areas of sand were used in proportion to availability. Johnson et al. (1988) report walleye selected fine substrates during June and July but were more common over rocky areas in August and September.

Although generally associated with either sand, gravel or a combination of these habitat types, walleye can rely on other habitats as well. Einhouse (1981) found walleye in Chautauqua Lake, New York to be strongly associated with submerged macrophytes despite the presence of large areas of more traditional walleye habitat. In another study submerged logs and brush were also important during the post spawn period, and one radio tagged female was always associated with this type of cover (Paragamian 1989).

McConville and Fossum (1981) noted walleye used shallow, flooded stumpfields in the Mississippi River.

Interspecific Relations

Walleye - Trout Interactions

Interactions between rainbow trout and juvenile walleye appeared to be minimal in Cooney Reservoir. Diet overlap was not significant on any date, and the continued success of the Cooney Reservoir fishery suggests the two species can co-exist under the present conditions of stocking size and timing in Cooney Reservoir. These results are similar to those of Joseph (1976) who also found little dietary overlap between rainbow trout and walleye in a North Dakota lake.

Several factors are probably responsible for maintaining this community. These include the low density of adult walleye, stocking larger (20.3 - 25.4 cm) rainbow trout, the apparent inability of walleye to recruit in the reservoir and the large number of white suckers which have been spawned annually for a forage base. McMahon (1992) fairly accurately describes Cooney Reservoir when he states, "A common thread among all the reservoirs where walleye have had a minor impact on trout or salmon is the presence of a low density walleye population and an abundant, reliable

supply of other small forage fish." However, suckers and black crappie may not prove to be "reliable" forage species.

Walleye predation on rainbow trout does exist, however. A number of trout with lacerated caudal peduncles were collected during this study, indicating adult walleye are feeding to some extent on trout. Fredenberg et al. (1985) reported finding rainbow trout in walleye stomachs in October, 1984, 5 months after the initial walleye introduction. However, MDFWP was stocking 10.2 cm rainbow trout at that time, which were much more vulnerable to walleye predation.

Walleye - Forage Fish Interactions

Biological control of the white sucker population was the primary reason for introducing walleye, and this objective appears to have been achieved. Brown (1971) gives the maximum age of white suckers as 10 years, so walleye should continue to have a reliable forage base through the late 1990's. However, if walleye continue to harvest the entire year class of suckers, as it appears they have done since 1990, the reliability of the sucker forage base will decrease as the adult population declines. If white suckers are completely eliminated from Cooney Reservoir, alternate

prey will be required, and walleye predation on trout will probably increase.

Interactions between walleye and black crappie will probably become more complex if crappie become more numerous in the future. At present, walleye appear to be having some success limiting crappie recruitment (personal observation), while also gaining an important food source for a short time. Crappie may become important in the walleye diet for longer periods if white sucker numbers are severely reduced in the future and the crappie population continues to expand.

Schiavone (1985) documented the response of walleye populations after the introduction of black crappie into 13 New York lakes, and found the response was closely tied to lake trophic levels. Walleye disappeared from shallow, highly productive lakes, and declined in number but remained viable in lakes of intermediate productivity. In lakes of low productivity, walleye populations remained stable, and crappie did not become established (Schiavone 1985). Cooney Reservoir has characteristics similar to those New York lakes of low or intermediate productivity. Considering these findings, future interactions between walleye and crappie appear uncertain.

Lake chubs (*Couesius plumbeus*) appear to have been eliminated from Cooney Reservoir since the introduction of walleye. Numerous schools of these small fish were observed along the shoreline in July, 1983 (Fredenberg and Swedberg 1984). Fredenberg et al. (1986) reported the presence of lake chubs in walleye stomachs collected in June, 1985, and lake chubs made up approximately 10% of the beach seine catch in September, 1988 (Fredenberg and Poor 1989). After 1988, however, there are no references to this species in MDFWP reports, and no lake chubs were observed during this study.

Walleye Spawning Activity

Walleye spawning activity was observed in Red Lodge Creek during April 1993, and the spawning habitat in Red Lodge Creek appears to be adequate for walleye reproduction (McMahon et al. 1984). The collection of larval walleye in the spring of 1993 confirms some spawning success. Because there is at least limited walleye spawning success and stocking walleye fry at 3.6 cm (MDFWP unpublished stocking data) has proven successful, walleye year class failures in Cooney Reservoir appear to be occurring during the first weeks of life.

I believe the apparent lack of walleye survival during these first few weeks is due to food limitation. After yolk sac absorption, post-larval walleye initially rely on copepods and later switch to cladocerans (Hohn 1966, Graham and Sprules 1992, Jackson et al. 1992, Raisanen and Applegate 1983). Zooplankton collected in the larval fish tows during spring 1993, however, was composed almost exclusively of *D. pulex*. The lack of copepods at this critical time in the walleye life cycle may be leading to starvation and the apparent inability of walleye to recruit successfully in Cooney Reservoir.

Management Recommendations

Abundance and growth rates of walleye in Cooney Reservoir should be monitored by continuing the annual gill net sampling and initiating annual electrofishing surveys to collect small walleye. The prey base of young walleye should also be monitored. This could be done using trends in the number of small suckers and crappie collected in fisheries surveys along with some estimate of crayfish abundance. By monitoring the abundance of these food items it may be possible to maintain the number of young walleye at a level where sucker control continues, but below the

point where adults become numerous enough to negatively affect the trout fishery. Growth rates of small walleye should be used as a means of adjusting their stocking density and frequency. Poor growth of young age classes may indicate over-exploitation of invertebrate food organisms resulting from excessive stocking.

If growth rates decline or adults become numerous enough to negatively impact the trout fishery, various cycles of stocking and non-stocking should be considered. For example, the present population of young walleye is the product of 3 years of stocking 50,000 fry annually following 3 years of no stocking. This stocking cycle produced acceptable growth, as well as white sucker control. This, or other stocking cycles may also allow the sucker forage base to be maintained at an acceptable level, further reducing potential walleye-trout interactions.

Collecting eggs from walleye ascending Red Lodge Creek should be considered in years walleye are to be stocked. Peak movement into the tributary appears to be in mid-April, and walleye of both sexes were successfully collected using both electrofishing and trap nets. It should be possible to collect more than enough eggs to supply the stocking needs of Cooney Reservoir. This would be especially important in years when egg collection at other reservoirs was low.

Application to Other Reservoirs

The apparent success of the walleye - trout combination in Cooney Reservoir is somewhat unique and not directly transferable to most other reservoirs. The maintenance of the fishery requires intensive management, and depends on plants of hatchery fish of both species. In most cases, walleye introduction will require changing trout management from put-grow-and-take to the more expensive put-and-take stocking program. However, even this may not be sufficient to maintain the trout fishery.

There are several factors influencing the current walleye - trout fishery in Cooney Reservoir. Most important is the fact that walleye have not become self sustaining, which has allowed managers to maintain relatively low numbers in the reservoir. Because of this and the increase in size of rainbow trout stocked, predation on trout is not limiting. Additionally, suckers and crayfish have provided the Cooney Reservoir walleye with alternate forage sources.

It may be too early to declare the Cooney Reservoir fishery a success. Less than 10 year classes of walleye have been planted in the reservoir, and already changes have occurred in the fish community. Lake chubs appear to have been eliminated, and sucker recruitment has nearly ceased.

If this continues it will not be until late in the 1990's before we see how the walleye and trout will interact in the absence of suckers.

There are other concerns (both positive and negative) which should be addressed before future walleye introductions are made. These deal with basin-wide effects, walleye life history, native species management and the prevailing philosophy in the fisheries profession regarding the introduction of non-native species.

On a basin scale, walleye introduction into one lake or reservoir may have unanticipated effects on other waters in the drainage. Walleye appear to have two distinct life history patterns. The first is a sedentary pattern where a fish establishes a home range and generally only leaves this areas in the spring to spawn. The second strategy is nomadic, with a fish either moving at a fairly constant rate, or remaining in an area for short periods of time before moving on (Einhouse 1981, Paragamian 1989, Prophet et al. 1989). Nomadic walleye have been reported to disperse as much as 42 km (Paragamian 1989), 209 km (Carbine and Applegate 1946) and 322 km (Doan 1942). Before a fish with this much potential for movement is introduced, the possibility and probable consequences of walleye moving into connected waters needs to be assessed.

In situations where walleye are not likely to negatively impact fish populations in adjoining waters, introduction may be appropriate. One example is biological control of non-game species such as the white sucker population in Cooney Reservoir. Another would be in a lake or reservoir where a hatchery-maintained trout fishery could be replaced with a self-sustaining walleye fishery. Finally lakes or reservoirs where there is evidence walleye would not reproduce successfully, but which would otherwise be suitable for walleye could prove appropriate. In this case, it may be possible to maintain both a trout and walleye fishery through hatchery supplementation. Unfortunately, this would be difficult to determine in advance, so managers should understand that the trout fishery may be eliminated if walleye become established and abundant.

Finally, the prevailing philosophy in fisheries management is moving toward the idea of ecosystem management, in which restoring, maintaining and managing native fish communities is an important part. If management goals can be achieved through the use of an indigenous species walleye introductions would be hard to justify.

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APPENDICES

APPENDIX A

Estimated Versus Actual Number of Zooplankters

Table 12. Comparison of estimated versus actual number of zooplankters in stomach samples collected from Cooney Reservoir, Montana, 1992.

Sample	Estimated number	Actual number	Percent difference
1	3,015	2,937	+ 2.6
2	4,933	5,171	- 4.6
3	1,160	1,108	+ 4.5
4	2,125	2,237	- 5.0
5	1,856	1,907	- 2.7

APPENDIX B

Mean lengths of *Daphnia pulex*

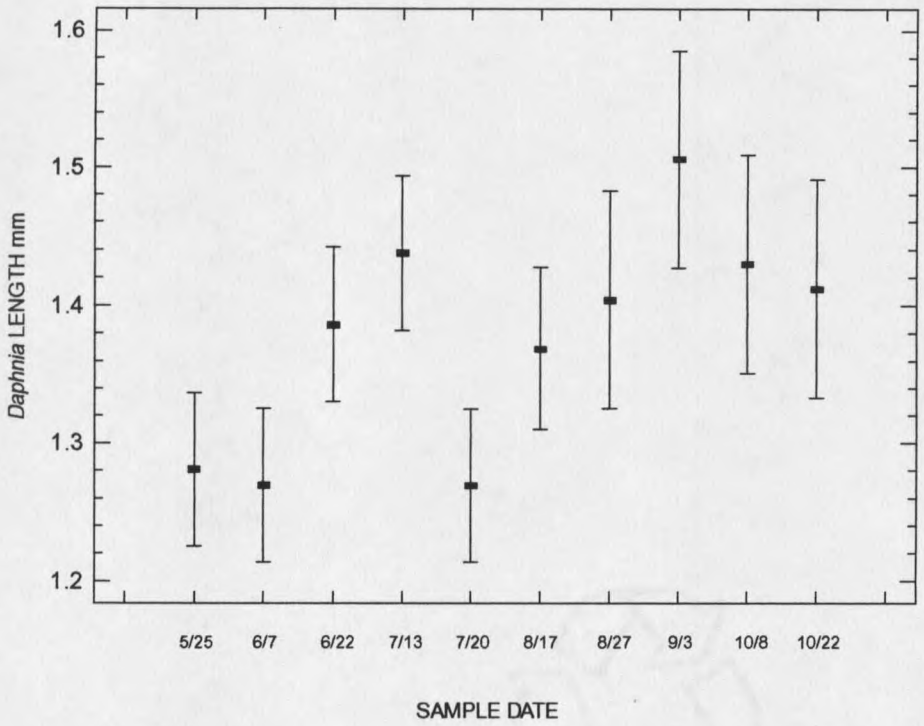

Figure 19. Mean length of *Daphnia pulex* with 95% confidence intervals collected in zooplankton availability tows from Cooney Reservoir, MT between May and October, 1992.

APPENDIX C

Regression models of relationships between number, weight and volume for zooplankton, chironomids, *Callibaetis* spp. and corixids.

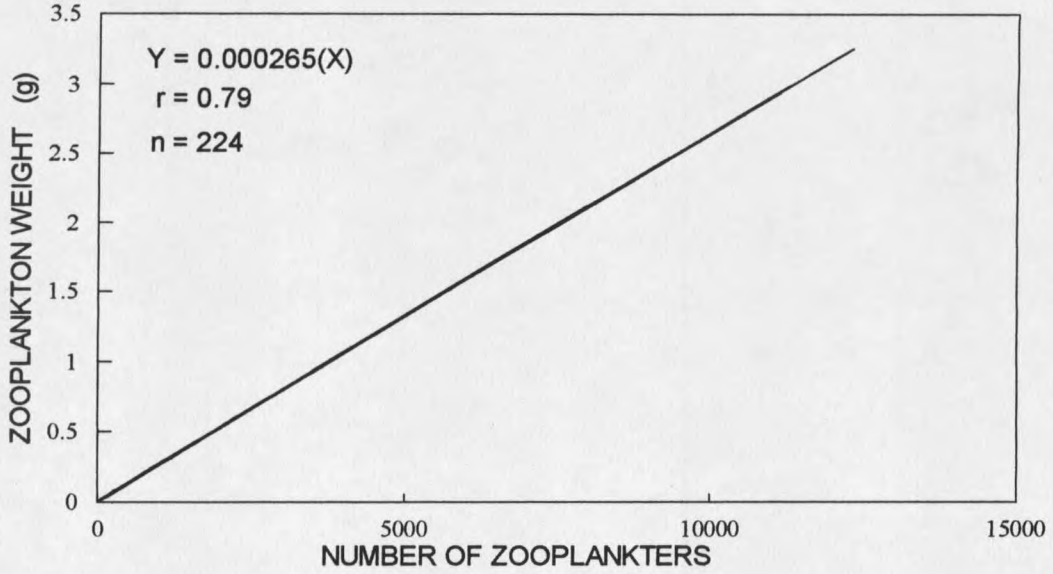

Figure 20. Regression line of zooplankton weight on zooplankton number from walleye and rainbow trout stomachs collected at Cooney Reservoir in 1992.

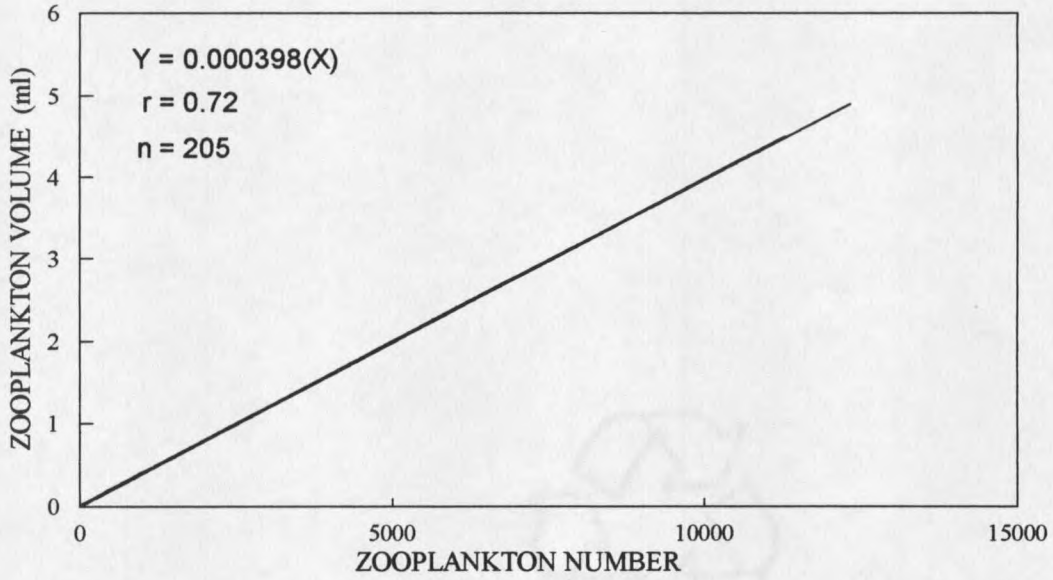

Figure 21. Regression line of zooplankton volume on zooplankton number from walleye and rainbow trout stomachs collected at Cooney Reservior in 1992.

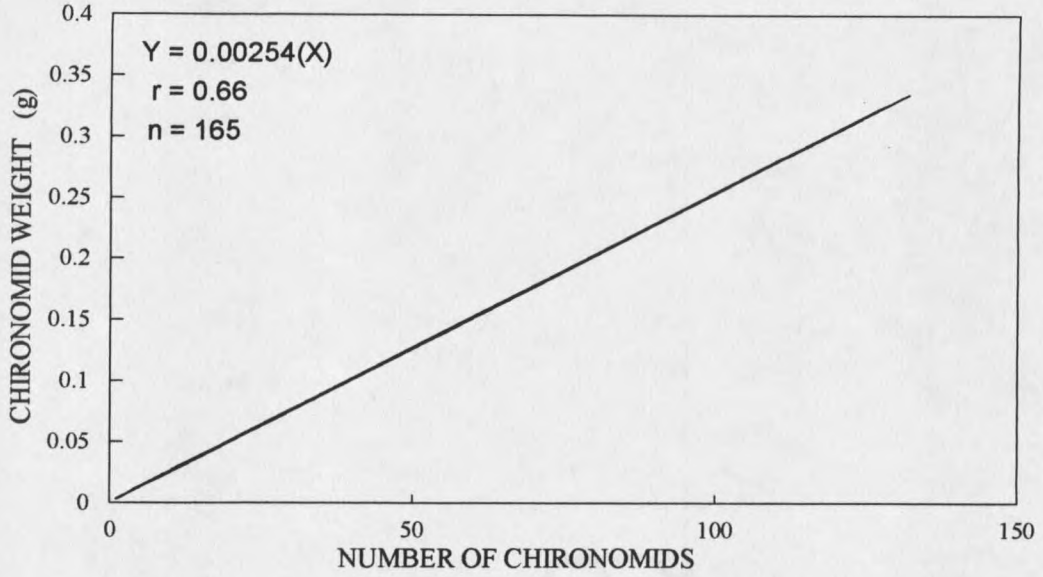

Figure 22. Regression line of chironomid weight on chironomid number from walleye and rainbow trout stomachs collected at Cooney Reservoir in 1992.

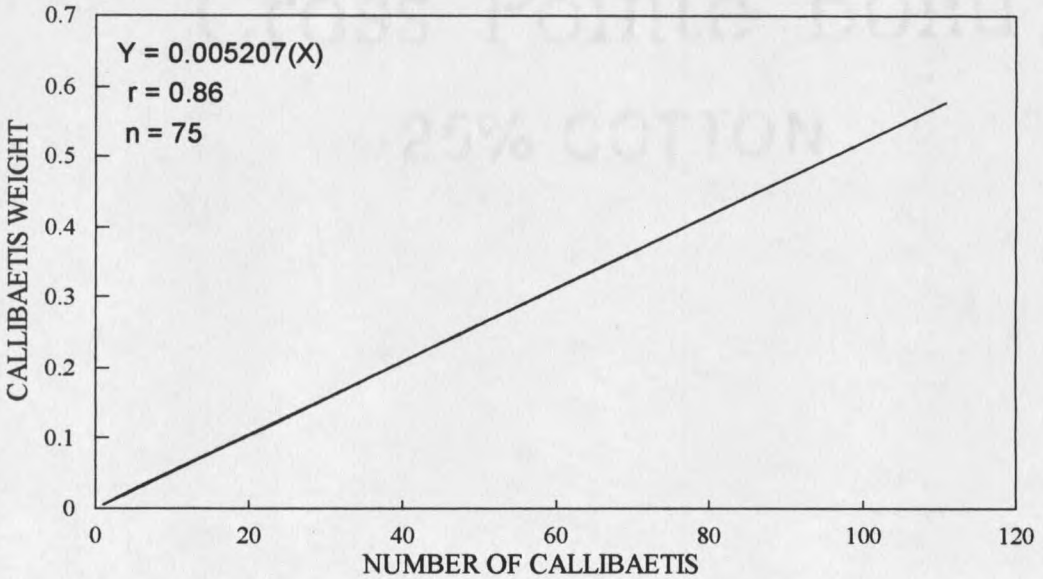

Figure 23. Regression line of *Callibaetis* spp. weight on *Callibaetis* spp. number from walleye and rainbow trout stomachs collected at Cooney Reservoir in 1992.

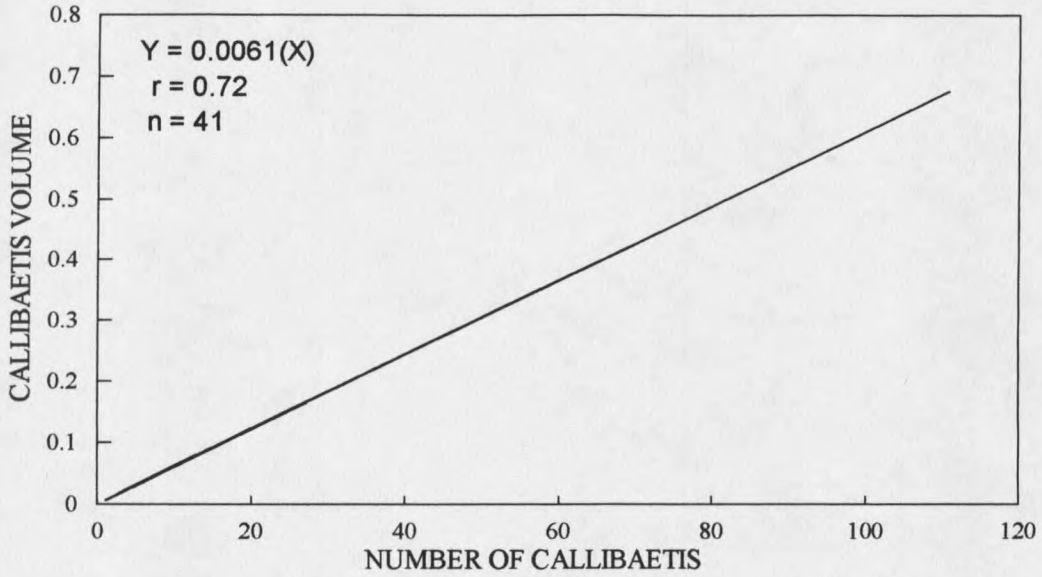

Figure 24. Regression line of *Callibaetis* spp. volume on *Callibaetis* spp. number from walleye and rainbow trout stomachs collected at Cooney Reservoir in 1992.

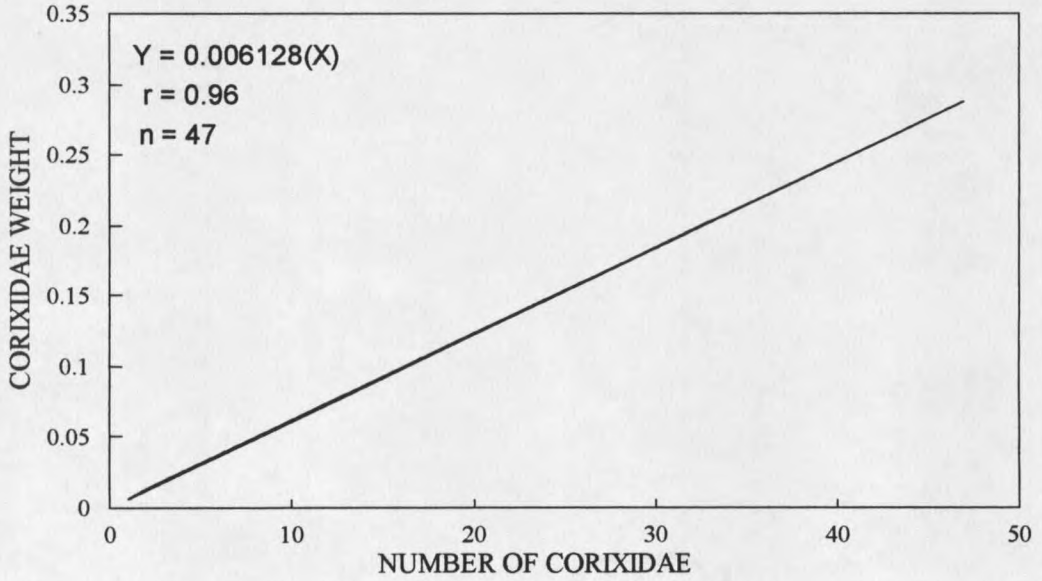

Figure 25. Regression line of Corixidae weight on Corixidae number from walleye and rainbow trout stomachs collected at Cooney Reservoir in 1992.

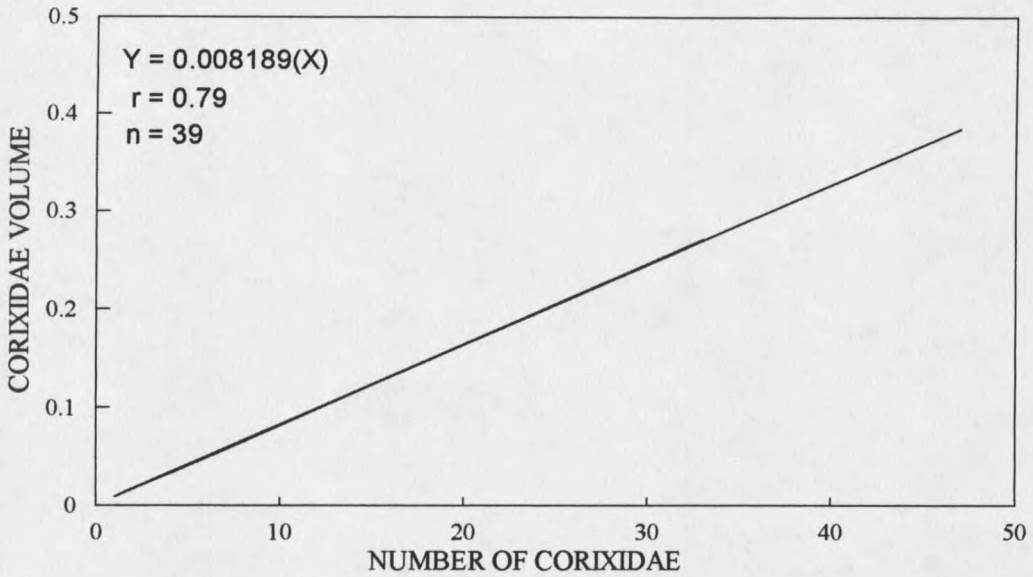

Figure 26. Regression line of Corixidae volume on Corixidae number from walleye and rainbow trout stomachs collected at Cooney Reservoir in 1992.