Stream Resource Utilization of Sympatric and Allopatric Juvenile Brown *(Salmo trutta)* and Steelhead Trout *(Salmo gairdneri)*

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By

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STREAM RESOURCE UTILIZATION OF SYMPATRIC AND

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The dietary and habitat preferences of sympatric and allopatric juvenile brown (Salmo trutta) and steelhead trout (Salmo gairdneri) were measured in order to assess potential areas of interaction between the two species.

Juvenile brown and steelhead trout in the Little Manistee, Pere Marquette, and Boardman Rivers were found to utilize the same food and space resources. Both species ate primarily chironomid and simuliid larvae of approximately the same size.

Analysis of habitat utilization indicated that both brown and steelhead trout are commonly associated with instream structure, particularly down timber. No major differences in utilization were observed for sympatic versus allopatric populations of these trout. However, differences in physical parameters such as depth and velocity did allow distinction to be made between trout populations from different rivers.

INTRODUCTION

The introduction of anadromous steelhead (rainbow) trout
and salmon into the Great Lakes has provided midwest
sportsmen a magnificent fishery. Annual stocking of these
anadromous species into tributaries of Lakes Michigan,
Huron, and Superior has led to the utilization of many
quality trout streams for spawning and nursery purposes by
these fish (Latta 1974). As a result, there has been
mounting concern regarding the impact of salmon and
steelhead trout on the resident stream brook (Salvelinus
fontinalis) and brown trout (Salmo trutta) populations
(Taube 1975, Stauffer 1977, Cunjak and Green 1983, and
Fausch 1986). Many anglers feel that salmon and steelhead
trout seriously impact the trout resources in coastal Great
Lakes streams and are the cause of the perceived decline
in the resident stream trout populations. Both anadromous
and resident salmonid species are popular, highly prized
game fish for Michigan sportsmen. Therefore, angler
interest in these fisheries necessitates further research
to determine proper management practices.

Salmonid species are usually territorial in stream
environments, maintaining relatively fixed positions within
their territories and feeding primarily on drifting benthic
invertebrates (Kalleberg 1958, Chapman 1966). In addition
to similarities in behavior, previous research has also

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indicated a similarity in the utilization of food and space
resources by sympatric populations of salmonids (Fausch
1981, Bowlby and Roff 1986). Therefore, development of
interspecific competitive relationships between these
fishes is a likely possibility.

Researchers have examined competitive interactions
between coho salmon (Oncorhynchus kisutch) and brown trout
(Taube 1975, Stauffer 1977, Fausch 1986), coho salmon and
rainbow trout (Salmo gairdneri) (Hartman 1965), steelhead
trout and chinook salmon (O. tshawytscha) (Everst and
Chapman 1972), rainbow and brook trout (Cunjak and Green
1983), and brook and brown trout (Nyman 1970, Fausch and
White 1981, Cunjak and Power 1986). However, with the
exception of diet studies (Wagner 1975, Johnson 1981,
Bolwby and Roff 1986), no studies have dealt specifically
with the interactions of juvenile steelhead and brown trout
in the stream environment.

A study conducted on the fishery of the Pere Marquette
River has indicated a significant decline in the brown
trout population over the past fifteen years whereas the
numbers of juvenile steelhead trout have increased (Kruger
1985). In addition, brown trout in this river system
exhibit growth rates below the Michigan state average for
fish measuring less than ten inches. The mechanisms
responsible for this decline in abundance and growth have
not been determined. However, the marked increase in

steelhead trout abundance and the fact that growth of brown
trout is above the state average after ten inches in length
(the time at which steelhead trout smolt) suggests there
may be some association between these two species.

Interaction between ecologically similar stream fishes
has been shown to cause displacement and/or declines of
individuals from one of the interacting fish populations
(Burton and Odum 1945, Gibson 1981, Hearn and Kynard 1986).
Displacement of subordinate species to marginal habitats
may negatively effect the fitness and subsequently the
growth of these displaced individuals (Werner and Hall
1976, Itzkowitz 1979). In order to determine if the
observations made on the Pere Marquette fishery are the
product of interactive mechanisms between brown and
steelhead trout, the degree of similarity for stream
resource utilization needs to be established for both
species.

The goal of this research was to observe the resource
preferences of juvenile brown and steelhead trout in the
stream environment to determine if interaction between
these species may act as a population regulating mechanism.
When closely related species occur in the same environment
certain aspects of their behavior or resource requirements
must differ sufficiently to allow their coexistence.
Observing niche shifts on allopatric versus sympatric
populations of closely related species may provide insight

into the mechanisms which operate to permit their coexistence. Therefore, in order to assess potential areas of interaction the specific objectives of this study were 1) to determine the dietary preferences in terms of taxon and size for both sympatric and allopatric juvenile steelhead and brown trout 2) to determine the habitat preferences for these same populations and 3) to determine the amount of overlap between these preferences with an emphasis on its implications for management practices.

MATERIALS AND METHODS

Site Selection

Stream survey data provided by Michigan Department of Natural Resources, Fisheries Division was reviewed in order to evaluate long term trends in brown and steelhead trout abundance in Lake Michigan tributaries and to collect information on the current status of several designated trout steams. The purpose of this review was to locate tributaries containing reproducing populations of brown and steelhead trout. With this accomplished, we began walking stretches of streams in order to locate study areas that could be electrofished effectively with backpack or stream shocking units, were easily accessible and contained similar substrate and cover to facilitate between stream comparisons. At the conclusion of the walking surveys, nine Lake Michigan tributaries were selected for

assessment of their current trout populations. The size
distribution and relative abundance of brown and steelhead
trout were evaluated by electroshocking a 100 meter section
on each tributary. All trout collected were placed in a
holding tank, measured to the nearest millimeter, weighed
on an Ohaus portable balance (D-500), and released.

Mapping Available Habitat

Following Instream Flow Methodology guidelines (Bovee
1982) depth, velocity, substrate, and cover were measured
to define available habitat in the 100 meter study sections
on each tributary. In order to standardize measurements,
codes and criteria to define cover (Table 1) and substrate
(Table 2) were established prior to collecting data in the
field. A metric wading rod and a Marsh-McBirney model 201D
microflow meter were utilized to measure depth and
velocity. Mapping of aquatic habitat was accomplished by
running bank to bank transects every three meters from the
downstream to the upstream boundaries of the study section.
Measurements were made at one meter intervals along each
transect. Depth, velocity, and codes for substrate and
cover were recorded at each location. In addition,
macrohabitat measurements (length and width) of all
riparian and instream structure were recorded.

The stream channel was mapped utilizing a modified
Deflection-Angle Traverse Method (Orth, 1983). Station one

Table 1. Stream habitat numeric codes and descriptions of
          cover types at study sites.

Cover Code	Description
1	No cover
2	Undercut bank < 30 cm
3	Undercut bank > 30 cm
4	Overhanging vegetation > 30 cm above surface
5	Overhanging vegetation < 30 cm above surface
6	Emergent or submergent aquatic vegetation
7	Down timber
8	Half-log improvement structure
9	Large rock or boulder

Table 2. Substrate numeric codes and descriptions of
          substrate types at study sites.

Substrate Code	Description
1	Rooted aquatic vegetation
2	Fines (sand, silt)
3	Pebble (up to 3 cm)
4	Gravel (3 to 8 cm)
5	Cobble (8 to 30 cm)
6	Boulder (greater than 30 cm)
7	Bedrock
8	Detritus
9	Down timber embedded in substrate

was located at the downstream boundary of the study
section. Consecutive stations were located at three meter
intervals until the upstream boundary of the study section
was reached. At each station, a transect was run across
the stream channel to the opposite bank, a metric measuring
tape was used to determine the width of the channel at the
transects location. A stand pole compass was utilized to
measure the deflection angle from the present station to
the following station and the traverse angle from the
station to the point across the stream that the transect
had been located.

Utilizing the channel morphology and habitat
measurements collected in the field, scale drawings of the
stream study sections were constructed. The abundance of
each habitat type and total area of the stream study
section was measured utilizing a digitizing program which
calculates the area of irregular polygons (Arnold and Van
Nort 1987, Eves 1975).

Underwater Observation

The utilization of available habitat by juvenile brown
and steelhead trout was observed by diving with mask and
snorkel. Samples were collected at monthly intervals from
June through November on each tributary except during
occasional times of poor visibility. As visibility was
essential for proper identification and length estimation

of juvenile trout, diving was usually done between 1000 and 1400 hours when direct sunlight hit the stream surface and light intensity was the greatest.

The study sections were divided lengthwise into right and left sides. Two divers, each working a side of the channel, crawled upstream from the downstream boundary investigating the main channel and all structures that might have contained trout. Due to the rheotaxic nature of trout, divers approached from the downstream direction reducing the chances of disturbing the trout and allowing observations of their natural positions to be made.

Upon visual location of a trout its behavior was observed to determine if it had been disturbed. Actions such as darting from one spot to another or digging into the substrate were assumed to be a reaction to the divers presence and no data were collected from these fish. If a fish did not appear to be disturbed, divers identified the species, estimated its total length and distance from the substrate with a centimeter scale, marked its position with a numbered lead weight, and recorded this information on an underwater slate.

At the conclusion of the dive, the lead weights were collected and measurements of depth, velocity, substrate, and cover were made at each location. A Marsh-McBirney model 201D microflow meter and metric wading rod were used to measure depth and velocity. The same codes and criteria

established for cover and substrate in the mapping
procedure were used to evaluate cover and substrate at each
fish position (Tables 1 and 2).

Electrofishing Procedure

The relative abundance of trout in each study section
was estimated monthly from June through November 1986 using
electrofishing. The electrofishing unit consisted of a
small wooden barge carrying a 250-v, 1.75-KW DC generator.
The electrofishing crew proceeded from the downstream to
the upstream boundary of the study section. A single pass
was made up each bank and another up the center of the
stream.

All trout collected were placed in a holding tank,
measured to the nearest millimeter and weighed on a Ohaus
portable balance (D-500). Scale samples were taken from
all size classes of trout for age and growth determination.
The trout were then released at the downstream boundary of
the section to allow olfactory orientation to their
previous positions in the stream.

Diet Analysis

A backpack and/or stream electrofishing unit was
utilized to collect trout for stomach content analysis
monthly from June through November. Trout were collected
from areas adjacent (above and below) to the study section
to avoid removing fish from the section. It was assumed

that prey availability above and below the study section
would be comparable to that available within the section.
All trout captured were measured to the nearest millimeter
and weighed on a Ohaus portable balance (D-500). A
subsample of up to 5 trout from each 10 mm size class
collected were preserved in a buffered 10% formalin
solution and analyzed for stomach contents. Food items
were identified to family and counted in the laboratory.
In addition, head capsules of all insects were measured for
size analysis of the diet.

Stomach contents were evaluated for intra- and
interspecific similarities in terms of prey size and taxon.
Intraspecific diet comparisons were made between species
from different river systems and for each trout species
within a river system between sampling dates.
Interspecific diet comparisons were made between species
within a river system.

Statistical Analysis

All statistical procedures and comparisons in this
study were performed using Statistical Analysis System (SAS
Institute Inc. 1985) on the Michigan State University
Computer Network. Statements of statistical significance
indicate p-values less than or equal to 0.05 unless stated
otherwise.

Habitat utilization was evaluated in terms of

availability and for species or population specific preferences. Utilization of instream structures as cover was compared to structure availability using a Chi-square test (Steel and Torrie 1980). Structure availability was measured in terms of the percent of the total study site area each type of structure comprised.

A logistic regression procedure was run to determine the physical and biological attributes of brown and steelhead trout that were helpful in classifying fish into a specific population or species. The logistic regression model is formulated mathematically by relating the probability of some event, E, occurring conditional on a vector of explanatory variables (Press and Wilson 1978). In this case, E, is the probability that a fish belongs to a particular species or population and the explanatory variables are the physical and biological measurements made in the field. The variables measured were total fish length, distance from the substrate, depth and velocity at the fish's position, and the type of structure and substrate with which the fish was associated.

Diet preferences were evaluated both qualitatively and quantitatively. Qualitative analysis was based on size and taxon of prey items. Similarities in prey taxon were evaluated through calculation of Schoener's (1970) index:

$$\text{Overlap} = 1 - 0.5 \, |Px_i - Py_i|$$

where:

Px_i= proportion of food i in the diet of species X

Py_i= proportion of food i in the diet of species Y

Overlap values of 0.6 or greater are considered significant (Smith 1985).

Differences in mean headcapsule width of prey items for each trout species between river systems and within river systems were tested using F-test and t-test comparisons (Steel and Torrie 1980). Differences in mean headcapsule width of prey items for each trout species within a river system between sampling dates was tested using a two-way analysis of variance and Student-Newman-Kuels' multiple comparison test (Steel and Torrie 1980).

A quantitative description of diet was developed by calculating percent occurrence, mean number per stomach, and number of stomachs containing an item for each insect taxon found in the stomach contents. These data were utilized to determine the predominate prey items for all trout species found in each river system throughout the sampling season.

Growth was evaluated by calculating the average daily increase in length for each trout population. A z-statistic was calculated for each paired comparison using the following formula: (Kendall and Stuart 1977)

$$z = \text{mean1} - \text{mean2} / \text{variance 1} + \text{variance 2}$$

In addition, the length and weight of each individual fish

captured in the electrofishing surveys were plotted to graphically depict the length-weight relationship for brown and steelhead trout in the river systems examined.

RESULTS

Study Site Selection

Preliminary electrofishing surveys conducted on nine Lake Michigan tributaries (Table 3) indicated that several of the streams supported populations of brown and steelhead trout. Utilizing this information, three streams, the Little South Branch of the Pere Marquette River, the Little Manistee River, and the South Branch of the Boardman River, were selected for research purposes. This selection was based upon physical properties, the abundance of young of the year trout captured within the survey section, and the ratio of brown to steelhead trout. The Pere Marquette contained primarily steelhead trout, the Boardman exclusively brown trout, and the Little Manistee a mixed population of both species. Therefore, these streams could be used to evaluate changes in resource utilization by both species of trout in sympatry versus allopatry.

Population Parameters

Relative abundance and growth data were collected from each river in order to make comparisons between study sections. Trout populations in the Little Manistee River

Table 3. Relative abundance of brown and steelhead trout in nine Lake Michigan tributaries surveyed as potential study streams, 1985.

	Abundance		
Stream	Brown Trout	Steelhead Trout	Total
Williamsburgh Creek	29	0	29
Boardman (S. Branch)	124	0	124
Bear Creek	1	5	6
L. Manistee	3	13	16
Platte	6	40	46
Pere Marquette (Little S. Branch)	7	80	87
Pine Creek	14	22	36
White River	2	0	2
Filer Creek	0	0	0

were the most abundant with an average of 118 fish in the
100 meter study section (Table 4). The Boardman and Pere
Marquette Rivers had an average of 56 and 50 fish in their
study sections respectively. The ratio of brown to
steelhead trout in the Little Manistee River was
approximately 1:2. On all sampling dates brown trout had a
larger mean length than steelhead trout (Table 4).
However, this difference in length between species
diminished across the sampling season. For example,
steelhead collected in July were 28 mm shorter than brown
trout but in September they were only 17 mm shorter than
the brown trout collected on the same date.

Growth was compared between all three rivers for both
species of trout. Brown trout from the Little Manistee and
Boardman Rivers had an average daily increase in length of
0.32 mm and 0.34 mm respectively. These values were not
statistically different from one another (z-test).
Steelhead trout from the Little Manistee and Pere Marquette
Rivers had a daily average increase in length of 0.56 mm
and 0.58 mm respectively. These values were also not
significantly different from one another (z-test).
Comparison of brown trout growth to steelhead growth
indicated that the average daily increase of these species
were significantly different from one another. All species
regardless of the river system in which they were found
exhibited similar length-weight relationships. In other

Table 4. Estimates of relative abundance and mean length of
trout species from shocking runs.

River	Date	Species	Length ± Standard Error (mm)	Number of Fish
Boardman (S. Branch)	Jun 25, 1986	Brown	61.6 ± 2.7	69
	Aug 23, 1986		81.7 ± 1.7	43
Pere Marquette (Little S. Branch)	Jul 31, 1986	Steelhead	56.1 ± 2.1	44
	Aug 27, 1986		72.3 ± 2.3	56
Little Manistee	Jul 24, 1986	Brown	75.0 ± 1.6	47
	Aug 11, 1986		83.1 ± 1.8	38
	Sep 9, 1986		90.5 ± 2.1	30
	Jul 24, 1986	Steelhead	46.5 ± 0.9	118
	Aug 11, 1986		59.6 ± 1.6	58
	Sep 9, 1986		73.4 ± 2.0	63

words, the weight of a fish at a particular length was the same for both brown and steelhead trout.

Available Habitat

The quality and quantity of available habitat was found to be very similar in each river's study section (Table 5). Open areas with no structures comprised the majority of the total study area for all three rivers. The second most abundant habitat type available in the sections was a combination of down timber and overhanging vegetation such as tag alder or cedar. However, each section did contain structures that were unique to their river's system. The Little Manistee river has had man-made habitat improvement structures constructed in its waters and the Pere Marquette river contains many large boulders and rock structures that were not found in the other sections. Despite these and other inherent differences that occur between river systems, I assumed that the study sections were similar enough to allow between stream comparisons to be made. This assumption was based on the fact that all three sections contained the same predominate instream structures and were capable of supporting trout populations.

Underwater Observations

Brown and steelhead trout appear to be selective for

Table 5. Area of habitat types (m^2) measured in all three study sections.

Habitat	River					
	Boardman South Branch		Pere Marquette Little S. Branch		Little Manistee	
	Area	%	Area	%	Area	%
None	529.4	59.3	547.8	59.1	731.8	64.3
Overhanging Vegetation-Timber Complex	208.2	23.3	221.1	23.9	156.9	13.8
Down Timber	109.8	12.3	69.2	7.5	39.3	5.8
Overhanging Vegetation	14.4	1.6	23.5	2.5	130.7	11.5
Boulder	0.0	0.0	35.7	3.9	0.0	0.0
Habitat Improvement Structure	0.0	0.0	0.0	0.0	65.6	5.8
Aquatic Vegetation	0.0	0.0	11.1	1.2	0.0	0.0
Island	20.7	2.3	0.0	0.0	0.0	0.0
Root Wad	0.0	0.0	9.9	1.1	0.0	0.0
Other	10.0	1.1	8.3	0.9	14.4	1.3

particular types of structure regardless of their availability. Utilization of habitat was significantly different from that expected based on habitat availability (Table 6). Both species whether allopatric or sympatric with one another, were most frequently found under logs or holding positions in close proximity (within a meter) to down timber, even though other types of structure were more abundant.

Logistic Regression

Brown Trout

Difference in total body length was found to be the most significant (X^2= 23.92) variable in classifying brown trout from the Boardman and Little Manistee Rivers. Brown trout observed in the Boardman river were on the average 8.57 centimeters long which was significantly larger (p < 0.0623) than the 5.68 centimeter average length of brown trout observed in the Little Manistee River (Table 7 and 8). The linear model developed by the logistic regression procedure contained several cover and substrate variables which pertained to microhabitat measurements taken at the fish's position. The significance of these variables is difficult to evaluate because their chi-square values are minimal and differences in availability of microhabitat between river systems is unknown.

The model correctly classified brown trout in the Boardman River 99.4% of the time. This indicates that

Table 6. Chi-square analysis for habitat utilization versus habitat availability.

Site	Species	Date	Calculated Chi-square	Critical Chi-square
Boardman River (South Branch)	Brown Trout	June–Nov.	158.01*	7.82
L. Manistee River	Brown Trout	June–Nov.	19.24*	7.82
L. Manistee River	Steelhead Trout	June 18	135.77*	9.49
		July 21	438.63*	11.07
		Aug. 18	82.93*	9.49
		Sept. 9	147.77*	11.07
		Nov. 7	95.50*	9.49
Pere Marquette River (Little S. Branch)	Steelhead Trout	July 7	188.64*	11.07
		July 29	73.22*	11.07
		Aug. 29	361.21*	11.07
		Oct. 30	341.94*	11.07
		Nov. 22	61.38*	11.07

* Significant values which indicate that habitat is not used in proportion to availability.

Table 7. Mean, range, and standard error of significant variables from logistic regression procedure for the South Branch of the Boardman River.

Species	Variable	Mean	Range		Standard Error of Mean
			Minimum Value	Maximum Value	
Brown Trout	Length	8.57	2.0	16.0	0.18
	Average Velocity	0.94	0.0	3.08	0.03
	Depth (cm)	48.4	14	100	0.96
	Distance from Substrate	2.61	0	30	0.15

Table 8. Mean, range, and standard error of significant variables from logistic regression procedure for the Little Manistee River.

| Species | Variable | Mean | Range | | Standard Error of Mean |
			Minimum Value	Maximum Value	
Steelhead Trout	Length	6.94	2.0	16.0	0.22
	Average Velocity	0.94	0.0	2.82	0.04
	Depth (cm)	39.6	11	105	1.31
	Distance from Substrate	3.09	0	23	0.23
Brown Trout	Length	5.68	3.0	12.0	0.42
	Average Velocity	0.66	0.0	2.49	0.08
	Depth (cm)	29.2	12	56	1.87
	Distance from Substrate	0.71	0	4	0.20

trout in this river have extremely consistent values for
the length, cover, and substrate variables found in the
model. Brown trout observed in the Little Manistee River
were more variable in length and utilization of
microhabitat than brown trout in the Boardman River.
Therefore, they were more difficult to classify and the
model was only correct 65.6% of the time.

Steelhead Trout

Steelhead trout in the Pere Marquette and Little
Manistee Rivers utilized different water velocities and
depths depending on the river system in which they were
located. Steelhead trout in the Little Manistee utilized a
wider range of water depths (11 to 105 cm) but on the
average were found in shallower waters than Pere Marquette
rainbow trout (Table 8 and 9). However, the mean depths
utilized by both trout populations were not statistically
different based on a t-test analysis. The range of
velocities utilized by both trout populations were very
similar. Pere Marquette River steelhead trout were found
in velocities ranging from 0.06 to 2.38 meters per second
and Little Manistee River steelhead trout were found in
velocities ranging from 0.0 to 2.82 meters per second. A
t-test comparison of mean velocity values for these
populations determined that steelhead trout in the Little
Manistee River utilize significantly faster velocities than
Pere Marquette River steelhead trout. Trout from both

Table 9. Mean, range, and standard error of significant variables from logistic regression procedure for the Little South Branch of the Pere Marquette River.

| Species | Variable | Mean | Range | | Standard Error of Mean |
			Minimum Value	Maximum Value	
Steelhead Trout	Length	8.69	2.0	16.0	0.23
	Average Velocity	0.85	0.06	2.38	0.03
	Depth (cm)	53.0	14	100	1.25
	Distance from Substrate	3.88	0	30	0.20

river systems were found most frequently in water velocities less than 1.5 meters per second. Little Manistee River steelhead trout were equally distributed in velocities ranging from 0 to 1.5 meters per second whereas steelhead trout in the Pere Marquette River were found concentrated in 0.5 meters per second and 1.3 to 1.4 meters per second water velocities.

The linear model developed by the logistic regression procedure found water depth and velocity to be the most significant variables in classifying steelhead trout in the Little Manistee and Pere Marquette Rivers. As with the logistic regression model developed to classify brown trout populations, the steelhead trout model also contains several cover and substrate variables whose chi-square values are insignificant. The model had a correct classification rate of 76.3% for steelhead trout observed in the Pere Marquette River and 84.9% for those in the Little Manistee River. Therefore, it appears that both populations vary to some extent in their utilization of cover and substrate as well as water depth and velocity.

Sympatric Brown and Steelhead Trout

Brown and steelhead trout in the Little Manistee River were found to differ most significantly in the distance above the substrate that they held positions. Brown trout were more closely associated with the substrate than steelhead trout. They held positions that were on the

average 0.71 cm above the stream bottom and were never
found in positions greater than 4 cm from the substrate.
Rainbow trout positions ranged from 0 to 23 cm above the
substrate and had a mean value of 3.09 cm. The mean
values for distance from the substrate (Table 8) were found
to be statistically different between species by a t-test
comparison.

The logistic regression procedure developed a model
that contained several cover and substrate variables as
well as distance from the substrate measurements. However,
the chi-square values for the cover and substrate variables
were insignificant. The model correctly classified
steelhead trout 95.6% of the time. This high percentage
suggests relatively consistent values for the variables
contained in the model. Brown trout, on the other hand,
appeared to be extremely inconsistent in their utilization
of these variables and were only classified correctly 38.8%
of the time.

Food Habits

Brown Trout

Brown trout in the Boardman and Little Manistee rivers
did not exhibit major differences in preference of prey
items. Larval insects belonging to the families
Chironomidae and Simuliidae were the most commonly
occurring food items in the stomach contents of both brown
trout populations (Tables 10 and 11). Diets were also

Table 10. Stomach contents of young of the year brown trout collected in the Little Manistee River, 1986.

Food Item	Number Stomachs Containing Item	Mean Number Per Stomach	Frequency of Occurrence
TRICHOPTERA	10	1.6	0.20
Hydropsychidae	15	1.8	0.31
Glossomatidae	21	2.7	0.43
Limnephilidae	3	2.0	0.06
Brachycentridae	4	1.0	0.08
DIPTERA	2	2.0	0.04
Tipulidae	6	3.0	0.12
Ceratopogonidae	6	2.2	0.12
Simuliidae	28	6.1	0.57
Chironomidae	30	6.3	0.61
Pupae	4	3.5	0.08
EPHEMEROPTERA	11	1.8	0.22
Baetidae	14	3.2	0.29
Ephemerellidae	8	2.5	0.16
PLECOPTERA			
Perlodidae	3	1.7	0.06
TERRESTRIAL INSECTS	8	3.5	0.16
GASTROPODA	14	1.6	0.29
ISOPODA	7	1.3	0.14
COLEOPTERA	4	2.5	0.08
OTHER	19	1.1	0.39

Table 11. Stomach contents for young of the year brown trout
collected in the South Branch of the Boardman
River, 1986.

Food Item	Number Stomachs Containing Item	Mean Number Per Stomach	Frequency of Occurrence
TRICHOPTERA	8	1.6	0.10
Hydropsychidae	5	1.0	0.06
Glossomatidae	9	1.3	0.11
Limnephilidae	9	4.6	0.11
Brachycentridae	17	3.5	0.21
DIPTERA			
Tipulidae	4	1.3	0.05
Ceratopogonidae	7	4.4	0.09
Simuliidae	31	4.0	0.39
Chironmidae	42	4.4	0.53
Pupae	7	2.3	0.09
EPHEMEROPTERA	17	1.4	0.21
Siphlonuridae	6	1.2	0.08
Baetidae	27	3.7	0.34
Heptageniidae	5	1.0	0.06
Ephemerellidae	10	1.8	0.13
Tricorythidae	3	1.3	0.04
TERRESTRIAL INSECT	7	1.9	0.09
GASTROPODA	10	1.7	0.13
COLEOPTERA	4	1.0	0.05
ISOPODA	3	2.0	0.04
OTHER	13	2.0	0.16

compared by calculating the overlap value for the stomach contents. The calculated Schoener's index had a value of 0.758 which indicated that brown trout in the Little Manistee and Boardman Rivers overlap significantly in terms of prey taxon present in the diet.

Size analysis of the diet produced results similar to that of prey taxon. The mean headcapsule width of prey was calculated for the entire season (Table 12). The average headcapsule width for brown trout in both the Boardman and Little Manistee Rivers was 0.588 mm. Therefore, despite the probable differences in prey availability between river systems brown trout appear to eat the same taxon and size class of prey regardless of their geographic location.

Steelhead Trout

Steelhead trout in the Pere Marquette and Little Manistee rivers exhibited a preference for the same prey taxa. Larval Chironomidae and Simuliidae were the predominate prey of both populations (Tables 13 and 14). Overlap of prey taxon in the diet was found to be significant between these populations with a calculated Schoener's index of 0.647.

Size analysis of the diet produced results which indicated that despite the similarity in preference of prey taxon steelhead trout in the Pere Marquette and Little Manistee Rivers eat different size classes of prey. Mean

Table 12. Diet data for each site and species
over the entire sampling season.

Site	Species	Number Fish Examined	Number Of Prey Items	Mean Head Capsule (mm)	Standard Error
Boardman River (South Branch)	Brown Trout	80	721	0.588	0.014
Little Manistee River	Brown Trout	49	701	0.588	0.015
Little Manistee River	Steelhead Trout	92	2275	0.653	0.031
Pere Marquette River (Little S. Branch)	Steelhead Trout	14	313	0.485	0.016

Table 13. Stomach contents for young of the year steelhead
trout collected in the Little Manistee River,
1986.

Food Item	Number Stomachs Containing Item	Mean Number Per Stomach	Frequency of Occurrence
TRICHOPTERA	15	1.6	0.16
Hydropsychidae	25	2.2	0.27
Glossomatidae	20	2.8	0.22
Limnephilidae	5	1.4	0.05
Brachycentridae	7	3.1	0.08
DIPTERA	5	3.2	0.05
Tipulidae	8	2.1	0.09
Ceratopogonidae	21	2.7	0.23
Simuliidae	53	8.1	0.58
Chironomidae	73	12.1	0.79
Pupae	32	10.1	0.35
Adult	12	2.8	0.13
EPHEMEROPTERA	24	2.1	0.26
Siphlonuridae	11	1.6	0.12
Baetidae	26	2.7	0.28
Ephemerellidae	8	1.8	0.09
Tricorythidae	6	4.0	0.07
PLECOPTERA Perlodidae	9	2.1	0.10
TERRESTRIAL INSECT	20	4.7	0.22
ISOPODA	12	1.4	0.13
OTHER	59	1.6	0.64

Table 14. Stomach contents for young of the year steelhead trout collected in the Little South Branch of the Pere Marquette River, 1986.

Food Item	Number Stomachs Containing Item	Mean Number Per Stomach	Frequency of Occurrence
TRICHOPTERA	6	1.5	0.43
Hydropsychidae	5	2.8	0.36
Glossomatidae	3	1.0	0.21
DIPTERA			
Tipulidae	4	2.0	0.29
Simuliidae	10	2.3	0.71
Chironomidae	11	17.6	0.79
Pupae	4	2.8	0.29
Adult	1	8.0	0.07
EPHEMEROPTERA	2	4.5	0.14
Baetidae	4	2.5	0.29
Tricorythidae	6	1.5	0.43
OTHER	10	1.4	0.71

headcapsule widths of prey items found in the Little

Manistee River steelhead trout was 0.653 mm and 0.485 mm

for Pere Marquette River steelhead trout (Table 12). These

mean values were found to be significantly different based

on a t-test analysis. Therefore, steelhead trout in both

river systems eat the same taxon of prey but appear to

choose different size classes of prey.

Sympatric Brown and Steelhead Trout

Brown and steelhead trout in the Little Manistee

River exhibit very little difference in food habits in

terms of both size and taxon of prey. Both species ate

predominately Chironomidae and Simuliidae larvae (Tables 10

and 13) and overlap of all prey taxon in the diet was

significant for the entire season with an index value of

0.705. Date-by-date comparisons indicated that overlap was

significant on all sampling dates except November (Table

15).

Size analysis of the diet produced the same results.

Seasonal mean headcapsule width of prey for brown trout was

0.588 mm and 0.653 mm for steelhead trout. These values

were not found to be significantly different based on a t-

test analysis. Date-by-date mean headcapsule widths were

also not significantly different between species (Table

15). Prey with headcapsules less than 1.0 mm were ingested

more frequently than other size classes (Figures 1 and 2).

Table 15. Schoener's diet overlap and comparison of mean
headcapsule width for sympatric brown and steelhead
trout in the Little Manistee River, 1986.

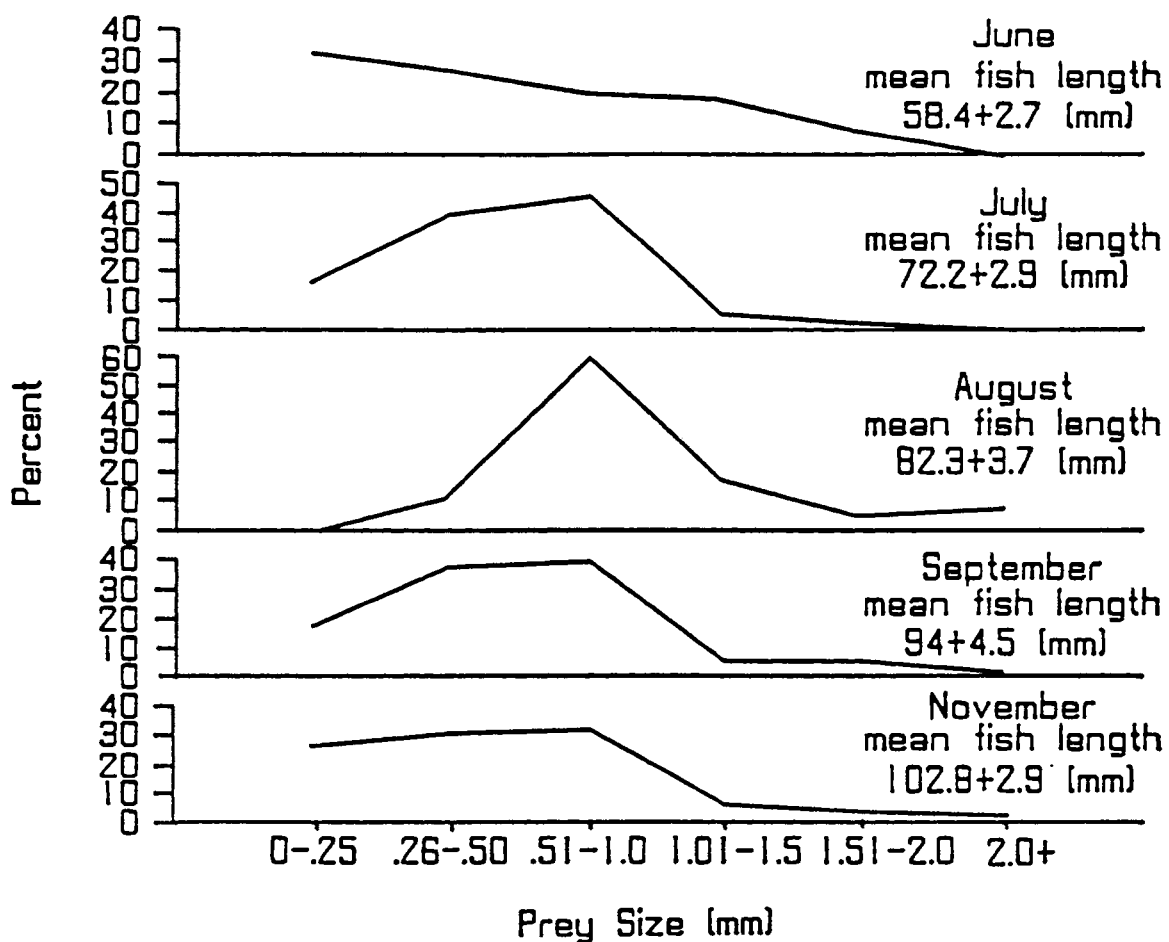| Date	Interacting Species	Overlap	T-Test Comparison of Mean Head Capsule
July	Brown-Steehead Trout	0.764	NS
Aug.	Brown-Steelhead Trout	0.704	NS
Sept.	Brown-Steelhead Trout	0.652	NS
Nov.	Brown-Steelhead Trout	0.447	NS

Figure 1. Percent composition of diet by prey size for Little Manistee River brown trout collected on each sampling date.
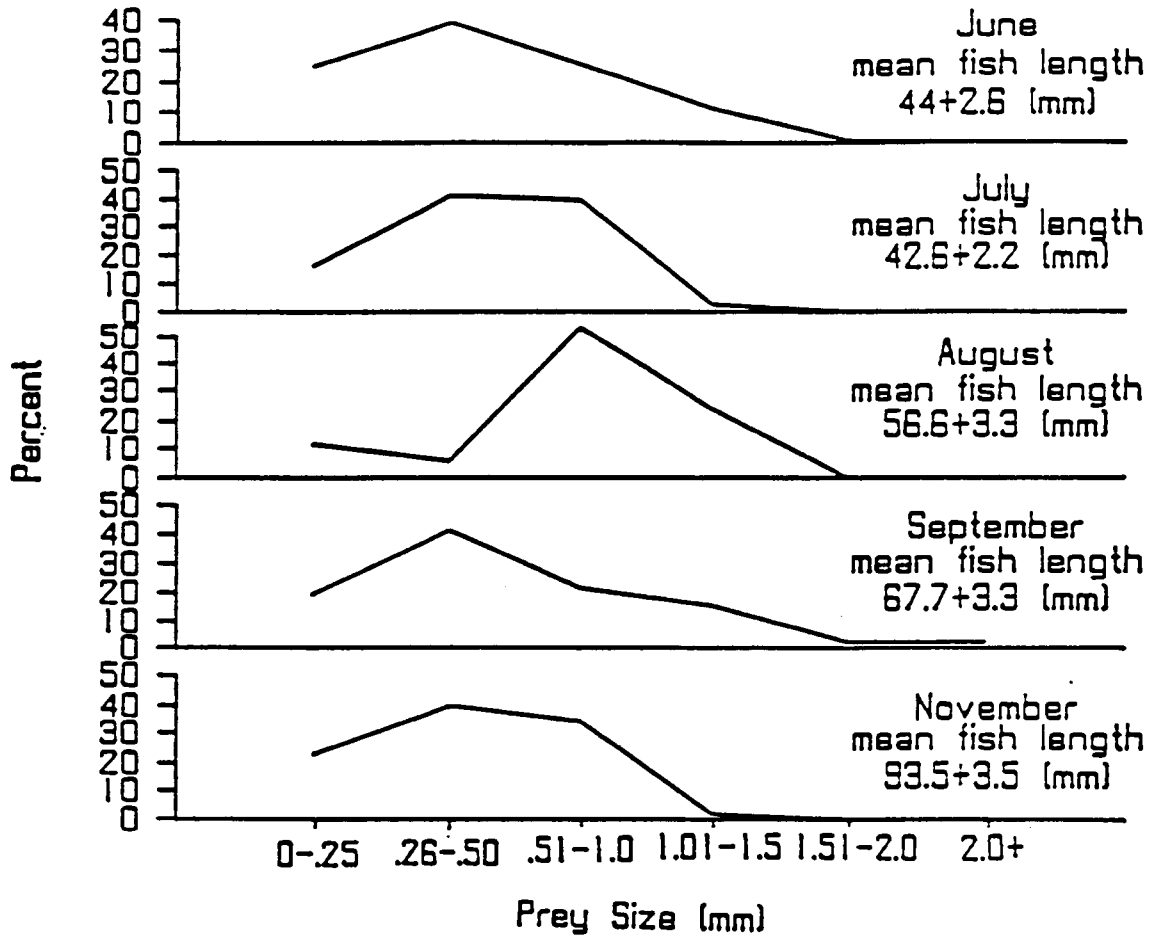
Figure 2.   Percent composition of diet by prey size for
            Little Manistee River steelhead trout collected
            on each sampling date.

Therefore, it appears that both brown and steelhead trout eat the same taxon and size class of prey in the Little Manistee River where they co-occur.

Monthly Diet Analysis

Within each river system diet overlap and mean headcapsule width of prey items for each trout species were compared between sampling dates to observe changes that may occur from June to November.

Boardman River Brown Trout

Brown trout in the Boardman River did not exhibit the same food habits across the sampling season. Date to date comparisons indicated that overlap of prey taxon was not significant from June through November (Table 16). Prey size also changed between sampling dates. Mean headcapsule width of prey items (Table 17) were found to be significantly different for different dates based on a 1-way analysis of variance. A Student-Newman-Kuels' multiple comparison test found the mean headcapsule width of prey items from each of the sampling dates to be significantly different from one another except for the months of June and November (Table 18). Prey with headcapsules ranging from 0.51 to 1.0 mm were eaten most frequently in all months except June (Figure 3). Therefore, prey in the diets of brown trout in the Boardman River appears to be dependent on the time of season when samples were

Table 16. Diet overlap as indicated by Schoener's index for
         between month comparisons for each trout species.

Site	Species	Interacting Months	Index
Boardman River (South Branch)	Brown Trout	June-July	0.435
		July-Aug.	0.492
		Aug.-Nov.	0.228
Pere Marquette (Little S. Branch)	Steelhead Trout	July-Aug.	0.628*
Little Manistee River	Brown Trout	July-Aug.	0.686*
		Aug.-Sept.	0.561
		Sept.-Nov.	0.217
Little Manistee River	Steelhead Trout	June-July	0.304
		July-Aug.	0.693*
		Aug.-Sept.	0.680*
		Sept.-Nov.	0.201

* indicates significant values

Table 17. Diet data for each site and species for each
sampling date, 1986.

River	Species	Month	No. Fish	No. Prey	Mean Head Capsule (mm)	Standard Error
Boardman	Brown	June	30	116	0.788	0.043
River	Trout	July	14	109	0.639	0.034
(South		Aug.	20	433	0.474	0.048
Branch)		Nov.	16	63	0.785	0.051
Little	Brown	June	1	5	0.213	0.031
Manistee	Trout	July	17	256	0.532	0.015
River		Aug.	13	147	0.575	0.039
		Sept.	5	249	0.583	0.027
		Nov.	13	44	0.985	0.105
Little	Steel-	June	18	163	0.512	0.028
Manistee	head	July	21	193	1.052	0.720
River	Trout	Aug.	13	318	0.457	0.014
		Sept.	3	1580	0.581	0.058
		Nov.	10	21	1.739	0.957
Pere	Steel-	July	12	151	0.512	0.026
Marquette	head	Aug.	2	162	0.458	0.019
River	Trout					
(Little						
S. Branch)						

Table 18. Student-Newman-Kuel's test results for between
month comparison of mean prey headcapsule.
Months with the same letters are not
significantly different.

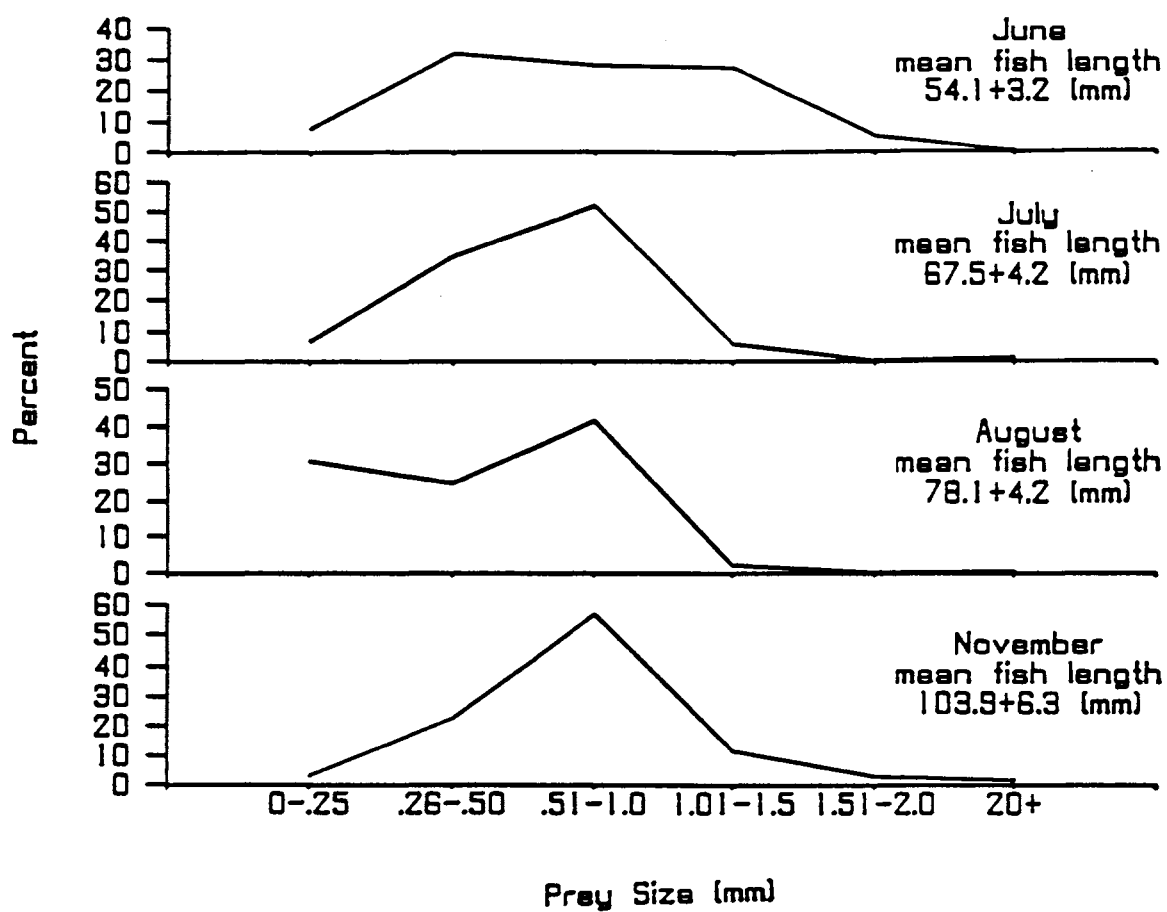| Site	Species	June	July	Aug.	Sept.	Nov.
Boardman River (South Branch)	Brown Trout	A	B	C	–	A
L. Manistee River	Brown Trout	B	B	B	B	A
L. Manistee River	Steelhead Trout	B	B	B	B	A
Pere Marquete River (Little S. Branch)	Steelhead Trout	–	A	A	–	–

Figure 3. Percent composition of diet by prey size for Boardman River brown trout collected on each sampling date.

collected.

Little Manistee River Brown Trout

Brown trout in the Little Manistee River exhibited relatively consistent food habits across the season. Prey taxon overlapped significantly between the July-August and August-September sampling dates (Table 16). Prey size was found to differ from June to November based on a 1-way analysis of variance procedure. Mean headcapsule width was calculated for each date sampled (Table 17). A Student-Newman-Kuels' multiple comparison test found the mean headcapsule width of prey from the July, August, and September sampling dates to not be significantly different from one another (Table 18). However, headcapsule width of prey from the July sampling date were significantly different from samples collected on the other dates. The majority of prey in the diets had headcapsules less than 1.0 mm in width (Figure 1). There did not appear to be a preference for a particular size class of prey except for during the month of August when prey with headcapsules ranging from 0.51 to 1.0 mm were eaten approximately 60% of the time. Therefore, brown trout in the Little Manistee River eat different taxa of prey items but eat the same size class of prey from July to September.

Little Manistee River Steelhead Trout

Steelhead trout in the Little Manistee River ate a wide

variety of taxon and size classes of prey from June to November. Overlap values for comparison of prey taxa from trout collected in June-July and September-November were not significant (Table 16). However, prey taxa did overlap significantly from July to September.

A 1-way analysis of variance on stomach contents indicted that prey size differed across the sampling season. Mean headcapsule widths were calculated for each sampling date (Table 17) and compared with a Student-Newman-Kuels' multiple comparison test. The results of this test found the mean headcapsule width of prey items from the November sampling date to be significantly different from the June, July, August, and September sampling dates (Table 18). The majority of prey found in the diets had headcapsules less than 1.0 mm in width with no particular size class preferentially selected Therefore, steelhead trout in the Little Manistee River exhibit some consistency in food habits between sampling dates but do not preferentially eat particular taxa and size classes of prey.

Pere Marquette River Steelhead Trout

Food habits of steelhead trout were based on a limited sample size (n=14). The size and taxa of prey were consistent between the two dates sampled. Overlap of prey taxa had a value of 0.628 (Table 16) which is significant.

Mean headcapsule widths calculated for each month (Table
17) were not statistically different based on a 1-way
analysis of variance procedure. Prey with headcapsules
less than 1.0 mm in width were eaten most frequently
(Figure 4). Samples from other points in the season may
have allowed a more complete analysis of food habits for
these trout.

DISCUSSION

Although juvenile brown and steelhead trout commonly
co-habit coastal Lake Michigan tributaries little work has
been done to measure relations between these species in
terms of food, space and growth. Results from this study
have been presented in an attempt to describe some aspects
of interactions between juvenile brown and steelhead trout
in the stream environment.

Habitat Utilization

Brown and steelhead trout have been shown to prefer
the same types of stream positions with similar depths,
water velocity, and cover (Jenkins 1969, Slaney and
Northcote 1974, Shirvell and Dungey 1983). The habitat
preferences of juvenile brown and steelhead trout in my
study appeared to support this premise. Both species
whether allopatric or sympatric were most often found
holding positions associated with instream cover,
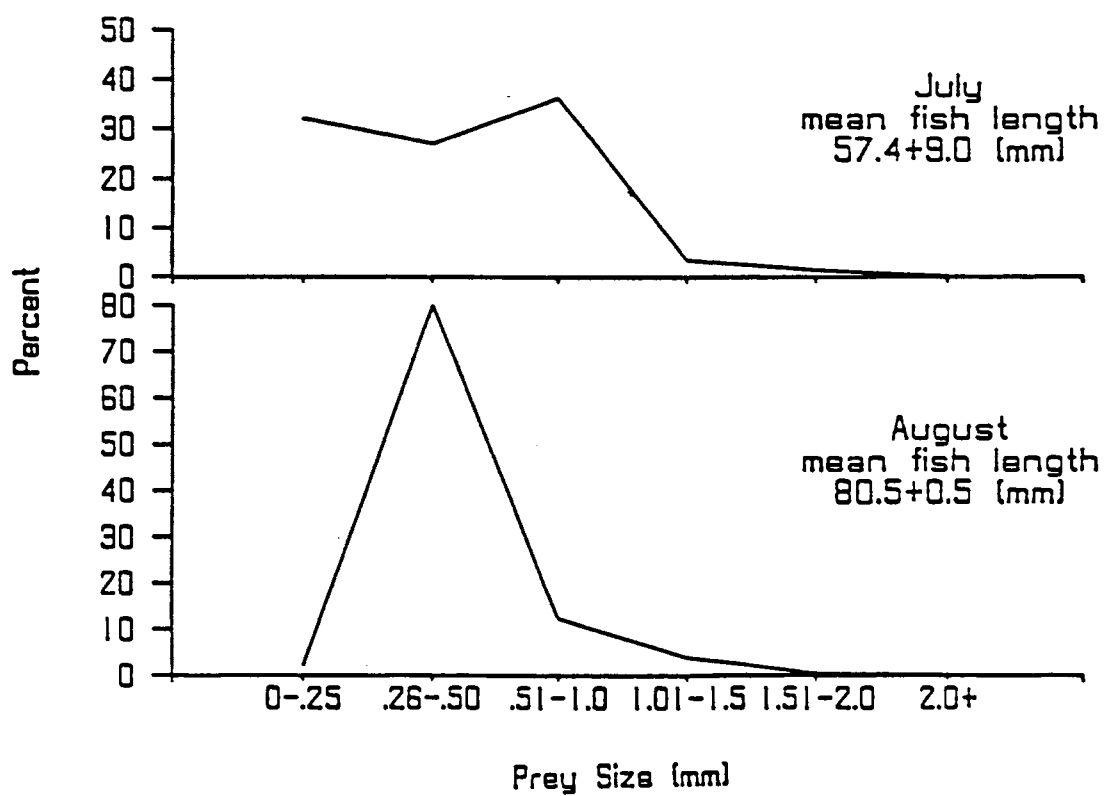
Figure 4. Percent composition of diet by prey size for
           Pere Marquette River steelhead trout collected
           on each sampling date.

particularly down timber.

Previous studies investigating habitat use of brown and steelhead trout have produced the same results. Fausch and White (1981) found brown trout associated with cover more often than in open positions of the Au Sable River. Their results indicated a particular preference for undercut banks, natural log jams, and half log habitat improvement structures. Similarly, Hartman (1965) found densities of young steelhead trout to be highest in the upstream reaches of the Salmon River where much of the shoreline was overgrown and covered with fallen trees. Of the instream cover available in these stretches, large log jams were found to have the largest number of steelhead trout associated with them.

Instream cover is of particular importance to trout because it conceals them from predators and shelters them from current (Devore and White 1978, Hartzler 1983). Mortensen (1977) further demonstrated the importance of cover when he found the natural mortality of age 0 brown trout to be higher in streams where cover was removed than in control streams which were not manipulated. In addition, the association with cover has been shown to become more pronounced when the amount of available cover is limited (Cunjak and Power 1986).

Both brown and steelhead trout have been shown in this and previous studies to have similar habitat preferences.

This similarity has created the potential for interaction and competitive relationships to develop between these two species. If the amount of available habitat is limited changes may occur in habitat utilization when brown and steelhead trout are allopatric versus sympatric with one another. This possibility was investigated by statistically comparing the data collected on stream positions of the trout populations in all three study sections.

The results from the logistic regression were used to evaluate the effect of instream cover and other physical parameters on the spatial distribution of brown and steelhead trout when allopatric and sympatric with one another. Intraspecific comparisons of brown trout from the Little Manistee and Boardman Rivers and steelhead trout from the Little Manistee and Pere Marquette Rivers demonstrated that utilization of instream cover and other physical parameters did not differ significantly between river systems for the majority of variables included in the logistic model. Many times the utilization of a particular type of cover or substrate was so infrequent that its significance is difficult to evaluate. Cover and substrate types included in the model very seldom had r^2 values of 0.25 or greater. Therefore, their contribution to the overall explanation of variance was minimal.

Water depth and velocity were important factors in

differentiating steelhead trout population habitat
preferences in the study sections. Field observations
showed that Little Manistee steelhead trout utilized a
wider range of depths but were on the average observed in
shallower water locations than steelhead trout in the Pere
Marquette River. Stream positions held by individual trout
from both populations were found to have significantly
different average velocity values when the two river
systems were compared. Little Manistee steelhead trout
were found in faster water than steelhead trout in the Pere
Marquette River. However, it is unlikely that depth or
velocity alone are the major limiting factors in habitat
choice for salmonid species. Kennedy and Strange (1982)
found differences in water depth and stream gradient
preferences by sympatric Atlantic salmon and brown trout
but concluded that neither depth or gradient by themselves
could account for the habitat choices exhibited by these
species. It is more likely that the combination of depth
and velocity effects stream position choice. The
differences in depth and velocity measured at the fish's
position in this study may have been a function of
availability which was different between river systems.
The Little Manistee had a higher percentage of open areas
which did not provide shelter from the current and a
steeper gradient than the Pere Marquette study section.

Brown trout in the Boardman and Little Manistee Rivers

did not exhibit habitat preferences which could be utilized
to differentiate between their populations.   The most
important distinguishing factor for these fish was total
body length of the individuals.   Juvenile brown trout in
the Boardman River were significantly larger than those in
the Little Manistee River.   Werner and Hall (1977) have
shown that when two ecologically similar species, bluegill
sunfish (Lepomis macrochirus) and green sunfish (Lepomis
cyanellus), occur in sympatry, bluegill sunfish growth rate
is depressed compared to its growth in allopatry.   Brown
trout are sympatric with steelhead trout in the Little
Manistee River.   Due to the similarity in ecological
requirements of these two salmonids, the presence of
steelhead trout may be the cause of the smaller body size
observed in the Little Manistee River brown trout.
However, analysis of growth did not show a significant
difference between river systems.   Brown trout in the
Little Manistee and Boardman Rivers exhibited average
daily growth rates that were not statistically different
form one another.   Therefore, the observed differences in
total body length for these populations is probably due to
the time of fry emergence or some other system specific
parameter rather than interaction between brown and
steelhead trout.

Interspecific comparisons of sympatric brown and
steelhead trout in the Little Manistee River demonstrated

that utilization of available habitat and other physical
attributes of the trout did not differ significantly
between species for all variables included in the logistic
model, except for distance from the substrate. Brown trout
were only identified correctly 38.8% of the time which
indicates that the variables measured in this study have
the same values for both brown and steelhead trout. In
other words, they appear to have the same habitat
preferences when they co-occur in a river system.

Distance from the substrate was the only environmental
factor that appeared to be helpful in differentiating
between trout species. Steelhead trout occupied positions
with a wider range and higher mean value for distance from
the substrate than brown trout. However, it is unlikely
that this factor alone is essential in determining habitat
choice between these species. This is evident by the fact
that even when utilizing distance from the substrate in the
logistic model brown trout were only correctly classified
approximately 38.8% of the time.

Diet Analysis

Brown and steelhead (rainbow) trout exhibit many
similar dietary habits. Both species feed on drifting and
epibenthic invertebrates and appear to be selective for
particular size classes and taxa of prey (Bryan and Larkin
1972, Tippets and Moyle 1977, Ringler 1979, Nilsson and

Northcote 1981). The food habits of juvenile brown and steelhead trout in my study were similar. Larval aquatic insects belonging to the taxonomic families of Chironomidae and Simuliidae were the most abundant items ingested by juvenile trout in the Pere Marquette, Little Manistee, and Boardman River systems. Both sympatric and allopatric brown and steelhead trout selected and ate the same taxonomic groups of insects.

Similarities in dietary taxon have been reported previously for brown and steelhead trout by Wagner (1975). He found significant correlations between diets of yearling rainbow (steelhead) and brown trout in the Platte River of Michigan. Idyll (1942) also presented results which indicated that for brown and steelhead fry and fingerlings (up to 100 mm) there was no difference in food items found in the stomach contents of both species. In contrast, Johnson (1981) showed that dietary overlap between coexisting yearling brown and rainbow (steelhead) trout was not significant for prey taxon in the stomach contents of these fishes. These results, as well as the results of my study, suggest that similarity in dietary behavior does occur between brown and steelhead trout but it may only be evident at particular life stages or size classes of these species.

Size analysis of diet indicated that mean headcapsule width of prey were not significantly different for brown

and steelhead trout in the Little Manistee and Boardman
Rivers. However, prey ingested by steelhead trout in the
Pere Marquette River were on the average smaller than prey
ingested by trout in the other study streams. The
mechanism behind this difference is unknown as the size
range of available prey was not established through forage
base sampling in the study sections.

Previous studies investigating size selective
predation by brown and steelhead trout have indicated that
the preferences of both species are similar. Bisson (1978)
found that body size was the most important factor
affecting vulnerability of prey to predation by both small
(3 g) and large (45 g) hatchery reared rainbow trout.
Larger individuals within the prey taxa were found to
constitute a greater proportion of the diet than their
proportion in the drift. Invertebrates less than 2 mm in
size were rarely consumed despite the fact that these
smaller size classes constituted the majority of the total
drift. Ware (1972) reported similar results in a
laboratory study where the density and size of prey were
controlled. Four rainbow trout ranging from 134 mm to 170
mm in length were obtained from Marion Lake, B.C. and
observed for feeding behavior in his study. The trout
selected large prey items over small prey items regardless
of the density of each size class in the drift. In
addition, his results demonstrated that rainbow trout were

capable of locating large prey from greater distances than small prey. Ware suggested that visual location of prey was the controlling factor determining the dietary preferences of these fish.

Size selective predation by brown trout has been investigated by Ringler (1979). He designed a laboratory study to determine the effect of prey size, density, and distribution on the feeding behavior of wild brown trout. His results indicated that selective predation by brown trout was most directly related to prey size. Large food items were preferentially ingested over small prey items regardless of the abundance or distribution of the smaller items. Therefore, body size appears to be the most important factor in determining the vulnerability of prey to predation by both brown and steelhead (rainbow) trout.

It is evident from data presented in this study and previous studies that juvenile brown and steelhead trout utilize the same size and taxon of prey resources. This similarity has created the potential for interaction and competitive relationships to develop between these two species. One species may limit the amount or type of prey available to another species and subsequently cause changes in the resource utilization of the subordinate species. Shifts in resource use by species when similar forms are present provide evidence for the action of competition in structuring communities.

Data in this study did not indicate changes in food habits when brown and steelhead trout were allopatric versus sympatric. Therefore, interaction or competition for food resources does not appear to occur.

Temporal segregation of food utilization was investigated by observing seasonal variation in dietary habits. This was accomplished by comparing gut contents of individuals collected from the same populations between sampling dates. Taxonomic dietary overlap was not found to be significant for the majority of between sample comparisons for both allopatric and sympatric brown and steelhead trout (Table 16). However, mean headcapsule width of ingested prey items were not found to be significantly different between sampling dates for all trout populations except Boardman River brown trout. This suggests that size, rather than taxonomy, is the more important factor in the food selection of both brown and steelhead trout in this study. Differences in taxon utilization between sampling dates may be a mechanism which allows coexistence of brown and steelhead trout. However, it is more likely the result of differences in prey availability due to emergence of various aquatic and terrestrial insects. Changes in taxon utilization would only need to occur when these species are sympatric for it to act as mechanism for coexistence. In this study, taxon utilization changed from date to date for both allopatric

and sympatric brown and steelhead trout which indicates these changes were probably due to prey availability.

Conclusions and Future Research

The potential of interaction or competition for stream resources between juvenile brown and steelhead trout exists. Both species ingest the same types and sizes of prey and have similar space requirements. This overlap of resource utilization did not appear to substantially effect the growth and survival of the young-of-the-year trout examined. However, in aquatic systems where resources are limited it is likely that interaction between brown and steelhead trout may affect the population dynamics of one another.

Evidence of a population level response to interaction between brown and steelhead trout was not documented in this study. However, there was a difference in population size structure observed between brown trout in the Boardman and Little Manistee Rivers. Trout measuring 203 mm to 254 mm in length were much more abundant in the Boardman River than in the Little Manistee River. Previous researchers have also observed the same distribution of sizes in the Little Manistee River during the course of their studies (Paul Seelbach, Mich. Dept. Nat. Res.).

Further research needs to be conducted to investigate the possible mechanisms that influence size structure of

trout populations. The results of this study do not indicate a specific population controlling mechanism which influences juvenile trout during their first summer of life. However, interaction between brown and steelhead trout may affect over-winter survival or have more pronounced affects on these species at later points in their life history. Future research should be designed to investigate population controlling mechanisms of brown and steelhead trout and to determine the results of interaction between these ecologically similar species throughout their life history.

Summary

Juvenile brown and steelhead trout in the Little Manistee, Pere Marquette, and Boardman Rivers were found to utilize the same food and space resources. Both species ate primarily chironomid and simulid larvae which were approximately the same size. Steelhead trout in the Pere Marquette River did ingest smaller prey compared to the other trout populations. However, these data were based on a limited sample size.

Analysis of habitat utilization indicated that both brown and steelhead trout are commonly associated with cover, particularly down timber. No major differences in utilization were observed for sympatric versus allopatric populations of these trout. However, differences in

physical parameters such as depth and velocity did allow distinction to be made between trout populations from different rivers. Sympatric brown and steelhead trout were difficult to classify into species categories through the measurement of physical and biological variables as there was little difference in the values of these variables between species.

In general, sympatric populations of brown and steelhead trout did not appear to exhibit niche shifts from those observed for allopatric populations. Growth of both species was the same regardless of their distribution (allopatric or sympatric). The only indication that interaction between these species may have a negative effect is in relative abundance. The abundance of sympatric brown trout diminished across the season and was on the average lower than that of the allopatric population. This observation may be the result of inherent variability in between river comparisons but interaction with steelhead trout may also play a role in the regulation of brown trout populations. In order to evaluate this possibility, it is necessary to manipulate the density of steelhead trout and observe the responses of the sympatric brown trout population.

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