FOOD HABITS OF SMOLT STEELHEAD TROUT, *SALMO GAIRDNERI GAIRDNERI* RICHARDSON, IN THE ALSEA RIVER, OREGON

by

JAMES DAVID MESSERSMITH

A THESIS

submitted to

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1958

APPROVED:

Redacted for privacy

Associate Professor of Fish and Game Management

In Charge of Major

Redacted for privacy

Head of Department of Fish and Game Management

Redacted for privacy

Chairman of School Graduate Committee

Redacted for privacy

Dean of Graduate School

Date thesis is presented January 15, 1958

Typed by Lenora Bond

ACKNOWLEDGMENT

Appreciation is expressed to Mr. Arthur S. Einarsen, Leader of the Oregon Cooperative Wildlife Research Unit, for the opportunity to carry out this study and associated relationships. Appreciation is also extended to Mr. R. E. Dimick, Head of the Department of Fish and Game Management, for his continued encouragement and guidance.

Sincere thanks are given to Mr. Carl Bond, Associate Professor, and Mr. Homer Campbell, Oregon Game Commission, for their invaluable advice, encouragement and critical review of the manuscript.

Thanks are extended to Dr. John Lattin, Instructor in Entomology, for his help and encouragement in insect identification; to Dr. James Oldfield, Associate Professor of Animal Husbandry, for laboratory space and equipment; and to Dr. Lyle Calvin, Agricultural Experiment Station Statistician, for his advice in collection, analysis, and graphical presentation of data.

Grateful appreciation is also due graduate assistants Don Chapman, Howard Horton, and especially Rupert Andrews, who provided assistance whenever needed.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

FOOD HABITS OF SMOLT STEELHEAD TROUT, *SALMO GAIRDNERI GAIRDNERI* RICHARDSON, IN THE ALSEA RIVER, OREGON

INTRODUCTION

General Background

The study of the food habits of smolt steelhead trout, *Salmo gairdneri gairdneri* Richardson, in the Alsea River is a part of an investigation on the life history of Oregon's coastal steelhead. Previous studies by Bali (1) and Chapman (2) have been concerned with the age, growth and migration of steelhead. The program was initiated by the Oregon Cooperative Wildlife Research Unit[1] in 1954, at the request of the Oregon Game Commission, for the purpose of providing factual information necessary for the proper management of these fish.

Initial research was concerned with an analysis of all available steelhead scale samples from Oregon coastal streams in order to determine age and life history patterns. Later, the Alsea River was chosen as a single stream for steelhead life history research because it was considered representative of other coastal streams, and because of its proximity to the Research Unit headquarters at Oregon State College.

---

[1] Oregon State Game Commission, U. S. Fish and Wildlife Service, Wildlife Management Institute, and Oregon State College cooperating.

Description of the Area

Located on the west slope of the Coast Range mountains in Western Oregon, the Alsea River empties into the Pacific Ocean at 44° 25' N. Latitude; 124° 05' W. Longitude at the town of Waldport. Extending inland approximately 41 river miles to the town of Alsea, the main stem branches into the North and South Forks. Fall Creek empties into the Alsea River approximately 13 river miles downstream from the town of Alsea. Approximately 450 square miles are included in the Alsea drainage basin, figure 1.

More complete physiographic data can be obtained from a thesis by Chapman (2).

METHODS AND PROCEDURES

Trapping

Fish to be studied were collected in traps of two basic types placed at four collection sites. The first type, an inclined screen trap, was modified to suit the location and proved very successful in all instances. One such trap was placed beneath the outflow from the Game Commission hatchery intake diversion on the North Fork. This trap, described by Chapman (2, p.6), utilizes a

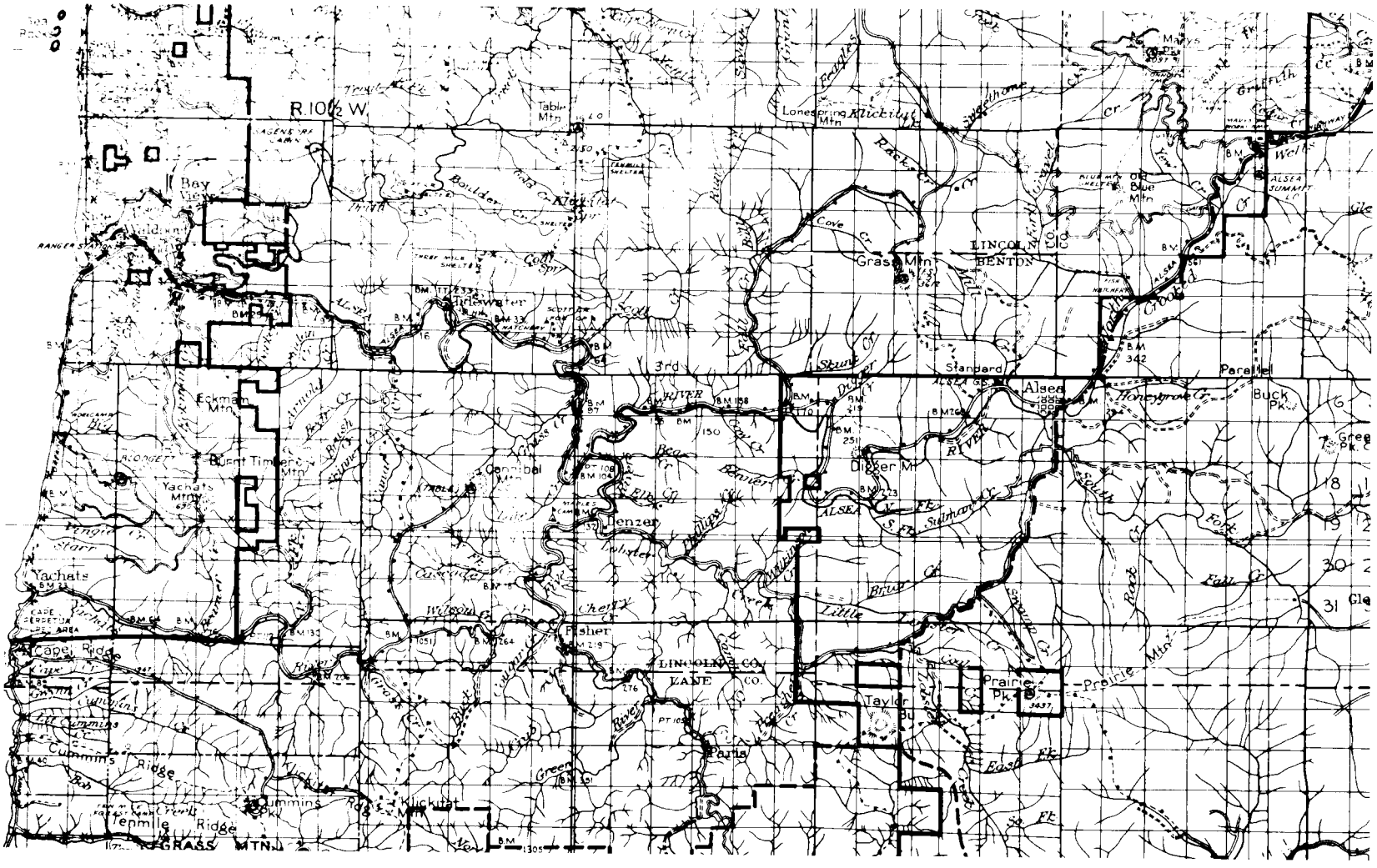


Figure 1. Map of Alsea River Drainage

collecting tube attached to the lower edge of an inclined screen leading into a live box.

Another modification of the inclined screen was used on the South Fork at an irrigation diversion dam about 200 yards upstream from the mouth of Tobe Creek. This type of trap was also used on Fall Creek at the Oregon Fish Commission hatchery diversion dam. These traps, described in detail by Chapman (2, p.7), utilize an inclined screen leading directly into a live box.

The second basic type of trap used was the fyke net. Originally designed to catch adult steelhead, the trap used was of all steel construction, eighteen feet long, ten feet in diameter, with two funnels. The frame and tunnels were covered with heavy gauge two inch mesh screen wire. In order to modify the net for trapping smolt steelhead, the "cod end" was lined with 3/8-inch mesh hardware cloth and the second tunnel with 1/4-inch mesh hardware cloth. For added strength the original screening was left in place. This trap was installed in the lower Alsea River about four miles above tidewater.

The fyke trap was considered to be very successful. In addition to the desired smolt steelhead, hundreds of smolt silver salmon, Oncorhynchus kisutch (Walbaum), and adult lampreys, Entosphenus tridentatus (Gairdner), were caught.

All traps were installed before April 19, 1957 and discontinued shortly after the cessation of downstream migration on June 1, 1957.

Sampling Techniques

Since tagged smolt steelhead were being used in another study, not all of the catch was available for use in stomach content analysis. In order to satisfy project requirements, a method was needed which would provide a representative sample of fish trapped, and be unbiased toward peak days of trapping success.

To determine a collection method within these limits, a statistician was consulted. The following system of collection was initiated: (1) If eight or fewer fish were in the trap, two would be taken. If only one or two were present, one or both would be taken. (2) If nine or more fish were present, every fourth one removed would be collected until a maximum of eight specimens had been taken. (3) Hatchery and wild fish were to be collected independently in the same manner.

Fish taken for stomach content analysis were tagged and preserved in 20 per cent formalin for future reference. The tag number, date, place of capture, and source (hatchery reared or wild) were recorded on standard International Business Machine (I. B. M.) code

sheets.

Collection of Length-Weight Data and Scales

Length-weight data and scales were obtained from each fish before it was tagged and preserved. Data were recorded on I. B. M. code sheets.

Fish length (5, p.108) measurements were taken in one-half centimeter increments to the nearest last increment. For example, if the measured fork length was 18.9 cm., it would be recorded as 18.5 cm.

Smolts were weighed to one-tenth gram on a triple beam balance. Scales were taken from the left side of the fish, anterior to the origin of the dorsal fin, and midway between the dorsal fin and the lateral line. Scales were placed in numbered coin envelopes. Inserts were not used (2, p.18).

Scale Analysis

Scales to be analyzed were examined by means of a binocular microscope prior to mounting so that only non-regenerated scales would be used. All scales were dry-mounted on a glass slide and covered with a cover slip held in place with cellulose tape (2, p.19). These scales were utilized without cleaning. Microslide boxes accommodating 100 slides were used for slide storage.

Scales were examined with a microprojector of 112 diameter magnifications. The number of annuli present were recorded on I. B. M. code sheets. Scale readings were recorded after the first examination unless the reading was classed as doubtful. If readings were still classed as doubtful after the third examination, the data were not recorded.

Techniques of Stomach Collecting and Identification of Contents

Traps were visited every day from the time they were installed until they were removed. This was done so that each fish would be removed and preserved within 24 hours of the time it was trapped, thus minimizing the amount of decomposition that takes place with digestion. Stomachs were not removed until all fish to be used had been collected.

The head and abdominal wall of each fish were removed to expose the stomach. The alimentary tract was severed at its junction with the pneumatic duct, and in front of the most anterior pyloric caecum (figure 2). When free from the rest of the viscera, the stomach was removed and placed in labeled two dram vials of 70 per cent ethyl alcohol for future content analysis.

In stomach content analysis it is of prime

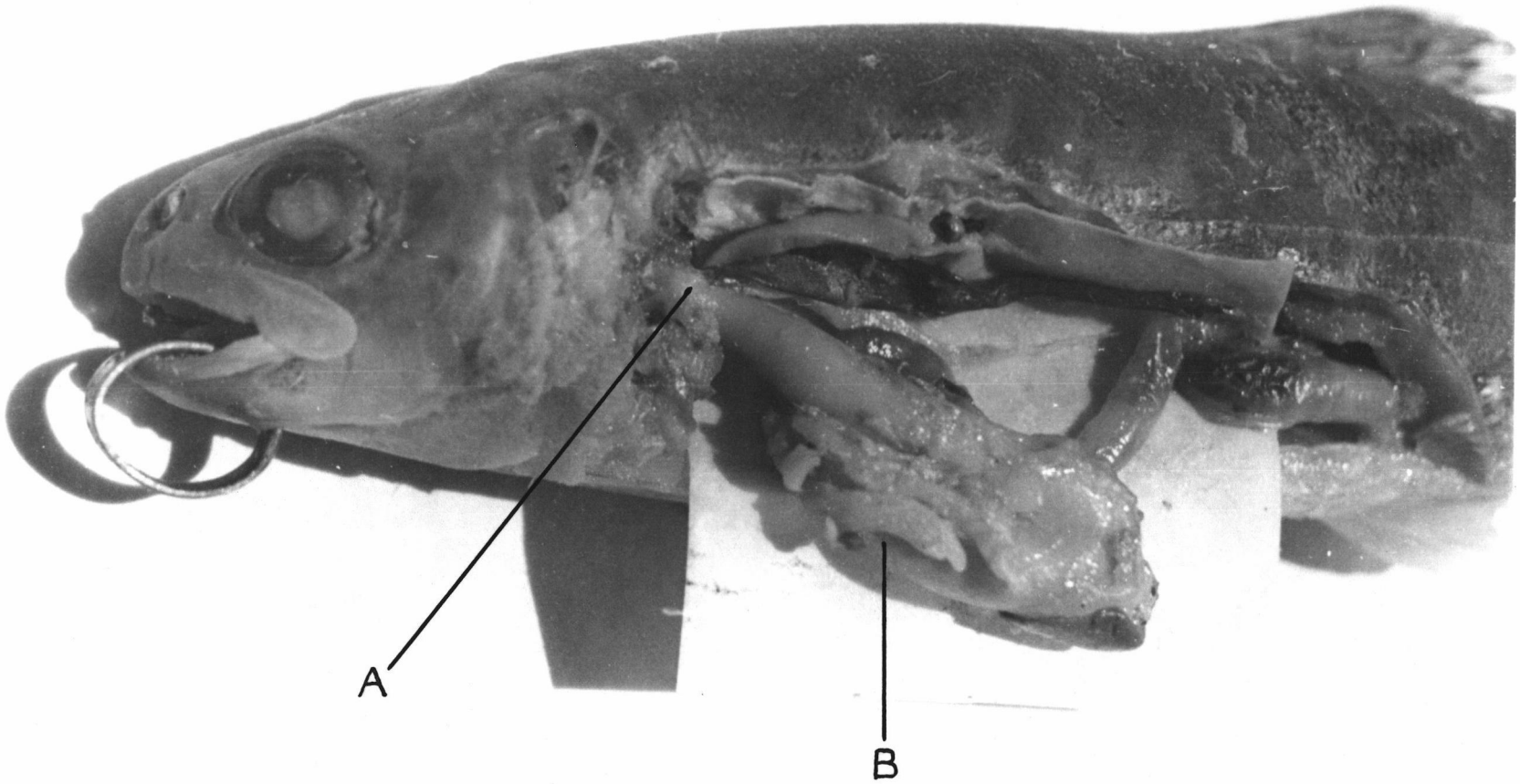


Figure 2. A and B show where cuts were made for stomach removal.

importance to be able to recognize specimens without reference to a key, because in most instances the organism is partially digested and parts needed for keying are missing. In order to become familiar with the aquatic organisms that might be present in the fish stomachs, aquatic insect collections were made in a variety of habitat types above each tributary trap. Insects collected were separated, keyed to family and placed in labeled vials. These specimens were later used to aid in the identification of insects found in fish stomachs.

When the stomach contents of each fish were examined, the organisms present were separated by Order only. Quantities of organisms in each Order were recorded on the I. B. M. code sheets previously mentioned. Quantities of organisms in each family, when identifiable, were recorded on data sheets. Whenever possible, notations were also made of the genera of organisms which occurred frequently.

Taxonomic groups were placed in disposable aluminum weighing pans which had been previously numbered and tared to 1/10 milligram. Pan numbers were recorded and the pan and contents placed in a drying oven. Organisms were dried for 24 hours at 70° Centigrade. This temperature was selected because it was high enough to dry the organisms but not high enough to boil off the fats.

Surber (8, p.256) used dry weights, drying the stomach contents for 24 hours at 60° Centigrade.

At the end of the 24 hour period the pans of organisms were removed and placed in a desiccator to cool. When cool each pan and contents were weighed to 1/10 milligram. The cooling period was not considered critical. Dry weights of the organisms were then recorded on I. B. M. code sheets.

Dry weights were used rather than wet weights because they were considered a more accurate measure of the amount of solids present. Insects to be weighed wet were blotted prior to weighing, introducing an error in degree of dryness to which insects weighed dry were not subjected. In addition, dry weights would be needed for any nutritional studies. As shown in Appendix A, dry weights were, on the average, 25 per cent of the wet weights.

Orders recorded on the I. B. M. code sheets were Coleoptera (Beetles), Diptera (True Flies), Ephemeroptera (Mayflies), Hemiptera (True Bugs), Hymenoptera (Ants, Wasps, Bees, etc.), Plecoptera (Stoneflies), and Trichoptera (Caddis Flies). Organisms not classified in one of these Orders were of infrequent occurrence, and therefore grouped together and recorded as "Other". Vegetable and mineral fragments were weighed and recorded as "Detritus". Unidentified fragments of food organisms were weighed and

recorded as "Unidentified". Organisms classed as "Other" include Arachnida (Spider), Fish, Fish eggs, a fish scale, Collembola (Springtail), Homoptera (Aphid), Hirudinea (Leach), Hydracarina (Water Mite), Lepidoptera (Moths and Butterflies), Oligochaete (Worm), and Neuroptera (Alder Flies).

Methods of Sexing

Sex in individual smolt steelhead was determined by gonadal examination and recorded on I. B. M. code sheets. It was noted that a superficial examination based upon the size and shape of the gonad was sufficient to determine sex. Testes are long and thin, whereas the ovaries are short and thick, often triangular in cross section. Microscopic examination proved this method to be valid. Appendix B contains a record of enlarged ovaries.

ANALYSIS OF STOMACH CONTENTS

Insects Available to Smolt Steelhead

The families of some genera of insects known to be available to smolt steelhead in the North Fork, South Fork, and Fall Creek within the period of this study, April 19-June 1, 1957, are tabulated in table 1. The table is based upon stomach content analysis of 116 smolt

TABLE 1

THE PRIMARY FOOD ORGANISMS AVAILABLE* TO SMOLT STEELHEAD AS SHOWN BY STOMACH CONTENT ANALYSIS AND BOTTOM SAMPLES

Organisms	North Fork	South Fork	Fall Creek	Lower Alsea River	
Coleoptera					
Aquatic					
Dytiscidae	B W	B W	B		
Elmidae				W	
Hydrophilidae					H
Terrestrial					
Anobiidae		W			
Cantheridae					H
Carabiidae	W		W		H
Cleridae		W			
Coccinellidae		W			
Cucujidae			B W		
Ostomidae	W				
Scolytidae	W	W	W	W	
Staphylinidae		W			
Diptera					
Ephydridae	W	B	B W	W	H
Rhagionidae					H
Simuliidae	B W	B W	B W	W	H
Tendipedidae	B W	B W	B W	W	H
Tipulidae	B	B W	B W		
Ephemeroptera					
Baetidae	B W	B W	B W	W	H
Baetis			B W		H
Ephemerella	B W		B W		H
Heptageniidae	B W	B W	B W	W	

* Identified in stomachs from at least one tributary.

Legend
B = Bottom sample
W = Wild smolt stomach
H = Hatchery reared smolt stomach

TABLE 1 (continued)

Organisms	North Fork	South Fork	Fall Creek	Lower Alsea River
Plecoptera				
Perlidae	W	B	B	
Hymenoptera				
Terrestrial				
Formicidae	W	W	W	
Formica	W	W	W	
Chalcididae		W		
Hemiptera				
Corixidae	B W	W		
Trichoptera				
Rhyacophilidae	B W	B W	B W	W H
Rhyacophila	W			H
Hydropsychidae	B W	B W	B W	W
Hydropsyche	B	B	B	H

Legend
B = Bottom sample
W = Wild smolt stomach
H = Hatchery reared smolt stomach

steelhead collected on the tributaries during the study period, and aquatic insect collections made shortly thereafter. Information concerning the number and kinds of smolt steelhead collected, as well as their location of collection are contained in table 2.

Six of eleven aquatic insect families, eaten in the tributaries, were utilized in common. These were

TABLE 2

SAMPLE SIZES USED IN STOMACH CONTENT ANALYSIS

Location	Number Sampled	
	Wild	Hatchery
North Fork Alsea (at hatchery diversion dam)	38	0
South Fork Alsea (200 yards above Tobe Creek)	37	0
Fall Creek (at hatchery weir)	41	0
Lower Alsea River (4 miles above Tidewater)	34	39

Baetidae, Heptageniidae, Simuliidae, Tendipedidae, Rhyacophilidae, and Hydropsychidae. Four of the remaining five were present in all the tributaries but were not eaten in common. Aquatic insects present in the tributaries but not found in any of the stomachs are listed in table 3.

Scolytidae (Bark beetle) and Formicidae (Ant) were the only two of eleven terrestrial families that were eaten on all three tributaries. No attempt was made to collect and establish the presence of remaining families on streams where they were not taken as food.

TABLE 3

FAMILIES AND GENERA OF ORGANISMS PRESENT IN BOTTOM SAMPLES BUT NOT IDENTIFIED IN STOMACHS ON ANY TRIBUTARY

Organism	Location		
	North Fork	South Fork	Fall Creek
Diptera			
Ceratopogonidae	X		X
Dixidae			X
Psychodidae			X
Ephemeroptera			
Baetidae			
Paraleptophlebia	X	X	X
Heptageniidae			
Heptagenia			X
Hemiptera			
Gerridae	X		X
Plecoptera			
Chloroperlidae	X		X
Nemouridae			X
Pteronarcidae	X		X
Trichoptera			
Limnephilidae	X		X
Philopotamidae			X
Rhyacophilidae			
Agapetus or *Anagapetus*	X	X	X
Glossosoma		X	
Rhyacophila	X		X

Unidentifiable Organisms

Examination of the stomach contents of fish not only reveals identifiable organisms, but fragments of organisms which could not be identified under the study conditions. "Educated guesses" could be made concerning the identification of these fragments, but so doing would possibly introduce errors greater than would be introduced by not guessing. To eliminate assumption and to identify as much of the stomach contents as possible, an entomologist was frequently consulted.

For the purpose of analysis the unidentifiable fragments were assumed to consist of the same organisms in the same ratio as did the identifiable foods. These fragments were weighed and recorded as Unidentified in the tables.

However, the assumption may not be valid. Fragments recorded as Unidentified could conceivably be primarily soft bodied organisms which decomposed too rapidly for their identity to be detected. If similar organisms were identified they could be present in different ratios. If the assumption is not valid the analysis of the data is probably incorrect to some degree. However, there is no strong evidence to suggest that the assumption is not valid.

Unidentified fragments ranged from a low of 36.7 per cent of the total contents by weight in the wild smolts in the North Fork to a high of 65.3 per cent by weight, of the total contents, in hatchery reared smolts in the lower Alsea River. On the average, 53.6 per cent, by weight, of the total stomach contents were unidentifiable.

Food Habits of Wild Smolts in the North Fork, South Fork and Fall Creek

General

Numerical data concerning weights, numbers, and per cent occurrence of the organisms utilized by the wild smolts on the North Fork, South Fork and Fall Creek are tabulated in table 4. Per cent number (% No.) and per cent weight (% Wt.) is the percentage of the total identifiable organisms comprising a specific item. Per cent occurrence (% occur.) is the per cent of the stomach samples in which the organism was found.

For simplicity, only the more important food organisms from each tributary will be mentioned. The complete list may be seen in table 4. Organisms considered important are those that make up the bulk of the identifiable stomach contents by weight and by number.

In parenthesis following the name of the organism

TABLE 4

STOMACH CONTENT ANALYSIS OF WILD SMOLT STEELHEAD
FROM NORTH FORK, SOUTH FORK AND FALL CREEK, APRIL 19 - JUNE 1, 1957

Classification	North Fork					South Fork					Fall Creek				
	Avg. No. (No.)	Avg. No. (%)	Avg. Wt. (mg.)	Avg. Wt. (%)	Occur. (%)	Avg. No. (No.)	Avg. No. (%)	Avg. Wt. (mg.)	Avg. Wt. (%)	Occur. (%)	Avg. No. (No.)	Avg. No. (%)	Avg. Wt. (mg.)	Avg. Wt. (%)	Occur. (%)
Ephemeroptera	2.78	22	3.60	13	39	1.45	18	1.22	16	54	4.75	59	3.78	57	46
Hemiptera	0.15	1	0.46	2	13	0.64	8	0.80	11	14	0.02	<1	0.00	0	2
Coleoptera	0.50	4	2.46	9	32	1.27	16	2.30	30	38	0.26	3	0.87	13	17
Trichoptera*	4.26	33	2.50	9	58	1.10	14	0.80	11	41	1.68	21	0.70	10	41
Plecoptera	0.39	3	3.98	14	21	0.40	5	0.92	12	14	0.09	1	0.19	3	12
Diptera	0.42	3	0.16	1	13	2.48	31	0.53	7	38	0.58	7	0.07	2	20
Hymenoptera	0.28	2	1.53	5	16	0.29	4	0.97	13	16	0.12	2	0.91	14	12
Fish Eggs	3.95	31	13.00	47	11	0.00	0	0.00	0	0	0.00	0	0.00	0	0
Other Identified	0.22	1	0.18	<1		0.32	4	0.03	<1		0.57	7	0.10	1	
Total Identified	12.96	100	27.84	100		7.94	100	7.57	100		8.07	100	6.62	100	
Unidentified			16.10					14.09					8.31		

*Weight of the caddis worm less case.

will be three figures. The first figure will indicate the per cent of weight composition; the second, per cent number composition; and the third, per cent of occurrence. Unless otherwise stated, all percentages of weight and number will be with respect to the identifiable stomach contents only. For example: Ephemeroptera (57-59-46) would indicate that at a given locality of collection Ephemeroptera comprised 57 per cent by weight, 59 per cent by number, and occurred in 46 per cent of the stomachs examined.

Table 1 contains a complete list of the genera and families of aquatic and terrestrial insects utilized in the North Fork, South Fork, and Fall Creek.

North Fork

In the North Fork the average weight and number of identifiable stomach contents was 27.84 mg. and 12.96 food items respectively. By weight this represents 63.3 per cent of the total contents. Thirteen per cent of the stomachs examined were empty.

As shown in figure 3 the most important food items were fish eggs (47-31-11), Plecoptera (14-3-21), Ephemeroptera (13-22-39), and Trichoptera (9-33-58). Terrestrial Hymenoptera, Coleptera, Homoptera, and Arachnida (spiders) contributed 14 per cent by weight,

and 6 per cent by number, of the organisms identified.

South Fork

In the South Fork the average weight and number of identifiable organisms was 7.57 mg. and 7.94 organisms respectively. These organisms represent 35 per cent of the total contents by weight. Sixteen per cent of the stomachs examined were empty.

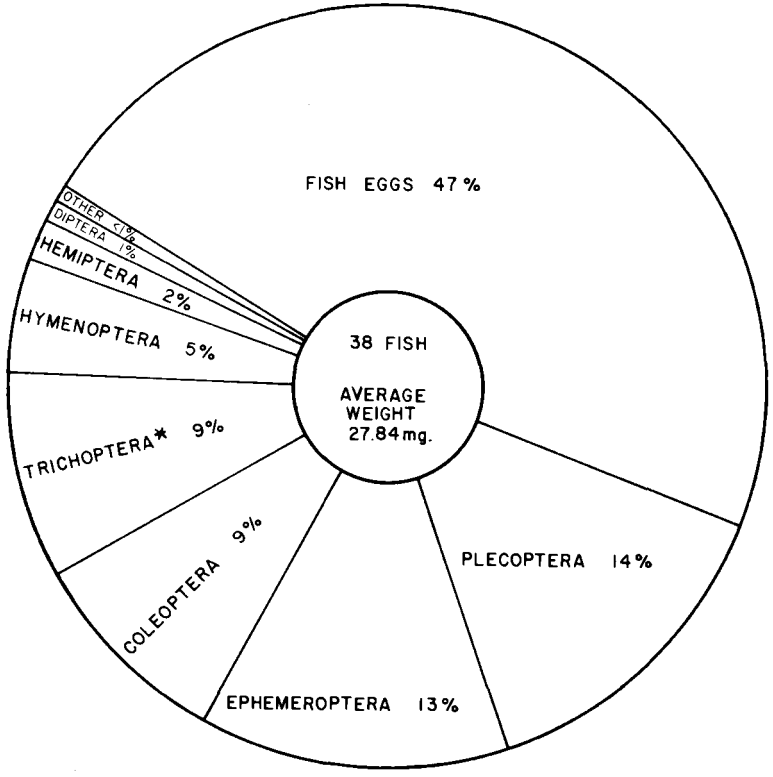
As shown in figure 4 organisms of greatest importance were Coleoptera (30-16-38), Ephemeroptera (16-18-54), Hymenoptera (13-4-16) and Diptera (7-31-38).

Terrestrial Hymenoptera, Coleoptera, Homoptera and Arachnida contributed a combined percentage of 36.5 by weight and 14.5 by number, of the identified organisms.

Fall Creek

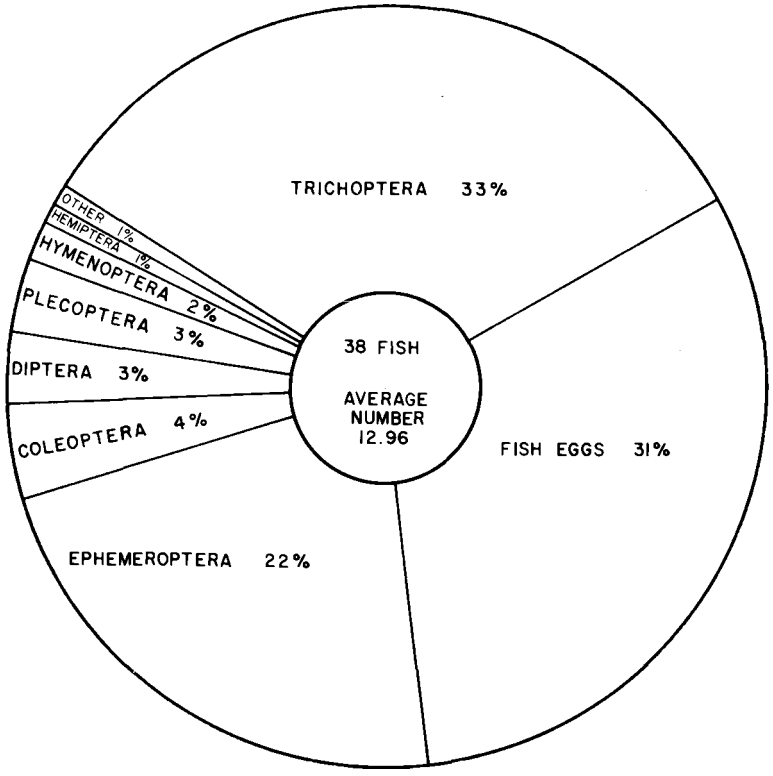
In Fall Creek an average of 6.6 mg., constituting an average of eight organisms were utilized by smolt steelhead. These identifiable organisms represent 44.3 per cent of the total contents by weight. Twenty-four per cent of the stomachs examined were empty.

Figure 5 contains pie diagrams of the identified stomach contents by weight and by number. Ephemeroptera (57-59-56), Hymenoptera (14-2-12), Coleoptera (13-3-17), and Trichoptera (10-21-41) were the most important foods



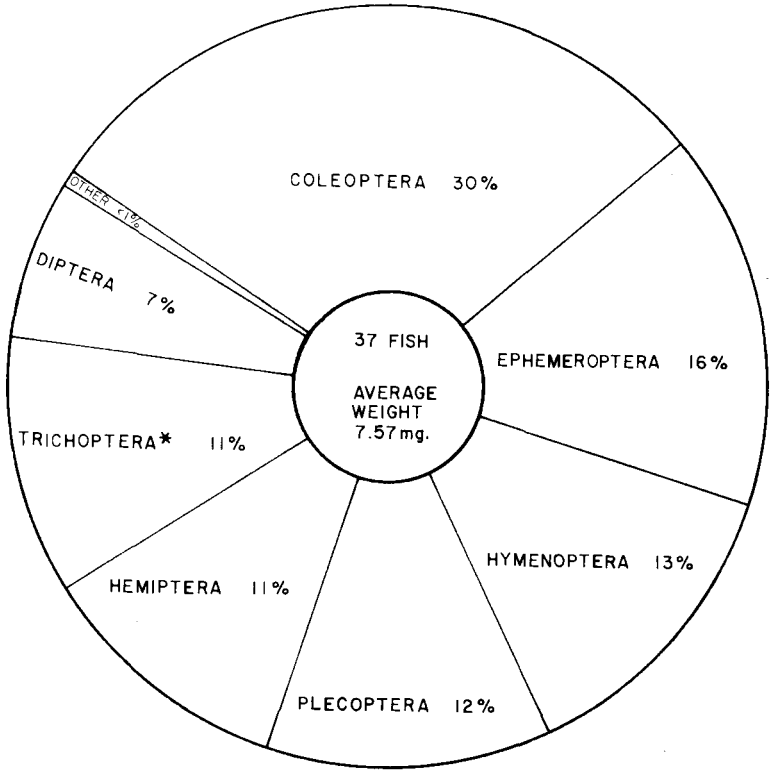
PERCENT OF THE TOTAL WEIGHT OF IDENTIFIED ORGANISMS EATEN. IDENTIFIED ORGANISMS EQUAL 63.3 PERCENT OF THE TOTAL WEIGHT.

* EQUALS WEIGHT OF WORM ONLY.



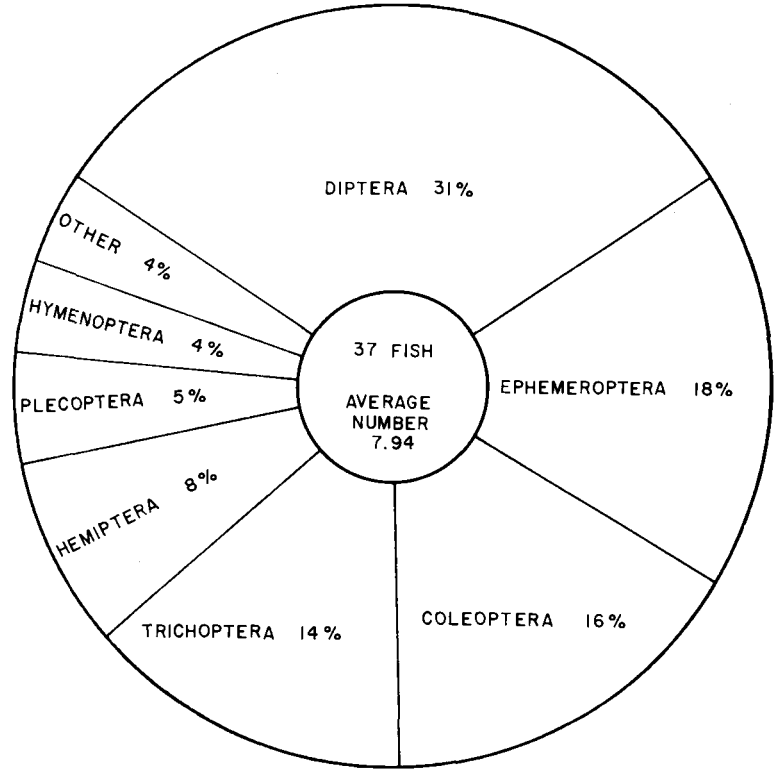
PERCENT OF THE TOTAL NUMBER OF IDENTIFIED ORGANISMS EATEN.

FIGURE 3. FOOD HABITS OF WILD SMOLT STEELHEAD IN THE NORTH FORK, APRIL 19 - JUNE 1, 1957.



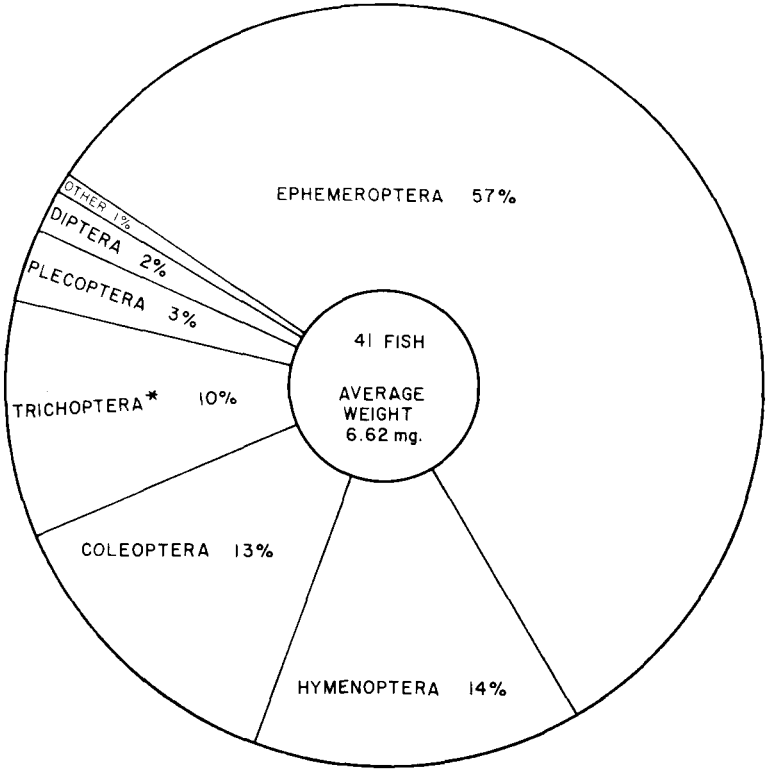
PERCENT OF THE TOTAL WEIGHT OF IDENTIFIED ORGANISMS EATEN. IDENTIFIED ORGANISMS EQUAL 35 PERCENT OF THE TOTAL WEIGHT.

* EQUALS WEIGHT OF WORM ONLY.



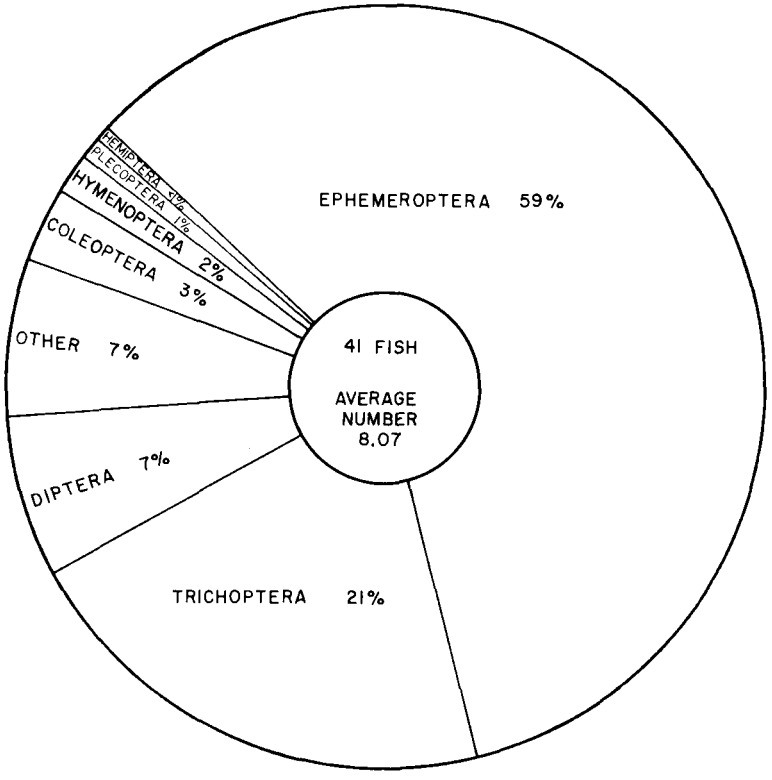
PERCENT OF THE TOTAL NUMBER OF IDENTIFIED ORGANISMS EATEN.

FIGURE 4. FOOD HABITS OF WILD SMOLT STEELHEAD IN THE SOUTH FORK, APRIL 19 – JUNE 1, 1957.



PERCENT OF THE TOTAL WEIGHT OF IDENTIFIED ORGANISMS EATEN. IDENTIFIED ORGANISMS EQUAL 44.3 PERCENT OF THE TOTAL WEIGHT.

* EQUALS WEIGHT OF WORM ONLY.



PERCENT OF THE TOTAL NUMBER OF IDENTIFIED ORGANISMS EATEN.

FIGURE 5. FOOD HABITS OF WILD SMOLT STEELHEAD IN FALL CREEK, APRIL 19 – JUNE 1, 1957.

utilized.

Terrestrial Coleoptera, Hymenoptera, Lepidoptera (butterflies and moths), and Homoptera contributed a combined percentage of 28 by weight and 5.2 by number of the identified organisms.

Comparison of the Food Habits of Wild Smolt Steelhead in the North Fork, South Fork and Fall Creek

Figures 3, 4 and 5 contain pie diagrams which show the percentage composition of the identifiable stomach contents by weight and by number, average weights and numbers of identifiable foods, and the sample size.

It can readily be seen that many different food types are utilized, and that foods of importance in one tributary are not necessarily important in another. Fish from the North Fork ate two and three times more food by weight than did smolts from the South Fork and Fall Creek respectively. Fish eggs (47-31-11) were eaten only on the North Fork. In the South Fork Coleoptera (30-16-17) were of considerable importance by weight, but of much less importance (13-3-38) and (9-4-32) on Fall Creek and the North Fork respectively. In Fall Creek Ephemeroptera (57-59-46) were very important by weight and number. Eighteen per cent of the stomachs examined were empty.

Terrestrial organisms were of varying importance on

the three tributaries, with a contribution range of 14 per cent by weight and 6 per cent by number on the North Fork, to 36.5 per cent by weight and 14.5 per cent by number on the South Fork. This is an average percentage of 20 per cent by weight and 8 per cent by number.

The average per cent composition of the three tributaries indicates that Ephemeroptera (29-33-46) and Coleoptera (17-8-29) are the two most important food organisms by weight. Trichoptera (10-23-47) was second in importance to Ephemeroptera by number, but slightly ahead in per cent of occurrence. Stomach analysis work done by Needham (6, p.120) showed that Trichoptera, contributing 50.54 per cent by number, and Diptera, contributing 36.29 per cent by number, were the two most important foods found in young steelhead stomachs from Waddell Creek, California. The fish he examined had not fed on Ephemeroptera.

Chapman and Quistorff (3, p.2) analyzed 819 steelhead stomachs collected May 14-October 2, 1937 and May 1-October 29, 1938, and found that 17.7 per cent were empty and 20.3 per cent of the contents were terrestrial. Numerically the main foods were grasshoppers, beetle larvae, Diptera larvae and ants.

In an attempt to explain these differences, data from each tributary were examined to determine if a

correlation existed between food habit and age, sex, length, weight or condition of the fish. No correlation could be demonstrated. Since differences between tributaries do exist, and since these differences are probably not due to the factors just mentioned, they must be due to differences in the abundance or availability of potential foods. Also, as Shapovalov and Taft (7, p.105) suggest, differences in food habits may be due to the selectivity of the trout, in that there is sometimes a marked variation in the foods of individuals of the same size taken at the same time and in the same place.

Food Habits of Hatchery Reared Smolt Steelhead and Wild Smolt Steelhead in the Lower Alsea River

General

Numerical data concerning weights, numbers, and per cent occurrence of the organisms utilized by wild and hatchery reared smolt steelhead are tabulated in table 5. A list of the aquatic and terrestrial organisms used as food is contained in table 1.

Wild Smolt Steelhead

In the lower Alsea River 34 wild smolt steelhead consumed an average of 11.57 mg. of identifiable food

TABLE 5

STOMACH CONTENT ANALYSIS OF 34 WILD AND 39 HATCHERY REARED SMOLT STEELHEAD FROM THE LOWER ALSEA RIVER, APRIL 19 - JUNE 1, 1957

	Wild Smolts					Hatchery Reared Smolts				
Classification	Avg. (No.)	No. (%)	Avg. (mg.)	Wt. (%)	Occur. (%)	Avg. (No.)	No. (%)	Avg. (mg.)	Wt. (%)	Occur. (%)
Ephemeroptera	3.41	45	2.98	26	71	5.58	31	2.21	54	90
Hemiptera	0.41	5	0.11	1	6	0.00	0	0.00	0	0
Coleoptera	0.14	2	0.20	1	24	0.10	1	0.13	3	8
Trichoptera*	1.11	15	0.60	5	41	1.20	7	0.30	7	54
Plecoptera	0.20	3	0.21	2	15	0.02	<1	0.31	8	5
Diptera	1.41	18	0.19	1	53	10.23	57	0.61	15	87
Hymenoptera	0.08	1	0.04	<1	6	0.12	1	0.12	3	10
Gastropod	0.76	10	7.00	60	9	0.00	0	0.00	0	0
Other identified	0.07	1	0.41	4		0.65	3	0.40	10	
Total identified	7.59	100	11.57	100		17.89	100	4.08	100	
Unidentified			9.57					7.63		

* Weight of the caddis worm less case.

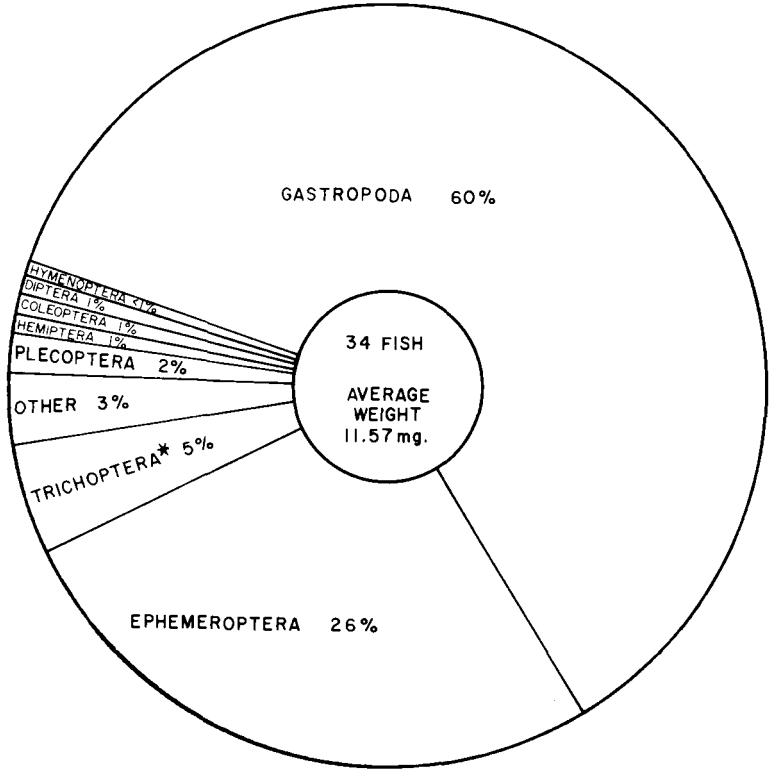
constituting an average of 7.59 organisms per fish. These figures represent 54.7 per cent of the total stomach contents by weight. Twelve per cent of the stomachs examined were empty.

Figure 6 contains pie diagrams showing the per cent identifiable food composition by weight and by number. Organisms that contributed the greatest weight and numbers were Gastropods (60-10-9), Ephemeroptera (26-45-71), Diptera (1-18-53) and Trichoptera (5-15-41). Gastropods (60-10-9) were probably not as important as their weight contribution might indicate, in that they occurred in only 9 per cent of the stomachs examined. It would seem that much of this weight would be valueless, due to the heavy shell, unless fish can use this source of calcium.

Terrestrial Hymenoptera and Coleoptera contributed 1.7 per cent by weight and 2.3 per cent by number of the identified stomach contents.

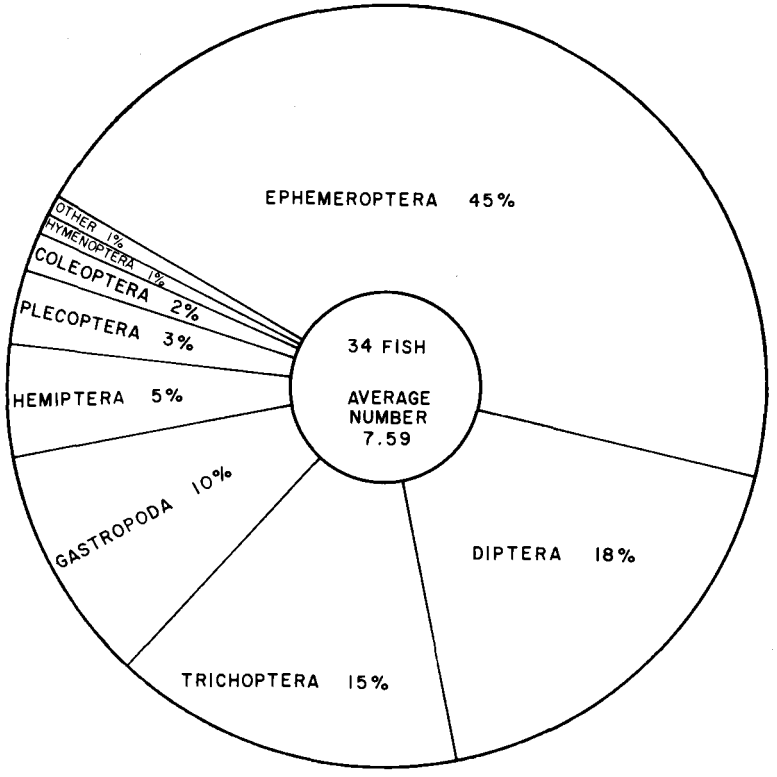
Hatchery Reared Smolt Steelhead

Thirty-nine hatchery reared smolt steelhead were collected in the lower Alsea River 2 to 17 days after release into the North Fork at the Game Commission hatchery. Stomach content analysis revealed that only 34.7 per cent, by weight, of the total contents were identifiable. This was an average of 4.08 mg. or



PERCENT OF THE TOTAL WEIGHT OF IDENTIFIED ORGANISMS EATEN. IDENTIFIED ORGANISMS EQUAL 54.7 PERCENT OF THE TOTAL WEIGHT.

* EQUALS WEIGHT OF WORM ONLY.



PERCENT OF THE TOTAL NUMBER OF IDENTIFIED ORGANISMS EATEN.

FIGURE 6. FOOD HABITS OF WILD SMOLT STEELHEAD IN THE LOWER ALSEA RIVER, APRIL 19 - JUNE 1, 1957.

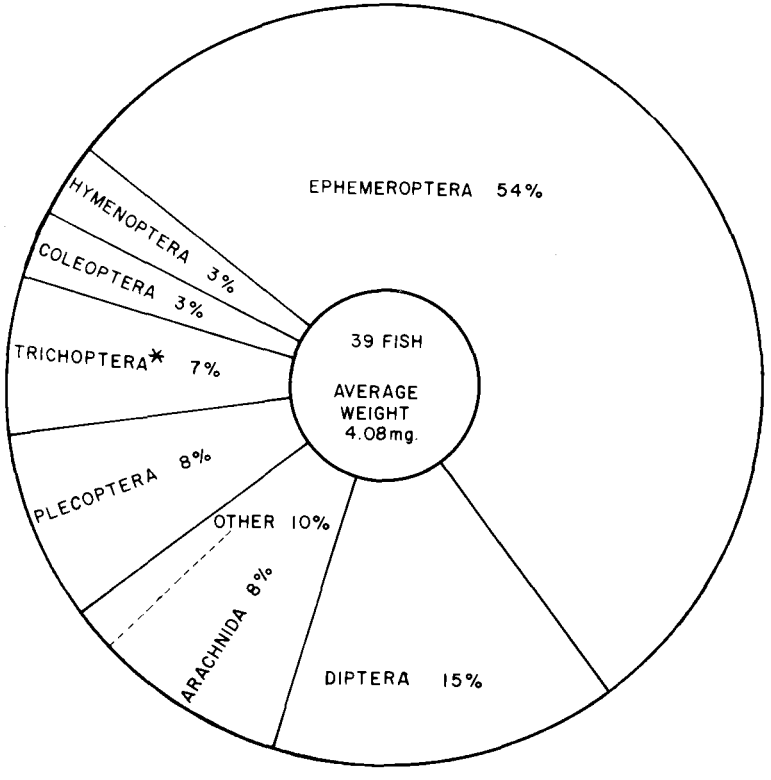
17.86 organisms per fish. Only 3 per cent of the stomachs were empty.

Figure 7 contains two pie diagrams of the per cent composition of the identifiable foods, one of weights and one of numbers. Organisms of the greatest importance were Ephemeroptera (54-31-90) and Diptera (15-57-87). Arachnids (8-2-9) classified under Other were of minor importance.

Terrestrial Hymenoptera, Lepidoptera, Coleoptera, Homoptera and Arachnida made up 12.5 per cent by weight and 3.9 per cent by number of the organisms utilized for food.

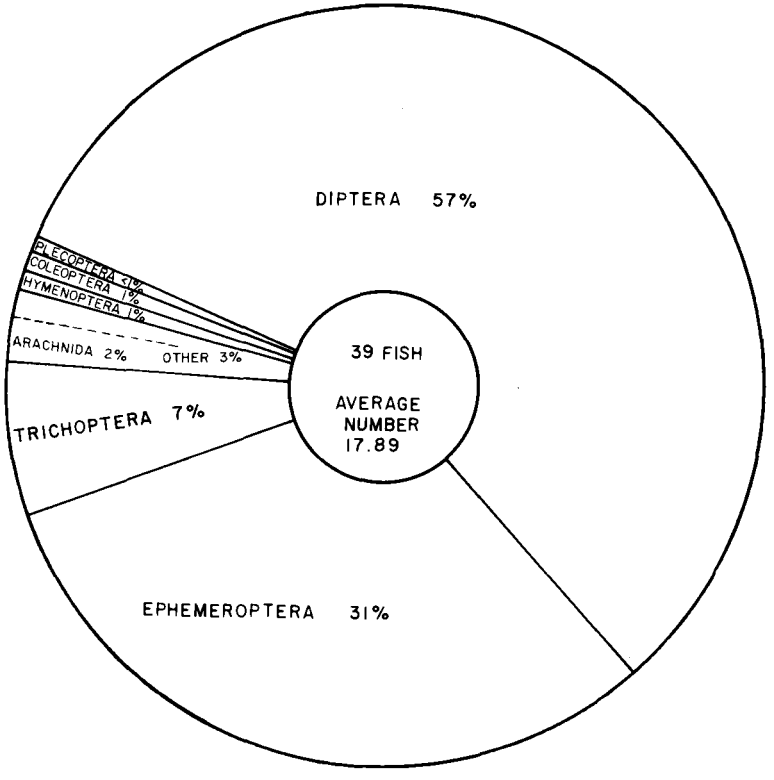
Comparison of the Food Habits of Hatchery Reared Smolt Steelhead and Wild Smolt Steelhead in the Lower Alsea River

A glance at table 5 and figures 6 and 7 will immediately reveal several differences in feeding habits. Numerically the wild smolt steelhead ate primarily Ephemeroptera (26-45-71) while the hatchery reared smolts concentrated on Diptera (15-57-87). Simuliidae (Black flies) and Tendipedidae (Midges) were the two most important Diptera eaten by the hatchery reared smolts. After the stomach content analysis had been completed, bottom samples from hatchery ponds demonstrated that



PERCENT OF THE TOTAL WEIGHT OF IDENTIFIED ORGANISMS EATEN. IDENTIFIED ORGANISMS EQUAL 34.7 PERCENT OF THE TOTAL WEIGHT.

* EQUALS WEIGHT OF WORM ONLY.



PERCENT OF THE TOTAL NUMBER OF IDENTIFIED ORGANISMS EATEN.

FIGURE 7. FOOD HABITS OF HATCHERY REARED SMOLT STEELHEAD IN THE LOWER ALSEA RIVER, APRIL 19 – JUNE 1, 1957.

Diptera, especially Tendipedidae, were exceedingly abundant. By weight, however, Gastropods (60-10-9) were the most important food of the wild smolts and Ephemeroptera (54-31-90) of the hatchery reared smolts.

By concentrating on small organisms the hatchery smolts averaged 11.7 mg. total food compared to 21.1 mg. of food per wild smolt. This would mean that when utilizing the diets shown in the tables, hatchery reared smolts would have to eat 6.69 times as many organisms as the wild smolts in order to consume the same weight of food.

SUMMARY

1. A food study of smolt steelhead (Salmo gairdneri gairdneri) in the Alsea River, Oregon, was conducted April 19 - June 1, 1957 as a continuation of a program of investigation on the life history of Oregon's coastal steelhead.

2. Wild smolt steelhead were collected for stomach content analysis in the North Fork (38), South Fork (37), Fall Creek (41), and in the lower Alsea River (34). Also collected in the lower Alsea River were 39 hatchery reared smolts which had been released 2 to 17 days before collections.

3. Organisms in the smolt stomachs examined were separated by Order, the quantity of organisms in each Order recorded on standard I. B. M. code sheets, and the quantity in each family, and genera where possible, on data sheets.

Food organisms were dried for 24 hours at 70° C., cooled in a desiccator and weighed to 1/10 milligram. The dried weights were also recorded on I. B. M. code sheets. Orders recorded were Coleoptera, Diptera, Ephemeroptera, Hemiptera, Hymenoptera, Plecoptera, and Trichoptera. Additional identified organisms were recorded as Other, vegetable and mineral fragments as Detritus, and unidentified fragments of food organisms as Unidentified.

4. On the average 53.6 per cent, by weight, of the total stomach contents were classified as unidentified. An assumption was made that unidentifiable fragments consist of the same organisms in the same ratio as the identifiable foods.

5. Collections revealed that aquatic insects utilized on any one tributary were present, although not necessarily eaten, on each of the other two tributaries.

6. Smolt steelhead on the North Fork ate two and three times more food, by weight, than did the smolts from the South Fork or Fall Creek respectively. Eighteen per cent

of the stomachs examined were empty.

Terrestrial organisms on the tributaries had a range of importance of 14 per cent by weight and 6 per cent by number in the North Fork to 36.5 per cent by weight and 14.5 per cent by number in the South Fork. A combined average percentage from the three tributaries of 20 per cent by weight and 8 per cent by number was found.

No correlation existed between food habits of the wild smolts and sex, age, weight, length or condition.

7. In the lower Alsea River a comparison was made of the food habits of wild and hatchery reared smolt steelhead. Stomach content analysis showed that 12 per cent of the wild smolts and 3 per cent of the hatchery reared smolts had empty stomachs. This examination also revealed that hatchery reared smolts were eating approximately 55 per cent as much food, by weight, as were the wild smolts. To eat the same weight of food they would have to eat 6.69 times as many organisms as the wild smolts. Terrestrial organisms were of minor importance to the wild fish but made up 12.5 per cent by weight and 3.9 per cent by number of the hatchery reared smolt diet.

8. On the average, by weight, number and by per cent occurrence, Ephemeroptera were the most important organisms utilized by the wild and hatchery reared smolts. Other organisms which ranked high were Coleoptera by

weight, Trichoptera by weight and number, and Diptera by number. The average per cent food composition for the wild smolts by weight, number, and occurrence was Ephemeroptera (29-33-46) respectively, Coleoptera (17-8-29), Trichoptera (10-23-47) and Diptera (4-20-41).

RECOMMENDATIONS FOR NEEDED STUDIES

Several suggestions can be made concerning future studies in or related to food habits of smolt steelhead trout. These suggestions include studies related to food abundance, rates of digestion of selected insects as suggested by Hess and Rainwater (4), and food habits.

The food habit study just completed shows that smolts on different tributaries feed on similar organisms with different degrees of intensity. A study of the relative abundance of the food organisms would help to determine why this is so.

Food habits of hatchery reared smolts prior to release may influence food selection after release. Therefore, hatchery ponds should not be overlooked as a source of aquatic insect food. This is particularly true of dirt bottom ponds, such as those at the Game Commission Hatchery on the North Fork where Dipterous larvae are exceedingly abundant.

It is trite to say that food habit studies are of necessity based upon the results of stomach content analysis. There can be little doubt that better methods of collection, and certainly more accurate analysis of data, could be had if the digestion rates of the food organisms were known. A study of the digestion rates of different food organisms is therefore suggested.

A single food habit study conducted during one part of one year should not be considered conclusive, but merely a beginning. It is suggested that a year-around food habit study of wild and hatchery reared steelhead be conducted in the North Fork. This would help to answer some of the many questions concerning hatchery reared steelhead. For example: Why do some of the released hatchery steelhead not migrate? Is it because of learned habits in the ponds or are there other influences. In this analysis consideration must be given to the direct and indirect influence of the hatchery effluent as a source of fish food and as an influence on insect growth.

BIBLIOGRAPHY

1. Bali, John M. Unpublished manuscript on scale analysis of steelhead trout, Salmo gairdneri gairdneri Richardson, from various coastal watersheds of Oregon. Corvallis, Oregon. Oregon Cooperative Wildlife Research Unit, 1957.

2. Chapman, Donald W. Studies on age growth, and migration of steelhead trout, Salmo gairdneri gairdneri, in the Alsea River, Oregon. Master's thesis. Corvallis, Oregon State College, 1957. 96 numb. leaves.

3. Chapman, W. M. and E. Quistorff. The food of certain fishes of North Central Columbia River drainage, in particular, young chinook salmon and steelhead trout. Seattle, Washington, Division of Scientific Research, Department of Fisheries, 1938. 14 p. (Biological Report No. 37A)

4. Hess, A. D. and J. H. Rainwater. A method for measuring the food preference of trout. Copeia 3:154-157. 1939.

5. Lagler, Karl F. Freshwater fishery biology. Dubuque, Iowa, William C. Brown, 1952. 360 p.

6. Needham, P. R. Notes on the food of trout. California Fish and Game 20(2):119-121. 1934.

7. Shapovalov, Leo and Alan C. Taft. The life histories of the steelhead rainbow trout, Salmo gairdneri gairdneri, and silver salmon, Oncorhynchus kisutch, with special reference to Waddell Creek, California, and recommendations regarding their management. Sacramento, California Department of Fish and Game, 1954. 375 p. (Fish bulletin no. 98)

8. Surber, E. W. A quantitative study of rainbow trout production in one mile of stream. Transactions of the American Fisheries Society 63:251-265. 1933.

9. Usinger, Robert L. (ed.) Aquatic insects of California with keys to North American genera and California species. Berkeley, University of California Press, 1956. 508 p.

APPENDICES

A. Wet Weight-Dry Weight Relationship of Selected Insects

The wet weight-dry weight relationship of selected insects was determined to provide a basis of comparison for those persons who have worked or are working primarily with wet weights. The relationships which follow are based upon single weights or groups of weights of individual organisms, except Diptera which were weighed in two groups of five each.

Organisms to be weighed were removed from 70 per cent alcohol, placed on a dish and blotted with no. 1 filter paper for five seconds. One minute after removal from the alcohol the organisms were weighed to 1/10 mg. in previously tared disposable aluminum weighing pans. The pans with insects were then placed in a drying oven and dried at 70° C. for 24 hours. At the end of the drying period the aluminum pans and insects were removed, allowed to cool in a desiccator and then weighed to 1/10 milligram. The wet and dry weights were recorded on data sheets.

The names of insects used, their average weight, average dry weight, and per cent dry weight are tabulated in table 6 by Order, Family, and Genus. Per cent dry weight is the dry weight expressed as a per cent of the wet weight.

TABLE 6

WET-DRY WEIGHT RELATIONSHIPS OF SELECTED INSECTS

Scientific Name	Number of Organisms	Avg. wet weight (mg)	Avg. dry weight (mg)	% dry weight
Ephemeroptera	8	6.6	1.7	25.7
Baetidae	5	7.5	2.3	30.6
Ephemerella	1	20.1	4.0	19.9
Ephemerella	1	6.6	1.1	16.6
Baetis	1	7.1	*5.5	*77.4
Baetis	1	2.5	0.5	20.0
Baetis	1	1.4	0.6	42.8
Heptageniidae	3	5.2	0.6	11.5
Unidentified sp.	1	3.7	0.4	10.8
Unidentified sp.	1	5.8	0.7	12.0
Unidentified sp.	1	6.2	0.8	12.9
Coleoptera	1	2.4	0.7	29.1
Scolytidae	1	2.4	0.7	29.1
**Trichoptera	3	22.1	4.86	22.0
**Rhyacophilidae	2	25.6	6.2	24.2
**Unidentified	1	0.3	0.1	33.3
***Unidentified	1	2.2	0.9	40.9
***Agapetus*	1	50.8	12.3	24.2
****Agapetus*	1	151.2	87.8	58.0
Hydropsychidae	1	15.0	2.2	14.6
Hydropsyche	1	15.0	2.2	14.6
Diptera	10	1.06	0.16	15.0
Simuliidae	5	1.02	0.14	13.7
Tendipedidae	5	1.1	0.18	16.3
Hymenoptera	3	44.3	16.5	37.2
Formicidae	3	44.3	16.5	37.2
Formica	1	31.3	11.3	36.1
Formica	1	51.2	21.2	41.4
Formica	1	50.3	17.0	33.7

* probably due to error in recording dry weight
** Caddis worm without case
*** Caddis worm with case

Per cent dry weight is used to show the fluctuation that exists in a wet weight-dry weight relationship. These fluctuations may be due to an inability to blot all organisms to the same degree of dryness. This is pointed out by the fluctuations of the per cent dry weight of Baetis, 20.0 per cent and 42.8 per cent. The 77.4 per cent dry weight notation must be discarded since the reading of 5.5 mg. dry weight for Baetis seems too high.

Per cent dry weights, wet weights, and dry weights of Trichoptera and Rhyacophilidae are weights of the caddis worm without case.

The overall per cent dry weight is about 25.6.

B. A Record of Enlarged Gonads and Spawning in Young Steelhead

Two smolt steelhead trout which were collected in traps on the North Fork had gonads of approximately two times as long and three to four times as thick as those of normal smolts. These fish will be referred to as Smolt A and Smolt B.

Smolt A was caught May 12, 1957, weighed 60.3 grams and was 18.5 cm. long. Three eggs of a mature size were enclosed in the ovaries. Scale analysis revealed three annuli and a spawning check at the edge.

Smolt B was collected May 13, 1957, weighed 52.0 grams and was 16.5 cm. long. No mature eggs were present. Scale analysis revealed two annuli and no spawning checks.