Distribution and Abundance of Fish, and Measurement of Available Habitat in the Tualatin River Basin Outside the Urban Growth Boundary

Kevin A. Leader
Michele L. Hughes

Columbia River Investigations Program

Oregon Department of Fish and Wildlife
17330 S.E. Evelyn Street
Clackamas, OR 97015

Funded by

Susan Gries, Project Manager
Tualatin River Watershed Council
1080 SW Baseline, Bldg. B, Ste. B-2
Hillsboro, OR 97123-3823

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ABSTRACT

We conducted fish, habitat, and water quality surveys on four tributaries of the Tualatin River and two reaches of the upper Tualatin River as part of an effort to assess the biotic health of the watershed. We sampled lower, middle, and upper reaches of most streams. Habitat surveys were conducted in summer 1999, whereas fish and water quality surveys were conducted in summer, fall, winter, and spring 1999-2000. Periodic monitoring is needed to ensure that important habitat and existing populations of native fish are protected. We found 13 fish species while sampling in all four streams and the upper Tualatin River. The native reticulate sculpin *Cottus perplexus* was the most abundant and widely distributed species. We found only one introduced species, which contributed 0.1% of the total catch. Native and introduced species moderately or very tolerant of habitat degradation made up 86.6% of the total catch, whereas native species sensitive to habitat degradation accounted for only 13.4% of the catch. Glides were the most common habitat type, and soil was the most common substrate. Little woody debris was found in any stream. Similar surveys will be conducted on an additional six streams in 2000-01. Upon completion of all surveys, various indices of fish community health will be used in conjunction with habitat and water quality information to comprehensively assess fish communities in all 11 streams.

INTRODUCTION

In recent years the Tualatin basin has become increasingly influenced by urban and agricultural development due primarily to the rapid expansion of urban as well as rural growth. The basin currently supports a growing population of more than 350,000 residents. The hydrology and landscape of the basin has been changed by modification of original stream channels and the inundation of natural floodplains resulting from agricultural, industrial, and forest practices (Shively 1993). The Oregon Department of Fish and Wildlife (ODFW), the Tualatin River Watershed Council (TRWC) and the Tualatin Soil and Water Conservation District (TSWCD) are concerned with the affects that these changes have on water quality, fish habitat, and fish assemblages throughout the basin.

In recent years extensive water quality investigations have been conducted throughout the basin (Ervin et al. 1993) though little information concerning aquatic habitat and fish assemblages exists. ODFW has conducted occasional fish surveys of Tualatin tributaries and the Oregon Fish Commission conducted aquatic inventories in 1958-59 (Willis et al. 1960). These inventories were single day events and focused mainly on salmonids and salmonid habitat in the mainstem Tualatin River. From 1993-95, ODFW conducted the first round of comprehensive fish and habitat surveys to establish a baseline condition of 15 streams in the Tualatin basin (Friesen and Ward 1996).

Residential, commercial, and agricultural growth and development continue throughout the Tualatin River drainage. Restoration and preservation efforts of aquatic habitat have been initiated by a number of private and government organizations. Objectives of this study are to (1) seasonally sample throughout the Tualatin River drainage to evaluate the abundance and distribution of fish and crayfish species, (2) conduct aquatic inventory surveys in the Tualatin River drainage to collect information on available aquatic habitat and, (3) identify relationships between aquatic habitat characteristics and fish species abundance in the Tualatin River drainage. In this report we begin to collect baseline information on the current status and condition of fish assemblages and habitat in rural Tualatin River tributaries. These findings will help ODFW meet its goal to maintain optimum populations and distribution of the basin's fish resources to provide the greatest recreational, commercial, economic, and consumptive benefits to future and present generations of Oregon citizens (ODFW 1993).

Study Area

The Tualatin River flows from its headwaters in the Coast Range of Northwestern Oregon to its confluence with the Willamette River at river kilometer 46.1 (Figure 1). The Tualatin River drainage consists of a 712 square-mile area situated west of the Portland metropolitan area, with the majority of the basin being located within Washington County.

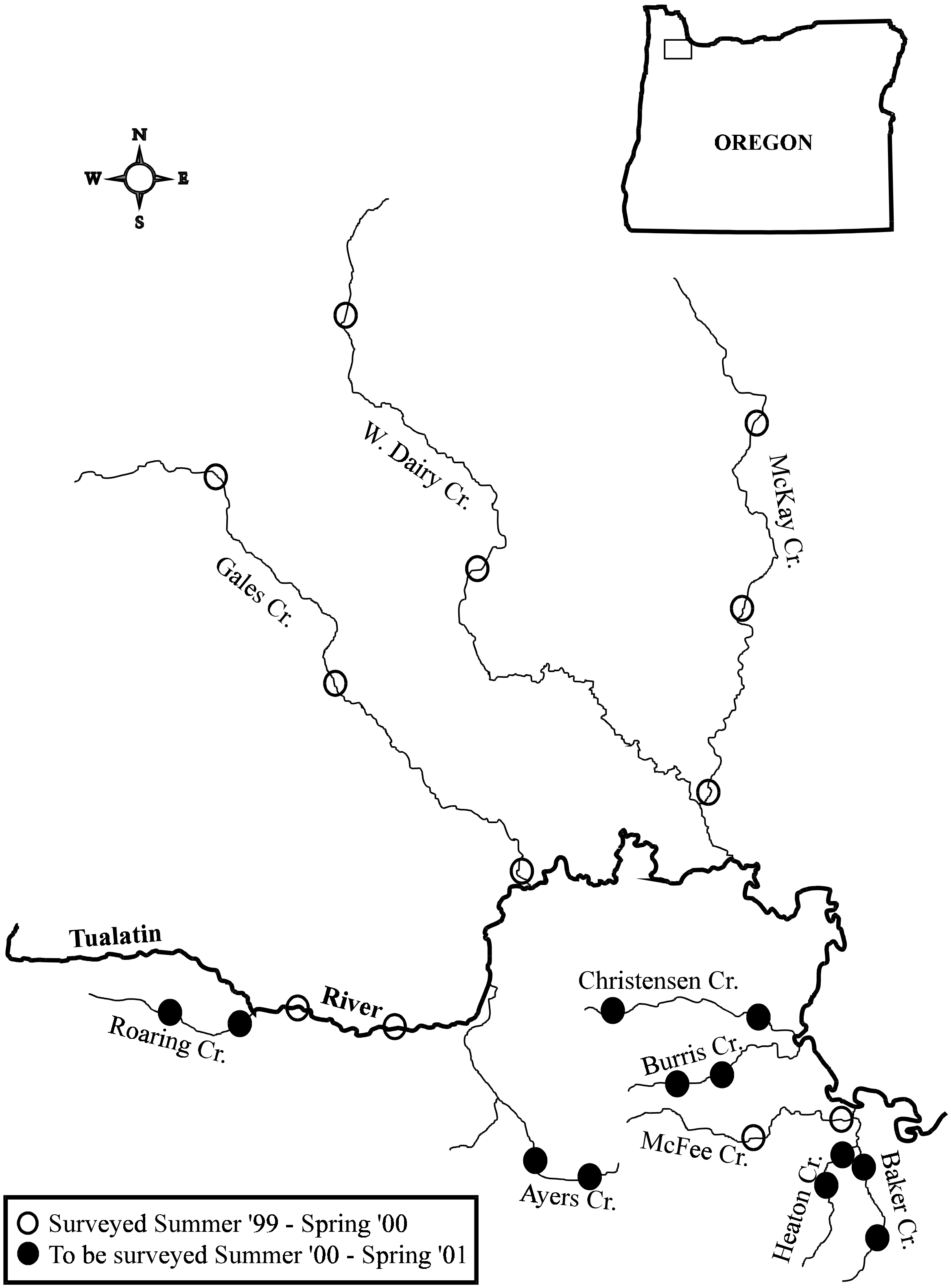

Figure 1. Tualatin River and tributaries surveyed, 1999-2000.

The study area included four tributaries of the Tualatin River (Gales Creek, West Fork of Dairy Creek, McFee Creek, McKay Creek) and two reaches of the upper Tualatin River above the town of Gaston (Figure1; Table 1). We identified and sampled 12 reaches within these streams. The reaches ranged in length from 665-1122 meters (Appendix A), and were generally located near the mouth, middle and headwaters of each stream.

METHODS

Habitat Surveys

During the summer of 1999 we conducted aquatic habitat surveys in each of the twelve stream reaches. We used standardized protocols developed by ODFW to describe and quantify stream habitat. The methods were developed by Bisson et al. (1982) and Hankin and Reeves (1988), and modified by Moore et al. (1993).

We surveyed three reaches each of Gales Creek and McKay Creek and two reaches each of McFee Creek, W. Dairy Creek, and the upper Tualatin River (Figure 1). Using 1:24,000 United States Geological Survey (USGS) maps, we selected two or three reaches of each stream to be surveyed. Reaches were selected to represent lower, middle, and upper sections of the streams. Criteria used to select stream reaches were (1) how well each reach represented the overall stream, (2) ease of accessibility, and (3) the acquisition of landowner permission to access the property on a seasonal basis.

Starting at predetermined point, we described general physical characteristics such as channel and valley form, vegetation class, land use and stream flow. We then walked upstream dividing the stream by habitat types such as pool, glide, riffle, etc. Within each habitat unit we visually estimated unit length and width, percent undercut bank, percent active bank erosion, and percent shade. We measured average depth in all units, with the exception pools, in which we measured maximum depth and depth at pool tail crest. We estimated the percentage of each substrate type within each habitat unit. Substrate types were categorized as silt and organic (silt containing fine sediment often containing a large proportion of organic material); sand (<0.2 cm.); gravel (between 0.2 and 6 cm.); cobble (6 to 25 cm.); boulders; and bedrock. We also noted habitat features such as beaver activity, culverts, and possible fish passage barriers.

Every habitat unit was given a woody debris rating depending on wood composition as it relates to fish habitat. A rating of one to five was given, with one being little or no wood, and five being large amounts of wood creating cover and refuge. In addition, we noted the configuration, type, location, and size of root wads and pieces of wood measuring at least 1.5-3.0 cm in width and 3m in length.

Table 1. Tributaries of the Tualatin River sampled in 1999-2000. Primary tributaries flow directly into the Tualatin River, secondary tributaries flow into primary tributaries. Location of confluence is given as river kilometer of the Tualatin River. Stream order is as defined by Orth (1983).

Stream	Designation	Location of Confluence	Order at Mouth	Main-stem Length(km)
McFee	Primary	45.2	4	13.0
Dairy	Primary	72.1	5	42.2
McKay	Secondary	--	4	30.4
Gales	Primary	91.1	4	42.3

Fish Surveys

To estimate the relative abundance of fish species in each stream reach we used a three-pass removal method (Armour et al. 1983). We selected a 100m section of each stream reach based on how well the section represented the overall reach. A Smith-Root model-12 backpack electrofishing unit was used to conduct the surveys. Depending on water conductivity, the electrofishing unit was set to between 100 and 400 volts. Before starting we placed block nets at the lower and upper ends of the 100m section to ensure population enclosure. We then made three successive passes starting at the downstream end of the stream section and working upstream. During each pass fish were netted and held in a holding tank until the completion of pass. After each pass all fish collected were enumerated, identified to species, measured to the nearest millimeter (a maximum of 50 fish per species), and checked for any anomalies (parasites, wounds, or any other physical abnormalities). Before starting the next pass all fish were released below the downstream block net. If no salmonids were collected during the second pass, a third pass was not conducted. We also collected and enumerated all crayfish during each pass. Fish sampling was conducted once in each stream reach during summer, fall, winter, and spring.

Water Quality

We collected water quality measurements in each stream reach concurrent with fish surveys. We measured conductivity (ns), turbidity (ntu), dissolved oxygen (% sat. & mg/l), salinity (ppt), water temperature (°C), stream velocity (m/s), and total dissolved solids (mg/l). All measurements were collected before electrofishing began and were taken from an undisturbed site with characteristics representative of the entire reach.

RESULTS

Habitat Surveys

Glides (characterized by uniform depth and flow) were the most common habitat type in all lower and middle reaches and in 2 of 4 upper reaches (Figure 2; Appendix B). Pools (low gradient, non-uniform depth) were the next most common habitat type, being found mostly in upper reaches and upper Tualatin River reaches. Riffles (faster flow and higher gradient) were also found predominantly in upper reaches and upper Tualatin River reaches. Rapids (swift, turbulent flow with higher gradient) were the least common habitat type and were only found in upper reaches of Gales Creek, McKay Creek, and the upper Tualatin River. The "Other" category consisted mostly of steps (short units with abrupt, discrete breaks in channel gradient), and were most abundant in upper reaches (Figure 2).

The most abundant substrate type was soil, which consisted of silt/organic material and sand (Figure 2). Soil was the dominant substrate in lower and middle reaches. Rock, a combination of gravel and cobble, was most common in upper reaches and in the upper Tualatin River reaches. Boulder and bedrock substrate were found primarily in upper reaches and the upper Tualatin and comprised a small portion of available habitat.

Actively eroding banks were most common in lower and middle reaches (Figure 3), and comprised more than 50% of the bank in 4 of 12 reaches. Undercut banks comprised less than 20% of the total area in all reaches except lower Gales Creek (27.3%). Shade exceeded 50% in most streams and was similar among lower (63%), middle (60%), and upper (65%) reaches. The index of woody debris was low (<2.0) for all streams and reaches.

Fish Surveys

We conducted 38 electrofishing surveys in 12 stream reaches during summer, fall, winter, and spring, 1999-2000. A total of 3,517 fish were collected representing 13 species and 6 families (Table 2; Appendix C). The number of individual fish collected was highest in Gales Creek (1,103). We also found the most species (12) in Gales Creek. Reticulate sculpin comprised the highest percent of our overall catch (57.2%), followed by cutthroat trout (11.1%), torrent sculpin (9.3%), and speckled dace (5.8%). Introduced species contributed 0.1% of the total catch. Upper reaches contained the highest number of salmonids, whereas the middle reaches had more redside shiners and brook lamprey (Figure 3).

Species moderately or very tolerant of warm temperatures, organic pollution, and sedimentation made up 86.6% of the total catch (Table 2), with the majority of these being reticulate sculpin. Other relatively tolerant species included northern pikeminnow, largescale sucker, and centrarchids (sunfish). The most common species sensitive to habitat degradation were cutthroat trout (11.1%), rainbow trout (1.2%), and coho salmon (0.2%).

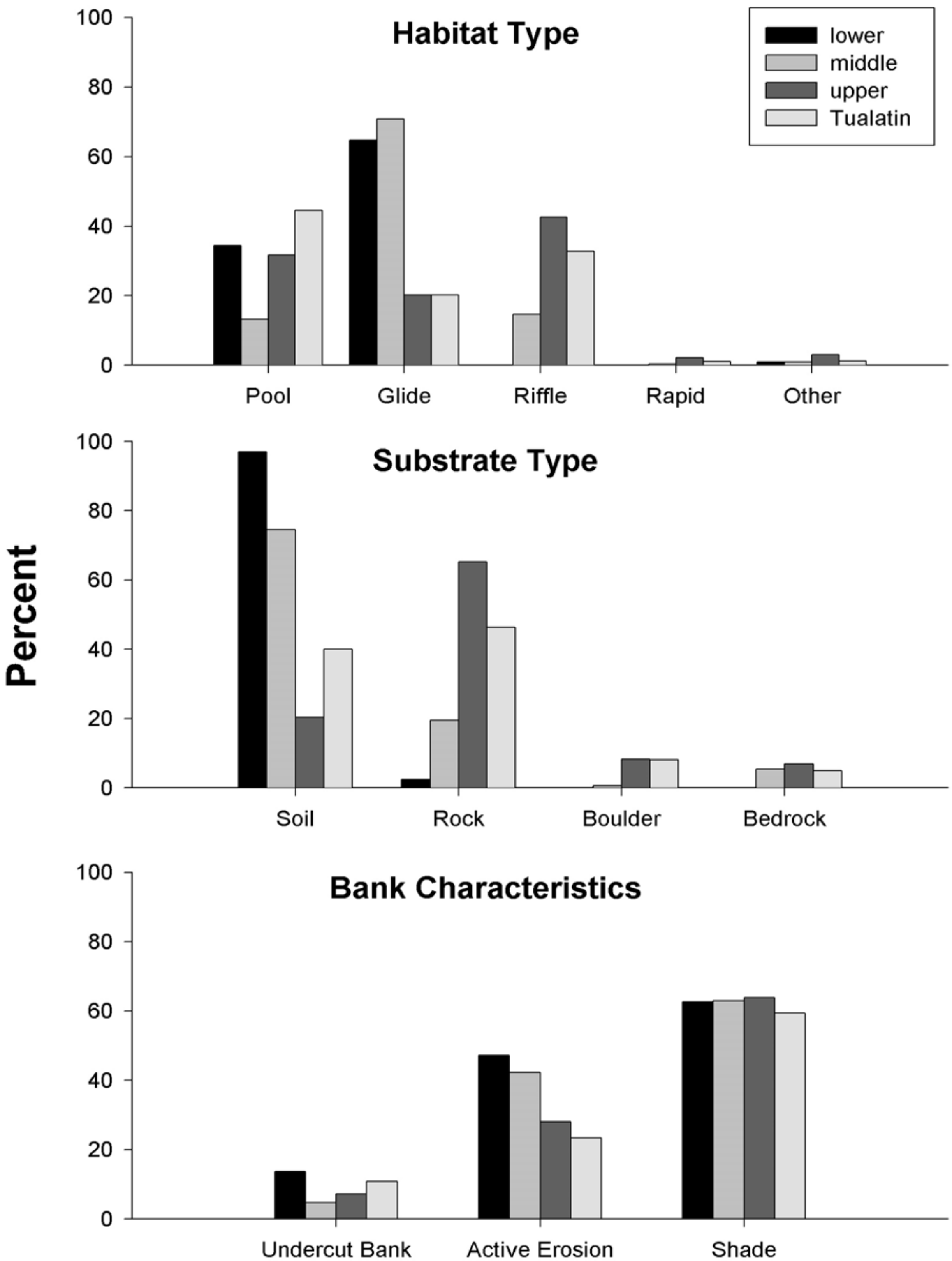

Figure 2. Habitat variables from 10 reaches of 4 tributaries of the Tualatin River and 2 reaches of the upper Tualatin River.

Table 2. Fish collected in 10 reaches of 4 tributaries of the Tualatin River and 2 reaches of the upper Tualatin River in summer, fall, winter, and spring 1999-2000. Relative tolerance and trophic group classifications from Zaroban et al. (1999).

Family, Species	Relative tolerance	Adult trophic group	Percent of Catch	No. of streams (reaches)
Petromyzontidae				
Western Brook lamprey *Lampetra richardsoni*	Intermediate	--[a]	2.4	5 (11)
Unidentified *Lampetra* spp.	Intermediate	--	0.1	1 (2)
Salmonidae				
Coho salmon *Oncorhynchus kisutch*	Sensitive	Insectivore	0.2	2 (3)
Cutthroat trout *Oncorhynchus clarki*	Sensitive	Insectivore	11.1	5 (10)
Rainbow trout *Oncorhynchus mykiss*	Sensitive	Insectivore	1.2	3 (5)
Mountain whitefish *Prosopium williamsoni*	Intermediate	Insectivore	0.1	1 (1)
Unidentified Salmonidae	Sensitive		1.0	4 (5)
Cyprinidae				
Northern pikeminnow *Ptychocheilus oregonensis*	Tolerant	Piscivore	0.2	1 (2)
Redside shiner *Richardsonius balteatus*	Intermediate	Insectivore	5.5	4 (5)
Speckled dace *Rinichthys osculus*	Intermediate	Insectivore	5.8	4 (7)
Longnose dace *Rhinichthys cataractae*	Intermediate	Insectivore	1.0	2 (3)
Catostomidae				
Largescale sucker *Catostomus macrocheilus*	Tolerant	Omnivore	0.7	4 (5)
Centrarchidae[b]				
Unidentified *Lepomis* spp.	Tolerant		0.1	2 (3)
Cottidae				
Reticulate sculpin *Cottus perplexus*	Intermediate	Insectivore	57.2	5 (12)
Torrent sculpin *Cottus rhotheus*	Intermediate	Piscivore	9.3	4 (6)
Prickly sculpin *Cottus asper*	Intermediate	Insectivore	4.2	4 (7)

[a] Adults do not feed
[b] Introduced family

The majority of the fish collected were insectivores (Table 2). The only omnivores found were largescale suckers. Torrent sculpin and northern pikeminnow were the only two piscivorous species collected.

Fish with anomalies were rare and comprised only 1.7% of the total catch (Table 3). Most of the anomalies were in the form of fin damage, scars, and other deformities. Parasites were found mostly during fall sampling. Anomalies were most common in reaches of McKay and Gales creeks, and least common in Dairy Creek and the upper Tualatin River.

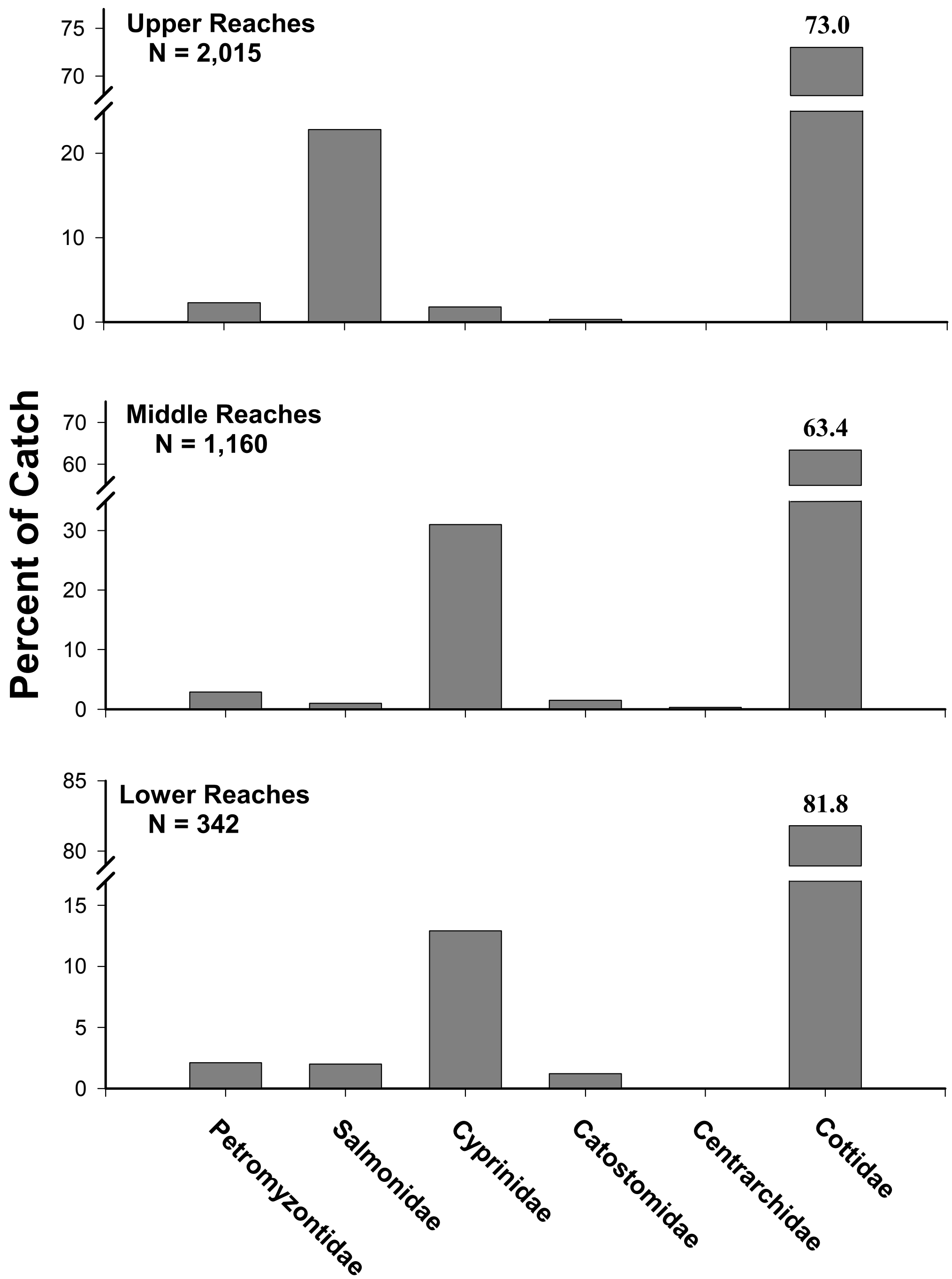

Figure 3. Family composition by reach for fish collected in tributaries of the Tualatin River.

Table 3. Anomalies found in fish collected from four tributaries of the Tualatin River and two reaches of the upper Tualatin River, 1999-2000.

Stream, reach	Anomalies		
	Number of fish (% of catch)	Number with parasites	Number with deformities
Gales			
Lower	2 (1.1)	2	0
Middle	11 (1.6)	7	4
Upper	4 (1.7)	2	2
McFee			
Middle	0 (0.0)	0	0
Upper	17 (2.8)	7	10
McKay			
Lower	7 (4.3)	3	4
Middle	6 (5.0)	1	5
Upper	6 (1.0)	0	6
W. Dairy			
Middle	0 (0.0)	0	0
Upper	8 (2.2)	3	5
Upper Tualatin River			
Middle	0 (0.0)	0	0
Upper	0 (0.0)	0	0

We counted the most crayfish (36) in upper McFee Creek, and the fewest in middle McFee Creek (1). The majority of crayfish were seen in summer (97), followed by spring (28), fall (10) then winter (0) (Appendix C).

Water Quality

Water quality varied among streams and seasons (Appendix D). Summer water temperatures were highest in middle reaches of Gales, McKay, and Dairy creeks, and lowest in the upper reaches of Gales and McFee creeks. Dissolved oxygen levels were highest in the streams with the lowest temperatures. Water temperatures generally dropped during fall and winter, but rose again in spring. We found little variation in pH among streams and seasons (range 7.0-8.0).

DISCUSSION

Species sensitive to habitat degradation (salmonids) were found primarily in stream reaches above obvious signs of habitat degradation. Habitat characteristics associated with these reaches include high gradient, swift water, rocky substrate and a high percent of shade. Important salmonid spawning and rearing habitat is most likely to be found in upper reaches of all streams surveyed.

A few sunfish (unidentified *Lepomis* spp.) were the only fish found that are extremely tolerant of warm temperatures, organic pollution and sedimentation (Zaroban et al. 1999). These individuals were found only in the middle reaches of two streams in summer. Excluding reticulate sculpin, which were found in all 12 stream reaches sampled, species moderately tolerant of habitat degradation were found predominantly in lower and middle reaches. These reaches also contained relatively few sensitive species such as salmonids, which may indicate the presence of factors limiting the production of sensitive species.

Crayfish populations in tributaries of the Tualatin River appear to be healthy. Crayfish were found in all twelve reaches sampled. Observations of crayfish were highest during summer sampling then declined during fall and winter with a marginal increase during spring. The high variability of crayfish counts among seasons was most likely due to changes in flow and turbidity during fall and winter months. In addition, crayfish become completely inactive during winter (Oregon State University Extension Service 1978).

Historically, coho salmon were not found in the Tualatin River basin. However, with the addition of a fish ladder at Willamette falls, the possibility of strays from other basins entering the Tualatin River, and the stocking of hatchery fish, some natural production of coho salmon is occurring in the basin. We observed juvenile coho salmon in reaches of Gales Creek and the upper Tualatin River.

Sustained water temperatures of above 12.8°C are considered too high for salmonid spawning and rearing, and temperatures above 20°C can have detrimental effects on other cold water species (DEQ 2000). None of the reaches sampled were found to have water temperatures above 20°C and only four reaches were above 12.8°C.

Dissolved oxygen levels above 11mg/L are considered adequate to support salmonid spawning and rearing (DEQ 2000). Dissolved oxygen levels were above 11mg/L at 23 of 41 of our seasonal site surveys. Most dissolved oxygen levels above 11mg/L occurred during winter and spring. None of the sites surveyed had dissolved oxygen levels below 5.5mg/L.

Stream pH levels usually range from 6.5 to 8.5, although wide variation can occur because of local watershed geology (DEQ 2000). In all of the sites we sampled pH ranged from 7.0 to 8.0.

We will conduct habitat and fish surveys on an additional six streams (Figure 1) in 2000-01. Habitat surveys will be completed in summer, whereas fish surveys and water quality measurements will be conducted concurrently during summer, fall, winter, and spring.

Information from summer fish inventories in all 11 streams will be used to calculate an index of biotic integrity (IBI; Karr 1981). IBI scores and other measures of fish community health will be used in conjunction with habitat and water quality information to comprehensively assess the condition of fish communities in rural Tualatin tributaries. We can then identify stream reaches that may benefit from restoration and enhancement projects or conservation.

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APPENDIX A

Stream Reach Locations

Appendix Table A-1. Approximate location of reaches designated during aquatic habitat inventories of Gales, McFee, McKay, W. Dairy Creeks, and the upper Tualatin River, 1999.

Stream	Reach	Location
Gales	Lower	Mouth to upstream 1002 meters.
	Middle	Confluence with Clear Cr. to upstream 1000 meters.
	Upper	Confluence with Beaver Cr. to upstream 991 meters.
McFee	Middle	Confluence with Baker Cr. to upstream 1000 meters.
	Upper	Confluence with Gulf Canyon Cr. to upstream 973 meters.
McKay	Lower	Mouth to upstream 1000 meters.
	Middle	Entrance to pond at South Ave. to upstream 1035 meters.
	Upper	Bridge crossing on Collins Rd. to upstream 879 meters.
W. Dairy	Middle	Confluence with Park Farms Cr. to upstream 1008 meters.
	Upper	Confluence with Cummings Cr. to upstream 665 meters.
Tualatin River	Middle	Bridge crossing at Mt. Richmond Rd. to upstream 960 meters.
	Upper	Bridge at SW South Rd to upstream 1122 meters.

APPENDIX B

Habitat Inventory Data

Appendix Table B-1. Habitat summary for reaches of Tualatin River tributaries and upper Tualatin River, summer 1999. L = lower reach, M = middle reach, and U = upper reach. Woody debris is a rating of wood complexity as it relates to fish habitat and ranges from 1 to 5 with 5 being the most complex (Moore et al. 1993).

	Stream					
	Gales			McKay		
	L	M	U	L	M	U
Meters sampled	1002	1000	991	1000	1035	879
Habitat type (%)						
Pool	35.8	9.9	41.1	32.1	24.5	24.7
Glide	63.3	46.2	3.3	67.1	75.0	10.4
Riffle	0.0	40.2	49.1	0.0	0.0	57.3
Rapid	0.0	2.4	5.5	0.0	0.0	0.7
Other	0.9	1.3	1.0	0.8	0.5	6.8
Substrate (%)						
Soil	96.1	5.4	4.6	98.1	100.0	8.4
Rock	3.9	70.5	66.4	1.0	0.0	69.9
Boulder	0.0	1.9	7.9	0.1	0.0	21.3
Bedrock	0.0	22.2	24.1	0.0	0.0	0.5
Bank type (%)						
Eroding	34.4	8.8	16.4	60.1	28.1	8.1
Undercut	27.3	2.4	4.4	0.1	5.5	8.2
Shade (%)	55.7	46.9	67.8	69.6	80.5	85.8
Gradient (%)	0.0	0.8	1.2	0.2	0.0	1.8
Woody debris	1.3	1.1	1.1	1.1	1.3	1.1

Appendix Table B-1 (continued). Habitat summary for reaches of Tualatin River Tributaries and upper Tualatin River, summer 1999. L = lower reach, M = middle reach, and U = upper reach. Woody debris is a rating of wood complexity as it relates to fish habitat and ranges from 1 to 5 with 5 being the most complex (Moore et al. 1993).

	Stream					
	W. Dairy		McFee		Upper Tualatin R.	
	M	U	M	U	M	U
Meters sampled	1008	665	1000	973	960	1122
Habitat type (%)						
Glide	4.4	26.4	11.7	28.4	56.2	38.4
Pool	93.3	36.0	77.0	49.8	26.2	17.1
Riffle	1.9	30.8	9.5	21.6	17.2	41.1
Rapid	0.0	0.0	0.0	0.0	0.0	1.7
Other	0.4	6.8	1.8	0.1	0.4	1.7
Substrate (%)						
Soil	100.0	29.8	91.3	40.5	63.5	20.0
Rock	0.0	66.3	7.7	59.5	35.8	55.5
Boulder	0.0	3.9	1.0	0.0	0.2	14.9
Bedrock	0.0	0.0	0.0	0.0	0.0	9.2
Bank type (%)						
Eroding	71.6	24.9	60.8	59.7	13.5	31.8
Undercut	0.0	10.2	10.7	7.3	5.4	15.6
Shade (%)	71.1	63.9	52.9	40.2	47.9	69.1
Gradient (%)	0.4	1.7	0.4	0.5	0.2	0.6
Woody debris	1.0	1.2	1.3	1.0	1.2	1.2

APPENDIX C

Fish Survey Data

Appendix Table C-1. Number of fish and crayfish collected in reaches of Tualatin River tributaries and upper Tualatin River, summer 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	Gales			McKay		
Species	L	M	U	L	M	U
Western brook lamprey	4	6	0	0	1	2
Unidentified lamprey	0	0	1	0	0	0
Coho salmon	0	0	0	0	0	0
Cutthroat trout	1	0	0	0	2	98
Rainbow trout	0	2	11	0	0	0
Mountain whitefish	0	0	0	0	0	0
Unidentified salmonid	0	0	0	0	0	0
Northern pikeminnow	1	3	0	0	0	0
Redside shiner	32	43	0	0	0	0
Speckled dace	2	40	0	0	1	0
Longnose dace	0	32	0	0	0	0
Largescale sucker	3	2	0	0	0	0
Unidentified Lepomis	0	0	0	0	2	0
Reticulate sculpin	60	112	54	41	57	55
Torrent sculpin	0	5	64	0	0	11
Prickly sculpin	1	2	0	0	0	56
Crayfish	1	7	3	9	1	18

Appendix Table C-1 (continued). Number of fish and crayfish collected in reaches of Tualatin River tributaries and upper Tualatin River, summer 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	W. Dairy		McFee		Tualatin R.	
Species	M	U	M	U	M	U
Western brook lamprey	4	0	6	4	4	0
Unidentified lamprey	0	0	0	0	0	0
Coho salmon	0	0	0	0	0	0
Cutthroat trout	1	44	0	37	0	2
Rainbow trout	0	0	0	3	0	1
Mountain whitefish	0	0	0	0	0	0
Unidentified salmonid	0	0	0	0	0	2
Northern pikeminnow	0	0	0	0	0	0
Redside shiner	0	0	0	0	22	0
Speckled dace	0	0	0	6	7	2
Longnose dace	0	0	0	0	0	0
Largescale sucker	2	0	0	2	0	0
Unidentified Lepomis	1	0	0	0	0	0
Reticulate sculpin	25	89	35	147	60	33
Torrent sculpin	0	17	0	0	0	6
Prickly sculpin	1	30	0	0	5	15
Crayfish	2	7	1	28	5	15

Appendix Table C-2. Number of fish and crayfish collected in reaches of Tualatin River tributaries and upper Tualatin River, fall 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	Gales			McKay		
Species	L	M	U	L	M	U
Western brook lamprey	--	0	2	0	--	0
Unidentified lamprey	--	2	0	0	--	0
Coho salmon	--	0	0	0	--	0
Cutthroat trout	--	0	1	2	--	67
Rainbow trout	--	0	15	0	--	0
Mountain whitefish	--	0	0	0	--	0
Unidentified salmonid	--	0	0	0	--	0
Northern pikeminnow	--	3	0	0	--	0
Redside shiner	--	62	0	0	--	4
Speckled dace	--	46	0	0	--	0
Longnose dace	--	0	0	0	--	0
Largescale sucker	--	12	0	1	--	0
Unidentified Lepomis	--	0	0	0	--	0
Reticulate sculpin	--	26	21	34	--	14
Torrent sculpin	--	11	10	0	--	20
Prickly sculpin	--	9	0	0	--	0
Crayfish	--	0	0	0	--	2

Appendix Table C-2 (continued). Number of fish and crayfish collected in reaches of Tualatin River tributaries and upper Tualatin River, fall 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	W. Dairy		McFee		Tualatin R.	
Species	M	U	M	U	M	U
Western brook lamprey	--	3	0	4	--	0
Unidentified lamprey	--	0	0	0	--	0
Coho salmon	--	0	0	0	--	0
Cutthroat trout	--	11	0	22	--	5
Rainbow trout	--	0	0	2	--	2
Mountain whitefish	--	0	0	0	--	0
Unidentified salmonid	--	0	0	0	--	0
Northern pikeminnow	--	0	0	0	--	0
Redside shiner	--	0	0	0	--	0
Speckled dace	--	0	0	8	--	3
Longnose dace	--	0	0	0	--	0
Largescale sucker	--	0	0	1	--	0
Unidentified Lepomis	--	0	0	0	--	0
Reticulate sculpin	--	20	8	98	--	17
Torrent sculpin	--	8	0	0	--	26
Prickly sculpin	--	10	0	0	--	16
Crayfish	--	0	0	6	--	2

Appendix Table C-3. Number of fish and crayfish collected in reaches of Tualatin River tributaries and upper Tualatin River, winter 1999-2000. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	Gales			McKay		
Species	L	M	U	L	M	U
Western brook lamprey	--	0	0	--	--	0
Unidentified lamprey	--	0	0	--	--	0
Coho salmon	--	0	0	--	--	0
Cutthroat trout	--	0	0	--	--	9
Rainbow trout	--	0	2	--	--	1
Mountain whitefish	--	0	0	--	--	0
Unidentified salmonid	--	0	0	--	--	0
Northern pikeminnow	--	0	0	--	--	0
Redside shiner	--	0	0	--	--	0
Speckled dace	--	48	0	--	--	0
Longnose dace	--	0	0	--	--	0
Largescale sucker	--	0	0	--	--	0
Unidentified Lepomis	--	0	0	--	--	0
Reticulate sculpin	--	27	5	--	--	3
Torrent sculpin	--	15	1	--	--	5
Prickly sculpin	--	0	0	--	--	0
Crayfish	--	0	0	--	--	0

Appendix Table C-3 (continued). Number of fish and crayfish collected in reaches of Tualatin River tributaries and upper Tualatin River, winter 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	W. Dairy		McFee		Tualatin R.	
Species	M	U	M	U	M	U
Western brook lamprey	--	0	--	0	--	0
Unidentified lamprey	--	0	--	0	--	0
Coho salmon	--	0	--	0	--	0
Cutthroat trout	--	2	--	2	--	1
Rainbow trout	--	0	--	0	--	1
Mountain whitefish	--	0	--	0	--	0
Unidentified salmonid	--	0	--	0	--	0
Northern pikeminnow	--	0	--	0	--	0
Redside shiner	--	0	--	0	--	0
Speckled dace	--	0	--	0	--	0
Longnose dace	--	0	--	0	--	0
Largescale sucker	--	0	--	0	--	0
Unidentified Lepomis	--	0	--	0	--	0
Reticulate sculpin	--	3	--	6	--	4
Torrent sculpin	--	1	--	0	--	1
Prickly sculpin	--	0	--	0	--	0
Crayfish	--	0	--	0	--	0

Appendix Table C-4. Number of fish and crayfish collected in reaches of Tualatin River tributaries and upper Tualatin River, spring 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	Gales			McKay		
Species	L	M	U	L	M	U
Western brook lamprey	1	2	0	2	1	6
Unidentified lamprey	0	0	0	0	0	0
Coho salmon	1	0	0	0	0	0
Cutthroat trout	0	0	1	3	1	32
Rainbow trout	0	0	1	0	0	0
Mountain whitefish	0	0	0	0	0	0
Unidentified salmonid	0	1	13	0	0	11
Northern pikeminnow	0	0	0	0	0	0
Redside shiner	8	4	0	0	0	0
Speckled dace	1	31	0	0	0	0
Longnose dace	0	0	1	0	0	0
Largescale sucker	0	1	0	0	0	0
Unidentified Lepomis	0	0	0	0	0	0
Reticulate sculpin	65	126	31	79	56	106
Torrent sculpin	0	6	8	0	0	92
Prickly sculpin	0	0	0	0	0	0
Crayfish	3	0	0	5	2	9

Appendix Table C-4 (continued). Number of fish and crayfish collected in reaches of Tualatin River tributaries and upper Tualatin River, spring 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	W. Dairy		McFee		Tualatin R.	
Species	M	U	M	U	M	U
Western brook lamprey	3	6	5	18	0	0
Unidentified lamprey	0	0	0	0	0	0
Coho salmon	0	0	0	0	0	4
Cutthroat trout	1	14	1	20	0	11
Rainbow trout	0	0	0	1	0	0
Mountain whitefish	0	0	0	0	0	0
Unidentified salmonid	0	7	0	0	0	2
Northern pikeminnow	0	0	0	0	0	0
Redside shiner	15	0	0	0	2	0
Speckled dace	0	0	1	9	0	0
Longnose dace	0	0	0	0	0	1
Largescale sucker	0	0	0	2	0	0
Unidentified Lepomis	0	0	0	0	0	0
Reticulate sculpin	41	82	89	214	16	53
Torrent sculpin	0	10	0	0	1	8
Prickly sculpin	2	0	0	0	0	0
Crayfish	5	1	0	2	1	0

APPENDIX D

Water Quality Data

Appendix Table D-1. Water quality measurements in reaches of Tualatin River tributaries and upper Tualatin River, summer 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	Gales			McKay		
	L	M	U	L	M	U
Turbidity (NTU)	4.0	1.4	0.6	9.5	9.1	1.5
Oxygen saturation (%)	64.7	106.1	110.9	93.5	59.5	119.5
Dissolved oxygen (mg/L)	7.1	11.4	13.1	10.1	6.4	13.2
Temperature (^oC)	11.2	12.3	7.9	11.6	12.2	9.5
Mean velocity (m/s)	1.0	1.1	3.2	3.4	0.6	1.8
Maximum velocity (m/s)	2.5	2.6	7.8	4.9	1.1	5.6
Conductivity (µS)	141.5	101.5	87.8	169.7	269.0	83.0
Total dissolved solids (mg/L)	67.4	48.2	41.6	81.0	129.3	39.3
Salinity (ppt)	0.1	0.1	0.0	0.1	0.1	0.0
pH	--	--	--	--	--	--

Appendix Table D-1 (continued). Water quality measurements in reaches of Tualatin River tributaries and upper Tualatin River, summer 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	W. Dairy		McFee		Tualatin R.	
	M	U	M	U	M	U
Turbidity (NTU)	6.1	3.7	16.7	5.7	1.8	2.9
Oxygen saturation (%)	98.3	105.5	98.2	78.9	97.6	107.0
Dissolved oxygen (mg/L)	10.5	11.8	10.3	9.3	10.5	11.9
Temperature (^oC)	12.4	10.4	9.4	8.5	11.8	11.3
Mean velocity (m/s)	1.3	1.3	0.0	2.2	10.2	2.1
Maximum velocity (m/s)	2.0	3.4	0.0	3.4	19.5	6.1
Conductivity (µS)	106.5	129.6	145.9	93.9	64.4	63.5
Total dissolved solids (mg/L)	50.5	61.7	69.5	44.5	30.4	29.9
Salinity (ppt)	0.1	0.1	0.1	0.0	0.0	0.0
pH	--	--	--	--	--	--

Appendix Table D-2. Water quality measurements in reaches of Tualatin River tributaries and upper Tualatin River, fall 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	Gales			McKay		
	L	M	U	L	M	U
Turbidity (NTU)	--	2.7	0.7	5.1	5.4	3.7
Oxygen saturation (%)	--	106.6	108.4	81.2	87.0	105.4
Dissolved oxygen (mg/L)	--	13.0	13.4	8.4	10.2	12.7
Temperature (^{o}C)	--	6.8	6.2	8.3	8.5	7.4
Mean velocity (m/s)	--	2.4	3.3	1.0	3.4	4.1
Maximum velocity (m/s)	--	4.1	7.5	1.5	3.6	9.6
Conductivity (µS)	--	99.0	88.2	162.8	100.0	82.3
Total dissolved solids (mg/L)	--	47.0	41.8	77.7	107.0	38.9
Salinity (ppt)	--	0.1	0.0	0.1	0.0	0.0
pH	--	7.8	--	--	7.4	--

Appendix Table D-2 (continued). Water quality measurements in reaches of Tualatin River tributaries and upper Tualatin River, fall 1999. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	W. Dairy		McFee		Tualatin R.	
	M	U	M	U	M	U
Turbidity (NTU)	--[a]	1.3	9.9	4.0	2.1	2.7
Oxygen saturation (%)	88.3	89.9	83.1	76.1	106.2	107.5
Dissolved oxygen (mg/L)	10.1	11.5	9.1	9.3	12.5	12.6
Temperature (^{o}C)	9.3	5.2	11.4	6.9	8.4	8.6
Mean velocity (m/s)	--[a]	1.0	0.6	1.4	8.3	6.3
Maximum velocity (m/s)	--[a]	2.2	0.8	2.6	16.7	13.2
Conductivity (µS)	109.2	113.5	112.7	88.2	65.7	66.8
Total dissolved solids (mg/L)	51.9	53.9	53.6	41.7	31.0	31.5
Salinity (ppt)	0.1	0.1	0.1	0.0	0.0	0.0
pH	--	--	7.0	--	--	--

[a] Measurements not taken due to equipment malfunction.

Appendix Table D-3. Water quality measurements in reaches of Tualatin River tributaries and upper Tualatin River, winter 1999-2000. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	Gales			McKay		
	L	M	U	L	M	U
Turbidity (NTU)	--	3.1	5.7	--	--	16.5
Oxygen saturation (%)	--	96.6	90.7	--	--	116.0
Dissolved oxygen (mg/L)	--	12.1	11.4	--	--	12.4
Temperature (^{o}C)	--	5.8	5.4	--	--	6.8
Mean velocity (m/s)	--	4.1	5.2	--	--	6.0
Maximum velocity (m/s)	--	5.9	7.5	--	--	7.2
Conductivity (µS)	--	65.0	64.4	--	--	33.0
Total dissolved solids (mg/L)	--	30.6	30.3	--	--	15.3
Salinity (ppt)	--	0.0	0.0	--	--	0.0
pH	--	7.4	7.5	--	--	--

Appendix Table D-3 (continued). Water quality measurements in reaches of Tualatin River tributaries and upper Tualatin River, winter 1999-2000. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	W. Dairy		McFee		Tualatin R.	
	M	U	M	U	M	U
Turbidity (NTU)	--	4.7	--	12.0	--	2.9
Oxygen saturation (%)	--	93.3	--	92.7	--	94.8
Dissolved oxygen (mg/L)	--	11.4	--	11.3	--	12.2
Temperature (^{o}C)	--	6.7	--	6.8	--	4.9
Mean velocity (m/s)	--	5.3	--	4.4	--	5.2
Maximum velocity (m/s)	--	8.0	--	7.1	--	7.8
Conductivity (µS)	--	17.2	--	45.2	--	56.5
Total dissolved solids (mg/L)	--	7.7	--	21.1	--	26.6
Salinity (ppt)	--	0.0	--	0.0	--	0.0
pH	--	7.4	--	7.3	--	7.7

Appendix Table D-4. Water quality measurements in reaches of Tualatin River tributaries and upper Tualatin River, spring 2000. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	Gales			McKay		
	L	M	U	L	M	U
Turbidity (NTU)	11.3	2.0	1.7	11.3	8.9	3.4
Oxygen saturation (%)	106.6	108.1	106.8	97.8	92.6	106.0
Dissolved oxygen (mg/L)	10.4	11.7	12.3	9.6	9.6	12.9
Temperature (^{o}C)	16.4	11.7	8.5	16.2	15.1	6.9
Mean velocity (m/s)	1.8	2.7	2.0	0.9	0.9	1.5
Maximum velocity (m/s)	2.5	5.6	7.8	1.4	1.3	5.2
Conductivity (µS)	99.5	80.9	74.6	109.1	119.6	47.1
Total dissolved solids (mg/L)	47.2	38.2	35.2	51.8	56.9	22.0
Salinity (ppt)	0.0	0.0	0.0	0.1	0.1	0.0
pH	7.2	8.0	7.9	7.8	7.6	7.7

Appendix Table D-4 (continued). Water quality measurements in reaches of Tualatin River tributaries and upper Tualatin River, spring 2000. L = lower reach, M = middle reach, and U = upper reach.

	Stream					
	W. Dairy		McFee		Tualatin R.	
	M	U	M	U	M	U
Turbidity (NTU)	5.6	2.9	9.4	7.1	5.5	1.6
Oxygen saturation (%)	94.2	102.7	93.9	103.0	108.0	113.3
Dissolved oxygen (mg/L)	9.3	11.8	10.2	12.3	11.0	12.5
Temperature (^{o}C)	15.6	9.8	11.7	12.1	11.6	10.9
Mean velocity (m/s)	0.9	1.2	2.0	2.0	6.0	3.6
Maximum velocity (m/s)	2.5	2.5	2.4	3.4	9.3	7.3
Conductivity (µS)	73.2	64.4	81.8	60.8	62.2	68.0
Total dissolved solids (mg/L)	34.5	30.3	38.7	28.6	29.3	32.1
Salinity (ppt)	0.0	0.0	0.0	0.1	0.0	0.0
pH	7.5	7.4	7.2	7.4	7.4	7.7