

Status and Condition of Fish Assemblages in Streams of the Tualatin River Basin, Oregon

Abstract

We conducted fish inventories at 38 sites on fifteen streams of the lower Tualatin River Basin as part of a study to document fish species and assess the impacts of urbanization on native fish assemblages. We used three-pass electrofishing techniques to survey each site in spring, summer, autumn, and winter. We collected 25 species of fish from ten families; twelve species from five families (6.3% of the total catch) were exotic to Oregon. Reticulate sculpin *Cottus perplexus*, a native fish tolerant of habitat degradation, comprised 68.4% of the catch. Number of species per stream ranged from 5 to 15; number of native species ranged from 4 to 10. Sites in the upper sections of streams contained the largest number of trout, native minnows, and sculpins, whereas lower sites contained more diverse species assemblages and a larger number of introduced fish. We found a significant difference in the number of native species among sites of different stream order, but no significant difference when all species were considered. Our catch also varied seasonally, likely due to species motility, gear selection, and variation in life history stages. Native species intolerant to habitat disturbances (torrent sculpin *Cottus rhotheus* and *Oncorhynchus* spp.) comprised only 1.7% of the total catch, and 2.0% of the total catch exhibited parasites or physical anomalies. The relatively low number of intolerant species, high proportion of fish with parasites or anomalies at some sites, introduction of exotic species, and reported habitat deficiencies suggest that native fish assemblages in the basin are at least moderately unhealthy.

Introduction

Like many river systems near urban areas, the Tualatin River and its tributaries within the urban growth boundary near Portland, Oregon, have undergone substantial changes in water quality, fish habitat, and fish assemblages. Agricultural practices, sewage treatment plant discharges, water allocation, and urbanization are all factors that may contribute to diminished water quality. The hydrology of the Tualatin River Basin has changed significantly with logging practices and the urbanization of natural floodplains (Shively 1993). The Tualatin River Basin has been the subject of intensive water quality investigations in recent years (Wolf 1992; Ervin et al. 1993; Miner et al. 1993), and the U. S. Environmental Protection Agency sampled fish, benthos, and habitat at several sites in 1982 (R. M. Hughes, unpublished data). Results of fish assemblage surveys have not been previously published, and the long-term effects of habitat disturbances on fish may never be known.

Historic information regarding fish assemblages in the Tualatin River Basin is scarce. Past surveys focused primarily on salmonids, with other species usually referred to as "rough fish" or even "trash fish." A report by the Oregon State Game Commission in 1963 addressed the need to document species other than salmonids, and included

some basic fish distribution data (Hutchison and Aney 1964). Dimick and Merryfield (1945) conducted extensive surveys of fishes of the Willamette River system, including some limited sampling of the Tualatin River and its tributaries. The Oregon Department of Fish and Wildlife (ODFW) has continued to perform occasional fish inventories, but information generally is limited to single day, non-replicated samples in the mainstem Tualatin River. In addition, consulting firms occasionally conduct site-specific fish surveys near construction or mitigation projects. Li and Gregory (1993) identified the need for a coordinated effort to survey all fish populations in the watershed.

The Tualatin River currently supports a significant warmwater fishery in its lower reaches, and limited opportunities for trout *Oncorhynchus* spp., including steelhead *O. mykiss*, in the upper reaches and tributaries. Once extensively stocked with hatchery trout, the basin now is being managed primarily for wild trout production. Approximately 60,000 coho salmon *O. kisutch* and 10,000 steelhead are planted annually as mitigation for the construction of a dam in the upper watershed (ODFW 1993).

This paper is part of a cooperative study by ODFW and the Unified Sewerage Agency of Washington County to evaluate the effects of urbanization on

fish populations of the basin. Our objective is to document fish species and describe their relative abundance in streams of the Tualatin River Basin within the urban growth boundary near Portland, Oregon. We also examine species assemblages as possible indicators of degraded water quality and habitat. This information may help managers identify areas requiring protection because of the presence of native fish species intolerant of environmental degradation.

Study Area

The Tualatin River flows easterly from its headwaters in the Coast Range of northwestern Oregon to its confluence with the Willamette River at river kilometer 46.1 (Figure 1). Portions of all streams we studied flow through the urban growth boundary near Portland, Oregon. These streams are characterized by low gradient, heavy siltation, seasonal flooding, and temperature extremes, especially in the lower reaches (ODFW, unpublished data).

We identified 38 sites in the fifteen streams to be sampled (Figure 1; Table 1). Sites were 100 meters long and were selected based on accessibility and proximity to concurrent habitat surveys (Neill et al. 1995). We generally identified one site near the mouth of each stream and one site near the headwaters. In larger streams, we identified an additional site between the upper and lower sites. Sites are referred to by stream and relative location (lower, middle, or upper) throughout this paper.

Methods

We used electrofishing equipment to conduct three-pass-removal sampling of fish populations (Armour et al. 1983; Riley and Fausch 1992) in spring (April-May), summer (July-August), and autumn (October-November) 1994, and winter (January-February) 1995. The ends of each 100-meter site were blocked with nets to ensure population enclosure, except in autumn and winter, when we were unable to use block nets because of high stream flows. We sampled downstream to upstream using a model 12 Smith-Root backpack electrofisher. Voltage, pulse rate, and pulse width settings varied depending on water conductivity and fish recovery.

After each pass, specimens collected were counted, identified to species, and inspected for

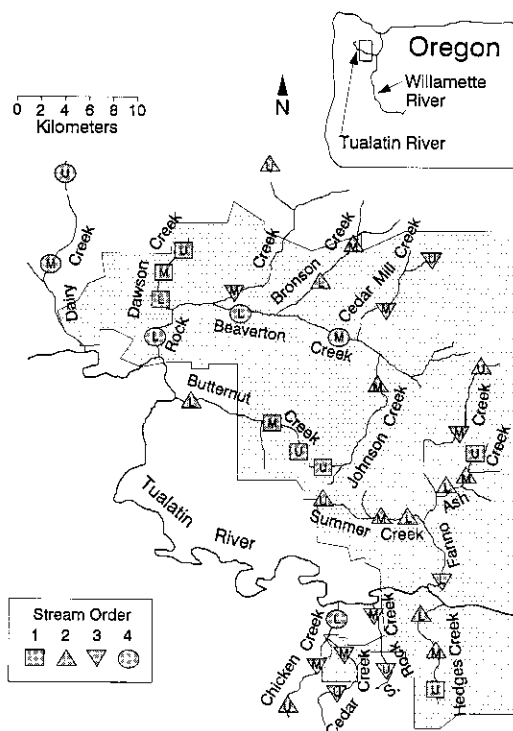


Figure 1. Streams of the Tualatin River Basin sampled in 1994-95. Stream order determined by methods described by Strahler (1957); minor tributaries not shown. Shaded area approximates urban growth boundary of Washington County, Oregon. L = Lower, M = Middle, U = Upper.

parasites or physical anomalies. We measured (fork length to nearest millimeter) up to 100 individuals of each species. To reduce mortality, we returned all fish to the stream below the downstream end of the site prior to the next pass.

We determined origin (native or introduced) and relative tolerance of organic pollution, warm water, and sedimentation (Hughes and Gammon 1987) for each species collected. For species not described by Hughes and Gammon, we determined tolerance assignments from species descriptions in Scott and Crossman (1973), Moyle (1976), and Wydoski and Whitney (1979).

We summarized our catch by species and family and constructed a site-species matrix to compare the relative occurrence of species among different streams, sites within streams, and stream orders. The number of species usually increases with increasing stream order in undisturbed waters (Lotrich 1973; Kuehne 1962; Moyle and Cech

TABLE 1. Streams of the Tualatin River Basin surveyed in 1994-95. L = Lower, M = Middle, U = Upper.

Creek	Mainstem length (km)	Number of sites (Location)	Sites sampled by season			
			Spring	Summer	Autumn	Winter
Hedges	3.8	3 (L,M,U)	3	2	2	2
Fanno	21.7	3 (L,M,U)	3	3	3	2
Ash	5.7	3 (L,M,U)	3	3	3	3
Summer	5.2	3 (L,M,U)	3	3	2	3
South Rock	8.4	2 (M,U)	2	2	2	0
Chicken	9.7	3 (L,M,U)	3	3	3	2
Cedar	10.9	2 (M,U)	2	2	2	1
Butternut	8.4	3 (L,M,U)	3	3	3	2
Rock	28.7	3 (L,M,U)	3	2	1	1
Dawson	6.5	3 (L,M,U)	3	2	1	1
Beaverton	15.3	2 (L,M)	2	2	1	0
Bronson	10.7	2 (L,M)	2	2	2	2
Cedar Mill	9.5	2 (M,U)	2	2	2	2
Johnson	6.3	2 (M,U)	2	1	1	1
Dairy	42.2	2 (M,U)	2	2	1	0

1988). To assess the degree of disturbance in the Tualatin River Basin, we used the Kruskal-Wallis test (Sokal and Rohlf 1981) to compare the mean number of species present among stream orders.

We examined seasonal trends in the relative abundance of various species, and constructed length-frequency histograms for eight commonly observed species to determine whether recruitment affected seasonal variation in the number of these species. We also described the general distributions of intolerant and introduced species. We determined the percent of fish exhibiting parasites or anomalies as a possible indicator of habitat or water quality problems.

Results

We collected 42,219 fish from ten families and sixteen genera in streams of the Tualatin River Basin (Table 2). Reticulate sculpin was the most abundant species; redbreast shiner, threespine stickleback, speckled dace, and mosquitofish also were common. Twelve fish species from five families were introduced and comprised 6.3% of the total catch.

Species intolerant of warm water, sedimentation, and organic pollution comprised 1.7% of the total catch and included torrent sculpin, cutthroat trout, rainbow trout, and coho salmon. Torrent sculpin were found only in upper Dairy Creek

(Figure 1), a free-flowing, forested site free from obvious urban or agricultural influences. The majority (80.7%) of cutthroat and rainbow trout also were captured at this site. Coho salmon were observed only in lower Fanno Creek.

Fish assemblages varied widely among streams and among sites within streams (Table 3). Total number of species per stream ranged from 5 in Johnson Creek to 15 in Summer Creek, whereas the number of native species ranged from 4 (Hedges and Johnson creeks) to 10 (Fanno, Chicken, and Rock creeks). Among specific sites, upper Butternut Creek contained the fewest species (1); lower Fanno and middle Summer creeks contained the most (13). The number of native species ranged from zero in upper Summer Creek to nine in lower Fanno, middle South Rock, and middle Chicken creeks. In general, sites in the upper sections of streams contained the largest numbers of trout, native minnows, and sculpins, whereas lower sites contained more diverse species assemblages and a larger number of introduced fish. Most sunfish (80.9%) and many mosquitofish (44.7%) were captured at three second-order sites (middle Hedges, middle Summer, and upper Summer creeks) near large ponds or wetlands. Three upper sites that were free-flowing, forested, and appeared free of major urban or agricultural influences (upper Dairy, upper Chicken, and upper Rock creeks) contained primarily trout and sculpin species.

TABLE 2. Fish collected in streams of the Tualatin River Basin, 1994-95. A small percentage (0.59) of the catch was not identified to species; introduced species comprised 6.3% of the total catch. Relative tolerance refers to physiological resistance to organic pollution, warm water, and sedimentation (Hughes and Gammon 1987; Scott and Crossman 1973; Moyle 1976; Wydoski and Whitney 1979).

Family, Species	Percent of catch	Relative tolerance
Petromyzontidae		
Western brook lamprey <i>Lampetra richardsoni</i>	0.64	Intermediate
Pacific lamprey <i>Lampetra tridentata</i>	0.73	Intermediate
Salmonidae		
Coho salmon <i>Oncorhynchus kisutch</i>	0.02	Intolerant
Cutthroat trout <i>Oncorhynchus clarki</i>	1.26	Intolerant
Rainbow trout <i>Oncorhynchus mykiss</i>	0.23	Intolerant
Cyprinidae		
Redside shiner <i>Richardsonius balteatus</i>	7.38	Intermediate
Speckled dace <i>Rhinichthys osculus</i>	4.82	Intermediate
Northern squawfish <i>Ptychocheilus oregonensis</i>	0.01	Tolerant
Fathead minnow <i>Pimephales promelas</i> ^a	0.07	Tolerant
Goldfish <i>Carassius auratus</i> ^a	0.07	Tolerant
Catostomidae		
Largescale sucker <i>Catostomus macrocheilus</i>	1.41	Tolerant
Ictaluridae ^b		
Yellow bullhead <i>Ameiurus natalis</i>	0.22	Tolerant
Brown bullhead <i>Ameiurus nebulosus</i>	0.01	Tolerant
Poeciliidae ^b		
Mosquitofish <i>Gambusia affinis</i>	3.09	Tolerant
Gasterosteidae		
Threespine stickleback <i>Gasterosteus aculeatus</i>	7.14	Intermediate
Centrarchidae ^b		
Largemouth bass <i>Micropterus salmoides</i>	0.38	Tolerant
Bluegill <i>Lepomis macrochirus</i>	0.81	Tolerant
Pumpkinseed <i>Lepomis gibbosus</i>	1.40	Tolerant
Warmouth <i>Lepomis gulosus</i>	0.02	Tolerant
Black crappie <i>Pomoxis nigromaculatus</i>	0.01	Tolerant
White crappie <i>Pomoxis annularis</i>	<0.01	Tolerant
Percidae ^b		
Yellow perch <i>Perca flavescens</i>	0.03	Intermediate
Cottidae		
Reticulate sculpin <i>Cottus perplexus</i>	68.40	Tolerant
Prickly sculpin <i>Cottus asper</i>	1.12	Intermediate
Torrent sculpin <i>Cottus rhotheus</i>	0.19	Intolerant

^aIntroduced species.

^bIntroduced family.

Species assemblages also varied considerably among stream orders (Table 3; Figure 2). First-order stream sites contained a large proportion of sculpins, native minnows, and threespine stickleback. The proportion of sculpins increased with increasing stream order, whereas the proportion of minnows and threespine stickleback decreased. Sculpins dominated the catch in third and fourth-order stream sites, and trout were captured primarily in fourth-order stream sites. Introduced fish comprised 14.7% of the catch in second-order sites, but only 2.3% in other sites.

The average number of fish species captured per site generally increased with increasing stream order (Figure 3). For all species combined, we observed the greatest increase in species diversity from first to second-order sites, largely because of the high occurrence of introduced fish in several second-order sites. The mean number of native fishes increased more uniformly with stream order. Kruskal-Wallis tests indicated a significant ($P = 0.02$) difference in the number of native species among stream orders; however, we found no significant difference among stream orders ($P = 0.12$) for all species combined.

TABLE 3. Presence/absence matrix by stream order for fish collected in tributaries of the Tualatin River, 1994-95. L = Lower site, M = Middle site, U = Upper site. Relative occurrence: R = Rare, comprised <2% of catch, I = Intermediate, comprised 2-20% of catch, C = Common, comprised >20% of catch, - = not present.

Order, Site	Species																									
	Brook Lamprey	Pacific Lamprey	Coho Salmon	Cutthroat Trout	Rainbow Trout	Redside Shiner	Speckled Dace	Northern Squawfish	Fathead Minnow	Goldfish	Largescale Sucker	Yellow Bullhead	Brown Bullhead	Mosquitofish	Threespine Stickleback	Largemouth Bass	Bluegill	Pumpkinseed	Warmouth	Black Crappie	White Crappie	Yellow Perch	Retenulate Sculpin	Prickly Sculpin	Torrent Sculpin	
First Order																										
Hedges U	I	C																								
Ash U																										
Butternut M																										
Butternut U																										
Dawson L	R	R																								
Dawson M	R	R																								
Dawson U																										
Johnson U																										
Second Order																										
Hedges L																										
Hedges M																										
Fanno U	R	R																								
Ash L																										
Ash M																										
Summer L	R	I																								
Summer M	R	R																								
Summer U																										
Chicken U																										
Butternut L	R	R																								
Rock U																										
Bronson M	I	R																								
Bronson U	I	I																								
Johnson M																										

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Third Order	Brook Lamprey	Pacific Lamprey	Coho Salmon	Cutthroat Trout	Rainbow Trout	Redside Shiner	Speckled Dace	Northern Squawfish	Fathead Minnow	Goldfish	Large-scale Sucker	Yellow Bullhead	Brown Bullhead	Mosquitofish	Threespine Stickleback	Large-mouth Bass	Bluegill	Pumpkinseed	Warmouth	Black Crappie	White Crappie	Yellow Perch	Reticulate Sculpin	Prickly Sculpin	Torrent Sculpin
Fanno L.	R	R	R	R			R				R		R	R	R	R		R							
Fanno M.	R	R	R	R		C	R				R			R	R	R							C	I	
S. Rock M.	R	R		R		R	R				R			R	I	C				R			C	I	
S. Rock U.	R	R		R		R	R				R			R	R	R							C	R	
Chicken M.	R	R		R		I	R				R			R	R	R							C	R	
Cedar U.	R	R		R		I	R				R			R	R	R							C	I	
Rock M.	R	R		R		I	R				R			R	R	R							C	I	
Bronson L.	R	R		R		I	R				R			R	R	R							C	I	
Cedar Mill M.	R	R		R		I	R				R			R	R	R							C	I	
Johnson U.	R	R		R		I	R				R			R	R	R							C	I	
Fourth Order																									
Chicken L.	I	I	I	I	R	I	R				R												C	I	
Rock L.	R	R	R	R	R	R	R				R												C	I	
Beaverton L.	R	R	R	R	R	R	R				R												C	I	
Beaverton M.	R	R	R	R	R	R	R				R												C	I	
Dairy M.	R	R	R	R	R	R	R				R												C	I	
Dairy U.	R	R	R	R	R	R	R				R												C	I	

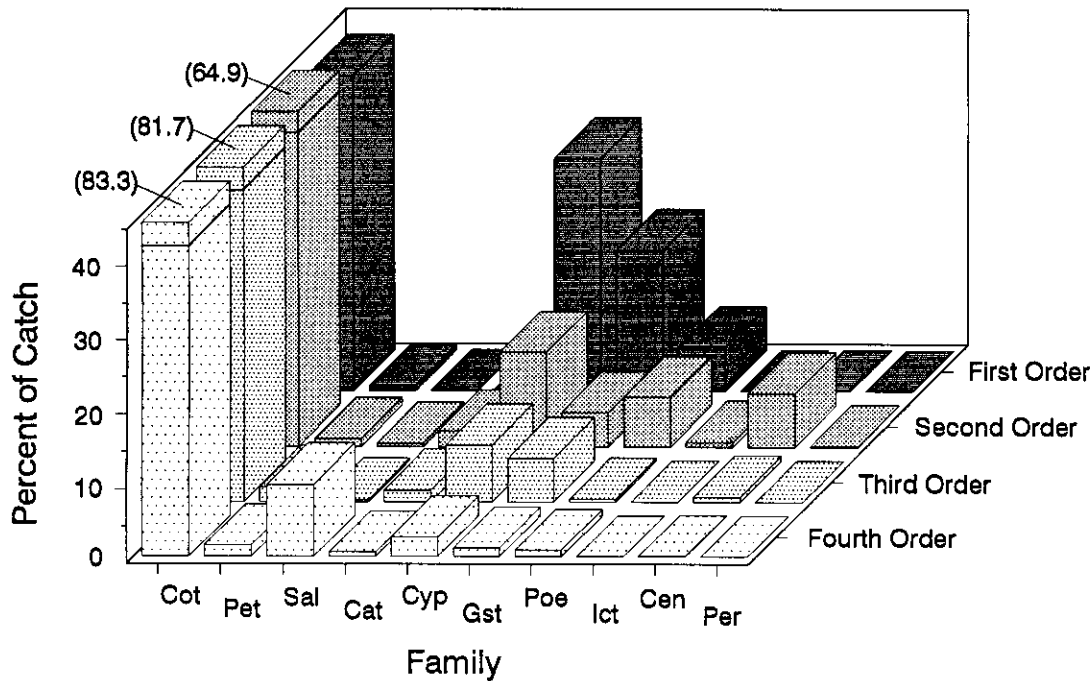


Figure 2. Percent of catch by family and stream order in the Tualatin River Basin, 1994-95. Pet = Petromyzontidae, Sal = Salmonidae, Cat = Catostomidae, Cyp = Cyprinidae, Gst = Gasterosteidae, Poe = Poeciliidae, Ict = Ictaluridae, Cen = Centrarchidae, Per = Percidae, and Cot = Cottidae.

Fish assemblages also varied seasonally (Figure 4). The proportion of minnows in our catch increased considerably from spring to winter, and the proportion of sculpins decreased over the same period. We captured the highest proportion of trout during summer sampling, whereas largescale sucker, threespine stickleback, and mosquitofish were common during autumn sampling.

Length-frequency histograms (Figure 5) for the eight most commonly observed species (reticulate sculpin, reidside shiner, threespine stickleback, speckled dace, mosquitofish, largescale sucker, pumpkinseed, and cutthroat trout) were highly variable. Histograms for mosquitofish, threespine stickleback, and cutthroat trout showed relatively high numbers of small fish in certain seasons: winter and spring for mosquitofish, summer for trout, and spring for threespine stickleback.

We found parasites or physical anomalies on 2.0% of all fish captured. Parasites generally were leeches (Class Hirudinea) or worms (Class Nematoda); a small proportion of fish had fungal infections, lesions, or physical deformities. The percent of fish with parasites or anomalies was highest for reidside shiner (8.4), largescale sucker

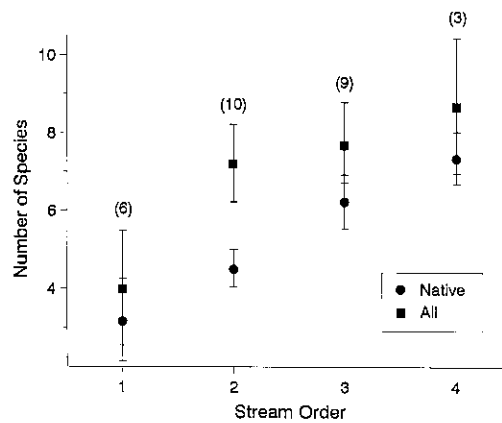


Figure 3. Mean number (and 95% confidence intervals) of species collected per site for each stream order in the Tualatin River Basin, 1994-95.

(5.1), and cutthroat trout (3.6), and ranged from 0.0 to 15.1 among stream sites. Parasites or anomalies were present on more than 5% of the catch in five of 38 sites surveyed (middle Fanno, lower Summer, middle Summer, lower Dawson, and middle Cedar Mill creeks).

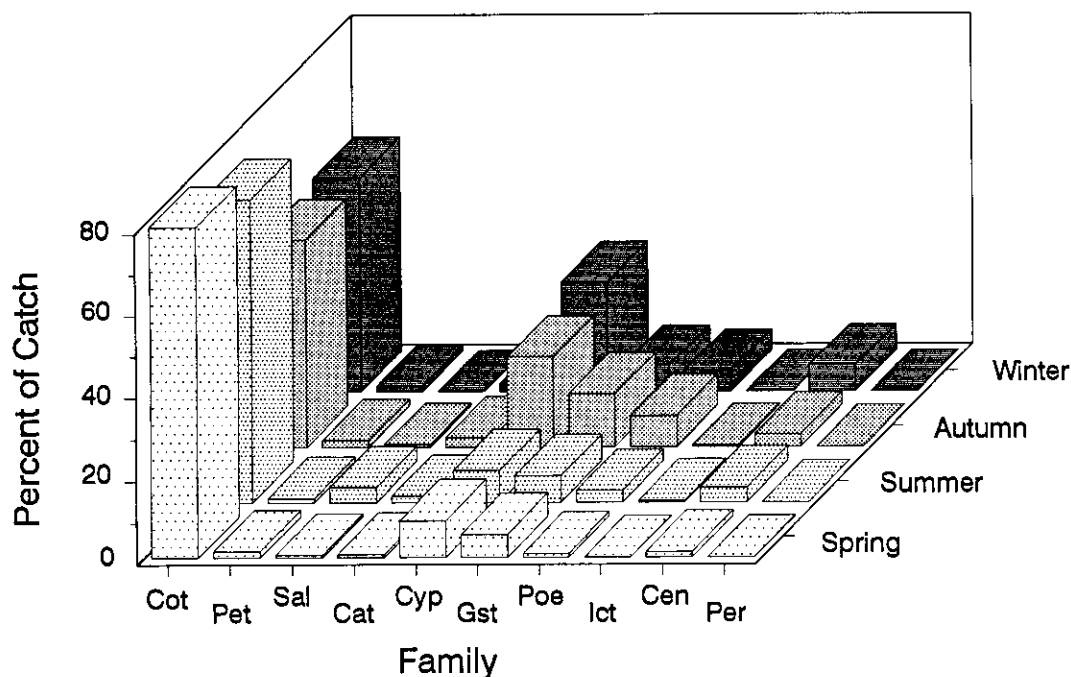


Figure 4. Percent of catch by family and season in the Tualatin River Basin, 1994-95. Per = Petromyzontidae, Sal = Salmonidae, Cat = Catostomidae, Cyp = Cyprinidae, Gst = Gasterosteidae, Poe = Poeciliidae, Ict = Ictaluridae, Cen = Centrarchidae, Per = Percidae, and Cot = Cottidae.

Discussion

The results of our surveys may be broadly compared to previous surveys in the Willamette River near the Tualatin River (Hughes and Gammon 1987; Farr and Ward 1993). Farr and Ward (1993) reported 39 fish species from 17 families in the lower Willamette River (downstream from river kilometer 27). Nineteen of these species were absent from our catch in the Tualatin River Basin. Hughes and Gammon (1987) surveyed the Willamette River up to river kilometer 283, including two sampling sites near the mouth of the Tualatin River. Eight species not observed in our survey of the Tualatin River Basin were captured at these sites. Species common to both Willamette River surveys, but not represented in our catch included mountain whitefish *Prosopium williamsoni*, mountain sucker *Catostomus platyrhynchus*, chinook salmon *Oncorhynchus tshawytscha*, chiselmouth *Acrochelius alutaceus*, peamouth *Mylocheilus caurinus*, common carp *Cyprinus carpio*, and smallmouth bass *Micropterus dolomieu*. We captured three species (brook lamprey, fathead minnow, and mosquitofish) not described by Farr and Ward (1993) or Hughes and Gammon (1987).

The smaller number of species occurring in the Tualatin River Basin may be attributable to a variety of factors. Willamette Falls, at Rkm 43.0 of the Willamette River, is a barrier to fish passage and may exclude species such as starry flounder *Platichthys stellatus* and American shad *Alosa sapidissima* from the Tualatin River. Chinook salmon probably were never abundant in the Tualatin River Basin (ODFW 1993). Mountain whitefish, peamouth, mountain sucker, and chiselmouth may be unable to survive in Tualatin River tributaries due to predation by introduced species, interspecific competition, poor water quality, or other habitat perturbations. These species may also prefer larger streams, as evidenced by their presence in the mainstem Willamette River. Common carp and smallmouth bass have been observed at other locations within the Tualatin River Basin (ODFW, unpublished data).

Dimick and Merryfield (1945) reported nine native species from five families and two introduced species from two families in the mainstem Tualatin River and one tributary (Scroggin Creek, since renamed Scoggins Creek). They identified two species, chiselmouth and riffle sculpin *Cottus*

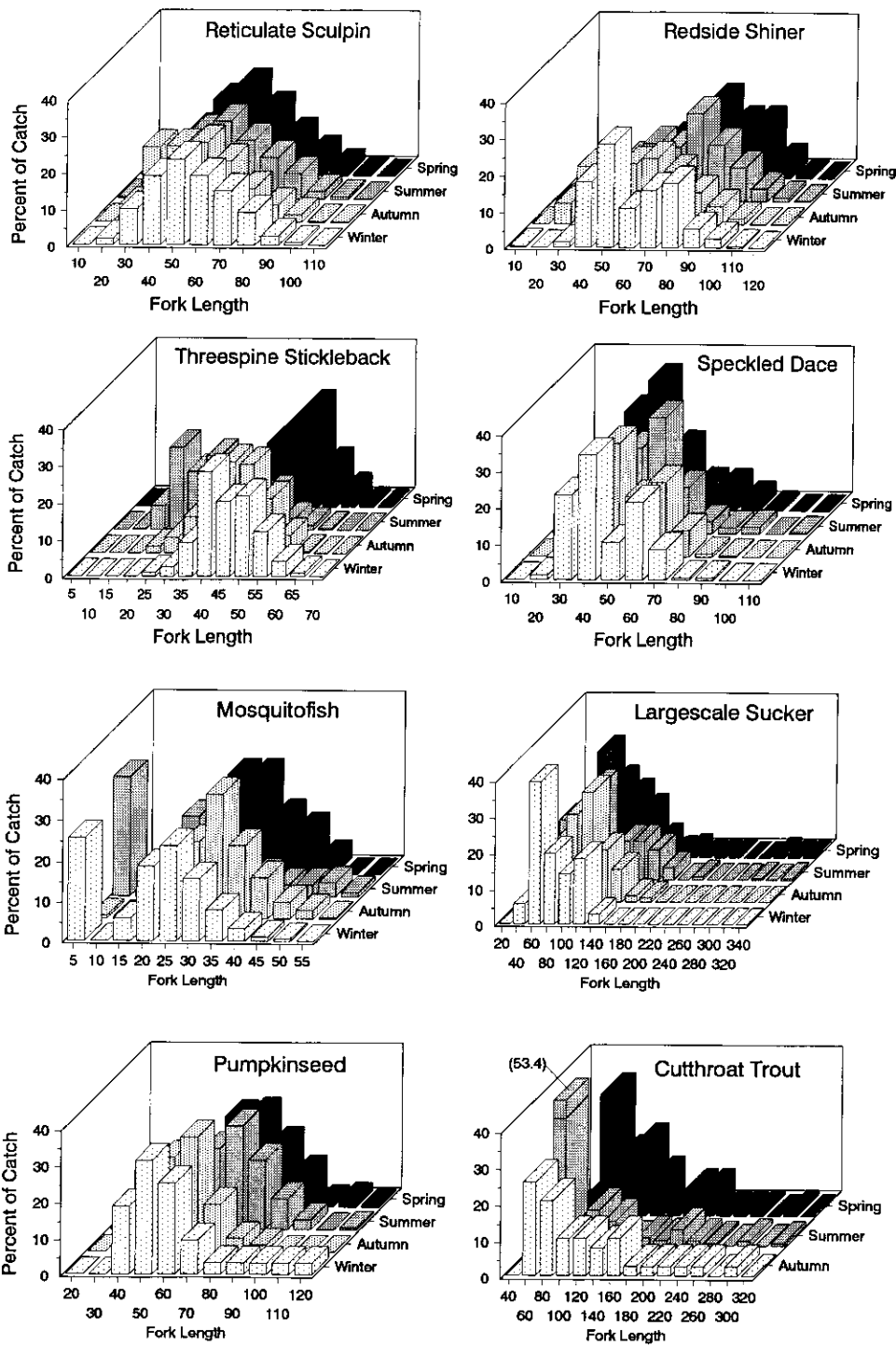


Figure 5. Length-frequency histograms for eight species comprising the greatest proportion of the catch in the Tualatin River Basin, 1994-95. Winter length-frequency data for cutthroat trout is omitted due to a very small sample size ($N = 3$).

gulosus, not observed in our surveys. However, it is believed that early literature did not recognize taxonomic distinctions between riffle sculpin and reticulate sculpin (Wydoski and Whitney 1979); therefore, Dimick and Merryfield (1945) most likely described reticulate sculpin considering the large number of this species we collected in tributaries of the Tualatin River. Although we identified fourteen more native species and eight more introduced species than Dimick and Merryfield (1945), a direct comparison to their work is probably inappropriate, as we surveyed a greater number of sites, none in the mainstem Tualatin River. However, we can say that ten of the eleven species recorded by Dimick and Merryfield in the 1940's also were present in the current study.

Introduced species appear to be well established at certain sites within the Tualatin River Basin. One such species, the fathead minnow, does not appear in any historical surveys of the Tualatin or Willamette rivers, and may be a recent introduction. The large number of sunfish and mosquitofish found near wetland areas reflects the ability of these species to proliferate in warm, shallow, weedy water, and should be a consideration for future mitigation projects specifying the construction of wetlands.

Intolerant species were relatively uncommon, but occurred in large numbers at the three sites that were forested, free-flowing, and apparently unaffected by urban or agricultural influences. However, trout or salmon were observed in smaller numbers at sixteen additional sites. No adult salmon or steelhead were observed, although it is likely that the rainbow trout captured were juvenile steelhead (Jay Massey, ODFW, personal communication).

Species diversity in temperate streams usually increases with increasing stream order (Kuehne 1962; Lotrich 1973). However, in systems affected by flooding, water removal by humans, or pollution, the number of species may decrease in larger order streams (Moyle and Cech 1988). The number of native species increased significantly with increasing stream order in the Tualatin River Basin; however, the number of all species did not differ significantly among stream orders, suggesting possible disturbances. Because the historic composition of fish assemblages in the basin is largely

unknown, the effect of species addition or replacement on the relationship between number of species and stream order remains uncertain.

The variability of species assemblages among seasons may be due to a variety of factors. Highly mobile species such as cutthroat trout may move throughout the basin to spawn or avoid high flows and temperature. The relatively high percentage of trout captured in upper Dairy Creek during summer sampling supports this point. Gear selectivity probably also plays a role in the observed seasonal patterns. Benthic species such as sculpin were often more difficult to capture at high flows or in turbid water, causing a decrease in the proportion of these species and an apparent increase in the proportion of more catchable pelagic species (i.e. Cyprinids) collected in autumn and winter.

Differences in catch among seasons may also be partially due to variability in the size structure of certain species. Although we routinely captured fish as small as 5 mm, our gear was not able to sample larval stages of most species. However, length-frequency histograms (Figure 5) indicate that we sampled early life stages for at least some species. The greatest proportion of small cutthroat trout and threespine stickleback, for example, were captured during or immediately after the known spawning periods for these species (spring and early summer, respectively; Wydoski and Whitney 1979). Although mosquitofish may spawn during all seasons (Moyle 1976), we observed large abundances of small fish in spring and winter.

Although not generally the cause of major fish kills, parasites may render fish susceptible to secondary infections or weaken their tolerance of environmental changes (Herman 1990). The relatively high incidence (>5%; Karr et al. 1986) of parasites and anomalies in fish at several sites in our study area may be indicative of poor water quality or other habitat disturbances. The relatively high proportion of parasites or anomalies observed in cutthroat trout, an intolerant species, is also cause for concern.

The status of fish habitat in our study area undoubtedly impacts fish populations to some degree. Neill et al. (1995) report that many sites in this study area have habitat characteristics that do not meet those required by native fish species. Siltation, bank erosion, lack of woody debris, and insufficient overhead cover (presumably resulting in increased water

temperatures) are factors significantly affecting fish habitat at these sites.

The occurrence of introduced species and parasitic infestations, the low number of intolerant species, and poor habitat quality indicate that native fish assemblages in the Tualatin River Basin within the urban growth boundary near Portland, Oregon are at least moderately unhealthy. A number of sites contain few or no native species or a large number of fish affected by parasites or physical anomalies. Because some sites are able to support populations of cutthroat trout and other intolerant species, they are likely important seasonal refuges and may contain critical spawning and rearing habitat. Fish habitat in these streams should be preserved or enhanced whenever possible to ensure the continued success of these species, and

of all fauna dependent on the basin. Although further changes in the basin probably are unavoidable due to continued urban growth, the health of watersheds such as the Tualatin River Basin are considered by many as important to the overall quality of life.

Acknowledgements

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