

## Ecology and Habitat Requirements of Fish Populations in South Fork Hoh River, Olympic National Park

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### ABSTRACT

Four distinct running water habitats are defined and examined on the South Fork Hoh River--main river channel, river off-channel areas, terrace tributaries, and valley wall tributaries. Species compositions, densities, and total fish biomasses are distinctly different for each habitat examined. Habitat formed by the main river channel and its tributaries is controlled by the valley terrace structure and the modifying effects of large woody debris. Without large wood, spawning and rearing habitat quality would be poorer, even in the large channel. Virtually all rearing of salmonid fish occurs in river off-channel areas and tributaries. The main channel is used mainly for spawning and migration. Fish densities and biomasses are highest in streams along the valley floor. Alteration of these areas will have greatest impact on fish production.

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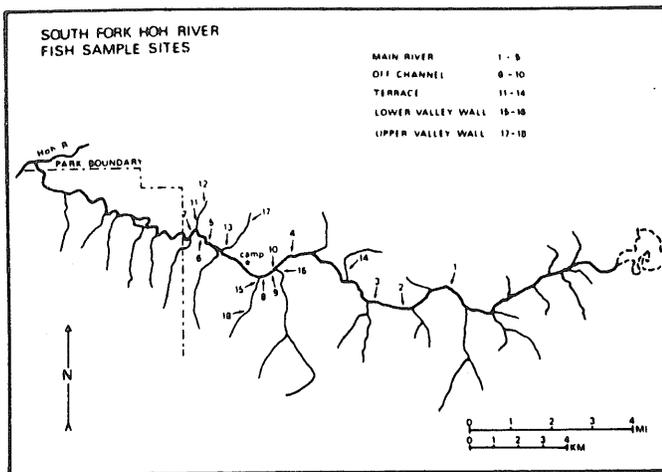


Figure 1.--Location of fish sample sites on the South Fork Hoh River and the tributaries.

## INTRODUCTION

Stream ecosystems are adaptations to interacting geologic forces (hydrology and fluvial forms and processes) and biotic modifiers (riparian vegetation and large downed trees). Diversities of flow velocities, organic input quality and quantity, storage and processes of organic materials, and habitat types are all directly affected. The major interest in the South Fork Hoh River stems from the fact that the headwaters flow from a glacier, resulting in a channel that has many migrating point bars and a continual supply of glacial flow sediments in suspension. At present, stream ecologists have no benchmark descriptive data for naturally sediment-rich streams. We know very little about aquatic habitats and how they are formed in pristine sediment-rich river valley systems. For these reasons, a description of this river in the Olympic National Park provides a needed and significant baseline for stream ecologists and fisheries managers in the Pacific Northwest.

Our part of the South Fork Hoh River "pulse study" was to examine fish populations in relation to the four previously defined habitats (main river channel, river off-channel areas, terrace tributaries, and valley wall tributaries (see Swanson and Lienkaemper, and Ward and Cummins in this report)). Species compositions, densities, and total fish biomasses were defined for each habitat type. With each habitat type, we obtained a description of the pools, channel stability, and role of large woody debris in the formation and stability of the habitat.

## MATERIALS AND METHODS

A beach seine was employed for sampling salmonid populations in the main stem South Fork Hoh River. A 600-volt backpack electric shocker was used to sample off-channel and tributary sites. A single pass method was used on 5 main stem sites and a two pass removal method on 13 off-channel and tributary areas (fig. 1). Fish collected from each site were anesthetized with MS 222 (tricaine methanesulfonate), identified to species, measured for fork length, and allowed to recover before release. Fish biomass estimates were calculated from length-weight relationships determined previously from other watersheds. Density, biomass, and species distribution were related to each habitat parameter and important relationships noted.

Each site was measured for length and width, and wetted surface areas were computed. Debris obstructions were counted; and their role in bank stability, fish cover, and flow deflection was noted. The stability of each site was determined using USDA Forest Service "Stream Reach Inventory and Channel Stability Evaluation," (Pfankuch 1975) and categorized as very stable, stable, or unstable. The quality of pools in each site was determined using a modified Duff and Cooper (1976) technique assessing pool volume and cover.

A survey of spring-summer chinook salmon spawning sites was conducted during September and October. Foot surveys were the primary method; helicopter surveys were utilized during peak spawning activity.

Gravel samples were taken at two sites on the main river and one tributary site. Likely spawning gravels were sampled with a McNeil cylinder and Koski Plunger. A total of 25 samples was analyzed volumetrically for percent material less than .85 mm.

## HABITAT DESCRIPTIONS

### Main River Channel

The main river was wide and shallow (table 1). Wet widths ranged from 8 to 10 meters in summer to 20 to 40 meters in winter. The main channel meandered within a wide channel of exposed gravel bars that averaged 100 m wide. The large cobble substrate was very unstable, gravel bars being formed and destroyed continuously. Some bank cutting was evident along the steep south valley side slope. The water was turbid due to suspended glacial material. Organic material transfer and storage was low. Edges of the main channel accumulated sediments, but riffle areas were relatively clean. The channel gradient was 2 to 3 percent and mainly riffles and deep runs with some pools associated with debris. Riparian vegetation did not significantly influence the course of the river; however, bank cutting caused inputs of large woody debris which would accumulate on bars and cutting edges to deflect the river flow (see Swanson and Lienkaemper in this report). Debris accumulations provided little fish cover in the main river, but diverted water through off-channel overflow areas.

Table 1--Physical characteristics of the major aquatic habitats in the South Fork of the Hoh River, autumn 1978

Physical characteristics				
Habitat type	Stability	Debris	Pool	Riffle
Site number			Percent	Percent
Main river sites (1,2,3,4,5)	<u>Poor stability</u> , winter and spring floods cause cutting and deposition.	Debris collected in small jams at cutting areas on bends in river, stabilizes banks and deflects flow.	20	80
Off-channel sites (6,7,8,9,10)	<u>Good stability</u> except during extremely high main river flows.	Debris accumulations on main channel creates and maintains most off-channel area. Individual pieces offer fish cover.	70	30
Terrace tribs. sites (11,12, 13,14)	<u>Very good stability</u> low gradient, debris-protected banks.	Individual pieces reduce cutting of banks and offer fish cover.	80	20
Lower valley wall tribs. sites (15,16)	<u>Very good stability</u> high gradient, boulder- and debris-stabilized banks.	Individual pieces help stabilize banks and form some plunge pools.	40	60
Upper valley wall tribs. sites (17,18))	<u>Excellent stability</u> high gradient steep banks, boulder-formed plunge pool and falls.	Large individual pieces offer some bank stability and with boulders form plunge pools and fish cover.	90	10

#### Off-Channel Areas

Channels subsidiary to the main river were located within the active exposed lower flood plain. Some were caused by debris accumulations on bars in the main channel, river flow was diverted, and a gravel berm was created downstream from the debris. Water percolated through the gravel berm and debris to create a side channel between the gravel berm and the bank opposite the main river flow channel. Other off-channel areas were intermittent overflow channels that received ground water from the main river and nearby terrace. Most were subject to direct flows during freshet periods; others became completely isolated during summer low flow periods. Flow velocities are lower than the main river, and water percolated through berm gravels carries reduced suspended sediment. Organic input from terrace vegetation and overflow accumulations from main river floods collected in off-channel pool bottoms. In the absence of heavy shading and the scouring effects of suspended glacial material, algal growth was promoted. High insect production occurred in these organically rich areas (see Ward and Cummins in this report). Woody debris and undercut bank vegetation provided cover for fish and created pool areas. Downstream tailouts offered good spawning locations.

#### Terrace Tributaries

Terrace tributaries result from spring networks on the flat valley flood plain and from tributaries draining the valley side slopes and continuing across the terraces to the main river. Many terrace tributaries paralleled the secondary river channels that cut through the lower terrace areas within the flood plain before emptying into the main river. These streams were very stable and had low gradients, slow velocities, and channel widths from 1 to 5 m. They were composed predominantly of pools and short sections of riffle. Pools accumulated large amounts of riparian leaf litter from the dense forest canopy, thus producing abundant aquatic insects (see Ward and Cummins in this report). Pool substrate was primarily fine sediments, although riffles were relatively clean. Banks were stabilized by live vegetation and downed woody debris. Debris and undercut banks provided excellent fish cover.

#### Lower Valley Side Wall Tributaries

Side slope streams originated from runoff on the steep valley walls. The lower ends of these streams flowed on the upper terrace areas from the north valley walls and directly into the main Hoh River from the south valley walls. These streams were typified by high gradients with alternating sections of riffles and plunge pools over woody debris and boulder obstructions. The substrate ranged from fine materials deposited above some of the debris to large boulders and bedrock in the

plunge pools. Lower valley side wall tributaries had clear water and high flow velocities. Organic material from the riparian vegetation was transported downstream or retained by the debris and boulders. The banks were steep but stable due to deeply embedded large boulders and debris. Productivity of algae and aquatic invertebrates was lower than other streams because the dense forest canopy limited light entry and scour forces of the rapidly moving water created considerable shear stress.

#### Upper Valley Side Wall Tributaries

Upper side slope streams had very steep gradients and high velocities. They flowed over a series of stair-step pools and cascades set up by boulders and large downed trees. The substrate was large cobbles, boulders, and bedrock, with some gravel accumulation at the tails of pools and behind embedded debris. The water ran clear and the high velocity transported downstream any organic material not retained by the boulders and debris. The steep banks with high boulder content and large downed trees maintained the stable riffle-cascade-pool nature of the channel. Low benthic algal production from reduced light penetration resulted in low densities of aquatic insects, except for some wood gougers.

#### THE ROLE OF LARGE ORGANIC DEBRIS IN THE MAINTENANCE OF FISH HABITATS

Large organic woody debris in streams of the spruce-hemlock forest have profound effects on channel form and fluvial processes, particularly in small sized streams. Woody debris (10-cm diameter) plays different roles in each of the habitat types described. We examined the extent to which debris intervened in the stream channel. We grouped debris interventions in the channel into three groups, depending on the extent of direct influence within the channel width. The groups were influences of one-third to two-thirds of the channel width and complete channel dams, bridges, or other direct interventions.

On large, main channels, the woody debris accumulated at the head of gravel bars and often regulated water movement into off-channel areas (see Swanson and Lienkaemper in this report). Even the largest trees seldom crossed the entire channel parallel with the flow or in accumulations below the curving bend of the river. We found large debris intervened up to one-third the channel width 10 times, two-thirds the channel width once, and crossed the main channel twice along 900 m of main river stem. Half of the debris interventions influencing up to one-third the channel were at the head of off-channel areas. The root wads of single trees in the main channel that were parallel to the flow sometimes deflected the flow toward other debris or boulders. These convergences of flow created pools, and the tailouts of these pools provided excellent spawning habitat for chinook salmon. The importance of a large downed tree to fish habitat in the stream channel cannot be minimized, even though it may intervene less than one-third of channel width. Their role as flow deflectors

contributed to the diversity of flow velocities that helped maintain spawning areas free of the fine fluvial sediments which could smother incubating fish eggs.

Off-channel habitat responding to intervention by large woody debris were highly variable. Often the flood flows had resulted in accumulated debris along the edge of the main channel, deflecting the flow and producing large backwater pools or alcoves. These off-channel alcoves often were important juvenile coho and steelhead rearing areas. These kinds of habitat were created by 100 percent intervention of the debris. The secondary and tertiary channels frequently took the form of small off-channel streams. The woody debris intervening in these channels was derived primarily from sources upstream and was deposited through a major storm event. For every 100 m of off-channel area, there were 12 interventions of wood one-third of the channel water or less, two interventions influencing up to two-thirds of the channel, and four interventions which dammed or influenced the complete channel width. About 60 percent of these channels were high quality pools formed by debris and were primary rearing areas for large juvenile coho and steelhead.

Terrace tributaries had accumulated large wood from their surrounding forest. These were predominantly pool environments except at their lower reaches where they merged with the main channel. For every 100 m of terrace tributaries channel, large woody debris less than one-third channel width category intervened nine times, four times for influences from one-third to two-thirds channel width, and three times the entire channel width was dammed or influenced directly. These pieces of wood were quite stable, and supported nurse trees and dense moss communities.

The valley wall tributaries had a stepped profile created by sediments stored behind large wood in the channel. Pools usually were created by debris and provided primary rearing areas for many of the river system's cutthroat trout. In general, for every 100 m of this stream type, we found 11 wood interventions influencing the channel width one third or less; 5 times the entire channel was dammed or directly influenced.

In general, the main channel and off channel areas utilized trees and large pieces of wood that originated upstream from where the accumulations were found. The forest along terrace tributaries and valley wall tributaries contributed the wood usually found in these streams. Debris was a major contributor to fish habitat for both spawning and rearing requirements of the different fish's life cycles. Although we tend to ignore debris influence on the physical channel of large rivers, its role in forming and maintaining anadromous fish habitats is very important regardless of size of streams. Without large trees being transported by the main channel, the very productive off-channel areas would maintain levels of invertebrate and fish densities and biomasses much lower than they now do.

Large trees or wood in streams do not have to dam a stream channel completely to have a major influence on fish habitat. The majority of debris intervening on channels influenced only one third or less of the channel width. This was enough to create diverse stream velocities, pocket pools, and cover, which resulted in stable and diverse fish habitat conditions.

#### LIFE HISTORIES OF SALMONID FISHES IN THE SOUTH FORK HOH RIVER

##### Mountain Whitefish - Prosopium williamsoni

Whitefish were taken only from the main river channel itself; no specimens were collected from off-channel or tributary areas. Within the main channel, whitefish probably frequented deeper runs and pools where they fed upon aquatic invertebrates. Car, Clemens, and Lindsey (1967) report that this species spawn in October and November, their eggs hatching around March. The mountain whitefish is not anadromous and apparently completes its entire life cycle within the main river channel.

##### Dolly Varden - Salvelinus malma

Most individuals of this species were collected from the main river channel, but a few juveniles were taken from off-channel areas. Larger adult fish have been known to feed extensively on small fish, including migrating smolts. Immature Dolly Varden feed mainly on aquatic invertebrates. This species is known to be anadromous in some cases, but we did not determine if the population in the South Fork Hoh was anadromous or resident. Dolly Varden are occasionally caught by anglers fishing the main river channel. With the exception of some off-channel rearing, this species also is confined to the main stem.

##### Coastal Cutthroat Trout - Salmo clarki

Cutthroat were captured in the tributaries, the majority of individuals being taken from the upper valley wall tributaries where they were collected from plunge pools and undercut banks and logs. All life history stages feed on aquatic and terrestrial invertebrates, although larger adult cutthroat will feed on small sculpins. Sea-run cutthroat populations occur in most coastal river systems of Washington, but scale analysis of samples collected from South Fork Hoh River specimens during this study indicated that the population was composed entirely of resident fish. This species spawns in the spring, probably in the valley wall tributaries. Emergence of young-of-the-year occurs in June and July. It is safe to conclude that cutthroat trout make up the great majority of the sport fishery in the valley wall tributary systems, and it is likely that more cutthroat are caught in the South Fork Hoh River drainage than any other sport fish.

##### Steelhead Trout - Salmo gairdneri

Juvenile steelhead were taken from the main channel, off-channel, terrace tributaries, and lower valley wall tributaries. No adult steelhead were captured, although they were known to be present in the main stem. Steelhead are anadromous rainbow trout; and two distinct runs are known to occur in the South Fork Hoh River--one run takes place in summer and a second run occurs in winter. Although the timing of the two runs is separate and individuals belonging to the runs are known to have certain genetic differences, spawning times show considerable overlap. Depending upon time of entry into fresh water, spawning can occur from December to May, although peak spawning activity probably takes place in February and March. Steelhead fry are usually out of the gravel by June, and most rearing occurs in off-channel and valley wall tributary areas. Size distribution of juveniles suggested that most steelhead spend 2 years in the South Fork habitat before smolting and migrating to sea. A notable sport fishery for adult steelhead exists on the main stem, and some legal-sized juveniles are probably caught in the tributaries along with cutthroat.

##### Coho Salmon - Oncorhynchus kisutch

Juvenile coho were found mainly in river off-channel and terrace tributary areas, where deep slow-moving water occurred. At the time of the study (late September), adult coho migration into the South Fork had not yet taken place; the bulk of the run was expected in November. Adult spawning probably occurs in both the main stem and valley wall tributaries; but juveniles were conspicuously absent from these areas, having moved to pools adjacent to the river and into the terrace tributaries for rearing. Young coho were heavily dependent upon terrestrial invertebrates for food, particularly during summer months. They usually spend over a year in fresh water before smolting in spring and returning as adults after 2 years at sea. The contribution of coho to the South Fork sport fishery probably is small.

##### Chinook Salmon - Oncorhynchus tshawytscha

No juvenile chinook were taken at any sample location in the South Fork Hoh River; apparently this species does not rear there in early autumn. Like steelhead, there are two adult runs in the river--one in late spring and the other in autumn. We observed adults spawning in the main river channel and in the lower reaches of the larger tributaries. These were presumably spring-summer run fish. Approximately one-third of the total spring-summer chinook run entering the Hoh River drainage spawns in the South Fork. Of these, about two-thirds spawn in the main and secondary river channels and one-third spawn in the terrace tributaries and the lower valley wall tributaries (table 2). Juvenile emergence occurs in late winter; and young-of-the-year move downstream to rear in other parts of the system, principally in the estuary.

Table 2--Spring-summer chinook salmon spawning

Percent of total redd count	River channel and river off-channel	Terrace tributaries	Valley wall tributaries
170	65	22	13

FISH POPULATION DENSITY, BIOMASS, AND GROWTH

The largest density and biomass of salmonids occurred in the off-channel habitat (table 3). Steelhead young-of-the-year (fry) represented 79 percent of the total density (fig. 2A and 2B). Coho salmon fry made up 19 percent of the total density, but were larger than the steelhead fry (table 4) and accounted for 56 percent of the total biomass. Steelhead, although more abundant than coho, comprised only 39 percent of the biomass. Cutthroat trout and Dolly Varden contributed little to salmonid density and biomass. Sculpin density was one-fourth of the total salmonid density, but sculpin biomass was equal to that of the salmonids.

The terrace tributaries possessed the second highest density of salmonids, yet density was less than half of the off-channel areas. Coho were the most abundant, and made up 76 percent of the total density, followed by cutthroat trout, with 17 percent of the total density. Coho fry were smaller in the terrace tributaries (table 4) than in the off-channel areas but, because of their higher density, accounted for a biomass nearly equal to that of coho in off-channel areas. The coho biomass was 62 percent of the total salmonid biomass in the terrace tributaries. Cutthroat trout averaged 35 percent of the total salmonid biomass. Steelhead fry were both small and rare in the terrace tributaries. Sculpins in terrace tributaries were smaller than those of off-channel areas but were twice as abundant.

Upper valley side wall tributaries had a total salmonid density lower than both off-channel area and terrace tributaries; total salmonid biomass was lower than the off-channel areas but higher than the terrace tributaries. Cutthroat trout represented 97 percent of the density and 92 percent of the biomass of salmonids collected. Cutthroat biomass was relatively high, and the wide range of sizes represented in the population indicated that several year-classes were present. A single steelhead yearling was the only other salmonid captured in upper valley wall tributaries. Sculpins were present, but their density and biomass was less than a third of those found in the off-channel and terrace tributaries.

Lower valley side wall tributaries had lower total salmonid density and biomass than the off-channel, terraces and upper side wall tributaries. Steelhead trout fry dominated both density and biomass. The mean length of steelhead fry exceeded that found in the terrace and off-channel areas. Several coho salmon and cutthroat also were captured. Cutthroat trout made up only 13 percent of the

total salmonid density but comprised 31 percent of the biomass due to two large yearlings in the sample. Sculpin density and biomass were lower than all the other habitat areas.

The main stem South Fork Hoh River had the lowest salmonid density and biomass of all habitats. A total of seven steelhead trout (three fry and three yearlings), one Dolly Varden, and one mountain whitefish were captured. No sculpins were collected. Total salmonid density was estimated to be less than .001 fish/m<sup>2</sup>, and biomass was less than .01 g/m<sup>2</sup>. Mature adult chinook salmon were observed migrating in the main stem to spawning sites in the off-channel areas and lower terrace tributaries, but none was collected in the seine samples. These low values probably reflect inefficient sampling techniques. While we believe the main river channel to possess fewer fish, the values in tables 3 and 4 and figure 2A should be considered tentative. Accurate main stem estimates will require a more effective large river sampling program.

Generally, the densities of fish in the South Fork Hoh River were lower than reports for other streams on the Olympic Peninsula outside of the Park. Coho density in off-channel and terrace tributaries were similar to values reported for some tributaries to the nearby Clearwater River (Edie 1975). Cutthroat trout density on the upper and lower valley wall tributaries were less than a third of that reported for lower gradient headwater streams in the Clearwater and Bogachiel Basins (Lestelle 1978, Martin et al. 1978).

Gravel samples taken in the main channel and lower valley wall tributaries (J. Cederholm, pers. comm.) were similar in percentage of fine sediment to pristine watershed in the Clearwater River. This is important, since the Clearwater is not a glacier-fed stream.

The importance of off-channel ponds in the successful rearing of coho salmon smolts in a river system has been documented by Peterson (1979). While our brief study did not include any ponds of the size and depth studied by Peterson, we feel that the numerous flood-influenced off-channel pools and alcoves along the river's border provided the bulk of the juvenile anadromous fish rearing areas.

MANAGEMENT IMPLICATIONS

Biological productivity of the South Fork Hoh River is largely dependent on stable terrace stream networks and valley wall tributaries. These productive zones can be protected from abuse by proper campground and trail placement. Major trails should avoid paralleling terrace tributaries; they would be better placed on lower valley walls. Avoiding terrace tributary areas for locating campgrounds also will help protect the streams. Existing road networks could be re-examined to determine if biologically diverse and productive areas have been cut off from the floor influence of the main channel and if fish passageways to and from off-channel rearing sites have been blocked.

Table 3--Density and biomass of fish species collected in stream habitats of the South Fork Hoh River, autumn 1978

Habitat type	Coho		Steelhead		Cutthroat		Dolly Varden		Total salmonid		Sculpin		Total fish	
	#/m <sup>2</sup>	g/m <sup>2</sup>												
Main river	--	--	.003	.01	--	--	.001	.01	.004	.01	*	*	*	*
Off-channel	.070	.33	.286	.23	.001	.02	.003	.02	.364	.59	.087	.59	.451	1.18
Terrace tributaries	.118	.26	.010	.01	.026	.15	--	--	.154	.42	.156	.47	.310	.89
Lower valley wall tributaries	.003	.01	.044	.08	.007	.04	--	--	.053	.13	.029	.09	.082	.22
Upper valley wall tributaries	--	--	.002	.04	.065	.48	--	--	.067	.52	.042	.13	.109	.64

\*Sculpins were not sampled in the main river; therefore, we omitted computation of total fish density and biomass.

Relative Biomass (g/m<sup>2</sup>)

- ☐ Coho salmon
- ▨ Steelhead trout
- ▤ Dolly varden trout
- ▧ Cutthroat trout

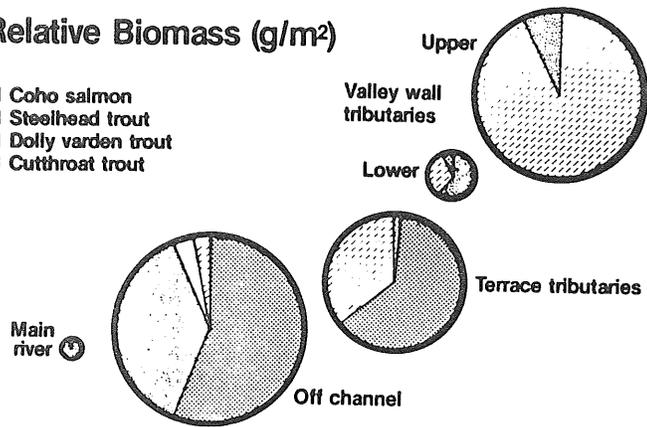


Figure 2A.--Average biomass of salmonid fishes in the South Fork Hoh River drainage system.

Figure 2B.--Average density of salmonid fishes in the South Fork Hoh River drainage system.

Relative Density (#/m<sup>2</sup>)

- ☐ Coho salmon
- ▨ Steelhead trout
- ▤ Dolly varden trout
- ▧ Cutthroat trout

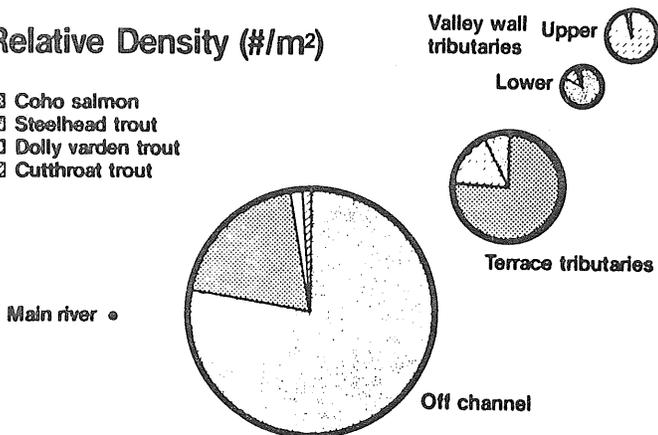


Table 4--Mean and range of length in millimeters of four species of fish collected in five aquatic habitats of the South Fork Hoh River, autumn 1978

Habitat type	Species			
	Coho	Steelhead	Cutthroat	Sculpin
Main river	--	125.0 (50-131)	--	--
Off-channel areas	73.6 (55-101)	42.0 (31-70)	113*	68.7 (24-117)
Terrace tributaries	57.3 (40-85)	36.3 (31-41)	77.0 (51-138)	57.0 (44-97)
Lower valley wall tributaries	68.5 (61-76)	51.3 (33-67)	74.0 (42-120)	55.0 (40-110)
Upper valley wall tributaries	--	131*	79.0 (38-170)	53.0 (41-95)

\*Only one individual captured.

The Olympic National Park provides a full range of pristine river systems which can be used as a bench mark for thousands of square kilometers of adjacent altered river systems. There is a basic need in the State of Washington and throughout the Nation to improve both the systems we manage and the system we manage with. Aquatic biologists lack comprehensive knowledge of pristine systems with relatively unmanaged fish population. The information we collected is of the kind needed for understanding the functioning of aquatic ecosystems. Moreover, it allows us to begin comparing the condition of pristine systems with the condition of similar, but altered, basins to develop an understanding of the control mechanisms and stability features of aquatic systems. An understanding of pristine watersheds should lead to more meaningful interpretation of the processes and effects of both natural and artificial habitat alteration and will also help promote more effective habitat improvement programs.

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