2004 Annual Report
Wenatchee Integrated Monitoring
Fish Population Sampling

Abstract

In 2004 we implemented a beta-test in Wenatchee Basin, Washington of a fish sampling component of an integrated sampling protocol following "*Monitoring Strategy for the Upper Columbia Basin*" (Hillman 2004). The protocol calls for sampling 50 random sites within the basin.

Our beta-test involved sampling at a subset of these 50 sites: the anadromous-accessible sites in Peshastin, Nason, and Chiwawa watersheds (13 sites). However no data could be obtained from one site (Nason above Mill Creek) due to high turbidities at time of sampling. This report therefore examines data from twelve sites: 3 sites in mainstem Nason Creek, 2 sites in mainstem Peshastin Creek, 3 sites in Peshastin tributaries, 2 sites in mainstem Chiwawa and 2 in a Chiwawa tributary.

We found clear differences in species assemblages and species/habitat relationships between sites. We also found strong habitat and temporal relationships, suggesting that this factors should be addressed when extrapolating from sampled sites to larger areas (e.g. basin-wide).

1. <u>Abundance and Species Richness</u>

   Fish abundance per wetted area increased with decreasing stream size. Because stream size at these sites was correlated with stream order, channel type, bedform, and water temperature, we cannot say which factor, if any, determined the relationship. Species richness, in contrast, decreased with decreasing stream size.

   At all sites, juveniles were an order of magnitude more abundant than adults.

   Abundance per thalweg length was also computed, as a metric potentially useful in extrapolating results to basin-wide fish abundance. While adults abundance per thalweg length was greater in higher order (wider) streams, juveniles showed no clear pattern by thalweg length. An outmigration event coincident with one snorkel date appeared to produce an outlier in juveniles per thalweg length.

2. <u>Diurnal Pattern</u>

Abundance estimates of juvenile steelhead and Chinook, and of other species, varied between day and night snorkels. At all sites, adult abundance/observability (all species combined) was higher at night (33-300%).

Most age-species groups showed a simple diurnal pattern. Sculpins, longnose dace, redside shiners, juvenile whitefish, and adult *O. mykiss* were more abundant at night. Adult whitefish and unidentified cypripideum juveniles were more abundant (or more observable) by day. The data is inconclusive for adult Chinook and for juvenile suckers (suckers were not identified to species).

Two groups showed two opposing diurnal patterns, possibly correlated with outmigration vs. rearing: juvenile Chinook and juvenile *O. mykiss*. In rearing-dominated sites, juveniles of these two species were typically more abundant/observable at night, with the degree of the difference correlated with habitat quality (juvenile cover). In outmigration-dominated sites, juveniles of these two species were slightly more abundant/observable by day.

3. Effect of habitat type (pool, riffle and side channel)

This is very preliminary data because it is based on very few sites (only three of the snorkeled site had pools and only two had side channels). The data suggests that in all age categories, fish density is highest in side channels, intermediate in pools, and lowest in riffles. For juveniles, side channels are an order of magnitude more densely populated than pools and riffles. For adults, pools and side channels are an order of magnitude more densely populated than riffles.

The differences in abundance by habitat type are as great or greater than differences between sites.

We were only able to compute abundance by habitat type where we modified the protocol to record habitat unit in which fish were observed. This protocol modification yielded valuable data for insignificant additional effort.

4. Temporal variation

At some sites, repeat day snorkels were conducted, either on two consecutive days, across the low-flow sampling season (approximately 20 days apart), or both. The sample size is very small but the data suggest that on consecutive days, the abundance estimate for a species may be doubled or halved. However across the season, order of magnitude differences were seen, particularly in juveniles of migratory species such as Chinook and steelhead.

5. Rare species

Abundance and distribution of species which were rare at these sites (including coho, bull trout, cutthroat and brook trout) were not well described by this protocol.

We compared our data with other snorkel protocols conducted in Nason and Peshastin Creeks in 2004, including: 1) targeted (non-random) sampling; 2) census sampling; 3) a systematic-downstream protocol which covered more area with a similar effort by giving up repeat day and night snorkels. Targeted and census snorkels were able to estimate abundances of rare species but could not extrapolate results beyond snorkeled areas. The systematic-downstream protocol did document presence of species that were not documented by our snorkeling (in the same reach), but

did not gather sufficient data on the rare species for good abundance estimates, and had no ability to consider diurnal or seasonal effects.

6. Future analysis

Future analysis could consider species diversity, using an index such as Shannon-Weiner diversity index. Diversity could be computed both by species and by species-age groups because different age groups may have different ecological functions or different habitat relationships.

7. Recommendations for future field sampling

We recommend the following protocol modifications: 1) collect fish information by habitat unit; 2) LWD and depth collected by or tied to habitat unit; and 3) habitat surveyors calculate wetted area (measure length and width) of habitat units.

Methods and Site Characterization

Day snorkels, night snorkels, and three pass electrofish sampling were conducted following the protocol in Hillman 2004. Twelve sites in three watersheds within Wenatchee basin were sampled.

Sampling dates are listed in Appendix A. In Peshastin Creek, sampling happened to coincide with a small out-migration event apparently triggered by a rain event/ local high flow.

Table one characterizes sites in terms of channel morphology, and LWD based on habitat data collected at these sites, courtesy of Glenn Merritt, Department of Ecology (DOE). Sites are also characterized by the range of stream temperatures encountered during snorkeling.

Table 1. Site Characterization.

Site	ROSGEN	BEDFORM	avg slope (%)	minimum slope (%)	maximum slope (%)	Total LWD	Min snorkel temp (C)	Max snorkel temp (C)
Nason - Coles	C	POOL-RIFFLE	0.8	0.2	2.1	122	17	21
Peshastin - mouth	B	PLANE-BED	1.2	0.3	3.7	7	14	17
Marble - lower	A	STEP-POOL	9.0	2.1	16.9	92	9	9
Chiwawa - RM 1	C	PLANE-BED	1.8	0.2	4.0	19	12	12
Tronsen - Bonanza	A	POOL-RIFFLE	2.5	0.7	4.5	19	7	9
Nason - Kahler	B	POOL-RIFFLE	2.1	0.8	3.0	47	13	22
Chiwawa - Chik Flats	C	POOL-RIFFLE	0.7	0.2	1.3	144	13	13
Chiwawa - Chik 2nd	*C*	*POOL-RIFFLE*	*0.2*	*0*	*0.5*	*111*		
Negro	A[1]	STEP-POOL[2]	5.7	0.1	12.3	41	7	9
Tronsen - upper	G	STEP-POOL	3.2	0.4	9.5	58	6	7
Tronsen - up 2nd	*G*	*STEP-POOL*	*3.7*	*1.3*	*10.7*	*62*		
Peshastin - Larsen	C[3]	PLANE-BED	0.9	0.2	2.0	21	12	14
Marble - upper	E	POOL-RIFFLE	0.6	0	2.2	132	10	10
Nason - Gill	C	POOL-RIFFLE	1.9	1.3	2.7	52	11	18
Nason - Gill 2nd surv	*C*	*POOL-RIFFLE*	*0.8*	*0.4*	*2.8*	*61*		

All data except temperature: unpublished data courtesy of Glenn Merritt, Washington Dept of Ecology. Three sites have two sets of habitat data (second visit shown in italics); these represent two visits by separate crews for quality control purposes.
Temperatures are at time of fish data collection (snorkel and/or electrofish). The minimum and maximum temperatures represent the highest and lowest collected during fish sampling, which in some cases spans part of a single day, and in other cases may include day and night samples and span a month or more.

[1] This site was classified as Rosgen A by the habitat crew but would have been classified as Rosgen B by the snorkel crew.
[2] This site would have been classified pool-riffle by the snorkel crew.
[3] This site was classified as Rosgen C by the habitat crew but would have been classified as Rosgen B by the snorkel crew.

Results

Two types of results are presented: biological and methodological. Biological analysis considers stream size, channel type, and habitat type relative to: 1) fish abundance per wetted area and 2) species richness. We also consider diurnal patterns of fish abundance.

Methodology issues addressed include: 1) identification of species, and categorization of a species into adult/juvenile based on length; 2) variability across the season of snorkel data collection; 3) quantification of rare species by this and alternative protocols; and 4) applying partnered habitat data (collected by DOE) to fish population data.

Abundance by site

At all sites juveniles are roughly an order of magnitude more abundant than adults (table 2).

All species/sizes: When all species and age classes are combined, there is a strong pattern by stream order, with total abundances 1-6 fish/100m^2 of wetted area in 4th order streams, rising to 7-45 fish/100m^2 in 2nd and 3rd order streams, and dropping to 5-9 fish/100m^2 in 1st order streams. This pattern is mainly driven by juvenile densities.

Table two. Abundance per wetted area and thalweg length at each site, all species combined.

Site	Name	Stream Order	Channel Type	Area (100m2)	Adults / 100m2	Juve / 100m2	Other / 100m2	Total / 100m2	Adults / 100 m thalweg	Juve / 100 m thalweg	Total / 100 m thalweg
38	Chiwawa – Chik Flats	4	C	116.8	0.4	2	0	2	9	46	55
17	Chiwawa RM 1	4	C	137.4	0.3	1	0	2	9	39	48
1	Nason – Coles	4	C	84.6	0.5	5	0.4	6	9	82	97
166	Nason – Gill	4	C	85.0	0.3	3	0.3	3	6	44	55
32	Nason – Kahler	4	B	105.7	0.2	1	0.1	1	4	17	22
155	Peshastin – Larsen	3	B	52.6	0.5	14	0.2	15	7	222	231
11	Peshastin – mouth	3	C/B	40.8	0.1	6	0.7	7	1	71	81
46	Negro	2	A/B	3.4	2.2	8	0	10	5	18	21
29	Tronsen – Bonanza	2	A	3.8	0.8	23	0	23	2	58	58
152	Tronsen – upper	2	G	1.8	1.6	45	0	45	2	55	55
164	Marble – upper	1	E	7.7	0	9	0	9	0	39	39
15	Marble – lower	1	A	6.2	0	5	0	5	0	21	21

Adults vs. juveniles were determined by length; see table 11 below. Two taxa were not separated into juvenile and adult: sculpin spp and longnose dace (called "other" in the table above). See discussion under "Methodology: species and age class categorization" below. Two values for a channel type indicates that it was classified differently by different crews.

Two sites contained over 20 total fish per 100m^2. Both were in Tronsen Creek: a small, single species, headwater stream in the Peshastin drainage containing only *O. mykiss*. The peak abundance occurred in 4-5 cm length classes, and the largest O. mykiss observed was 18 cm long.

Two other sites (Negro and Peshastin-Larsen) contained over 10 total fish per $100m^2$. Negro Creek is also a Peshastin headwater stream containing only *O. mykiss*, and Peshastin-Larsen is a site in the Peshastin mainstem dominated by *O. mykiss* and juvenile Chinook of outmigratory size.

Adults: At 9 sites, adult densities were $0.5/100m^2$ or less; at 3 sites adult densities were $0.8\text{-}2.2/100m^2$. The two sites with lowest adult densities (Marble Creek) and the three sites with highest adult densities were dominated by *O. mykiss*[4]. Under "methodology" below, we document concerns with separating *O. mykiss* into adult/juvenile categories based on a single size cut-off; this methodology problem may be introducing "noise" into adult estimates at sites dominated by *O. mykiss*.

We also calculated abundance by thalweg length. This my allow estimates to be more easily extrapolated to a whole basin, where stream length can be modeled, but stream width may be less available. As would be expected, adult fish per thalweg length are more abundant in bigger (wider) streams. However, there was no clear relationship between juvenile fish/100m and stream size, nor between total fish/100m (largely driven by juveniles) and stream size.

No clear pattern was apparent for total fish per thalweg length. Total fish/thalweg length was of the same order of magnitude at all sites except one. The outlier, Peshastin-Larsen, which had twice the fish/thalweg of other sites, was likely influenced by outmigration.

Taxa richness

Third and fourth order streams had higher taxa richness than lower order streams (table 3). The greatest number of taxa (7-8) were observed at two mainstem Nason Creek sites: one near Coles Corner and one just above. Intermediate taxa richness (5-6 taxa present and lower "evenness" across taxa) occurred at Peshastin-mouth and Nason-Gill. The Chiwawa and Marble sites were not night-sampled and so are not directly comparable to the other sites, because night snorkeling typically increased the taxa richness.

[4] One brook trout occurred at lower Marble. All other fish encountered at lower Marble and all fish at the other 4 sites were *O. mykiss*.

Table 3. Taxa observed at each site

Site Num	Site Name	number taxa at site	Number of fish observed										
			rainbow / steelhead	Chinook	whitefish	sculpin	Longnose Dace	sucker	Bull trout	juvenile cyprinid	coho	Redside shiner	Brook trout
1	Nason - Coles	8	402	705	91	46	47	30		106		31	
32	Nason - Kahler	7	143	45	1	19	10	2		43			
11	Peshastin - mouth	6	303	40		10	30	2			1		
166	Nason - Gill	5	216	277	46	57	1						
38	Chiwawa - Chik	4	52	112	107				5				
17	Chiwawa RM 1	4	82	87	70				3				
155	Peshastin - Larsen	3	789	419		18							
15	Marble - lower	2	31										1
164	Marble - upper	1	71										
46	Negro	1	89										
29	Tronsen - Bonanza	1	87										
152	Tronsen - upper	1	83										

Day vs Night Abundances

In comparing day vs. night snorkel counts, we may refer to abundance “increasing” or “decreasing.” We presume that generally what we are measuring is fish became more or less observable, rather than migration into or out of the site (although migration is not ruled out). For several species, we noted differences in behavior between night and day that would account for altered observability: many fish ranging farther from cover at night, and some species were apparently concealed within the substrate during the day but active at night.

A night:day ratio of one would indicate that the species was equally abundant/observable both day and night. Night:day ratios greater than one indicate that the species was more abundant/observable at night, and vice versa.

At all sites, adult abundance increased at night (table 4). The increase ranged from 33% to 300%.

Juvenile abundance showed two contrasting patterns. At most sites, juvenile abundance increased at night (22% – 1767%). At two sites where an outmigration event was occurring, juvenile abundance decreased at night (33-64%).

The diurnal pattern of total fish abundance mirrored the juvenile pattern.

Species which we did not categorize into juvenile/adult (sculpin and Longnose Dace) were more abundant at night (400-1150% increase).

Table 4: Abundances in day vs. night snorkel

Site Num	Name	Fish/100m2 Day snorkel	Fish/100m2 Night snorkel	Adults/100m2 Day snorkel	Adults/100m2 Night snorkel	Juveniles/100m2 Day snorkel	Juveniles/100m2 Night snorkel	Uncategorized/100m2 Day snorkel	Uncategorized/100m2 Night snorkel
166	Nason - Mill	0.6	7.3	0.3	0.4	0.3	5.6	0	1.2
32	Nason - Kahler	0.7	2.8	0.3	0.5	0.3	1.9	0.04	0.5
1	Nason - Coles	5.0	7.2	0.4	0.8	4.5	5.5	0.1	0.9
46	Negro	5.0	17.7	1.8	3.4	3.3	14.3	0	0
11	Peshastin - mouth	7.6	4.6	0.05	0.2	7.3	2.6	0.2	1.8
155	Peshastin - Larsen	16.6	12.1	0.3	0.8	16.2	10.8	0.1	0.5

Only sites with both day and night snorkels are included. Where sites received snorkels across the season, only day and night snorkels occurring within 5 days of each other are included. Dates of each snorkel are given in Appendix A. Except at Nason-Coles, all "adults" are salmonids. Juveniles include salmonids and non-salmonids, and "uncategorized" includes two taxa (sculpins and Longnose dace) that were not classified adult/juvenile.

While table 4 lumps all taxa, table 5 (below) considers diurnal patterns specific to species and age class.

Most species-age groups showed a simple day/night pattern. The exceptions were juvenile Chinook and juvenile *O. mykiss*, which exhibited strong but complex diurnal patterns. There was also no clear day/night pattern for juvenile suckers, but we can draw no conclusions from this because we did not identify them to species.

Sculpins, longnose dace, redside shiners, juvenile whitefish, and adult *O. mykiss* were more abundant at night. Adult whitefish and unidentified cypripideum juveniles were more abundant in day. The data is inconclusive for adult Chinook and juvenile suckers. Juvenile chinook and juvenile *O. mykiss* each showed two opposed patterns, apparently correlated with outmigration vs. rearing.

Juvenile Chinook were more abundant at night at three sites in Nason Creek, and more abundant during the day at two sites in Peshastin Creek. At one Nason site they were only seen at night; at one they were 50% more abundant at night, and at one they were an order of magnitude (20 times) more abundant at night. Based on our observations of juvenile Chinook behavior at these sites, we hypothesize that these differences relate to differences in habitat and cover at the three sites; that is, the most extreme difference in day/night abundances in Nason Creek occurred at the sites with least cover.

In Peshastin Creek, juvenile Chinook were 20% more abundant during the day. Peshastin smolt-trap and flow data indicate that a small spike in flow and in outmigration happened to occur on the days we snorkeled Peshastin Creek. Outmigrating Chinook and steelhead may migrate more at night (Keely Murdoch, pers. comm.) and may have been more observable by day, holding in pocket water behind boulders. Peshastin Creek did not offer the type of cover preferred by juvenile Chinook and steelhead in Nason Creek.

In Nason Creek, nearly all juvenile Chinook and steelhead were associated with one of three types of cover: 1) woody debris, 2) large boulder bank rip-rap or 3) a bankside area with protruding underwater

fine roots, and in some cases also underwater branches and/or undercut bank. Juvenile steelhead also used an additional form of cover which juvenile Chinook did not use: extremely low depths (typically 1.5 inches water or less) often in very small habitat areas (less than one meter squared) such as tiny alcove pools or shallow streambanks. Juvenile Chinook and steelhead were very tightly associated with these cover types during the day. At night they were still associated with this cover but not as tightly; most were within a meter of the cover at night vs within inches of the cover during the day; and at night a few were found even farther from cover.

The two Peshastin Creek sites did not contain these types of cover. The banks were armored by substrate; underwater roots did not protrude. Woody debris abundance was very low. In Peshastin Creek, juvenile Chinook and steelhead occurred in small (typically 2 - 8 individuals) uni- or bi-species schools in the quieter water behind boulders. A few, especially the smaller steelhead, used the quieter water along the banks.

If the Peshastin and Nason sites were viewed from above in 100 m2 pixels, in Peshastin Creek the abundance of juvenile Chinook and steelhead per pixel would be relatively uniform. In Nason Creek it would be extremely non-uniform, extremely clustered, with occurrence dependent on cover occurrence, and juvenile Chinook and steelhead absent from 80-90% of the pixels in the low-cover Nason sites.

Another difference between the Nason and Peshastin sites is that the Peshastin sites were known to be sampled during a small out-migration spike apparently linked to higher flows following a summer rain. We do not have comparable data for the Nason sites but they were not sampled during a local high flow event.

Juvenile *O. mykiss* showed a similar pattern to juvenile Chinook. Day/night abundance at the Nason sites was correlated with cover abundance. Nason-Kahler, with almost none of the 3 cover types described above, had 70 times greater abundance at night; Nason-Mill with low cover had 20 times greater abundance at night, and Nason-Coles with abundant cover, actually had 20% lower abundance at night. Both Peshastin sites had lower abundances of *O. mykiss* at night (40-70% lower). In Negro Creek, a 2nd order headwater stream with an apparently stable, mono-species population and no known migratory component, we observed 4 times more juvenile *O. mykiss* at night.

It appears that while other species showed a single day/night pattern, juvenile Chinook and steelhead showed two opposite day/night patterns, depending on cover and/or outmigration.

We have insufficient data to compare adult Chinook day/night patterns. However in general we saw the same individuals both day and night, except during spawning when we deliberately did not disturb spawning areas, but during the day could observe and count adult Chinook from the bank.

We saw adult Chinook only in Nason and Chiwawa. In Nason prior to spawning, over 80% of adult Chinook were observed schooling at depth in pools over six feet deep; occasional individuals were observed alone and deep in cover during the day. At night adult Chinook appeared to move a bit more freely but the majority were still schooled in deep water, and therefore had reduced observability at night depending on turbidity.

Day and night, adult whitefish were always observed schooling in pools of roughly 1-meter or greater depth. Schools of adult Chinook typically also contained adult whitefish. Adult whitefish appear to be less observable at night, probably due to depth/turbidity.

Sculpins and longnose dace were an order of magnitude more abundant at night. These taxa appeared highly "substrate-oriented" in that they were usually encountered resting on substrate and their "flight" response was usually to move into the substrate. We hypothesize that they are mainly concealed in the substrate and undetected during the day.

Juvenile suckers were somewhat substrate-oriented (typically encountered on the substrate but did not flee by moving into the substrate). At three sites suckers were more abundant at night, and at one site they were seen only by day. Since we may be observing different species at different sites, our conclusions are limited.

Adult redside shiners were only seen at one site, which was snorkeled twice during the day and once at night: they were only seen at night. All redside shiners observed were in one off-channel less than 0.5 m deep with no perceptible velocity.

Based on a small amount of data, more unidentified *Cypripideum* juveniles were observed during the day, and slightly more juvenile whitefish at night.

Table 5. Day/night patterns by taxa and age class.

			Adults / 100m2			Juveniles / 100m2			Uncategorized/100m2		
Species	**Site Num**	**Site Name**	**Day SN**	**Night SN**	**Ratio N:D**	**Day SN**	**Night SN**	**Ratio N:D**	**Day SN**	**Night SN**	**Ratio N:D**
Sucker spp.	1	Nason - Coles				0.02	0.31	13.0			
	11	Peshastin - mouth				0.05	0.00	only day			
	32	Nason - Kahler				0.00	0.04	only night			
	average	**all sites**				**0.02**	**0.12**	**4.8**			
Sculpin spp.	1	Nason - Coles							0.11	0.32	2.8
	11	Peshastin - mouth							0.05	0.48	9.8
	32	Nason - Kahler							0.02	0.30	15.0
	155	Peshastin - Larsen							0.06	0.51	8.9
	166	Nason - Gill							0.00	1.22	only night
	average	**all sites**							**0.05**	**0.56**	**11.9**
Unidentified	1	Nason - Coles				0.53	0.20	0.4			
Cypripideum	32	Nason - Kahler				0.26	0.00	only day			
juveniles	**average**	**all sites**				**0.39**	**0.10**	**0.3**			
rainbow/	1	Nason - Coles	0.05	0.24	4.4	1.55	1.30	0.8			
steelhead	11	Peshastin - mouth	0.05	0.18	3.7	6.48	2.04	0.3			
	32	Nason - Kahler	0.00	0.40	only night	0.02	1.40	71.0			
	46	Negro	1.78	3.44	1.9	3.25	14.27	4.4			
	155	Peshastin - Larsen	0.29	0.78	2.7	10.64	6.54	0.6			
	166	Nason - Gill	0.00	0.35	only night	0.09	1.80	19.5			
	average	**all sites**	**0.36**	**0.90**	**2.5**	**3.67**	**4.56**	**1.2**			
Chinook	1	Nason - Coles	0.11	0.09	0.9	2.25	3.54	1.6			
	11	Peshastin - mouth				0.74	0.60	0.8			
	32	Nason - Kahler	0.34	0.06[5]	0.2[4]	0.00	0.45	only night			
	155	Peshastin - Larsen				5.58	4.29	0.8			
	166	Nason - Gill	0.02[5]	0.04[6]	2.4[5]	0.18	3.72	20.2			
	average	**all sites**	**0.15**	**0.07**	**0.4[7]**	**1.75**	**2.52**	**1.4**			
whitefish	1	Nason - Coles	0.23	0.11	0.5	0.17	0.17	1.0			
	32	Nason - Kahler				0.00	0.02	only night			
	166	Nason - Gill	0.26	0.04[8]	0.2[7]	0.00	0.09	only night			
	average	**all sites**	**0.24**	**0.08**	**0.3**	**0.06**	**0.09**	**1.6**			
Longnose	1	Nason - Coles							0.00	0.56	only night
dace	11	Peshastin - mouth							0.20	1.32	6.7
	32	Nason - Kahler							0.02	0.18	9.0
	166	Nason - Gill							0.00	0.02	only night
									0.05	**0.52**	**9.6**
Redside	1	Nason - Coles	0.00	0.37	only night						
shiner	**average**	**all sites**	**0.00**	**0.37**	**only night**						

Data from all sites where both day and night survey occurred; only data from surveys occurring within 5-day span included. Sculpins and Longnose dace were not categorized adult/juvenile.

[5] Incomplete data. During both day and night snorkels we walked around an x-m stretch of active spawning. During the day we observed and recorded the spawning adults but at night we did not observe them.
[6] Misleading comparison. One male jack was seen at the site on both day and night snorkels; on the night snorkel a second fish was observed: a dead female on the bottom of a pool.
[7] Data from Nason-Mill excluded for reason given above.
[8] The night snorkel was terminated below the area where the bulk of adult whitefish were observed in the day.

Effect of habitat type (Pool/Riffle/Side Channel) on fish populations

In 2004, 4 sites were snorkeled with the standard protocol, which does not take note of what habitat unit fish are encountered in. Fish abundance is known for the whole site only. At 6 sites, we supplemented the standard protocol by enumerating habitat units, measuring length and width, and recording which habitat unit each fish was observed in.

Fish within habitat unit was enumerated at six snorkel sites (three in Nason, two in Peshastin, and one in Negro), in all of which we also made day/night comparisons. All six sites had riffle habitat, but only three had pool habitat and only two had side channel habitat.

This is very preliminary data because it is based on very few sites. It suggests that in all age categories, fish density was highest in side channels, intermediate in pools, and lowest in riffles. For juveniles, side channels were an order of magnitude more densely populated than pools and riffles. For adults, pools and side channels were an order of magnitude more densely populated than riffles.

Table 6: Abundance by habitat type

	Per 100m2 area			
Habitat Type	Adult	Juvenile	Uncategorized	Grand Total
Pool	1.2	7.0	0.5	8.6
Riffle	0.1	3.3	0.2	3.7
Side	3.7	27.0	1.7	32.3

Data from 6 snorkel sites, 3 of which had only riffle habitat.

We next took the data presented in table 6 and considered diurnal and habitat effects simultaneously (table 7). As before we caution that the data is very preliminary due to the small number of sites.

The data suggests that the increase in adult abundance/detectability at night occurs in all habitat types but is greatest in side channels. This adult-side channel usage may represent fish movement as well as detectability.

Juvenile abundance/detectability increases modestly (16 %) at night in riffles, but roughly doubles in pools and side channels. Night-time increases in “uncategorized” species (sculpins and longnose dace) are very high in all habitat types, but are highest (an order of magnitude) in pools and side channels.

Table 7: Abundance by habitat type and day/night.

		Per 100 m2 area			
Habitat Type	Day/Night	Adult	Juvenile	Uncategorized	Total
Pool	DS	1.1	5.6	0.1	6.9
	NS	1.3	10.2	1.5	13.0
Pool Total		1.2	7.0	0.5	8.6
Riffle	DS	0.1	3.1	0.1	3.3
	NS	0.3	3.7	0.7	4.7
Riffle Total		0.1	3.3	0.2	3.7
Side	DS	0	20.6	0	20.6
	NS	10.9	39.6	4.9	55.3
Side Total		3.7	27.0	1.7	32.3

Data from 6 snorkel sites, 3 of which had only riffle habitat.

Table 8 breaks this data apart even further: by site, species and life stage.

Adult fish were not found in side channel habitat by day, only by night (table 8).

Juvenile Chinook showed two patterns: at Nason sites they were more abundant (or more observable) in all habitat types at night; in Peshastin sites, which have only riffle habitat, they were more abundant/observable by day.

Juvenile *O. mykiss* showed a highly variable pattern. In Negro Creek, Nason-Kahler, and Nason-Gill they were more abundant/observable at night in all habitat types occurring at the site. At Nason-Coles they had similar day/night abundances in riffles and side channels, and were more abundant in pools in the day. In the two Peshastin sites, which had only riffle habitat, they were more abundant in the day. As discussed above, in Peshastin they may have exhibited different behavior due to outmigration.

In contrast *O. mykiss* larger than 17 cm were more abundant at night in every habitat type at every site. This implies that at night larger *O. mykiss* are either moving out of cover, or are moving into the snorkeled sites from different habitat types.

Sculpins were more abundant at night in every habitat type at every site. Redside shiners were only seen at one site (Nason-Coles): they were seen only at night there, and only in pool and side channel habitat. Suckers showed no clear pattern, but we did not identify them to species.

Table 8. Abundance by species, life stage, day/night, habitat type and site

		Adult						Juvenile						Uncategorized					
		Pool		Riffle		Side		Pool		Riffle		Side		Pool		Riffle		Side	
Species	Site	DS	NS	DS	NS	DS	NS	DS	NS	DS	NS	DS	NS	DS	NS	DS	NS	DS	NS
CASP	1	0	0	0	0		0	0	0.44	0.03	0.25	0.20	0.36						
	11			0	0					0.05	0								
	32			0	0					0.00	0.04								
CASP Total		0	0	0	0		0	0	0.44	0.01	0.13	0.20	0.36						
COSP	1													0.13	0.40	0.11	0.29		0.36
	11															0.05	0.48		
	32															0.02	0.30		
	155															0.06	0.51		
	166													0.00	2.64	0.02	0.44		
COSP Total														0.06	1.33	0.05	0.37		0.36
CYPR	1							0.27	0	0.56	0.02	1.99	5.84						
	32									0.21	0.00								
CYPR Total								0.27	0	0.34	0.01	1.99	5.84						
ONMY	1	0.20	0.62	0	0.05		1.09	2.74	1.56	0.66	0.69	12.36	12.41						
	11			0.05	0.18					6.48	2.04								
	32			0	0.40					0.26	1.40								
	46	3.81	5.25	0.90	2.60		0.00	5.71	22.30	2.26	8.66	0	17.39						
	155			0.29	0.78					10.64	6.54								
	166	0	0.75	0	0.14			0.50	1.45	1.07	1.99								
ONMY Total		0.13	0.77	0.04	0.30		1.05	1.58	1.92	2.09	2.18	12.08	12.61						
ONTS	1	0.40	0.31	0	0.02		0.00	7.27	8.81	0.09	0.69	8.37	21.89						
	11			0	0					0.74	0.60								
	32			0.09[9]	0.06[10]					0	0.45								
	155			0	0					5.58	4.29								
	166	0.04[10]	0.06[11]	0	0.03[11]			1.13	6.98	0.53	1.95								
ONTS Total		0.21	0.21	0.04	0.03		0.00	3.98	8.05	0.76	1.39	8.37	21.89						
PRWI	1	0.87	0.36	0	0.02		0.00	0.02	0.22	0.24	0.15	0	0						
	32			0	0					0	0.02								
	166	0.77	0.13[11]	0	0			0.00	0.13	0	0.07								
PRWI Total		0.81	0.26	0.00	0.01		0.00	0.01	0.18	0.07	0.09	0	0						
RHCA	1													0	0.27	0	0.47		4.74
	11															0.20	1.32		
	32															0.00	0.18		
	166													0	0	0	0.03		
RHCA Total														0	0.16	0.02	0.39		4.74
RIBA	1	0	0.13	0	0		10.22	0	0	0	0	0	0	0	0	0	0		0
RIBA Total		0	0.13	0	0		10.22	0	0	0	0	0	0	0	0	0	0		0

Blank field indicates that this combination did not occur: (for example, this habitat type was not present at this site; or this species was not categorized into juvenile and adult). A zero in the field indicates that the combination occurred but this type of fish was not observed.

[9] Incomplete data. During both day and night snorkels we walked around an x-m stretch of active spawning.
[10] Misleading comparison. Day snorkel: one male jack was observed in a pool. Night snorkel: one male jack was observed in a riffle and one dead female was observed in a pool.
[11] The night snorkel was terminated below the area where the bulk of adult whitefish were observed in the day.

Habitat Comparison using standard protocol

At two mainstem Chiwawa sites (17 and 38) and two Marble Creek sites (15 and 164) we do not know which fish are within which habitat type nor the precise area of each habitat type. We can say, based on 100 evenly-spaced transects in each reach, what percent of transects fell within a given habitat type.

Table 9. Percent of transects by habitat type at Chiwawa and Marble sites

Site	Missing data	Pool (dammed)	Pool (scour)	Glide (nonturbulent riffle)	Riffle (turbulent)	Grand Total
15	10			20	70	100
17				15	85	100
164		4	55	11	30	100
38[12]			51	49		100
38[13]			39	57	4	100

Data courtesy of Glenn Merritt, DOE

One mainstem Chiwawa site (17) had no pool habitat and was largely turbulent riffle. The other mainstem Chiwawa site (38) had 40-50% pool, and the remainder glide (non-turbulent riffle). The pool/glide site had roughly a 25% higher density of adults and roughly double the density of juveniles (all species combined) than the riffle site (table 6). By species, the pool/glide site had lower densities of adult Chinook and *O. mykiss*, but higher densities of adult bull trout and whitefish. When they occurred, juveniles of all species except *O. mykiss* were higher at the pool/glide site.

In Marble Creek, one site (164) was over half pool and the other site (15) had no documented pool habitat. The site with pool habitat had approximately twice the density of juvenile *O. mykiss*. One juvenile brook trout was observed at site 15 and none at site 164.

Table 10. Species abundance at standard protocol sites

		Fish per 100m2									
	Site	Chinook		*O. mykiss*		Bull trout		Brook trout		Mtn Whitefish	
Stream	number	Juv	Adult	<17 cm	>17 cm	Juv	Adult	Juv	Adult	Juv	Adult
Chiwawa River	38	0.92	0.03	0.44	0.01	0	0.04	0	0	0.62	0.30
Chiwawa River	17	0.57	0.06	0.56	0.04	0	0.02	0	0	0.30	0.21
Marble Creek	164	0	0	9.28	0	0	0	0	0	0	0
Marble Creek	15	0	0	5.01	0	0	0	0.16	0	0	0

Data courtesy of Tracy Hillman, BioAnalysts

[12] First habitat survey at site on 3-August-04.
[13] Repeat habitat survey at site on 5-August-04.

Methodological Results

The preceding section focused on biological results. The rest of this analysis considers methodological and protocol issues.

Species and age class categorization

Salmonids

For most salmonids encountered this year, there were clear size breaks between juvenile and adult fish. The exception was *O. mykiss*.

O. mykiss includes both resident rainbow and anadromous steelhead, which are visually indistinguishable pre-smolt, but may differ in size-at-age, behavior, etc. Other researchers in Wenatchee basin have used either 6 inches (15 cm) or 8 inches (20 cm) as a size cut-off to divide *O. mykiss* juveniles from adults.

During spring spawning surveys in the Wenatchee basin, biologists from WDFW and USFS have observed *O. mykiss* smaller than 8 inches spawning (pers. comms. M. Tonseth, J. Haskins, C. Thomas, G. Torretta). In the eastern Cascades, sexual maturity has been recorded in cutthroat and rainbow as small as 5 inches in length[14].

In this study we categorize all *O. mykiss* 16 cm and smaller as juveniles, and fish 17 cm and greater as adults. This may over-count adults in areas dominated by steelhead outmigration (for example our two Peshastin sites), and/or may under-count small resident rainbow adults in headwater tributaries (for example Tronsen sites). This problem may be unavoidable when a single size break is used, and we have no better solution to offer at this time.

Non-salmonids

Three non-salmonid taxa could not be identified to species during this study: sculpins, juvenile suckers, and a 1-cm cyprinid. Sculpins (size range 2-18 cm) and Longnose dace (4-14 cm size range) were not broken into age classes.

[14] Unpublished data courtesy of Phil Howell. Fish were collected from several eastern Cascade watersheds including Wenatchee, Entiat, Methow, and Yakima. Randomly collected cutthroat and rainbow of all sizes were given a non-destructive "squeeze test" that might produce eggs or ejaculate from a mature fish. Presence of maturity was definitive but absence was not, and the test appeared to identify males more easily that females.

Table 11. Age class categorization based on length used in this study.

Species	Common name	Juve (cm)	Adult (cm)	Adult Migratory (cm)	Comment
Oncorhynchus mykiss	Rainbow/steelhead	<=16.9	17-39.9	>=40	No migratory-sized fish (adult steelhead) were observed
O. tshawytscha	Chinook	<=25.9	>=26	same as adult	All fish observed were either <=14 cm (juves) or >= 36 cm (adults). All adults considered migratory.
Catostomus spp.	Sucker spp	<=19.9	>20	N/A	The largest Catostomus seen was 16 cm. All were judged juvenile.
Prosopium williamsoni	Whitefish	<=17.9	>=18	N/A	
Richardsonius balteatus	Redside shiner	<3	>=3		The only sizes seen were 6-10 cm. All were called adult. (see CYPR)
Salvelinus confluentus	Bull trout	<=19.9	>20		
O. kisutch	Coho				Only one ONKI seen. 4 cm. Called juve.
Rhinichthys cataractae	Longnose dace				We had insufficient information to distinguish juve from adult longnose dace. In future we will focus more on visibility of the lateral line.
Cottus	Sculpin				We did not believe we could reliably distinguish juveniles from adults since we could not separate species
Juve. Cyprinid					These 1-cm long fish were difficult to identify. Definitely juvenile cyprinids - probably longnose dace based on side stripe and spot near tail - possibly red side shiners.

Repeat day snorkel variability

At three sites we repeated day snorkels to test measurement variability. Twice a repeat snorkel occurred on the following day, and twice a repeat snorkel followed the previous snorkel(s) by 21-27 days (table 15). When a snorkel was repeated on consecutive days, the ratio of the two snorkel measurements was typically[15] less than two (a ratio of one would indicate no difference between measurements, a ratio of 2 would indicate a repeat count of double or half).

In contrast, when several weeks elapsed between snorkels, abundance per $100m^2$ could vary by an order of magnitude, with the ratio of the two measurements sometimes near one and sometimes as high as 6, 10 or 18. The biggest changes were seen in migratory juveniles (Chinook and steelhead).

[15] One exception was the unidentified cyprinids. These 1-cm fish had a very patchy and locally abundant distribution. At Nason-Coles, the repeat snorkel crew did not snorkel one shallow off-channel area, and thus missed a large portion of the unidentified-cyprinids at this site.

Table 12. Repeat day snorkels: Abundances per 100m^2.

		Nason - Coles		Nason - Kahler			Nason - Gill		Avg measurement ratio[16]	
		17-Aug-04	18-Aug-04	17-Aug-04	18-Aug-04	8-Sep-04	12-Aug-04	8-Sep-04	consecutive days	seasonal
O. mykiss	>=17 cm	0.05	0.06	0	0	0	0	0	1.3	
	< 17 cm	1.51	1.61	0.15	0.42	0.02	1.34	0.09	1.9	17.8
Chinook	Adult	0.13	0.08	0	0.02	0.34	0.01	0.02	1.6	9.7
	Juvenile	1.83	2.68	0	0	0	1.12	0.18	1.5	6.1
Whitefish	Adult	0.22	0.24	0	0	0	0.31	0.26	1.1	1.2
	Juvenile	0.15	0.19	0	0	0	0	0	1.2	
Longnose dace		0	0	0	0	0.02	0	0		
Sucker spp	Juvenile	0.05	0	0	0	0	0	0		
Sculpin spp		0.12	0.11	0.02	0.02	0.02	0.02	0	1.1	1.0
Cyprinid[9]	Juvenile	0.85[9]	0.20[9]	0.13	0.23	0.26	0	0	3.0[9]	1.1

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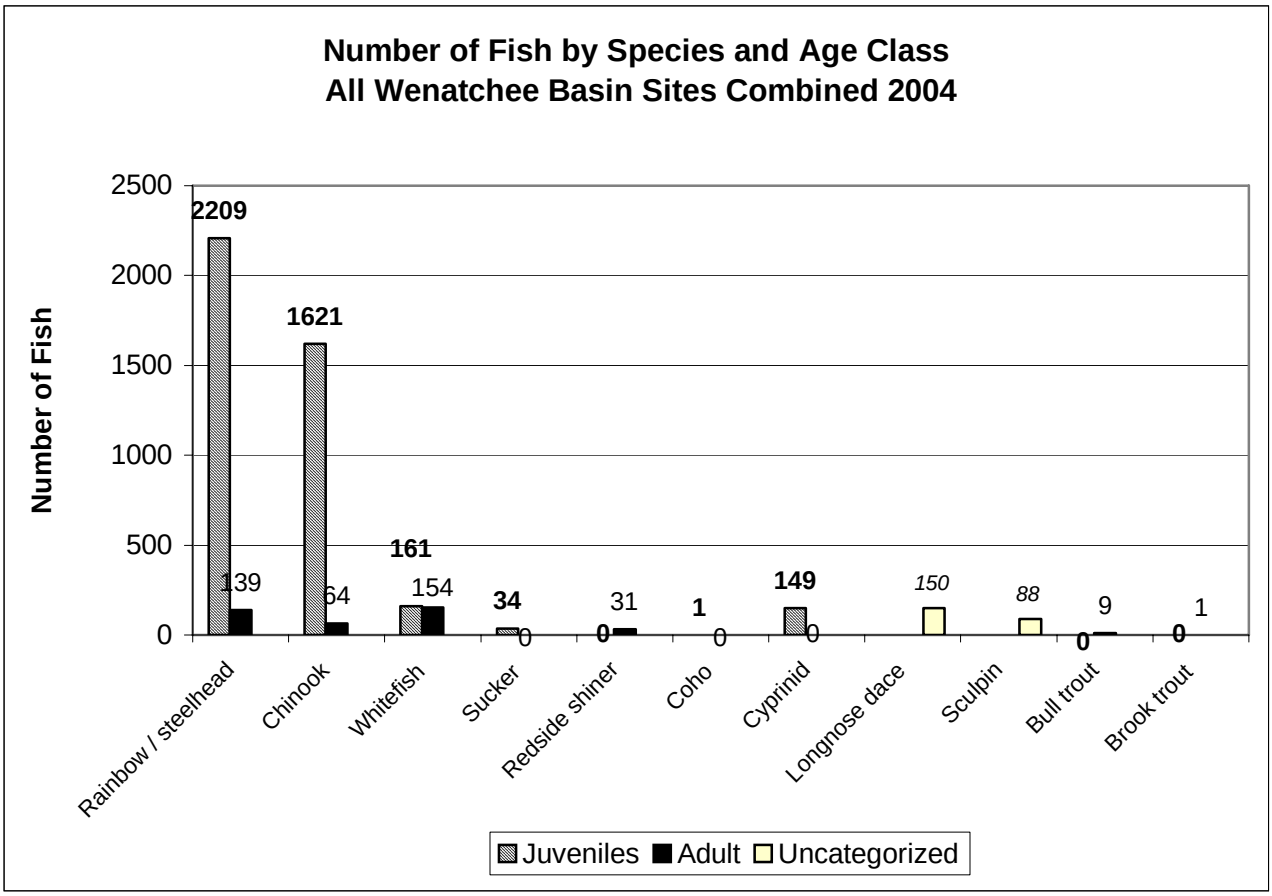
[16] Any comparison where one or both values were zero was not included. The ratio was always greater than one, that is we always divided the larger number by the smaller. Where there were two changes with no zeros, we averaged the two ratios.

Appendix A: Sampling Dates

Site num	Site	First Habitat Date	Second Habitat Date	First Fish Sample Date	Second Fish Sample Date	Third Fish Sample Date	Fourth Fish Sample Date	First Fish Sample Type	Second Fish Sample Type	Third Fish Sample Type	Fourth Fish Sample Type
1	Nason - Coles	12-Aug-04		17-Aug-04	18-Aug-04	19-Aug-04		Day SN	Day SN	Night SN	
11	Peshastin - mouth	20-Aug-04		26-Aug-04	31-Aug-04			Night SN	Day SN		
15	Marble - lower	8-Jul-04		3-Sep-04				Day SN			
17	Chiwawa - RM 1	28-Jul-04		31-Aug-04				Day SN			
29	Tronsen - Bonanza	25-Aug-04		14-Sep-04				Electrofish			
32	Nason - Kahler	12-Aug-04		17-Aug-04	18-Aug-04	8-Sep-04	9-Sep-04	Day SN	Day SN	Day SN	Night SN
38	Chiwawa - Chikamin Flats	3-Aug-04	5-Aug-04	30-Aug-04				Day SN			
46	Negro	26-Aug-04		31-Aug-04	1-Sep-04	7-Sep-04		Night SN	Day SN	Electrofish	
152	Tronsen - upper	25-Aug-04	27-Aug-04	22-Sep-04				Electrofish			
155	Peshastin - Larsen	19-Aug-04		25-Aug-04	26-Aug-04			Day SN	Night SN		
164	Marble - upper	15-Jul-04		3-Sep-04				Day SN			
166	Nason - Gill	30-Jul-04	6-Aug-04	12-Aug-04	8-Sep-04	9-Sep-04		Day SN	Day SN	Night SN	

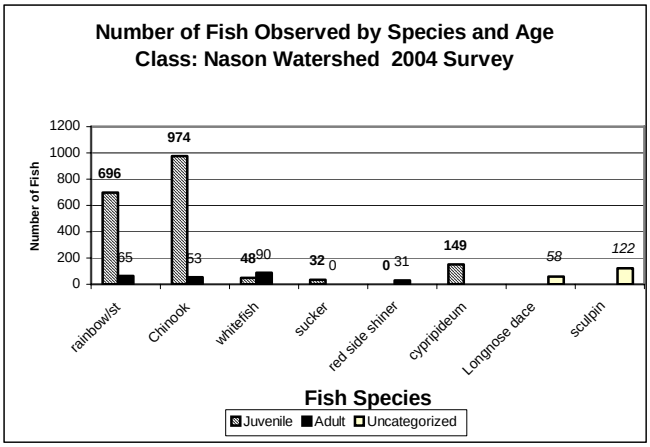
Appendix B: Graphs

Graph one: total numbers of fish observed at all sites (data not adjusted by wetted area)

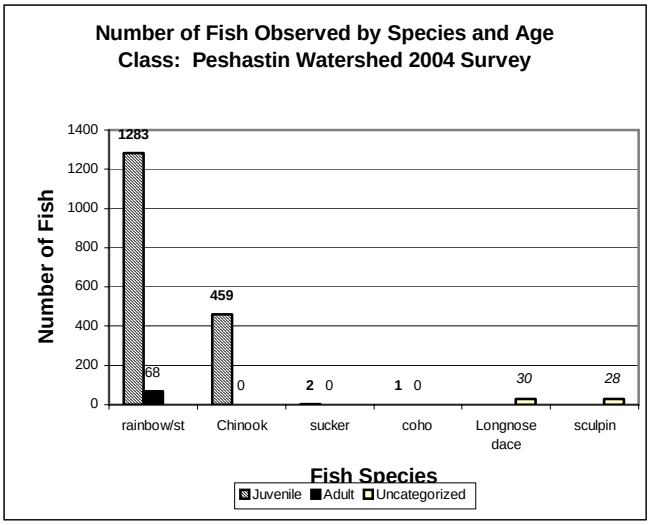


Graph two: number of fish observed by watershed (data not adjusted by wetted area)

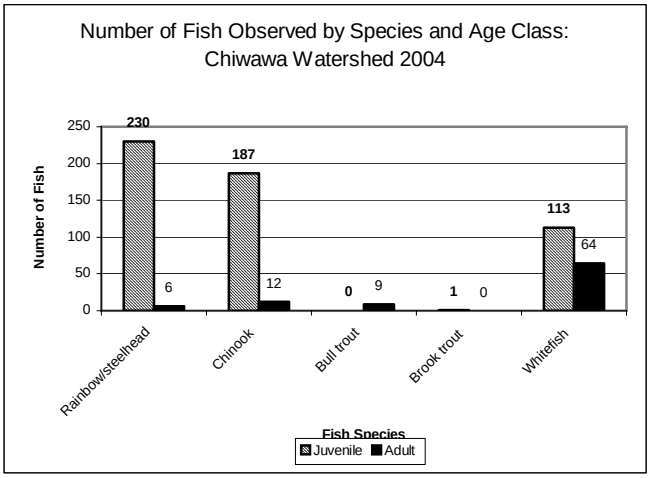
Graph 2A: Nason Watershed



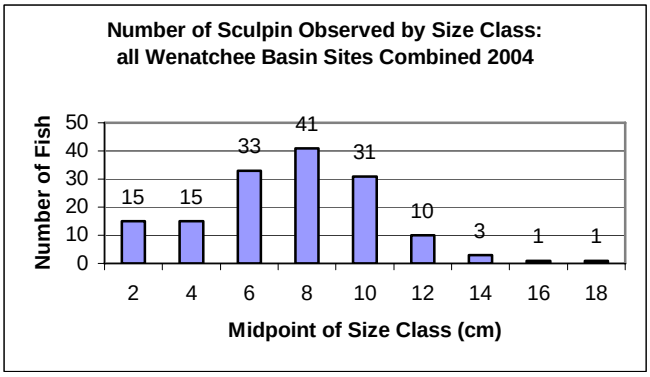
Graph 2B: Peshastin Watershed

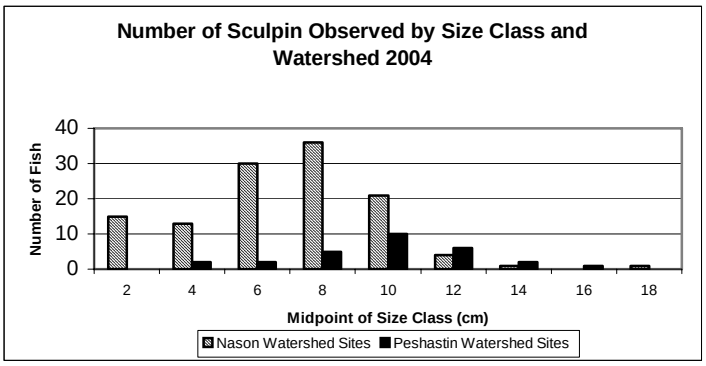


Graph 2C: Chiwawa Watershed

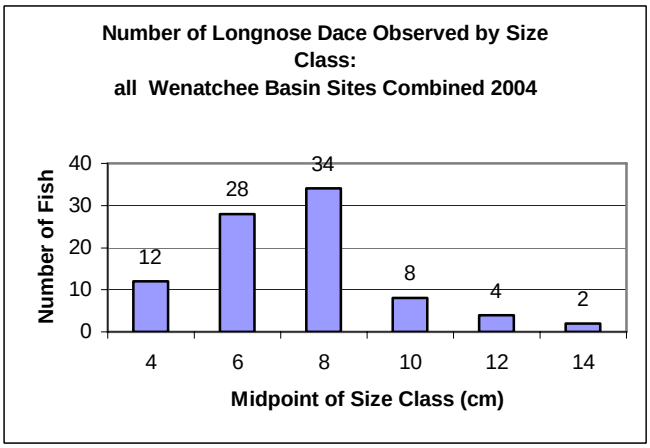


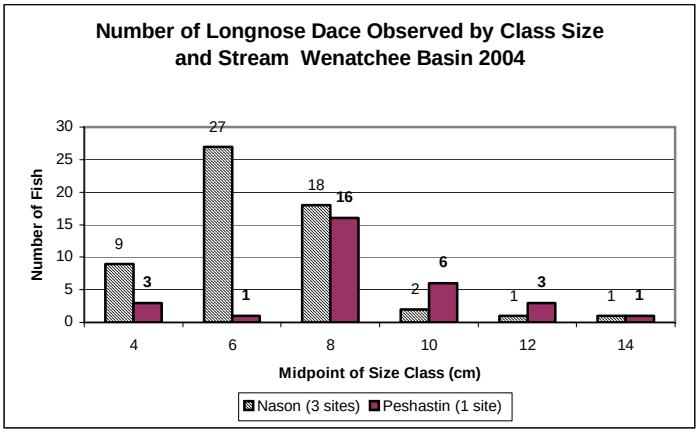
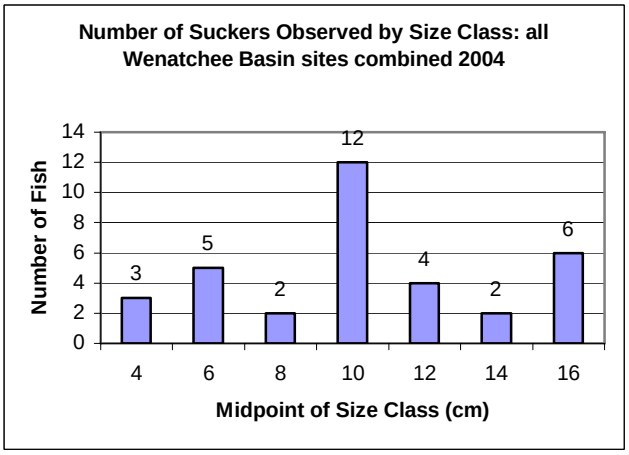
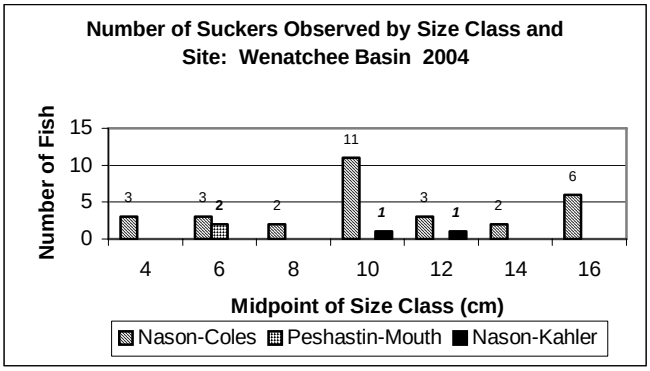
Graph 3A: Sculpin by size class and watershed
(data <u>not</u> adjusted by wetted area)





Graph 3B: Longnose Dace by size class and watershed (data <u>not</u> adjusted by wetted area)





Graph 3C: Sucker spp. by size class and watershed (data <u>not</u> adjusted by wetted area)