Supplemental Materials for:

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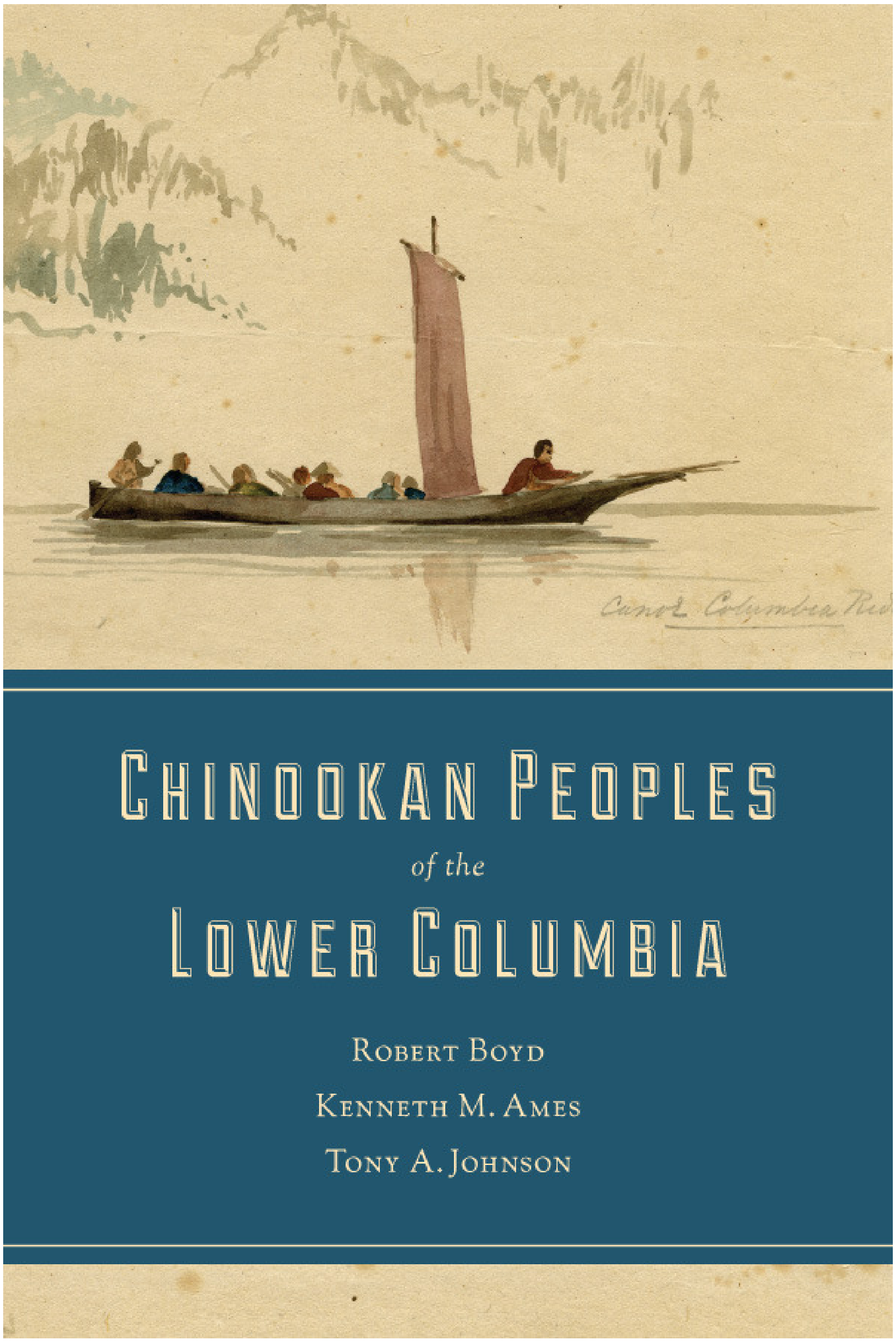


Appendix Chapter 4, Virginia L. Butler and Michael A. Martin.

Methods Used in Fish Bone Analysis and Data Synthesis

Taxonomic identification

Sturgeon and salmonid remains are difficult to identify to species. Sturgeon, lacking a bony vertebral spine, is represented mainly by the external bony skeleton (scutes - robust bony scales; pectoral fin and cranial elements). Sturgeon remains are often so eroded they cannot be identified to skeletal element and are identified as sturgeon based on distinctive surface texture (see Butler 2009). Salmonid remains are mainly identified by postcranial elements from the vertebral column and pectoral and pelvic fins and teeth, which are not species diagnostic; species-distinctive bony cranial elements (Gorshkov 1979) and otoliths (Casteel 1974) are rarely found in Lower Columbia River sites. Several investigators have suggested that since the surface texture of salmonid vertebrae makes them easier to identify than similar-sized fragments of other fish vertebrae, an error has been introduced which overstates their abundance (Moss 1989; Frederick 2007; Minor et al. 2008). To address this concern, as part of analysis of two assemblages (35MU117, Station Camp-45PC105), Butler created the category "nonsalmonid" for fish vertebrae that clearly were not salmonid but could not be identified to another fish taxon (Butler 2000b, Butler et al. 2009). The "nonsalmonid" category constituted less than 1% of the total identified fish fauna suggesting this bias is negligible for Lower Columbia projects. Vertebrae from minnows and suckers are not easily distinguished (except for the first two vertebrae on the column) and thus archaeological specimens tend to be assigned to the joint family category, cyprinid/catostomid. As well, a common practice is for analysts to assign skeletal elements that are clearly from one of the two families but were too eroded or fragmentary for family identification to the joint family category.

NISP to quantify fish representation

The main counting unit we used to estimate fish taxonomic abundance among sites was number of identified specimens or NISP (Grayson 1984), where any fragment or complete element that can be assigned to a taxon is counted. NISP was the unit most commonly recorded for project sites so we use it for our study. As well, Grayson (1984; and Butler 1987, 2005 regarding fish) has shown NISP is highly correlated to other counting measures like minimum number of individuals (MNI). NISP has been challenged for several reasons though (see Lyman 2008 for recent review), so it is important to address them. Since differing numbers of bones and teeth can be identified from different animal taxa, NISP tends to create built-in differences across taxa. For example the number of vertebrae in Lower Columbia fish species varies considerably (e.g., Chinook salmon with 67-75; northern pikeminnow with 44-46; stickleback with 29-33 [Froese and Pauly 2009]) and sturgeon has no vertebrae at all. This problem is mitigated if the measure is used to track *relative* change rather than *absolute* differences in taxonomic frequency. As long as the same skeletal elements are recorded across sites, then differences in taxonomic abundance are independent of inter-taxonomic variation in skeletal element count. NISP also has been criticized because it violates a key assumption of statistical analysis, specimen independence. For example, two specimens identified to Taxon A could be from the same individual animal, or two bone fragments could be from the same element. In both cases the NISP would be two, yet the specimens are not independent of each other, since they could come from the same animal or the same original skeletal element. This problem is mitigated by assuming that interdependence is randomly distributed across taxa and sites. Perhaps the most serious challenge to this assumption is bone fragmentation and the extent it varies systematically across taxa and site contexts. If fragmentation *does vary*, changing NISP values could be telling us more about fragmentation patterns than fish taxonomic frequencies. For example, site A may show relatively more salmon than site B, because vertebrae are more fragmented here than in Site B. Saleeby (1983) and Butler (2000b) have noted the variable condition of faunal assemblages from the study area, with some containing relatively complete elements in good condition and others highly fragmented. However, variable fragmentation or specimen condition shouldn't affect NISP values and inter-site comparisons much. All of the assemblages collected using 6.4 mm mesh (see below) are in relatively good condition and only one of the assemblages recovered using 3.2 mm mesh was highly fragmented (Station Camp, 45PC105). Four of the assemblages obtained exclusively using 1 mm mesh (35MU105, 35MU112, 35MU117, and 35MU119) are highly fragmented, though, so NISP values may be affected, particularly if fragmentation alters identifiability (Lyman and O'Brien 1987).

Screen Size Effects

Recovery method, especially screen mesh size, has been shown to greatly affect fish taxonomic frequency (Casteel 1972; Nagaoka 2005; Partlow 2006; Moss 2007). Remains of small fish tend to be lost through large mesh screens, although fragmentation can add additional complexity to the effect. Since regional faunal assemblages have been obtained using various mesh sizes (e.g., some exclusively with 6.4 mm [1/4 in], or 3.2 mm [1/8 in], or 1 mm [≤ 1/16 in] mesh, and combinations of mesh sizes), we need to understand and control for their effects in our study.

Similarity in field recovery and laboratory processing methods at two sites (Cathlapotle - 45CL1, St. Johns - 35MU44/46) allow us to compare effects of screen size on taxonomic representation. Faunal remains at both sites are relatively well preserved, thus differences in fragmentation should not affect taxonomic representation. At both sites during field excavation some matrix was screened through nested 6.4 mm and 3.2 mm mesh screens; and at both sites, bulk samples were collected and then screened through nested screens (4, 2, 1 mm mesh) and fish remains were sorted out and identified in the lab using low power microscope. Samples from each site have been aggregated by main recovery method (field/lab) and mesh size to identify trends. We expect the sites to show some similar trends in taxonomic representation across sampling methods, yet differences, given the potential underlying differences in the population of fishbone in each site.

For the field samples, remains of large-bodied fishes--sturgeon, salmonids, and minnow/sucker (with most species ≥ 200 mm long), dominate both the 6.4 mm and the >3.2 mm [3.2 mm + 6.4 mm] mesh samples with only scant representation of small fish--eulachon and stickleback (≤ .15 mm long) (Figure S4.1). Comparing the 6.4 mm and >3.2 mm shows a decrease in the proportion of sturgeon in the smaller screen and an increase in minnow-sucker in both sites, whereas salmon proportion decreases at Cathlapotle (Figure S4.1A) and increases at St Johns (Figure S4.2B). The decline in sturgeon representation in the >3.2 mm mesh appears to result from decreasing identifiability as specimen size decreases. For minnow/sucker, the 15-20% increase in the 3.2 mm mesh is mainly due to the greater representation of vertebrae (versus cranial elements) in the finer mesh.

The 4 mm, 2 mm and 1 mm mesh screening and laboratory processing of bulk samples highlights the abundance of small fish in both sites. We compared the relative frequency of fish taxa in the largest mesh (4 mm) with the next smallest meshes: > 2 mm (4 mm + 2 mm) and > 1 mm (4 mm + 2 mm + 1 mm) (Figure S4.2A, S4.2B). The large-bodied fishes (sturgeon, salmon, minnow-sucker) show a progressive decline in relative abundance with decreasing mesh size. One small fish taxon, eulachon, increases in proportion from the 4 mm to 2 mm, but then declines in the 1 mm. The proportion of stickleback, however, increases in a step-wise manner (from 0 to 11 to 73% at Cathlapotle; from 1 to 5 to 28% at St. Johns) (Figure S4.2A, S4.2B). Remains of the small-bodied sculpin and sandroller are extremely uncommon even in the fine mesh sizes.

Together these records confirm the great effect screen mesh size has on taxonomic representation and suggest some general trends for Lower Columbia fish assemblages. The 6.4 mm mesh underestimates minnow-sucker; the 3.2 mm mesh biases against small fishes such as eulachon and stickleback; and the 2 mm mesh underestimates stickleback.

Table S4.1 19th-Century Records of Lower Columbia Fish

Source, affiliation, length of stay (reference)	**White [1] Sturgeon**	**Eulachon**	**Chinook [2] Salmon**	**Chum**	**Coho**	**Steelhead [3]**	**Lamprey**	**Trout**	**Small Fish [4]**	**Marine Fish [5]**
Lewis & Clark *Corps of Discovery* November 1805 - April 1806 (Lewis and Clark 1990, 1991, 1995, 1996)	+	+			+	+			+	flounder skeet 'fish with green flesh'
Duncan McDougall *Pacific Co*. 1811-1813 (1999)	+	+	+	+		+				
Gabriel Franchere *Pacific Fur Co., NW Fur Co.* 1811-1814 (Franchere 1967)	+	+	+						mullet	
Robert Stuart *Pacific Fur Co.* 1811-1813 (Stuart 1935)	+	+	+	+			+		chub	
Alexander Henry *Northwest Co*. Winter - May 1813-1814 (Henry 1992, Henry 1897)	+	+		+		+				sea perch
Peter Corney *Northwest Fur Co*, Aug-Dec. 1816 (Corney 1965)	+	+	(salmon)						+	
John Work Trapper, *Hudson's Bay Co*. May - July 1824 (Work 1824 - 1825)	+		(salmon)							
David Douglas *Royal Botanic Institution of Glasgow* 1825 (no records for 1830s) (Douglas 1959)	+			+		+				
John Scouler Surgeon, Naturalist, with David Douglas April – May 1825 (Scouler 1905)	+		(salmon)						*Cyprinus*	
William Tolmie April 30-May 21 1833 (Tolmie 1963)			+						+	
John Townsend Naturalist/ *Wyeth Expedition* 1834-1835 (Townsend 1966, 1978)	+		+				+	+		
Charles Wilkes *U.S. Exploring Expedition* May - October 1841 (Wilkes 1845)			+						sucker	
George Swan *Settler* 1852 - 1855 (Swan 1972)	+		+	+	+			+		flounder sole turbot herring skeet

Table S4.1 19th-Century Records of Lower Columbia Fish

Footnotes

[1] All accounts with any description of sturgeon refer to the larger, more palatable white sturgeon, rather than green sturgeon.

[2] The term salmon is listed when salmon use was noted in account without additional information to assist with species identification (run time, location, body size).

[3] Suggested species when "salmon trout" is mentioned

[4] Suggested taxa for common names listed in accounts: mullet, chub = minnow or sucker

[5] Suggested taxa for common names: Lewis & Clark - flounder (Pleuronetidae), skeet (*Bathyraja* or *Raja spp.*), fish with green flesh, possibly lingcod (*Ophiodon elongatus*), known for its green flesh (Eschmeyer et al. 1983:157); Henry - sea perch (= surfperch, Embiotocidae); Swan - sole, flounder, turbot (Pleuronectidae, one species likely is *Platichthys stellatus).*

Table S4.2. Lower Columbia archaeological sites with fish remains.

Location Site Number (name)	**Citation**	**Time Unit(s)**	**Recovery Method**
Portland Basin – Columbia Slough			
35MU29/32*	Ellis 1992 Olson 1993	Mult. 1, Mult. 2	Field Screens: 3.2 mm Bulk Samples: 1 mm
35MU44/46 (St. Johns)	Pettigrew 2005 Butler 2005	Mult. 2	Field Screens: 6.4, 3.2 mm Bulk Samples: 4, 2, 1 mm
35MU57* (Broken Tops)	Ellis & Fagan 1993 Olson 1993	Mult. 1, Mult. 2	Field Screens: 3.2 mm Bulk Samples: 1 mm
35MU105*	Ellis 1996 Butler 1996	Mult. 2	Bulk Samples: 1 mm
35MU112*	Ellis 1998 Butler 1998	Mult. 1	Bulk Samples: 1 mm
35MU117*	Ellis 2000 Butler 2000b	Merrybell (Strat II)	Bulk Samples: 1 mm
35MU119*	Ellis & Zehendner 2002 Butler 2002b	Mult. 1	Bulk Samples: 1 mm
Portland Basin – Sauvie Island & Vicinity			
35MU1 (Cholick)	Pettigrew 1987 Saleeby 1983	Mult. 1	Field Screen: 6.4 mm
35MU4* (Sunken Village)	Croes et al. 2009 Wigen 2009	Mult. 2	Bulk Samples: 1 mm
35MU6* (Lyons)	Pettigrew 1987 Saleeby 1983	Mult. 3	Field Screen: 6.4 mm
35MU9* (Merrybell)	Pettigrew 1987 Saleeby 1983	Merrybell	Field Screen: 6.4 mm
35CO3*	Pettigrew 1987 Saleeby 1983	Mult. 1	Field Screen: 6.4 mm
35CO5+ (Meier)	Pettigrew 1987 Saleeby 1983	Mult. 2/3 combined	Field Screen: 6.4 mm
35CO5+ (Meier)	Ames et al. 1992 Butler 1992	Mult. 2/3 combined	Field Screen: 6.4 mm
35CO5+ (Meier)	Frederick 2007	Mult. 2/3 combined	Field Screen: 6.4 mm Bulk Samples: 4, 2 mm
35CO7 (Pumphouse)	Pettigrew 1987 Saleeby 1983	Mult. 2, Mult. 3	Field Screen: 6.4 mm
35CO34 (Ede)	Minor 1985 Greenspan 1985	Merrybell/Mult. 1 combined	Field Screen: 3.2 mm

Table S4.2

Location Site Number (name)	**Citation**	**Time Unit(s)**	**Recovery Method**
Portland Basin – Lake River			
45CL1 (Cathlapotle)	Ames et al. 1999 Butler 2002a	Mult 2, Mult. 3	Field Screen: 6.4, 3.2 mm Bulk Samples: 4, 2, 1 mm
45CL4	Minor & Toepel 1985	Merrybell/Mult. 1/2 combined	Field Screen: 3.2 mm
45CL31	Wessen & Daugherty 1983	Mult. 2/3 combined	6 mm and 1.5 mm water screened
Portland Basin – Northeast Edge			
45CL6 (Fisher's Landing)	Applied Archaeological Research 2006	Mult. 2/3 combined	Field Screen: 3.2 mm
45CL406	Chatters & Reid 1997	Mult. 2/3 combined	unknown mesh size
The Cascades			
45SA5	Dunnell & Beck 1979	Mult. 2/3 combined	Field Screen: 6.4 mm, some fine screening
45SA11*	Minor et al. 1989	Mult. 2/3 combined	Field Screen: 6.4
45SA12	Dunnell & Campbell 1977	Mult. 2/3 combined	Field Screen: 6.4 mm, some fine screening
45SA13	Dunnell & Campbell 1977	Mult. 2/3 combined	Field Screen: 6.4 mm, some fine screening
45SA19	Dunnell & Campbell 1977	Mult. 2/3 combined	Field Screen: 6.4 mm, some fine screening
Columbia River Mouth			
35CLT33 (Eddy's Point)	Minor 1983	Merrybell; Mult. 1	Field Screen: 6.4 mm
35CLT34 (Indian Point)	Minor et al. 2008	Mult. 1/2/3 combined	Field Screen: 6.4 mm
45PC35 (Fishing Rocks)	Minor 1983	Merrybell; Mult. 1	Field Screen: 6.4 mm
45PC105* (Station Camp)	Wilson et al. 2009 Butler et al. 2009	Mult. 3	Field Screen: 3.2 mm, some fine screening

* report notes highly fragmentary assemblages

+ Three collections from Meier (35CO5) recovered with 6.4 mm mesh screens combined for quantitative analysis.

Table S4.3. List of fish taxa and frequency (NISP) by habitat type, time period and mesh size recovery. "+" refers to site assemblages included in quantitative analysis. For 35CO5, "S" refers to assemblage analyzed by Saleeby (1983), "B" refers to Butler's analysis (1992), and "F" refers to Fredrick's (2007) analysis.

Portland Basin - - Columbia Slough												
	site number	**35MU29/32**	**35MU29/32**	**35MU44/46+**	**35MU44/46+**	**35MU44/46+**	**35MU57**	**35MU57**	**35MU105+**	**35MU112+**	**35MU117+**	**35MU119+**
	time unit	Mult 1	Mult 2	Mult 2	Mult 2	Mult 2	Mult 1	Mult 2	Mult 2	Mult 1	Merrybell	Mult 1
Taxon	*mesh size*	> 3.2/1 mm	> 3.2/1 mm	> 6.4 mm	> 3.2 mm	> 1mm	> 3.2 mm	> 3.2 mm	> 1 mm	> 1 mm	> 1 mm	> 1 mm
Migratory												
Acipenser sp.				222	364	142	3	77	29		55	
Thaleichthys pacificus					30	1057			21		21	
Salmonidae		1	78	92	579	695	8	15	32	6	951	27
Resident Freshwater												
Catostomidae			2	93	478	115	3		4		24	2
Catostomus macrocheilus				14	15							
Catostomus columbianus												
Cyprinidae			11	6	106	241	4		16	2	18	5
Acrocheilus alutaceus					11							
Gila bicolor												
Mylocheilus caurinus				7	36						2	
Ptychocheilus oregonensis				5	15							1
Rhinichthys osculus												
Richardsonius sp.					2							
Rhinichthys/Richardsonius					2							
Cyprinidae/Catostomidae				73	755	648			8	23	92	69
Cottidae				1	8	3						
Gasterosteus aculeatus					17	1108			147	24	580	110
Percopsis transmontana					11	6						
Marine/Lower Estuary												
Clupea pallasii												
Elasmobranch												
Embiotocidae												
Pleuronectidae												
Platichthys stellatus												
Sebastes sp.												
Trachurus symmetricus												
Total NISP		**1**	**91**	**513**	**2429**	**4015**	**18**	**92**	**257**	**55**	**1743**	**214**

Table S4.3. List of fish taxa and frequency (NISP) by habitat type, time period and mesh size recovery. “+” refers to site assemblages included in quantitative analysis. For 35CO5, “S” refers to assemblage analyzed by Saleeby (1983), “B” refers to Butler’s analysis (1992), and “F” refers to Fredrick’s (2007) analysis.

Portland Basin - - Sauvie Island and Vicinity												
site number	**35MU1**[+]	**35MU4**[+]	**35MU6**	**35MU9**	**35CO3**	**35CO5** S[+]	**35CO5** B[+]	**35CO5** F[+]	**35CO5** F[+]	**35CO7**[+]	**35CO7**[+]	**35CO34**
time unit	Mult 1	Mult 2	Mult 3	Merrybell	Mult 1	Mult 2/3	Mult 2/3	Mult 2/3	Mult 2/3	Mult 2	Mult 3	Merr/Mult 1
Taxon *mesh size*	> 6.4 mm	> 1 mm	> 6.4 mm	> 6.4 mm	> 6.4mm	> 6.4 mm	> 6.4 mm	> 6.4 mm	> 2 mm	> 6.4 m	> 6.4 mm	> 3.2 mm
Migratory												
Acipenser sp.	57	54	37	7	12	190	1066	1484	226	116	35	
Thaleichthys pacificus	1	149				100	45	25	541			
Salmonidae	150	182	3	10	7	474	797	940	541	127	61	2
Resident Freshwater												
Catostomidae		31					1277	1781	203			1
Catostomus macrocheilus	72		2			71	433			75	28	x
Catostomus columbianus							1					
Cyprinidae	59	65				8	442	544	226	4	31	
Acrocheilus alutaceus						3	35					
Gila bicolor						2	4					
Mylocheilus caurinus	12		1			27	116			2	2	x
Ptychocheilus oregonensis	36					28	102			33	13	x
Rhinichthys osculus												
Richardsonius sp.												
Rhinichthys/Richardsonius												
Cyprinidae/Catostomidae	54	131	3	2		95	418	148	383	39	14	5
Cottidae		3										
Gasterosteus aculeatus		559						25	135			
Percopsis transmontana												
Marine/Lower Estuary												
Clupea pallasii												
Elasmobranch												
Embiotocidae												
Pleuronectidae												
Platichthys stellatus												
Sebastes sp.												
Trachurus symmetricus								x				
Total NISP	**441**	**1174**	**46**	**19**	**19**	**998**	**4736**	**4947**	**2255**	**396**	**184**	**7**

Table S4.3. List of fish taxa and frequency (NISP) by habitat type, time period and mesh size recovery. "+" refers to site assemblages included in quantitative analysis. For 35CO5, "S" refers to assemblage analyzed by Saleeby (1983), "B" refers to Butler's analysis (1992), and "F" refers to Fredrick's (2007) analysis.

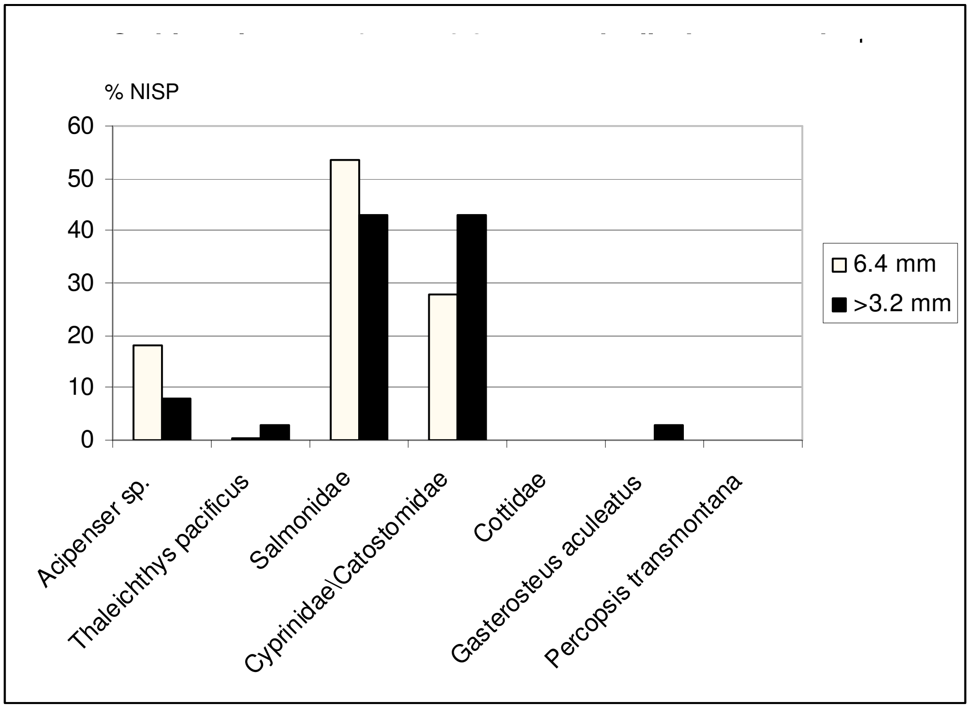
Portland Basin - - Vancouver Lake, Lake River, Lacamas Lake, Columbia Main Channel												
site number	**45CL1[+]**	**45CL1[+]**	**45CL1[+]**	**45CL1[+]**	**45CL1[+]**	**45CL1[+]**	**45CL1[+]**	**45CL1**	**45CL4**	**45CL31**	**45CL6[+]**	**45CL406**
time unit	Mult 2	Mult 3	Mult 2	Mult 3	Mult 2	Mult 3	Mult 2	Mult 3	Merryb/ Mult 1/2	Mult 2/ 3	Mult 2/3	Mult 2/ 3
Taxon *mesh size*	> 6.4 mm	> 6.4 mm	> 3.2mm	> 3.2mm	> 2 mm	> 2 mm	> 1 mm	> 1mm	> 3.2 mm	unknown	> 3.2 mm	unknown
Migratory												
Acipenser sp.	573	1289	83	48	34	109	21	26		x	138	2
Thaleichthys pacificus	5		25	14	47	1218	187					
Salmonidae	1522	1622	335	241	116	180	192	5	x		28	4
Resident Freshwater												
Catostomidae	279	322	47	58	14	28	30				27	8
Catostomus macrocheilus	36	70	8	10	2		3					
Catostomus columbianus												
Cyprinidae	114	303	45	62	14	65	79		x	4	4	42
Acrocheilus alutaceus	14	60	3	14	1		1					
Gila bicolor	3	5		4		1						
Mylocheilus caurinus	34	66	12	14	2	6	8			x	4	
Ptychocheilus oregonensis	33	92	20	31	4	3	7		x			35
Rhinichthys osculus							4					
Richardsonius sp.												
Rhinichthys/Richardsonius					1		1					
Cyprinidae/Catostomidae	179	226	110	165	40	178	191	2		14	229	108
Cottidae	4		1	1	1		1					
Gasterosteus aculeatus		1	13	23	30	19	1985				1	
Percopsis transmontana		1										
Marine/Lower Estuary												
Clupea pallasii												
Elasmobranch												
Embiotocidae												
Pleuronectidae												
Platichthys stellatus												
Sebastes sp.												
Trachurus symmetricus												
Total NISP	**2796**	**4057**	**702**	**685**	**306**	**1807**	**2710**	**33**		**18**	**431**	**199**

Table S4.3. List of fish taxa and frequency (NISP) by habitat type, time period and mesh size recovery. "+" refers to site assemblages included in quantitative analysis. For 35CO5, "S" refers to assemblage analyzed by Saleeby (1983), "B" refers to Butler's analysis (1992), and "F" refers to Fredrick's (2007) analysis.

		The Cascades					River Mouth			
	site number	**45SA5**	**45SA11**	**45SA12**	**45SA13**	**45SA19**	**35CLT33**	**35CLT34+**	**45PC35**	**45PC105+**
	time period	Mult 2/ 3	Mult 2/3	Mult 2/ 3	Mult 2/ 3	Mult 2 /3	Mult 1	Mult 1/2/3	Mult 1/2	Mult 3
Taxon	*mesh size*	> 6.4 mm	> 6.4 mm	> 6.4 mm	> 6.4 mm	> 6.4 mm	> 6.4 mm	> 6.4 mm	> 6.4 mm	> 3.2 mm, 1.6 mm
Migratory										
Acipenser sp.		x	x	x	x	x	x	2551	x	6326
Thaleichthys pacificus										x
Salmonidae			x	x	x		x	321	x	787
Resident Freshwater										
Catostomidae				x	x					2
Catostomus macrocheilus							x	464		1
Catostomus columbianus										
Cyprinidae				x	x		x	141		
Acrocheilus alutaceus										
Gila bicolor										
Mylocheilus caurinus							x	38		
Ptychocheilus oregonensis								48		
Rhinichthys osculus								1		
Richardsonius sp.										
Rhinichthys/Richardsonius										
Cyprinidae/Catostomidae								198		12
Cottidae								3		
Gasterosteus aculeatus										
Percopsis transmontana										
Marine/Lower Estuary										
Clupea pallasii										x
Elasmobranch									x	1
Embiotocidae								1	x	
Pleuronectidae								10		21
Platichthys stellatus								25		x
Sebastes sp.								1	x	12
Trachurus symmetricus								92		
Total NISP								**3894**		**7162**

Figure S4.1

A



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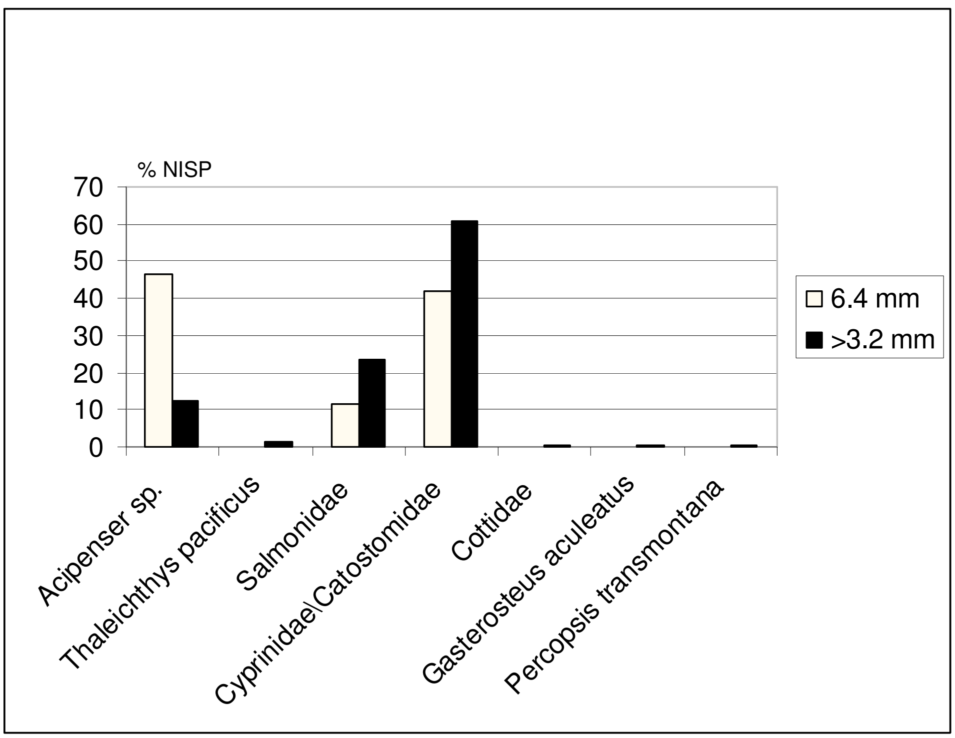
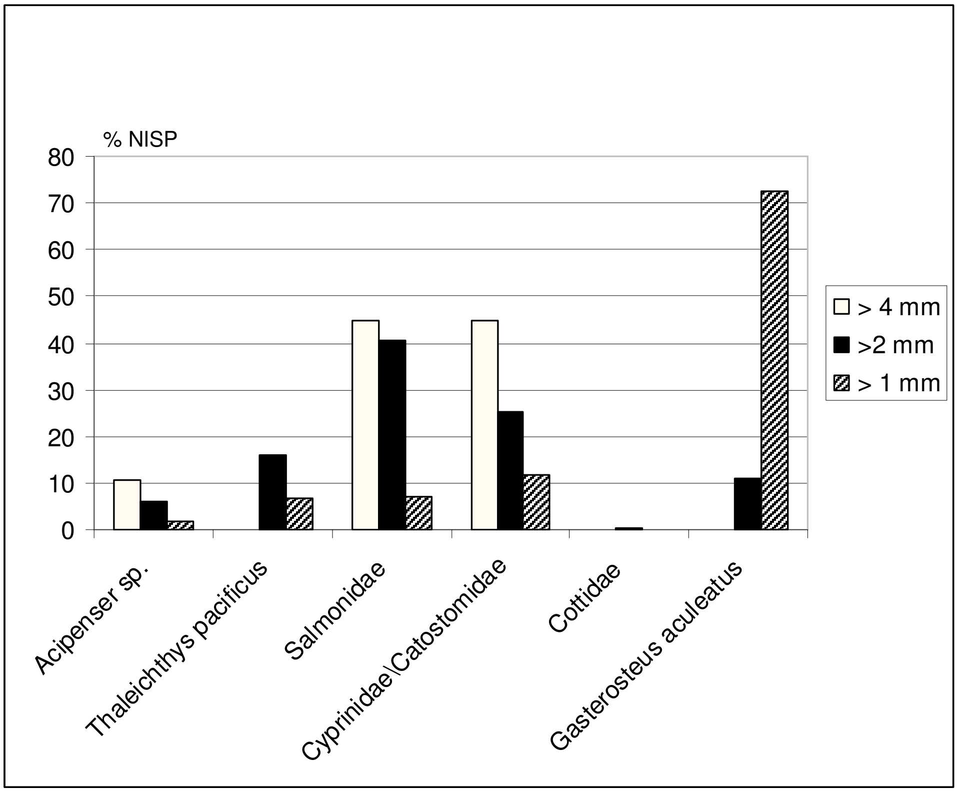


Figure S4.1 Relative frequency (% NISP) of taxa by mesh size, field recovery, 6.4 mm mesh vs. >3.2 mm. A) Cathlapotle site (45CL1, total NISP = 1249) B) St. Johns Site (35MU44/45, total NISP = 1879)

Figure S4.2

A



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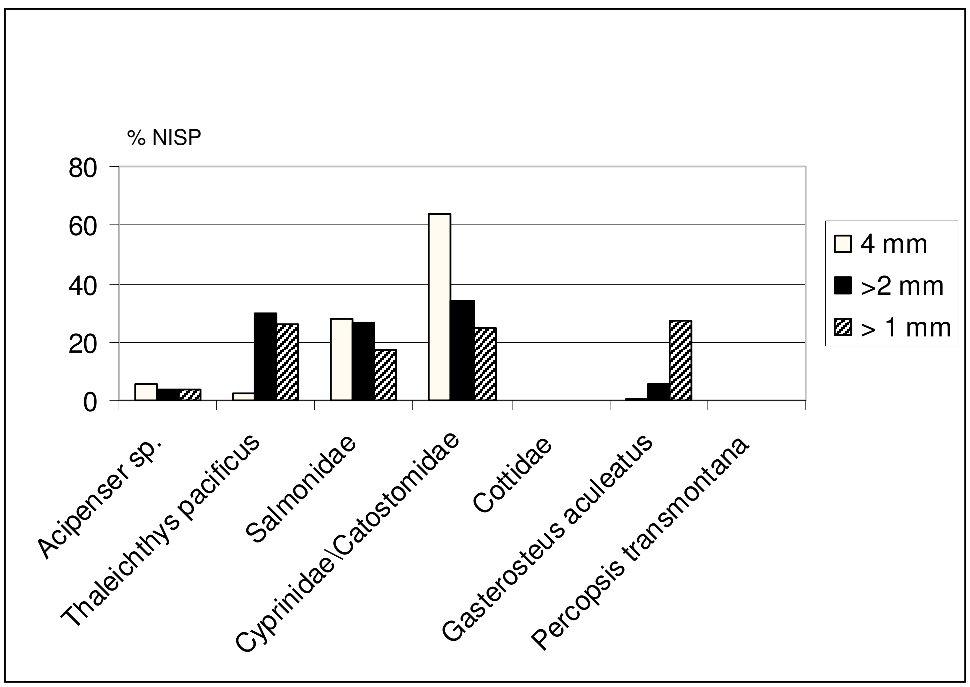

Figure S4.2 Relative frequency (% NISP) of taxa by mesh size, bulk samples A) Cathlapotle site (45CL1, total NISP = 2743, volume 20 l bulk samples) B) St. Johns Site (35MU44/45, total NISP = 4015, volume 25.2 l)