

# Natural Versus Cultural Salmonid Remains: Origin of The Dalles Roadcut Bones, Columbia River, Oregon, U.S.A.

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*(Received 18 September 1991, revised manuscript accepted 5 December 1991)*

The most secure evidence for early Holocene fishing in Pacific North-western North America resides in the huge deposit of 9500–7600-year-old salmonid remains from The Dalles Roadcut site (Columbia River, Oregon). Recently the cultural origin for the fish remains has been challenged. Here, criteria for distinguishing natural (fluvial) from cultural salmonid deposits are developed in order to determine the agents responsible for the Roadcut faunal materials. Comparative analysis of one natural and three cultural assemblages from riverine settings indicates that body-part representation and skeletal completeness vary between natural and cultural settings. Analysis of the Roadcut assemblage suggests the salmonid deposit results largely from cultural processes, although the strength of this conclusion is weakened by significant curatorial biases with the collection.

**Keywords:** SALMONID ARCHAEOFAUNAS, TAPHONOMY, PREHISTORIC SALMON UTILIZATION, NORTH-WEST NORTH AMERICA

## Introduction

The importance of salmonids to the subsistence of native peoples in North-western North America during historic times has long been realized. Early explorers of the region exclaimed over the abundance of the anadromous fish and the zeal with which native peoples pursued them (e.g. Wilkes, 1845; Winthrop, 1862; Lord, 1866; Gibbs, 1877; Lewis & Clark: in Thwaites, 1905). Early 20th century ethnographers suggested that salmon was the hallmark of the hunter-gatherer cultures which embodied attributes usually associated only with agrarian societies. Specifically, anthropologists noted that the complex social organization and semisedentary settlement pattern which included aggregation into villages during the winter months was made possible largely by catching, drying and storing salmon (e.g. Teit, 1900; Haeberlin & Gunther, 1930; Ray, 1933; Post, 1938; Smith, 1940).

Although the significance of salmonids to the subsistence of recent native inhabitants of the region is accepted (cf. Ames & Marshall, 1980–81), the prehistoric roots of this focused adaptation have been the subject of much dispute among archaeologists. One position holds that the early Holocene inhabitants of the region relied heavily on salmonids

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(Cressman, 1960; Borden, 1975; Matson, 1976; Aikens, 1978; Carlson, 1983). Aikens (1978) finds this position intuitively appealing, given the superabundance of salmon in regional streams historically. A second position maintains that early Holocene peoples were broad-spectrum hunter-gatherers and that salmon did not become a significant focus of subsistence until much later times. Schalk (1977) argues that technological innovations, particularly involving storage, were required before the resource could be utilized efficiently and become the subsistence mainstay. Fladmark (1975) posits that salmonid population density was insufficient to support human populations until the mid-Holocene when stream gradients and sea-levels stabilized. Nelson (1969, 1973) argues that intensive salmon use could not occur until mass harvesting techniques were developed and that these were not available to Columbia Plateau peoples until they were introduced to them by Salishan speakers who migrated south from the Fraser River drainage, about 2000 BP. Finally, Campbell (1989) suggests that historic descriptions that emphasize the intensive use of salmon by native peoples are largely an artifact of drastically reduced population levels. She offers that prehistoric populations were probably more dispersed across the landscape and relied on numerous resources of which only one was salmon.

Archaeological evidence with which to evaluate these positions is limited. For sites of mid-Holocene and younger ages, the relative abundance of salmon remains varies greatly between coastal and interior environments. Coastal and riverine sites west of the Cascade Range commonly bear relatively large quantities of salmon remains, and thus support the notion that salmon was a key resource to coastal peoples prior to European contact (e.g. Casteel, 1976a; Huelsbeck, 1983; Stiefel, 1985; Butler 1987a, 1990a; Wigen & Stucki, 1988; Moss, 1989). On the other hand, salmon remains are extremely scarce in similarly aged sites east of the Cascade Range on the Columbia Plateau. Whether the paucity of remains reflects limited use of salmonids or other factors such as poor preservation, recovery techniques or cultural processing is still under review (Gunkel, 1961; Nelson, 1969; Johnston, 1984; Greengo, 1986; Butler, 1987b).

Importantly, evidence for early Holocene salmon use from both the coast and interior is extremely limited: early Holocene sites throughout the region rarely contain fish bone assemblages of any size. A prominent exception to this situation is the Roadcut site, adjacent to Five Mile Rapids at The Dalles, Oregon, from which over 250 000 salmonid remains dating between 9500 and 7600 BP were recovered (Cressman, 1960: 23-24,67). The Roadcut site is located on the Columbia River, about 32 km east of the point where the river cuts through the Cascade Mountain Range (Figure 1). The stretch of river adjacent to the site is known as "The Dalles of the Columbia", which, prior to construction of The Dalles Dam, consisted of a group of rapids about 19 km long, with a total fall of about 25 m. At extreme high water, most of the area was flooded and the major falls became rapids. During low water, flow was reduced to one or two channels and some of the falls became dry. These distinctive hydrological conditions made The Dalles one of the premier ethnohistoric fisheries of the Columbia Basin (e.g. Netboy, 1980). The waterfalls and rapids created a barrier to migrating fish which allowed them to be caught with relative ease.

Since its excavation in the 1950s, the site has represented the best evidence for early Holocene salmon fishing in Pacific North-west North America (Butler, 1961; Matson, 1976; Carlson, 1983). For example, B.R. Butler notes,

"The important discovery of salmon bones at Five Mile Rapids combined with indirect evidence from Fraser River Canyon leaves no doubt that salmon fishing was well established in the Pacific Northwest when early lithic hunters were still stalking big game in other parts of the continent." [Butler, 1961: 57].

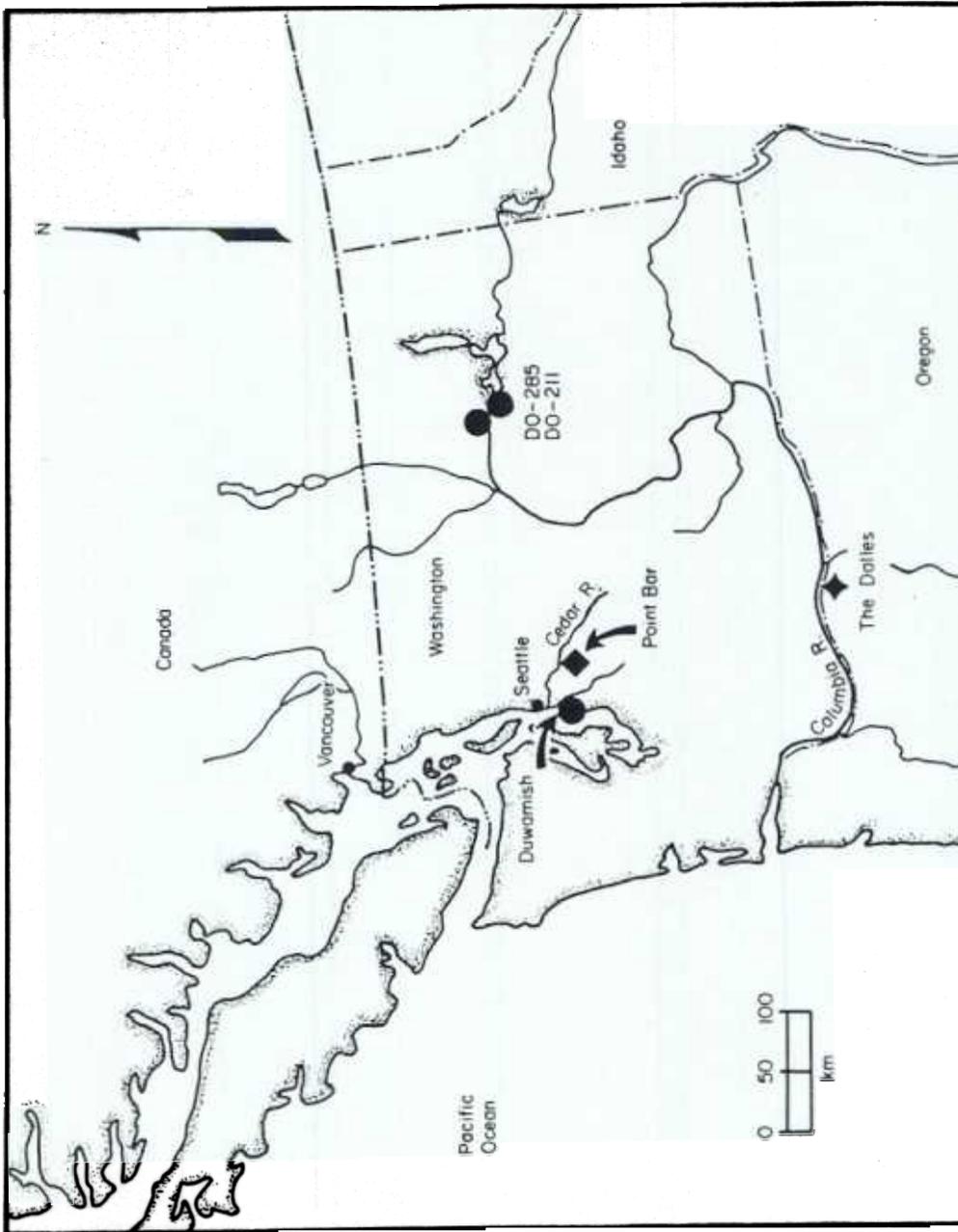


Figure 1 Location of sites in study.

Interpretation of the exceptional Dalles deposit has not been straightforward, however. Proponents of the early Holocene fishing model point to this site as the best empirical evidence for an early Holocene adaptation to salmonid fishing (Borden, 1975; Matson, 1976; Carlson, 1983). However, Schalk (1983) has challenged the presumption that The Dalles fish remains represent a cultural accumulation. He argues that The Dalles fish remains may represent a natural accumulation, citing the prominence of scavenger birds (e.g. raven, crow, gull, vulture) in the assemblage, the depositional conditions, and the huge size of the fish deposit itself, which differs markedly from others in the region.

Could The Dalles salmon bone deposit be natural? Uncertainty about the source of some of the The Dalles faunal material was implied in the original monograph: Taylor (in Cressman, 1960: 75) noted that some of the freshwater mollusc remains may have washed in from the Columbia River or a side channel.

Importantly, a major aspect of salmonid life history may introduce non-cultural fish remains into the fossil record. Near the end of the fishes' life-cycle, individuals migrate to freshwater streams to spawn and die. Prior to historic industrial practices, millions of fishes migrated yearly into regional streams and expired in a relatively brief period. Depending on fluvial conditions, it is reasonable to suggest that some and perhaps many of the carcasses rafted to shore or gravel bars and were subsequently buried and preserved.

Given the significance of The Dalles Roadcut site to interpretation of early Holocene subsistence in the region, and the potential for the salmonid remains it contains to have resulted from fluvial deposition, it is crucial that their origin be determined. As much as the area's prehistory turns on interpretations of fish utilization, clarifying the nature of non-human mechanisms that accumulate salmonids should be of general concern.

Here, I focus on the identification of criteria that distinguish natural from cultural salmonid deposits, with special attention paid to Holocene sites in the Pacific North-west. These criteria are then used to assess the origin of The Dalles Roadcut salmonid remains. My work rests on the assumption that natural and cultural salmonid assemblages have distinctive taphonomic histories. Prehistoric cultural practices, including procurement, butchering, storage, cooking and disposal, will produce fish faunal assemblages distinct from those generated by natural, primarily fluvial processes.

Briefly, this work involved securing assemblages of known cultural and natural origin, isolating characteristics that distinguish these control samples and, finally, examining these attributes in The Dalles Roadcut assemblage to ascertain its origin. This paper summarizes results from this work. In particular, I examine how body-part representation and spatial distribution of elements distinguish depositional origin and assess the source of The Dalles assemblage.

## The Sites

### *Natural site*

To identify attributes that characterize fluvial salmonid deposits, I located and sampled such deposits. During a field survey of several rivers in Washington State, I located a point bar on the Cedar River near Seattle (Figure 1), which was literally covered with fish remains. These materials are from whole, spent sockeye salmon (*Oncorhynchus nerka*) carcasses which had rafted on to the bar over the course of several years. I focused my collection efforts here, recovering by hand or forceps over 17 000 specimens which could be identified to element. These specimens came from 20 4 × 4 m units, representing a 20% random sample of the site (Butler, 1990b). To obtain information on smaller scale spatial patterns, a 0.5 × 0.5 m grid was laid out in each of the designated 4 × 4 m units; remains were collected from the resulting 64 0.5 × 0.5 m units in each of the 4 × 4 m units. To determine whether hand-collecting the remains introduced a bias against recovery of

smaller elements, fish remains from an additional 4 × 4 m unit were collected using nested screens of 1/4" (0.64 cm), 1/8" (0.32 cm) and 1/16" (0.16 cm) mesh size.

#### *Cultural sites*

To characterize cultural salmonid assemblages, I needed to select assemblages that were unequivocally cultural accumulations. It was also crucial that the assemblages selected had been recovered using relatively fine mesh (1/8") screens or that bulk samples were available for analysis, to minimize (or in some cases estimate) collection bias against smaller elements. Most sites in the region could be eliminated from consideration simply because they were excavated using large mesh screens. Three sites meeting these requirements were selected for analysis.

The Duwamish No. 1 site (45-KI-23) is a large prehistoric shell midden located on a low-lying terrace adjacent to the Duwamish River near its confluence with Elliot Bay in Seattle, Washington (Figure 1). The prehistoric cultural deposits are distributed in an area about 225 m long and 45 m wide and represent cultural occupation dating between 1280 and 150 BP (Campbell, 1981). Based on detailed analyses of recovered cultural materials, Campbell (1981) interprets the Duwamish site as a major domestic habitation occupied during several seasons of the year.

Although I identified over 11 000 fish remains collected from this site (Butler, 1987a), my analysis here focuses on the 3444 salmonid specimens from a single 4 × 4 m unit. This I do for two reasons. First, a large volume of 1/8" matrix was saved from the unit, allowing assessment of element loss through 1/4" mesh. Second, the block provided material from a large horizontal exposure which would facilitate analysis of element spatial distribution.

The other two cultural sites, 45-DO-285 and 45-DO-211, located on the upper Columbia River just downstream from Grand Coulee Dam (Figure 1), were excavated as part of the Chief Joseph Dam Cultural Resources Project by the University of Washington (Campbell, 1985). 45-DO-285, a specialized processing site which lacks structured features, dates between 2500 and 450 BP (Miss, 1984) and provided a total of 116 salmonid remains. Analysis of 45-DO-211 focuses on material from Analytic Zone 4, a housepit occupation which dates to between 3600 and 2700 BP, reflects generalized domestic use (Lohse, 1984) and provided 839 salmonid remains. All materials were recovered from 1/8" mesh screens.

#### *The Dalles Roadcut site*

The Roadcut site (35-WS-8/WS-4) is located on the south shore of the Columbia River, about 8 km upstream from the town of The Dalles, Oregon (Figure 1). The site was excavated by the University of Oregon in the 1950s (Cressman, 1960); excavation focused on contiguous units within a block about 12 × 12 m (Butler, 1990b). Abundant stone, bone and antler artefacts were recovered from the 7.8 m thick deposit, indicating substantial cultural use of the site area. Fish remains were recovered from 1/4" mesh screens (V. and D. Scheans, pers. comm.). Although over 250 000 remains were reported for the site, a much smaller fish assemblage was located at the Oregon State Museum of Anthropology, University of Oregon, where the site collections have been stored. I identified 12 305 fish specimens, of which 12 022 are salmonid.

#### **Methods**

Recovery procedures, particularly screen-size selection, have a significant effect on the results of faunal analysis in general (Thomas, 1969; Watson, 1972; Payne, 1972; Grayson, 1984) and fish faunal recovery in particular (Casteel, 1972, 1976b; Wheeler & Jones, 1989). Whereas most workers have emphasized the effects of screen size on taxonomic representation and relative abundance, I was concerned with isolating the effects of recovery on element representation. As seen in Table 1, the assemblages included in this research were

Table 1. Summary of recovery techniques

Site	Technique
Cedar River Point Bar	collected by hand; matrix from single 4 × 4 m unit screened with 1/4", 1/8" and 1/16" mesh
Duwamish No. 1	matrix screened with 1/4" mesh; bulk samples of 1/8" matrix available for analysis
45-DO-285	matrix screened with 1/8" mesh
45-DO-211	matrix screened with 1/8" mesh
Dalles Roadcut	matrix screened with 1/4" mesh

Table 2. Salmonid elements recovered in 1/16" mesh, Cedar River Point Bar

Element	NISP
Branchiostegal	5
Gill raker	120
Neural spine	9
Misc. pectoral/pelvic fin ray	24
Rib	48
Tooth	8
Vertebra, centrum fragment	7
Vertebra, spine	2
Total	223

collected in a variety of ways—by hand, with 1/4" mesh, with 1/8" mesh, and with a combination of 1/4" and 1/8" mesh. It is reasonable to suppose that the hand-collected Point Bar remains, and the Roadcut materials, retrieved from 1/4" mesh screens, would have proportionately fewer smaller elements than assemblages collected with 1/8" mesh. Since my research rests on the notion that element representation informs on taphonomic histories, systematic bias against elements lost because of recovery techniques must be identified.

To determine whether hand-collected samples are biased against recovery of smaller specimens at the Point Bar site, I compared element frequencies between the hand-collected and screened samples. For the Duwamish deposit I compared element representation of the 1/4" mesh samples with that of the greater than 1/8" mesh samples (1/4" samples plus the 1/8" sample). For The Dalles Roadcut site, which provided no bulk samples, estimating element loss through the 1/4" mesh is attempted using results from the Point Bar and Duwamish screen-size studies.

Importantly, element types included in the study are caught in 1/8" mesh screens. I have previously shown that salmonid remains which passed through 1/8" mesh and are retrieved in 1/16" mesh screens include only neural spines and vertebra fragments (Butler, 1987b). Furthermore, analysis of the 1/16" matrix collected from the Cedar River Point Bar indicates that while a variety of elements are recovered from this fine mesh screen (Table 2), such elements are not used in assemblage comparisons. Therefore, use of 1/8" mesh does not bias recovery of salmonid elements used in the analyses.

Fish remains were identified to the lowest taxonomic level possible, but are treated here at the family level to allow for the inclusion of skeletal elements not identifiable to genus or species, which comprise the bulk of the assemblages. Nomenclature for cranial and fin

Table 3. Salmonid elements recorded

Element	Abbreviation	Element	Abbreviation
<b>Cranial</b>		<b>Post-cranial</b>	
		<b>Pectoral Fin</b>	
Angular	ANG	Cleithrum	CLT
Basioccipital	BSO	Coracoid	COR
Basisphenoid	BSI	Mesocoracoid	MSC
Ceratohyal	CRH	Pectoral fin ray*	PEC
Dentary	DEN	Post-cleithrum†	PCL
Ectopterygoid	ECT	Post-temporal	PST
Epihyal	EPH	Scapula	SCP
Epiotic	EPO	Supracleithrum	SCL
Exoccipital	EXO		
Frontal	FRN	<b>Pelvic Fin</b>	
Hyomandibula	HYO		
Hypohyal, upper	HPI	<b>Basipterygium</b>	<b>BSP</b>
Hypohyal, lower	HP2		
Interopercle	IPC		
Lingual plate	LGP	<b>Vertebral Column</b>	
Maxilla	MAX		
Mesopterygoid	MSP	Vertebra type-1	VT1
Metapterygoid	MTP	Vertebra type-2	VT2
Opercle	OPC	Vertebra type-3	VT3
Opisthotic	OPI	Vertebra type-4	VT4
Otolith (sagitta)	OTO	Caudal bony plate	CBP
Palatine	PAL	Hypural‡	HYP
Parasphenoid	PSP		
Prefrontal	PRF		
Premaxilla	PRM		
Preopercle	POP		
Prootic	PRO		
Pterosphenoid	PTS		
Pterotic	PTO		
Quadrata	QUD		
Sphenotic	SPO		
Subopercle	SOP		
Supraethmoid	SPE		
Supraoccipital	SOC		
Urohyal	URH		
Vomer	VOM		

\*Largest element in fin with prominent disc-shaped head.

†Includes upper and middle elements of series.

‡Includes two most ventral elements, H1, H2 (after Norden 1961: 789).

elements follows Norden (1961) (Table 3), except for the pectoral fin ray which here refers to the prominent element in the series with a disc-shaped anterior end. The term caudal bony plate refers to the paired lateral element on the caudal fin (Cannon, 1987). Elements were divided into cranial and post-cranial categories (Table 3); post-cranial elements include all bones of the vertebral column as well as the pectoral and pelvic fin. Cranial elements include those specimens strictly associated with the head. I divided the vertebral column into four groups, vertebra types 1, 2, 3 and 4 (Figure 2).

Data were quantified using Number of Identified Specimens (NISP; Grayson, 1984), Minimal Number of Elements (MNE) and Minimal Animal Unit (MAU; Binford, 1984).

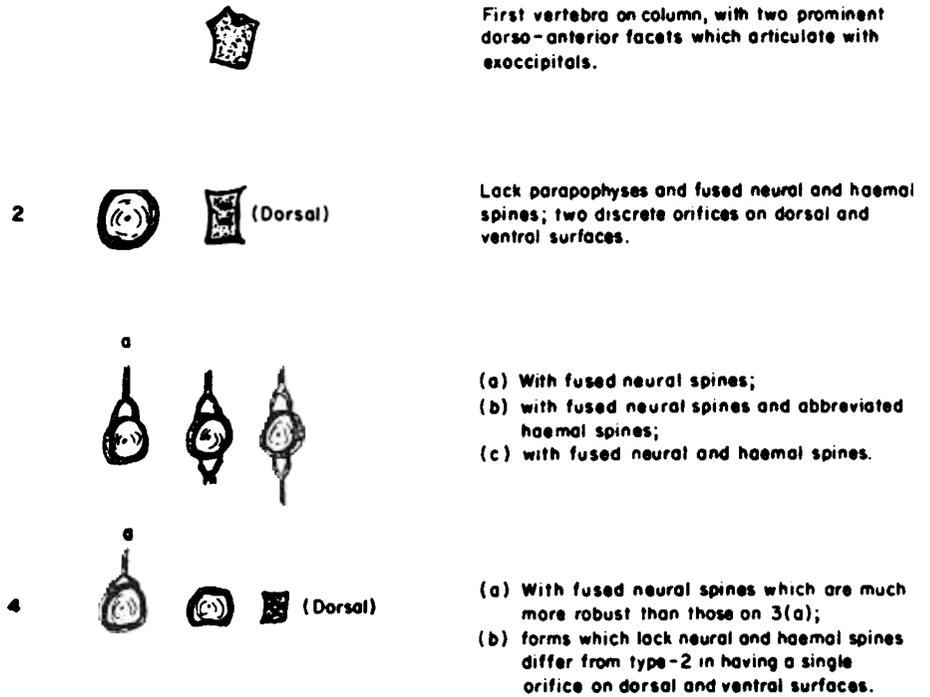


Figure 2. Salmonid vertebra types (modified from Morales, 1984).

MNE involves selecting the best-represented section of each element and simply counting the number of times it occurred in a given aggregate (Grayson, 1988). For example, for the angular (articular on many other fishes), the minimum portion counted was the posterior facet for the quadrate; for the exoccipital, it was the ventro-posterior facet for the first vertebra. The MNE for vertebra types was based on the presence of 50% or more of the centrum. MAU is the frequency of an element divided by the number of times it occurs in a skeleton (Binford, 1981).

### Results and Discussion

#### *Body-part frequency*

Body-part frequencies of natural and cultural salmonid accumulations may differ because of differences in the proportion of the carcass originally deposited in each setting and major differences in destruction agents. Each of these factors will be reviewed in turn.

In natural settings, whole carcasses are routinely deposited by fluvial processes. In October 1985, during collection of the Cedar River Point Bar salmon bones, I observed that whole fish carcasses began to pile up along the periphery of the bar next to the stream channel (Figure 3). In subsequent visits, over 45 whole carcasses were found scattered across the site. Their presence indicated that high waters crested the bar and subsided, depositing the carcasses during retreat. Field biologists on the Skagit River of northwest Washington state also report the accumulation of whole carcasses along the point bars in the vicinity of Rockport, Washington (Wiley, 1978; Susan Scagen, U.S. Fish and Wildlife, pers. comm.).

By contrast, in some cultural settings, only a portion of the carcass may have been deposited. For example, at a processing site near a river, heads may have been removed



Figure 3. Fluvially deposited sockeye salmon (*Oncorhynchus nerka*) carcasses Cedar River Point Bar.

from the carcass and trunks alone transported to a domestic camp. Archaeologists in the Pacific North-west often have used differential transport of body parts to account for the scarcity of cranial elements in regional sites (e.g. Ozette, Huelsbeck, 1983; Hoko River Rockshelter, Wigen, 1983; all documented Fraser River Delta sites, Ham 1982; Stiefel, 1985; Black River, Butler 1990a). Although such explanations clearly need to consider the role of differential density of elements and in situ destruction in accounting for element frequencies (Lyman, 1984, 1985; Grayson, 1988, 1989; Kreutzer, 1992), differential transport of body parts is not an unlikely event. Some cultural assemblages may be dominated by trunk elements and others dominated by cranial elements because of differential transport of carcass parts.

Major differences in agents of destruction may also lead to differences in element frequency. In cultural settings, butchering, cooking, storage, human consumption, vertebrate scavengers and trampling affect bone preservation (e.g. Chaplin, 1971; Yellen, 1977; Binford, 1978; Brain, 1981; Jones, 1984; O'Connell *et al.*, 1988, 1990; Bunn *et al.*, 1988). In ethnographic accounts, salmonid heads and trunks were invariably processed independently. Most descriptions of salmonid butchering focus on preparing the carcass for storage. Although there was variation in techniques used to preserve salmon, most practices were guided by the concern to reduce the amount of oil and fat in the carcass to prevent spoilage (Schalk, 1984; Romanoff, 1985). One primary technique involved removing the fattiest portions of the body and then cooking and consuming these portions immediately or processing and storing them apart from the rest of the body. The head is particularly fatty and apparently for this reason was invariably processed differently from the trunk. Heads required longer drying times, more heat to dry them, and were stored separately from the trunk when they were preserved (Ray, 1933, Sanpoil/Nespelem, Columbia River, Washington; Post, 1938, Okanogan, Columbia River, Washington; Smith, 1940, Puyallup-Nisqually, Puget Sound Lowlands, Washington; Albright, 1984,

Tahltan, Coastal British Columbia; Romanoff, 1985, Lillooet, Fraser River, British Columbia).

It is also reasonable to argue that heads and trunks were treated differently because of major differences in the distribution of bones in the soft tissues of these body parts. The trunk consists mainly of muscle supported along the mid-line by vertebrae and ribs. By contrast, the head is comprised of numerous bones surrounded by small quantities of muscle and fat. Most of the muscle mass on the trunk could be extracted without disturbing the vertebrae at all. On the other hand, defleshing would probably break or destroy a number of the many superficial bones of the head. Indeed, given the relatively small quantity of soft tissue in the head, the most efficient way of extracting its food value may have been to cook it whole.

Thus inherent properties of the salmonid carcass, particularly the differential distribution of fat and bones between the head and trunk, may have guided decisions during processing activities. Accordingly, if the head and trunk were treated differently, the bones that represent these body parts would be differentially affected as well. If heads were often cooked—roasted or boiled—and trunks were cooked infrequently, cranial remains would likely be less resistant to post-depositional destruction than post-cranial specimens. Bone that has been boiled or roasted loses much of its organic matter and structure; depending on the extent of heating, bone can become exceedingly brittle and crumbly (Chaplin, 1971). If processing involved simply defleshing the carcass, then vertebrae would tend to suffer less attrition than cranial remains, because of the relative difficulty of extracting flesh from the head versus the trunk.

In fluvial settings, vertebrate scavengers and weathering are the primary destructive agents and clearly would not be governed by the same considerations as humans. I assume that while bone density is probably the ultimate cause of element destruction in all contexts, proximate causes are very different in cultural and natural settings. Thus, I predict that in cultural salmonid deposits, which result from whole carcass transport to the site, cranial remains will have much lower frequencies than post-cranial remains primarily because of differential processing of body parts. In natural settings, I expect cranial and post-cranial remains to have much more equal frequencies given the absence of a dominant taphonomic agent (e.g. humans) focused on soft tissue anatomy.

Do fluvial and cultural deposits differ in representation of cranial and post-cranial elements? As seen in Figure 4, this expectation is met: the cultural assemblages have very different frequencies of cranial elements than the Cedar River Point Bar. The Duwamish and 45-DO-211 assemblages have much lower cranial element frequencies than the Point Bar site, while 45-DO-285 has much higher frequencies of cranial remains than the Point Bar. The 45-DO-285 deposit results from the almost exclusive deposition of salmon heads (Butler, 1990*b*). Post-cranial elements are absent because trunks were not deposited at the site. A moderate and significant correlation between salmonid element density and element representation in the Duwamish assemblage suggests that the salmonid remains result from whole carcass deposition and in-situ destruction (Butler, 1990*b*). The prominence of both otoliths and vertebrae in the 45-DO-211 assemblage suggest the deposit reflects whole carcass deposition followed by in-situ destruction as well (Butler, 1990*b*). Cranial elements are scarce at these sites because they were destroyed with greater frequency than post-cranial bones, whether because of intensive cultural processing, trampling, scavenging by dogs or other factors.

Recovery practices have no discernible effect on these results. For the Cedar River Point Bar assemblage, element representation (% NISP) is virtually the same in the hand-collected and screened sample (Pearsons  $r=0.993$ ,  $P<0.001$ ), indicating that hand collecting did not introduce a bias against recovery of smaller specimens. In the Duwamish assemblage, while several elements had much higher frequencies in the greater

## SALMONID REMAINS: THE DALLES ROADCUT BONES

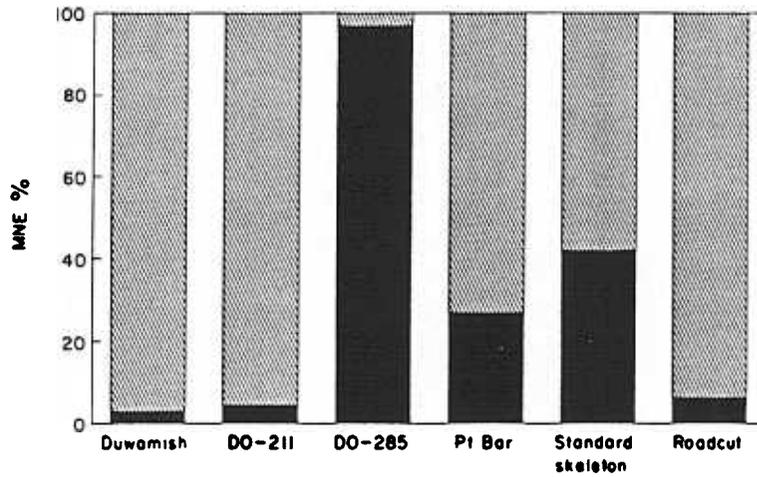


Figure 4. Frequency of cranial and post-cranial remains. ■ = Cranial, ▨ = Post-cranial.

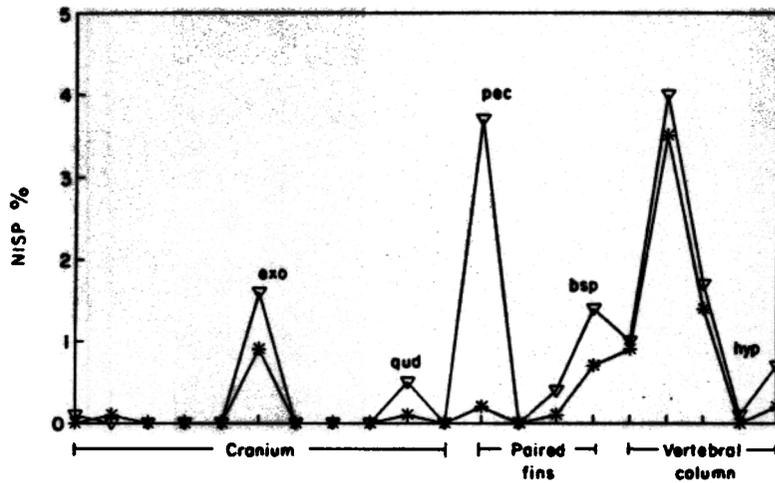


Figure 5. Element frequency in 1/4" and more than 1/8" screen fractions, excluding vertebra type-2 and type-3, Duwamish No. 1. \* = 1/4", N = 2877; ▽ = > 1/8", N = 3449.

than-1/8" fraction than in the 1/4" mesh (Figure 5), cranial elements are rare in both fractions. Of the estimated 4982 MNE in the combined 1/4" and 1/8" fractions, only about 7% are cranial (Figure 6).

### *Skeletal completeness*

Besides body-part frequencies, it is also reasonable to suggest that culturally and naturally derived salmonid assemblages will differ in element spatial distribution. In natural riverine settings, fish carcasses tend to be deposited whole and elements undergo limited

V. L. BUTLER

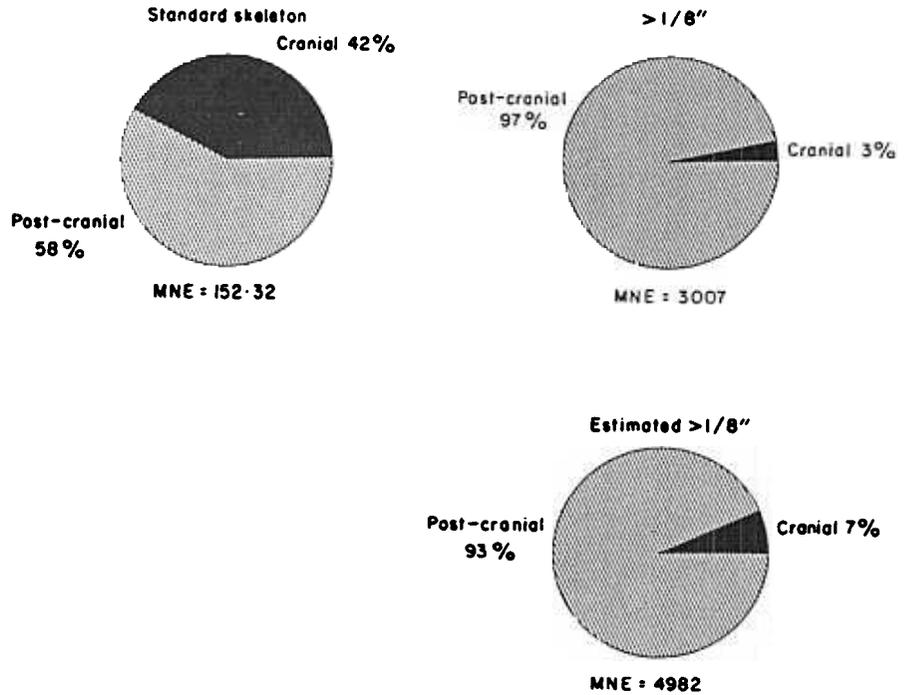


Figure 6. Frequency of cranial and post-cranial specimens, Duwamish No. 1.

post-depositional dispersal. In cultural settings, carcasses should undergo extensive processing before deposition and hence elements of an individual should be dispersed across a much greater area (Thomas, 1971). As a result, I predict that natural and cultural bone deposits will vary in the spatial distribution of skeletal parts because of major differences in the extent of carcass part dispersal.

I assessed carcass dispersal for the natural and cultural salmonid assemblages by examining the spatial distribution of elements representing the two ends of an individual fish. I used the ratio of the largest MAU cranial element to the largest MAU post-cranial element to determine the relative frequency of head and trunk parts contained within a given spatial unit (Butler, 1987c). This ratio is termed the completeness ratio. To avoid dividing by zero, and to limit the range of values between zero and one, the larger value of the two body-part groups was placed in the denominator. Ratios approaching one indicated that a similar number of individuals were represented by the anterior and posterior ends of an individual fish, and hence suggested intact carcasses. Ratios approaching zero suggested that a dissimilar number of upper and lower body portions were represented and indicated incomplete carcasses.

The relative nature of the measure should be emphasized; degree of carcass completeness is not an absolute, but depends on the scale of observation. For example, dispersal could be examined in an area comprising several point bars along a river reach, a single point bar, a 4 x 4 m unit, or subunits therein. I predict that natural and cultural assemblages should differ from one another in the spatial scale at which carcasses appear complete. In natural deposits, where dispersal of body parts is probably minimal, I expect to obtain relatively high completeness ratios for relatively small areas. In cultural deposits, where body parts should be widely dispersed, I expect to obtain relatively low

## SALMONID REMAINS: THE DALLES ROADCUT BONES

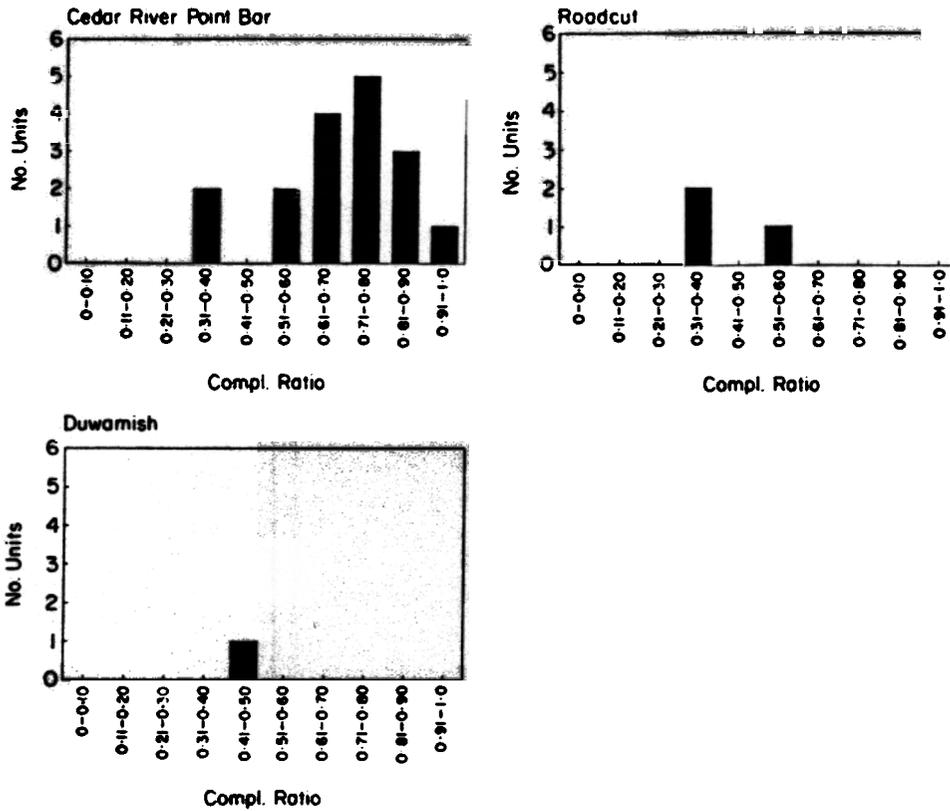


Figure 7. Completeness ratios, 4 x 4 m units.

completeness ratios for relatively small areas. In short, in natural assemblages, carcasses are expected to appear complete for smaller areas than in cultural assemblages, because of major differences in the extent of dispersal.

Do the data match these expectations? Figure 7 shows the relative frequency of 4 x 4 m units by completeness ratios for the Duwamish and Point Bar assemblages. Ratios could not be calculated for 4 x 4 m units in the Chief Joseph sites either because units this large were not excavated there or because salmonid remains were absent from them. Ratios also could not be calculated for 45-DO-211 because units lack either cranial or post-cranial elements. The ratio obtained from the Duwamish 4 x 4 m unit is smaller than those obtained from over 89% of the Point Bar units although it falls within the range of those obtained from the Point Bar. The Duwamish ratio is significantly different from the sample of ratios at the Point Bar, at  $P=0.10$  ( $t=1.429$ ;  $t_{0.10(1),16}=1.337$ ). This indicates that the difference in completeness ratios between the shell midden and the Point Bar reflect real differences in the populations from which the samples were drawn, rather than random sampling error.

The tendency for cultural assemblages to have lower completeness ratios than fluvial deposits also holds for comparisons at the scale of 2 x 2 m (Figure 8). Completeness ratios from 45-DO-285 and the Duwamish shell midden are much lower than those from most of the Point Bar units (Figure 8). Although ratios from the shell midden overlap those found at the Point Bar, a  $t$ -test indicates that the ratios from the shell midden and the Point Bar represent two different populations ( $t=2.06$ ;  $t_{0.025(1),37}=2.026$ ).

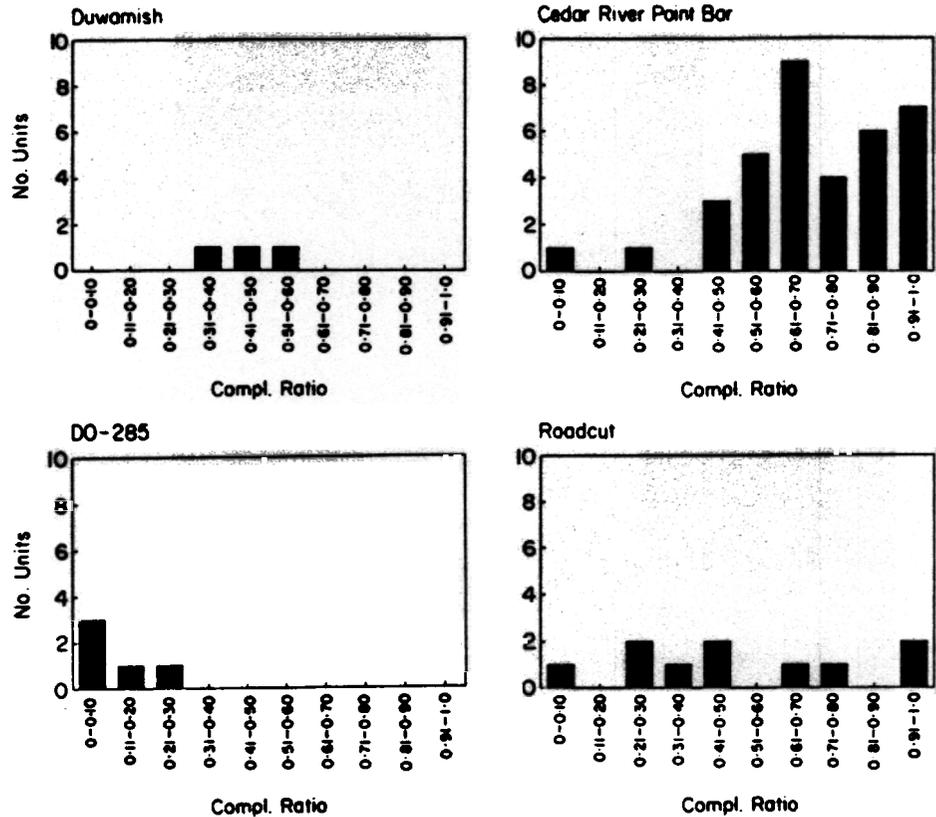


Figure 8. Completeness ratios, 2 × 2 m units.

At yet smaller spatial scales, 1 × 2 m areas, differences between natural and cultural deposits are not so clear. (The Duwamish assemblage could not be included in this comparison because the minimum unit size excavated was 2 × 2 m.) While 45-DO-285 has ratios much lower than most of the units at the Point Bar (Figure 9), 45-DO-211 provides ratios as high or higher than those from the Point Bar (Figure 9). The mean completeness ratio found at 45-DO-211 is 0.64, while the mean ratio obtained from the Point Bar sample is 0.63. Thus, the ratios obtained from 45-DO-211 for areas 1 × 2 m in size run counter to the expectation that cultural assemblages will have lower ratios than fluvial deposits. Indeed, the similarly high ratios obtained from both 45-DO-211 and the Point Bar indicate that dispersal of carcass parts was not extensive at either site. The relatively high ratios obtained from 45-DO-211 suggests that completeness ratios are not always a clear indicator of deposit origin.

In summary, high completeness ratios obtained at small spatial scales at Cedar River Point Bar match the expectation that dispersal of body parts is minimal in fluvial deposits. The expectation for cultural deposits to exhibit low completeness at small spatial scales was met in the Duwamish and 45-DO-285 assemblages, which provide low to extremely low ratios. However, at neither site is degree of dispersal indicated *per se*. Ratios are low at 45-DO-285 because primarily heads alone were deposited on site. Ratios are low at Duwamish because most of the cranial remains were destroyed. On the other hand, ratios which could be calculated for 1 × 2 m units at 45-DO-211 are as large or larger than those

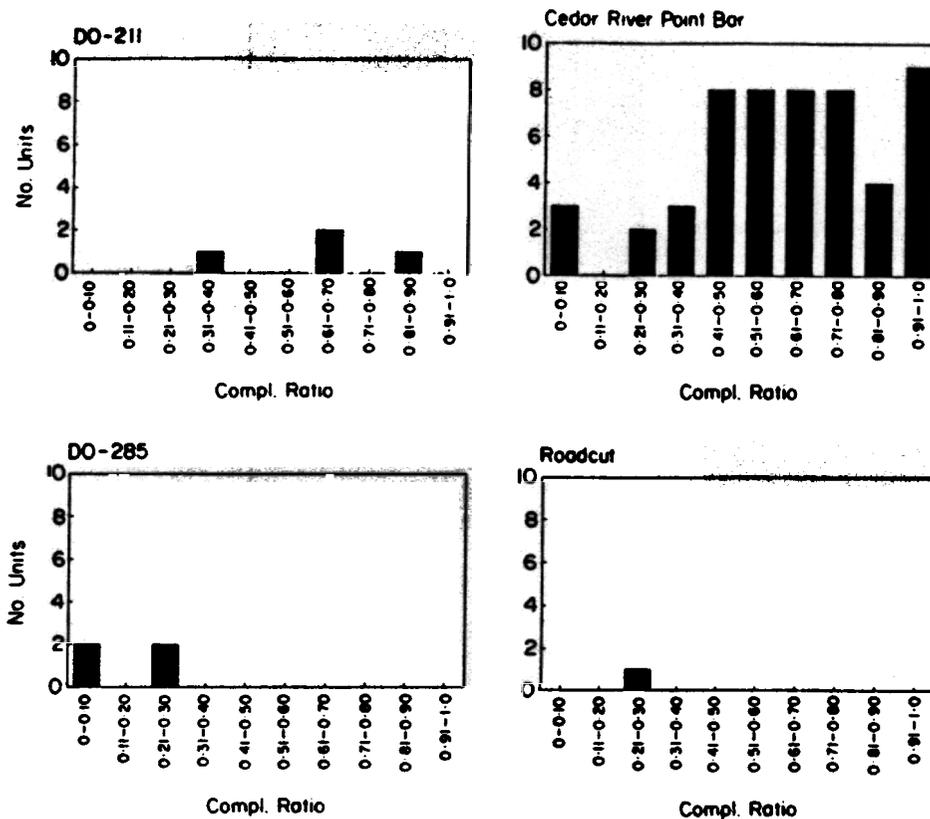


Figure 9. Completeness ratios, 1 x 2 m units.

from the Point Bar, which suggests minimal dispersal of body parts for this cultural site. That relatively high ratios were obtained from this cultural site indicates that skeletal completeness ratios will not discriminate natural from cultural deposits in all cases.

#### The Dalles Roadcut Site

##### Screen-size bias

The Dalles Roadcut remains were retrieved from 1/4" mesh screens and the extent of bias against smaller elements is unknown. The bias against smaller elements should not be as great as that for the Duwamish and Point Bar deposits, however. For the Duwamish shell midden, several elements, notably the pectoral fin ray, exoccipital, quadrate, basiptyrgium and hypural, are present in much lower frequencies in the 1/4" mesh than in the greater than-1/8" mesh screen (Figure 5). At the Point Bar, screen-size effects on element recovery are minor; vertebra type-4 and to a lesser extent, the otolith, caudal bony plate, hypohyal 2 and the hypural are relatively underrepresented in the larger mesh screen (Figure 10).

These screen-size effects may not be used to infer element loss through large mesh during excavation of the Roadcut site for one main reason: the Roadcut site fish specimens are larger, in general, than those from the Duwamish and Cedar River Point Bar sites. The larger size of the Roadcut fish specimens results from the deposition of much larger fish here than at the other two sites. Fish elements from larger-bodied individuals will, all

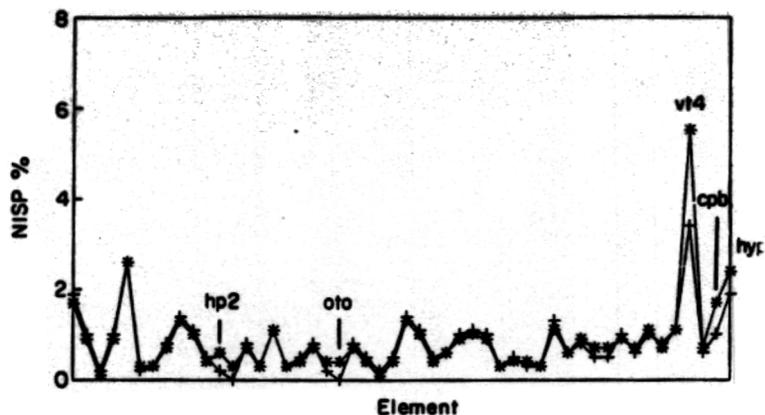


Figure 10. Element representation in 1/4" and more-than-1/8" fractions, excluding vertebra type-2 and type-3, Cedar River Point Bar. + = 1/4", N = 625; \* = > 1/8". N = 704.

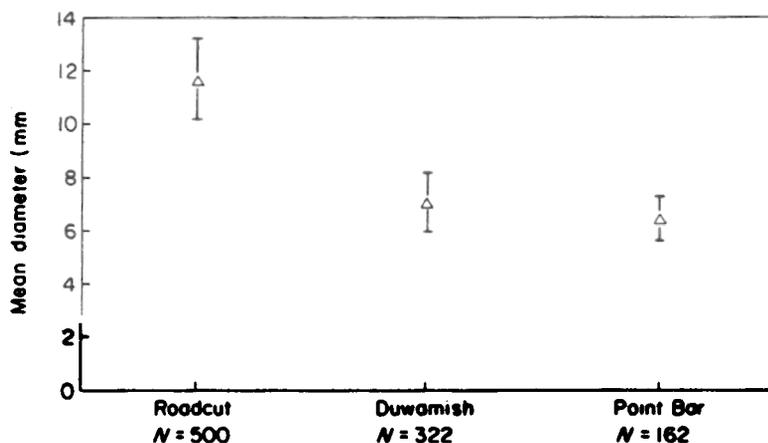


Figure 11. Mean diameter (mm) of vertebra type-2 (bar = standard deviation).

things being equal, be larger than those from smaller-sized individuals. The differences in fish body size between the Roadcut deposit versus the Duwamish and Point Bar deposits is demonstrated by comparing element sizes at the sites.

Casteel (1976c) showed that fish size (e.g. total length, total live weight) and vertebral width are strongly and positively correlated. To estimate body size of the fishes deposited, diameters of 984 vertebra type-2 recovered from 1/4" mesh screens were measured. The mean diameter of the Roadcut vertebrae is 11.58 mm, over 4 mm larger than that for the Duwamish vertebrae (mean = 7.01 mm) and Point Bar vertebrae (mean = 6.39 mm) (Figure 11). The presence of larger vertebrae in the Roadcut deposit signifies the presence of much larger individuals. A modern chinook salmon (*Oncorhynchus tshawytscha*) measuring 915 mm in total length has vertebra type-2 with a mean size of 11.85 mm; a modern coho salmon (*O. kisutch*) with a total length of 620 mm is comprised of vertebra type-2 with a mean diameter of 7.47 mm. These data suggest the Roadcut bonebed results

from the deposition of fish over 900 mm in total length; the Duwamish shell midden and Point Bar represent fish about 600 mm long and smaller.

Vertebrae from medium-sized salmonids were retrieved from 1/4" mesh at the Point Bar and Duwamish sites. If vertebrae of medium-sized salmon were present in the Roadcut deposit, such vertebrae would have been retrieved in 1/4" mesh at this site as well. Overall then, the Roadcut site contains the remains of larger fish than the Duwamish and Point Bar deposits.

Because larger fish are represented at the Roadcut site, the skeletal elements it contains tend to be larger here than at the Point Bar and the Duwamish shell midden. To illustrate this tendency, I compared the size of six elements from two modern salmonid individuals roughly the size of the fishes represented at the Roadcut, Duwamish and Point Bar deposits: a chinook measuring 915 mm in total length (comparable in size to the fishes in the Roadcut site) and a coho with a total length of 620 mm (comparable to the body sizes represented at the Duwamish and Point Bar sites). The elements were selected because their frequencies are particularly affected by screen size, being present in much lower frequencies in the 1/4" (6.4 mm) fraction versus 1/8" (3.2 mm) mesh in the Duwamish and Point Bar deposits. As shown in Table 4, the size of the chinook elements tend to be at least 3 mm greater than the coho specimens. That the elements from the chinook salmon—comparable in size to The Dalles fishes—are considerably larger than the specimens from the coho salmon—similar to the fishes represented at the Duwamish and Point Bar, supports the argument that the Roadcut elements will tend to be larger than those from the other two sites. Accordingly, recovery bias against such elements because of their size should not be as severe at the Roadcut site as that noted for Duwamish and the Point Bar deposits.

The use of relatively large mesh screens during the excavation of the Roadcut site may have resulted in loss of specimens. However, because relatively large specimens comprise the assemblage, I assume element representation is not seriously affected and will not obfuscate comparisons with other assemblages retained in finer screens. While screen size bias is probably minor for the Roadcut assemblage, this conclusion may not apply to other collections where small-bodied fishes are represented.

#### *Curation bias*

Aside from screen-size bias, assessing sample representativeness is particularly difficult for the Roadcut assemblage because the sample I located and analysed may be considerably different from that excavated. Cressman estimated that over 125 000 remains were excavated in the first three field seasons (1953–55) and an additional 125 000 were obtained during winter 1956–57. I located only 12 022 specimens from the four field seasons. This major discrepancy may result from the policy of saving only a portion of the remains from each excavation unit-level, a practice described by personnel during the 1950s' excavation (V. Scheans, pers. comm.). If the remains I located indeed represent such a sample, and they were randomly selected, then the sample included in my analysis may be representative of the remains in the deposit. However, other evidence indicates considerable differences in curation policy among collection years which has implications for the sample examined.

A plan map of the Roadcut deposit in Figure 12 shows the distribution of identified specimens and vertebrae by collection year. The denominator in each unit represents the total NISP; the numerator is the number of vertebrae. Specimen abundance varies tremendously among units. Almost 11 000 remains are in the most eastern units (0–1x, 4.5–7y) while only 1 m to the west, 108 specimens are recorded. Units 6–12x, 4–6y contain between 100–300 specimens, whereas the units north and south bear between two and 30 identified remains. Importantly, variation in spatial distribution of specimens

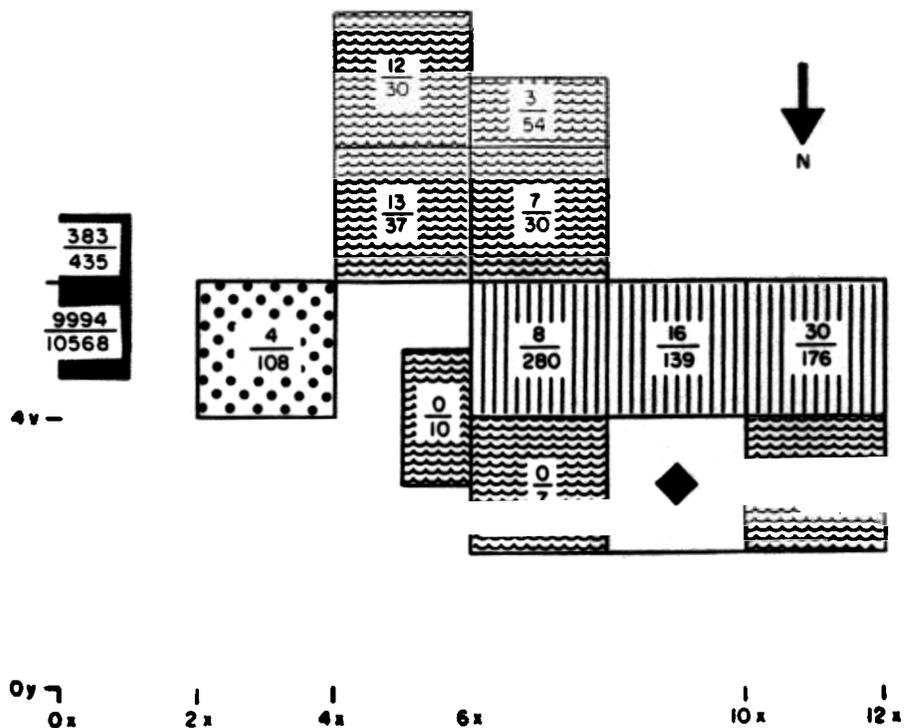


Figure 12. Plan view of Roadcut site showing distribution of identified specimens (NISP) and vertebrae by collection year.

corresponds to the field season the units were excavated (Figure 12). The eastern units which contained about 11 000 remains were excavated during winter, 1953-54, and the unit 1 m to the west was dug 3 years later. The three 2 x 2 m units which contain between 100 and 300 specimens in the central portion of the site were dug during the summer of 1954 while the units north and south were excavated 1 year later. The spatial distribution

Table 4. Comparison of element size between chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon

Chinook	Coho	Element (portion measured)	
8.9 mm	5.6 mm	Exoccipital	
7.3 mm	4.3 mm	Quadrate	
8.6 mm	5.6 mm	Pectoral fin ray	
13.0 mm	7.1 mm	Basipterygium	
9.9 mm	6.5 mm	Vertebra type-4	
9.4 mm	5.5 mm	Hypural	

of vertebrae also roughly corresponds to collection year. Remains in the eastern-most units 0-1x, 4.5-7y are predominately vertebrae, whereas in units to the west, vertebrae are very uncommon (Figure 12).

The spatial distribution of salmonid specimens noted here may reflect real variation in the spatial distribution of bone in the Roadcut deposit. However, the variation may also result from differences in curation policy among collection years. The superabundance of remains in the units excavated in winter 1953-54 may reflect a "save everything" policy. For units to the west excavated in subsequent field seasons, the paucity of remains in general and vertebrae in particular may reflect a more selective curation policy. Whatever the specific practice, the importance of curation policy in structuring the spatial patterns cannot be excluded given the correspondence of specimen distribution and collection year.

The Roadcut sample I located and analysed may be affected by significant biases, which may in part structure site-wide patterns of element representation and spatial distributions. Depending on the magnitude of the biases, interpretations of depositional origin may be affected. Unfortunately, it is impossible to estimate the direction of bias, whether curation practices would tend to make attributes of Roadcut match those of cultural or natural assemblages. Despite potential problems with the sample, it provides the only current access to the deposit and thus the only base from which to assess depositional origin. I rely on the sample to assess origin of The Dalles Roadcut salmonid remains, although emphasize that my conclusions regarding the deposit must remain tentative.

#### *Origin of the Roadcut salmonid remains*

Based on body-part frequency, the Roadcut site is most similar to the cultural deposits in having extremely low cranial element representation (Figure 4). Skeletal completeness

ratios also indicate that The Dalles Roadcut remains result primarily from human processes. At the scale of  $4 \times 4$  m,  $2 \times 2$  m, and  $1 \times 2$  m, ratios from the Roadcut site are considerably lower than most of those from the Point Bar (Figures 7, 8, 9). On the other hand skeletal completeness at the Roadcut site and the cultural sites are generally similar (Figures 7, 8, 9).

#### Conclusions

Comparative analysis of one natural and three cultural deposits from riverine settings indicates that body-part representation and skeletal completeness vary between natural and cultural settings. Cultural deposits are characterized by uneven frequencies of cranial and post-cranial elements and low skeletal completeness whereas natural deposits have relatively even representation of cranial and post-cranial elements and high skeletal completeness. In future studies of salmonid remains from regional archaeological sites, these criteria will be useful indicators of depositional origins.

A primary goal of the research was to identify the source of the Dalles Roadcut salmonid remains. Analysis of body-part representation and skeletal completeness in the Roadcut assemblage suggests that cultural processes are largely responsible for the salmonid deposit. What are the implications of this finding to interpretations of regional prehistory? As discussed previously, there is some debate as to when salmon became a focal resource to prehistoric inhabitants of the Pacific North-west. One position holds that salmon was a significant resource early in the Holocene; The Dalles Roadcut salmonid remains have been the primary evidence to support this argument. Others contend that early Holocene peoples were broad-spectrum hunter-gatherers and that salmon was just one of the many resources used. The Dalles fish remains are not incompatible with the latter argument, since its proponents do not deny that salmon were utilized in the early Holocene.

If my analysis had shown that The Dalles remains were naturally derived, such a conclusion would obviously have challenged the argument for an early Holocene salmon subsistence focus, given the significance of this Columbia River fish bone deposit to the argument. However, my work indicates a cultural source for the bones. The results suggest that salmon were part of the subsistence base during the early Holocene, a conclusion compatible with both accounts.

My conclusions regarding The Dalles Roadcut fish remains are necessarily tentative, since the collection may be significantly biased. Indeed, curation policy may have more to do with the patterns of body-part representation and completeness in the Roadcut assemblage than taphonomic agents. To substantiate the results, it is crucial that a more representative sample of fish remains be obtained from the site itself through additional excavation of the Roadcut deposit and that detailed physical and chemical analyses of the Roadcut deposit be conducted as well. Only with the result of such a project will we know with any certainty the relative contribution of natural and cultural agents in the formation of The Dalles deposit.

#### Acknowledgements

The paper is based on dissertation research conducted at the University of Washington. I would like to thank members of my committee, R.C. Dunnell, T.W. Pietsch, C.C. Swift and especially my chairman, D.K. Grayson, for advice on numerous aspects of the research and incisive comments on the dissertation itself. D.K. Grayson, A.G. Fountain and two anonymous reviewers provided thoughtful comments on this manuscript. Conversations with S.K. Campbell, R.L. Lyman and D.R. Rhode sharpened my thinking on several issues addressed here. Extremely able field assistance was provided by M.L. King, S.K. Campbell, M.L. Moss, P.A. Teltser, E.W. Butler, D.M. Butler, S. Livingston, A.G. Fountain, C.J. Miss, R.D. Mitchell and D.R. Rhode. A number of individuals

responsible for the excavation or curation of the archaeological collections used in the study assisted in numerous ways: L. Salo (U.S. Army Corps of Engineers), A. Fredine (Colville Confederated Tribes), S. Campbell—Chief Joseph Sites; D. Dumond and P. Endsweig (University of Oregon Museum of Anthropology)—The Dalles Roadcut; D. Lewarch, C. Miss, and S. Campbell—Duwamish No. 1. The research was supported by the Rachel Royston Permanent Scholarship Foundation, Sigma Xi, Achievement Rewards for College Scientists and the University of Washington Dissertation Fellowship. Analysis of the Duwamish No. 1 remains was funded through a contract from the Municipality of Metropolitan Seattle (METRO) to URS Corporation.

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## SALMONID REMAINS: THE DALLES ROADCUT BONES

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