Číx^{w}icən Faunal Sample Selection and Processing for the 2012-2019 Analysis

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1. Introduction

Číxʷicən[1] (pronounced *ch-WHEET-son*) is a Lower Elwha Klallam Tribe (LEKT) village in Port Angeles, WA at the base of Ediz Hook on the south shore of the Strait of Juan de Fuca (Figure 1) that was occupied for the past 2,700 years (Larson, 2006). In 2004, as part of a large-scale mitigation for a proposed Washington State Department of Transportation project (WSDOT), Larson Anthropological Archaeological Services (LAAS) and members of the LEKT, excavated Číxʷicən using a modified isolated block technique. This approach provided vertical and horizontal control and allowed for excavation by fine stratigraphic divisions. Excavation units totaled 518 m² in area, and 261 m³ of sediment were excavated (Fig. 2, see inset map). Butler et al. (2019a) summarize the history of site excavation; Campbell et al. (2019) and Reetz et al. (2006) provide an overview of geo-chronology and landform history.

Fig. 1. Map showing location of Číxʷicən. Dashed line outlines the Salish Sea watershed. (Figure drafted by Kendal McDonald.)

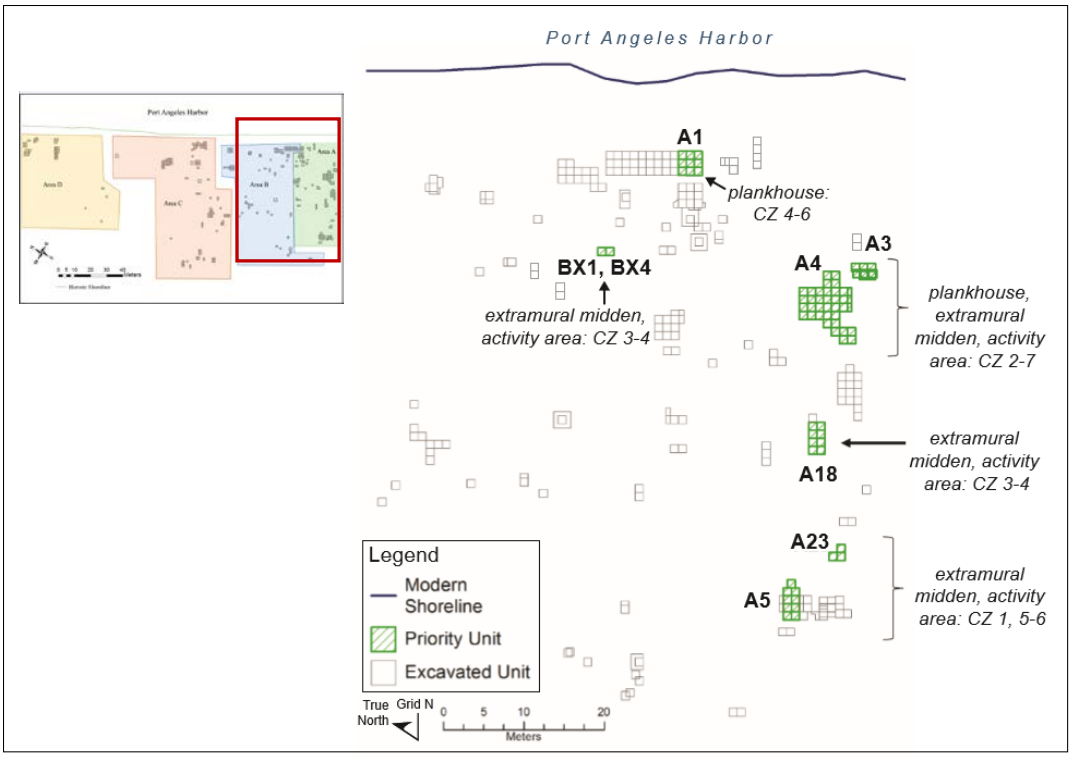

Fig. 2. Map showing areas targeted for geo-zooarchaeological analysis, chronozone (CZ) represented, and cultural activity indicated ("priority units"). (Figure drafted by Kristina Dick.) Inset map shows all areas excavated in 2004 mitigation, with red outlined box indicating focus of NSF project. (Figure drafted by Laura Syvertson.)

For various reasons, most of the materials from the site were not studied until our project began in 2012, with funding mainly from the National Science Foundation (NSF). Our project focused on faunal remains for their potential to contribute to understanding resilience in human adaptive strategies in the face of a range of environmental and social changes, focusing on the past 2150 years of occupation (Butler et al., 2019b). Project PIs were K.M. Bovy (University of Rhode Island), V.L. Butler (Portland State University), S.K. Campbell (Western Washington University), M.A. Etnier (Western Washington University), and S. L. Sterling (Portland State University).

This report describes the main field and sampling methods used by LAAS, including original laboratory analysis and cataloging, and specific procedures we used for the faunal project overall. For methods pertaining to particular faunal types, please see the specific reports on invertebrates (Campbell et al., 2018), fish (Butler et al., 2018), birds (Bovy, 2018) and mammals (Etnier, 2018) in Open Context.

2. Field methods

Field sampling was explicitly designed to allow for integration of all classes of faunal data (Reetz et al., 2006), and simple calculation of matrix volume. According to the original site report (Kaehler and Lewarch, 2006), matrix was excavated from each uniquely defined micro-stratigraphic deposit into 10 L buckets, which were water- screened through graded mesh 1" (25.6 mm), 1/2" (12.8 mm), and 1/4" (6.4 mm) or in some cases to 1/8" (3.2 mm) mesh. Most buckets from a given micro-stratum were screened

to 1/4" and called *Sample* or 'S' buckets. Invertebrate shell was not retained from S buckets. A minimum of one bucket was processed from each stratum of each 1 m^2 grid unit and screened to 1/8" mesh. As noted by Kaehler and Lewarch (2006), all faunal remains were retained from such buckets labeled *Complete* or 'C' buckets. Finally, relatively large remains were recorded *in situ* during excavation and referred to as 'E' samples.

3. NSF project sampling

Given the large scale of excavation, the enormous quantity of faunal remains recovered, and the impracticality of studying the entire collection, we needed to develop a sampling strategy that would allow us to examine representative faunal samples from a range of spatial and temporal contexts. We used radiocarbon ages from the 2004 mitigation report to identify deposits that were among the oldest and youngest on the landform, which allowed us to obtain samples from as full a range of human occupation as possible. We devised a sampling strategy targeting seven different excavation Areas/Blocks (Fig. 2, Table 1), which included remains from activity areas, extramural middens, and at least two house structures (in Areas A4 and A1). The NSF project prioritized radiocarbon dating and geoarchaeological analysis on these seven Areas/Blocks. As shown in Table 1, invertebrate and mammal remains were studied in two additional areas (A6, A9) that were not included in the geoarchaeological study or radiocarbon dating. Fish remains *were not* studied from A3.

Table 1. List of Areas/Blocks included in faunal analysis by faunal type, 2012-2019 analysis.

Area/Block[1]	Invertebrate	Fish	Bird	Mammal
A1	x	x	x	x
A3	x		x	x
A4	x	x	x	x
A5	x	x	x	x
A6	x			
A9	x			x
A18	x	x	x	x
A23	x	x	x	x
BX1/BX4	x	x	x	x

[1] The term "Area" or "Block" are used interchangeably in our reporting. The original site report (Larson, 2006) uses the term "Area" to define the four massive project areas that were assigned in 2004 field work (Area A, B, C, D, see inset Figure 2) and the term "Block" for the contiguous excavation units excavated in a particular "Area". However, the site catalog refers to this set of contiguous units as "Area" (e.g., A1, A3) as well. The NSF project nomenclature for the contiguous grouping of excavation units includes the alpha code (A, B) and the numeric code (1, 3, 4, etc.). Areas/Blocks in bold were included in geoarchaeological study with chronozones (CZs) assigned. Geoarchaeological study of A6 and A9 was not undertaken; remains from these areas were not included in project results publications (e.g., Butler et al. 2019b; Bovy et al., 2019).

Given our interest in exploring patterning for all the fauna simultaneously, we prioritized our faunal analysis on the C buckets because the original site report explained that all classes of remains were retained in this sample type (Kaehler and Lewarch, 2006). As well, it was our understanding that the C buckets were screened to 1/8" mesh, so targeting this bucket type insured that we obtained samples from small-bodied fish and invertebrates (and fragmentary remains from all fauna).[2] The 10 L bucket sampling also made estimating volume relatively simple, and in turn density and accumulation rate, measures important to our goals. To increase the volume sampled for the mammal and bird remains, which were much less common than invertebrate and fish remains, S buckets from some site areas were also studied (Table 2). Syvertson (2017) studied fish remains from 269 S buckets in A4, as part of her thesis project, which examined the value of "sampling to redundancy" for fish faunal analysis. All faunal analysts also included the "in situ" remains (E samples), collected during excavation in the priority Areas/Blocks. Table 2 summarizes the coding system for the sample types.

Číxʷicən faunal remains were curated at the Burke Museum of Natural and Cultural History (Seattle, WA). The NSF project team consulted with the LEKT, the WSDOT, and the collection manager at the Burke, in setting up the loan of the collections from prioritized Areas/Blocks and bucket types. Remains from each main animal type from the targeted excavation blocks were sent to our respective laboratories for study: birds, KMB (University of Rhode Island); fish, VLB (Portland State University); mammals, MAE (Western Washington University); and invertebrates, SKC (Western Washington University).

Table 2. Summary of field sampling methods and sample types at Číxʷicən, including number of bucket samples included in 2012-2019 analysis.

Sample Code	Cu Meters	Description	Analyzed 2012-2019 [1]	
			Num. Buckets	Liters
C	4.57	10 L bucket, to 1/8" mesh, all faunal types	457	4570
CX	3.63	10 L bucket, to 1 /4" mesh, all faunal types	363	3630
S[2]	18.97	10 L bucket, to 1 /4" mesh – mammal	1897	18970
	4.01	bird	401	4010
	2.69	fish	269	2690
E		Recorded in situ, typically larger specimens, all faunal types	---	---

[1] Samples from excavation areas A1, A3, A4, A18, A23, A5, BX1/BX4.

[2] Because of relatively small numbers of specimens which could be identified to taxon in the C/CX buckets, mammal remains from S buckets from A4 and A5 were studied. Bird remains from S buckets from A5/A23 were studied along with remains from A4, Unit 17-20. A sample of S buckets from A4 were studied for a fishbone project by Syvertson (2017).

4. Three problems encountered with faunal records

As our group began analysis in 2012-2013, we noticed three main problems with the faunal records that we needed to address (Table 3).

1) First, the size of the remains within each bag did not necessarily match the screen size recorded for the bag/or in the catalog. For example, fish remains that were cataloged as coming from 1/4" mesh contained much larger specimens that should have been captured in the 1/2" mesh, as well as much smaller specimens that should have fallen through the 1/4" screen. This pattern was concerning. Given the importance of mesh size on faunal recovery, taxonomic representation, etc., we needed to feel confident that the mesh size assignments were valid; and comparable to faunal studies elsewhere.

2) A large number of bags labelled C in the catalog and on bag labels, lacked 1/8" mesh faunal remains entirely. According to LAAS records, matrix from C bags was supposed to have been screened down to 1/8" mesh. We needed to know whether this absence of 1/8" mesh bags was real (that 1/8" animal remains did not exist in a given sampled context) or whether the absence was because some of the 1/8" mesh samples were not retained after excavation, perhaps because of a change in protocol.

Table 3. Summary of three main problems the 2012-2019 Číxʷicən project encountered while working with the 2004 LAAS excavation and catalog records.

Problem	Ways addressed	Implication for Analysis
Mesh size listed did not match the bone size.	Re-screened all the faunal remains from priority areas and any areas NSF project studied. Added a field to catalog "Re-screened", with code "0.99", to indicate this action.	Assigned new catalog numbers to faunal remains from re-screened bags. No effect on analysis/results.
Large number of C catalog/bag numbers listed in catalog did not have 1/8" mesh bags.	Closely analyzed all C bag catalog listings. Bag numbers that lacked 1/8" mesh were called CX bags. Created "Analytic Bag Type" field, to distinguish matrix from buckets screened to 1/8" mesh (C) vs. 1/ 4" mesh (CX).	Treated C and CX bags distinctly in analysis, especially for shell and fish, where 1/8" mesh has such great impact on faunal recovery. Both bag types useful, they simply need to be considered independently.
More than one catalog/bag number from one unit/stratum. Since each C bag number is supposed to represent 10 L volume, having >1 catalog number attached to one bucket would affect volume, density, accumulation rates.	Close analysis of all C bag catalog listings. Created "Analytic Bag Number", which represents all the bag numbers that we surmise are from one original 10 L bucket.	When studying density/accumulation rates of animal types for given contexts, must use "Analytic Bag Number" for estimating volumes, densities, accumulation rates, rather than "Bag Number".

3) We noticed multiple instances where more than one C bag number was listed for the same unit/stratum. According to LAAS documentation (Kaehler and Lewarch, 2006), for C buckets, minimally one 10 L bucket from each excavation unit and each stratum was screened through nested screens 1", 1/2", 1/4" and 1/8"; all constituents from this single 10 L bucket were sorted. If a stratum was thick and exceeded 20 liters, then two 10 L buckets would have been collected and two catalog numbers would be present. However, we noticed that in some cases of multiple C bucket numbers from the same unit/stratum, that one of them would be represented only by 1/4" bone samples, rather than the full suite of multiple size fractions and shell as well as bone. In these cases, the catalog number for the

minimal sample was much higher than the others, reflecting a later assignment date. Systematic comparison of the constituents of multiple examples confirmed that the higher catalog number comprised solely 1/4" samples and solely bone (usually all of the types). Further, the lower catalog number from the same provenience lacked 1/4" bone samples although it would have 1/4" shell, and generally had bone in other size fractions. This pattern appears to be consistent with the lab personnel separating bone from the 1/4" fraction and setting it aside for sorting later, and then when it was sorted, assigning a new catalog bag number rather than using the previous bag number.

Critical to our project was the analysis of faunal accumulation rates and densities, which was predicated on controlling for the matrix volume that generated our faunal samples. We needed to know when lab personnel created new bag numbers for the original 10 L bucket.

The following describes how we addressed these issues (Table 3).

4) Mesh size discrepancies. To address this problem, we rescreened all of the faunal remains that were included in our study (both C and S bags, from the seven priority areas; and C bags from A6 and A9 studied for mammal and invertebrates). Each faunal lab conducted their own screening using a similar protocol. For each C bag catalog number, lab personnel carefully passed all the remains through a series of nested screens (1", 1/2", 1/4" and 1/8") and bagged, weighed and assigned new catalog numbers to the remains retained in each mesh fraction, and the residue that passed through the 1/8" mesh.

5) Absence of 1/8" mesh for some C bucket samples. We realized after a few months into the analysis that LAAS had changed their sampling protocol in September 2005. According to the LAAS final report, Appendix 3, Rationale for Revised Laboratory and Sorting Methodology, in September 2005, project management determined that a sufficient number of 1/8" samples had been sorted from the site. At this time, LAAS lab personnel ceased sorting 1/8" specimens to main animal type; remains in the 1/8" mesh were no longer retained or cataloged. Importantly, such samples were not distinctly labelled in the catalog; they were still coded as C bags/buckets. We needed to distinguish these sample types in our analysis, given the huge impact mesh size has on faunal recovery and taxonomic representation. To do this, Butler closely analyzed the LAAS catalog numbers for C bags from our priority Areas/Blocks. She sorted the catalog records by catalog number—and examined the listings for mesh size and constituents for each catalog number. If a 1/8" mesh sample was not listed for a given catalog number, this was taken to mean that 1/8" mesh samples *were not sorted and retained*. We think this logic is sound. Given the high abundance of shell and bone across the site, if matrix had been screened to 1/8" mesh, at least a few specimens from fish, shell or other animal type, would be retained, sorted and cataloged. We think it is highly probable that the *absence of 1/8" mesh samples* for a given catalog number means *1/8" mesh samples were not studied and retained.*

For such sample types, we created a new bag label, "CX" for the buckets/bags that had been originally labelled "C", but which represent matrix screened only to 1/4". We have reproduced catalog entries for three contexts to illustrate how we identified these situations and reconciled them (Table 4). Seen here, the field name "Bag Type" refers to the original code the bucket/bag was assigned to by LAAS. Our project team added the field, "Analytic Bag Type" for the site records. The codes included here reflect our assessment of the bag/bucket type, based on our analysis of catalog records.

Table 5 lists the frequency of buckets (and total volume of matrix) that was studied across the Areas/Blocks targeted for analysis. For the CX buckets, we focused our attention on faunal remains

Table 4. Examples from the catalog, showing process for determining if the bag number was redundant (was derived from another bucket/bag) and if the bag was originally screened to 1/8" (C bag) or 1/ 4" (CX bag).

Area	Bag Number	Analytic Bag Num	Unit	Stratum	Level	Count	Material Class	Material Type	Mesh Size	Bag Type	Analytic Bag_Type
A4	2110	2110	5	5.2	1	>50	Bone	Fish	WS 1/8"	C	C
A4	2110	2110	5	5.2	1	3	Bone	Fish	WS 1/2"	C	C
A4	2110	2110	5	5.2	1	1	Bone	Fish	WS 1"	C	C
A4	2110	2110	5	5.2	1	15	Bone	Mammal	WS 1/8"	C	C
A4	2110	2110	5	5.2	1	>50	Shell		WS 1/8"	C	C
A4	2110	2110	5	5.2	1	>50	Shell		WS 1/4"	C	C
A4	2110	2110	5	5.2	1	25	Shell		WS 1/4"	C	C
A4	2110	2110	5	5.2	1	>50	Shell		WS 1/2"	C	C
A4	2110	2110	5	5.2	1	25	Shell		WS 1"	C	C
A4	2110	2110	5	5.2	1	14	Bone	Avian	WS 1/8"	C	C
A4	22444	2110	5	5.2	1	>50	Bone	Fish	WS 1/4"	C	C
A4	22444	2110	5	5.2	1	1	Bone	Avian	WS 1/4"	C	C

Bag Number 2110 lacked 1/4" mesh bone. Bag Number 22444 had only two faunal types and one mesh size (1/4") the ones not present in Bag 2110. Surmise that 22444 materials originated in Bucket/Catalog number 2110. Assigned to "C" bucket because 1/8" mesh remains were present in the catalog.

Area	Bag Number	Analytic Bag Num	Unit	Stratum	Level	Count	Material Class	Material Type	Mesh Size	Bag Type	Analytic Bag_Type
A4	1481	1481	6	3.4	1	1	Bone	Mammal	WS 1"	C	C
A4	1481	1481	6	3.4	1	>50	Bone	Fish	WS 1/8"	C	C
A4	1481	1481	6	3.4	1	25	Bone	Mammal	WS 1/8"	C	C
A4	1481	1481	6	3.4	1	5	Bone	Avian	WS 1/8"	C	C
A4	1481	1481	6	3.4	1	>50	Shell		WS 1/4"	C	C
A4	1481	1481	6	3.4	1	36	Shell		WS 1/2"	C	C
A4	1481	1481	6	3.4	1	>50	Shell		WS 1/8"	C	C
A4	22375	1481	6	3.4	1	14	Bone	Fish	WS 1/4"	C	C
A4	22375	1481	6	3.4	1	3	Bone	Avian	WS 1/4"	C	C
A4	22375	1481	6	3.4	1	22	Bone	Mammal	WS 1/4"	C	C

Bag number 1481 lacks 1/4" mesh for mammal, fish, bird, while Bag number 22375 has all of these listed. It is unlikely that one 10 L bucket would have 1" , 1/2" and 1/8" samples, but lack 1/4" remains from the animal types. Presence of 1/8" mesh samples from the unit/strat indicates this is a "C" bag.

Area	Bag Number	Analytic Bag Num	Unit	Stratum	Level	Count	Material Class	Material Type	Mesh Size	Bag Type	Analytic Bag_Type
A4	3299	3299	5	5.1.2	1	9	Bone	Fish	WS 1/2"	C	CX
A4	3299	3299	5	5.1.2	1	3	Bone	Fish	WS 1/2"	C	CX
A4	3299	3299	5	5.1.2	1	14	Bone	Fish	WS 1/2"	C	CX
A4	3299	3299	5	5.1.2	1	1	Bone	Fish	WS 1"	C	CX
A4	3299	3299	5	5.1.2	1	1	Bone	Mammal	WS 1"	C	CX
A4	3299	3299	5	5.1.2	1	34	Shell		WS 1/4"	C	CX
A4	3299	3299	5	5.1.2	1	>50	Shell		WS 1/4"	C	CX
A4	3299	3299	5	5.1.2	1	>50	Shell		WS 1/2"	C	CX
A4	3299	3299	5	5.1.2	1	7	Shell		WS 1/2"	C	CX
A4	3299	3299	5	5.1.2	1	48	Shell		WS 1"	C	CX
A4	19534	3299	5	5.1.2	1	>50	Bone	Fish	WS 1/4"	C	CX
A4	19534	3299	5	5.1.2	1	1	Bone	Avian	WS 1/4"	C	CX
A4	19534	3299	5	5.1.2	1	1	Shell		WS 1/4"	C	CX
A4	19930	3299	5	5.1.2	1	8	Bone	Fish	WS 1/4"	C	CX
A4	19930	3299	5	5.1.2	1	3	Bone	Avian	WS 1/4"	C	CX
A4	19930	3299	5	5.1.2	1	1	Bone	Mammal	WS 1/4"	C	CX

Bag Number 3299 lacked 1/4" mesh bone. Bag Num 19534 had both 1/4" bird, shell and fish (but lacked any larger mesh size samples). Constiuents listed for Bag 19930 are similar (1/4" mesh only). None of the catalog entries for this unit/strat show 1/8" mesh, thus assigned this bag/bucket to "CX".

from 1/4" mesh and larger sizes. During re-screening (see above), for many CX bags, some items slipped through the 1/4" and were retained in 1/8". We saved and bagged this material, but in the main, did not include such material in our analysis (e.g., Butler et al., 2018). However, we realized this problem a few months into our project. In some cases for CX bags, we had already analyzed and recorded remains from what came to be 1/8" mesh, because of the re-screening. In these cases, constituents in the 1/8" mesh were not included in our publications of project results (e.g., Bovy et al., 2019; Butler et al., 2019b), but the faunal remains are listed in the catalog.

6) Buckets artificially separated into two catalog/bucket numbers. For all the priority Areas/Blocks we studied (A1, A3, A4, A5, A18, A23, BX1/BX4), Butler (conferring with Campbell) closely analyzed the original LAAS catalog faunal records and flagged bag numbers which appeared to be a "redundant" number, detected with this reasoning. In principle, for a single catalog/bag number, we expected to see multiple animal types (shell, fish, bird, mammal) from the range of mesh sizes possible for a C bucket (down to 1/8") or a CX bucket (down to 1/4"). Butler flagged potential "redundant" bag numbers when she noted two or more catalog/bag numbers from the same unit/stratum and an incomplete listing of animal types and mesh sizes for the catalog number. This pattern was consistent enough that we felt confident in re-associating the 1/4" bone samples with the C or CX bucket from the same provenience that had no 1/4" bone samples.

We added a field, "Analytic Bag Number" to address these situations. The analytic bag number is our best estimate for the original 10 L bucket number. Of course in many cases, the "analytic bag number" is the same as the "bag number". The bag numbers, which we surmise were added in the lab in 2005, were assigned to this original bag number, labelled as the "analytic bag number". We illustrate how we identified and resolved such issues by presenting the faunal catalog records for three contexts (Table 4).

Table 5. Overview of samples included in the 2012-2019 Číxʷicən analysis (note: 1 cu m = 1000 liters). (Excavated volumes from Reetz et al., 2006: 4-30, 4-62).

Area	Volume Excavated (m^3)	C buckets[2]		CX buckets[3]	
		Liters	% total excavated	Liters	% total excavated
A1	10.21	450	4.4	540	5.3
A3	6.9	240	3.5	80	1.2
A4	33.16	3170	9.6	2620	7.9
A5[1]	5.941	370	6.2	290	4.9
A18	1.53	40	2.6	40	2.6
A23	1.9	90	4.7	30	1.6
BX1/BX4	0.85	210	24.7	40	4.7

[1] calculated excavation depth from 2004 LAAS field forms for the 11 1x1 m units from A5 included in 2012-2019 project.

[2] C refers to complete buckets that were screened to 1/8" mesh and which provided invertebrate, fish, bird and mammal remains.

[3] CX refers to buckets that were screened to 1/ 4" mesh and which provided invertebrate, fish, bird and mammal remains.

5. Transfer of specimens from one analyst to another

As is typical of archaeological projects and lab sorting, some faunal remains were initially sorted into the wrong animal type, and such remains needed to be transferred, studied and documented by the appropriate analyst.

We developed a protocol for making these transfers. As we found specimens that needed to be transferred, we set them aside, inventoried them by creating an Excel spread sheet, then every six months or so, we mailed or hand-carried the specimen to the appropriate analyst. When we were about to make these transfers, we contacted Laura Phillips (Burke Museum) and sent her a copy of the spreadsheet. Mailed items were insured.

Endnotes

[1] An alternative spelling for the site name, Tse-whit-zen, has been used in some previous reports and publications. The Klallam language spelling, Číxʷicən (Montler, 2012), is preferred by the Lower Elwha Klallam Tribe.

[2] Much research (Butler and Schroeder, 1998; Gobalet, 1989; Moss et al., 2017) demonstrates that remains of extremely small fish taxa (and small elements of larger fish) are lost when 1/8" mesh screens are used. Only a limited number of small volume bulk samples were retained in the 2004 mitigation project, which limited our ability to study the impact of this bias on fish representation.

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