Čḯxʷicən Bird Bone Project: Methods, Analytical Protocols, and Descriptive Summary for the 2012-2019 Analysis

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1. Introduction

The Čǐxʷicən site[1] is a Lower Elwha Klallam Tribe (LEKT) village in Port Angeles, WA, U.S.A., at the base of Ediz Hook on the south shore of the Strait of Juan de Fuca (SJDF; Fig. 1) that was occupied for the past 2,700 years (Butler et al., 2019a; Larson, 2006). In 2004, Larson Anthropological Archaeological Services (LAAS) and LEKT members excavated the site with large open blocks of 1 x 1 m units by finely defined stratigraphic layers (Reetz et al., 2006). In 2012, Kristine Bovy (University of Rhode Island), Virginia Butler (Portland State University [PSU]), Sarah Campbell (Western Washington University), Michael Etnier (Western Washington University), and Sarah Sterling (PSU) initiated a research project focusing on Čǐxʷicən's faunal remains and geo-archaeological records from the 2004 mitigation. As part of project design, we selected to study excavation areas that were linked to two possible plankhouses, to include interior and extramural deposits (Fig. 2).

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

[1] An alternative spelling for the site name, Tse-whit-zen, has been used in some previous reports and publications. The Klallam language spelling, Čǐxʷicən (Montler, 2012) is preferred by the Lower Elwha Klallam Tribe. Please see http://www.klallam.montler.net./WordList/PLACENAMES.htm, for spelling.

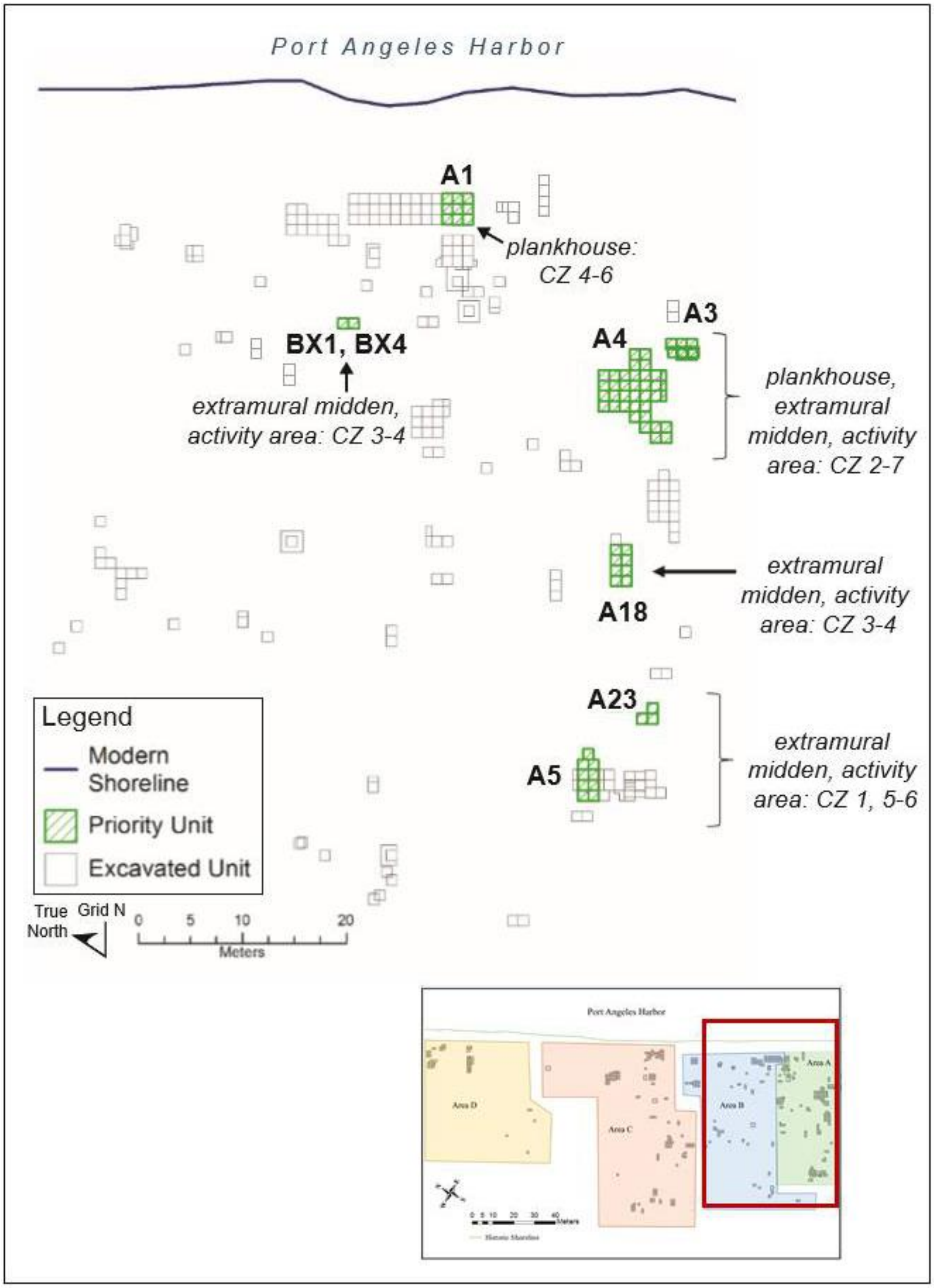

Fig. 2. Map showing areas targeted for geo-zooarchaeological analysis, chronozone (CZ) represented, and cultural activity indicated ("priority units"). (Figure drafted by Kristina Dick.) Inset map shows all areas excavated in 2004 mitigation, with red

outlined box indicating focus of 2012-2019 project. (Figure drafted by Laura Syvertson.)

Elsewhere (Bovy et al., 2019; Butler et al., 2019b), we have begun to examine and interpret temporal and spatial trends in the vast faunal assemblage. The goal of this report is to provide essential information needed to understand the bird assemblage itself, which will be especially important for future researchers interested in using the existing bird data or conducting additional analyses on the assemblage. To that end, this report describes the bird bone sample selection and processing decisions, provides taxonomic and taphonomic summaries, including analysis criteria for taxonomic identifications, and provides the primary data files generated from the analysis.

2. Sample selection and processing

Butler et al. (2018) summarizes the faunal sample selection and processing for our 2012-2019 zooarchaeological project. I reiterate some of the most critical aspects of that methodology here, and provide additional details related to the bird analysis.

2.1. Initial sample processing

Field sampling was explicitly designed to allow for integration of all classes of faunal data (Butler et al., 2019a; Reetz et al., 2006), and simple calculation of matrix volume. Matrix was excavated from each uniquely defined deposit into 10 L buckets, which was water- screened through graded mesh 1" (25.6 mm), ½" (12.8 mm), and ¼" (6.4 mm) or in some cases to ⅛" (3.2 mm) mesh (Kaehler and Lewarch, 2006). Processing varied by bucket or bag type (Table 1).

Table 1. Description of bucket/bag sample types at Číxʷicən (2012-2019 analysis project).

Bag Type	Explanation
E	Small numbers of faunal remains were recovered *in situ* during excavation, rather than in the screens; these were typically relative complete or large bones.
C	'Complete' bag, which includes ⅛" fraction and larger for invertebrates, fish, mammals and birds; a minimum of one bucket from each stratum of each 1 m² grid unit was screened to ⅛".
CX	'C' buckets that are lacking the complete ⅛" fraction (see Butler et al., 2018); CX buckets are similar to 'S' buckets (¼" mesh and above), but invertebrates were collected.
S	'Sample' bag, which was screened to ¼"; fish, mammal and bird bones were retained; invertebrates and ⅛" materials were not retained; most buckets were processed in this way.

After excavation, LAAS personnel sorted faunal remains into four main animal groups (fish, bird, mammal, invertebrates). Remains from each faunal type in a given bucket and screen size were counted and listed in the catalog. Specimen counting ceased when the tally reached 50 specimens; the catalog entry noted > 50 specimens. Thus counts listed in the original catalog were underestimates. All materials excavated, processed and cataloged by LAAS were transferred to the Burke Museum of Natural History and Culture in Seattle, Washington for curation. Arrangements are being made to transfer the materials to the LEKT.

2.2. Sampling procedures

Our analysis began with a pilot study comprised of four units from Area A4: Units 17, 18, 19 and 20. In 2011 and 2012, I analyzed 100% of the bird bones from all contexts (C, CX, E, S) from these four units. Once we received the NSF funding (July 2012), we prioritized analysis of 'C' buckets from the targeted block excavations, as they were screened to ⅛" mesh. While ¼" mesh can be sufficient for mammal and bird analyses (see Bovy, 2011a), ⅛" mesh is essential to get an accurate representation of the fish and invertebrates; the analysis of C buckets therefore, allows for better integration of all faunal classes. However, remains from some 'S' buckets were also incorporated into the project to increase sample size of larger animals, including mammals, birds, and large-bodied fish.

In sum, all of the bird remains from the C/CX buckets and 'E' (*in situ*) remains, and a subsample of S buckets were borrowed from the Burke Museum and analyzed at the University of Rhode Island, Department of Sociology & Anthropology. After requesting and receiving the initial loan, we made some changes in our analysis strategy, based on stratigraphic/contextual information and time constraints, which resulted in decisions to exclude some material from analysis or consider it lower priority. Table 2 explains which bird material was and was not analyzed for each spatial Area. As discussed below, ⅛" from CX and S bags will not be included in this analysis, although many of these specimens do have preliminary identifications. Also, individual bags were excluded from various areas because of poor provenience (e.g. no stratigraphic information available).

2.3. Re-screening procedures

Prior to beginning analysis, the zooarchaeological material in our sample was re-screened by each analyst in our labs (with the exception of E or *in situ* material, as these were not screened originally; see discussions in Butler et al., 2018 for more information). All separate bird specimens for a given bag number (one 10-liter bucket sample) were removed from their bags and screened through nested geological sieves (½", ¼", ⅛"). We then re-bagged and weighed the newly screened material into 1", ½", ¼", ⅛" and <⅛" screen size bags, and assigned new catalog numbers to each set of materials. New catalog numbers were assigned to specimens after re-screening, although *in situ* (E) material retained the original catalog numbers (e.g., A4-132.01.01). Table 3 lists the total number of specimens identified as bird (NSP) and the number of specimens identified at least to taxonomic Order (NISP) by screen size and sample type.

While the re-screening process sounds straightforward, there are a few complications to mention. First, given that I did not have a 1" sieve in the lab, my students and I made a visual assessment of whether larger items would have been caught in a 1" or ½" screen, based on the shortest dimension of the bone. In retrospect, I believe we labeled some specimens as ½", when they may have more likely remained in a 1" screen (e.g., entire limb bones in which the width was much narrower than 1", but the length was much longer). Therefore, the distinction between 1" and ½" is less meaningful than for the other size classes; in the analysis, the 1", ½" and ¼" will most often be grouped together as ≥¼", which mitigates this problem. Second, after the fact I also learned that some of the students made a concerted effort to make particularly long and thin elements (e.g., relatively complete radii) pass through the ¼" and into the ⅛" screen; it is likely that some of these would have ended up in ¼" (rather than ⅛") in typical screening circumstances, given their length (if they had landed flat in the screen

Table 2. List of Areas/Blocks included in bird analysis. Bird remains from Areas A6, A9, B1, and B6 were borrowed from the Burke, but later excluded from the 2012-2019 analysis project. See discussion below (Sec. 2.5) for explanation of 'partially analyzed materials.'

Area	Units Analyzed	C/CX	S	E	Material Excluded	Comments
A1	1- 11	Yes	No	Yes		Some CX ⅛" remains were 'partially analyzed'
A3	10- 14	Yes	No	N/A	⅛" bags	Due to time constraints, only the ≥¼" remains for A3 were analyzed
A4 Pilot	17- 20	Yes	Yes	Yes		Most of the ⅛" remains from CX and S buckets were 'partially analyzed'
A4 Non-Pilot	1-16, 21-38, 40	Yes	No	Yes		
A5	1, 3- 5, 8-12, 16, 19	Yes	Yes	N/A	Units 2, 13-15, 17-18, 28-33	
A6		No	No	*Yes	All Units	*E bags were 'partially analyzed'
A9		*Yes	No	N/A	All Units	*C/CX were 'partially analyzed' (excluding transfers); only IDs for ¼" and larger were recorded.
A18	1, 2, 3	Yes	No	N/A	Units 5- 7	
A23	1, 2, 3	Yes	Yes	N/A		
B1		No	No	*Yes	All Units	*E bags were 'partially analyzed'
B6		No	No	*Yes	All Units	*E bags were 'partially analyzed'
BX1/BX4	1	Yes	No	N/A		

Table 3. Number of Specimens (NSP) and Number of Identified Specimens (NISP; in parentheses) for birds for each sample type by screen size.

Screen Size	C	CX	S	Total NSP (NISP)
1"[1]	4 (3)	12 (12)	17 (14)	33 (29)
½"	99 (85)	86 (72)	284 (228)	469 (385)
¼"	2247 (1083)	1515 (741)	2880 (1288)	6642 (3112)
⅛"[2]	2377 (642)			2377 (642)
Total	4727 (1813)	1613 (825)	3181 (1530)	9521 (4168)

[1] The number of 1" specimens is conservative; see note about re-screening (Sec. 2.3).

[2]Bovy also identified 5806 specimens from the ⅛” C material as vertebrate (non-fish). Some may be bird bones, though most are likely mammal, given the extreme fragmentation in the mammal assemblage (Bovy et al., 2019).

versus with the proximal or distal end down). The screen size of a few specimens was changed when this issue was noticed, but there may still be a few relatively long and thin specimens cataloged as ⅛”.

Importantly, according to LAAS records, ⅛” mesh was the finest screen used for C buckets, but in many cases, some remains slipped through this mesh; it is possible these tiny fragments stuck to larger fragments during the original screening process, which seems likely if the deposits were moist. We re-bagged and re-cataloged such materials, with mesh size labeled <⅛”. Likewise, although CX and S bags were reportedly only screened to ¼”, many ⅛” fragments were collected during the re-screening process; these remains were bagged, but not included in the analysis, as they do not represent a complete sample of the finer mesh size. All <⅛” and ⅛” CX and S bags were retained for future study. Interestingly, we noticed a few very tiny bird bone phalanges (toes) that fell through the ⅛” screens during processing.

2.4. Transfer of specimens between analysts

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 on an Excel spreadsheet, and mailed or hand-carried the specimens to the appropriate analyst periodically. At the end of the project, I created a master excel database of all transfers to and from my lab. A total of 1053 non-bird bones and shells were found in the bird bags and were transferred to other analysts, unless the analyst was not studying that particular bag type or area (e.g., S bags were not sent to Butler or Campbell, since these were not included in their sample). A total of 2724 bird bones were received as transfers from other analysts between 2012 and 2016; we kept the transferred specimens physically separate, so the Burke Museum staff, and future researchers, would know which items had been transferred. In addition, there is a column entitled ‘Initial ID’ in the bird database, which keeps track of the original identification (Aves, Mammal, Fish, Shell). Transferred remains that were not clearly identifiable as bird were labeled as ‘vertebrate (non-fish)’ or occasionally transferred again (e.g., if I received a bone from Butler that I recognized as mammal). Multiple transfers are noted in the master transfer database. It is important to note, however, that these processes developed over the course of the project; I know, for example, that I did not consistently record mammal transfers in C/CX bags from the initial pilot study, so the number of transfers recorded is likely a minimum of transferred specimens.

While the mis-sorting of these faunal remains by lab technicians, who did not necessarily have any zooarchaeological training, is not surprising, it did create some problems for the analysis. Preparing the material for transfer and integrating all of the transferred material into existing bags was time consuming, and in some cases I received transferred material after I had already completed the identifications for a given taxon and/or area, so the transferred material may not be identified as specifically, and the specimens may not have been considered for re-fits. In addition, while I should have 100% of bird bones pulled from fish, mammal or invertebrate C/CX bags for Areas A1, A4, A5, A18, A23, BX1, and BX4, there were some areas and bag types that were not analyzed by other researchers and therefore any mis-sorted bird bones were never pulled (Table 4). Relatively few bird bones (mostly calcined fragments) were initially sorted to invertebrate bags (n=203), but many were recovered from fish (783) and mammal (1737) bags; however, many of these transfers were identifiable only as 'bird,' which reduces the importance of this problem.

Table 4. List of un-analyzed fish, invertebrate and/or mammal samples which main contain mis-sorted bird bones.

Area	Bag Type	Comments
A3	C/CX	No fish transfers, as Butler did not identify fish from A3. Mis-sorted bird bones from mammal and invertebrates were transferred.
A4 (Pilot)	S	Invertebrates from S buckets were not analyzed. Only a sample of the fish S bags were analyzed (see Syvertson, 2017) and mis-sorted bird bones transferred. Mammal S bags were analyzed and mis-sorted bird bones transferred.
A5	S	No fish or invertebrates analyzed. Mammal S bags were analyzed and mis-sorted bird bones transferred.
A23	S	No mammal, fish or invertebrates analyzed.

2.5. 'Partially analyzed' and excluded material

For various reasons, many of the bird specimens from Čı́xʷicən were only partially analyzed (Table 2). The main reason this occurred is that I began the analysis of the A4 Pilot study material (C and S bags) in Fall 2011, before we discovered that the material needed to be rescreened and that the ⅛" fraction was not saved for all C bags, necessitating our CX designation (see discussions in Butler et al., 2018). In short, I had begun to analyze many of the ⅛" S and CX fragments before we decided to exclude these from our analysis, since we did not have a complete sample of this size fraction. In addition, I occasionally analyzed remains (especially transfers) by mistake even after I was aware of these analysis decisions. Also, I have preliminary identifications for some *in situ* material from excluded areas (B1, B6, A6), as well as the small A9 assemblage, which I began to analyze before we decided to exclude these areas from our analysis. Although these remains were not fully analyzed, I kept them sorted (with their preliminary identifications) to aid possible future researchers. Slips were inserted into these bags indicating they were partially analyzed.

I refer to these remains as 'partially analyzed,' because although I started the analysis process, some of the identifications still needed to be verified with additional work, and many were not identified as specifically as the specimens in my final analysis. I would estimate these identifications are approximately 90% accurate and might therefore be useful for some future analyses, but are not of the same quality as the other identifications, since the analysis process/verification was never completed. In addition, a smaller number of identified remains were finalized, but later excluded from the Access database because they lacked provenience information (typically lacking a strata or level designation). Therefore, the partially analyzed and excluded specimens are not included in the final bird database or in the descriptive summary below, but are summarized briefly in Sec. 4.1, and are available in a separate excel file submitted to the Burke Museum.

Table 5 summarizes the number of excluded bone fragments and total number of identified specimens (in parentheses). Of those fragments that were excluded (n=2151), nearly half were indeterminate vertebrate (likely bird or mammal) fragments (n=1098). There were 1053 definite bird bones in the excluded material, of which 395 have preliminary, or in some cases final, taxonomic identifications; the remaining 658 fragments are either elements excluded from my analysis (vertebrae, ribs, phalanges), too fragmented to identify, or potentially identifiable fragments that were never completely analyzed.

Table 5. Total number of bone fragments[1] and identified bird bones (NISP; in parentheses) for 'partially analyzed' or 'excluded material' from bird bone analysis. This material is not included in the descriptive summary that follows.

Reason Excluded	A1	A4	A5	A6	A9	A18	A23	B1	B6	BX1/BX4	Total
<¼" from CX bag	53	196 (31)	12 (1)							25	286 (32)
<¼" from S bag		1568 (191)									1568 (191)
Entire area excluded				6 (3)	82 (33)			6 (4)	131 (90)		225 (130)
Specific units excluded						5 (3)					5 (3)
No stratum listed	11 (4)	42 (25)									53 (29)
Strat 2.0 excluded		8 (5)	2 (2)				4 (3)				14 (10)
Total	64 (4)	1814 (252)	14 (3)	6 (3)	82 (33)	5 (3)	4 (3)	6 (4)	131 (90)	25	2151 (395)

[1]Total bone fragments includes 1) indeterminate vertebrate (non-fish), 2) bird fragments not identified to taxon (either because they were too fragmented or the analysis process was not completed), and 3) specimens with taxonomic identifications.

2.6. Final analyzed bird samples

The Čí̓xʷicən site is divided into numerous spatial areas and chronozones, which are described in detail in Campbell et al. (2019). Tables 6 and 7 show the number of bird bones recovered from each spatial area and chronozone by sample type (note that this report does include information on bird remains from CZ 4b, a re-deposited stratum, which was excluded in our previous publications). While spatial and temporal analysis and interpretation is beyond the scope of this report, the accompanying database allows these data to be analyzed by area or chronozone.

It should be emphasized that only a small sample of the bird bones from this immense collection was analyzed. A total of 2611 bird bones were recovered from the S bags from the four units in the pilot study (Table 6); while there was a particularly dense faunal accumulation in this area, it does indicate that many more thousands of bird bones are likely present in the S bags from the other areas and units.

Table 6. Bird NSP (NISP) for each area by sample type.

Area	E	C	CX	S	Total
A1	8 (4)	259 (95)	115 (56)		382 (155)
A3		507 (297)	182 (106)		689 (403)
A4	343 (304)	3279 (1199)	1248 (621)	2611 (1287)	7481 (3411)
A5		112 (50)	20 (8)	478 (205)	610 (263)
A18		44 (14)	11 (8)		55 (22)
A23		14 (7)	5 (2)	92 (38)	111 (47)
BX1/BX4		512 (151)	32 (24)		544 (175)
Total	351 (308)	4727 (1813)	1613 (825)	3181 (1530)	9872 (4476)

Table 7. Bird NSP (NISP) by Chronozone (CZ) and sample type.

Chronozone	Cal BP	E	C	CX	S	Total
CZ 7	300-150		75 (20)	41 (23)		116 (43)
CZ 6	550-300	156 (138)	1834 (649)	724 (354)	1751 (865)	4465 (2006)
CZ 5	1000-550	184 (163)	1998 (873)	578 (311)	1156 (536)	3916 (1883)
CZ 4b[1]			18 (8)	7 (3)		25 (11)
CZ 4	1300-1000	11 (7)	662 (210)	230 (121)	91 (50)	994 (388)
CZ 3	1550-1300		76 (23)	21 (10)	1 (0)	98 (33)
CZ 2	1750-1550		37 (16)	3 (0)		40 (16)
CZ 1	2150-1750		27 (14)	9 (3)	182 (79)	218 (96)
Total		351 (308)	4727 (1813)	1613 (825)	3181 (1530)	9872 (4476)

[1]Material from CZ 4B was re-deposited; specimens from CZ 4b were excluded from our published analyses (Bovy et al., 2019; Butler et al., 2019b), but are included in this report.

3. Bird bone analysis procedures

The bird bone analysis took place between September 2011 and June 2016 at the University of Rhode Island under my direction. Thirteen URI Anthropology undergraduate students helped with the bird bone analysis and curation of the assemblage over the years (Amanda Arnold, Thom Brassil, Morgan Breene, Nathanial Crockett, Sara Facincani, Corin Guimond, David Hanos, Ana Opishinksi, Marielle Orff, Amanda Ouellette, Erick Reels, Rick Rossi, Danielle Verrier), as paid workers, independent study students or volunteers; one motivated high school student, Abra Clawson, also helped in the zooarchaeology lab.

I followed quality control protocols consistent with Driver's (2011) recommendations (see also Wolverton, 2013): the universe of possible bird taxa was established at the beginning of the project using Gaydos and Pearson's (2011) list of bird species recorded in the Salish Sea, *Birds of Washington: Status and Distribution* (Wahl et al., 2005) and *Marine Birds and Mammals of Puget Sound* (Angell and Balcomb, 1982); identification criteria were specified and referred to over the course of the project;

difficult to distinguish taxa and elements were specified; and a descriptive summary, which includes rules, protocols, and criteria used for assigning skeletal elements was prepared (*this report*).

Given that none of the student helpers had zooarchaeological experience before working on this project, the analysis procedures were designed to facilitate their training: first identifying bird bone elements, and then starting to recognize different taxa. Students first sorted the material within a given bag by element, making separate smaller bag/tags for each element and pulling out any non-bird bone or non-bone material. Second, we would pick an element, such as the humerus, and lay out comparative specimens for each possible taxonomic order. Students would then systematically try to identify each fragment to a given taxonomic group (duck, Alcid, loon, Passerine, etc.) for a particular area. Students recorded the initial identification, along with portion, side, and taphonomy information on the tag, and I later checked all of these identifications. These initial steps were repeated numerous times as different areas were analyzed, and different students were learning analysis methods. While this process was inefficient in the sense that bags were opened, re-filed, and re-sorted numerous times, it was necessary given the level of student knowledge and the large number of possible bird taxa present in the Pacific Northwest. This procedure also ensured that we took the time to carefully look at representatives of all possible taxonomic orders/families, and establish criteria for which fragments could be securely identified to a given taxonomic level (e.g., could a small section of a murre humerus shaft be securely distinguished from a shearwater humerus shaft fragment?). Finally, I attempted to obtain more specific identifications, sometimes aided by more advanced students (see discussions below).

To facilitate identification in the URI zooarchaeology laboratory, additional modern comparative specimens were borrowed from the Ornithology Department of the Burke Museum, Michael Etnier (Applied Osteoarchaeology), and Diane Hanson (Department of Anthropology, University of Alaska-Anchorage). In addition, I made one trip to the Burke Museum (Seattle) and numerous trips to the Museum of Comparative Zoology (Harvard University) to consult additional comparative specimens. Although comparative specimens were the primary resource for taxonomic identifications, I also used criteria found in Cohen and Serjeantson (1996), Gilbert et al. (1996), and Olsen (1979) to perform the initial sort, as well as my own previous observations and drawings compiled while working with the extensive comparative specimens at the Burke Museum for my dissertation (Bovy, 2005). Importantly, the specificity of final identifications varied depending on available comparative collections and time available; see Sec. 3.1, and individual discussions by taxon in Sec. 4 (Taxonomic Summary) for more information. While the specificity of taxonomic identifications is sometimes variable depending on the Area, Family level identifications are consistent across the site.

We made no attempt to identify vertebrae, ribs, and phalanges (toes) beyond the class level. While phalanges of some bird taxa are fairly diagnostic, they are time-consuming to identify, as most birds have four separate digits with variable numbers of unique phalanges. For consistency, even very obvious phalanges (e.g. loon, albatross, raptors) were not quantified, but the likely identification was sometimes noted in the ID Comments field of the database. We typically attempted to refit specimens within bags, and occasionally between bags (e.g., when an obvious refit was noted during analysis of a given element or taxon), though this did not always happen with transferred specimens received later.

Refits were counted as one specimen to avoid over-counting. In most cases, the refits appeared to be recent breaks, occurring during or after excavation.

Many (n=5806) of the unidentifiable bones in the bird sample were coded as 'Vertebrate (non-fish)' rather than unidentified bird. This category was necessary as it can be extremely difficult to distinguish bird and mammal indeterminate fragments (those not identifiable to element) that are smaller than ¼". For example, small rodents often have hollow bones similar to birds and large diving birds have thick dense bones similar to mammals. While some indeterminate fragments smaller than ¼" may be identified as bird with some confidence, the process is time consuming and has little analytic value. Therefore, no attempt was made to identify ⅛" unidentifiable remains to class. They were counted, coded as Vertebrate, and filed with the bird bag for the respective screen size. A very small number of these ⅛" fragments could be fish bone, but any specimens exhibiting a possible 'fishy' texture were sent to Butler.

During analysis individual tags/bags were made for each unique taxon/element combination for a given catalog number and placed together within a larger bag; this will allow future researchers to easily find a particular specimen recorded on the database. Acid-free labels summarized taxon, element, and burning information for each interior bag. All bird records were entered into an Excel spreadsheet (see explanation of database fields in Sec. 3.3), proofed for errors, and then transferred to the Access database where they were queried for coding errors associated with catalog numbers, provenience, and faunal identifications. Our database manager then linked chronozone assignments for each excavation area, unit, and stratum to each bucket/catalog number. Excel files with this analytical information were then returned for further analysis. Non-faunal material was sometimes found in the master bird bone bags, such as rock, charcoal, wood or plastic. We bagged and labeled these accordingly, placing them in the main bird bag. These were not recorded in the bird database.

Two units will be used for quantitative analysis. Number of identified specimens (NISP) is simply a tally of bird remains identified to Order. Number of specimens (NSP) includes all NISP plus remains that could only be assigned to bird. In addition to taxonomic identifications, modifications such as burning and cut marks were recorded; the procedures for the taphonomic analysis are discussed below (Sec. 5).

3.1. A note on the specificity of the Identifications

It is apparent from the list of taxa identified (Table 8), that my identifications for the Čǐxʷicən assemblage are less specific than some of my previous work—most notably my analysis of three Pacific Northwest assemblages (Watmough Bay, Minard, Umpqua/Eden) for my dissertation (Bovy, 2005). Many of the identifications described here are at the family level, rather than genus or species level. There are a number of reasons for this more conservative approach to the identifications. Most importantly, my access to comparative collections was limited, in comparison to my dissertation work, which was conducted at the Ornithology department of the Burke Museum. The Burke Museum has an outstanding ornithology collection, including many recent acquisitions from oil spill causalities, with numerous individual specimens of different sexes available for most species. In contrast, Harvard often had only a small handful of specimens for a given taxa, and the specimens themselves were often collected and processed long ago, so the condition of the skeletons was often not as good (e.g., some elements missing or still articulated). In addition, the Harvard collections were understandably not as focused on Pacific taxa as the Burke Museum. The Harvard collections, however, were only a few hours away from Rhode Island, which was a benefit, as were the helpful staff and state of the art facilities. I had hoped to make additional trips to the Burke Museum to refine identifications, but this proved logistically challenging due to distance and time constraints.

Second, my analysis procedure was to identify all specimens first to Order or Family level, and then work more intensively on refining identifications from one Order, which sometimes involved travel

Table 8. Complete list of identified bird bones from Čx́ʷicən 2012-2019 analysis project.

Scientific Name	Common Name	NISP
Anseriformes		
Anatidae	Duck, Goose, Swan	9
cf. Anatidae	Duck, Goose, Swan	3
Anserinae	Goose	43
cf. Anserinae	Goose	6
Anatinae[1]	Duck	715
cf. Anatinae	Duck	149
Anatinae- small	Duck, small-sized	59
cf. Anatinae- small	Duck, small-sized	5
Anatini	Dabbling Duck	14
Aythya spp.	Pochard	20
cf. *Aythya* spp.	Pochard	1
Mergini	Sea Duck	61
Melanitta spp.	Scoter	57
cf. *Melanitta* spp.	Scoter	3
Melanitta fusca	White-winged Scoter	1
Clangula hyemalis	Long-tailed Duck	1
Bucephala albeola	Bufflehead	32
Bucephala spp.- large	Common or Barrow's Goldeneye	1
Mergus spp.	Common or Red-breasted Merganser	10
Total		1190
Podicipediformes		
Podicipedidae	Grebe	11
cf. Podicipedidae	Grebe	16
Podicipedidae- small	Grebe, small-sized	27
cf. Podicipedidae- small	Grebe, small-sized	3
Podicipedidae- large	Grebe, large-sized	129
cf. Podicipedidae- large	Grebe, large-sized	16
Podiceps spp.- small	Horned or Eared Grebe	6
Podiceps grisegena	Red-necked Grebe	27
Aechmophorus spp.	Western or Clark's Grebe	3
cf. *Aechmophorus* spp.	Western or Clark's Grebe	1
Total		239
Columbiformes		
Columbidae	Pigeons and Doves	1

Table 8. Continued.

Scientific Name	Common Name	NISP
Gruiformes		
Rallidae- small	Virginia Rail or Sora	1
Fulica americana	American Coot	1
Total		2
Charadriiformes		
Charadriiformes- small	Shorebird, small-sized	26
cf. Charadriiformes- small	Shorebird, small-sized	4
Charadriiformes- medium	Shorebird, medium-sized	11
Charadriiformes- large	Shorebird, large-sized	16
Alcidae	Auk, Murre, Puffin	6
cf. Alcidae	Auk, Murre, Puffin	3
Alcidae- small	Alcid, small-sized	67
Alcidae- medium	Alcid, medium-sized	47
cf. Alcidae- medium	Alcid, medium-sized	2
Alcidae- large	Alcid, large-sized	732
cf. Alcidae- large	Alcid, large-sized	119
Uria spp.[2]	Common or Thick-billed Murre	674
cf. *Uria* spp.	Common or Thick-billed Murre	52
Uria aalge	Common Murre	5
Uria cf. *aalge*	Common Murre	6
Cepphus columba	Pigeon Guillemot	3
Brachyramphus spp.	Murrelet	1
Laridae	Gull and Tern	415
cf. Laridae	Gull and Tern	56
Total		2245
Gaviiformes		
Gavia spp.	Loon	18
cf. *Gavia* spp.	Loon	24
Gavia spp.- small	Loon, small-sized	226
cf. *Gavia* spp.- small	Loon, small-sized	30
Gavia spp.- large	Common or Yellow-billed Loon	81
cf. *Gavia* spp.- large	Common or Yellow-billed Loon	6
Gavia stellata	Red-throated Loon	9
Gavia cf. *stellata*	Red-throated Loon	4
Gavia cf. *pacifica*	Pacific Loon	28
Gavia cf. *immer*	Common Loon	2
Total		428

Table 8. Continued.

Scientific Name	Common Name	NISP
Procellariiformes		
Phoebastria spp.	Albatross	30
cf. *Phoebastria* spp.	Albatross	5
Procellariidae[1]	Shearwater, Fulmar, Petrel	131
cf. Procellariidae	Shearwater, Fulmar, Petrel	37
Fulmarus glacialis	Northern Fulmar	2
Ardenna (=*Puffinus*) spp.	Shearwater	95
cf. *Ardenna* spp.	Shearwater	3
Total		303
Suliformes		
Phalacrocorax spp.	Cormorant	24
cf. *Phalacrocorax* spp.	Cormorant	7
Phalacrocorax cf. *auritus*	Double-crested Cormorant	2
Total		33
Pelecaniformes		
Pelecanus spp.	American White or Brown Pelican	3
Ardea herodias	Great Blue Heron	7
cf. *Ardea herodias*		2
Total		12
Accipitriformes		
Accipitridae- large	Bald or Golden Eagle	2
cf. Accipitridae- large	Bald or Golden Eagle	1
Total		3
Piciformes		
Picidae	Woodpecker	1
Passeriformes	Perching Bird	12
Corvus spp.- small	Crow	6
Corvus corax	Common Raven	1
Total		19
Aves	Bird, unidentified	5397
Total		9872

[1]Only pilot study material (A4 units 17-20) was systematically identified beyond family.
[2]Material from A4 units 1-16 and 21-40 was identified only to family level (Alcidae-large).

to Harvard. This procedure was hindered by the fact that so many of the bird bones were initially mis-sorted as mammal, fish or shell (see Sec. 2.4). Therefore, I frequently received additional transferred specimens for a given taxa after I had already worked on identifying the taxa from that Order. More specific identifications might have been possible, if I had the total universe of bird bones at one time.

Third, the Čí́xʷicən assemblage included ⅛" fragments unlike my dissertation assemblages, and these specimens were frequently broken fragments of larger birds. Even the bird bones from larger size fractions from the Čí́xʷicən assemblage were rather fragmented, which made identifications challenging. There were few whole bird bones in the assemblage (see Bovy et al., 2019, Table 7; for example, only about 2% of the humeri were relatively complete).

Finally, as recognized by Driver (2011), I have become more conservative in my identifications over time as I have gained experience and come to realize how challenging it is to distinguish birds from the same genera based on morphology alone. While measurements can sometimes be useful, getting a large enough sample of comparative samples is a challenge, and it is possible that the average size of birds may have varied through time and space.

In the Taxonomic Summary that follows (Sec. 4), I describe my efforts to identify each taxa beyond the Family level and note when I think that the identifications could be refined with more work; similar comments may also be noted directly in the corresponding database entries.

3.2. A note on the 'cf.' identifications

Many of the identifications described below are qualified with the '*cf.*' (compares favorably) designation. These designations make it inconvenient when sorting or working with the database, but I felt these were necessary to both obtain as much information as possible about the assemblage, while still recognizing the limitations in the identifications. The *cf.* identifications are typically small fragments of a bird that was common in the assemblage; the specimen matched well with the proposed taxa, but likely could not have been identified independently on its own merit, apart from the context of the larger assemblage.

One way to explore the fragmentation of the identifications starting with *cf.* is to look at the bone zones present for these specimens. The bone zones indicate the particular landmarks/portions present on each specimen (Serjeantson, 2009; Appendix 2). Thirteen elements (carpometacarpus, coracoid, femur, furculum, humerus, pelvis, radius, scapula, sternum, synsacrum, tarsometatarsus, tibiotarsus and ulna) had 8 bone zones each for a complete specimen. As is evident from Table 9, 86% of all *cf.* identifications had two or fewer bone zones present, meaning that less than 25% of the element was intact. In practice, combining the *cf.* identifications with the more definitively identified specimens from the same taxa would be appropriate for most research questions.

Table 9. The number of 'bone zones' present for all of the identifications beginning with '*cf.*' Includes all elements (n=13) with 8 bone zones possible in a complete specimen.

# of bone zones present	NISP	%
0	20	4.2
1	205	43.2
2	183	38.6
3	40	8.4
≥4	26	5.5
Total	474	

3.3. Explanation of database fields (see Appendix 1 for complete list)

3.3.1. Faunal Category

All specimens were either coded either as 'Aves' or 'Vertebrate.' This allowed easy sorting of the bird specimens from the unidentifiable fragments, which could be either bird or mammal.

3.3.2. Finest Taxon

Finest Taxon refers to the most specific taxonomic classification (e.g., class, order, family, genus, species) to which a specimen can be assigned. Fragments that could only be securely identified as bone (primarily the ⅛" fraction) were coded as Vertebrate (non-fish); see discussion above (Sec. 3.) for an explanation of this code. As stated above, all vertebrae, ribs, and phalanges were identified only as Aves. Taxonomic names follow the Seventh Edition of the American Ornithologists' Union (AOU) check-list (1998), as well as the numerous (and often substantial) changes made to the check-list in recent years, which are available as supplements on the AOU website and published in *The Auk* each year. Genetic studies have altered many earlier assumptions about taxonomic relationships of birds, changing the placement and taxonomic names of many species.

3.3.3. Element/ Segment/ Side/ Zone

Element refers to the specific skeletal element (e.g., humerus, skull, vertebra, etc.), while segment denotes a portion of a skeletal element, either a specific name (e.g., pterygoid) or a description (e.g., proximal). If the element was complete, 'whole' was entered in the segment field. Avian skeletal part terminology follows Howard (1929). In most cases, the side of the element was also recorded; however, in a relatively few cases the side could not be securely determined, even though the element was identifiable (e.g., ulnae or radii shaft fragments). The Zone field indicates which particular portions/landmarks of the bone were present (e.g., FEM 1 is located at the head of the femur). Bone zone codes are from Serjeantson (2009: Appendix 2), except for mandible and second wing digit (Phalanx 1; see Bovy, 2005: Figure A-1). The side and bone zone were recorded to aid in the calculation of minimum number of elements (MNE), if desired.

3.3.4. Quant_Bird

The 'Quant_Bird' field is either NSP (for all specimens identified as 'bird') or NISP (for those identified more specifically). Refit specimens were counted as one specimen, and the refit was noted in the ID Comments field. For example, a specimen broken into 3 fragments would be listed as '1' in the Quant_Bird field; in a number of cases, a specimen is listed with a '0' quantity, which means it refits to a specimen with a different catalog number (frequently a different screen size within the same bag).

3.3.5. Age

A protocol was in place to record the relative age of the bird specimens (Bovy, 2011b; Broughton, 2004). 'Adult' specimens have developed cortical bone and muscle attachments. 'Juvenile' specimens may approach adult size, but lack complete development of cortical bone, and muscle attachments may or may not be present. Finally, 'chicks' are small in size, porous, and lack cortical bone and muscle attachments. Only 14 of the Čḯxʷicən bird bones appeared to be sub-adult (all 'juveniles').

3.3.6. Burn/ Burn Type

The presence/absence (yes or no) of burning was recorded in the 'Burn' field. The decision of whether a bone fragment was burnt was made primarily on the basis of color. Three different kinds of burning types were recorded: 'burnt' (darkly discolored or blackened), 'calcined' (whitish, grayish or bluish), and 'partially burnt on shaft' (bones that appeared to have been intentionally heated mid-shaft/element and broken). See Taphonomic Summary (Sec. 5.1) for more details on burning.

3.3.7. Initial ID

The 'Initial ID' field was a way to keep track of bird bones that were initially mis-sorted (by LAAS laboratory staff) as mammal, fish or shell, pulled by Etnier, Butler or Campbell, and later transferred for analysis.

3.3.8. ID Comments

This field provides additional information on the specimen that does not fall into any of the above categories (e.g., whether the specimen was fragmented or refit, specific taxonomic identification notes, unusual taphonomy, etc.). Comments about the catalog # or provenience were also recorded here.

3.3.9. Original ID

In the process of writing this report, I made minor updates to the database to make the finest taxon identifications more standardized (e.g., deleting sizing information if this was not consistently done throughout the analysis). I preserve the earlier identification in this column, since that is the taxonomic name written on the analysis labels on the bags themselves, which had already been returned to the Burke Museum.

3.3.10. Modification

Characteristics such as surface alteration or carnivore damage, and cultural modification were recorded if obviously present. However, specimens have not been systematically examined under a microscope. See Taphonomic Summary (Sec. 5) for more information.

3.3.11. Photo

A small number of specimens were photographed to document modifications (especially cut marks, burning and fragmentation) or to aid in analysis. 'Yes' was recorded in this field if photos were taken, and a separate excel spreadsheet of all the photos taken was created (on file at the Burke Museum).

4. Taxonomic Summary

The following section describes the basis for taxonomic identifications, in particular listing the skeletal elements assigned to taxonomic level and the criteria used to justify those decisions. The order of taxa reflects recent changes in the organization of the AOU check-list (e.g., Chesser et al., 2018). Unless otherwise specified, comments on current bird distributions come from Gaydos and Pearson's (2011) list of bird species recorded in the Salish Sea, *Birds of Washington: Status and Distribution* (Wahl et al., 2005) and *Marine Birds and Mammals of Puget Sound* (Angell and Balcomb, 1982). Observations about average or relative sizes of birds are from Sibley (2000).

Table 8 lists all of the identified specimens, while Table 10 is a summary of the minimum number of species present for each taxonomic Order.

Table 10. Minimum number of bird species present in the Čʼíxʷicən assemblage, based on the size and/or morphology of specimens.

Order	Minimum # of Species	Description
Anseriformes	11	2 geese; 2 dabblers; 1 pochard; White-winged Scoter; Surf or Black Scoter; Long-tailed Duck; Bufflehead; Common or Barrow's Goldeneye; Common or Red-breasted Merganser
Podicipediformes	3	Horned or Eared Grebe; Red-necked Grebe; Western or Clark's Grebe
Columbiiformes	1	Pigeon or dove
Gruiformes	2	Virginia Rail or Sora; American Coot
Charadriiformes	9	2 shorebirds; 1 murrelet (likely Marbled); Pigeon Guillemot, Common Murre; 3 gulls; 1 jaeger or kittiwake
Gaviiformes	3	Red-throated Loon; Pacific Loon; Common Loon
Procellariiformes	5	2 albatross; Northern Fulmar; Sooty-type Shearwater; non-Sooty type Shearwater
Suliformes	1	Double-crested Cormorant
Pelecaniformes	2	American White or Brown Pelican; Great Blue Heron
Accipitriformes	1	Bald or Golden Eagle
Coaraciiformes	1	Belted Kingfisher (identified from excluded material— ⅛" S bag from pilot study)
Piciformes	1	1 woodpecker
Passeriformes	3	1 small passerine; Common or Northwestern Crow; Raven
Total	43	

Anseriformes

Anatidae (Ducks, Geese, Swans)

Material: 2 skulls (1 maxillary, 1 quadrate), 2 coracoids, 2 ulnae, 1 carpometacarpus, 1 tibiotarsus, 1 tarsometatarsus: 9 specimens.

Remarks: Most of these specimens were too fragmented to distinguish between a small goose (e.g., *Branta bernicla*) and a large duck (e.g., *Melanitta fusca* or *Anas platyrhynchos*). The maxillary and quadrate should be identifiable with additional work. One specimen was a complete tarsometatarsus of a juvenile (WS-6401.99.02.22); it was clear it was an Anatid, but no further identification was attempted.

cf. Anatidae (Ducks, Geese, Swans)

Material: 1 coracoid, 1 ulna, 1 tibiotarsus: 3 specimens.

Remarks: These three specimens were highly fragmented, but were most similar to a small goose or large duck.

Anserinae (Geese, Swans)

Material: 2 skulls (1 pterygoid, 1 quadrate), 1 pelvis, 1 synsacra, 1 sternum, 3 furculae, 4 coracoids, 2 scapulae, 4 humeri, 4 radii, 2 ulnae, 6 carpals (3 cuneiforms, 3 scapholunars), 2 carpometacarpi, 4 second wing digits (3 first phalanges, 1 second phalanx), 1 pollex, 4 tibiotarsii, 2 tarsometatarsii: 43 specimens.

Remarks: There are six species of geese and two native swans present in the Salish Sea. They are, in approximate order of size, from largest to smallest: Trumpeter Swan (*Cygnus buccinator*), Tundra Swan (*Cygnus columbianus*), Canada Goose (*Branta canadensis*), Snow Goose (*Anser* [=*Chen*] *caerulescens*), Greater White-fronted Goose (*Anser albifrons*), Emperor Goose (*Anser* [=*Chen*] *canagicus*), Cackling Goose (*Branta hutchinsii*), Brant (*Branta bernicla*), and Ross' Goose (*Anser* [=*Chen*] *rossii)*. Note that three of these species were formerly in the genus *Chen*, but were recently moved to *Anser* (Chesser et al., 2017).

Many of these specimens were similar in size to, or a bit smaller than, a Canada Goose comparative specimen (347645) at Harvard. At least one specimen (a distal radius, WS-16156.99.04.22) was similar in size to a Brant. Most geese skeletal elements, aside from the skulls, mandibles, furculae and sterna, are notoriously difficult to identify even to genus on the basis of morphology, although very large specimens are often identified as Canada Goose (Broughton, 2004; Livezy, 1996; Woolfenden, 1961). In addition, almost all of the Čǐxʷicən specimens were quite fragmented, aside from one complete carpometacarpus (A4-468.01.03) and a few relatively complete proximal or distal limb bones. With additional work, the skull, sternum and/or furculum fragments might be identifiable to genus.

cf. Anserinae (Geese, Swans)

Material: 2 coracoids, 1 scapula, 1 ulna, 1 carpal (scapholunar), 1 tibiotarsus: 6 specimens.

Remarks: All of these specimens were quite fragmented, but were more similar to geese than other families.

Anatinae (True Ducks)

Material: 54 skulls (5 premaxillae, 2 palatines, 9 frontals, 4 pterygoids, 3 basipterygoids, 6 occipitals, 24 quadrates, 1 vomer), 30 mandibles, 2 hyoids, 21 pelvises, 15 synsacra, 33 sternum, 24 furculae, 71 coracoids, 21 scapulae, 95 humeri, 53 radii, 67 ulnae, 28 carpals (11 cuneiforms, 17 scapholunars), 39 carpometacarpi, 39 second wing digits (25 first phalanges, 14 second phalanges), 2 third wing digits, 9 pollices, 25 femora, 52 tibiotarsii, 6 fibulae, 29 tarsometatarsii: 715 specimens.

Remarks: At least 28 species of ducks are found in the Salish Sea (Gaydos and Pearson, 2011). These ducks are divided into four tribes: Anatini (dabbling ducks- 9 species), Aythyini (bay ducks/pochards—6 species), Mergini (sea ducks- 12 species), and Oxyurini (Ruddy Duck- 1 species). In addition, the Wood Duck (*Aix sponsa*), a dabbling duck, is found in freshwater ponds and lakes in the region. Most duck elements, if complete enough, can be identified at least to tribe or genus (Oates et al., 2003; Woolfenden, 1961), although I have never attempted to identify carpals, wing digits or pollices beyond the family level, and duck pelves are also difficult to differentiate taxonomically when fragmented (Woolfenden, 1961:87).

I only had time to identify a small sample of the ducks. I systematically attempted to identify the ducks from the pilot study, including all elements except pelves/synsacra, furculae, carpals, wing digits, pollices, and any specimens that were quite fragmented. Therefore the pilot study data gives an idea of the kinds of ducks present at the site (Table 11), although this is obviously limited in spatial extent (A4, Units 17- 20). In addition, as discussed above, I received some pilot study transfers at a later date, so no attempt was made to identify a small proportion (about 2%) of specimens more specifically. In total, 39% (160/415) of the duck specimens from the pilot study were identified beyond the family level. Of these, 5% were dabblers (n=8), 11% were bay ducks/pochards (17), and 84% were sea ducks (135).

Table 11. Ducks identified from A4 Units 17-20 (‘pilot study’).

Taxon	Common Name	N
Anatinae[1]	True ducks (unidentified)	204
cf. Anatinae	True ducks (unidentified)	41
Anatinae-small	Duck, small-sized (unidentified)	10
Anatini	Surface-feeding duck (dabbler)	8
Aythya spp.	Pochards and allies	16
cf. *Aythya* spp.	Pochards and allies	1
Mergini	Sea ducks and Mergansers	50
Melanitta spp.	Scoter	46
cf. *Melanitta* spp.	Scoter	3
Melanitta fusca	White-winged Scoter	1
Bucephala albeola	Bufflehead	26
Bucephala spp.- large	Common or Barrow’s Goldeneye	1
Mergus spp.	Common or Red-breasted Merganser	8
Total		415

[1] A small number of transferred specimens (≈8) were received after the ducks were identified; a few of these might be identified more specifically with additional work.

To increase the sample size of identified ducks, I also identified additional complete or particularly diagnostic elements from other units in A4 (n=37), A18 (n=2), and BX1 (n=2). The species recovered from this additional analysis were all the same as the pilot study, with the exception of one additional species, the Long-tailed Duck (*Clangula hyemalis*), which was recovered elsewhere in A4 (Unit 23). In total, 201 specimens were identified more specifically than Anatinae. Although not systematically identified beyond sub-family, most of the ducks from the other areas and units appeared similar to sea ducks, which were the most abundant ducks in the pilot study. I did make note of small-sized ducks (see below); the medium and large-sized ducks were not systematically coded as such, but there were a variety of sizes present. Many more of the specimens coded as Anatinae could be identified more specifically with additional work.

cf. Anatinae (True Ducks)

Material: 7 skulls (1 premaxilla, 1 maxillary, 2 frontals, 3 quadrates), 1 mandible, 8 pelvises, 3 synsacra, 10 sterna, 3 furculae, 5 coracoids, 3 scapulae, 21 humeri, 15 radii, 25 ulnae, 1 carpal (cuneiform), 11 carpometacarpi, 2 second wing digits (1 first phalanx, 1 second phalanx), 1 third wing digit, 2 femora, 19 tibiotarsii, 12 tarsometatarsii: 149 specimens.

Remarks: All of these specimens were quite fragmented, but were more similar to ducks than other families.

Anatinae- small (Duck, small-sized)

Material: 3 skulls (1 frontal, 1 pterygoid, 1 quadrate), 1 mandible, 4 sterna, 1 furculum, 4 coracoids, 4 scapulae, 6 humeri, 12 radii, 9 ulnae, 2 carpals (1 cuneiform, 1 scapholunar), 4 carpometacarpi, 3 second wing digits (first phalanx), 5 femora, 1 tibiotarsus: 59 specimens.

Remarks: These specimens were similar in size to the Bufflehead (*Bucephala albeola*), teals (Green-winged [*Anas crecca*], Blue-winged [*Spatula* discors] or Cinnamon Teal [Spatula *cyanoptera*]), or the Ruddy Duck (*Oxyura jamaicensis*). The Bufflehead was the most common small duck identified from the assemblage (Table 11); Buffleheads are more common in marine habitats than most teals, although the Green-winged Teal is abundant in the Strait (Gaydos and Pearson, 2011). Many of these specimens could be identified more specifically with additional work.

cf. Anatinae- small (Duck, small-sized)

Material: 1 sternum, 1 scapula, 2 ulnae, 1 tibiotarsus: 5 specimens.

Remarks: These highly fragmented specimens were more similar to small ducks than other small birds (e.g. shorebirds, passerines).

Anatini (Surface-feeding Ducks)

Material: 1 coracoid, 1 scapula, 3 humeri, 1 radius, 5 carpometacarpi, 2 tibiotarsii, 1 tarsometatarsus: 14 specimens.

Remarks: Members of the Anatini tribe are surface-feeding or dabbling ducks. The taxonomy of dabbling ducks changed recently (Chesser et al., 2017); the genus *Anas* was split into three, so there are now four genera in this tribe: *Aix*, *Anas, Spatula*, and *Mareca*. Aside from the teals (discussed above), the remaining dabblers in the region are: Wood Duck (*Aix sponsa*), Northern Shoveler (*Spatula clypeata*), Gadwall (*Mareca strepera*), Eurasion Wigeon (*Mareca penelope*), American Wigeon (*Mareca americana*), Mallard (*Anas platyrhynchos*), and the Northern Pintail (*Anas acuta*). Of these, the Northern Pintail, American Wigeon and Mallard are most abundant in the Salish Sea today (Gaydos and Pearson, 2011). One of these specimens, a distal tarsometatarsus (WS-13501.99.04.22) is similar in size to teal, and a few are very large (similar to a Mallard), so at least a few different species are present in the assemblage.

Aythyini (Pochards and Allies)
Aythya spp.

Material: 1 skull (quadrate), 1 coracoid, 4 scapulae, 1 humerus, 3 radii, 4 ulnae, 5 carpometacarpi, 1 tarsometatarsus: 20 specimens.

Remarks: Six species of pochards or bay ducks are present in the Salish Sea. The most abundant and most dependent on marine habitats is the Greater Scaup (*Aythya marila*). The Lesser Scaup (*A. affinis*) and Canvasback (*A. valisineria*) are also fairly common winter visitors. The Redhead (*A. americana*), Ring-necked Duck (*A. collaris*), and Tufted Duck (*A. fuligula*) are much less common today. No attempt was made to distinguish these closely related species.

cf. *Aythya* spp.

Material: 1 coracoid: 1 specimen.

Remarks: This coracoid was relatively complete, but was difficult to distinguish definitively from a large goldeneye (*Bucephala* spp.).

Mergini (Sea ducks and Mergansers)

Material: 2 skulls (quadrate), 1 mandible, 2 sterna, 2 coracoids, 7 scapulae, 3 humeri, 5 radii, 5 ulnae, 2 carpometacarpi, 8 femora, 14 tibiotarsii, 10 tarsometatarsii: 61 specimens.

Remarks: There are a variety of members of the Mergini in the Salish Sea, including the King Eider (*Somateria spectabilis*), Harlequin Duck (*Histrionicus histrionicus),* Surf Scoter (*Melanitta perspicillata*), White-winged Scoter (*M. fusca*), Black Scoter (*Melanitta americana [=nigra*]), Long-tailed Duck (*Clangula hyemalis*), Bufflehead (*Bucephala albeola*), Common Goldeneye (*Bucephala clangula*), Barrow's Goldeneye (*Bucephala islandica*), Hooded Merganser (*Lophodytes cucullatus*), Common Merganser (*Mergus merganser*), and Red-breasted Merganser (*Mergus serrator*). Of these, the Bufflehead is much smaller and can typically be distinguished by size; however, my examination of comparative specimens at the Burke Museum revealed that large male Buffleheads may approach the size of small female Hooded Mergansers (Bovy, 2005:301).

The unidentified Mergini in the Číxʷicən assemblage are a variety of sizes, though the smallest Mergini were typically identified as Bufflehead. Relatively complete Mergini elements, or particularly diagnostic elements, may be identified to genus (Woolfenden, 1961). In my lab I had five comparative specimens from the Burke Museum: Harlequin Duck (48046), White-winged Scoter (40013), Long-tailed Duck (51217), Common Goldeneye (40020), and Common Merganser (36753), as well as two Buffleheads from Mike Etnier (A-105, A-107), which made it possible to identify relatively complete specimens to genus. Of the pilot study specimens identified more specifically than Mergini (Table 11), 59% (n=50) are scoters, 31% Bufflehead (26), 9% (8) mergansers, and 1% goldeneye (1).

Melanitta spp. (Scoter)

Material: 1 mandible, 7 coracoids, 5 scapulae, 10 humeri, 5 radii, 8 ulnae, 10 carpometacarpi, 2 femora, 9 tibiotarsii: 57 specimens.

Remarks: Scoters are one of the most abundant diving birds in the eastern portion of the SJDF, occurring in large rafts; while most common in winter, non-breeders are also present year round (Wahl et al., 1981). Scoters feed on mussels, crustaceans and snails (Vilchis et al., 2015), as well as herring roe, when available (Wahl et al., 1981). Of the three scoters found in the Pacific Northwest, the bones of the Surf Scoter and Black Scoter are generally smaller and more gracile, while those of the White-winged Scoter are larger and more robust. Since I only had access to a White-winged Scoter comparative specimen in my lab, I did not systematically categorize all of the scoter remains by size. I did occasionally record (in the ID Comments section of the database), whether the scoter was likely large or small; the majority of the specimens seemed similar to the White-winged Scoter, but some were clearly smaller in size (similar to the Surf Scoter).

cf. *Melanitta* spp. (Scoter)

Material: 1 scapula, 2 ulnae: 3 specimens.

Remarks: The two ulnae were highly fragmented. The scapula was complete and appeared to be similar to a large scoter, but had a pathology, which made it difficult to identify definitively.

Melanitta fusca (White-winged Scoter)

Material: 1 ulna: 1 specimen.

Remarks: White-winged Scoters are abundant year-round in the SJDF, and prefer to feed on crabs, clams and mussels (Angell and Balcomb, 1982). I was able to identify this specimen (a complete ulna) to species, because complete ulnae of the three scoter species can be easily distinguished. The ulna of the Black Scoter and White-winged Scoter are similar in length, but the Black Scoter has a much narrower shaft. The Surf Scoter ulna is shorter than the other two species and has a relatively wider shaft than the Black Scoter. In addition, the shape of the prominence for the anterior articular ligament differs between the species; it is broad and almost circular in the White-winged Scoter and Surf Scoter, and narrow and elongated in the Black Scoter.

Clangula hyemalis (Long-tailed Duck; formerly Oldsquaw)

Material: 1 carpometacarpus: 1 specimen.

Remarks: Long-tailed Ducks are commonly found among the huge rafts of scoters in the Salish Sea (Lewis and Sharpe, 1987:77). I was able to identify this complete carpometacarpus using criteria in Woolfenden (1961).

Bucephala albeola (Bufflehead)

Material: 3 mandibles, 4 coracoids, 1 scapula, 3 humeri, 2 radii, 3 ulnae, 7 carpometacarpi, 2 femora, 4 tibiotarsii, 3 tarsometatarsii: 32 specimens.

Remarks: These tiny diving ducks are common migrants and winter residents of the shallow bays, lakes and estuaries of the region. Their bones can easily be distinguished from the Common (*Bucephala clangula*) and Barrow's Goldeneye (*B. islandica*) on the basis of their small size, and from other small ducks (teals, Ruddy Duck) due to morphological differences (Woolfenden, 1961). As mentioned above, many of the 'Anatinae- small' specimens, which could be identified more specifically with additional work, may also be Bufflehead.

Bucephala spp.- large (Common or Barrow's Goldeneye)

Material: 1 carpometacarpus: 1 specimen.

Remarks: Of the three species of the genus *Bucephala* in the region, the goldeneyes are distinguished by their significantly large size compared to the Bufflehead. The Common and Barrow's Goldeneye are migrants and winter residents in the region.

Mergus spp. (Common or Red-breasted Merganser)

Material: 1 skull (1 pterygoid), 1 mandible, 1 coracoid, 2 humeri, 1 radii, 1 ulna, 1 carpometacarpus, 1 tibiotarsus, 1 tarsometatarsus: 10 specimens.

Remarks: Both the large Common Merganser (*Mergus merganser*) and smaller Red-breasted Merganser (*M. serrator*) winter in the Salish Sea; the Common Merganser favors deep, clear lakes and rivers, while the Red-breasted Merganser prefers shallow marine habitats. No attempt was made to identify these specimens more specifically. It might be possible to distinguish certain elements (e.g. carpometacarpus) on the basis of size, though there is some overlap between the male Red-breasted and female Common Mergansers (Bovy, 2005:314). These specimens were larger than a Hooded Merganser (*Lophodytes cucullatus*).

Podicipediformes
Podicipedidae (Grebes)

Material: 1 skull (quadrate), 1 synsacrum, 2 coracoids, 1 scapula, 1 carpometacarpus, 2 carpals (1 cuneiform, 1 scapholunar), 2 second wing digits (1 phalanx 1, 1 phalanx 2), 1 tarsometatarsus: 11 specimens.

Remarks: There are three small grebes and three large grebes present in the Salish Sea (see below). I assigned most grebe elements to size class, except for the carpals and second wing digits, but inadvertently forgot to assign size classes to the other 7 specimens listed here.

cf. Podicipedidae (Grebes)

Material: 2 pelvises, 1 synsacrum, 1 sternum, 1 furculum, 1 humerus, 1 radius, 3 ulnae, 1 second wing digit (phalanx 1), 2 tibiotarsii, 1 fibula, 2 tarsometatarsii: 16 specimens.

Remarks: Most of these fragments were highly fragmented and therefore difficult to determine size class.

Podicipedidae- small (Small Grebes)

Material: 1 pelvis, 2 sternae, 3 coracoids, 2 humeri, 1 radius, 6 ulnae, 1 carpometacarpus, 3 femora, 6 tibiotarsii, 2 tarsometatarsii: 27 specimens.

Remarks: Three small grebes, from two different genera, winter in the region: the Pied-billed (*Podilymbus podiceps*), Horned (*Podiceps auritus*) and Eared Grebe (*Podiceps nigricollis*). Of these, the Horned Grebe is the most abundant in the SJDF and most dependent on marine habitats and prey, including demersal fish and crustaceans (Gaydos and Pearson, 2011; Vilchis et al., 2015). These two genera can be distinguished fairly easily for certain elements (e.g. Bocheński, 1994; Broughton, 2004; Howard, 1929). I prioritized identification of relatively complete elements. While many of the specimens identified as 'Podicipedidae- small' were quite fragmented, it may be possible to identify more specimens to genus with additional work.

cf. Podicipedidae- small (Small Grebes)

Material: 1 humerus, 1 carpometacarpus, 1 tarsometatarsus: 3 specimens.

Remarks: All three of these specimens were quite fragmented.

Podicipedidae- large (Large Grebes)

Material: 4 skulls (quadrates), 3 pelvises, 3 synsacra, 2 sterna, 4 furculae, 14 coracoids, 2 scapulae, 13 humeri, 5 radii, 10 ulnae, 4 carpometacarpi, 10 femora, 2 patellae, 32 tibiotarsii, 6 fibula, 15 tarsometatarsii: 129 specimens.

Remarks: The majority of the grebe specimens in the assemblage were relatively large. There are three large grebes, from two different genera, in the Salish Sea today: the Red-necked (*Podiceps grisegena*), Western (*Aechmophorus occidentalis*) and Clark's Grebe (*A. clarkii*). All of these piscivorous diving birds are most common in winter.

The Harvard collections had only a few incomplete skeletons of *P. grisegena* (341015, 340624) available and one specimen of the Great Grebe (*Aechmophorus major*), which was collected in Brazil. I also had one *A. grisegena* specimen checked out from the Burke Museum (28714). Although I had limited comparative specimens, I was able to distinguish about 18% of the larger specimens to genus using criteria in Bocheński (1994), Broughton (2004), and Howard (1929). I prioritized my analysis on less fragmented specimens of the most diagnostic elements: mandible, coracoid, scapula, humerus, carpometacarpus, femur, tibiotarsus and tarsometatarsus. The specimens coded as 'Podicipedidae-large' or 'cf. Podicipedidae- large' tended to be quite fragmented (e.g. mid-shafts of long bones) or from less diagnostic elements or parts of elements (e.g. distal tibiotarsus, distal humerus).

Interestingly, I identified two grebe patellae from this assemblage (Fig. 3). I had not identified a grebe patella before, and was initially not certain of the element.

Fig. 3. Grebe patellae. Courtesy of the Washington Dept. of Transportation, catalog numbers WS-4831.99.04.22 and WS-9320.99.04.22 (Photograph by Kris Bovy).

cf. Podicipedidae- large (Large Grebes)

Material: 1 skull (occipital), 1 pelvis, 1 radius, 3 ulnae, 1 carpal (cuneiform), 1 femur, 6 tibiotarsus, 2 tarsometatarsii: 16 specimens.

Remarks: Many of these specimens were quite fragmented (e.g. 2 trochlea for digit 3 on the tarsometatarsus), or difficult to distinguish from other diving birds (e.g., loons, cormorants).

Podiceps spp.- small (Horned or Eared Grebe)

Material: 2 coracoids, 1 scapula, 3 femora: 6 specimens.

Remarks: I was able to identify all six of these relatively complete elements as *Podiceps* using criteria in Bocheński (1994), Broughton (2004), and Howard (1929). The larger Horned Grebe is more common in the Salish Sea than the Eared Grebe today (Gaydos and Pearson, 2011); both are more common in winter months than summer. Harvard did not have any Eared Grebe skeletons, although I was able to borrow one specimen from Mike Etnier. With such limited comparative specimens, I did not attempt to distinguish Horned vs. Eared Grebes.

Podiceps grisegena (Red-necked Grebe)

Material: 2 mandibles, 4 coracoids, 5 scapulae, 4 humeri, 3 carpometacarpi, 3 femora, 1 tibiotarsus, 5 tarsometatarsii: 27 specimens.

Remarks: The majority of the large grebes that could be identified to genus were Red-necked Grebes. The Red-necked Grebe is a common migrant and winter visitor in Washington. These diving birds prey on forage and demersal fish (Vilchis et al., 2015), and favor nearshore habitats, including kelp and eelgrass beds (Wahl et al., 2005).

Aechmophorus spp. (Western or Clark's Grebe)

Material: 2 scapulae, 1 humerus: 3 specimens.

Remarks: The Western and Clark's grebes were formerly considered to be conspecific, but are now listed as two distinct species given that they rarely interbreed (AOU, 1998). I made no attempt to distinguish them on the basis of morphology. These four specimens are likely Western Grebes, however, given that Clark's Grebes are quite rare west of the Cascades. Since the Western Grebe is a non-breeder in the Salish Sea, they have been known to over-winter elsewhere if conditions are not favorable (e.g., lack of available forage fish); for example, there was an estimated 95% decrease in Western Grebes in the SJDF in recent decades (1975-2010), but a 300% increase in the California Current during this same period (Vilchis et al., 2015; Wilson et al., 2013).

cf. *Aechmophorus* spp. (Western or Clark's Grebe)

Material: 1 tarsometatarsus: 1 specimen.

Columbiformes
Columbidae (Pigeons and Doves)

Material: 1 second wing digit (phalanx 1): 1 specimen

Remarks: Both the Band-tailed Pigeon (*Patagioenas fasciata*) and smaller Mourning Dove (*Zenaida macroura*) are present in the Olympic Peninsula. In addition, there are some reports that the now-extinct Passenger Pigeon (*Ectopistes migratorius*) formerly occurred in the state (see Wahl et al., 2005:368). With access to more specimens, this wing digit may be identifiable, on the basis of size and/or morphology.

Gruiformes
Rallidae (Rails, Coots)
Rallidae- small (Virginia Rail or Sora)

Material: 1 tarsometatarsus: 1 specimen.

Remarks: There are two small members of the Rallidae in the region: the Virginia Rail (*Rallus limicola*) and Sora (*Porzana carolina*). At Harvard, I was able to view one Virginia Rail (343237) and one Sora

(344055). This complete tarsometarsus was similar in morphology to the Virginia Rail, and was larger than both comparative specimens. I have conservatively identified this specimen as Rallidae-small, as I was not able to examine multiple comparative specimens of each species.

Fulica americana (American Coot)

Material: 1 ulna: 1 specimen.

Remarks: The American Coot (*Fulica americana*) is a year-round resident in the Port Angeles area, and is easily distinguished from other Gruiformes on the basis of size. This complete ulna was similar in size and morphology to a comparative specimen at Harvard (341381); it was larger than the specimen I had checked out from the Burke (36750).

Charadriiformes

Charadriiformes- small (Shorebirds)

Material: 2 pelvises, 1 scapula, 1 humerus, 4 ulnae, 5 carpometacarpi, 2 second wing digits (first phalanx), 2 pollices, 3 femora, 4 tibiotarsus, 2 tarsometatarsus: 26 specimens.

Remarks: Charadriiformes is a large order, with at least 75 species recorded in the Salish Sea (Gaydos and Pearson, 2011). Specimens that were not identified beyond the order level were assigned to size class. Most of the small Charadriiformes specimens are likely shorebirds (e.g., Scolopacidae, Charadriidae), but a few fragments were difficult to distinguish from a tern, very small gull, or small alcid. Scolopacidae (sandpipers) is a huge family with thirty-two species recorded in the Salish Sea; these include the following subfamilies: Numeniinae (Curlews, 1 genera, 2 species), Limosinae (Godwits, 1 genera, 3 species), Arenariinae (Turnstones and Calidridine Sandpipers, 2 genera, 15 species), Scolpacinae (Dowitchers and Snipe, 2 genera, 3 species), Tringinae (Tringine Sandpipipers and Phalaropes, 3 genera, 9 species). In addition to Scolopacidae, five species of plovers (from two genera, Family Charadriidae) are also present in the Salish Sea.

Many of these specimens are whole (or nearly so), including 3 carpometacarpi, 2 ulnae, 1 femur, and 2 tarsometatarsii. These specimens, along with many of the complete proximal or distal ends, would likely be identifiable to family or sub-family with more work.

cf. Charadriiformes- small (Shorebirds)

Material: 1 synsacrum, 1 coracoid, 2 tarsometatarii: 4 specimens.

Remarks: All four of these specimens were most similar to shorebirds than other small birds, such as passerines, but the identification is tentative given the degree of fragmentation.

Charadriiformes- medium

Material: 1 sternum, 1 furculum, 1 scapula, 4 ulnae, 1 carpometacarpus, 1 pollex, 1 femur, 1 tibiotarsus: 11 specimens.

Remarks: Almost all of these specimens were very fragmented and were difficult to distinguish between a small gull, medium-sized alcid or larger shorebird, such as the American Avocet (*Recurvirostra americana*), Whimbrel (*Numenius phaeopus*), or Marbled Godwit (*Limosa fedoa*), which made it difficult to assign to family. There was one complete ulna (A4-363.01.02), which would likely to be identifiable with more work; this ulna appeared to be a larger shorebird, though it was smaller than the Whimbrel I had checked out from the Burke (47757).

Charadriiformes- large

Material: 4 skulls (1 pterygoid, 3 occipitals), 1 pelvis, 2 sterna, 1 scapula, 1 radius, 1 carpometacarpus, 2 second wing digits (first phalanx), 3 tibiotarsii, 1 tarsometatarsus: 16 specimens.

Remarks: Most of these specimens were very fragmented and were difficult to distinguish between larger members of the Charadriiformes, such as gulls, alcids, jaegers, or very large shorebirds, such as the Black Oystercatcher (*Haematopus bachmani*) or Long-billed Curlew (*Numenius americanus*). Some of these specimens were relatively complete, including a whole pterygoid (WS-14677.99.08.22), radius (A4-163.01.01), carpometacarpus (A4-468.01.03), and two second wing digits (WS-13246.99.04.22, WS-8819.99.04.22); these five specimens along with a proximal tarsometatarsus (WS-8727.99.04.22) would likely be identifiable with more work. For example, the carpometacarpus was similar to a gull, but the shaft was wider and stouter than a gull; both jaegers (*Stercorarius* spp.) and the Black-legged Kittiwake (*Rissa tridactyla*) have wider/stouter shafts (according to my previous observations), so these taxa could be checked for a match.

Alcidae (Auks, Murres and Puffins)

Material: 2 coracoids, 1 humerus, 1 radius, 2 carpometacarpi: 6 specimens.

Remarks: While most of the Alcids were assigned to size class (see below), these specimens were extremely fragmented, making it difficult to accurately assign a size designation.

cf. Alcidae (Auks, Murres and Puffins)

Material: 1 skull (quadrate), 1 pelvis, 1 radius: 3 specimens.

Alcidae- small (Alcid, small-sized)

Material: 3 mandibles, 1 synsacra, 5 sterna, 7 coracoids, 3 scapulae, 16 humeri, 4 radii, 20 ulnae, 3 carpometacarpi, 1 second wing digit (first phalanx), 3 tibiotarsii, 1 tarsometatarsii: 67 specimens.

Remarks: The small-bodied alcids present in the Salish Sea include the rare Long-billed Murrelet (*Brachyramphus perdix*), and more common Marbled Murrelet (*Brachyramphus marmoratus*), Ancient Murrelet (*Synthliboramphus antiquus*), and Cassin's Auklet (*Ptychoramphus aleuticus*). In addition, four other species are 'very rare' or 'casual' in the region, including Kittlitz's Murrelet (*Brachyramphus brevirostris*), Xantus' Murrelet (*Synthliboramphus hypoleucus*), Parakeet Auklet (*Aethia psittacula*) and Whiskered Auklet (*Aethia pygmaea*); there is a single record in Washington for both the Kittlitz Murrelet and Whiskered Auklet (Wahl et al., 2005).

The bones of the Marbled Murrelet, Ancient Murrelet and Cassin's Auklet can be distinguished based on morphology. I had a Cassin's Auklet specimen (06:02:04) in my lab on loan from Diane Hanson at the University of Alaska, but Harvard unfortunately did not have any *Brachyramphus* or *Synthliboramphus* specimens. None of the specimens coded as Alcidae- small compared favorably to the Cassin's Auklet specimen; for example, the humerus shaft of the Cassin's Auklet is relatively narrower than either the Marbled or Ancient Murrelet, but the archaeological specimens had wider/stouter shafts. I identified one complete humerus as *Brachyramphus* using notes and drawings I had made previously while working on my dissertation at the Burke Museum. However, since I was not able to directly compare the archaeological specimens with comparative specimens of the Marbled and Ancient Murrelet, I did not identify the others beyond Alcidae- small. Most of these specimens should be identifiable with additional work.

Alcidae- medium (Alcid, medium-sized)

Material: 1 skull (quadrate), 8 sterna, 4 furculae, 7 coracoids, 2 scapulae, 6 humeri, 7 radii, 2 ulnae, 4 carpals (2 cuneiform, 2 scapholunars), 2 carpometacarpi, 1 second digit (second phalanx), 2 pollices, 1 tarsometatarsus: 47 specimens.

Remarks: Of the medium-sized alcids found in the Salish Sea, both the Pigeon Guillemot (*Cepphus columba*) and Rhinoceros Auklet (*Cerorhinca monocerata*) are abundant year-round residents. In contrast, the Horned Puffin (*Fratercula corniculata*), a pelagic species, is only rarely observed this far south.

I borrowed a Pigeon Guillemot (00:02:06), juvenile Rhinoceros Auklet (03:01:02), and two Horned Puffins (04:03:01, 1 unlabeled) from Diane Hanson. Some of these archaeological specimens were similar to the Pigeon Guillemot in terms of both size and morphology. However, many of the specimens coded as 'Alcidae- medium' were similar in size to the Pigeon Guillemot, but appeared more similar to the Common Murre (*Uria aalge*) in terms of morphology. The Common Murre I was using in my lab (Burke 44844), was the largest specimen (out of 14) that I previously measured for my dissertation research (Bovy, 2005:391). It is likely that some of these 'Alcidae- medium' specimens are small individuals of the Common Murre, which seemed especially small given my large comparative specimen, and were hence sorted into the medium, rather than large, category. Additional comparative specimens, including both males and females, of all possible species could help to identify some of these specimens. None of the archaeological specimens seemed more similar to the Rhinoceros Auklet or Horned Puffin. Other fragments coded as Alcidae- medium were highly fragmented and likely only identifiable to family.

cf. Alcidae- medium (Alcid, medium-sized)

Material: 1 ulna, 1 femur: 2 specimens.

Alcidae- large (Alcid, large-sized)

Material: 34 skulls (1 nearly complete, 1 maxillary, 7 frontal, 4 occipital, 19 quadrates, 1 basipterygoid, 1 basitemporal plate), 31 mandibles, 5 pelvises, 11 synsacra, 30 sterna, 26 furculae, 62 coracoids, 19 scapulae, 118 humeri, 60 radii, 139 ulnae, 35 carpals (18 cuneiforms, 17 scapholunars), 45 carpometacarpi, 33 second wing digits (16 first phalanges, 17 second phalanges), 16 pollices, 23 femora, 30 tibiotarsii, 4 fibulae, 11 tarsometatarsii: 732 specimens.

Remarks: Three species of alcids fit into my 'Alcidae-large' grouping. The Common Murre (*Uria aalge*) is common in the Salish Sea year round (Gaydos and Pearson, 2011), but there is a "spectacular influx" in the fall, when they leave their breeding grounds on the outer Pacific coast and enter the Strait of Juan de Fuca (Wahl et al., 1981:7). The Thick-billed Murre (*Uria lomvia*) has a more northerly distribution than the Common Murre. Wahl et al. (2005:197) lists the Thick-billed Murre as a very rare visitor in inland marine waters in the state, but the species is not included on Gaydos and Peason's (2011) list of birds found in the Salish Sea. The third large alcid is the Tufted Puffin (*Fratercula cirrhata*), which is most frequent in the Salish Sea in summer months; Tufted Puffin populations have declined steadily in the last century (Wahl et al., 2005).

The skeletal elements of murres are usually quite distinct from those of the Tufted Puffin, unless highly fragmented. The only element I had difficulty distinguishing was the ulna, especially when fragmented (but see Bovy 2005:361 for a list of morphological differences in the ulna). In addition, the bones of murres are generally larger than those of the Tufted Puffin, but some overlap in size may occur. In my lab I had a Common Murre (44844) and Tufted Puffin (33415) from the Burke, and a second Tufted Puffin (06:02:06) from Diane Hanson.

As discussed above, my procedure for identifying the bird remains was to first sort the specimens to Order and/or Family, and then go back through and focus on a given taxa more specifically. Therefore, I initially sorted specimens as 'Alcidae- large,' using a Common Murre specimen for comparison, and then systematically looked at these specimens again, using notes and additional comparative specimens to make more specific identifications, when possible. I completed this procedure for the A4 pilot study and all other areas, but did not have a chance to go back to the 'Alcidae- large' specimens in Area A4, units 1-16 and 21- 40, to make more specific identifications on the 552 Alcidae- large specimens from these units, beyond pulling one complete radius (see below).

Therefore, specimens in the 'Alcidae- large' category are either relatively small fragments from the entire site that could not be assigned to genus, or were more complete specimens from the non-pilot study units in A4, for which no further identification was attempted. The latter are all likely *Uria* spp., given that I did not identify any specimens as *Fratercula cirrhata* from any other areas of the site, and I would likely have flagged any specimen that looked unusual during the initial pass. Therefore, I think the Alcidae- large, cf. Alcidae- large, *Uria* spp. and cf. *Uria* spp. can all be combined for analytic purposes. Many of these specimens from the non-pilot A4 units could be identified more specifically with additional work.

cf. Alcidae- large (Alcid, large-sized)

Material: 4 skulls (1 premaxilla, 1 frontal, 2 quadrates), 7 mandibles, 2 pelvises, 4 synsacra, 10 sterna, 2 furculae, 4 coracoids, 2 scapulae, 15 humeri, 14 radii, 17 ulnae, 5 carpals (4 cuneiforms, 1 scapholunar), 14 carpometacarpi, 2 second wing digits (first phalanx), 1 third wing digit, 6 femora, 6 tibiotarsii, 3 fibulae, 1 tarsometatarsus: 119 specimens.

Remarks: The 'cf. Alcidae- large' specimens are highly fragmented and challenging to identify on their own merit, but are likely fragments of large Alcids (murres), given their abundance at the site.

Uria spp. (Common or Thick-billed Murre)

Material: 55 skulls (1 maxillary, 16 frontal, 2 premaxilla, 1 temporal, 5 occipitals, 28 quadrates, 2 vomers), 39 mandibles, 6 pelvises, 5 synsacra, 27 sterna, 23 furculae, 56 coracoids, 37 scapulae, 145 humeri, 36 radii, 61 ulnae, 5 carpals (2 cuneiforms, 3 scapholunars), 56 carpometacarpi, 26 second wing digits (24 first phalanges, 2 second phalanges), 39 femora, 35 tibiotarsii, 1 fibula, 22 tarsometatarsii: 674 specimens.

Remarks: As discussed above, I systematically compared all of the large alcids to both Common Murre and Tufted Puffin for all areas and units, except Area A4, units 1-16, and 21-40. All of the specimens that could be identified to genus are murres, rather than puffins. Common Murres are the most abundant wintering bird in the SJDF; they occur in small flocks, moving daily between nearshore foraging and offshore roosting areas (Wahl et al., 1981). They feed primarily on small fishes, such as sandlances, herring and smelt (Angell and Balcomb, 1982).

cf. *Uria* spp. (Common or Thick-billed Murre)

Material: 8 skulls (2 premaxilla, 2 frontal, 1 pterygoid, 1 sphenoid, 1 occipital, 1 quadrate), 7 mandibles, 1 pelvis, 1 sternum, 3 furculae, 2 coracoids, 3 scapulae, 10 humeri, 1 ulna, 4 carpometacarpi, 2 femora, 9 tibiotarsii, 1 tarsometatarsus: 52 specimens.

Remarks: The 'cf. *Uria* spp.' specimens are highly fragmented and challenging to identify on their own merit, but are likely fragments of murres, given their abundance at the site.

Uria aalge (Common Murre)

Material: 1 skull (premaxilla), 4 mandibles: 5 specimens.

Remarks: I was able to identify relatively complete mandible and premaxilla fragments to species because the dentary of a Common Murre is noticeably longer than the Thick-billed Murre.

Uria cf. *aalge* (Common Murre)

Material: 6 radii: 6 specimens.

Remarks: I measured complete radii from the pilot study to attempt to identify these to species. For my dissertation research (Bovy, 2005:362), I measured 14 radii of Common Murre (5 female, 9 male) and 16 Thick-billed Murre specimens (5 female, 11 male) available at the Burke Museum. I measured the greatest length (GL) and the breadth of distal end (Bd; see von den Driesch, 1976:118). I found that the radii of the Thick-billed Murre were substantially larger than those of the Common Murre (Bovy, 2005:Fig. A-13a); all of the Thick-billed specimens were greater than 65 mm in length, while all of the Common Murre were less than 65 mm. The six complete radii I measured from Čí̓xʷicən ranged in size from 59.8 to 63.9 mm, all in the range of the Common Murre. This finding makes sense given the range distribution of these two species.

Cepphus columba (Pigeon Guillemot)

Material: 1 scapula, 2 humeri: 3 specimens.

Remarks: Pigeon Guillemots are common residents and breeding birds in the Salish Sea, feeding on small fish in shallow waters and nesting in a variety of habitats (Wahl et al., 1981:59, 2005; Angell and Balcomb, 1982). The 'Alcidae- medium' category may contain additional Pigeon Guillemots, which could be identified with further work.

Brachyramphus spp. (Murrelet)

Material: 1 humerus: 1 specimen.

Remarks: As noted above, the bones of the Marbled Murrelet can be fairly easily distinguished from the synthliboramphine murrelets (e.g., Ancient Murrelet) and similarly- sized auklets (e.g., Cassin's Auklet) on the basis of morphology. The humerus of the Marbled Murrelet has a much wider shaft and the olecranon fossa is only slightly concave, while the olecranon fossa is deeply excavated in Cassin's Auklet and quite shallow in the Ancient Murrelet. This specimen is very likely Marbled Murrelet, versus the Long-billed or Kittlitz's Murrelet, given that the latter two species have more northerly distributions, and are very rare in the strait. A number of the other humeri in the assemblage resembled the Marbled Murrelet, but were not complete, so I conservatively identified them as Alcidae- small. The Marbled Murrelet, which nests in old growth forests along the Pacific coast, has declined due to loss of nesting habitat and is currently listed as 'endangered' in Washington (WDFW, 2019; Wahl et al., 2005).

Laridae (Gulls, Terns, and Skimmers)

Material: 12 skulls (2 premaxilla, 10 quadrates), 4 mandibles, 2 pelvises, 19 sterna, 15 furculae, 45 coracoids, 13 scapulae, 31 humeri, 50 radii, 76 ulnae, 27 carpals (20 cuneiforms, 7 scapholunars), 52 carpometacarpi, 40 second wing digits (31 first phalanges, 9 second phalanges), 1 third digit, 3 pollices, 6 femora, 12 tibiotarsii, 2 fibulae, 5 tarsometatarsii: 415 specimens.

Remarks: The taxonomy of Laridae has changed in recent years (see Banks et al., 2006, 2008); the jaegers and skuas are now in their own family (Stercorariidae), and several species previously in the genus *Larus* are in new genera. Twenty-two members of the Laridae have been identified in the Salish Sea, including 16 gulls from five different genera (*Chroicocephalus* [2 species], *Hydrocoloeus* [1], *Larus* [11], *Leucophaeus* [1], *Xema* [1], five terns from three genera (*Chlidonias* [1], *Hydroprogne* [1], *Sterna* [3]), and the Black-legged Kittiwake (*Rissa tridactyla*). These birds range in size from the tiny Black Tern (*Chlidonias niger*) at 62 g (average weight) to the Glaucuous Gull (*Larus hyperboreus*) at 1400 g (Sibley, 2000). No attempt was made to identify specimens from this complex family more specifically. It is clear that numerous species of Laridae are present in the assemblage, given the variety of sizes of specimens, including a few very small specimens (similar in size to large shorebirds), and a few very large specimens, with most falling somewhere in between.

Note that I did not compare the Laridae specimens with jaegers or skuas—four species of this family (Stercorariidae) have been observed in the Salish Sea, although they are highly pelagic and much less common than many Larids. Given that this family was once part of Laridae (AOU, 1998), the skeletal morphology may be similar, so it is possible a small number of the Laridae specimens could be jaegers.

cf. Laridae (Gulls, Terns, and Skimmers)

Material: 2 skulls (quadrates), 2 pelvises, 2 sterna, 3 furculae, 3 coracoids, 3 scapulae, 3 humeri, 2 radii, 13 ulnae, 3 carpometacarpi, 3 second wing digits (first phalanx), 2 femora, 7 tibiotarsii, 1 fibula, 7 tarsometatarsii: 56 specimens.

Remarks: These specimens were quite fragmented and difficult to distinguish securely from other Charadriiformes.

Gaviiformes
Gaviidae (Loons)
Gavia spp. (Loons)

Material: 2 synsacrae, 2 furculae, 5 humeri, 1 radius, 3 ulnae, 1 second wing digit (phalanx 1), 1 pollex, 2 femora, 1 tibiotarsus: 18 specimens.

Remarks: There are three small loons and two large loons present in the Salish Sea (see below). I assigned almost all the loons specimens as either large or small; those identified as '*Gavia* spp.' or 'cf. *Gavia* spp.' were almost all highly fragmented (e.g. a mid-shaft of a limb bone), which made size classification tenuous.

cf. *Gavia* spp. (Loons)

Material: 1 skull (occipital), 3 mandibles, 1 sternum, 1 furculum, 4 coracoids, 4 humeri, 1 radius, 3 ulnae, 1 second wing digit (phalanx 1), 1 femur, 1 fibula, 3 tarsometatarsii: 24 specimens.

Gavia spp.- small (Small Loons)

Material: 14 skull (1 nearly complete, 2 premaxillae, 1 nasal, 2 palatines, 6 quadrates, 2 occipitals), 12 mandibles, 10 pelvises, 4 synsacra, 4 sterna, 1 furculum, 10 coracoids, 17 scapulae, 19 humeri, 16 radii, 20 ulnae, 10 carpals (1 cuneiform, 9 scapholunars), 25 carpometacarpi, 6 second wing digits (5 phalanx 1, 1 phalanx 2), 3 pollices, 15 femora, 10 tibiotarsii, 2 fibulae, 28 tarsometatarsii: 226 specimens.

Remarks: There are three small loons present in the Salish Sea: the Pacific (*Gavia pacifica*) and Red-throated Loons (*G. stellata),* both of which are fairly common in winter months, and the very rare Arctic Loon (*G. arctica*), which was once classified as conspecific with the Pacific Loon (Wahl et al., 2005). While Harvard had a number of Red-throated Loon specimens (e.g., 337590, 337607), there were no Pacific or Arctic Loons, aside from one skull (341660). However, I did have one Pacific Loon from the Burke (50668). Given the limited comparative specimens, I focused on a very small subset of the most complete specimens and/or the most diagnostic elements for further identification: coracoid, humerus, proximal radius, and tibiotarsus. Most of the specimens coded as '*Gavia* spp.- small' were smaller fragments, although a few were more complete and/or contain potentially diagnostic landmarks) and may be possible to identify with more work. Tentative species identifications are recorded in the ID Comments section of the database for a small number of these specimens.

cf. *Gavia* spp.- small (Small Loons)

Material: 3 skull (1 premaxilla/nasal, 1 quadrate, 1 occipital), 1 mandible, 8 pelvises, 1 synsacrum, 1 sternum, 2 humeri, 4 radii, 2 ulnae, 1 pollex, 1 femur, 4 tibiotarsii, 2 tarsometatarsii: 30 specimens.

Remarks: All of these specimens were quite fragmented and were difficult to distinguish from the bones of other diving birds, such as grebes and cormorants. Fragments of the thick-walled shafts of loon leg and wing bones are especially hard to distinguish.

Gavia spp.- large (Common or Yellow-billed Loon)

Material: 4 skulls (1 frontal, 3 quadrates), 3 mandibles, 1 pelvis, 2 furculae, 6 coracoids, 2 scapulae, 10 humeri, 9 radii, 4 ulnae, 7 carpals (3 cuneiforms, 4 scapholunars), 5 carpometacarpi, 8 second wing digits (6 phalanx 1, 2 phalanx 2), 5 femora, 9 tibiotarsii, 6 tarsometatarsii: 81 specimens.

Remarks: There are two large loons in the Salish Sea: the Common (*Gavia immer*) and Yellow-billed Loon (*G. adamsii*). The Common Loon is a common migrant and winter visitor to nearshore marine environments. The larger Yellow-billed Loon is a rare migrant and year-round visitor, which was not recorded in Washington state prior to the 1960s (Wahl et al., 2005:77). Numerous Common Loon specimens (e.g., 347948, 347957), but no Yellow-billed Loons, were available at Harvard. While only two specimens were coded as the Common Loon, the majority of the large loons are likely Common Loons, given the current distributions of the two species.

cf. *Gavia* spp.- large (Common or Yellow-billed Loon)

Material: 1 coracoid, 1 radius, 2 carpometacarpi, 1 fibula, 1 tarsometatarsus: 6 specimens.

Gavia stellata (Red-throated Loon)

Material: 1 skull (premaxilla), 2 coracoids, 2 scapulae, 4 tibiotarsii: 9 specimens.

Remarks: The Red-throated Loon is smaller and more gracile than the Pacific Loon, and many elements can be distinguished if they are relatively complete or contain diagnostic characteristics. These specimens were identified using criteria in Howard (1929), Boertmann (1990), and Broughton (2004). In addition, the trochlea width (WT) of the carpometacarpus was more similar to *G. stellata* (see Bovy, 2005:384; Fig. A-6a). While both Pacific and Red-throated Loons are divers who pursue forage and demersal fish (Vilchis et al., 2015), Red-throated Loons favor nearshore marine waters, while Pacific Loons are found more often in deeper offshore waters (Angell and Balcomb, 1982; Wahl et al., 2005).

Gavia cf. *stellata* (Red-throated Loon)

Material: 1 humerus, 1 carpometacarpus, 2 tibiotarsii: 4 specimens

Gavia cf. *pacifica (=arctica)* (Pacific Loon)

Material: 8 coracoids, 1 scapula, 9 humeri, 5 radii, 1 ulna, 4 tibiotarsii: 28 specimens.

Remarks: No attempt was to distinguish the Pacific and Arctic Loon on the basis of morphology. However, I identified these specimens as *Gavia* cf. *pacifica*, given that the Arctic Loon is such a rare visitor to the region.

Gavia cf. *immer* (Common Loon)

Material: 1 humerus, 1 carpometacarpus: 2 specimens.

Remarks: There are a few possible differences between the Common and Yellow-billed Loon in terms of morphology and size (Bovy, 2005; Broughton, 2005; Fitzgerald, 1980). However, I did not feel confident trying to distinguish these two species without access to comparative specimens of the Yellow-billed Loon, with two exceptions. One carpometacarpus was tentatively identified on the basis of size (GL=92.3, WT=8.91 mm; see Bovy, 2005:384; Fig. A-6a). Second, a complete humerus was tentatively identified on the basis of size and the fact that the capital groove was deeply excavated. Common Loons spend the night on open water, but feed in both nearshore and open water habitats, favoring both forage and demersal fish, such as sculpins, herring, and flounders (Angell and Balcomb, 1982; Wahl et al., 1981).

Procellariiformes
Diomedeidae (Albatrosses)
Phoebastria spp. (Albatrosses)

Material: 2 skull (1 frontal, 1 quadrate), 2 mandibles, 1 pelvis, 1 synsacrum, 2 sterna, 1 furculum, 4 coracoids, 2 scapulae, 4 humeri, 2 radii, 1 ulna, 1 carpometacarpus, 3 carpals (1 cuneiform, 2 scapholunars), 2 second wing digits (1 phalanx 1, 1 phalanx 2), 2 tibiotarsii: 30 specimens.

Remarks: True pelagic birds, albatross are only rarely seen in the inland waters of Washington. Gaydos and Pearson (2011) list only the Black-footed Albatross (*Phoebastria nigripes*) as occupying the Salish Sea. However, the Short-tailed Albatross (*P. albatrus*) was once much more abundant, and there have been historical sightings and archaeological specimens of this species recorded in the Salish Sea (e.g., Crockford et al., 1997, Miller et al., 1935). The smaller Laysan Albatross (*P. immutabilis*) is also an uncommon winter visitor to the outer coast. Previous researchers have distinguished these three species on the basis of size (Porcasi, 1999) and certain morphological differences (Yesner, 1976). However, I believe that discrimination based on size is challenged by the lack of adequate comparative specimens in museums. I did make notes about the size of some albatross specimens (see ID Comments section of the database), but did not feel I had adequate comparative specimens to systematically group each specimen by size. Harvard did not have any complete specimens of a Short-tailed Albatross. It was apparent, however, that only a few of the specimens were more similar in size to the Laysan Albatross (Harvard 348512); most were significantly larger and likely represent Short-tailed albatross.

cf. *Phoebastria* spp. (Albatrosses)

Material: 1 mandible (dentary), 1 humerus, 2 radii, 1 carpometacarpus: 5 specimens.

Procellariidae (Shearwaters and Petrels)

Material: 11 skulls (1 premaxilla, 2 palatines, 2 occipitals, 1 basipterygoid, 5 quadrates), 1 mandible, 2 pelvises, 2 synsacra, 5 sterna, 1 furculum, 4 coracoids, 7 scapulae, 25 humeri, 14 radii, 21 ulnae, 2 carpals (1 cuneiform, 1 scapholunar), 4 carpometacarpi, 8 second wing digits (6 first phalanges, 2 second phalanges), 1 third wing digit, 3 pollices, 2 femora, 3 tibiotarsii, 1 fibula, 14 tarsometatarsii: 131 specimens.

Remarks: According to Gaydos and Pearson (2011), six species of Procellariids have been recorded in the Salish Sea: the Northern Fulmar (*Fulmarus glacialis*), and Buller's (*Ardenna* [=*Puffinus*] *bulleri*), Short-tailed (*A. tenuirostris*), Sooty (*A. grisea* [=*griseus*]), Pink-footed (*A. creatopus*) and Flesh-footed Shearwater (*A. carneipes*). In addition, Wahl et al. (2005) lists a number of "casual vagrants" or "rare visitors" to the Washington coast, including the Great (*A. gravis*) and Manx Shearwaters (*Puffinus puffinus*) and the Providence (*Pterodroma solandri*), Murphy's (*P. ultima*), Mottled (*P. inexpectata*) and Cook's Petrels (*P. cookii*). Note that most of the shearwaters were recently re-classified from the genus *Puffinus* to *Ardenna* (Chesser et al., 2016).

It is important to note that I did not have a Northern Fulmar specimen in my lab at URI, and so have conservatively identified many specimens as 'Procellariidae' rather than to genus level. However, I did systematically attempt to identify all of the Procellariids from the pilot study (A4, Units 17- 20) to genus level, during trips to the Burke Museum and Harvard. Therefore, the specimens assigned to 'Procellariidae' or 'cf. Procellariidae' fall into three primary categories: 1) small fragments that could not be securely identified beyond the family level, 2) quadrates, distal wing digits and fibulae, which I did not attempt to identify to genus, and 3) non-pilot study specimens that might be identifiable with further work. In addition, there were a small number of relatively complete specimens from the pilot study (including a whole carpometacarpus, A4-440.01.03), which I apparently either forgot to identify (or code) to genus.

It is usually quite easy to distinguish Northern Fulmar bones from those of shearwaters, unless the specimens are highly fragmented. Although only material from the pilot study was systematically identified to genus, most of the specimens from other areas and units were comparable in size and morphology to the Sooty Shearwater specimen I had checked out from the Burke Museum (33231). In some cases, I did make a note in the ID Comments section of the database that a given specimen from the non-pilot material was likely a shearwater. Specimens consulted during the identification process of the pilot study material include: Northern Fulmar (Burke 26373, 28709; Harvard 347654), Sooty Shearwater (Burke 26888, 30364, 33231; Harvard 337110, 344093) and Pink-footed Shearwater (Harvard 346807). See further discussion below on identification of shearwaters.

cf. Procellariidae (Shearwaters and Petrels)

Material: 3 skulls (1 premaxilla, 1 frontal/nasal, 1 occipital), 1 mandible, 3 pelvises, 1 synsacrum, 1 sternum, 1 furculum, 4 coracoids, 2 scapulae, 4 humeri, 3 radii, 4 ulnae, 4 tibiotarsii, 6 tarsometatarsii: 37 specimens.

Fulmarus glacialis (Northern Fulmar)

Material: 1 humerus, 1 tarsometatarsus: 2 specimens.

Remarks: The Northern Fulmar is highly pelagic, and only rarely seen in inland waters. In Washington, they are most common along the outer coast in winter months (Angell and Balcomb, 1982). At least two specimens were confidently identified as Northern Fulmar: a complete humerus from the pilot study (WS-8252.99.01.22) and a complete tarsometatarsus (WS-12016.99.02.22) from Area A3. This latter specimen is the one exception from my statement above that only pilot study material was assigned to genus.

Ardenna (=Puffinus) spp. (Shearwaters)

Material: 3 skulls (1 maxillary, 1 premaxilla, 1 pterygoid), 5 mandibles, 4 pelvises, 4 synsacra, 1 sternum, 3 furculae, 9 coracoids, 8 scapulae, 17 humeri, 6 radii, 11 ulnae, 3 carpometacarpi, 4 femora, 5 tibiotarsii, 12 tarsometatarsii: 95 specimens.

Remarks: Shearwaters are highly pelagic, but may be found in the deeper parts of the Strait of Juan de Fuca; of the shearwaters regularly found in the Salish Sea (see above), the Sooty Shearwater is by far the most abundant, especially during the summer and early fall (Angell and Balcomb, 1984; Gaydos and Pearson, 2011; Wahl et al., 2005). The Sooty Shearwater is a long-distance trans-equatorial migrant, breeding in New Zealand and Chile in the winter months, and migrating along the Washington coast from July to October (Spear and Ainley, 1999).

Shearwaters can be divided into subgroups on the basis of the flying and aquatic habitats (Kuroda, 1954). Buller's, Pink-footed and Flesh-footed shearwaters are all good gliders with a moderate ability to swim and dive, while Sooty, Short-tailed and Manx Shearwaters are fluttering flyers (short gliders) and have good diving and swimming abilities. These behavioral differences are correlated with osteological differences between the subgroups; for example, the humerus of the latter "sooty type" is "short, thick and is flattened for adaptation for underwater use" (Kuroda, 1954:84), while the humerus of the former group is relatively longer and less flattened. The three species in the sooty type also vary by size, with the Sooty Shearwater the largest (avg. 780 g), the Manx Shearwater the smallest (450 g), and the Short-tailed intermediate (550 g; Kuroda, 1954; Sibley, 2000).

On the basis of morphology and size, the vast majority of the shearwaters at Čí̓xʷicən are likely Sooty Shearwaters. However, I have conservatively identified the pilot study specimens to *Ardenna* spp., given that there may be some size overlap between the Sooty and Short-tailed Shearwaters (Bovy, 2005:328-9). There were at least five specimens in the assemblage that were noticeably different than the Sooty Shearwater and more closely resembled the non-sooty type (Buller's, Pink-footed or Flesh-footed Shearwater). One tibiotarsus shaft from the pilot study, coded as 'cf. *Ardenna* spp.' (WS-9404.99.02.22), was more similar to the non-sooty type, as were a complete humerus (A4-216.01.03), a proximal humerus shaft (A4-216.01.03), a complete ulna (WS-13820.99.02.22) and an ulna shaft (WS-19990.02.22) from three other units in area A4 (all coded as 'Procellariidae,' since the non-pilot material was not systematically analyzed to genus). These five specimens were similar in size and morphology to a Pink-footed Shearwater specimen at Harvard (346807). More careful analyses, including morphological observations and measurements of the shearwater specimens from the Čḯxʷicən assemblage, could result in more definitive species level identifications.

cf. *Ardenna (=Puffinus)* spp. (Shearwaters)

Material: 1 humerus, 1 ulna, 1 tibiotarsus: 3 specimens.

Suliformes
Phalacrocoracidae (Cormorants)
Phalacrocorax spp. (Cormorants)

Material: 1 skull (quadrate), 1 mandible (articular), 1 sternum, 1 furculum, 4 coracoids, 2 scapulae, 2 humeri, 1 radius, 5 ulnae, 1 carpal (cuneiform), 1 second wing digit (phalanx 1), 1 femur, 2 fibulae, 1 tarsometatarsus: 24 specimens.

Remarks: There are three species of cormorants commonly found in the Salish Sea: the Double-crested (*Phalacrocorax auritus*) and Pelagic Cormorants (*P. pelagicus*), both of which are found year-round, and Brandt's Cormorant (*P. penicillatus*), a summer visitor. These three cormorants can typically be distinguished using size and morphology (Bovy, 2005:336-7; Broughton, 2004; Howard, 1929; Ono, 1980; Siegel-Causey, 1998). While I did attempt to get more specific identifications while at Harvard, my success was hindered by the fact that the archaeological specimens were highly fragmented. Interestingly, 39% of all the cormorants (13/33) were originally mis-sorted as mammal (n=11) or shell (n= 2 calcined fragments).

cf. *Phalacrocorax* spp.

Material: 1 sternum, 2 synsacra, 1 ulna, 1 second wing digit (phalanx 1), 1 third wing digit, 1 femur: 7 specimens.

Phalacrocorax cf. *auritus* (Double-crested Cormorant)

Material: 2 tarsometatarsii: 2 specimens.

Remarks: The two specimens (both tarsometatarsii) that I was confident identifying to species were Double-crested Cormorants. Double-crested Cormorants breed in the Salish Sea and feed on forage and demersal fish (Vilchis et al., 2015).

Pelecaniformes

Pelecanidae (Pelicans)

Pelecanus spp. (American White or Brown Pelican)

Material: 2 ulna, 1 carpal (cuneiform): 3 specimens.

Remarks: Both the American White (*Pelecanus erythrorhynchos*) and Brown Pelican (*Pelecanus occidentalis*) are present in the Salish Sea (Gaydos and Pearson, 2011). *P. occidentalis* is smaller on average than *P. erythrorhynchos*, and archaeological specimens have been distinguished based on size (Broughton, 2004; Howard, 1929)*;* however, I previously noted size overlap between the wing elements of male *P. occidentalis* and female *P. erythrorhynchos* specimens available at the Burke Museum (Bovy, 2005:332). Broughton (2004:15) does list morphological criteria for distinguishing ulna, so it may be possible to identify these two specimens using these criteria and additional comparative specimens. Specimen WS-11001.99.01.22 is a proximal left ulna that had been grooved and snapped at the broken shaft for tool or ornament production (see Sec. 5.2.1). This specimen was larger than a male *P. occidentalis* skeleton available at Harvard (336969).

Ardeidae (Herons, Bitterns)

Ardea herodias (Great Blue Heron)

Material: 2 furculae, 2 carpometacarpi, 2 tibiotarsii, 1 tarsometatarsus: 7 specimens.

Remarks: The Great Blue Heron (*Ardea herodias*) is a common year-round resident in the Salish Sea, found along marine shorelines and estuaries. They can be easily distinguished from other herons and bitterns on the basis of their large size.

cf. *Ardea herodias* (Great Blue Heron)

Material: 1 humerus, 1 tarsometatarsus: 2 specimens.

Remarks: Both of these specimens were highly fragmented, which made a definitive identification difficult. However, both were more similar to the Great Blue Heron specimen at Harvard (347038) than other large birds I checked, including *Pelecanus occidentalis* (33969), *Haliaeetus leucocephalus* (343519), *Grus candadensis* (347482), *Cygnus columbianus* (343048), *Branta canadensis* (347645), and *Phoebastria immutabilis* (348512).

Accipitriformes

Accipitridae (Hawks, Kites, Eagles and Allies)
Accipitridae- large (Bald or Golden Eagle)

Material: 1 ulna, 1 second wing digit (phalanx 1): 2 specimens.

Remarks: There are two eagles in the Pacific Northwest: the Bald (*Haliaeetus leucocephalus)* and Golden Eagle *(Aquila chrysaetos)*. Only the Bald Eagle is listed as inhabiting the Salish Sea today (Gaydos and Pearson, 2011). Golden Eagles favor mountainous, rather than coastal, regions, but are fairly common in the nearby San Juan Islands (Lewis and Sharpe, 1987; Wahl et al., 2005). These two fragmented specimens are most likely Bald Eagles, but were conservatively identified as 'Accipitridae-large,' since no attempt was made to distinguish them based on morphology. Definitive identifications may be possible with additional work (Bovy, 2005:340).

cf. Accipitridae- large (Bald or Golden Eagle)

Material: 1 skull (quadrate): 1 specimen.

Remarks: This quadrate was similar in size to Bald Eagle, but lack of comparative specimens made a definitive identification difficult.

Piciformes
Picidae (Woodpeckers and Allies)

Material: 1 ulna: 1 specimen.

Remarks: While a number of woodpeckers are occasional visitors to the Olympic Peninsula, there are five more common year-round residents: Red-breasted Sapsucker (*Sphyrapicus ruber*), Downy Woodpecker (*Dryobates [=Picoides] pubescens*), Hairy Woodpecker (*Dryobates [=Picoides] villosus*), Northern Flicker (*Colaptes auratus*), and Pileated Woodpecker (*Dryocopus pileatus*) (Wahl et al., 2005). No attempt was made to identify this complete ulna beyond the Family level, though a more specific identification is likely possible with additional work.

Passeriformes (Perching Birds)

Material: 1 mandible, 2 radii, 1 carpometacarpus, 1 pelvis, 1 synsacrum, 1 femur, 2 tibiotarsii, 3 tarsometatarsii: 12 specimens.

Remarks: These 12 specimens are either small passerines or highly fragmented. I made no attempt to identify small passerine specimens. Some of these are complete elements (1 carpometacarpus, 1 tibiotarsus, 2 tarsometatarsii) and might be identified with further work.

Corvidae (Jays, Magpies, Crows)
Corvus spp.- small

Material: 1 radius, 1 pelvis, 1 femur, 1 tibiotarsus, 2 tarsometatarsi: 6 specimens.

Remarks: Crows can be distinguished from all other passerines in the region based on their larger size. Gaydos and Pearson (2011) recognize two species of crows in the Salish Sea: Common Crow *(Corvus brachyrynchos*) and the slightly smaller, more coastally oriented Northwestern Crow *(Corvus caurinus*). No attempt was made to distinguish the two species, given the disagreement about whether the two are truly distinct species or sub-species (Wahl et al., 2005).

Corvus corax (Common Raven)

Material: 1 tarsometatarsus: 1 specimen.

Remarks: Ravens are abundant in Washington state; although generally more common at high elevations, they do use coastal beaches and are found in great numbers in the nearby San Juan Islands (Lewis and Sharpe, 1987; Wahl et al., 2005). This Raven tibiotarsus shaft (WS-11706.99.02.22) was worked (polished with abrasion scratches).

Aves (Unidentified Bird)

Material: 173 skulls (2 maxillary, 12 premaxilla, 34 frontal, 2 interorbital septums, 2 sphenoids, 4 palatines, 6 pterygoids, 1 jugal, 1 vomer, 9 parietals, 2 temporals, 46 occipitals, 17 quadrates, 35 indeterminate), 27 mandibles, 2 hyoids, 26 tracheal rings, 66 pelves, 84 synsacra, 4 pygostyles, 1643 vertebrae, 194 ribs, 191 sternae, 66 furculae, 61 coracoids, 68 scapulae, 161 humeri, 146 radii, 177 ulnae, 106 carpometacarpi, 9 carpals (2 cuneiforms, 7 scapholunars), 5 pollices, 22 second wing digits (20 first phalanges, 2 second phalanges), 2 third wing digits, 85 femorae, 178 tibiotarsii, 13 fibulae, 127 tarsometatarsii, 311 phalanges, 1450 indeterminate fragments: 5397 specimens.

Remarks: No attempt was made to identify the vertebrae, ribs, phalanges, or tracheal rings beyond 'bird.' Most of the specimens coded as Aves were not identifiable because they were highly fragmented. Specimens from the ⅛" fraction that were not identifiable to element, were coded as Vertebrate (non-fish), since it is very difficult to assign such small fragments securely to class (with the exception of 17 specimens that appeared to be condyles or other possibly identifiable fragments). Unidentifiable fragments from the ¼" and above were assigned to class.

4.1. Taxonomic identifications from 'partially analyzed' and 'excluded' material

The only unique identification from the 'partially analyzed' and 'excluded' material was a second wing digit (phalanx 1) of a Belted Kingfisher (*Megaceryle alcyon*), which was identified from a ⅛" S bag from A4/Unit 19 (WS-7024.99.08.22). Aside from this specimen, identified remains from the partially analyzed/excluded material were very similar to the rest of the assemblage (murres, ducks, gulls, shearwaters, loons, grebes, etc.).

5. Taphonomic summary

In addition to taxonomic designations, I also recorded the presence of burning and other taphonomic modifications that were visible with the naked eye. It is important to note that the bones were not washed, so the amount of modified bird bone (e.g., cut marks) may be underrepresented due to diminished visibility. This taphonomic summary is not meant to be comprehensive, but to provide future researchers with information needed to understand the information in the database. Bovy et al. (2019) provides additional taphonomic information about the bird remains (in comparison to the mammal remains).

5.1. Burning/heat modification

All analysts recorded the presence or absence of burning on the specimens ('Burn' field), and agreed to be conservative in coding to include only fragments that were clearly burned, charred, or calcined (see Fig. 4)—i.e. were dark brown to black to blue-ish white. That said, we realized during the course of our analyses that we were having difficulty clearly distinguishing various types and degrees of thermal alteration using only visual characteristics. For example, there were many dark brown specimens, which were possibly stained by the surrounding sediment. In addition, many of the bird and mammal specimens were uniformly gray, with a characteristic sound quality reminiscent of porcelain, which may have been subjected to indirect heating (Bennett, 1999). I first noticed these specimens during the re-screening process, given the 'clinky' noise they made when dropped onto a tray. In some cases, these 'clinky' specimens had no sign of discoloration, but still made the distinctive sound (see example in Fig. 5).

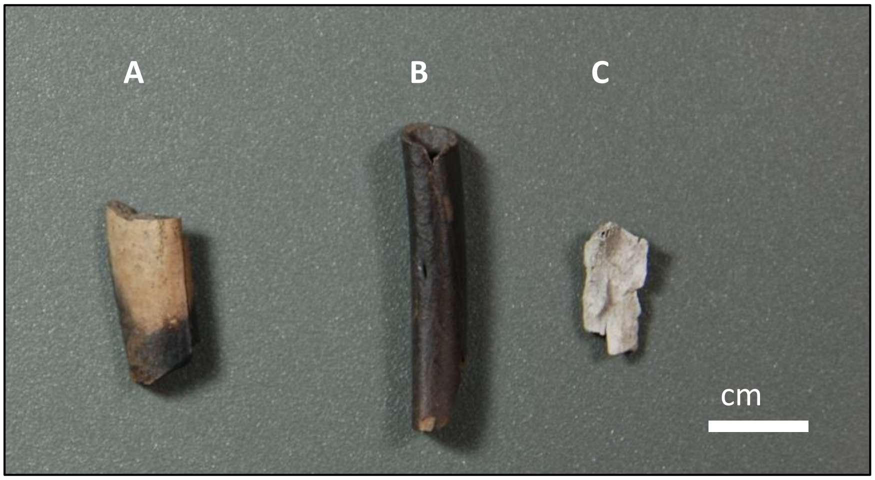

Fig. 4. Examples of burning from Čı̓xʷicən bird assemblage. A: Partial burning/charring on broken murre humerus shaft (WS-18082.99.04.22). B: Completely burnt duck humerus shaft (WS-18082.99.04.22). C: Completely calcined proximal murre humerus (WS-12145.99.04.22). Courtesy of the Washington Dept. of Transportation. (Photograph by Marielle Orff).

Fig. 5. Murre ulna broken into three fragments (all of which refit). All three fragments look similar visually, but the mid-shaft (middle) makes a 'clinky' sound, while the proximal (left) and distal (right) do not. The 'clinky' noise may result from indirect heating (Bennett, 1999). Courtesy of the Washington Dept. of Transportation, catalog number WS-16709.99.04.22. (Photograph by Kris Bovy).

As we became aware of these challenges, we agreed to exclude both the possible stained and indirectly heated specimens from the burned category, although I frequently recorded 'stained' or 'clinky' in the ID Comments field. However, I struggled with accurately characterizing the burning throughout the analysis, and was likely not consistent in the coding. In a reanalysis of random samples of fish remains, Nims and Butler (2017) found up to 10% error in burning assessments, indicating that subtle differences in burning rates for fish may not be meaningful. I believe this is even more likely to be true for the bird coding, given our confusion with the possible indirectly heated bones. In particular, while I did record burning for the ⅛" bird and vertebrate (non-fish) fragments, it was particularly challenging to distinguish burning from staining on these small fragments. Therefore, any interpretations about burning is best restricted to the ¼" and above specimens.

I used the second field ('Burn Type') to distinguish three types of burning (Fig. 4, Table 12): 'burnt' (darkly discolored or blackened), 'calcined' (whitish, grayish, or bluish), and 'partially burnt on shaft' (for bones that appeared to have been intentionally heated mid-shaft/element and broken; see Fig. 6). Overall 27.3% of the bird bones were burned or calcined, which from previous experience seems quite high, even given possible errors with coding the burning (e.g., erroneously including some 'stained' or 'clinky' specimens). Of those specimens coded as burned, 62.0% are burnt, 31.5% calcined, and 6.6% partially burned on shaft. Fig. 7 shows the range of colors found in calcined specimens.
The 'partially burned on shaft' designation was used mainly for limb bones that were burned only along the edges of the broken shaft, although some coracoids and one furculum were coded as such, since they were broken mid-element. Many of these specimens have distinctive jagged breaks on the shaft (see Fig. 6B). The discoloration on the edges of the break varied from very subtle/slight to obviously charred. This distinctive pattern of burning has been noted in other bird bone assemblages in the region, including the Minard site on the outer Washington coast (Bovy, 2005:120) and Emeryville Shellmound in San Francisco Bay (Howard, 1929:379). Of the 126 specimens coded as 'partially burnt on shaft' and identified to element in the Čḯx̣wicən assemblage (Table 13), 81 (64.3%) were humeri, followed by tibiotarsii (13; 10.3%) and coracoids (12; 9.5%). This distinctive burning pattern was present on many different kinds of birds found in the assemblage (Table 13).

Table 12. Number and percentage of all bird specimens by 'Burn Type' category. Includes *in situ* and ≥¼" specimens only, given the difficulty in coding the ⅛" fragments.

'Burn Type'	NSP	%
Burned	1267	16.9
Partially burned on shaft	134	1.8
Calcined	643	8.6
Unburned	5451	72.7
Total	7495	

Fig. 6. Murre specimens, which are partially burnt on the broken shafts. A. Burke comparative specimen (44184) is shown on the left with a proximal humerus (WS- 14294.99.02.22) on top right and distal (WS-10919.99.04.22) bottom right. B. Close-up of proximal (posterior side) showing jagged edges and discoloration due to heating. Courtesy of the Washington Dept. of Transportation. (Photograph by Kris Bovy).

Fig. 7. Four unidentified bird limb bone fragments from Area A3, showing the range of colors for calcined specimens, including gray, white, green and blue. Courtesy of the Washington Dept. of Transportation, catalog number WS-18445.99.04.22. (Photograph by Kris Bovy).

Table 13. Specimens coded as 'partially burnt on shaft' by Family and element. Listed in order of abundance (by Family). Includes all screen sizes.

Taxon	Coracoid	Furculum	Humerus	Radius	Ulna	Carpometacarpus	Femur	Tibiotarsus	Tarsometatarsus	Indeterminate	Total
Alcidae	1		37	1	3	1		1			44
Anatidae	7		13	1	3			7			31
Aves (unid.)	1		11	2		1	1	1		11	28
Procellaridae			10	2			1	2	1		16
Gaviidae	2		2				1	1			6
Podicipedidae	1	1	4								6
Laridae			3					1			4
Ardeidae			1								1
Phalacrocoracidae					1						1
Total	12	1	81	6	7	2	3	13	1	11	137

Although a detailed analysis of burning by Area and chronozone is beyond the scope of this report, it is important to note that frequencies of burning were much higher in some areas and contexts than others (Table 14). In particular, the bird bones from A3 and BX1/BX4 were frequently calcined. For example, there were 688 bird bone fragments (¼" and above) in Area A3 (CZ5); of these 49.1% (338) were calcined (see Fig. 7 for an example).

5.2. Additional modifications

In addition to burning, the bird bones were modified in a number of other ways (Table 15), each of which is briefly discussed here. It is important to note that the data presented here only include obvious modifications that were noticed during the faunal analysis. Additional modified bird bones were pulled during the initial lab processing and catalogued as artifacts. Although Bovy did not examine these, Etnier and Campbell did study a sample (from Area A4, Units 1-3, 5-6, 9-16) of bone artifacts at the Burke Museum. They recorded 8 bird bone artifacts from this sample (Bovy et al., 2019: Table 8). Therefore, the number of grooved-and-snapped and worked bones in Table 15 is under-represented in the assemblage as a whole. Additional information on the grooved-and-snapped, worked and cut marked bones is provided in Table 16.

Table 14. Percentage of burned bird bone by Area and Chronozone (CZ). Total NSP for all bird bone (burned and unburned) from a given Area/CZ in parentheses. Includes ≥¼" and *in situ* specimens only.

	A1	A3	A4	A5	A18	A23	BX1/BX4	Total
CZ 7			0.205 (83)					0.205 (83)
CZ 6	0.232 (69)		0.225 (3176)	0.076 (224)				0.216 (3469)
CZ 5	.0268 (168)	0.696 (688)	0.244 (2000)	0.102 (128)		0.121 (91)		0.337 (3075)
CZ 4	0.10 (10)	0.0 (1)	0.256 (340)		0.077 (26)		0.629 (186)	0.368 (563)
CZ 3			0.179 (39)		0.0 (7)		0.0 (1)	0.149 (47)
CZ 2			0.032 (31)					0.032 (31)
CZ 1				0.138 (198)		0.067 (15)		0.117 (213)
Total	0.251 (247)	0.695 (689)	0.232 (5669)	0.098 (550)	0.061 (33)	0.113 (106)	0.626 (187)	0.273 (7481)

5.2.1. Grooved-and snapped

One proximal pelican ulna (WS-11001.99.01.22; Fig. 8) was "grooved-and-snapped" (Parmalee, 1977). Groove-and-snap specimens are the discarded articular ends of long bones, which are used for tools (awls) or ornaments (beads, drinking tube, whistle).

Fig. 8. Grooved-and-snapped proximal ulna of a pelican. Arrow shows where bone was grooved/scored. Courtesy of the Washington Dept. of Transportation, catalog number WS-11001.99.01.22. (Photograph by Kris Bovy).

Table 15. Modified bones observed during the zooarchaeological analysis[1]. Numbers in parentheses are possibly modified (not confirmed). See text for discussion of each type of modification.

Modification	NSP	Comments	Photo (example)
Grooved-and-snapped[2]	1	Proximal pelican ulna	Fig. 8: WS-11001.99.01.22
Worked[2]	3 (1)	1 gull radius shaft, 1 raven tibiotarsus shaft, 1 duck mandible, 1 Aves humerus shaft	Fig. 9: WS-8361.99.02.22
Cut marks	15 (1)	4 ducks, 4 Aves (unid.), 2 Alcids, 2 vertebrate (non-fish), 1 albatross, 1 heron, 1 Procellariid, 1 gull	Fig. 10: WS-6528.99.04.22
Chop mark	1	Aves, indeterminate long bone	N/A
Flaked bone	1	Alcid, humerus shaft	Fig. 11: A4-132.01.01
Disarticulation: distal humerus	4	All 4 specimens are ducks	Fig. 12: WS-8528.99.04.22
Disarticulation: proximal ulna	97	68 Alcids, 12 ducks, 12 Procellariids, 2 gulls, 2 grebes, 1 medium-sized Charadriiformes	Fig. 13: WS-14490.99.04.22
Disarticulation: peeling[3]	(4)	All proximal ulnae: 2 ducks, 1 shearwater, 1 Alcid	Fig. 14: WS-8621.99.04.22
Gnawing	8 (3)	3 ducks, 2 loons, 2 Procellariids, 1 albatross, 2 Aves (unid.), and 1 vertebrate (non-fish)	Fig. 15: A4-446.01.03
Tooth Puncture	1 (1)	1 loon humerus, 1 duck scapula	Fig. 16: WS-14390.99.04.22
Digested	8 (16)	5 ducks, 3 Alcids, 2 geese, 1 Procellariid, 1 gull, 12 Aves (unid.)	N/A
Weathering[3]	2		N/A

[1]Three specimens (two with cut marks and one possibly gnawed) were coded as vertebrate (non-fish); all others were birds.
[2]Additional worked bird bones were catalogued separately as artifacts and are not included in this analysis.
[3]Peeling and weathering were not systematically recorded.

5.2.2. Worked bone

Three specimens are 'worked' (1 gull radius shaft, 1 raven tibiotarsus shaft, 1 duck mandible) and one was possibly worked (1 unidentified bird humerus shaft; Table 16). Specimens were coded as 'worked' if they were ground, had visible abrasion scratches and/or were polished. For example, Fig. 9 shows a ground and polished gull radius shaft (WS-8361.99.02.22).

Table 16. Worked and cut marked bird bone observed during zooarchaeological analysis. Specimens are listed in order by type of modification and catalog number.

Catalog Number	Finest Taxon	Element	Description	Photo
WS-11001.99.01.22	*Pelecanus* spp.	ulna proximal	grooved and snapped	Yes
WS-10827.99.02.22	Aves	humerus shaft	worked (?): abrasion scratches; possibly polished	No
WS-8361.99.02.22	Laridae	radius shaft	worked: ground and polished	Yes
WS-11706.99.02.22	*Corvus corax*	tibiotarsus shaft	worked: abrasion scratches, polished	Yes
WS-12016.99.04.22	Anatinae	mandible (dentary)	worked on broken cranial edge	Yes
A1-147.01.01	Anatinae	ulna shaft	multiple cut marks perpendicular to shaft	Yes
A4-216.01.03	Procellariidae (likely non-sooty shearwater)	humerus (nearly complete)	multiple parallel cut marks perpendicular to shaft (on posterior and lateral surfaces of distal end); gnawing on proximal end	Yes
A4-300.01.01	*Ardea herodias*	tibiotarsus shaft	multiple cut marks or abrasion scratches (perpendicular to shaft) on medial and anterior surfaces	Yes
A4-469.01.02	cf. *Phoebastria* spp.	radius shaft	3 parallel cut marks perpendicular to proximal shaft	Yes
WS-637.99.04.22	Aves	Indeterminate	multiple overlapping cut marks (or abrasion scratches) perpendicular to shaft	No
WS-6528.99.04.22	*Uria* spp.	synsacrum	2 parallel short deep cut marks on distal synsacrum	Yes
WS-7395.99.04.22	cf. *Melanitta* spp.	scapula	multiple (9?) parallel cut marks	Yes
WS-8258.99.04.22	Laridae	tibiotarsus shaft	2 cut marks perpendicular to shaft near broken distal end	No
WS-8546.99.01.22	Aves (large bird)	humerus shaft	multiple parallel cut marks perpendicular to shaft	Yes
WS-9498.99.04.22	cf. Anatinae	tibiotarsus shaft	3 parallel cut marks perpendicular to shaft (anterior surface)	Yes
WS-9502.99.04.22	Alcidae-large	ulna shaft	4 possible cut marks near distal end (relatively shallow parallel marks)	No
WS-10406.99.04.22	Anatinae	tibiotarsus distal	2 short parallel cut marks perpendicular to shaft (posterior surface)	No

Table 16. Continued.

Catalog Number	Finest Taxon	Element	Description	Photo
WS-11500.99.08.20	Vertebrate (non-fish)	indeterminate	4 parallel cut marks	Yes
WS-12074.99.04.22	Aves	indeterminate	2 parallel cut marks perpendicular to shaft (near broken shaft)	No
WS-15677.99.08.20	Vertebrate (non-fish)	Indeterminate	3 parallel cut marks perpendicular to shaft	Yes
WS-17185.99.04.22	Aves	coracoid	multiple parallel cut marks	Yes
WS-10497.99.04.22	Aves	indeterminate	1 chop mark (perpendicular to shaft) near broken end	No
A4-132.01.01	Alcidae-large	humerus shaft	flaked (notch on broken edge)	Yes

Fig. 9. Ground and polished gull radius shaft. Arrow shows ground and polished area. Courtesy of the Washington Dept. of Transportation, catalog number WS-8361.99.02.22. (Photograph by Kris Bovy).

5.2.3. Cut marked bone

Fifteen specimens have cut marks and one is possibly cut marked (Table 16). Cut marks were present on a variety of kinds of birds, including ducks (4), Alcids (2), albatross (1), Procellarid (1), heron (1), and gull (1). In addition, four are on unidentified bird bones and two on specimens coded as vertebrate (non-fish); the latter two are likely either long bones of dense seabirds (e.g., loon) or mammal bones. Specimens were coded as 'cutmarks' if there were multiple parallel deep marks visible. For example, Fig. 10 shows a Murre synsacrum (WS-6528.99.04.22) with two short deep parallel cut marks.

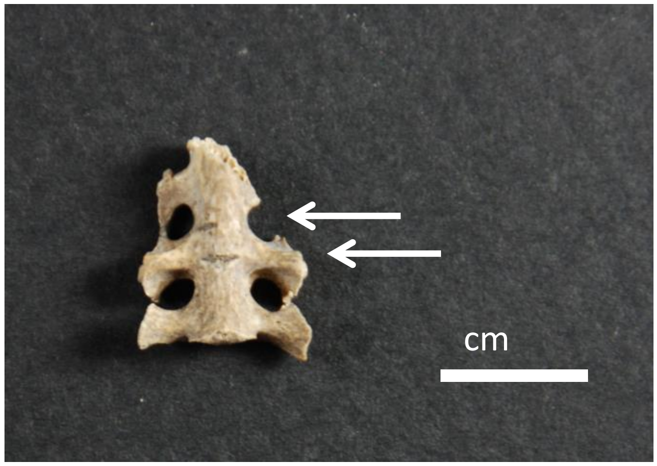

Fig. 10. Murre synsacrum with two parallel short deep cut marks. Arrows show location of cut marks. Courtesy of the Washington Dept. of Transportation, catalog number WS-6528.99.04.22. (Photograph by Marielle Orff).

5.2.4. Chop Mark

One specimen (WS-10497.99.04.22), an indeterminate bird long bone, had a chop mark perpendicular to the shaft, near the broken end. Note that in Table 8 of Bovy et al. (2019) two chop marks are listed for birds; this was an error in the database.

5.2.5. Flaked bone

One specimen (A4-132.01.01), a large Alcid (likely Murre) humerus shaft, has a flake scar possibly due to a percussion impact (see Fig. 11).

Fig. 11. Alcid humerus shaft with flake scar. Arrow shows location of flake scar. Courtesy of the Washington Dept. of Transportation, catalog number A4-132.01.01. (Photograph by Kris Bovy).

5.2.6. Disarticulation of wings

Four distal duck humeri have holes or crush marks in the olecranon fossa indicative of disarticulation (see Fig. 12 for an example). Perforations or notches may occur in the olecranon fossa of distal humeri when the wing joints are bent and overextended in the process of separating the humerus and ulna (Laroulandie, 2005: Fig. 10; Serjeantson, 2009:144-146). In addition, damage to the olecranon fossa of the ulna may occur when the humerus and ulna are disarticulated from each other (Fig. 13; Laroulandie, 2005: Fig. 11; Serjeantson, 2009:145). Ninety-seven archaeological specimens have damaged proximal ulnae, including 68 Alcids, 12 ducks, 12 Procellarids, 2 gulls, 2 grebes, and 1 medium-sized Charadriiformes.

'Peeling' may also occur during disarticulation when strain is put on a bone and a portion of the bone surface is removed (Laroulandie, 2005; Serjeantson, 2009:Fig. 6.11). Although I did not systematically record the presence of peeling in the assemblage, I did note four proximal ulnae (2 ducks, 1 shearwater, 1 Alcid) with possible evidence for peeling (see Fig. 14 for an example).

Fig. 12. Distal duck humerus with perforation in olecranon fossa, which occurred during disarticulation with ulna. Courtesy of the Washington Dept. of Transportation, catalog number WS-8528.99.04.22. (Photograph by Kris Bovy).

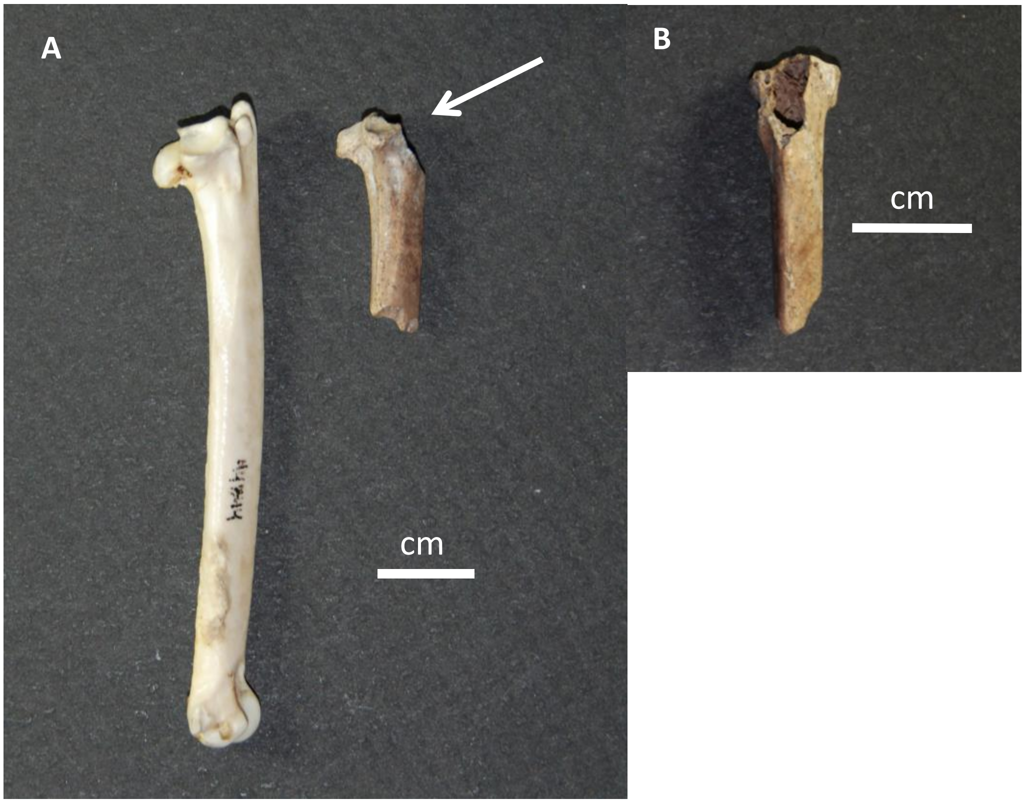

Fig. 13. Proximal ulna of large Alcid, which was broken during disarticulation with humerus. A. Image shows complete comparative specimen of a Common Murre from the Burke Museum (44844) on left. B. Close-up of damage to archaeological specimen. Courtesy of the Washington Dept. of Transportation, catalog number WS-14490.99.04.22. (Photograph by Kris Bovy).

Fig. 14. Proximal ulna of duck with possible ‘peeling’ marks (black arrows). Courtesy of the Washington Dept. of Transportation, catalog number WS-8621.99.04.22. (Photograph by Marielle Orff).

5.2.7. Gnawing & tooth puncture marks

Eleven specimens showed evidence for gnawing, including 3 ducks, 2 loons, 2 Procellarids, 1 albatross, 2 unidentified birds and 1 vertebrate (non-fish) specimen. The gnawing was likely from carnivores or humans; there was no evidence for rodent gnawing. See Fig. 15. for an example. In addition, two specimens (a loon humerus and a duck scapula) had distinct puncture marks that were likely made by carnivores or humans (see Fig. 16 for an example).

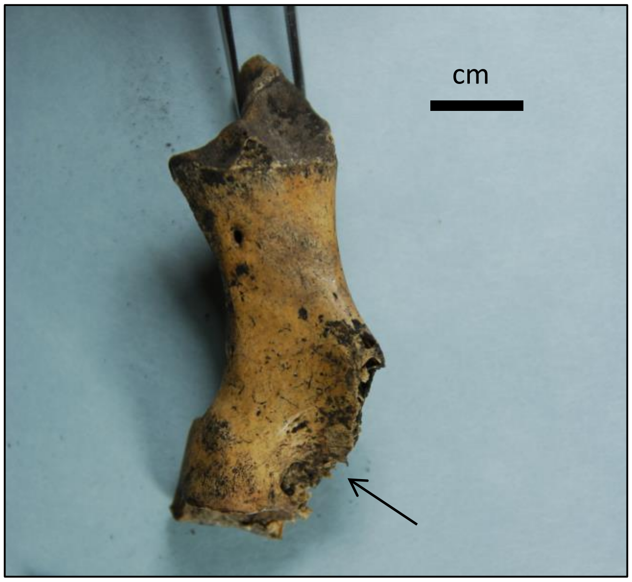

Fig. 15. Albatross coracoid with gnaw marks. Courtesy of the Washington Dept. of Transportation, catalog number A4-446.01.03. (Photograph by Kris Bovy).

Fig. 16. Duck (*Aythya* spp.) scapula with possible tooth puncture. Courtesy of the Washington Dept. of Transportation, catalog number WS-14390.99.04.22. (Photograph by Kris Bovy).

5.2.8. Digestion

Twenty-four specimens had wall thinning that may be indicative of digestion. These included 5 ducks, 3 Alcids, 2 geese, 1 Procellarid, 1 gull and 12 unidentified birds.

5.2.9. Weathering

Although surface weathering was not systematically recorded, I did note two specimens that appeared to be weathered.

5.3. Skeletal Part Representation

Numerous archaeological sites in the Strait of Georgia in the Salish Sea (Fig. 1) have bird assemblages dominated by distal wing bones (Bovy, 2002; Bovy, 2012). For example, distal wing bones comprise 98% of the large duck bone assemblage (n=4195) recovered from the Watmough Bay site on Lopez Island (Bovy, 2012). Although the Čі́xʷicən site is relatively close by, the bird assemblage is not similar in this regard. I have not yet systematically examined the skeletal part representation, although I did record bone zones during analysis, so MNE values could be calculated, if desired. However, of the 1190 specimens classified as Anseriformes, only 188 (16%) were distal wings (carpals, carpometacarpi, wing phalanges, and pollices). Other body parts, including legs, are also common. It appears as if entire bird carcasses were deposited at Čі́xʷicən, unlike Watmough Bay. Despite the proximity of the two sites, they were occupied by different groups of people (the Lower Elwha Klallam tribe at Čі́xʷicən, and Samish and/or Lummi at Watmough Bay) who may have had different bird hunting and/or processing practices.

6. Conclusion

Čі́xʷicən village is an incredible site with a vast bird assemblage. For future researchers who may be interested in understanding or continuing analysis on the Čі́xʷicən birds, I highlight a few key features of the assemblage:

- Only a relatively small portion of the bird assemblage has been analyzed for this project. There are many more S buckets that were not studied for the areas in our study, including S buckets from Areas A1, A3, A4 (Units 1-16, 21-40), A18, and BX1/BX4. In addition, there are very likely bird bones remaining in unanalyzed fish and mammal bags that were initially mis-sorted (see Table 4). Additional samples could be analyzed, although the findings may not change our current understanding of the spatial and temporal trends for these areas.

- There are also many more bird bones in many other areas of the site that have not yet been analyzed. Analyzing these bones could add new information about how the bird use varied across the site, although such an undertaking would first require substantial investment in understanding the stratigraphy and chronology of those additional areas.

- Many specimens in the sample could be identified more specifically (to genus or species) with additional work and access to more extensive comparative collections (see notes throughout the taxonomic summary). For example, only a sample of the ducks were identified more specifically than Anatinae, and lack of comparative specimens hindered more specific identifications of small Alcids. This effort might be worthwhile if a researcher had an interest in a particular kind of bird.

- Taphonomy was not the goal of the current project, so although some taphonomic information is presented here, a much more thorough study could be undertaken in the future. This could include more systematic examination of specimens under a microscope and also analysis of bird bones curated as 'artifacts.'

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Appendix 1: Definitions/Explanations for Column Headings on Čı́xʷicən Bird Database

By Kristine M. Bovy

Bird_IDNum

Bird Identification Number—this is a unique identifier for this specific row/line. Note that each row/line may represent multiple specimens (see ‘Quant_Bird’ below).

Catalog Number

Catalog numbers match the artifact and faunal specimen inventory maintained by the Burke Museum. Catalog numbers take one of two basic formats depending on whether they were collected *in situ* during the excavations or if they were collected in the water screens.

Most samples included in our 2012-2019 project were collected from water screens and are designated as ‘WS’ (e.g., ‘water screen’) catalog numbers. Because of various issues (see Butler et al., 2018), the project team re-screened all the water-screened samples in our study. This process led us to create a slightly revised catalog system (from the original LAAS/Burke Catalog) with FOUR sub-numbers.

WS-<u>16788</u>.<u>99</u>.<u>04</u>.<u>21</u>

The number after the WS- is the ‘bag number’ (see ‘Bag Number’ below), which is the number assigned by LAAS lab/field personnel (Kaehler and Lewarch, 2006) with numbers assigned in the order in which the Unit/Level bags were added to the Master Catalog. The bag number can range from one to five digits. The ‘99’ after the bag number specifies that this sample was re-screened by the 2012-2019 project.

The ‘04’ in the example above designates the screen size fraction for that particular entry (here, ¼ -inch). Screen size designations are as follows:

01	1-inch
02	½ -inch
04	¼ -inch
08	⅛ -inch
99	<⅛ -inch

The final sub-number (‘21’ in the example above) specifies the main animal type to which the sample belongs. Those categories are:

10 Invertebrate
20 Unidentified Vertebrate (non-fish)
21 Mammals
22 Birds
23 Fish

Samples collected *in situ,* termed ‘E’ samples (see ‘Bag Type’ and ‘Analytical Bag Type’ below), maintain their original Master Catalog number from the LAAS/Burke Museum. The numbering system begins with the excavation area/block designation (Area A4 in the following example):

A4-197.01.01

The number after the dash (197) refers to the Field Bag number, which can be matched to bag numbers listed in the Unit/Level records (Kaehler and Lewarch, 2006). Explanations for the two sub-numbers after the Bag Number are described in Appendix 5 of the LAAS report (Larson, 2006, Appendix 5: pg 4)

BagNumber
This is the first number of the Catalog Number (see above), which is the number assigned by LAAS lab/field personnel (Kaehler and Lewarch, 2006) with numbers assigned in the order in which the Unit/Level bags were added to the Master Catalog. This is the original bag number as it appears in the LAAS/Burke Museum catalog.

Analytic_BagNum
In most situations, 'Analytic_Bag Number' and 'BagNumber' are the same. However, as explained by Butler et al. (2018), we encountered situations where it appeared that constituents from a single original field bag/bucket were split into >1 Bag Numbers during laboratory processing. Butler et al. (2018) explain how this was deduced. The Analytic Bag number is the team's best identification for the complete, 10 L water-screened bucket that had later been subdivided; and is used when estimating excavation volume for calculations of density/accumulation rate.

Re-screened
This duplicates the sub-number information in the Catalog Number (see above). All of the water-screened samples have the '0.99' code to indicate these were re-screened as part of the 2012-2019 project. The 'E' samples—those that were collected *in situ* during excavation, were not re-screened.

ScreenSize
This duplicates the sub-number information in the Catalog Number (see above). This refers to the mesh size from which the constituents were recovered as noted above.

01	1-inch
02	½ -inch
04	¼ -inch
08	⅛ -inch
99	<⅛ -inch

Screen size was not listed for the 'E' samples, as they were collected *in situ* without screens.

Material Type
This duplicates the sub-number information in the Catalog Number (see above). This number specifies the main animal type. Those categories are:

10 Invertebrate
20 Unidentified Vertebrate (non-fish)
21 Mammals
22 Birds
23 Fish

Area

The terms 'Area' or 'Block' are used interchangeably in our reporting. The original site report (Larson, 2006) used the term 'Area' to define the four massive project areas that were assigned during 2004 field work (Area A, B, C, D) and the term 'Block' for the contiguous excavation units excavated in a particular 'Area' (e.g., Block A1, A4, B1, etc., where the alpha code refers to 'Area' and the number is the excavation 'Block' within the Area). However, the Master Catalog (and faunal bag labels) column heading/field the Burke Museum sent us referred to the set of contiguous units as 'Area' *not Block* (e.g., Area A1, A3). For our 2012-2019 project and faunal catalog, we followed the convention used in the Master Catalog. We use Area to refer to the contiguous grouping of excavation units that combines the <u>Area code (A)</u> and the Block number (1, 4, etc.), thus A1, A4. Since most of the NSF project focused on one of the massive Areas (e.g., Area A), the distinction between Area and Block is not critical.

Unit

Unit refers to an excavation unit number (e.g., 1, 2, 3) that was assigned sequentially as an Area/Block was being excavated by LAAS crews (Reetz et al., 2006). The labels listed in 'unit' are exactly the code as assigned in the field, in the catalog and on the original faunal bags sent to us. Most units are $1m^2$. Most unit codes are single whole numbers (e.g., 1, 2, 3), but sometimes the label includes an 'A' (e.g., 1A, or other alpha), or sometimes units were joined with slashes (e.g., 2/13, 30/32). Reetz et al. (2006) provides detailed maps that show unit numbers in each Area/Block.

Adjusted_Unit

When the Unit code is a simple number (e.g., 1, 2, 3) the Adjusted Unit label is the same as the Unit code. We created the Adjusted Unit field to recode the unit labels that had an 'A' or were aggregate units (e.g., 2/13) so that such units could easily be manipulated in the database. LAAS added the 'A' codes to excavation unit labels when field crews returned to excavate units that had previously been dug. Thus, in Area/Block A4, field crews returned to the southern part of the block and dug deeper in units 1, 2, 3, 6, 7, 8, 11, 12, 30, 40 that had previously been partly excavated (see Reetz et al., 2006: 40-36). The 'A' code was added to these 'revisited units' but the excavation units with or without the 'A' are the same unit. The Adjusted Unit code that we created simply assigns the units with the 'A' to the original Unit number. What was '1A' in the Unit code becomes '1' in the Adjusted Unit code. In a few cases, mostly involving features that overlap two units, provenience was recorded as both units (e.g., 2/13). In these cases, the adjusted unit is the unit in which the strat was most extensive.

Strat

This is the stratigraphic code assigned in the field based on a variety of geoarchaeological criteria, including relative position in the stratigraphic sequence, composition, color, texture, lithology, etc. (Sterling et al., 2006).

Adjusted_Strat

In most cases, the Adjusted_Strat code is the same as the Strat code. In a very small number of cases, the Adjusted Strat was used to correct data entry errors in the Burke Museum catalog. In other cases, matrix with similar characteristics were designated as two or more strata with a slash convention, e.g. 5.1.3.2/6.5, because of uncertainty about the best match. Unit level records were consulted to resolve this; generally, there were notes about later determinations of the strat, or continuity with adjacent units was the determinant.

Feature
This code refers to the sequential number unique to each Area (e.g., A, B, C, D) assigned to a cultural feature (e.g., hearths, post molds, etc.,) over the course of fieldwork (Reetz et al., 2006).

Level
Designates an arbitrary level within a natural stratum (Reetz et al., 2006). We retained 'OVB' for overburden and 'U' designating materials recovered from a collapsed wall as per the Burke Museum catalogue. Our project added the code 'NLR' to indicate that no level records existed for the sample.

CZ
CZ refers to chrono-stratigraphic or more simply, 'chronozone' (CZ). Campbell et al. (2019) defined seven CZs based on use of 59 radiocarbon ages and analysis of depositional sequences of field-identified strata (see table below). Through this process, all unique field-documented strata and associated samples (C, CX, S buckets and *in situ* E specimens) were assigned to one of the seven CZs, from CZ 1 (2150–1750 cal BP) to CZ 7 (300–150 cal BP). Chronozone 4b (CZ 4b) consisted of material that had been displaced in the past by erosion or house construction; fauna from these samples were not included in the overall analysis.

Chronozone	Age Range (CalBP)	Mid-Point (CalBP)
CZ 7	300–150	225
CZ 6	550–300	425
CZ 5	1000–550	775
CZ 4	1300–1000	1150
CZ 3	1550–1300	1425
CZ 2	1750–1550	1650
CZ 1	2150–1750	1950

The bird database includes material from CZ4b, but excludes any other material that was not included in the final analyses, such as strata not assigned to chronozone because of construction disturbance (e.g., Strat 2.0). See Bovy (2018: Section 2.5: '*Partially analyzed' and excluded material*) for more information on this excluded material.

Depositional Context
Depositional context was determined by Campbell following close analysis of matrix characteristics. Deposits associated with house occupation were designated as floor or fill depending on their characteristics (Floor = spongy, dark, compact, horizontal; Fill = loose, structureless, sloping). Floors were numbered sequentially within a house with 1 designating the initial, or lowest floor. Transition Zone designates the area closest to the wall, inside the house, where the stratified floor sequence cannot be traced due to the different depositional processes in that area. The designations Pre-house and Post-house were used only within the footprint of the house. Extramural deposits lie outside of house footprints.

Extramural
Fill
Floor 1
Floor 2
Floor 3

Floor 4
post-house
pre-house
Transition Zone

Bag Type
This code refers to one of three main field sampling methods described by LAAS personnel (Kaehler and Lewarch, 2006) and which appears in the original Master Catalog. Most buckets from a given stratum were screened to ¼" 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 ⅛" mesh. Such buckets were labeled *Complete* or 'C' buckets. Finally, relatively large remains were recorded *in situ* during excavation and referred to as 'E' samples. The codes listed under Bag Type refer to one of these three codes, S, C, or E from the original catalog. The 2012-2019 project team found that about half of the so-called 'C' bags were not in fact 'complete', but rather were missing ⅛" mesh materials. LAAS protocols changed over the project. Importantly—the Master Catalog did not distinguish such buckets. Both were labelled 'C' in the Master Catalog. The project team created a revised coding system to address this issue. See 'Analytic_Bag Type' and Butler et al. (2018).

Analytic_Bag Type
For S and E buckets, the code for Bag Type and Analytic Bag type is the same. We created a new code, 'CX' to distinguish true 'C' buckets (that included matrix >⅛") from those buckets from which only ¼" mesh and larger were retained. Thus, for Analytic Bag Type, possible codes include **S, E, C** (which includes all matrix >⅛") and **CX** (which includes only matrix > ¼"). While I did analyze some specimens from CX buckets listed from ⅛" matrix (before we understood the 'C' and 'CX' distinction), I have excluded these from the database because they should not be included in systematic analysis of faunal representation, given lack of control on mesh size. See Bovy (2018: Section 2.5: '*Partially analyzed' and excluded material*) for more information on this excluded material.

Quant_Bird
The 'Quant_Bird' field is either NSP (for all specimens identified as 'bird') or NISP (Number of Identified Specimens) for those identified more specifically. Refit specimens were counted as one specimen, and the refit was noted in the ID Comments field. For example, a specimen broken into 3 fragments would be listed as '1' in the Quant_Bird field; in a number of cases, a specimen is listed with a '0' quantity, which means it refits to a specimen with a different catalog number (frequently a different screen size within the same bag).

FaunalCategory
All specimens were either coded as 'Aves' or 'Vertebrate (non-fish).' This allowed easy sorting of the bird specimens from the unidentifiable fragments, which could be either bird or mammal; see discussion in Bovy (2018: Sec. 3: *Bird bone analysis procedures*) for more information. Note that with a few exceptions (2 cut marked bones and 1 gnawed bone) the Vertebrate (non-fish) remains are not discussed in the bird bone report (Bovy, 2018), though they are summarized in Bovy et al. (2019). Importantly, the Vertebrate (non-fish) remains that were originally identified as bird, or were later transferred to my lab as possible bird, are listed in the bird database. Therefore, when sorting the bird database, the Vertebrate (non-fish) remains need to be filtered out, if only information on bird remains is desired.

A Note on Taxonomic/Linnaean Hierarchy
In general, I attempted to identify bones/bone fragments to the most specific taxon possible; but see discussions in Bovy (2018: Sec. 3.1: *A note on the specificity of the Identifications* and Sec. 3.2: *A note on the 'cf.' identifications*) for more guidance on the varying specificity of the identifications. Also, all vertebrae, ribs, and phalanges were identified only as Aves.

Identification was recorded according to the Linnaean hierarchy, using the most recent nomenclature available. Taxonomic names follow the Seventh Edition of the American Ornithologists' Union (AOU) check-list (1998), as well as the numerous (and often substantial) changes made to the check-list in recent years, which are available as supplements on the AOU website and published in *The Auk* each year. Genetic studies have altered many earlier assumptions about taxonomic relationships of birds, changing the placement and taxonomic names of many species.

If a particular level of the hierarchy could not be reached, say a specimen could only be identified to the level of Family, all lower fields (Genus and Species, in this example) are left blank. Note that for species-level IDs, only the species epithet is listed in the 'Species' field—both the Genus and the Species fields must be combined to extract the Linnaean species.

Finally, the most specific taxonomic level for each specimen is also listed under 'Finest Taxon' (see below).

Class
Order
Family
Subfamily (for Anseriformes only)
Tribe (for Anseriformes only)
Genus
Species

Finest Taxon
Finest Taxon refers to the most specific taxonomic classification (e.g., class, order, family, genus, species) to which a specimen can be assigned. This may or may not correspond to a Linnaean taxon. See 'A Note on Taxonomic/Linnaean Hierarchy' above. Specimens which could only be assigned to a faunal category are listed here as that category. Thus, specimens which can only be assigned to 'Bird' are listed in Finest Taxon as 'Aves.' Fragments that could only be securely identified as bone (primarily the ⅛" fraction) were coded as Vertebrate (non-fish); see 'FaunalCategory' above and Bovy (2018: Sec 3.) for an explanation of this code.

Element/ Segment/ Side/ Zone
Element refers to the specific skeletal element (e.g., humerus, skull, vertebra, etc.), while Segment denotes a portion of a skeletal element, either a specific name (e.g., pterygoid) or a description (e.g., proximal). If the element was complete, 'whole' was entered in the segment field. Avian skeletal part terminology follows Howard (1929). In most cases, the element side (left or right of the body) was also recorded; however, in a relatively few cases the side could not be securely determined, even though the element was identifiable (e.g., ulnae or radii shaft fragments). The Zone field indicates which particular portions/landmarks of the bone were present (e.g., FEM 1 is located at the head of the femur). Bone zone codes are from Serjeantson (2009: Appendix 2), except for mandible and second wing digit

(Phalanx 1; see Bovy, 2005: Figure A-1). The side and bone zone were recorded to aid in the calculation of minimum number of elements (MNE), if desired.

Age

A protocol was in place to record the relative age of the bird specimens (Bovy, 2011; Broughton, 2004). 'Adult' specimens have developed cortical bone and muscle attachments. 'Juvenile' specimens may approach adult size, but lack complete development of cortical bone, and muscle attachments may or may not be present. Finally, 'chicks' are small in size, porous, and lack cortical bone and muscle attachments. Only 14 of the Č̓ix̣ʷicən bird bones appeared to be sub-adult (all 'juveniles').

Burn/ Burn Type

The presence/absence (yes or no) of burning was recorded in the 'Burn' field. The decision of whether a bone fragment was burnt was made primarily on the basis of color. Three different kinds of burning types were recorded: 'burnt' (darkly discolored or blackened), 'calcined' (whitish, grayish or bluish), and 'partially burnt on shaft' (bones that appeared to have been intentionally heated mid-shaft/element and broken). Because bone specimens showed a wide range of colors that could be interpreted as staining rather than burning, we took a conservative approach to identifying burning and thermal alteration. See Bovy (2018: Sec. 5.1: Burning/heat modification) for more details on burning.

Initial ID

The 'Initial ID' field was a way to keep track of bird bones that were initially mis-sorted (by LAAS laboratory staff) as mammal, fish or shell, pulled by Etnier, Butler or Campbell, and later transferred to my lab for analysis.

ID Comments

This field provides additional information on the specimen not already captured in another field, including taxonomic identification notes (e.g., thoughts or impressions on what the likely taxon may be), details about the condition of the bone (e.g., whether the specimen was fragmented or refit), and additional notes on surface modifications. Comments about the catalog # or provenience were also recorded here.

Original ID

In the process of writing this report, I made minor updates to the database to make the finest taxon identifications more standardized (e.g., deleting sizing information if this was not consistently done throughout the analysis). I preserve the earlier identification in this column, since that is the taxonomic name written on the analysis labels on the bags themselves, which had already been returned to the Burke Museum.

Modification

Characteristics such as surface alteration or carnivore damage, and cultural modification were recorded if obviously present. However, specimens have not been systematically examined under a microscope. See Bovy (2018: Sec. 5.: Taphonomic summary) for more information.

Photo

A small number of specimens were photographed to document modifications (especially cut marks, burning and fragmentation) or to aid in analysis. 'Yes' was recorded in this field if photos were taken, and a separate excel spreadsheet of all the photos taken was created (on file at the Burke Museum).

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