Appendix C:
An Analysis of Three Shellfish Assemblages from Ts'ishaa, Site DfSi-16 (204T), Benson Island, Pacific Rim National Park Reserve of Canada

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Introduction

This report describes and analyzes marine shellfish recovered from three archaeological excavation units at the Tseshaht village of Ts'ishaa (DfSi-16). The mollusc materials were collected from two different areas investigated in 1999 and 2001. The source areas are located within the village proper and on an elevated landform positioned behind the village. The two areas contain stratified cultural deposits dating to the late and middle Holocene periods, respectively.

With an emphasis on mollusc species identification and quantification, this preliminary analysis examines discarded shellfood remains that were collected and processed by the site occupants for approximately 5,000 years. The data, when reviewed together with the recovered vertebrate fauna materials, will contribute to our understanding of past ecosystems and subsistence patterns in the Barkley Sound area. Furthermore, the analyses of both invertebrate and vertebrate remains will augment interpretations regarding local food resource availability, habitat exploitation, food procurement strategies, scheduling of human and food resources, and pre-contact economics.

This study comprises four sections. It commences with a description of the field and post-field procedures used in the identification and quantification of the invertebrate samples. The second section consists of descriptions and comparisons of the assemblages, highlighting intra-site and temporal patterns. Other quantitative and interpretative studies are presented in the third section with discussions exploring grain size distributions, bivalve umbo counts, dietary contributions of different shellfish species, intertidal habitats exploited, and species ubiquity. The fourth section includes a conclusion.

The marine mollusc assemblages discussed below were obtained using a vertical column sampling strategy. During the 3-year archaeological project, column sampling, plus a second shell data collecting method, hand-collection/screen sampling, were used to recover seven shellfish data sets for investigating the site's invertebrate materials. The analysis reported here focuses on three column assemblages collected by the researcher during the 1999 (Unit S14–16/W25–27) and 2001 (Units S56–57/W50–52, S62–64/W62–64) excavations only.

Procedures and Methods of Quantification and Identification

The primary purpose of collecting and examining the Ts'ishaa shellfish remains was to sample, identify, and quantify the marine invertebrate species for each major stratigraphic layer. Sets of quantitative information were compiled through out the analysis in order to accomplish these objectives. In addition, the data sets were used to explore other interpretative studies, such as: to examine patterns in intertidal shell gathering strategies and subsistence through time and space; to identify particular habitats exploited for shellfish gathering; to make intra-site comparisons between the late and early temporal components; and to contribute information on shell midden site formation processes by examining the grain-size distributions of specific shell species per stratigraphic layer and excavation area.

This section describes the procedures used for processing the marine shell samples in the field and laboratory and the methods of species identification and quantification. While the discussion below focuses on the three 1999 and 2001 column assemblages, information pertaining to all seven column and hand-collection/screen sample data sets are presented for interest to other researchers.

Field and Laboratory Processing of Column and Hand-Collection/Screen Samples

Four vertical column and three hand-collection/screen sample assemblages of various sizes and volumes were collected during the 3-year excavation project at Ts'ishaa for the purpose of analyzing shellfish and small vertebrate remains. All column and hand-collection/screen samples were removed by trowel.

Two of the four columns (1999 Unit S14–16/W25–27, 2000 Unit N2–4/W102–104) were collected at the same time that their respective units were being excavated; two (2001 units S62–64/W62–64 and S56–57/W50–52) were removed after excavations were completed. In most cases, the sediment samples were collected in 10 cm levels (at maximum) to the base of each matrix layer, thus eliminating concerns regarding stratigraphic mixing and ensuring uncontaminated samples for later inter-layer comparisons. In the field the samples were stored in plastic zip-lock bags for later water screening through a series of nested hand screens comprising four mesh sizes: 25 mm (1"), 12.5 mm (½"), 6.3 mm (¼"), and 3 mm (⅛"). The objective of processing the shellfish assemblages through the nested screens was to quantify relative abundance of shellfish taxa, to interpret grain size distributions of selected invertebrate species, and to examine breakage patterns and taphonomic processes by level and stratigraphic layer. One column, from 1999 Unit S14–16/W25–27, was water screened and sorted on site for public interpretation purposes. The two 2001 columns were washed and processed in the Parks Canada archaeology lab, Victoria. Unit N2–4/W102–104 column sample, recovered from the west end of the village midden in 2000, was not examined.

Due to time constrains and the rich abundance of shell material, not all level samples from the 1999 and 2001 column assemblages were examined (Table 1). Approximately 50% or more level samples (odd number only) in columns S62–64/W62–64 and S56–57/W50–52 from the elevated landform behind the village were studied. In column S14–16/W25–27, located in the central portion of the village midden proper, only 12 of 37 level samples were analyzed because of the depth of cultural deposits (3.5 m dbs). Table 1 summarises column sample and volumetric data for those assemblages discussed in this study.

The three column samples were placed so that they would intersect all shell-bearing stratigraphic layers within their corresponding excavation units. The two early component column samples from units S62–64/W62–64 and S56–57/W50–52 intersected four (A–D) and two (B–C) stratigraphic layers, respectively. Late component column sample, S14–16/W25–27, intersected six of seven stratigraphic layers extending through its unit (A–C, E–G). Stratigraphic layers in the midden deposits were not continuous between excavation units, and as such stratigraphic Layer A located in the main village midden does not correspond with an upper-lying Layer A on the elevated landform deposit behind the village.

Three hand-collection/screen grab sample data sets were also collected for marine mollusc species identification and quantification. These assemblages included: two recovered from the village midden proper, 1999 Unit S14–16/W25–27 and 2000 Unit N2–4/W102–104; together with screen materials recovered from 2001 Unit S62–64/W62–64, positioned on an elevated landform behind the village midden proper. All hand-collection/screen grab samples were collected from three excavation units that measured 2 x 2 metres. Most levels measured 10 cm thick, but in some cases they varied in volume according to the thickness and configuration of the matrix layer.

The hand-collection/screen sample shellfish assemblages comprised mostly whole shell specimens, valves with hinges and umbones, and samples of gastrapods, univalves, and barnacles that were troweled or hand collected during excavation or grabbed from the ¼" sifting screen. Following collection, the hand collected/screen specimens were placed into their respective marked provenience bags (paper) and stored for later identification. In using this strategy, larger and whole shell specimens are well represented, while smaller and more friable molluscs tend to be under represented. The potential biases and subsequent results and misinterpretations from using this judgemental sampling technique have been stressed elsewhere by Northwest Coast archaeologists (Frederick 2002, pers comm.; Hanson 1991; Muckle 1986).

Table 1. Ts'ishaa shellfish column sample and volume data.

Column Sample	# of Levels Examined	Sample Volume (x 1000 cm^3)	Level Sample Size	Sample Fraction by Vol	# of Major Stratigraphic Layers in Column	Vertical Depth of Column (m dbs)	Analytical Sample Wt (g)
S14–16/W25–27	12	71.9	25 x 25 x 10	33%	6	3.50 m	32,964.8
S56–57/W50–52	13	12.9	10 x 10 x 10	52%	2	2.49 m	5,812.3
S62–64/W62–64	5	20	20 x 20 x 10	55%	4	0.88 m	4,885.2

In the laboratory, all selected column sediment samples were weighed prior to processing. The samples were then dumped into the top of four stacked 8-inch diameter sieves (25 mm, 12.5 mm, 6.3 mm, 3 mm), gently shaken, and washed. The contents from each sieve was placed onto newspaper and air-dried for later sorting and weighing. Sieved materials measuring less than ⅛" (3 mm) were not examined. All dried samples were then hand sorted and the constituents separated into three groups: shell, vertebrate fauna, and non-fauna. Non-fauna material comprised rocks, rootlets, and charcoal. Found artifacts were collected and submitted for cataloguing. The constituents from each mesh size were then weighed and the information recorded on shell data record code sheets. Non-fauna materials were discarded after weighing. Vertebrate fauna were weighed, with weights documented on the shell data sheets, bagged by grain size, and then stored for later identification.

Method of Identification

All shell remains from Ts'ishaa were identified using a Parks Canada comparative collection and an assortment of reference texts on marine invertebrate taxonomy, including: Harpo (1997), Coan et al. (2000), Quayle (1960), Cornwall (1970), Griffith (1967), and Morris (1996). In general, the identification of whole shells, valves with hinges and umbone, and large fragments with exterior markings were usually easily completed; decreasing fragment size, however, reduced identifiability and consumed more time. Where identification allowed, taxonomic classification was made to the species-, genus-, and family-levels. In some cases, more generalised categories were used, for example, unidentified clam and unidentified shell.

In conjunction with species identification, data recording activities included documenting the state of specimen completeness, evidence of burning, and the presence of exterior exfoliation or erosion.

Methods of Quantification

In this analysis, mollusc taxon weights and bivalve umbo counts were quantified first for each level selected for examination and then values totalled by stratigraphic layer. As mentioned above, due to time constraints and the size of column samples collected, only 33% to 55% of each column by volume was subject to identification and analysis. Small, broken, and washed shell fragments measuring less than ⅛" and calcite/calcium carbonate debris accumulated as a result of sample handling and processing were not examined, but were saved for later inspection.

Shellfish remains were quantified using shellfish weights and relative frequency. Quantification measures of bivalve species are also supported with umbo (or beak) counts. While some researchers have identified problems with using shellfish weight and umbo count as shellfish quantification variables (Calvert 1980; Classen 1998), the application of these variables with column sample data is deemed a more reliable representative unit of measurement than relying on 6.3 mm (¼") hand-collection/screen shell data.

All shellfish remains were weighed on an electronic scale with a minimum capacity of 0.1 grams. Shell taxa were recorded by stratigraphic unit and by column sample assemblage, thus allowing for intra-stratigraphic layer, intra-assemblage, and intra-site comparisons.

Descriptions and Comparison of Column Shellfish Assemblages

The following section presents a description and comparison of the three column shellfish assemblages. A general description for the over-all site assemblage is first given, followed by a more detailed examination of intra-assemblage variations by inclusive shellfish groups. This is then succeeded by a detailed discussion of each individual assemblage.

Site Assemblage Variation

A total of 43.7 kg of shellfish was examined, identified, and analyzed during this study (Table 2). Over 75% of this material by weight is associated with the 1999 column sample from Unit S14–16/W25–27, located in the main village midden. Radiocarbon dates collected in the vicinity of 1999 column S14–16/W25–27 indicate that this part of the site was first occupied approximately 1800 years before present. The 1999 column is temporally affiliated with the later period of Mitchell's (1990) West Coast Culture Type. The remaining 24.5% of the shellfish materials are from two column assemblages recovered in units S56–57/W50–52 and S62–64/W62–64. Excavated in 2001, the two latter units were located on an elevated landform positioned behind the main village. The two 2001 units yielded radiometric dates ranging 2960–4850 calibrated years before present.

Table 2. Relative frequencies of Ts'ishaa column sample shellfish remains (≥3 mm) by mollusc taxa family.

COMPONENT	Late Component Assemblage						Early Component Assemblages					
COLUMN SAMPLE	S14–16/W25–27						S56–57/W50–52		S62–64/W62–64			
STRATIGRAPHIC LAYER	A	B	C	E	F	G	B	C	A	B	C	D
MOLLUSC TAXA FAMILY												
Glycymerididae (Bittersweet Clam)	<0.1%											
Mytilidae (Mussel)	78.4%	85.5%	92.3%	95.3%	86.3%	84.2%	92.5%	93.4%	91.8%	95.9%	95.6%	95.2%
Pectinidae (Scallop)				<0.1%								
Carditidae (Cardita Clam)	<0.1%											
Cardiidae (Cockle)	<0.1%		<0.1%	<0.1%	0.2%							
Veneridae (Venus Clam)	3.4%	2.2%	0.7%	0.6%	1.4%	1.2%	0.3%	0.1%		0.8%		
Mactridae (Horse Clam)	0.9%		0.3%		0.5%	0.1%				<0.1%		
Hiatellidae (Nestling Saxicave Clam)	<0.1%		<0.1%	<0.1%	<0.1%		<0.1%					
Unidentified Clam	3.3%	1.7%	0.7%	0.3%	5.1%	3.3%	1.3%	0.9%	4.7%	1.4%	0.6%	0.3%
Haliotidae (Abalone)	0.1%	0.7%	0.2%		<0.1%	<0.1%	<0.1%	<0.1%				
Fissurellidae (Keyhole Limpet)	<0.1%		<0.1%			<0.1%				<0.1%		
Turbinidae (Turban Snail)	<0.1%	2.2%	<0.1%	<0.1%	<0.1%	0.7%	0.1%			0.6%		
Acmaedidae ("True" Limpet)	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%		<0.1%		
Littorinidae (Periwinkle)	<0.1%			<0.1%		<0.1%	<0.1%			<0.1%		
Lacunidae (Lacuna Shell)	<0.1%		<0.1%	<0.1%		<0.1%						
Cerithiidae (Bittium Snail)	<0.1%			<0.1%								
Calyptraeidae (Slippersnail)			<0.1%	<0.1%						<0.1%		
Muricidae (Rocksnail)			<0.1%	<0.1%			<0.1%					
Nucellidae (Dogwinkle)	<0.1%	0.1%	0.1%	0.1%	<0.1%	0.2%	0.1%	0.1%		0.1%	<0.1%	0.4%
Buccinidae (Whelk)				<0.1%				<0.1%				
Columbellidae (Amphissa & Dove Shell)	<0.1%		<0.1%	0.1%						<0.1%		
Pyramidellidae (Pyramid Snail)	<0.1%		<0.1%									
Indeterminate Marine Snail	<0.1%	<0.1%	<0.1%	<0.1%	0.8%	0.1%	<0.1%	<0.1%		<0.1%	0.1%	<0.1%
Lepidochitonidae (Lined Chiton)			<0.1%									
Mopaliidae (Chiton)	0.1%	0.2%	0.1%	0.2%	<0.1%	0.1%	<0.1%	0.2%		<0.1%		
Acantitochitonidae (Chiton)	<0.1%		0.1%	0.3%	<0.1%	0.1%	<0.1%					
Archaeobalanidae/ Balanidae (Acorn Barnacle)	12.6%	5.2%	4.9%	2.7%	4.2%	8.5%	5.3%	4.5%	3.5%	0.9%	3.3%	3.0%
Scalpellidae (Gooseneck Barnacle)	0.5%	0.5%	0.1%	0.1%	<0.1%	0.1%	0.3%	0.3%		0.1%	0.1%	0.6%
Strongylocentrotidae (Sea Urchin)	0.3%	1.7%	0.2%	0.1%	<0.1%	0.1%	<0.1%	0.3%				
Unidentifiable Shell	0.3%	0.2%	0.1%	0.2%	1.3%	1.2%	0.1%	0.2%		0.2%	0.4%	0.6%
Total Shellfish Remains Weight 100%	**11,784.6 g**	**1,329.8 g**	**8,745.7 g**	**6,593.5 g**	**1,198.2 g**	**3,313.0 g**	**2,943.6 g**	**2,868.5 g**	**17.0 g**	**3,964.6 g**	**796.3 g**	**107.3 g**

In total, 57 marine mollusc species (excluding three general unidentifiable categories) were identified in the three assemblages, indicating that the site occupants exploited a number of intertidal shellfoods and habitats. The site assemblage includes: 12 marine bivalves, 35 univalves (including 25 marine sea snails), five species of chitons, three sea urchins, and two barnacles. The relative contributions of the shellfish taxa to the column sample weight data are presented in Tables 11, 12, 13. The high proportion of mussel *(Mytilus)* in the shellfish remains weight data however obscures the contributions of other smaller and lighter mollusc taxa. Of the 57 identified species, 44 contribute less than 0.1% of the total site shell sample weight. Due of the disproportionate amount of weight represented by California mussel *(Mytilus californianus)* relative to other mollusc shells, relative frequencies by weight of remains for the Family taxonomic level are presented in Table 2.

In both early and late cultural components, California mussel is by far the most dominant shell. This heavily exploited mollusc species contributes between 87% and 96% of the shellfish remains weight in the three column assemblages (Table 3). Lower frequencies of this shell are found in the late component assemblage from the village midden, Column S14–16/W25–27. In this column, mussel weight values range between 78% in Layer A to a maximum high exceeding 95% in Layer E. Tables 2 and 3 show that all stratigraphic layers in both early column assemblages contain high proportions of mussel with values approximating or exceeding 92% of the column shellfish by weight.

Barnacles *(Archaeobalanidae/ Balanidae)* represent the second largest contributor to weight data in both late and early period columns. Table 2 reveals that higher frequencies of acorn barnacle occur in Late Column S14–16/W25–26, ranging

Table 3. Relative frequencies of Ts'ishaa column shell weight data by major shell groups (≥3-mm mesh).

Late Component							
	1999 Column Sample S14–16/W25–27						
Layer	A	B	C	E	F	G	**Totals**
Major Shell Group	%	%	%	%	%	%	%
Mussel	78.4	85.5	92.3	95.3	86.3	84.2	86.6
Clam	7.6	3.8	1.8	0.9	7.2	4.7	4.3
Marine Snail	<0.1	2.2	0.1	0.2	0.8	1.0	0.3
Limpet&Abalone	0.1	0.7	0.2	<0.1	<0.1		0.1
Chiton	0.2	0.2	0.2	0.5	0.1	0.2	0.2
Scallop				<0.1			<0.1
Barnacle	13.2	5.7	5.0	2.8	4.2	8.6	7.9
Sea Urchin	0.3	1.7	0.2	0.1	<0.1	0.1	0.3
Unid Shell	0.3	0.2	0.1	0.2	1.3	1.2	0.3
Shell Totals 100%	**11,784.6 g**	**1,329.8 g**	**8,745.7g**	**6,593.5g**	**1,198.2g**	**3,313.0g**	**32,964.8 g**
Bone Wt	6.1g	74.4g	39.4g	13.4g	16.1g	25.0g	174.4g
Non-Fauna Wt							

Early Component								
	2001 Column Sample S56–57/W50–52			2001 Column Sample S62–64/W62–64				
Layer	B	C	**Totals**	A	B	C	D	**Totals**
Major Shell Group	%	%	%	%	%	%	%	%
Mussel	92.5	93.4	92.9	91.8	95.9	95.6	95.2	95.8
Clam	1.6	1.0	1.3	4.7	2.2	0.6	0.3	1.9
Marine Snail	0.2	0.1	0.2		0.7	0.1	0.4	0.6
Limpet & Abalone	<0.1	<0.1	<0.1		<0.1			<0.1
Chiton	<0.1	0.2	0.1		<0.1			0.2
Barnacle	5.6	4.7	5.2	3.5	1.0	3.4	3.6	1.5
Sea Urchin	<0.1	0.3	0.1					0
UnidShell	0.1	0.2	0.1		0.2	0.4	0.6	0.2
Shell Totals 100%	**2,943.6g**	**2,868.7g**	**5,812.3g**	**17.0g**	**3,964.6g**	**796.3 g**	**107.3 g**	**4,885.2g**
Bone Wt	11.4g	17.9g	29.3g	0.6g	18.2g	7.4g	5.2g	31.4g
Non-Fauna Wt.	564.9g	1,910.3g	2,475.2g	1,892.4g	860.4g	1,086.7g	415.3g	4,254.8g

from 2.7% in Layer E to 12.6% in Layer A. Mean weights for acorn barnacle in the two early assemblages include 4.9% in Column S56–57/W50–52 and 2.7% in Column S62–64/W62–64.

Clams comprise the third most abundant shell group in all three assemblages. The two prominent clams include unidentifiable clam and those belonging to the *Veneridae* Family. Two identified *Veneridae* family species include the butter clam *(Saxidomus gigantea)* and native littleneck clam *(Protothaca staminea)*, with butter clam being the most dominant. The unidentifiable clam material comprises a high number of incomplete clam valves missing large portions of their hinges and/or diagnostic landmarks such as the umbo. Butter clam, coupled with lesser quantities of horse clam *(Tresus)*, probably represent the major contributors to this group. Table 3 indicates that clams are most abundant in the late component, contributing over 4% of shellfish weight in Column S14–16/W25–27. Clam frequencies in the two early columns range between 1.3% and 1.9% only.

The most diverse class of marine shells, with regard to the number of species present, are gastropods. A total of 25 marine snails were identified to the genus level in the three column samples (Tables 11–13). Interestingly, 80% or more of the snails are present in the late component column sample; only 32% occur in the two early shellfish assemblages. In terms of weight, only two marine snail families account for over 0.1% of the total stratigraphic layer sample weight – *Turbinidae* and *Nucellidae* (dogwinkles) (Table 2). Turbin snails (predominantly *Astrea gibberosa)* are most plentiful in Late Column S14–16/W25–27 Layers B and G. The highest relative frequency of dogwinkles occur in Early Column S62–64/W62–64 Layer D.

Intra-assemblage shellfish weight comparisons in more inclusive categories or groups retain a similar pattern. These groupings are presented in Table 3. California mussel is by far the most frequently occurring shellfish material in all stratigraphic layers, in all three assemblages. Barnacle (predominantly *Archaeobalanidae*/*Balanidae*, but also including *Pollicipes polymerus* [gooseneck barnacle]) appears to be a second favourite, particularly in Late Column S14–16/W25–27 Layer A. The highest frequencies of clam are also found in the late period shellfish assemblage. Clams occur most often in Layers A and F and less frequent in the middle portion of the stratigraphic column. In Early Column S62–64/W62–64, Table 3 shows that clams tend to decrease in frequency as one proceeds down through the stratigraphic layers. This pattern, however, may be more a sampling factor than reality, in view of the low shellfish weights for both Layers A and D. The data suggest that sea urchins are more common in Late Column S14–16/W25–27, particularly in Layer B (1.7%). Sea urchin is present in only one of two early column samples. All other shell groups in the columns afford frequencies of less than one percent.

Intra-assemblage Variation

Further important information on shellfish data can be gleaned by examining the distributions and patterns of mollusc variability between stratigraphic layers and column assemblages. Intra-assemblage variations are examined below by investigating major shell groups or classes at the taxon level. Seven major shell groups are discussed (Table 3), including Mussel, Clam, Marine Snail, Limpet & Abalone, Chiton, Scallop, and Barnacle. Species data for each major group are presented in Tables 4–10.

California mussel *(Mytilus californianus)* is the most frequent mussel species in both cultural components and in all three columns. Only traces of the foolish mussel *(Mytilus trossulus)* were identified. The latter species was observed in only one stratigraphic layer in each of the two early period columns, contributing less than 0.1% of the layer weight (Table 4). In Late Column S14–16/W25–27, foolish mussel was found to be more frequent, occurring in four of six stratigraphic layers. It is possible that the distribution of this fragile mussel species may be an effect of preservation, sampling, or environmental change. The British Columbia crenella *(Solamen columbianum)* is rare at Ts'ishaa, with only a single specimen being recovered in Late Column S14–16/W25–27 Layer A.

Relative frequencies of barnacle *(Thoracica* order), the second most abundant major shellfish group by weight, are summarised in Table 5. The Suborder Balanomorpha represents weight data for all recovered *Archaeobalanidae* and *Balanidae* Family (acorn barnacle) specimens, dominated by *B. nubilus*, and including lesser quantities of *Semibalanus cariosus*, *B. glandula*, and possibly other species. Due to time constraints, quantitative data on acorn barnacles were not collected at the species-level.

Acorn barnacle is by far the most frequent barnacle in all three columns, with high values occurring in all stratigraphic layers. Slightly

Table 4. Relative frequencies by weight of shellfish remains within Mussel *(Mytilidae)* Group.

	Late Component						**Early Component**					
	1999 Column Sample S14–16/W25–27						**2001 Column Sample S56–57/W50–52**		**2001 Column Sample S62–64/ W62–64**			
Layer	A	B	C	E	F	G	B	C	A	B	C	D
Mussel Group	%	%	%	%	%	%	%	%	%	%	%	%
Mytilus californianus	99.9	99.9	99.9	99.9	100.0	100.0	100.0	99.9	100.0	99.9	100.0	100.0
Mytilus trossulus	<0.1	0.1	<0.1	<0.1				<0.1		<0.1		
Solomen columbianum	<0.1											
Wt of all mussel (100%)	9,234.8 g	1,136.6 g	8,068.8 g	6,284.6 g	1,033.5 g	2,790.5 g	2,723.3 g	2,678.8 g	15.6 g	3,802.5 g	760.9 g	102.2 g
Group Wt Totals	**28,548.8 g**						**5,402.1 g**		**4,681.2 g**			

Table 5. Relative frequencies by weight of shellfish remains within Barnacle *(Thoracica)* Group.

	Late Component						**Early Component**					
	1999 Column Sample S14–16/W25–27						**2001 Column Sample S56–57/W50–52**		**2001 Column Sample S62–64/W62–64**			
Layer	A	B	C	E	F	G	B	C	A	B	C	D
Taxa	%	%	%	%	%	%	%	%	%	%	%	%
Archaeobalanidae/Balanidae	95.9	91.9	97.5	96.9	98.6	98.7	95.3	94.6	100.0	88.2	97.4	84.2
Pollicipes polymerus	4.1	8.1	2.5	3.1	1.4	1.3	4.7	5.4		11.8	2.6	15.8
Wt of all barnacle (100%)	1,553.2g	75.6g	441.1g	183.7g	50.9g	285.4g	165.0g	136.2g	0.6g	39.9g	26.6g	3.8g
Group Wt Totals	**2, 589.9 g**						**301.2 g**		**70.9 g**			

lower proportions of acorn barnacle in Early Column S62–64/W62–64 layers B and D reflect increased quantities of goose barnacle *(Pollicipes polymerus)*. The latter observation, however, may be influenced by the small barnacle sample weight.

Clams represent the third most frequent shell group. Table 6 reveals that unidentified clam, most likely comprising mostly broken butter clam and some horse clam valves without identifiable landmarks, are the most abundant material in this group. Unidentified clams occur in all stratigraphic layers, in all columns. Greater quantities of butter clam *(Saxidomus gigantea)*, the largest identified clam taxon, are found in Late Column S14–16/W25–27. Frequencies of this specimen range between 16% and 19% in the middle and lower midden layers, and from 42% and 54% in upper layers A and B. The low occurrence of butter clam in the two early column assemblages is somewhat surprising. Relative proportions of butter clam to others in the Clam Group in the deep 2001 Column S56–57/W50–52 are very low, ranging from 4% in upper Layer B to less than 1% in lower Layer C. In the shallower 2001 Early Column S62–64/W62–64, butter and native littleneck *(Protothaca staminea)* clams are present in Layer B only.

Horse clam (predominantly *Tresus capax)*, the second most common identified clam by weight, has much higher weights in Late Column S14–16/W25–25. Present in four of six stratigraphic layers, larger quantities of horse clam occur in layers A and C, comprising 12% to 16% of the Clam Group weight respectively. Small quantities of native littleneck clam *(Prothaca staminea)*, the third largest identified clam species, are present in the two early columns. Larger quantities of this clam are found in Late Column S14–16/W25–27, with the highest relative frequencies in layers C and E. Rare or absent in the two early assemblages, but more common in Late Column S14–16/W25–27, are the two bivalves, Nuttallii cockle *(Clinocardium nuttallii)* and nestling saxicave *(Hiatella* sp.). Trace amounts of purple-hinged rock scallop *(Crassadoma gigantea)* and carpenter's candita *(Glans carpenteri)* were found only in Late Column S14–16/W25–27. A bivalve species not recovered in the column samples, but present in the hand-collection/screen grab sample, is the Pacific gaper horse clam *(Tresus nuttallii)*. Samples of this

Table 6. Relative frequencies by weight of shellfish remains within Clam and Scallop *(Bivalvia)* Group.

	Late Component						**Early Component**					
	1999 Column Sample S14–16/W25–27						**2001 Column Sample S56–57/W50–52**		**2001 Column Sample S62–64/ W62–64**			
Layer	A	B	C	E	F	G	B	C	A	B	C	D
Taxa	%	%	%	%	%	%	%	%	%	%	%	%
Saxidomus gigantea	42.2	53.6	16.6	16.1	18.0	19.1	4.1	<0.1		26.1		
Clinocardium nuttallii	0.7		2.0	1.3	2.8							
Tresus capax	6.7		10.6									
Tresus sp.	4.8		5.4		6.9	2.6				1.1		
Protothaca staminea	2.3	2.6	24.2	47.1	1.2	7.3	13.9	8.7		9.3		
Glycymeris septentrionalis	0.5							0.7				
Hiatella sp.	<0.1		0.5	0.3	0.3		<0.1					
Glans carpenteri	<0.1											
Unidentified clam	42.8	43.8	40.7	34.6	70.8	71.0	82.0	90.7	100.0	63.4	100.0	100.0
Crassadoma gigantean				0.6								
Wt of all clam/ scallop (100%)	900.9 g	50.9 g	156.5 g	62.8 g	86.6 g	155.7 g	46.0 g	30.0 g	0.8 g	87.0 g	4.9 g	0.3 g
Group Wt Totals	**1,413.4 g**						**76.0 g**		**93.0 g**			

clam species were observed in both 1999 and 2000 hand-collection/screen materials.

The higher frequencies of clam in the late column assemblage, relative to their abundance in the two early assemblages (Table 3), is interesting and possibly suggests that clams may not have been as important economically to the early site occupants as perhaps they were during later times. While this subsistence pattern may be plausible and requires further investigation, shellfish resource availability in Barkley Sound during the middle Holocene period may in fact have been influenced by environmental factors, such as beach habitat development and sea level change. If relative sea level in Barkley Sound reached 3 to 4 m above present levels, and remained at this elevation from about 6000 to 4800 cal BP, as proposed by Friele (1992; Friele and Hutchinson 1993), then the proportions of rocky shore to sediment beach would have been very high with less land mass affording more protected habitat. Subsequent drops in mean sea level following the standstill would likely have resulted in improved beach development and marine biomass productivity. As such, shoreline habitat conducive for producing larger bivalve populations may not have been established again until the late Holocene. Among the marine snails remains, there is an obvious difference between the late and early assemblages (Table 7). Late Column S14–16/W25–27 contains a more diverse sea snail assemblage, of which a significant proportion likely entered the site in an incidental or inadvertent manner. Interestingly, this late period pattern may relate to changes in technology and/or an increase in kelp being discarded on site. Moreover, local environmental and marine conditions during the late Holocene may have been more favourable for producing larger concentrations of kelp offshore. In the late column assemblage, 13 of 25 identified taxa contribute less than 0.1% to the Marine Snail Group by weight. Only a combined total of 11 identified marine snails were found in both early assemblages. Five of the 11 taxa contributed less than 0.1% of the column weight.

The most common marine snail in all three columns is the channelled dogwinkle *(Nucella canaliculata)*. This taxon occurs in all stratigraphic layers, in both cultural components, except Early Column S62–64/W62–64 Layer A. The second most abundant snail is the red turban snail *(Astrea gibberosa)*. This snail is also found in all columns, but most frequently in Late Column S14–16/ W25–27, and particularly layers B and G. Red turban snail is not as common in the early assemblages. It is present in moderate to high amounts in Column S56–57/W50–52 Layer A and Column S62–64/W62–64 Layer B only. The third ranking snail in all three columns is indeterminate marine snail. This category represents those individuals not identifiable to the family or genus level. Also included in this indeterminate category are marine snail opercula, most of which almost certainly

Table 7. Relative frequencies by weight of shellfish remains within Marine Snail *(Gastropoda)* Group.

	Late Component						Early Component					
	1999 Column Sample S14–16/W25–27						2001 Column Sample S56–57/W50–52		2001 Column Sample S62–64/W62–64			
Layer	A	B	C	E	F	G	B	C	A	B	C	D
Taxa	%	%	%	%	%	%	%	%	%	%	%	%
Nucella canaliculata	13.5	2.4	47.6	21.4	<0.1	7.3	34.5	48.5		6.9	20.0	99.9
Nucella emarginata			1.6				5.2	6.1		0.7		
Nucella lamellosa			4.8	43.8		11.8	<0.1	12.1		1.8		
Nucella lima			11.9									
Nucella sp.	<0.1							<0.1				
Astrea gibberosa		94.9	7.9	7.1	4.1	74.5	46.6			85.9		
Tegula funebralis	62.2	2.4										
Tegula pulligo	5.4		10.3									
Ceratostoma foliatum					<0.1							
Crepidula sp.			<0.1							<0.1		
Crepidula adunca			<0.1	<0.1						2.2		
Crepidlula nummaria				<0.1								
Amphissa columbiana			2.4							0.7		
Amphissa sp.			0.8	0.9								
Lirularia sp.	<0.1											
Littorina sitkana	<0.1			<0.1			<0.1			<0.1		
Littorina scutulata	2.7					<0.1						
Bittium eschrichtii	<0.1											
Bittium sp.			2.4	<0.1								
Ocinebrina lurida				<0.1			<0.1					
Ocinebrina interfossa			<0.1									
Searlesia dira				<0.1				<0.1				
Alia gausapala	<0.1		<0.1	<0.1								
Lacuna variegata	2.7		<0.1	<0.1		<0.1						
Turbonilla sp.	<0.1											
Indeterminate marine snail	13.5	0.3	10.3	26.8	95.9	6.4	13.8	33.3		1.8	80.0	<0.1
Wt of all marine snails (100%)	3.7 g	29.5 g	12.6 g	11.2 g	9.8 g	33.0 g	5.8 g	3.3 g	0.0 g	27.7 g	1.0 g	0.4 g
Group Wt Totals	**99.8 g**						**9.1 g**		**29.1 g**			

belong to the red turban snail. Traditionally, the Nuu-chah-nulth and other Northwest Coast native groups used the operculum of the latter snail species for decorative purposes. Two marine snails not found in the three column data sets, but were recovered in the hand-collection/screen samples in adjacent excavation units, include Lewis's moonsnail *(Polinices lewisii)* in Unit S14–16/W25–27 and the baetic olive *(Olivella baetica)* in Unit S62–64W62–64.

Differences in shell content are also obvious in the Limpet & Abalone Group (Table 8). Four limpets in the two early assemblages occur in only trace amounts (<0.1%). Eight limpet species were recovered in the late column sample; most of which occur in larger quantities than those in the early assemblages. The ribbed limpet *(Lottia digitalis)*, the most common limpet, is present in a number of layers in Late Column S14–16/W25–27, but in very small amounts. In Late Column S14–16/W25–27 Layer E, indeterminate limpet *(Lottiidae)* material makes up almost 67% of the sample. Two rare limpet species include the shield limpet *(Lottia pelta)* in Late Column S14–16/W25–27 Layer C, and the fenestrate limpet *(Tectura fenestrata)* in Early Column S62–64/W62–64 Layer B only.

Northern abalone *(Haliotis kamtschatkana)* was recovered in two of the three assemblages. In the Late Column S14–16/W25–27, over 34 g of abalone were found in five of six stratigraphic layers; whereas only 0.6 g of the shell was recovered in Early Column S56–57/W50–52 layers B and C. Seven of nine limpet species from the Ts'ishaa shell assemblage are referenced as having been primary or secondary sources of food (Wessen 1994). Northern abalone was consumed as a food, however its primary function was for decorative or ceremonial purposes.

In the sixth major shellfish group, Chiton, the most abundant species are the black katy

Table 8. Relative frequencies by weight of shellfish remains within Limpet and Abalone *(Gastropoda)* Group.

	Late Component						Early Component					
	1999 Column Sample S14–16/W25–27						2001 Column Sample S56–57/W50–52		2001 Column Sample S62–64/W62–64			
Layer	A	B	C	E	F	G	B	C	A	B	C	D
Taxa	%	%	%	%	%	%	%	%	%	%	%	%
Acmaea mitra			0.6									
Lottia digitalis	<0.1	<0.1	1.3	<0.1			<0.1	<0.1		25		
Tectura persona	2.2		2.5	33.3								
Tectura scutum	<0.1			<0.1								
Lottia pelta			<0.1									
Tectura fenestrata										25		
Lottiidae	<0.1	<0.1	<0.1	66.6	<0.1	<0.1	<0.1			25		
Diodora aspera	<0.1					<0.1						
Fissurellidea bimarculata			<0.1			<0.1				25		
Haliotis kamtschatkian	97.8	99.9	95.5		99.9	99.9	99.9	99.9				
Wt of all limpet/abalone (100%)	9.0 g	8.8 g	15.7 g	0.3 g	0.3 g	1.3 g	0.2 g	0.7 g	0.0 g	<0.1 g	0.0 g	0.0 g
Group Wt Totals	**35.4 g**						**0.6 g**		**<0.1 g**			

(Katharina tunicata) and giant Pacific or gumboot *(Cryptochiton stelleri)* chitons (Table 9). Both taxa are dominant in the Late Column S14–16/W25–27 assemblage, occurring in five or more of the six stratigraphic layers. Black katy is the most abundant chiton in the late period assemblage, yielding high relative proportions (56% to 75%) in five of six layers. These two chiton species were recovered in much smaller quantities however, in the two early columns. In Early Column S56–57/W50–52, the black katy chiton was common throughout. In Early Column S62–64/W62–64, this chiton was observed in Layer B only.

The giant Pacific chiton, a less common species, was recovered in Early Column S56–57/W50–52 Layer B only. The largest quantity of giant Pacific chiton in Late Column S14–16/W25–27 occurs in Layer E. The mossy chiton *(Mopalia muscosa)* was found in both the Late Column S14–16/W25–27 and Early Column S62–64/W62–64 assemblages, but in very small amounts. Mossy chiton comprised only 1.3% of the group's weight in the Late Column S14–16/W25–27 Layer E and less than 0.1% in Early Column S62–64/W62–64 Layer B. Less than 0.1 g of unidentified lined chiton *(Tonicella* sp.) was recovered, this being limited to Late Column S14–16/W25–27 Layer C. Indeterminate chiton *(Mopaliidae* family) occur in low frequencies in each Late Column S14–14/W25–26 stratigraphic layer, and is less common in the two early columns. Wessen (1994) states that both the mossy and black katy chitons were traditionally taken by the Makah and other Nuu-chah-nulth groups as primary food sources. The giant Pacific chiton was pursued as a secondary food source (Wessen 1994:169; Swan and Ellis 1981).

The seventh and final major shellfish class discussed here is the Sea Urchin Group (Table 10). The extremely friable nature of this shellfish has resulted in spines being the primary recovered material, supplemented with small numbers of test and jaw fragments. This group is dominated by the purple sea urchin *(Strongylocentrotus purpuratus)* and indeterminate sea urchin *(Strongylocentrotus* sp.), both being recovered in almost identical quantities. The indeterminate urchin remains are grey in colour, which may possibly represent modification by natural or cultural processes. As such, the latter could not be identified to the species-level. Both sea urchin species were recovered in all stratigraphic layers in Late Column S14–16/W25–27. Very low quantities of sea urchin were found in Early Column S56–57/W50–52, with almost all remains coming from lower Layer C. Sea urchin was not found in Early Column S62–64/W62–64 samples. Green sea urchin *(Strongylocentrotus droebachiensus)* is present in very small amounts in Late Column S14–16/W25–27 layers A and G only. The gonads of all three sea urchin species were traditionally collected as primary prey (Wessen 1994; Ellis and Swan 1981).

In reviewing the above shell assemblages, the preliminary analysis suggests some interesting shellfish use patterns between the two temporal periods. Column weight data show an increase in two economically important shellfish groups on

Table 9. Relative frequencies by weight of shellfish remains within Chiton *(Polyplacophora)* Group.

	Late Component						Early Component					
	1999 Column Sample S14–16/W25–27						2001 Column Sample S56–57/W50–52		2001 Column Sample S62–64/W62–64			
Layer	A	B	C	E	F	G	B	C	A	B	C	D
Taxa	%	%	%	%	%	%	%	%	%	%	%	%
Cryptochiton stelleri	28.6		40.6	63.2	18.2	28.3	53.8					
Katharina tunicata	67.6	75.0	56.3	30.3	72.7	70.0	46.2	79.7		99.9		
Mopallia muscosa				1.3						<0.1		
Tonicella sp.			<0.1									
Mopaliidae	3.8	25.0	3.1	5.2	9.1	1.7		20.3		<0.1		
Wt of all chiton (100%)	18.2 g	3.2 g	19.2 g	31.0 g	1.1 g	6.0 g	1.3 g	6.4 g		0.2 g		
Group Wt Totals	**78.7 g**						**7.7 g**		**0.2 g**			

Table 10. Relative frequencies by weight of shellfish remains within Sea Urchin *(Strongylocentrotidae)* Group.

	Late Component						Early Component					
	1999 Column Sample S14–16/W25–27						2001 Column Sample S56–57/W50–52		2001 Column Sample S62–64/W62–64			
Layer	A	B	C	E	F	G	B	C	A	B	C	D
Taxa	%	%	%	%	%	%	%	%	%	%	%	%
Strongylocentrotus purpuratus	30.9	52.9	82.2	49.3	<0.1	13.8		38.4				
Strongylocentrotus droebachiensus	0.6					<0.1						
Strongylocentrotus sp	68.5	47.1	17.8	50.7	99.9	86.2	100.0	61.6				
Wt of all sea urchin (100%)	34.9 g	22.5 g	20.8 g	7.3 g	0.3 g	2.9 g	<0.1 g	7.3 g				
Group Wt Totals	**88.7 g**						**7.3 g**		**0.0 g**			

site, clams and barnacles, during later occupation. In the late period, clams increase to 4.3% from a mean of 1.6% during the early period; barnacles increase to 7.9% from a mean of 3.4 per cent. With the data in hand, it is difficult at this time to determine whether this relationship may be in response to dietary or environmental change.

A second observation with respect to inter-assemblage variation is species diversity. In the Late Column S14–16/W25–27 assemblage, 56 shellfish species were identified in its six stratigraphic layers. These species encompassed: 12 bivalves, 34 univalves (including 25 marine snails), five chitons, three sea urchins, and two barnacles. Layer C yielded the highest number of different species, producing 37 shellfish taxa. Layers A and E yielded 36 and 31 species, respectively. Column S14–16/W25–27 Layer B contained only 16 different shellfish species.

In Early Column S56–57/W50–52, 23 different shellfish species were found in stratigraphic layers B and C. These included: five bivalves, 11 univalves (including eight sea snails), three chitons, two sea urchins, and two barnacles. Eighteen species were recovered in upper Layer B, whereas lower Layer C yielded 17. In Early Column S62–64/W62–64, 22 shellfish taxa were observed in its four stratigraphic layers: five bivalves, 12 univalves (including eight marine snails), three chitons, and two barnacles. All 22 species were present in thicker Layer B. Only two to four different taxa were noted in thin stratigraphic layers A, C, and D. Evidence for scallops were not found in the two early column assemblages.

Column Assemblage Descriptions

Each column sample assemblage is discussed individually below. Relative frequencies for all shellfish species identified in each column sample assemblage are presented in Tables 11–13.

Late Component, Column S14–16/W25–27 Assemblage (Main Village, Excavation Area 1)

A total of 32,964.8 g of shellfish remains were examined and analyzed from this column assemblage (Table 11), of which 32,854.7 g (99.7%) were identified to the species, genus, or family level. The single 25 x 25 x 350-cm vertical column sample was collected from the NW corner of a 2 x 2-m unit excavated in 1999. The column comprised 37 level samples, most of which measured 25x25x10 cm in volume. Due to time constraints however, only 12 level samples (71.9 cubic decimetres) were examined (33% sampling fraction by volume). In addition to the mollusc remains, other recovered faunal materials included <0.1 g of fringed tubeworm, 3.7 g of terrestrial snail, and 192.0 g of bone. On average, each examined column level sample (≥3 mm) yielded 458.5 g of shellfish remains and 2.7 g of bone per 1 cubic decimetre (1000 cm^3).

Unit S14–16/W25–27 is one of five 2 x 2-m units excavated in a 2 x 10-m trench in the central part of the village midden (Excavation Area 1). The 1999 column intersected six of seven distinct midden stratigraphic layers (A–C, E–G) observed in its excavation unit. In addition to the column sample, a second shellfish data set was collected during excavation and comprised both hand-collection and screen (¼") materials. The hand-collection data set was examined in 1999–2000 by the researcher, and the results summarised elsewhere (McMillan and St. Claire 2000).

Fifty-six identified species of bivalve and univalve molluscs, chitons, sea urchins, and barnacles are present in the Column S14–16/W25–27 assemblage. Mussels are the most common, encompassing almost 87% of the column by weight (Table 3). Barnacles are the next dominant group (7.9%). Clams, including cockles, account for only 4.3% of the assemblage's shellfish weight. All other major shell groups (marine snail, limpet, chiton, scallop, and sea urchin) contribute less than 1% to the sample weight each.

California mussel *(Mytilus californianus)* is the most dominant shell taxon, comprising 86.6% of the shellfish remains by weight (Table 11). Unidentified clam and butter clam are the most common clam materials, together making up 3.5% of the total sample weight. All other bivalve species contribute to less than 0.8% combined. Column Layer A, which encompasses 36% of the shellfish assemblage by weight, contains the highest frequency of California mussel (32%) and clams (64%) (Figure 1).

In the Marine Snail Group, red turban snail *(Astrea gibberosa)*, channelled dogwinkle *(Nucella canaliculata),* and frilled dogwinkle *(Nucella lamellosa)* are the most dominant species, encompassing over 76% of the group's weight combined. The highest proportions of marine snails were encountered in stratigraphic layers B (30%) and G (33%) (Figure 1). Within the Limpet & Abalone Group, northern abalone *(Haliotis kamtschatkana)* is the chief shell, comprising almost 97% of the group weight. 43% of all abalone was recovered in Layer C. The mask limpet *(Tectura persona)* is the most prevalent limpet found. Traces amounts of various small marine snails were recovered from two midden layers positioned midway down the stratigraphic profile, layers C and E (Table 11).

In the Barnacle Group, various subspecies of acorn barnacle contribute to more than 96% of the group weight. Although none of this family were identified or quantified to the species-level, three dominant species were observed: *Balanus nubilus*, *Semibalanus cariosus*, and *B. glandula*. The gooseneck barnacle *(Pollicipes polymerus)*, a primary food source, is also present (3.5% of group weight). Although the gooseneck barnacle was found in all six layers of Column S14–16/W25–27, it never exceeds 8% of the group's layer weight (Table 5). The majority (60%) of barnacle material was recovered in Layer A (Figure 1).

In the Chiton Group, the giant Pacific *(Crytochiton stelleri)* and black katy *(Katharina tunicata)* are most common chiton species. Recovered in almost equal quantities, higher proportions of giant Pacific chiton were found in stratigraphic Layer E, whereas the majority of black katy chiton was recovered in Layer A (Figure 1).

With respect to the Sea Urchin Group, purple sea urchin and indeterminate sea urchin are the most popular. Almost 40% of the purple sea urchin was recovered in Layer C, whereas over 53% of the indeterminate sea urchin material was found in stratigraphic Layer A.

The relative contributions of the seven major shellfish groups by stratigraphic layer for the Late Period Column S14–16/W25–27 is presented below in Figure 1.

Early Component, Column S56–57/W50–52 Assemblage (Elevated landform)

A total of 5,812.3 g of shellfish remains were retained for analysis from this assemblage (Table 12). Of this sample, 5,804.0 g (99.9%) were identified. The assemblage comprises a

Table 11. Relative frequency of shellfish taxa and data weight by layer (≥3 mm), Late Period Column S14–16/W25–27.

STRATIGRAPHIC LAYER	A	B	C	E	F	G	Taxa Totals	
TAXA								
Bivalvia	%	%	%	%	%	%	Wt	%
Mytilus californianus	78.4	85.4	92.3	95.3	86.3	84.2	28,545.8	86.6
Mytilus trossulus	< 0.1	< 0.1	< 0.1	< 0.1			2.9	< 0.1
Solamen columbianum	< 0.1						< 0.1	< 0.1
Saxidomus gigantea	3.2	2.1	0.3	0.2	< 0.1	0.9	488.9	1.5
Clinocardium nuttallii	< 0.1		< 0.1	< 0.1	0.2		13.1	< 0.1
Tresus capax	0.5		0.2				76.7	0.2
Tresus sp	0.4		0.1		0.5	0.1	61.6	0.2
Protothaca staminea	0.2	0.1	0.4	0.4	0.1	0.3	101.4	0.3
Glycymeris septentrionalis	< 0.1						4.5	<0.1
Hiatella sp	<0.1		<0.1	<0.1	<0.1		1.4	<0.1
Glans carpenteri	<0.1						<0.1	<0.1
Unidentified Clam	<0.1	1.7	0.7	0.3	5.1	3.3	665.4	2.0
Crassadoma gigantea				<0.1			0.4	<0.1
Gastropoda								
Nucella canaliculata	<0.1	0.1	0.1	<0.1	<0.1	0.1	12.0	<0.1
Nucella emarginata			<0.1				0.2	<0.1
Nucella lamellosa			<0.1	0.1		0.1	9.4	<0.1
Nucella lima			<0.1				1.5	<0.1
Nucella sp	<0.1						<0.1	<0.1
Astrea gibberosa		2.1	<0.1	<0.1	<0.1	0.7	54.8	0.2
Tegula funebralis	<0.1	<0.1					3.0	<0.1
Tegula pulligo	<0.1		<0.1				1.5	<0.1
Ceratostoma foliatum					<0.1		<0.1	<0.1
Crepidula sp			<0.1				<0.1	<0.1
Crepidula adunca			<0.1	<0.1			<0.1	<0.1
Crepidula nummaria				<0.1			<0.1	<0.1
Amphissa columbiana			<0.1				0.3	<0.1
Amphissa sp			<0.1	<0.1			0.2	<0.1
Lirularia sp	<0.1						<0.1	<0.1
Littorina sitkana	<0.1			<0.1			<0.1	<0.1
Littorina scutulata	<0.1					<0.1	0.1	<0.1
Bittium eschrichtii	<0.1						<0.1	<0.1
Bittium sp			<0.1	<0.1			0.3	<0.1
Ocenebra lurida				<0.1			<0.1	<0.1
Ocenebra interfossa			<0.1				<0.1	<0.1
Searlesia dira				<0.1			<0.1	<0.1
Alia gausapala	<0.1		<0.1	<0.1			<0.1	<0.1
Lacuna variegata	<0.1		<0.1	<0.1		<0.1	0.1	<0.1
Turbonilla sp	<0.1						<0.1	<0.1
Indeterminate marine snail	<0.1	<0.1	<0.1	<0.1	0.8	0.1	16.4	<0.1
Acmaea mitra			<0.1				0.1	<0.1
Lottia digitalis	<0.1	<0.1	<0.1	<0.1			0.2	<0.1
Tectura persona	<0.1		<0.1	<0.1			0.7	<0.1
Tectura scutum	<0.1			<0.1			<0.1	<0.1
Lottia pelta			<0.1				<0.1	<0.1
Lottiidae	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1
Diodora aspera	<0.1					<0.1	<0.1	<0.1
Fissurellidea bimarculata			<0.1			<0.1	<0.1	<0.1
Haliotis kamtschatkana	0.1	0.7	0.2		<0.1	<0.1	34.2	0.1
Polyplacophora								
Cryptochiton stelleri	<0.1		0.1	0.3	<0.1	0.1	34.5	0.1
Katharina tunicata	0.1	0.2	0.1	0.1	<0.1	0.1	39.9	0.1
Mopalia muscosa				<0.1			0.4	<0.1
Tonicella sp.			<0.1				<0.1	<0.1
Mopaliidae	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.9	<0.1
Echinoidea								
Strongylocentrotus purpuratus	0.1	0.9	0.2	0.1	<0.1	<0.1	43.8	0.1
Strongylocentrotus droebachiensus	<0.1					<0.1	0.2	<0.1
Strongylocentrotus sp	0.2	0.8	<0.1	0.1	<0.1	0.1	44.7	0.1
Cirripedia								
Archaeobalanidae/Balanidae	12.6	5.2	4.9	2.7	4.2	8.5	2498.2	7.6
Pollicipes polymerus	0.5	0.5	0.1	0.1	<0.1	0.1	91.7	0.3
Unidentified Shell	0.3	0.2	0.1	0.2	1.3	1.2	110.1	0.3
Total Marine Invertebrates Wt (100%)	**11,784.6 g**	**1,329.8 g**	**8745.7 g**	**6,593.5 g**	**1,198.2 g**	**3,313.0 g**	**32,964.8 g**	**100%**
Fringed tube worm Wt			< 0.1 g	< 0.1 g			< 0.1 g	
Terrestrial snail Wt	0.4 g	1.1 g	2.2 g	< 0.1 g			3.7 g	
Bone Wt	23.7 g	74.4 g	39.4 g	13.4 g	16.1 g	18.3 g	192.0 g	

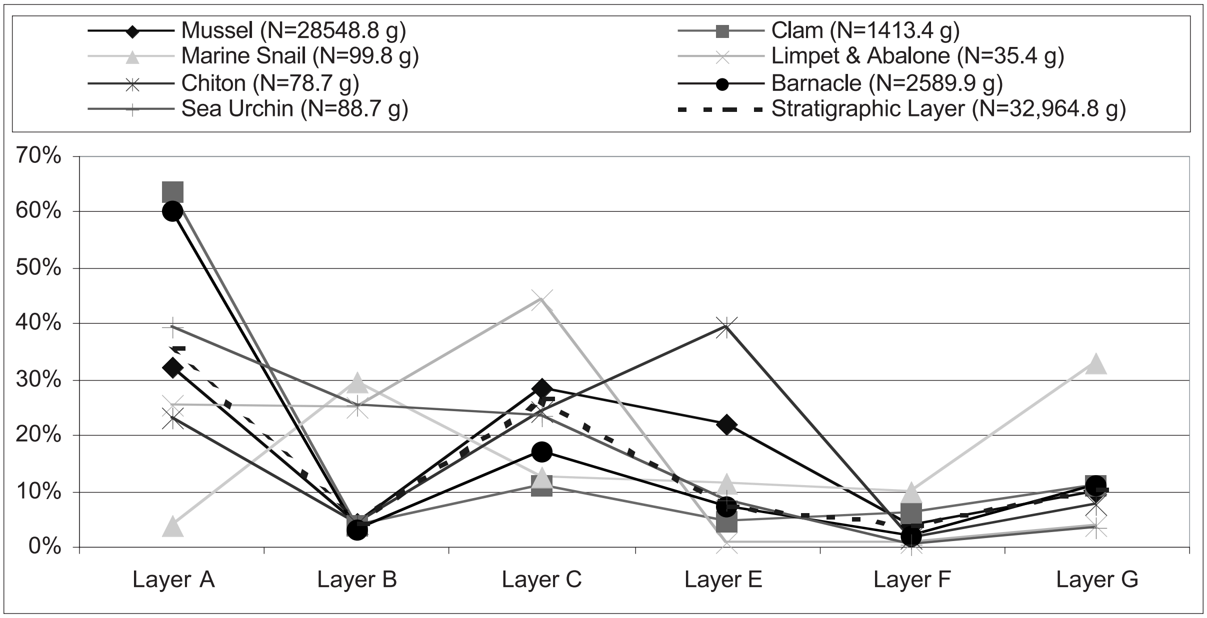


Figure 1. Relative contribution of major shellfish groups by stratigraphic layer, Late Period Column S14–16/W25–27 assemblage.

Table 12. Relative frequency (%) of shellfish taxa and data weight by layer (≥3 mm), Early Period Column S56–57/W50–52 assemblage.

STRATIGRAPHIC LAYER	B	C	Taxa Totals	
TAXA				
Bivalvia	%	%	Wt	%
Mytilus californianus	92.5	93.4	5,402.1	92.9
Mytilus trossulus		<0.1	<0.1	<0.1
Saxidomus gigantea	0.1	<0.1	1.9	<0.1
Protothaca staminea	0.2	0.1	9.0	0.2
Glycymeris septentrionalis		<0.1	0.2	<0.1
Hiatella sp	<0.1		<0.1	<0.1
Unidentified Clam	1.3	0.9	64.9	1.1
Gastropoda				
Nucella canaliculata	0.1	0.1	3.6	0.1
Nucella emarginata	<0.1	<0.1	0.5	<0.1
Nucella lamellosa	<0.1	<0.1	0.4	<0.1
Nucella sp		<0.1	<0.1	<0.1
Astrea gibberosa	0.1		2.7	<0.1
Littorina sitkana	<0.1		<0.1	<0.1
Ocenebra lurida	<0.1		<0.1	<0.1
Searlesia dira		<0.1	<0.1	<0.1
Indeterminate marine snail	<0.1	<0.1	1.9	<0.1
Lottia digitalis	<0.1	<0.1	<0.1	<0.1
Lottiidae	<0.1		<0.1	<0.1
Haliotis kamtschatkana	<0.1	<0.1	0.6	<0.1

STRATIGRAPHIC LAYER	B	C	Taxa Totals	
TAXA				
Polyplacophora	%	%	Wt	&
Cryptochiton stelleri	<0.1		0.7	<0.1
Katharina tunicata	<0.1	0.2	5.7	0.1
Mopallidae		<0.1	1.3	<0.1
Echinoidea				
Strongylocentrotus purpuratus		0.1	2.8	0.1
Strongylocentrotus sp	<0.1	0.2	4.5	0.1
Cirripedia				
Archaeobalanidae/ Balanidae	5.3	4.5	286.1	4.9
Pollicipes polymerus	0.3	0.3	15.1	0.3
Unidentified Shell	0.1	0.2	8.3	0.1
Total Marine Invertebrate Wt (100%)	**2,943.6 g**	**2,868.7 g**	**5,812.3 g**	**100%**
Fringed tube worm Wt	<0.1 g		<0.1 g	
Terrestrial snail Wt		0.5 g	0.5 g	
Bone Wt	11.4 g	23.9 g	35.3 g	
Non-Fauna Wt	564.9 g	2,649.2 g	3,214.1 g	

single 10 x 10 x 249-cm vertical sediment column collected midway along the south wall of 1 x 2-m Excavation Unit S56–57/W50–52. This unit, excavated in 2001, was located towards the front of an elevated landform situated behind the village midden. The column consisted of 25 level samples. The upper 24 level samples measured 1 cubic decimetre (1000 cm^3) in volume; the basal level measured 900 cubic centimetres. Due to time constraints, only the 13 odd-numbered level samples (12.9 cubic decimetres) were examined (52% sampling fraction).

The column encompassed all three stratigraphic layers (A, B, C) observed in the 1 x 2-m unit. Layer A is a thin shell-free Ah soil horizon that caps upper midden Layer B. Almost 51% of the shellfish sample weight was from Layer B. In addition to the shellfish remains, other sample constituents included: fringed tubeworm (<0.1 g), terrestrial snail (0.5 g), vertebrate fauna (35.3 g), and non-fauna material (3,214.1 g) (Table 12). On average, each examined column level sample (≥3 mm) yielded 450.6 g of shellfish remains, 2.7 g of bone, and 249.3 g of non-fauna material per 1 cubic decimetre (1000 cm^3).

Twenty-three species of bivalve and univalve molluscs, chitons, sea urchins, and barnacles were identified in the assemblage (Table 12). Mussels are the most prevalent group, contributing 92.9% of the column sample weight. Next is the Barnacle Group, representing 5.2% of the total assemblage weight (Table 3). Clams are less frequent, making up only 1.3% of the total sample weight. The Marine Snail, Limpet, Chiton, and Sea Urchin groups are also poorly represented, each consisting of less than 0.2% of the total sample weight. Scallops are not present in the column assemblage.

In the Mussel Group, California mussel *(Mytilus californianus)* is the most common mussel taxon (Table 4). It encompasses almost all the group by weight, except for <0.1% of foolish mussel *(Mytilus trossulus)* in Layer C. Just over 50% of all mussel was recovered in upper Layer B (Figure 2). In layers B and C, *Archaeobalanidae* and *Balanidae* materials make up 94.6% and 95.3% of the Barnacle Group shell weight respectively (Table 5). Column Layer B yielded approximately 55% of the barnacle material.

Four identified clam species and an unidentifiable category are present in the Clam Group. Of these five however, only three clams exceed 1% of the group by weight: butter, littleneck, and unidentified clam (Table 6). Almost 61% of all clam occurred in Layer B (Figure 2). Unidentified clam, which more than likely contains a high proportion of broken butter and possible horse clam valves without hinges or umbones, is the most prevalent clam material in both stratigraphic layers. In layers B and C, unidentified clam remains comprise 82.0% and 90.7% of the group shell weight respectively (Table 6).

The relative frequency values for the other major shell groups in Early Column S56–57/W50–52 are summarised in Tables 7–10. Within the Marine Snail Group, the most common taxa are the red

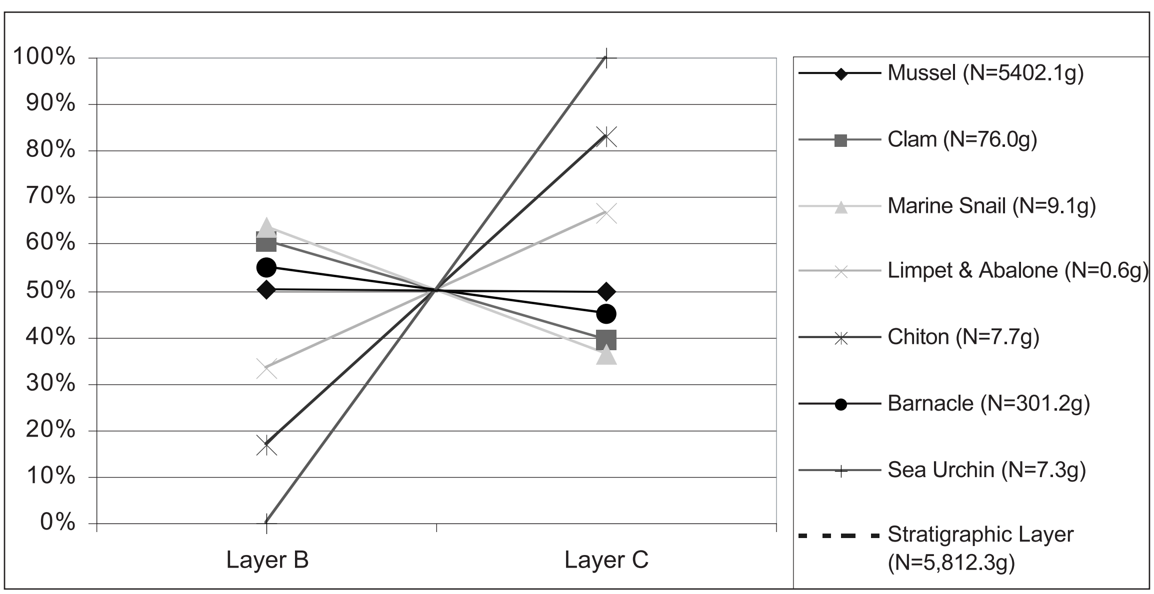


Figure 2. Relative contribution of major shellfish groups by stratigraphic layer, Early Period Column S56–57/W50–52 assemblage.

turban snail (46.6%) in Layer B and the channelled dogwinkle (48.5%) in Layer C. Limpets are poorly represented, with northern abalone comprising more than 99% of the Limpet & Abalone Group weight for each layer. The giant Pacific (53.8%) and black katy (46.2%) represent the chiton remains in Layer B. The dominant chiton species in Layer C is the black katy *(Katharina tunicata)* (79.7%). Indeterminate sea urchins dominate the Sea Urchin Group.

The relative contributions of all major shellfish groups by stratigraphic layer in the Early Period Column S56–57/W50–52 assemblage are presented in Figure 2.

Early Component, Column S62–64/W62–64 Assemblage (Elevated landform)

Of the 4,885.2 g of mollusc remains examined in this assemblage, 4874.4 g (99.8%) were identified to species, genus, or family (Table 13). The assemblage was collected from a single 20 x 20 x 88-cm vertical sediment column positioned midway along the north wall of 2 x 2-m Excavation Unit S62–64/W62–64. The unit was excavated approximately 11 m southwest of Unit S56–57/W50–52 in 2001, on an elevated landform positioned behind the main village. Eleven sediment samples from nine levels make up the column. Nine of the 11 sediment samples measured 20 x 20 x 10-cm in size; two measured less: 20 x 20 x 4 cm and 20 x 20 x 8 cm. Due to time constraints, only the five odd-numbered level samples (20 cubic decimetres total) were examined (55% sampling fraction by volume).

The column sample intersected all four distinct stratigraphic layers (A, B, C, D) occurring in its adjoining 2 x 2-m excavation unit. (A second shellfish assemblage, comprising hand-collected samples of level/screen marine vertebrate remains, was collected but is not reviewed here). Stratigraphic layers B and C encompass the largest proportions

Table 13. Relative frequency of shellfish taxa and data weight by layer (≥3 mm), Early Period Column S62-64/W62-64 assemblage.

STRATIGRAPHIC LAYER	A	B	C	D	Taxa Totals	
TAXA						
Bivalvia	%	%	%	%	Wt (g)	%
Mytilus californianus	91.8	95.9	95.6	95.2	4,681.2	95.8
Mytilus trossulus		<0.1			<0.1	<0.1
Saxidomus gigantea		0.6			22.7	0.5
Tresus sp		<0.1			1.0	<0.1
Protothaca staminea		0.2			8.1	0.2
Unidentified Clam	4.7	1.4	0.6	0.3	61.2	1.3
Gastropoda						
Nucella canaliculata		<0.1	<0.1	0.4	2.5	0.1
Nucella emarginata		<0.1			0.2	<0.1
Nucella lamellosa		<0.1			0.5	<0.1
Astrea gibberosa		0.6			23.8	0.5
Crepidula sp		<0.1			<0.1	<0.1
Crepidula adunca		<0.1			0.6	<0.1
Amphissa columbiana		<0.1			0.2	<0.1
Littorina sitkana		<0.1			<0.1	<0.1
Indeterminate marine snail		<0.1	<0.1	<0.1	1.3	<0.1
Lottia digitalis		<0.1			<0.1	<0.1
Tectura fenestrata		<0.1			<0.1	<0.1
Lottiidae		<0.1			<0.1	<0.1
Fissurellidea bimarculata		<0.1			<0.1	<0.1
Polyplacophora						
Katharina tunicata		<0.1			0.2	<0.1
Mopalia muscosa		<0.1			<0.1	<0.1
Mopaliidae sp.		<0.1			<0.1	<0.1
Cirripedia						
Archaeobalanidae/Balanidae	3.5	0.9	3.3	3.0	64.9	1.3
Pollicipes polymerus		0.1	0.1	0.6	6.0	0.1
Unidentified Shell		0.2	0.4	0.6	10.8	0.2
Total Marine Invertebrate Wt (100%)	**17.0 g**	**3,964.6 g**	**796.3 g**	**107.3 g**	**4,885.2 g**	**100%**
Terrestrial snail Wt		0.9 g			0.9	
Bone Wt	0.6 g	18.2 g	7.4 g	5.2 g	31.4 g	
Non-Fauna Wt	1,892.4 g	860.4 g	1,086.7 g	415.3 g	4,254.8 g	

of the assemblage shellfish weight, comprising 81.2% and 16.3% respectively (Figure 3). In addition to the shellfish remains, other column sample constituents included terrestrial snails (0.9 g), vertebrate fauna (31.4 g), and non-fauna material (4,254.8 g) (Table 13). On average, each examined column level sample (≥3 mm) yielded 244.3 g of shellfish remains, 1.6 g of bone, and 212.7 g of non-fauna material per 1 cubic decimetre (1000 cm^3).

Twenty-two species of bivalve and univalve molluscs, chitons, and barnacles are identified in Early Column S62–64/W62–64. Major shellfish groups include Mussel (95.8%), Clam (1.9%), and Barnacle (1.5%) (Table 3). Other major shell classes, Marine Snail, Limpet & Abalone, Chiton, and Barnacle, contribute less than 1% of the sample by weight each. Sea urchins and scallops were not observed in the column samples.

California mussel *(Mytilus californianus)* is the most frequent species in the Mussel Group by weight. This shell represents the entire Mussel Group except for a trace of foolish mussel *(Mytilus trossulus)* recovered in Layer B (Table 4). Over 81% of the mussel material was recovered in thick Layer B (Figure 3).

Within the Clam Group (Table 6), only three were identified to the species-level. The three identified clam species occur in Layer B only. Butter clam is the most common identified clam (26.1% of layer weight). Other identified clams in Layer B include native littleneck (9.3%) and horse clam (1.1%). As in the other assemblages, unidentified clam represents the most abundant material in this group, comprising 65.8% of the group weight. Unidentified clam material makes up 63.4% of the Layer B clam by weight and 100% of layers A, C, and D.

The abundance of barnacles in this column assemblage is very low by comparison to the other two assemblages (Tables 3 and 5). *Archaeobalanidae* and *Balanidae* materials are the most common, comprising 92% of the group by weight. Small amounts of gooseneck barnacle *(Pollicipes polymerus)* were recovered in three layers, most of which occurred in lower stratigraphic layer D. The largest quantities of barnacle occur in Layers B (56.3%) and C (37.5%) (Figure 3).

Eight identified marine snails are present in the assemblage's Marine Snail Group, almost all being restricted to Layer B (Table 13). The red turban snail *(Artrea gibberosa)* is the most abundant, encompassing 81.7% of the group by weight. Smaller amounts of dogwinkle *(Nucella canaliculata* 6.9%, *N. lamellosa* 1.8%) and slippersnail *(Crepidula adunca* 2.2%) can also be found in Layer B. The channelled dogwinkle *(Nucella canaliculata)* and indeterminate marine snail represent the only snails in lower layers C and D.

Only three species in the Chiton Group are

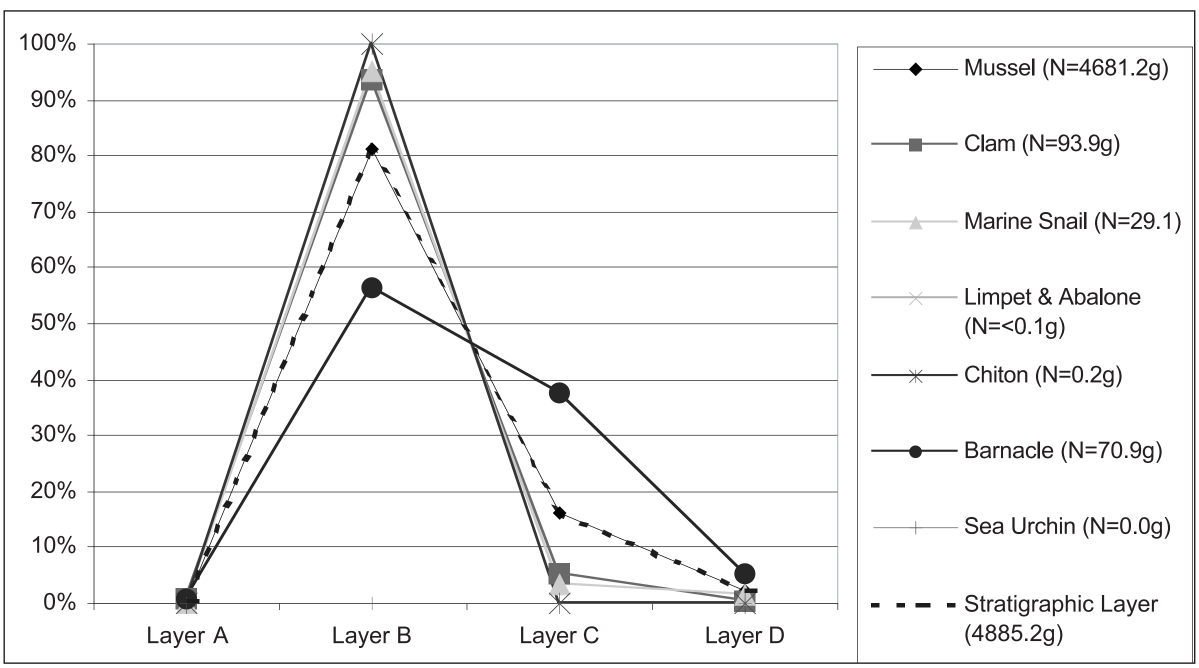


Figure 3. Relative contribution of major shellfish groups by stratigraphic layer, Early Period Column S62–64/W62–64 assemblage.

present in Column S62–64/W62–64: black katy *(Katharina tunicata)*, mossy chiton *(Mopalia muscosa)*, and indeterminate chiton *(Mopallidae)*. All three taxa occur in extremely low quantities and are present in Layer B only. The most abundant chiton by weight is the black katy chiton at 0.2 g (Table 13). The mossy chiton and indeterminate chiton contribute less than 1% to the Chiton Group weight (Table 9). Only trace amounts of four limpet species, ribbed *(Lottia digitalis)*, 2-spot keyhole *(Fissurellidae bimarculata)*, fenestrate limpet *(Tectura fenestrata)*, and indeterminate limpet *(Lottiidae)* were observed in this column, each weighing less than 0.1 gram.

The relative contributions of all major shellfish groups by stratigraphic layer in the Early Period Column S62–64/W62–64 assemblage are presented below in Figure 3.

Other Quantitative and Interpretative Studies

In the preceding section, the taxonomic compositions of three shellfish assemblages were examined. In addition, the researcher carried out further analytical and quantitative studies to enhance the understanding and interpretation of the three shellfish data sets. These other studies relate to: grain size distributions (stratigraphic texture), bivalve umbo counts, dietary contributions, habitat exploitation, and species ubiquity. Each is discussed below.

Grain Size Distributions

This discussion examines the grain or mesh size distributions of shellfish taxa in the stratigraphic layers of each column assemblage. With the view that various shellfish taxa enter the archaeological record in different sizes, this study explores the relationship between shell taxa and grain size distributions (stratigraphic texture). The benefits in comparing specific taxa and grain size classes, and the information generated concerning site formation processes has been highlighted recently in the archaeological literature (Classen 1998), particularly Ford (1992) and other shell midden researchers on the Northwest Coast (Hanson 1991, Keen 1990, Muckle 1986).

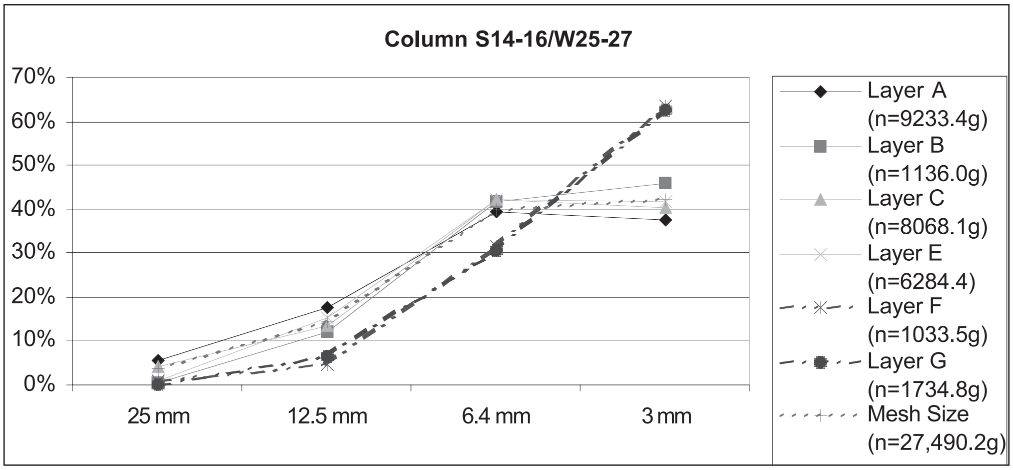
The data below represent relative abundances and weights of selected shellfish groups passed through a series of nested sieves. Four mesh size classes were used to entrap the shellfish specimens: 25 mm (1"), 12.5 mm (½"), 6.3 mm (¼") and 3 mm (⅛"). The shellfish data sets include the same column matrix samples discussed in the previous section, with one exception: Level 35 sediment sample from 1999 Column S14–16/W25–27, Layer G. Time restrictions did not allow for the sorting of constituents in this large 3-mm mesh sample. The three column shellfish data sets and their respective sample weights include: 1999 Late Period column S14–16/W25–27 assemblage, 31,683.3 g; 2001 Early Period column S56–57/W50–52 assemblage, 5,812.3 g; and 2001 Early Period column S62–64/W62–64 assemblage, 4,885.2 g.

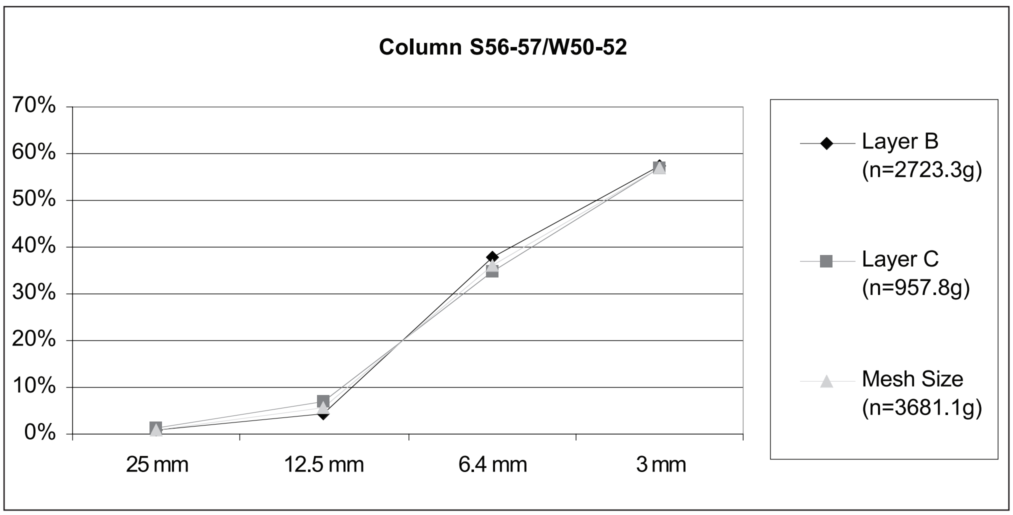
A general description highlights the grain size distribution patterns as calculated for four shell groups from each column assemblage. The grain size distributions are presented as line graphs based upon proportional (%) weight data of each shell within the four size classes. The shellfish groups include: California mussel, barnacles, clam, and all shell.

<u>California Mussel.</u> The California mussel *(Mytilus californianus)* is one of the most prevalent rocky shore mollusc species present in the open, exposed environs of Barkley Sound. Shell weight data in the preceding section indicate that the taxon is the most significant contributor to all column assemblages, thus emphasising its dietary and economic importance. The relative value of this mussel species does not change through time. It is the most common shell in all midden layers, in each column assemblage. California mussel comprises 87% to 96% of the shellfish assemblages by weight (Tables 11, 12, 13). This subsistence and exploitation pattern is characteristic of invertebrate assemblages found at open coast archaeological sites along the Northwest Coast.

Traces of a second *Mytilus* species, the foolish mussel *(Mytilus trossulus)*, were also identified in the samples, but this taxon was limited to less than 3.0 g by total sample weight. Large quantities of fragmented indeterminate *Mytilus* material were present in the samples. Extremely friable, these pieces often measured less than 2 mm thick. In view of the insignificant numbers of foolish mussel quantified (shell weights, umbo counts) and observed in the assemblages, the indeterminate mussel remains were combined with the California mussel data.

Figure 4 illustrates the distributions of California mussel by grain size (mesh size) for each of the three column assemblages. The graphs show that the shell entered the midden deposits in all four grain sizes, with the highest proportions found





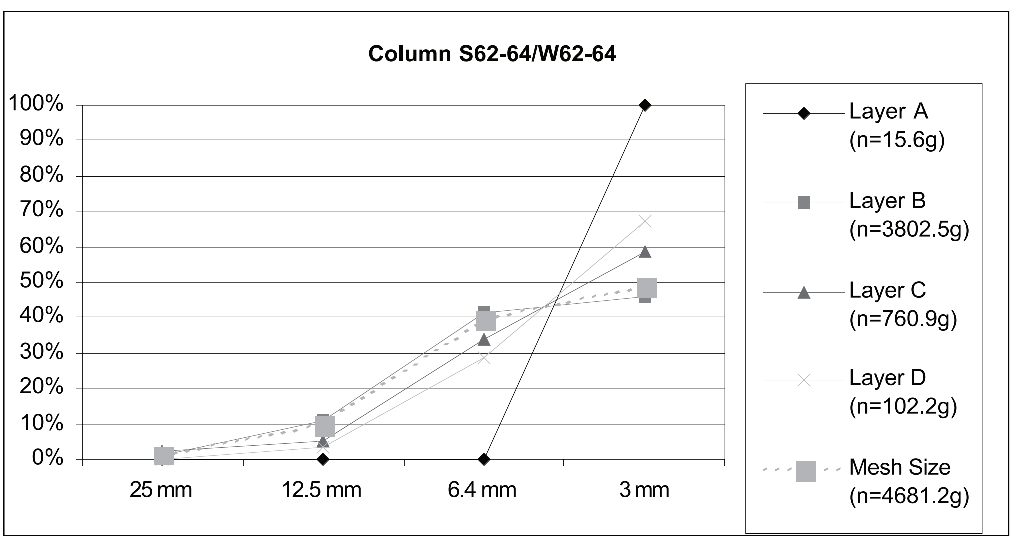


Figure 4. Grain size distributions of California mussel *(Mytilus californianus)* by stratigraphic layer, all assemblages.

in the 3-mm mesh. In some layers, California mussel was not recovered in the largest fraction, 25-mm mesh. In one instance, Early Column S62–64/W62–64 Layer A, fragments of mussel were present in the 3-mm mesh only. Because of the very fragile nature of the California mussel, no specimens were recovered whole.

Variations in shell grain size patterns are evident when the late and early assemblage distributions and frequencies are compared. The data indicate that larger mussel valve fragments are more frequent in the Late Column S14–16/W25–27 assemblage. Almost 18% of the mussel material in this column is 12.5 mm in size and larger; over 82% measures 6.4 mm or less. Surprisingly, upper Layer A in Column S14–16/W25–27 contained the highest proportion (23.4%) of mussel fragments measuring 12.5 mm or larger. This pattern may indicate that the upper layer of cultural deposits in this particular location of the midden received larger, more complete mussel specimens and/or was subjected to less trampling and other post-deposition processes. The largest quantity of small-size (3-mm mesh) mussel materials were found in the lower reaches of the midden, in layers F and G. Together, both layers yielded over 62% of the total column mussel sample weight. The high occurrence of smaller sized mussel material in these lower layers may be due to sediment compaction or food processing activities.

Different breakage or depositional patterns concerning California mussel can be found in the two early period column assemblages: the texture of mussel in all stratigraphic layers tend be more fragmented, containing higher amounts of smaller materials measuring 6.4 mm in size or less. In Early Column S56–57/W50–52, over 93% of the California mussel was recovered from the two smaller meshes, 57.1% in the 3-mm mesh alone. The two midden layers found in Column S56–57/W50–52 are very simiIar in texture, with values for the two smaller fraction materials ranging from 94.9% and 91.6% in layers B and C respectively. In Early Column S62–64/W62–64, 11.3% of this mussel shell was captured in the two larger fraction sizes; 88.7% was recovered in the two smallest meshes (49.9% in 3-mm mesh only). The highest quantities of 3 mm mesh mussel in Column S62–64/W62–64 were recovered in upper Layer A (100%) and lower Layer D (67.5%). These values may be the result of post-deposition crushing or compaction. Furthermore, frequencies in Layer A may be skewed by its low sample weight (15.6 g).

Acorn Barnacle Acorn barnacles, comprising species of the *Archaeobalanidae* and *Balanidae* families, are the second largest shell group by weight at Ts'ishaa after California mussel. At present, acorn barnacles can be found in abundance over the broad range of microenvironments and exposed, outside rocky shores in the sound. Based on Makah and Nuu-chah-nulth ethnohistoric data, Wessen (1994b:354) relates that traditionally, the acorn barnacle was a secondary prey species, a main food resource "collected in more casual, fortuitous, and less systematic manners" (Wessen 1994a:148). Acorn barnacles would have also likely entered the site area inadvertently as by-products of other activities.

Although barnacle specimens in the assemblage were not identified or quantified to the genus- or species-level, observed species included: *Balanus nubilus, Semibalanus cariousus*, *B. glandula*, *B. crenatus*, and probably other species. The acorn barnacle remains, comprising basal, body, and opercular plates, are largely fragmented.

Relative frequencies for this shell group vary between assemblages, ranging from 7.6% of the total shellfish weight in the Late Column S14–16/W25–27 assemblage, to 1.3% in the Early Column S62–64/W62–64, hinting that the dietary importance of barnacle may be possibly changing through time. The grain size distributions of acorn barnacles by layer for each assemblage are presented in Figure 5. Acorn barnacle remains are present in all stratigraphic layers sampled, and most often measure less than 25 mm in size. In all assemblages, barnacle materials were most common in the 6.4 mm mesh size.

When we examine the Late Column S14–16/W25–27, almost 50% of the acorn barnacles were found in the 6.4-mm size class. High values for remains in this fraction size occur in the upper four layers, ranging from 49% to 53% of the sample weight data. Figure 5 indicates that the quantity of barnacle remains in the 3-mm mesh size class tend to increase through time, possibly suggesting that more smaller sized specimens in the lower layers of Column S14–16/W25–27 were entering the site, or that the acorn barnacle materials in these lower layers are more susceptible to degradation from post-depositional processes caused by natural (organic acids, increased ground water, poorer preservation, sediment compaction) or cultural (i.e., trampling) factors. The abundance of larger sized barnacle materials, 12.5- and 25-mm meshes, were found to vary by layer. Materials in the two larger meshes range from 3.8% in

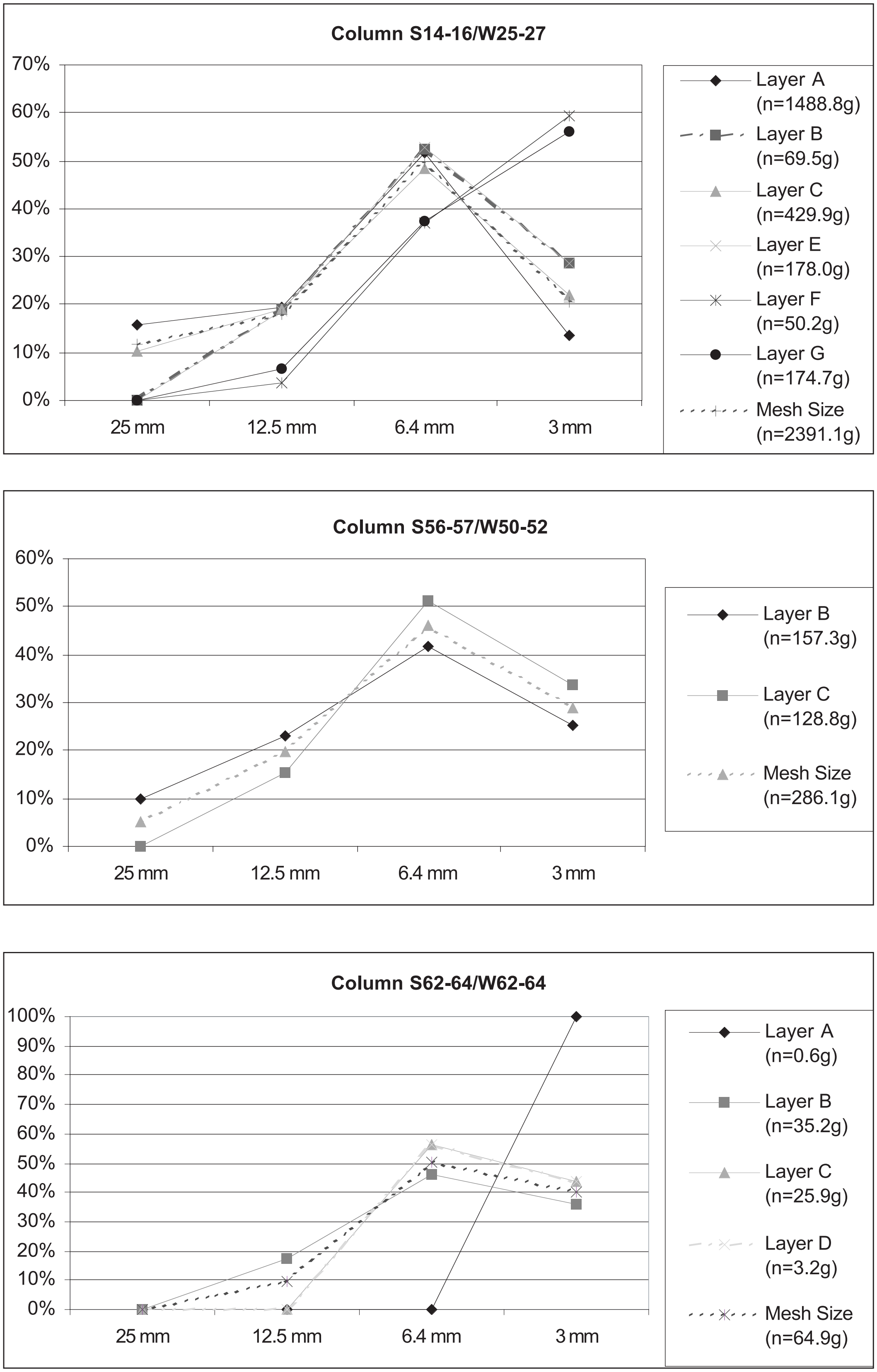


Figure 5. Grain size distributions of acorn barnacle *(Archaeobalanidae, Balanidae)* by stratigraphic layer, all assemblages.

Late Column S14–16/W25–27 Layer F to 35% in Layer A.

Some differences in the grain-size distributions of barnacle materials in Early Column S56–57/W50–52 layers B and C are evident. Over 32% of Layer B barnacle is 12.5 mm or larger, decreasing to 15.5% in lower Layer C. In total, 75% of all acorn barnacles in Column S56–57/W50–52 were recovered in the two smallest size meshes. In the second early assemblage, Column S62–64/W62–64, over 90% of the barnacle remains were recovered from the two smallest meshes. The largest sized barnacle in this column was recovered from the 12.5 mm mesh. The 12.5 mm barnacle material contributes over 17% of Layer B barnacle by weight. A very small amount of acorn barnacle (0.6 g) in Layer A was recovered from the 3-mm mesh.

<u>Clams</u> The third most frequent invertebrates at Ts'ishaa are clams. The most dominant species is the butter clam *(Saxidomus gigantea)*. Other notable clams in the site assemblages include the horse *(Tresus capax, Tresus sp.)* and native littleneck *(Protothaco staminea)* clam. Past biophysical studies reveal that butter and native littleneck clams are the most abundant sediment beach-dwelling clam species in the Broken Group Islands (Lee and Bourne 1977:30). Butter, horse, and native littleneck clams inhabit mud and gravel beaches and bars found in less exposed environments in the sound.

A marine resource inventory conducted in Pacific Rim Park Reserve during the mid-1970s revealed that nearby Clarke Island represents one of nine major bivalve population sites in the Broken Group Islands (Lee and Bourne 1977). On Clarke Island, native littleneck and butter clams can be found on gravel beaches and bars in substantial to moderate quantities. Lee and Bourne report that the northwest corner of Clarke Island is the only site in the Broken Group Islands Unit yielding a high percentage of legal-sized butter clams (1977:30).

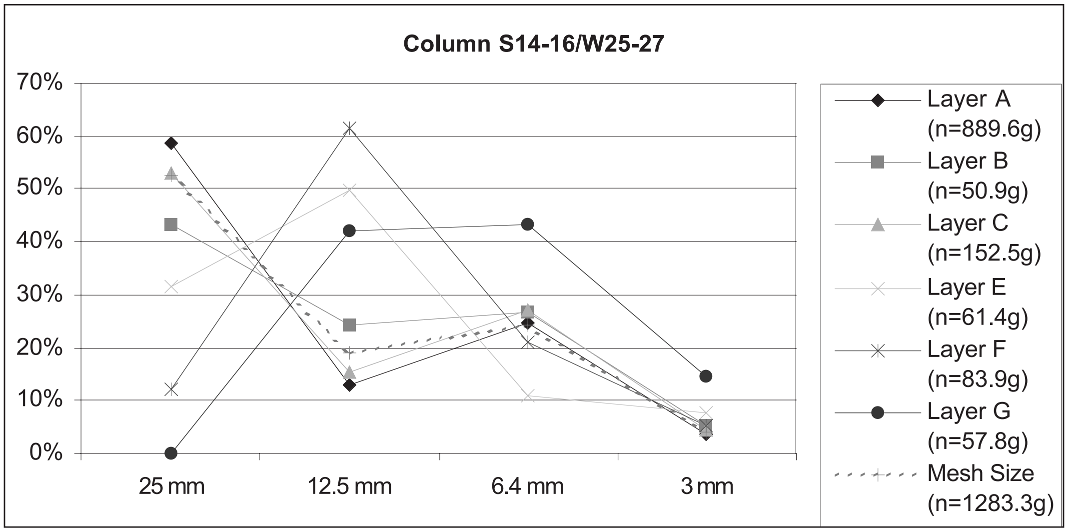
The clam data examined here comprises the combined weight values of three identifiable species (butter clam, horse clam, native littleneck clam) and one unidentifiable category (most likely butter and horse clams). These weights are lumped together in order to enhance the sample size caused by the low counts of key clam species, and to minimise skewing due to species identification problems.

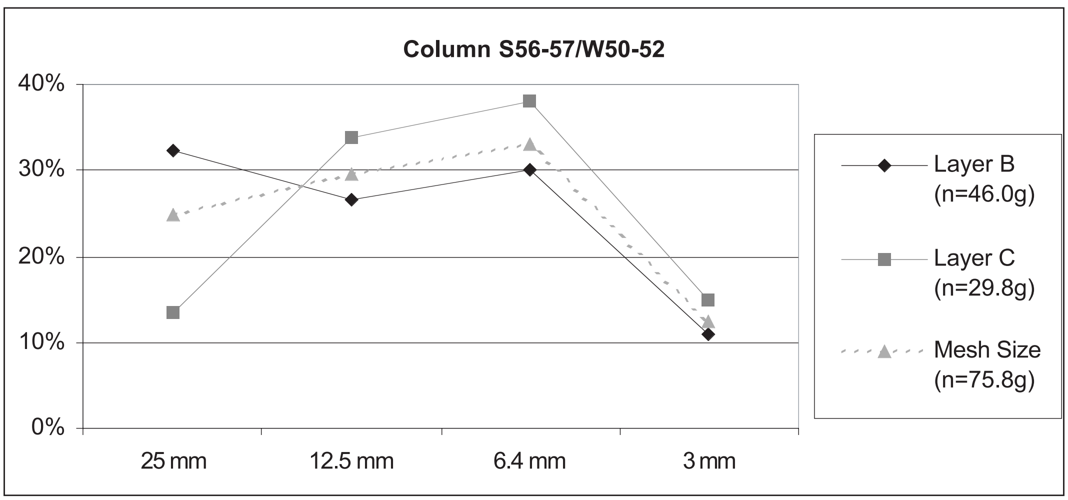
Figure 6 shows the distributions of clams by mesh size for each assemblage. The graphs reveal that clams entered the deposit in all four sizes. All three identified shell species are robust and vary from moderate to large in size. Nevertheless, complete clam valves were limited to a very small number of specimens (butter and native littleneck clams) in the Late Column S14–16/W25–27 assemblage. No complete butter and native littleneck clams were recovered in Early Columns S56–57/W50–52 and S62–64/W62–64. No whole horse clams were observed.

Variations in clam shell-grain size patterns are evident when the early and late assemblage distributions and frequencies are compared. Fraction size data shows that larger clam valve fragments are more common in the Late Column S14–16/W25–27 assemblage. Almost 72% of the clams by weight in the late assemblage were recovered in the two largest mesh sizes, with 52.7% found in the 25 mm mesh size alone. The upper three stratigraphic layers (A, B, C) in the late assemblage contain the highest relative frequency of large fraction materials, decreasing in values as one proceeds down through the cultural stratum. A high proportion of 12.5-mm material (61.6%) can be found in Layer F.

Smaller clam fragments are more abundant in the two earlier assemblages, with most material being recovered in the 12.5- and 6.4-mm meshes. Different distribution patterns can be seen in Early Column S56–57/W50–52 layers B and C. Most noteworthy is the high proportion of larger, 25-mm mesh size clam specimens (32.4%) in upper Layer B. Almost 55% of the clam samples in Column S56–57/W50–52 were recovered in the two largest meshes. Figure 6 show that Early Column S62–64/W62–64 contains the least amount of larger sized clam material. Over 54% of the clam in this column was recovered in the two smallest meshes. The small clam sample sizes from these two early assemblages however, limit the level of confidence.

<u>All Shell</u> The grain size distributions or sediment textural attributes for all shell from the three column assemblages and their affiliated stratigraphic layers are graphed in Figure 7. The data reveal that only small proportions of all shell were found in the two largest sized meshes (25 mm, 12.5 mm). In Late Column S14–16/W25–2, only 21% of all shell recovered measured 12.5 mm or larger. Distribution values for the same larger-sized materials in the two early period columns are much smaller, encompassing 8% and 12% of the two samples by weight respectively.





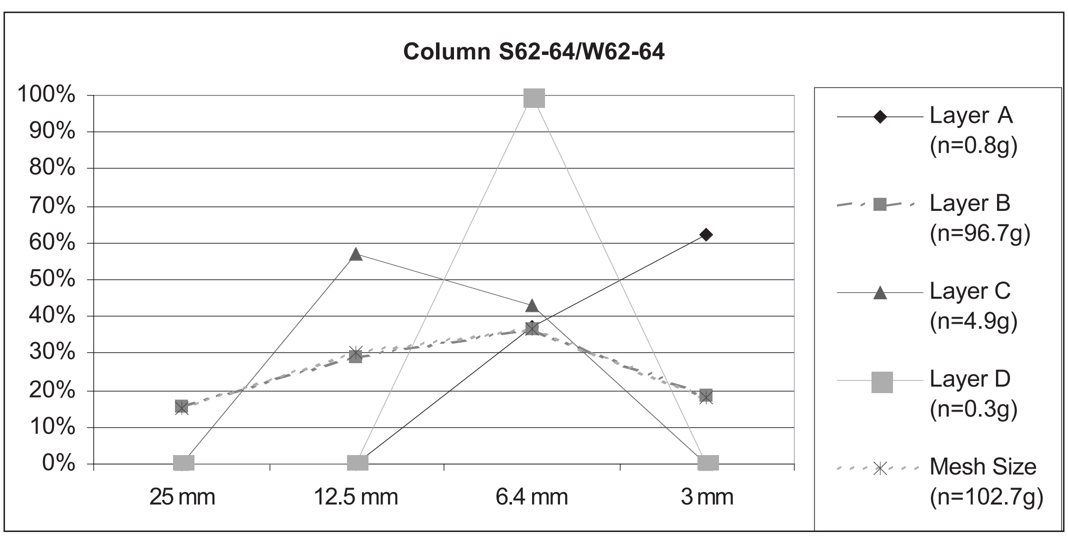


Figure 6. Grain size distributions of clams *(Saxidomus gigantea, Tresus capax, Tresus sp., Protothaca staminea,* unidentified clam) by layer, all assemblages.

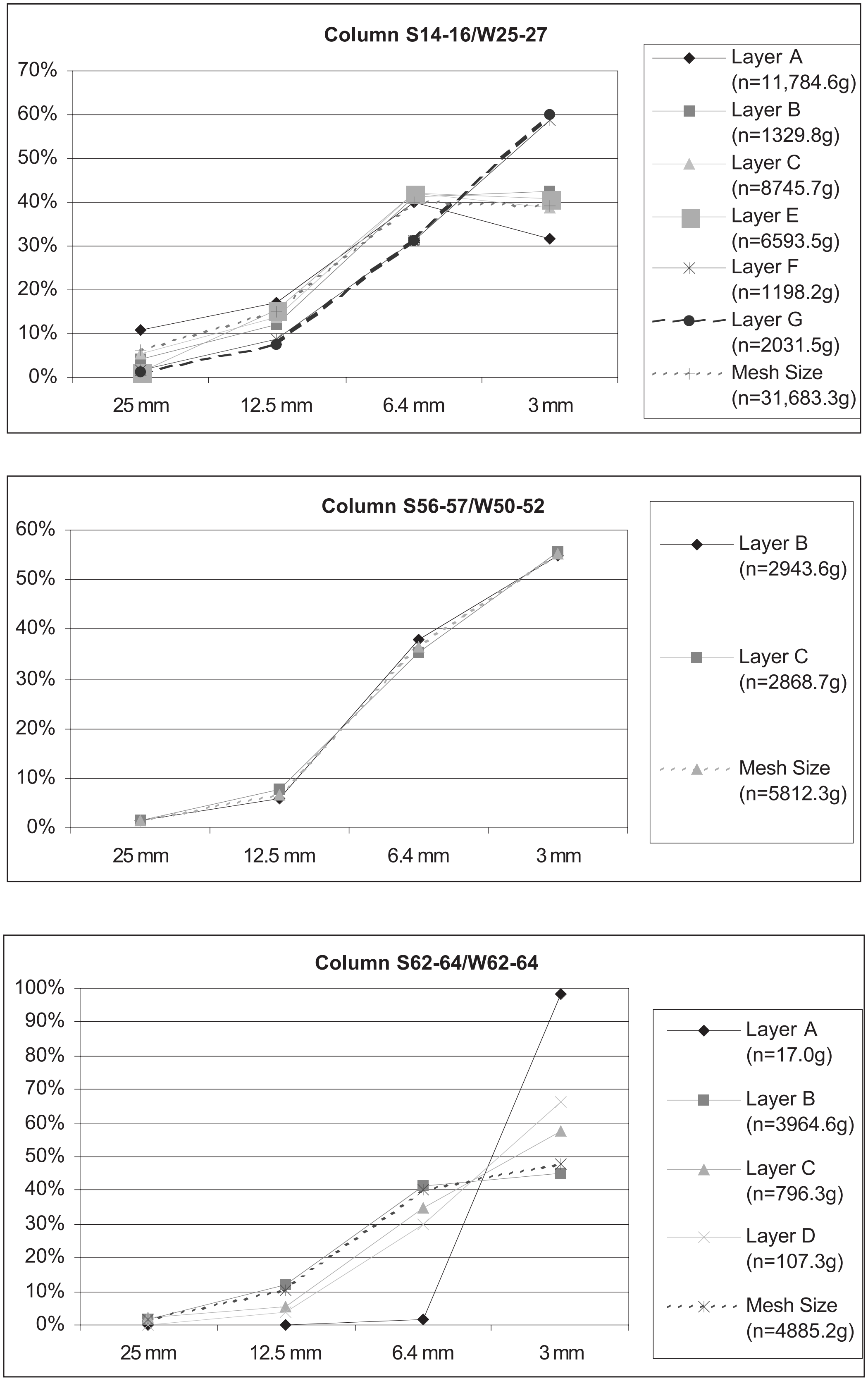


Figure 7. Grain size distributions of all shell by stratigraphic layer, all assemblages.

The majority (79.1%) of shellfish in Late Column S14–16/W25–27 was caught in the two smallest meshes, in almost equal proportions (Figure 7). This pattern changes however in the lower reaches of the column's stratigraphic profile. There is a sharp increase in the quantity of 3-mm size materials in lower layers F and G. Layer A, in Late Column S14–16/W25–27, contains the highest frequency of 25-mm mesh materials (11%) of all three assemblages.

The texture of shell in the two early assemblages tends to be finer. Higher proportions of 3-mm mesh size material were found in these two columns, comprising 47.9% and 55.2% of the samples by weight. In Column S56–57/W50–52, only 8.2% of the sample ended in the two larger meshes. Slightly higher contributions (12.2%) were noted for these same mesh sizes in Early Column S62–64/W62–64. The higher frequencies of 3-mm size shell in the two early assemblages reflect the larger amounts of fragile, small California mussel fragments. The extremely high value (98.2%) for finer materials in Column S62–64/W62–64 Layer A is questionable however, due to its very small sample size (17.0 g).

A pattern of increasing, finer grain materials is evident as one proceeds down through the strata in all three columns (Figure 7). Further analysis of this pattern is necessary. These results may reflect one or a combination of natural and/or cultural factors occurring during or after site formation (i.e, chemical weathering from acidic groundwater, shell robustness, age, sediment compaction, trampling, or refuse disposal patterns).

Also noteworthy is the strong similarities of matrix textural attributes (Figure 7), taxonomic content (composition), and shellfish weight (Table 2) in Early Column S56–57/W50–52 layers B and C. Key composition differences however include higher frequencies of non-fauna material (rock, charcoal, and rootlets) and small vertebrate fauna in upper Layer B, whereas lower Layer C contains higher quantities of fine mineral sediment (black silt).

Bivalve Umbo Counts

A third variable used to quantify the Ts'ishaa shellfish is the count of bivalve umbones. A bivalve features a pair of umbones or beaks, both located at the dorsal end of each valve. The umbo (plural, umbones) is positioned at the end of the hinge, behind the cardinal teeth area. As a major character on the bivalve shell, the umbo or beak is "the point of shell origin" (Coan et al. 2000:31). Umbo counts are introduced here to confirm the shellfish weight data. In order to obtain a count of bivalves present in the Tsi'shaa sample, the number of umbones for each species was calculated. This quantification method is preferred here as an alternative to the popular technique of establishing the minimal number of individuals (MNI). Classen (1998:106) highlights some of the problems affiliated with using MNI, including results that can be skewed by species preservation and sampling, but also the influential effects of trampling, food processing techniques, discard behaviour, leaching, and other chemical (acidic soil, ground water) processes.

The frequencies and proportions of bivalve umbones for each assemblage are summarised in Table 14. For comparative purposes, these values are tabulated side-by-side with their corresponding relative abundances of shell weight. The proportional data for the bivalve umbo counts and their respective weight data confirm the observation that California mussel is consistently the most prevalent shellfish species exploited at the site through time. Furthermore, the umbo count data show that clams are not under-represented or skewed in this study because of sampling factors.

Some interesting relationships between bivalve umbo counts and their respective weight data are evident in Table 14. In instances where a bivalve species is present in two or more columns, all species, with the exception of California mussel and unidentified clam, consistently score higher values in umbo count data. The most outstanding is the foolish mussel *(Mytilus trossulus)*. Umbo count data for this extremely fragile, fragmentary shell show a higher yield when compared to its respective weight values. The umbo count data suggest that larger quantities of foolish mussel likely entered the site than revealed by the shellfish weight alone. Other bivalves showing enhanced contributions to the shellfish assemblage when umbo counts are used include: butter, horse, native littleneck, and nestling saxicave *(Hiatella)* clams.

The relationship between umbo counts and shellfish weight data for California mussel in all three assemblages is strong. Values for the two quantitative variables differ by only 4.6 to 5.2 percent. The above mollusc consumption pattern (the relative importance of California mussel with less emphasis placed on the exploitation of clams and other shellfish groups) is typical of what one would expect at "outside" or open coast sites. A subsistence pattern, involving the dominant contribution to one's diet by one shellfood, is similar to that of

Table 14. Quantitative comparison of bivalve species present – umbo counts vs shellfish weight, all assemblages.

	Late Column S14–16/W25–27				Early Column S56–57/W50–52				Early Column S62–64/W62–64			
Bivalve Species	**Umbo Totals**		**Shellfish Wt**		**Umbo Totals**		**Shellfish Wt**		**Umbo Totals**		**Shellfish Wt**	
	N	%	Wt (g)	%	N	%	Wt (g)	%	N	%	Wt (g)	%
Mytilus californianus	2,302	90.1	28,545.9	95.3	603	97.6	5,402.1	92.9	257	93.5	4,681.2	98.1
Mytilus trossulus	67	2.6	2.9	<0.1	2	0.3	<0.1	<0.1	1	0.4	<0.1	<0.1
Solamen columbianum	1	<0.1	<0.1	<0.1								
Saxidomus gigantea	67	2.6	488.9	1.6	3	0.5	1.9	<0.1	7	2.5	22.7	0.5
Clinocardiium nuttallii	0	0	13.1	<0.1								
Tresus sp.	30	1.2	138.3	0.5					1	0.4	1.0	<0.1
Protothaca staminea	26	1.0	101.4	0.3	3	0.5	9.0	0.2	2	0.7	8.1	0.2
Glycymeris septentrionalis	1	<0.1	4.5	<0.1	1	0.2	0.2	<0.1				
Hiatella sp	25	1.0	1.4	<0.1	2	0.3	<0.1	<0.1				
Glans carpenteri	1	<0.1	<0.1	<0.1								
Unidentified Clam	36	1.4	665.4	2.2	4	0.7	64.9	1.1	7	2.5	61.2	1.3
Crassadoma gigantean	0	0	0.4	<0.1								
Column Totals	**2,556**	**100**	**29,961.8**	**100**	**618**	**100**	**5,478.1**	**100**	**275**	**100**	**4,774.2**	**100**

other "outer" sites on the north Pacific coast, such as the Kunghit Haida (Keen 1990), early Zone I occupation at Yuquot (Clarke and Clarke 1980:53), Chesterman Beach (Wilson 1990), Ch'uumat'a and T'ukw'aa (St. Claire 2002 pers comm.), and Yaquinna Head in Oregon (Minor 1989).

Dietary Contributions of Different Shellfish Species

This discussion investigates the dietary contributions of various shellfish to the site's mollusc assemblages. This is explored by converting shell weights into a nutritional unit or 'currency', edible meat weight. To determine meat weights in this study, the average meat weight to shell weight ratio is used, a method in which shell weights are multiplied by conversion factors derived for a particular taxon. The edible meat weights (g) for four major shellfish species and their respective relative contributions are reported below. The major shellfish species include only those taxa that were consumed as primary prey and whose relative contribution to the shellfish assemblage is greater than 1% of the total sample weight.

Four major shellfish were examined in Late Column S14-16/W25–27: California mussel *(Mytilus californianus)*, butter clam *(Saxidomus gigantea)*, unidentifiable clam, and acorn barnacle *(Archaeobalanidae, Balanidae)*. In the two early period columns, the meat yields from only three major shellfish categories were investigated: California mussel, unidentifiable clam, and acorn barnacle.

The shellfish conversion factors used in this study are derived from formulae and archaeological data established by other researchers in a number of areas on the North Pacific coast, including Alaska (Erlandson 1989; Moss 1989), British Columbia (Clarke and Clarke 1980; Ham 1982), and California (Erlandson 1994). Conversion index values have been averaged where multiple sources for a specific taxon are available. The conversion factor for the unidentifiable clam category, which most likely comprises broken butter and horse clams without umbones or other landmarks (majority of their hinge), represents a mean value for *Saxidomus gigantea* and *Tresus capax* combined.

Estimated meat weights for four major shellfish from Late Column S14–16/W25–27 are presented in Table 15. Calculations show that California mussel is prominent in the column assemblage, making up 89.5% of the total edible shellfish meat yield. Unidentified clam, acorn barnacle, and butter clam contribute 4.2%, 3.9%, and 2.4% respectively.

Meat yield estimates for the major shellfood species in Early Columns S56–57/W50–52 and S62–64/W62–64 are provided in Tables 16 and

Table 15. Meat weight (g) of major shellfish taxa from Late Period Column S14–16/W25–27.

Species	Layer A	Layer B	Layer C	Layer E	Layer F	Layer G	Total meat wt (g)	% Total	Conversion Factor
Mytilus californianus	3,693.4	454.4	2,027.2	2,513.8	413.4	1,116.2	**10,218.4**	89.5%	0.40
Saxidomus gigantea	209.1	15	14.3	5.6	8.6	16.4	**269**	2.4%	0.55
Unidentifiable clam	277.6	16.1	45.9	15.6	44.1	79.6	**478.9**	4.2%	0.72
Archaeobalanidae, Balanidae	268	12.5	77.4	31.5	9	50.7	**449.1**	3.9%	0.18

Table 16. Meat weight (g) for major shellfish taxa from Early Period Column S56–57/W50–52.

Species	Layer B	Layer C	Total meat Wt (g)	% Total	Conversion Factor
Mytilus californianus	1089.3	1071.5	**2160.8**	95.7%	0.40
Unidentifiable clam	27.1	19.6	**46.7**	2.1%	0.72
Archaeobalanidae, Balanidae	27.8	23.2	**51.0**	2.3%	0.18

Table 17. Meat weight (g) for major shellfish taxa from Early Period Column S62–64/W62–64.

Species	Layer A	Layer B	Layer C	Layer D	Total meat Wt (g)	% Total	Conversion Factor
Mytilus californianus	6.2	1521	304.4	40.9	**1872.5**	97.1%	0.40
Unidentifiable clam	0.6	39.7	3.5	0.2	**44**	2.3%	0.72
Archaeobalanidae, Balanidae	0.1	6.3	4.7	0.6	**11.7**	0.6%	0.18

17. In the Column S56–57/W50–52 conversions, California mussel accounts for 95.7% of the meat weight, followed by acorn barnacle (2.3%) and unidentifiable clam (2.1%). California mussel meat weights are also predominant in Early Column S62–64/W62–64, comprising over 97% of the total weight. Unidentifiable clams and acorn barnacles make limited contributions: only 2.3% and 0.6% of the total shellfish meat weights respectively.

Despite the drawbacks that have been identified by researchers (Classen 1998:187–191; Moss 1989; Grayson 1984; Wessen 1994) with respect to analyzing the dietary contribution of different shell species to site subsistence activities, the data presented here indicate the potential yield and contribution of shellfish (particularly California mussel) as a food resource at Ts'ishaa. This preliminary analysis suggests, based on only a 33% sampling fraction by volume, that more than 11.4 kg of shellfish meat are represented in the Late Column S14–16/W25–27 sample from Excavation Area 1 in the main village (Table 15). If the entire column sample have been examined, it is conceivable that 30+ kg of shellfish meat may be represented by the remains of the four dominant shellfish from this 25 x 25 x 350-cm column alone, and 1920 kg (4,224 pounds) in the adjoining 3.5 m deep, 2 x 2-m excavation unit.

Column sample data from the terrace behind the village midden indicate that the strong focus on California mussel harvesting, with a lesser emphasis on the collection of clams and barnacles, dates back to earlier site occupation (3000–5000 BP). An examination of the three major species from the Early Column S56–57/W50–52 shell sample (52% sample fraction) produced a converted meat yield totalling 2.25 kg (Table 16). Had 100% of the 2.49-m-deep, 10 x 10-cm column been examined, potential meat yields of as much as 4.5 kg may be represented. Following this formula for the three shell species, it is conceivable that 900 kg (1,980 lb) of shellfish meat from the adjoining 1 x 2-m unit may have been consumed.

Excavation Unit S62–64/W62–64, positioned 11 m upslope from Unit S56–57/W50–52 on the elevated landform, revealed shallow cultural deposits overlying bedrock. An examination of mollusc materials from the Early Column S62–64/W62–64 assemblage sample (55% sampling fraction) suggests that over 1.9 kg of meat were acquired from the three shellfish species (Table 17), and possibly 3.5 kg of meat from the entire 88-cm deep, 20 x 20-cm column. Using these conversion factors, it is estimated that the shell-rich sediments excavated from adjacent 2 x 2-m Unit S62–64/W62–64 may have represented, at minimum, over 350 kg (770 lb) of edible meat.

Habitat Exploitation

A major factor contributing to intra-assemblage differences in faunal remains is the exploitation of various habitats by the site occupants (Calvert 1980). Past exploitation of numerous micro-environmental zones in the open, "outside" sections of coast surrounding Ts'ishaa is indicated by the diverse collection of intertidal mollusc taxa present in the shellfish assemblages.

Three habitat types have been identified for the Broken Group Islands area (Lee and Bourne 1977; see also Haggarty and Inglis 1985). Based on substratum materials and wind exposure, the intertidal habitats and their shore classes include:

1. Exposed Habitats:
   <u>Rock & Boulder Beaches</u>: rocky shore substratum intertidal zone exposed to the rigorous conditions of heavy surf; high salinity; constant water temperature.
   Exposed sub-tidal habitat types include: rocky shores;
2. Semi-Exposed Habitats:
   <u>Boulder Beaches and Rocky Shores</u>: boulder beach and rock substratum on the outer islands subject to some surf action; high salinity; slight water temperature fluctuations.
   <u>Gravel, Sand, and Shell Beaches</u>: gravel, sand, and shell beaches located on the shores of the inner islands subject to less wave action; high salinity; slight fluctuations in water temperature.
   Semi-exposed sub-tidal habitat types include: gravel and shell shores with isolated boulders; cobble, boulder, and rock shores; and rocky shores;
3. Protected Habitats:
   <u>Boulder Beaches and Rocky Shores</u>: rock shores found in NE shore of inner islands, some bays, and along the shores of clustered islands; boulder beaches common in sheltered bays and in channels between islands; less wave action; lower salinity; some temperature variation;
   <u>Cobble Beaches</u>: sheltered cobble substratum subject to less wave action, lower salinity; some temperature variation;
   <u>Shell and Sand Beaches</u>: sheltered shell and/or sand substratum intertidal zone subject to less wave action, lower salinity; some temperature variation;
   <u>Sand/Shell/Gravel Beaches</u>: protected sand, shell, and gravel beaches common in pocket beaches and along sheltered shores; lower salinity, some temperature variation;
   Sheltered subtidal habitats include Sand and mud flats and Sand, mud, gravel, and shell slopes.

Table 18 lists the shellfish species recovered at Ts'ishaa and their related intertidal habitats based on exposure and shore class. The distributions of the three intertidal habitats in original Tseshaht territory are shown in Figure 8. Data reveal that various beach types and habitats within the Broken Group Islands were harvested for bivalves and univalve species.

The Ts'ishaa shellfish assemblage indicates that rocky shores in exposed, semi-exposed, and sheltered habitats were the primary focus of shellfish exploitation through the duration of site occupation. Shellfish taxa consumed as primary and secondary food sources from these environments were predominantly infauna invertebrates, including: California mussel, barnacles (acorn, gooseneck), sea urchin, selected marine snails, chitons, limpets, and abalone. Some smaller marine snails would have entered the site unintentionally, having been attached to seaweed and kelp, others in the stomach of sea mammals and fish. The meat of some species would have been gathered for food and the shells used for decorative or utilitarian purposes.

The shellfish weight data suggests that rocky shore and boulder beach habitats produced over 98% of the mollusc remains during the early period (pre-3000 BP) of site occupation (Table 3). In later times, the focus on rocky shore (infauna) shell-foods continued (~96% of shell by weight), but with an increase in the consumption of sediment-dwelling (epifauna) bivalves, particularly butter clams, native littleneck clams, and horse clams. Interestingly, this slight change in the Ts'ishaa shellfish subsistence pattern during the late Holocene coincides with receding sea-evels in the Barkley Sound area (Friele 1992, McMillan 1999). It is possible that this increase in epifauna species at this time reflects the development and increased biological productivity of sediment beaches.

Species Ubiquity

The fifth and final variable examined in this study is species ubiquity: the number of proveniences in which a shell taxon is present. Graphic indices showing the number of stratigraphic layers in which each shellfish species was identified are presented in Figures 9, 10, and 11. Each index plots the number of layers containing species x on the y-axis and the total weight of the shell taxon on the other. Multiple species are plotted on one graph for comparison of ubiquity.

The ubiquity index for Late Column S14–16/W25–27 in Figure 9 indicates that 14 (24%) of 59

Table 18. Shellfish habitat categories in the Broken Group Islands, Barkley Sound.

Taxa	Exposed Rock & Boulder Beachs	Semi-exposed Boulder Beaches & Rocky Shores	Semi-exposed Gravel, Sand, & Shell Beaches
Bivalvia			
California mussel, *Mytilus californianus*	X	X	
Foolish mussel, *Mytilus trossulus*			
Butter clam, *Saxidomus gigantea*			
Nuttall's cockle, *Clinocardium nuttallii*			
Fat Gaper clam,*Tresus capax*			X
Horse clam, *Tresus sp*			X
Native littleneck clam *Protothaca staminea*			X
Western bittersweet clam, *Glycymeris septentrionalis*			X
Nestling Saxicave clam, *Hiatella sp*	X	X	
British Columbia cranella, *Solamen columbianum*			
Carpenter's candita clam, *Glans carpenteri*			
Purple-hinged rock scallop, *Crassadoma gigantea*	X	X	
Gastropoda			
Channelled dogwinkle, *Nucella canaliculata*	X	X	
Striped dogwinkle, *Nucella emarginata*	X	X	
Frilled dogwinkle, *Nucella lamellosa*	X	X	
File dogwinkle,*Nucella lima*		X	
Dogwinkle *Nucella sp*	X	X	
Red turban snail, *Astrea gibberosa*	X	x	
Black turban snail,*Tegula funebralis*	X	X	
Dusky turban, *Tegula pulligo*	X	X	
Leafy hornmouth, *Ceratostoma foliatum*	X	X	
Slippersnail,*Crepidula sp*	X	X	
Hooked slippersnail*Crepidula adunca*	X	X	
White slippersnail,*Crepidula nummaria*		X	
Wrinkled amphissa, *Amphissa columbiana*		X	
Topsnail, *Lirularia sp*	X	X	
Sitka periwinkle, *Littorina sitkana*	X	X	
Checkered periwinkle, *Littorina scutulata*	X	X	
Threaded bittium snail, *Bittium eschrichtii*			
Bittium snail, *Bittium sp*			
Lurid rock shell,*Ocenebra lurida*	X	X	
Sculptured rock shell,*Ocenebra interfossa*	X		
Dire whelk, *Searlesia dira*	X	X	
Dovesnail, *Alia gausapala*	X	X	
Variegated lacuna shell, *Lacuna variegata*			
Pryramid snail, *Turbonilla sp*			
Whitecap limpet, *Acmaea mitra*	X	X	
Fingered limpet,*Lottia digitalis*	X	X	
Mask limpet, *Tectura persona*	X	X	
Plate limpet, *Tectura scutum*	X	X	
Shield limpet, *Lottia pelta*	X	X	
Fenestrate limpet,*Tectura fenestrata*	X	X	
Limpet, *Lottiidae*	X	X	
Rough keyhole limpet, *Diodora aspera*	X	X	
2-spot keyhole limpet,*Fissurellidea bimaculata*	X		
Northern abalone, *Haliotis kamtschatkana*	X	X	
Polyplacophora			
Giant pacific chiton, *Cryptochiton stelleri*	X	X	
Black katy chiton, *Katharina tunicata*	X	X	
Mossy chiton, *Mopalia muscosa*		X	
Lined chiton, *Tonicella sp*	X	X	
Mopaliidae	X	X	
Echinoidea			
Strongylocentrotus purpuratus	X	X	
Strongylocentrotus droebachiensus	X	X	
Strongylocentrotus sp	X	X	
Cirripedia			
Acorn barnacle, *Archaeobalanidae, Balanidae*	X	X	
Gooseneck barnacle, *Pollicipes polymerus*	X	X	

Protected Boulder Beaches & Rocky Shores	Protected Cobble Beaches	Protected Shell and/or Sand Beaches	Protected Sand/ Shell/ Gravel Beaches
X			
X			X
		X	X
		X	X
			X
		X	X
		X	X
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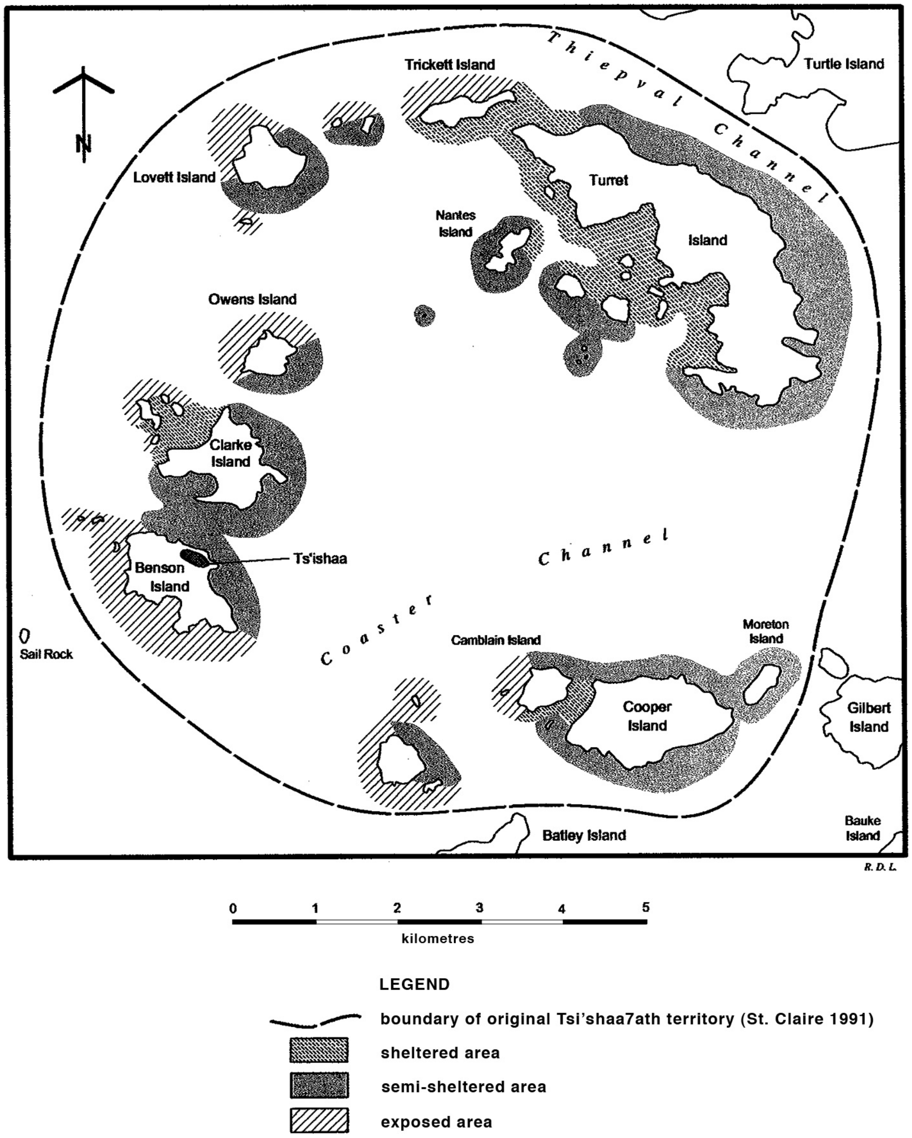


Figure 8. Map showing distribution of intertidal exposure types in the original territory of the Tseshaht local group (after Lee and Bourne 1977).

shell species, including three general unidentifiable categories, are present in all six stratigraphic layers. The highly ubiquitous species, ranked by total sample weight, include: California mussel, acorn barnacle, unidentifiable clam, butter clam, unidentified shell, native littleneck clam, gooseneck barnacle, indeterminate sea urchin, purple sea urchin, black katy chiton, indeterminate marine snails, channeled dogwinkle, indeterminate chitons *(Mopaliidae* family), and indeterminate limpets *(Lottiidae* family). All of these species or families, with the exception of the channeled dogwinkle, indeterminate marine snail, and unidentified shell, represent primary or secondary prey.

Nine shell taxa (15%) in Late Column S14–16/W25–27 were recovered in four or five stratigraphic layers. This moderate group included: additional primary/secondary prey foods, horse clam *(Tresus* sp.), foolish mussel *(M. trossulus)*, basket cockle *(Clinocardium nuttallii)*, giant Pacific [gumboot] chiton *(Cryptochiton stelleri)*; and shells used for decorative or utilitarian purposes, red turban snail *(Astrea gibberosa)*, northern abalone *(Haliotis kamtschatkana)*, and horse clam. Thirty-six (61%) identified shell species in this column were observed in one to three stratigraphic layers only. The latter are predominantly univalves and sea snails, taxa that would have entered the site in an inadvertent or incidental manner. Excluding the fat gaper horse clam, *Tresus capax*, all shellfish taxa in the lower ubiquity groups (1–3 layers) weighed less than 5.0 grams.

Interpretations regarding species ubiquity in Early Column S56–57/W50–52 (Figure 10) are simplified in that only two stratigraphic layers are represented. Thirteen of the 25 (52%) shellfish species (including three general unidentifiable categories) found in this column were recovered in both thick layers. Dominated by California mussel (92% of group weight), other primary and secondary prey shellfoods in this group include: varying quantities of acorn barnacles, unidentified clam, native littleneck clam, black katy chiton, indeterminate sea-urchin, and butter clam. Some materials likely used for decorative or other utilitarian purposes in this group include abalone and dye shells *(Nucella)*. In Column S56–57/W50–52, 12 identified shellfish taxa were recovered in only one of two statrigraphic layers: three chitons, purple sea urchin, six marine snails, a limpet, and blue mussel. Of the 12 species, only three *(Astrea gibberosa, Stronglyocentrotus purpuratus,* and *Mopaliidae)* in this group weight more than 1.0 gram.

Only three of 26 (11.5%) shellfish in Early Column S62–64/W62–64 occur in all (four) stratigraphic layers (Figure 11). Species ranking very high in the ubiquity index for this column include California mussel, acorn barnacle, and unidentified clam. Four taxa are present in three of the four layers: unidentified shell, goose barnacle *(Pollicipes polymerus)*, channelled dogwinkle, and indeterminate sea snail. The goose barnacle, deemed as primary prey by many Nuu-chah-nulth, Ditidaht, and Makah peoples, is often plentiful amongst the California mussel community. Nineteen species in this column were found in one layer only, Layer B, 16 of which are rocky shore dwellers. The three sediment beach (epifauna) species include the butter, native littleneck, and horse clams. Fifteen of the 19 taxa in Layer B weight less than 1.0 gram. The Column S62–64/W62–64 shell data should be viewed with caution however, as two of four layers (A and D) contain small sample weights (17.0 g and 107.3 g respectively).

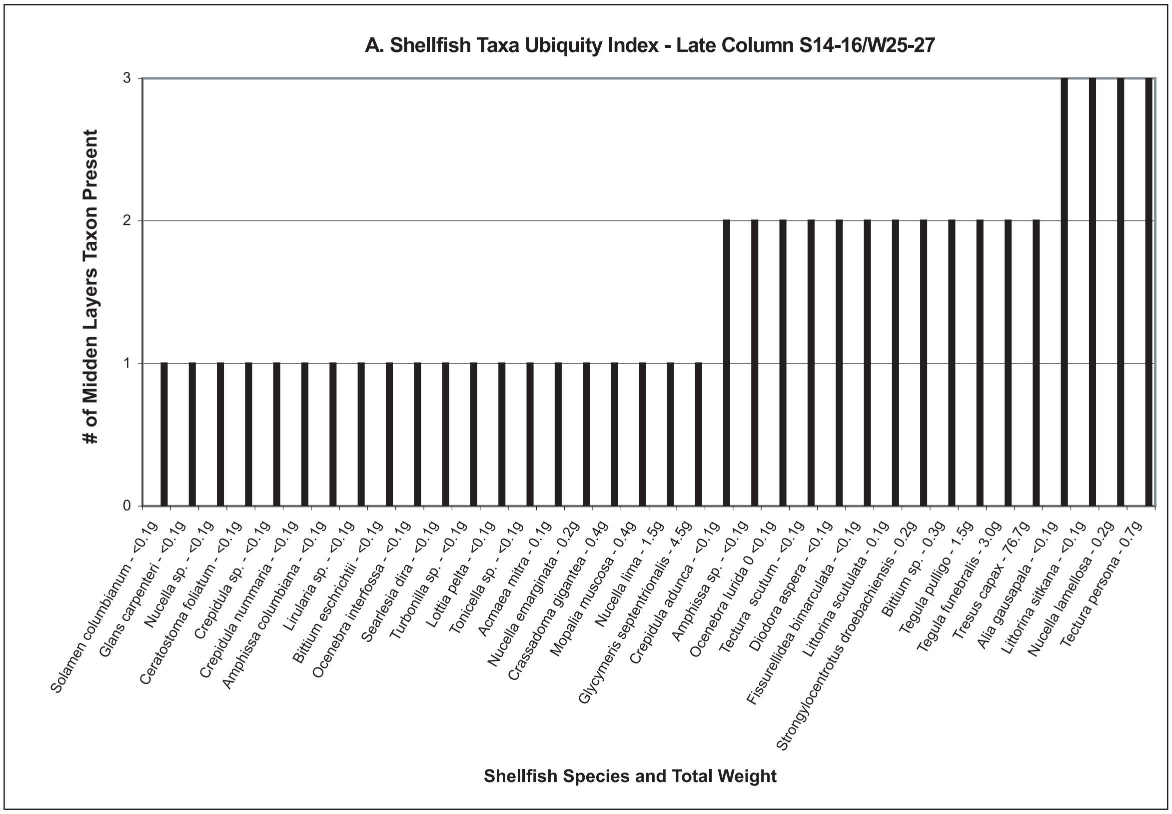
Summary And Conclusions

A preliminary analysis of shellfish materials from the village of Ts'ishaa has revealed insights into the human exploitation of marine molluscs in south-central Barkley Sound, the traditional territory of the Tseshaht First Nation. The study demonstrates that, in those areas of the site subject to invertebrate faunal sampling, California mussel *(Mytilus californianus)* was the predominant shell species harvested and consumed through the duration of occupation. The shellfish diet was supplemented with lesser quantities of acorn barnacle and clam, particularly butter, horse, and native littleneck clams. Other bivalves, univalves, chitons, and sea urchin also contributed to the daily fare, but in minor amounts.

The primary quantification variable used in this study is shell weight. Although biases are introduced into the analysis by using shell weight, a number of other quantitative studies were conducted to help mitigate these sampling factors and to support the report's interpretations. These additional interpretive studies included: grain size distributions, bivalve umbo counts, shellfood dietary contributions, habitat exploitation, and species ubiquity.

Examination of the shell weight data revealed that California mussel comprised an extremely high proportion of marine shell material in all three column assemblages sampled. Data from late period Column S14–16/W25–27 show that California mussel made up almost 87% of the assemblage by weight. During earlier times (pre-3000 BP), however, information suggests a stronger focus was placed on the consumption of this species. Analyses of the two early period column samples show higher values of California mussel with respect to relative abundance (93% and 96%). (As an interesting footnote, a comparison of the shell weight data between two column samples [S14–16/W25–27, S62–64/W62–64] and their affiliated hand-collection/screen data sets by the researcher yielded contrasting results).

Investigations pertaining to grain size distribution patterns of specific shell categories enhanced our understanding of shell breakage, refuse disposal patterns, site formation, and possible post-deposition processes at the site. The relationship of four shell groups (California mussel, barnacle, clam, and all shell) and their grain size distributions between stratigraphic layers and assemblages were explored using multiple-sized sieve meshes. The research was productive in illustrating correlations between taxon-specific breakage patterns and grain size distributions. Not surprisingly, California mussel, the most fragile member of the large bivalves, was most common (82% to 93%)



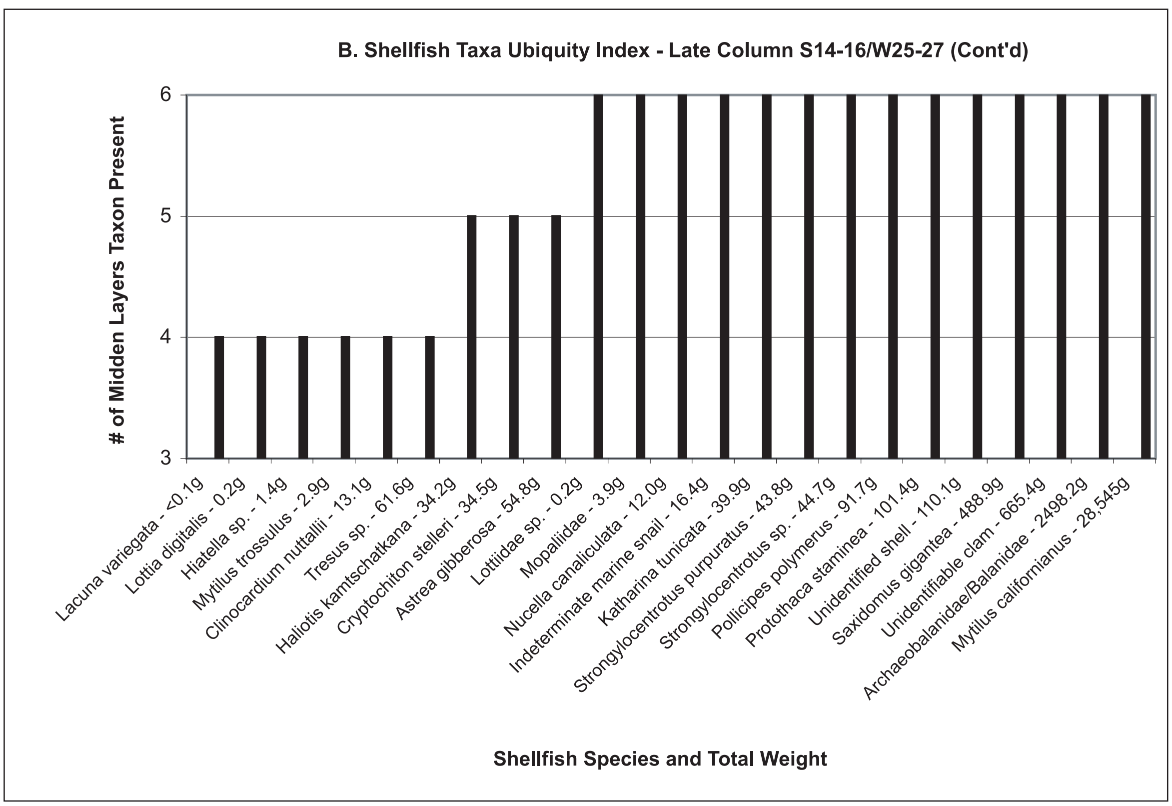


Figure 9. Shellfish Taxa Ubiquity Index – Late Column S14–16/W25–27.

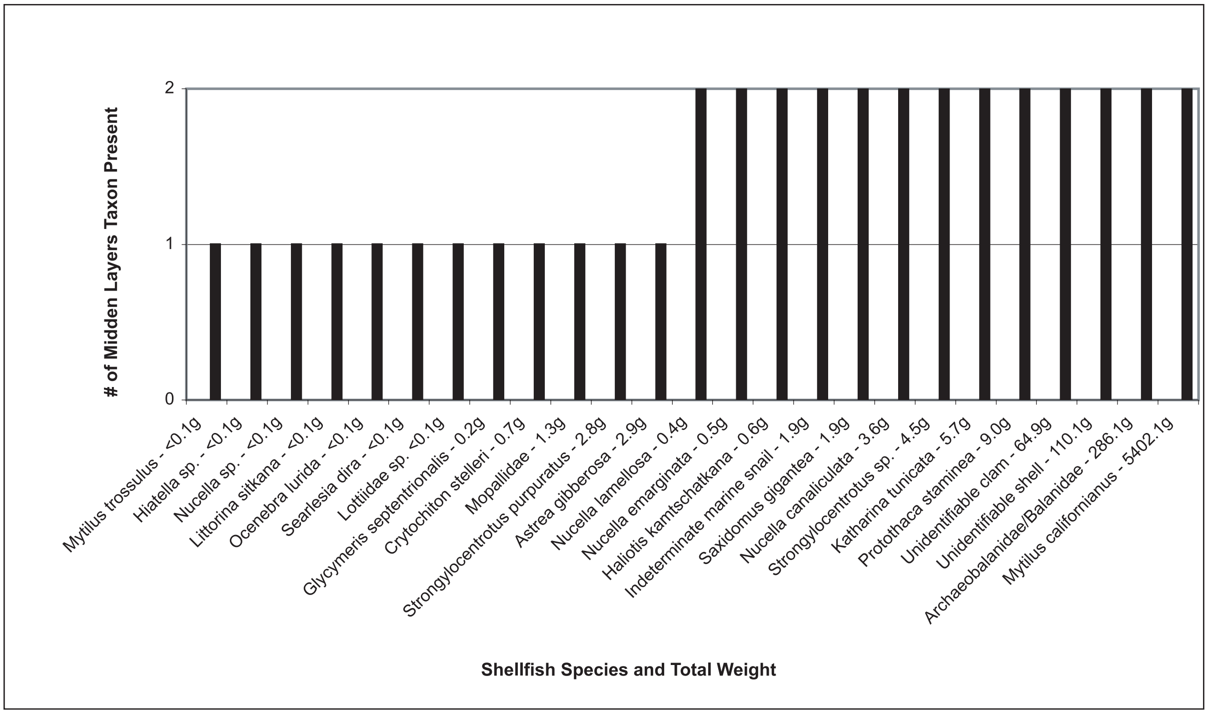


Figure 10. Shellfish Taxa Ubiquity Index – Early Column S56–57/W50–52.

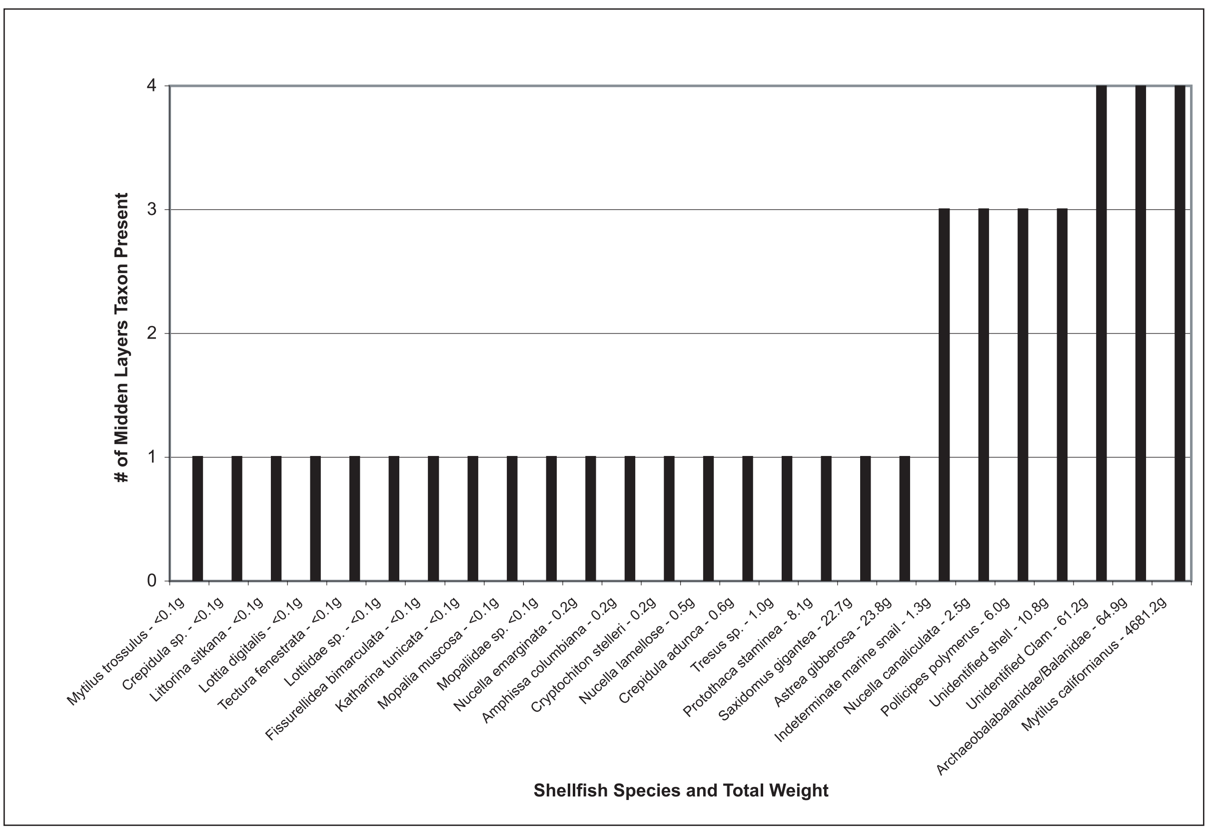


Figure 11. Shellfish Taxa Ubiquity Index – Early Column S62–64/W62–64.

in mesh sizes measuring less than 12.5 mm (½"), in all assemblages. Larger mussel shell specimens (≥12.5 mm [½"]) were most frequent in the Late Column S14–16/W25–27 samples, particularly in the upper midden stratum.

Acorn barnacle occurred most often in the 6.3-mm [¼"] size, in all assemblages. Clams, the most robust of all shell groups, yielded the largest quantity of larger-sized materials. Studies show that proportions of larger-sized clam material (>½") were much higher in the later assemblage (72%), than in two earlier assemblages (45%–55%). With respect to the grain-size distributions for all shell assemblages, values measured close to those of the California mussel: 79% of all shell from Late Column S14–16/W25–27 measured less than 12.5 mm (½"); 87.9% of same sized materials from Early Column S62–64/W62–64; and 93.3% in Early Column S56–57/W50–52. The proportions of small (3 mm, ⅛") all shell material varied between the late and early period assemblages: 42.1% – late period column; and 48.9% and 57.1% – Early Column S62–64/W62–64 and Early Column S56–57/W50–52 respectively.

Furthermore, the grain-size distribution information showed the potential for data loss and sampling biases by researchers when they limit their examinations of faunal remains to 6.3-mm (¼") mesh material only. Significant proportions of shell material were recovered in the 3-mm [⅛"] mesh during this research: 41% of the total shell by weight – Late Column S14–16/W25–27 sample; 48% – Early Column S62–64/W25–27 sample; and 56% – Early Column S56–57/W50–52 sample. Similar concerns are valid with respect to the loss of vertebrate fauna. Between 63% and 69% of all bone material from the three column assemblages were found in the ⅛" mesh screen.

The counting of bivalve umbones was investigated as an alternative quantitative measure. Column bivalve umbo counts were in most cases found to have a good relationship with a specimen's weight proportion data. Differences in the two values for the California mussel were found to vary between 4.6% and 5.2%, and less than 2.6% for all other bivalves. With the exception of three cases, umbo counts yield a higher value, suggesting that bivalve umbo counts may reflect a more realistic and less biased shell quantification method. The umbo count technique also tends to reflect a more accurate contribution of lightweight bivalve species (i.e., *Mytilus trossulus)* to the assemblage that may otherwise be distorted by heavier bivalve species (i.e., *Mytilus californianus).*

The conversion of shell weight into estimated edible meat weights was explored. Shell/meat yield estimates indicate that specific marine molluscs, particularly the California mussel, were a major contributor to the Ts'ishaa subsistence base. The heavy exploitation of this specific marine resource is supported by on site field observations – in some areas within the village, shells heaps have accumulated to depths greater than 4 metres. The Ts'ishaa data indicate a potential for high yield estimates of edible shellfish meat during both early and late cultural components. Prior to 3000 BP, the California mussel, may have contributed 96% to 97% of all primary prey shellfish meat. In later times, sample data from the central part of the village hint at a decrease in the consumption of this species, supplemented with higher yields of clam and barnacle meat.

This study revealed that a wide array of marine mollusc species (57) entered the site. The species illustrate that a number of intertidal habitats in the Broken Group archipelago were the focus of shell gathering activities. The shellfish material, however, indicate a strong emphasis was placed on the exploitation of outside, exposed, and semi-exposed rocky shore shellfoods (particularly California mussel) by the site occupants for the past 5,000 years. In addition to California mussel, other primary and secondary prey harvested for consumption included: acorn and gooseneck barnacles, selected marine snails, limpets, chitons, and sea urchin. Assortments of shell species were also obtained from these environmental zones for decorative, ceremonial, and/or utilitarian purposes: abalone, the operculum of the red turban snail, and dogwinkle. In more sheltered environs in the archipelago, a variety of clams could be found on mud, sand, and gravel beaches. Past shellfish inventories in the Broken Group Islands have shown that some beaches produce a high yield of intertidal bivalve species, particularly native littleneck, butter, and horse clams. A number of these productive beaches would have been only hours from Ts'ishaa by canoe.

The final quantitative variable examined as part of this study was shellfish species ubiquity, the number of proveniences in which a particular taxon was recovered. Index data revealed that three shell categories, California mussel, acorn barnacle, and unidentified clam, were present in all stratigraphic layers, in all column samples. Further investigation of this variable is warranted as it offers the possibility to identify patterns in diet, refuse disposal behaviour, and other cultural activity within the site.

Finally, an examination of marine shell taxanomic richness or species diversity over time proved interesting. Preliminary site data revealed that an average of 25.5 shellfish species were harvested during the middle Holocene. In the late Holocene major changes in shell resource procurement are evident, with up to 56 identified shell taxa entering the site. Such a significant increase in shellfish diversity over the past 3000 to 2500 years may reflect several factors, such as technological improvements, the use and exploitation of additional habitat, or environmental change.

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