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Faunal Analysis: Fish Remains

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Anyone who has been to Burton Acres Park will notice the constant wind that makes it an ideal place to dry fish. Not surprisingly, fish remains were found in abundance in this shell midden. Salmon were, and are, one of the most important foods for the people of the Puget Sound. At the Burton Acres Shell Midden, however, salmon takes a notable second place to herring. This small fish comprises nearly 80% of the fish found in the layers. Burned fish bone is further evidence of drying and cooking. Many remains found in the archaeological deposits are from fish that no longer live in Quartermaster Harbor, victims of destroyed habitat and pollution.

Excavation, recovery and analysis of almost 9000 fish remains from the Burton Acres Shell Midden provides an opportunity to address the question of prehistoric fish use in southern Puget Sound. While the fish fauna is represented by a wide variety of fish common to the Puget Sound today, herring (Clupeidae) dominate the assemblage. The abundance of fish bone at this site, especially herring, reflects a significant reliance on aquatic resources besides shellfish. From this analysis, the spatial distribution of different taxa and the condition of the remains that have been recovered provide a picture of changing fish utilization at the site, and may indicate the changing subsistence patterns of Native peoples as a result of European contact.

METHODS

Sorting and Sampling

Given time constraints, all of the fish remains could not be analyzed. The sampling strategy was designed to provide even spatial coverage and allow our results to be comparable to other project analyses. The fish remains examined were recovered from approximately 25% of the buckets excavated, selecting every first and fourth bucket from each excavation level. Specimens were recovered from all four mesh sizes (1 inch, 1/2 inch, 1/4 inch, and 1/8 inch) used during excavation.

Analysis Protocol

Fish remains were identified to the finest taxonomic level possible using the comparative collections of Virginia Butler (Portland State University), Mike Etnier (University of Washington), and the National Marine Mammal Laboratory at the Sand Point National Oceanic and Atmospheric Administration (NOAA) station in Seattle, Washington. Besides taxonomic information, specimens were visually examined for evidence of burning. A coding system was developed (see Appendix

Chapter opening photo: Archaeologist Bob Kopperl (center) gives instructions to two volunteers, while friends watch over their shoulders. Fish bones were found in such large numbers at the Burton Acres Shell Midden that people had to be reminded to keep excavating and not stop to identify individual bones while excavating. It was much more efficient to identify the hundreds of fish bones after the bucket was screened and contents spread on sorting trays.

G) for entering data from the fishbone analysis onto a database. Certain pieces of information were entered for each specimen examined, including a code for the finest taxon to which it could be identified, a code for the element (bone), whether or not it has a diagnostic landmark, whether or not the specimen is burned, and the quantity of specimens that share this same information from a particular provenience (for example, the number of burned herring caudal vertebrae from the same bucket and mesh size).

Analysis commenced at the Burke Museum of the University of Washington. Each bag of fish bones, which had an individual catalogue number, was separated into elements, burned and unburned, from different taxa. Each group (a particular element from a particular taxa, either burned or unburned) is a separate entry in the database. All fish remains, bagged by excavation unit, level, bucket and screen fraction, were rebagged by taxon. Blank forms with spaces for all the variables were created on Microsoft Excel, filled in by hand, entered into an SPSS (Statistical Package for the Social Sciences) file using the same variables, and saved both in SPSS for statistical analysis and Excel for compact data tables (see Appendix G).

Fish remains are quantified using NISP, or Number of Identified Specimens, which is the quantity of all remains identified for each taxon. Each specimen, whether broken or unbroken, is treated as a single NISP. Other methods of quantification were not used, such as MNI, or Minimum Number of Individuals. This counting unit is the minimum number of individuals represented by a taxon (quantified by either the left or the right most abundant elements, or just the number if the element is unpaired, such as vertebrae). Grayson (1984) and Butler (1987) have shown that MNI and NISP are highly correlated. Given the aggregation problems associated with MNI, NISP is used to quantify taxonomic abundance in this analysis.

DESCRIPTIVE SUMMARY

This section provides a description of the fish taxa identified in the Burton Acres Shell Midden. The data discussed in this section are displayed in Table 10.1. The first column provides the scientific name of each taxon found at the site. Each of these taxa are described in further detail below. The second column gives the common name of each taxon. The last five columns provide the quantity of each taxon found in each excavation unit, as well as the total number of fish bones from each taxon found at the site.

The descriptive summary below details each fish taxon found at 45KI437. Of the almost 9000 fish bones analyzed, 5321 specimens are identified to at least the taxonomic level of order. The scientific name for each taxon, including class, order and family, genus, and species where appropriate, is given. A list of the skeletal elements found for each taxon is followed by remarks regarding how these elements are identified, and pertinent ecological and ethnographic information where available. Also included are data regarding each taxon's particular distribution in modern-day Puget Sound. This information comes from a report published by Miller and Borton (1980) for the Washington Sea Grant, who compiled a series of distribution maps for every species of fish reported in Puget Sound, based on reports from both private citizens and government agencies.

Class Chondrichthyes (cartilaginous fish)
Subclass Elasmobranchii (sharks, rays)
Order Squaliformes
Family Squalidae
Squalus acanthias (Spiny Dogfish)

Material: 15 vertebrae fragments.
Total: 15 specimens.
Remarks: Spiny dogfish vertebrae have a very distinctive spool-shape, which allows for species-level identification when encountered. They are the most abundant of seven shark Families and ten shark species in Puget Sound (Miller and Borton 1980). They inhabit both shallow and deep water and feed on small fish such as herring and smelt (Hart 1973).

Order Rajiformes (skates and rays)
Family Rajidae
Raja sp. (Skate)

Materials: 29 teeth, 1 dermal denticle.
Total: 30 specimens.
Remarks: Skate teeth have distinctive mushroom-shaped bases and their dermal denticles have flared bases with serrated edges. There are four species of skate in Puget Sound, all being shallow bottom-feeders. Comparative material was limited, so identification of these specimens is made at the genus-level. *Raja*

Table 10.1 Identified Fish Specimens (NISP)

Scientific Name	Common Name	Unit				Total
		22/58	26/57	28/58	29/58	
Squalus acanthias	Spiny dogfish	3	-	4	8	15
Raja sp.	Skate	7	-	1	22	30
Hydrolagus colliei	Spotted ratfish	4	-	4	9	17
Clupea harengus pallasi	Pacific herring	427	4	1011	2838	4280
Oncorhynchus sp.	Salmon	9	-	291	268	568
Porichthys notatus	Plainfin midshipman	-	-	1	5	6
Family Gadidae	Codfish	-	-	2	6	8
Family Embiotocidae	Surfperch	24	-	2	55	81
Embiotoca lateralis	Striped seaperch	2	-	-	6	8
Rhacochilus vacca	Pile perch	-	-	-	3	3
Family Scorpaenidae	Rockfish	4	-	-	24	28
Family Cottidae	Sculpin	5	-	4	34	43
Leptocottus armatus, cf.	Pacific staghorn sculpin	-	-	-	14	14
Scorpaenichthys marmoratus, cf.	Cabezon	-	-	-	2	2
Order Pleuronectiformes	Flatfish	69	1	21	116	207
Family Pleuronectidae	Right-eye flatish	-	-	-	2	2
Lepidopsetta bilineata, cf.	Rock sole	1	-	-	1	2
Microstomus pacificus, cf.	Dover sole	-	-	-	1	1
Parophyrs vetulus, cf.	English sole	-	-	-	3	3
Platichthys stellatus, cf.	Starry flounder	-	-	-	3	3
Total		555	5	1341	3420	5321

binoculatas (big skate) and *Raja rhina* (longnose skate) are by far the most common skates in the area and have been recorded in Quartermaster Harbor (Miller and Borton 1980).

Order Chimaeriformes
Family Chimaeridae (Chimeras)
Hydrolagus colliei (Spotted ratfish)

Materials: 17 teeth.
Total: 17 specimens.
Remarks: The teeth of the spotted ratfish are distinctive wavy bony plates with vertical ridges perpendicular to the cutting edge. The spotted ratfish is the only member of the order Chimaeriformes found along the Northwest Coast (Hart 1973). Therefore, identification is made at the species level. The fish often inhabits deep waters but has been known to exhibit seasonal variation in its depth in Puget Sound. This occurs mainly in the spring when the spotted ratfish shows greater abundance in shallower water (Quinn et al. 1980).

Class Osteichthyes (bony fishes)
Order Clupeiformes
Family Clupeidae
Clupea harengus pallasi (Pacific herring)

Materials: 42 articulars, 1 basihyal, 24 basioccipitals, 4 basypterygia, 43 ceratohyals, 23 cleithra, 63 dentaries, 5 ectopterygoid, 27 epihyals, 43 exoccipitals, 37 frontals, 32 hyomandibulae, 25 upper hypohyals, 2 lower hypohyals, 37 interopercles, 40 maxillae, 1 metapterygoid, 68 opercles, 12 parasphenoids, 15 parietals, 30 postcleithra, 19 posttemporals, 63 prefrontals, 39 preopercles, 345 prootics, 67 pterotics, 37 quadrates, 10 scapulae, 42 subopercles, 34 supraoccipitals, 5 urohyals, 7 vomers, 16 1st vertebrae, 916 abdominal vertebrae, 1817 caudal vertebrae, 35 hypurals, 11 miscellaneous spines, 8 unidentifiable fragments.
Total: 4280 specimens.
Remarks: Herring is by far the most abundant fish taxon in the Burton Acres Shell Midden assemblage.

There are two species of clupeids found in the northeast Pacific: *Clupea harangus pallasi* (Pacific herring) and *Sardinops sagax* (Pacific sardine) (Hart 1973). The Pacific sardine is very rare in Puget Sound, whereas a herring run has been reported in the immediate vicinity of Burton Acres Shell Midden in Quartermaster Harbor (Miller and Borton 1980). Pacific herring are an anadromous schooling fish that migrate to shallow water in the late winter to spawn into the early spring (Hart 1973). In all likelihood, the archaeological material from 45KI437 represents Pacific herring, but given that comparative material from *Sardinops sagax* was not available for review, the identification must remain somewhat tentative.

Order Salmoniformes
Family Salmonidae
cf. *Oncorhynchus* sp. (Salmon)

Materials: 1 basioccipital, 1 ceratohyal, 1 cleithrum, 2 dentaries, 1 exoccipital, 1 parasphenoid, 1 parietal, 7 radials, 1 scapula, 1 suborbital, 2 supracleithra, 17 teeth, 3 type 1 (1st) vertebrae, 30 type 2 (abdominal) vertebrae, 57 type 3 (caudal) vertebrae, 2 type 4 (ultimate) vertebrae, 425 indeterminate vertebrae, 2 hypurals, 12 unidentifiable fragments.

Total: 568 specimens.

Remarks: Salmonid vertebrae and many other skeletal elements are easy to identify due to their morphology (Cannon 1987). Abdominal and caudal vertebrae can be distinguished on the basis of caudal and haemel processes (Butler 1993). However, discrimination beyond genus level is very difficult to accomplish without otoliths, as in the case for this assemblage. Butler (1987) developed a discriminant function analysis that uses measurements on 1st vertebrae of salmon to statistically assign a specimen to a particular species. With only three first vertebrae from this site, all in fragmentary condition, identification below genus-level is not possible.

The waters of Puget Sound and surrounding coastal streams are home to seven species in the genus *Oncorhynchus* (salmon and trout), two species of *Salvelinus* (*S. malma* - dolly varden; *S. confluentus* - bull trout), and one species of whitefish (*Prosopium williamsoni* - mountain whitefish) (Miller and Borton 1980). The remains from Burton Acres Shell Midden could be from any of these species, although in general, their large size suggests that the archaeological sample is from *Oncorhynchus* (salmon and trout). However, chinook salmon (*Oncorhynchus tshawytscha*) are the only reported salmon to be observed in the vicinity of Quartermaster Harbor (Miller and Borton 1980).

Salmon are anadromous fish that spend part of their lives growing to maturity in fresh waters, part of their lives in marine waters, then returning to the same fresh water system to spawn. Salmon are common throughout the Pacific Northwest in most marine environments, and have been extensively documented as being utilized ethnographically and historically, and are found in most archaeological sites.

Order Batrachoidiformes
Family Batrachoididae (toadfish)
Porichthys notatus (Plainfin midshipman)

Materials: 1 abdominal vertebra, 2 caudal vertebrae, 3 indeterminate vertebrae.

Total: 6 specimens.

Remarks: The vertebrae identified to this taxa display neural and haemal processes that are diagnostic of Batrachoididae. Identification beyond family-level to species is made because no other species of Batrachoididae has been found north of Point Conception, California (Butler 1987). In Puget Sound, the plainfin midshipman is widespread, dwelling in both shallow intertidal waters where spawning occurs in the spring and in deeper waters at other times of the year (Miller and Borton 1980; Hart 1973).

Order Gadiformes
Family Gadidae (Codfish)

Materials: 1 otolith, 4 abdominal vertebrae, 1 caudal vertebra, 2 indeterminate vertebra.

Total: 8 specimens.

Remarks: Although there are numerous otoliths found in the Burton Acres Shell Midden assemblage, only one could be identified to family Gadidiae. The others are too fragmentary to determine taxon. The vertebrae are identifiable to family as well. Despite the availability of all four species of codfish found in Puget Sound available in the comparative collections, any finer identification is difficult because the bones are too fragmented. The four species of codfish are Pacific cod (*Gadus macrocephalus*), Pacific hake (*Merluccius productus*), Pacific tomcod (*Microgadus proximus*), and walleye

pollock (*Theragra chalcogramma*). All four have been found in Quartermaster Harbor (Miller and Borton 1980).

Order Scorpaeniformes

Family Scorpaenidae (Scorpionfish and Rockfish)

Materials: 1 dentary, 1 exoccipital, 1 hyomandibular, 3 abdominal vertebrae, 15 caudal vertebrae, 7 indeterminate vertebrae.

Total: 28 specimens.

Remarks: Because of the limited comparative material available, identification of rockfish elements is to family. There are two genera and 27 species of rockfish found in Puget Sound today (Miller and Borton 1980). The species most commonly found near Vashon Island today are brown rockfish (*Sebastes auriculatus*), copper rockfish (*Sebastes caurinus*), yellowtail rockfish (*Sebastes flavidus*), quillback rockfish (*Sebastes maliger*), black rockfish (*Sebastes melanops*), bocaccio (*Sebastes paucispinis*), and the canary rockfish (*Sebastes pinniger*) (Miller and Borton 1980). Rockfish are bottom fish that inhabit waters ranging from intertidal zones to very deep open water (Hart 1973).

Family Cottidae (Sculpin)

Materials: 1 articular, 1 upper hypohyal, 2 opercles, 1 palatine, 2 premaxillae, 1 quadrate, 2 radials, 3 abdominal vertebrae, 29 caudal vertebrae, 1 hypural.

Total: 40 specimens.

Remarks: There are 36 species of sculpin known to inhabit Puget Sound today (Miller and Borton 1980). The genera of Cottidae available in the comparative collections used are *Leptocottus* sp., *Cottus* sp., *Myoxocephalus* sp., *Enophrys* sp., *Scorpaenichthys* sp., *Hemilepitotus* sp., and *Chitonotus* sp. Unfortunately, only a few elements such as some of the jaw parts and some cranial elements, especially the preopercle, can be identified to species-level, and these assignments are based on exact matches with the limited comparative material available. This makes those identifications rather tentative. The rest of the elements, mainly vertebrae and fragmented cranial elements, have only been identified to family-level.

cf. *Leptocottus armatus* (Pacific staghorn sculpin)

Materials: 2 basioccipitals, 1 frontal.

Total: 3 specimens.

Remarks: These identifications are tentative because of the number of Cottidae genera that exist and the limited comparative material. The Pacific staghorn sculpin is perhaps the most widespread sculpin in Puget Sound. Besides this species, there is only one other sculpin reported in Quartermaster Harbor: the slim sculpin (*Radulinus asprellus*) (Miller and Borton 1980). The slim sculpin has a very gracile skeleton (hence the name), and is on average a third of the size of the Pacific staghorn sculpin (Hart 1973), which aided in the identification of these elements as belonging to the genus *Leptocottus*.

Leptocottus armatus (Pacific staghorn sculpin)

Materials: 1 dentary, 5 premaxillae, 1 preopercle, 3 vomers, 1 miscellaneous jaw fragment.

Total: 11 specimens.

Remarks: The elements of the mouth region, and especially the antler-shaped preopercle of the Pacific staghorn sculpin, are diagnostic (Wydoski and Whitney 1979; Butler 1987). Based on their morphology, these elements from the Burton Acres Shell Midden assemblage have been assigned to *Leptocottus armatus*.

cf. *Scorpaenichthys marmoratus* (Cabezon)

Materials: 1 dentary, 1 frontal.

Total: 2 specimens.

Remarks: Identification of the cranial fragments is from comparative collections at the National Marine Mammal Lab at NOAA, Seattle, WA. The specimens from Burton Acres Shell Midden are from an extremely large sculpin. There are only two species of sculpin that attain this size: the great sculpin (*Myoxocephalus polyacanthocephalus*) and cabezon (*Scorpaenichthys marmoratus*) (Hart 1973). The archaeological specimens were morphologically identical to the cabezon from the comparative material, most notably in proportional tooth-socket width and in the angle between the toothed portion and the inferior portion of the dentary. The size and patterning on the frontal bone is identical to the cabezon as well. The cabezon is one of the largest sculpins, and is probably the largest to inhabit Puget Sound. It has been reported in the area around Vashon Island but not within Quartermaster Harbor proper (Miller and Borton 1980). They inhabit water of moderate depths although they are also found in shallow water (Hart 1973).

Order Perciformes

Family Embiotocidae (Surfperches)

Materials: 1 quadrate, 1 vomer, 5 lower pharyngeals, 58 pharyngeal teeth, 1 symplectic, 2 miscellaneous jaw fragments, 6 abdominal vertebrae, 5 caudal vertebrae, 1 indeterminate vertebra, 1 unidentifiable fragment.

Total: 81 specimens.

Remarks: Identification of surfperches to species can only be done with confidence to mouthparts, especially pharyngeals and premaxillae, as well as the parasphenoid. Teeth from surfperch pharyngeals are fairly common in the assemblage but cannot be assigned to species in this analysis based on the available comparative material. This was the case with the elements in this category. There are six species of surfperch that inhabit Puget Sound today, only three of which are common near Quartermaster Harbor: shiner perch (*Cymatogaster aggregata*), striped seaperch (*Embiotoca lateralis*), and pile perch (*Rhacochilus vacca*) (Miller and Borton 1980). Bays and intertidal zones, especially near rocky shores and old piers, are common habitat for surfperch (Hart 1973).

Embiotoca lateralis (Striped seaperch)

Materials: 2 premaxillae, 4 lower pharyngeals, 2 upper pharyngeals.

Total: 8 specimens.

Remarks: There are no modern reports of striped seaperch in Quartermaster Harbor, but they have been found nearby in Colvos and Dalco Passages (Miller and Borton 1980).

Rhacochilus vacca (Pile perch)

Materials: 1 parasphenoid, 1 premaxilla, 1 lower pharyngeal.

Total: 3 specimens.

Remarks: The bones of the pile perch's jaw are diagnostic. Although more common today in Tacoma Narrows, there are a few reports of pile perch in Quartermaster Harbor (Miller and Borton 1980).

Order Pleuronectiformes (Left- and right-eyed flounders)

Materials: 4 articulars, 1 basihyal, 3 basypterygia, 3 ceratohyals, 1 cleithra, 3 dentaries, 1 epibranchial, 3 epihyal, 1 frontal, 3 hyomandibulae, 3 upper hypohyals, 1 lower hypohyal, 2 maxillae, 1 metapterygoid, 1 pharyngobranchial, 2 posttemporals, 1 premaxilla, 1 preopercle, 2 pterotics, 4 quadrates, 1 retroarticular, 1 scapula, 1 supracleithrum, 2 urohyals, 4 vomers, 3 1st vertebrae, 41 abdominal vertebrae, 96 caudal vertebrae, 1 hypural, 13 indeterminate vertebrae, 1 unidentifiable fragment.

Total: 205 specimens.

Remarks: There are two species of left-eyed flounder (family Bothidae) and 13 species of right-eyed flounder (family Pleuronectidae) found in Puget Sound today, and all have been reported either in Quartermaster Harbor or in the vicinity of Vashon Island. Specific flatfish taxa are diverse and difficult to determine from the fish bone in the Burton Acres Shell Midden assemblage. General rules about size (Pleuronectidae tend to be larger than Bothidae) do not apply here because of the range of size classes within this sample. Therefore most specimens that could be identified confidently to order Pleuronectiformes are left at that taxonomic level unless they are mouthparts or other well-preserved cranial elements. Pleuronectiformes are bottom-dwelling fish and have a long history of being used by humans. In this assemblage, pleuronectiformes are the most abundant type of fish after herring and salmon.

Family Pleuronectidae (Right-eyed flounders)

Materials: 2 ceratohyals.

Total: 2 specimens.

Remarks: These two cranial elements are identified to Pleuronectidae because they are definitely not from either Bothid species that inhabit Puget Sound. However, they cannot be firmly identified to any particular Pleuronectidae species.

cf. *Lepidopsetta bilineata* (Rock sole)

Materials: 1 frontal, 1 premaxilla.

Total: 2 specimens.

Remarks: Identification of these two elements as rock sole is based on exact matches with comparative material, but because the comparative collection is incomplete, this is a tentative identification. Puget Sound is a well-known spawning ground of the rock sole; this species has been reported within Quartermaster Harbor (Hart 1973; Miller and Borton 1980).

cf. *Microstomus pacificus* (Dover sole)

Materials: 1 premaxilla.

Table 10.2 Relative Abundance (NISP) of Fish Remains by Excavation Unit and Taxon

Unit	Layer	Volume Sampled (liters)	Dogfish		Skate		Ratfish		Herring		Salmon		Toadfish		Codfish		Rockfish		Sculpin		Surfperch		Flatfish		Total	
			C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V
22/58	2A‡	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2B‡	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2C‡	16	-	-	-	-	-	-	2	0.1	1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	3	0.2
	2D	16	-	-	-	-	-	-	42	2.6	3	0.2	-	-	-	-	-	-	-	-	16	1.0	1	0.1	62	3.9
	2E	14	1	0.1	5	0.4	3	0.2	223	15.9	-	-	-	-	-	-	3	0.2	-	-	3	0.2	44	3.1	282	20.1
	2F	6	2	0.3	-	-	1	0.2	139	23.2	3	0.5	-	-	-	-	-	-	5	0.8	1	0.2	8	1.3	159	26.5
	2G	8	-	-	2	0.3	-	-	11	1.4	-	-	-	-	-	-	-	-	-	-	2	0.3	14	1.8	29	3.6
	3A	8	-	-	-	-	-	-	10	1.3	2	0.3	-	-	-	-	1	0.1	-	-	4	0.5	4	0.5	21	2.5
26/57	2A‡	26	-	-	-	-	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1
	2B	10	-	-	-	-	-	-	2	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.2
	3A	4	-	-	-	-	-	-	1	0.3	-	-	-	-	-	-	-	-	-	-	-	-	1	0.3	2	0.5
28/58	2A‡	34	-	-	-	-	-	-	71	2.1	10	0.3	-	-	-	-	-	-	-	-	-	-	2	0.1	83	2.4
	2B‡	74	2	0.1	-	-	2	0.1	769	10.4	245	3.3	1	0.1	2	0.1	-	-	4	0.1	1	0.1	2	0.1	1028	13.9
	2C‡	32	2	0.1	1	0.1	1	0.1	149	4.7	34	1.1	-	-	-	-	-	-	-	-	1	0.1	11	0.3	199	6.2
	3A	16	-	-	-	-	1	0.1	22	1.4	2	0.1	-	-	-	-	-	-	-	-	-	-	6	0.4	31	1.9
29/58	2A‡	40	1	0.1	-	-	-	-	160	4.0	6	0.2	-	-	-	-	-	-	-	-	-	-	1	0.1	168	4.2
	2B‡	22	-	-	-	-	-	-	176	8.0	16	0.7	3	0.1	1	0.1	1	0.1	-	-	-	-	4	0.2	201	9.1
	2C‡	44	1	0.1	-	-	-	-	50	1.1	76	1.7	-	-	3	0.1	5	0.1	2	0.1	4	0.1	27	0.6	168	3.8
	2D	32	2	0.1	8	0.3	3	0.1	136	4.3	46	1.4	-	-	-	-	8	0.3	4	0.1	9	0.3	11	0.3	227	7.1
	2E	36	3	0.1	9	0.3	4	0.1	984	27.3	94	2.6	2	0.1	1	0.1	4	0.1	24	0.7	28	0.8	36	1.0	1189	33.0
	2F	24	1	0.1	5	0.2	2	0.1	1332	55.5	30	1.3	-	-	1	0.1	6	0.3	20	0.8	23	1.0	46	1.9	1466	61.1
Total		462	15	0.1	30	0.1	17	0.1	4280	9.3	568	1.2	6	0.1	8	0.1	28	0.1	59	0.1	92	0.2	218	0.5	5321	11.5

‡ = layers thought to date to post-contact with Euro-Americans; all other layers date to pre-contact (see Table 5.1). C = count. C/V = count/volume.

Total: 1 specimen.
Remarks: This identification is tentative because of the incomplete comparative collection used. The Dover sole is considered one of the most hardy flatfishes, living off the bottom of waters after an extended pelagic (living free from the bottom) life as a juvenile (Hart 1973). Dover sole have been reported in Quartermaster Harbor and surrounding Vashon Island (Miller and Borton 1980).

cf. *Parophrys vetulus* (English sole)
Materials: 1 premaxilla, 1 quadrate, 1 vomer.
Total: 3 specimens.
Remarks: Identification of this taxon is based on exact matches, but like the other species-level identifications of flounder taxa it must remain tentative because of limited comparative material. English sole congregate seasonally in shallow water in the spring shortly after spawning, and move into deeper waters by winter (Hart 1973). Like other species of flatfish, English sole is common in the Puget Sound and has been reported in Quartermaster Harbor (Miller and Borton 1980).

cf. *Platichthys stellatus* (Starry flounder)
Materials: 1 premaxilla, 2 interhaemal spines.
Total: 3 specimens.
Remarks: Starry flounder are mainly a shallow water flatfish and are unique among Pleuronectidae in that they may be either left-eyed or right-eyed. They also have an uncommon tolerance for freshwater (for flatfish), and they have been found in larger rivers emptying into the Pacific Ocean (Hart 1973). Starry flounder are a common fish both in the Puget Sound area and around Vashon Island specifically (Miller and Borton 1980).

RESULTS

Almost 9000 fish remains representing 21 taxa are identified from the Burton Acres Shell Midden, 5321 (about 60%) of which are identified to at least order-level. Clupeidae (herring) dominates the assemblage as a whole, representing approximately 80% of the identified specimens. Salmonid remains constitute approximately 10% of the fish fauna, Pleuronectiformes (flatfish) provide about 4% of the remains, and the remaining 18 taxa make up the balance. About 3500 fish remains cannot be identified to any particular taxon. The abundances of fish bone divided into different taxa are given in Table 10.2. This table lists the four excavation units divided into their respective stratigraphic layers. The volume of excavated sediment in liters from each layer that was sampled for the analysis of fish bone is also listed. For each taxa, two numbers are given. The first is a count of all specimens belonging to that taxa in a particular unit and layer. The second is the count divided by the number of liters sampled in the layer in which it was found. The count divided by volume of the sample standardizes the counts, and gives a measure of density that can be compared horizontally and vertically across the site.

Although most fish taxa are seen in small densities throughout all units and layers, with the exception of Unit 26/57, there are some noticeable patterns in the distribution of some taxa. Corrected for volume, Table 10.2 shows that the densest deposits of fish bones in Unit 22/58 are in the middle layers, 2E and 2F. Herring are the only substantial taxa in this unit, although dogfish, skate, ratfish, salmon, rockfish, sculpin, surfperch, and flatfish are present in small quantities. There are very few fish bones in Unit 26/57, only four herring and one flatfish specimen. The densest deposits of fish bones in Unit 28/58 are in the middle layers, 2B and 2C. Herring and, to a much lesser extent, salmon are the dominant taxa here. Small numbers of dogfish, skate, ratfish, toadfish, cod, sculpin, surfperch, and flatfish are present as well. Unit 29/58 has the densest deposits of fish bone in its bottom layers, 2E and 2F. Like the other units, this one is dominated by herring and salmon, but contains numerous remains of flatfish, surfperch, and sculpin. Dogfish, skate, ratfish, toadfish, cod, and rockfish are also present.

DISCUSSION

Taphonomic Summary

The fish bones at 45KI437 are well preserved, which is common in shell middens because of the alkalinity of the surrounding sediment. Most soils in the Northwest are acidic rather than alkaline, due to the decomposition of organic matter and release of organic acids. The calcium carbonate in the shells of the midden turns the sediment alkaline and lessens the effects of these acids. The result of this alkalinity at the Burton Acres Shell Midden is a fish bone assemblage that is well preserved. Very delicate herring cranial fragments

Table 10.3 Relative Abundance (NISP) of Burned Fish Remains by Excavation Unit and Taxon

Unit	Layer	Volume Sampled (liters)	Dogfish		Ratfish		Herring		Salmon		Toadfish		Codfish		Rockfish		Surfperch		Flatfish		Unid.Taxa		Total	
			C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V	C	C/V
22/58	2A‡	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2B‡	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2C‡	16	-	-	-	-	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1
	2D	16	-	-	-	-	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	14	0.9	15	0.9
	2E	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2F	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2G	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3A	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26/57	2A‡	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2B	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3A	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28/58	2A‡	34	-	-	-	-	-	-	2	0.1	-	-	-	-	-	-	-	-	-	-	-	-	2	0.1
	2B‡	74	-	-	1	0.1	17	0.2	219	3.0	-	-	-	-	-	-	-	-	-	-	120	1.6	357	4.8
	2C‡	32	-	-	1	0.1	79	2.5	25	0.8	-	-	-	-	-	-	1	0.1	-	-	56	1.8	162	5.1
	3A	16	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1
29/58	2A‡	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2B‡	22	-	-	-	-	21	1.0	11	0.5	1	0.1	-	-	-	-	-	-	2	0.1	3	0.1	38	1.7
	2C‡	44	-	-	-	-	25	0.6	58	1.3	-	-	1	0.1	1	0.1	-	-	7	0.2	54	1.2	146	3.3
	2D	32	-	-	-	-	-	-	-	-	-	-	-	-	2	0.1	-	-	1	0.1	-	-	3	0.1
	2E	36	1	0.1	1	0.1	15	0.4	5	0.1	-	-	-	-	-	-	1	0.1	-	-	-	-	23	0.6
	2F	24	1	0.1	-	-	78	3.3	7	0.3	-	-	-	-	-	-	8	0.3	5	0.2	5	0.2	104	4.3
Total		462	2	0.1	4	0.1	235	0.5	329	0.7	1	0.1	1	0.1	3	0.1	10	0.1	15	0.1	252	0.5	852	1.8

‡ = layers thought to date to post-contact with Euro-Americans; all other layers date to pre-contact (see Table 5.1). C = count. C/V = count/volume.

are preserved to the point of being identified to particular element. Not all shell middens in the Northwest have such excellent preservation.

Burned fish bones are present in small quantities in certain parts of the site (see Table 10.3). Lyman (1994) notes that color is the most frequently used criterion for determining whether or not bone has been burned. Shipman et al. (1984) performed numerous experimental studies on this subject and caution against the use of color to judge the nature of burning on bone, as numerous chemical processes during bone diagenesis can change the color of bone in a similar manner. Instead, proper analysis of bone for evidence of burning, and the temperature range to which bone has been exposed, can be done effectively by examining the specimen's crystalline structure using scanning electron microscopy (SEM). The difference between carbonized bone, which has been blackened, and calcined bone, which has turned white and lost all organic material in its chemical composition, is the temperature to which it has been exposed. McCutcheon (1992) performed experimental studies as well on the chemical and microscopic changes that occur to bones at high temperatures.

Because SEM and other techniques are quite expensive, and the small number of elements in this assemblage whose colors are characteristic of burning, this analysis used color as sufficient for recording whether or not a fish bone has been "burned". The summary of burned bone is given in Table 10.3. Within each column, the first number is the count of burned bone for each taxa in each unit and layer. The second number is the standardized count per volume. The last column gives the total abundance of burned fish bone in each unit and layer.

Of all the fish bones analyzed, 852 were identified as burned. Most burned fish bone is found in Units 28/58 and 29/58. In Unit 22/58, 16 burned specimens were found, and no burned specimens were found in Unit 26/57. The most notable concentration of burned fish bone is in Unit 28/58, Layer 2B. A dense deposit of salmon bones and other unidentifiable fish bones were found here, burned to the point of grayish-white discoloration, possibly indicating high temperatures. A deposit of burned herring bones lies below this in Layer 2C. Unit 29/58 had fewer burnt bones than Unit 28/58, and these tend to occur in lower layers than the burned bones in Unit 28/58. A small concentration of burned salmon, herring, and unidentifiable fish bones occurs in Layer 2C, and a small concentration of burned herring bones occurs in Layer 2F of Unit 29/58. Other taxa display evidence of burning, including dogfish, ratfish, flatfish, codfish, surfperch, and rockfish. They occur in small numbers throughout Units 28/58 and 29/58.

The burned fish bones at 45KI437 are evidence of fire use at Burton Acres Shell Midden. Possible fires associated with a shell midden such as Burton Acres Shell Midden are cooking hearths and food drying operations, as well as fires of natural origin. Bones could have been burned as they fell off a rack and into a fire used to smoke and dry fish.

Markings are more difficult to interpret on fish bones than coloration indicating burning. These marks, such as butchering and cut marks, are usually rare on fish remains and are not present on any of the remains analyzed from Burton Acres Shell Midden.

Differential survivorship of bone fragments due to bone density has been documented as an important factor in fish bone assemblage formation (Butler 1987, 1993). There are few salmon cranial elements as opposed to vertebrae, which in many contexts can be accounted for by bone density. However, there is an abundance of herring cranial fragments at 45KI437, which are even less dense. Therefore, bone density probably played a minor role in the composition of this assemblage.

Effects of Screen Size

Fish bones, like the fish they come from, vary greatly in size. The Pacific halibut (*Hippoglossus stenolepis*), is one of the largest bony fishes in the north Pacific, sometimes reaching over 2 1/2 meters in length, while the smallest species of fish are only a few centimeters long. The size of the fish and their fragmentation after death affect the screen size distribution of the assemblage. Although large fish such as Pacific halibut have been found at the mouth of Quartermaster Harbor (Miller and Borton 1980), the largest species found in the fish bone assemblage is the cabezon (*Scorpaenichthys marmoratus*). Most of the specimens found were Pacific herring (*Clupea harengus pallasi*), or fragmented salmon (*Oncorhyncus sp.*).

The screen size distribution reflects the composition of taxa: almost all specimens are from either 1/4 inch or 1/8 inch screens (Figure 10.1). For example, in Units 28/58 and 29/58, 5.4% of the specimens are from the 1/4

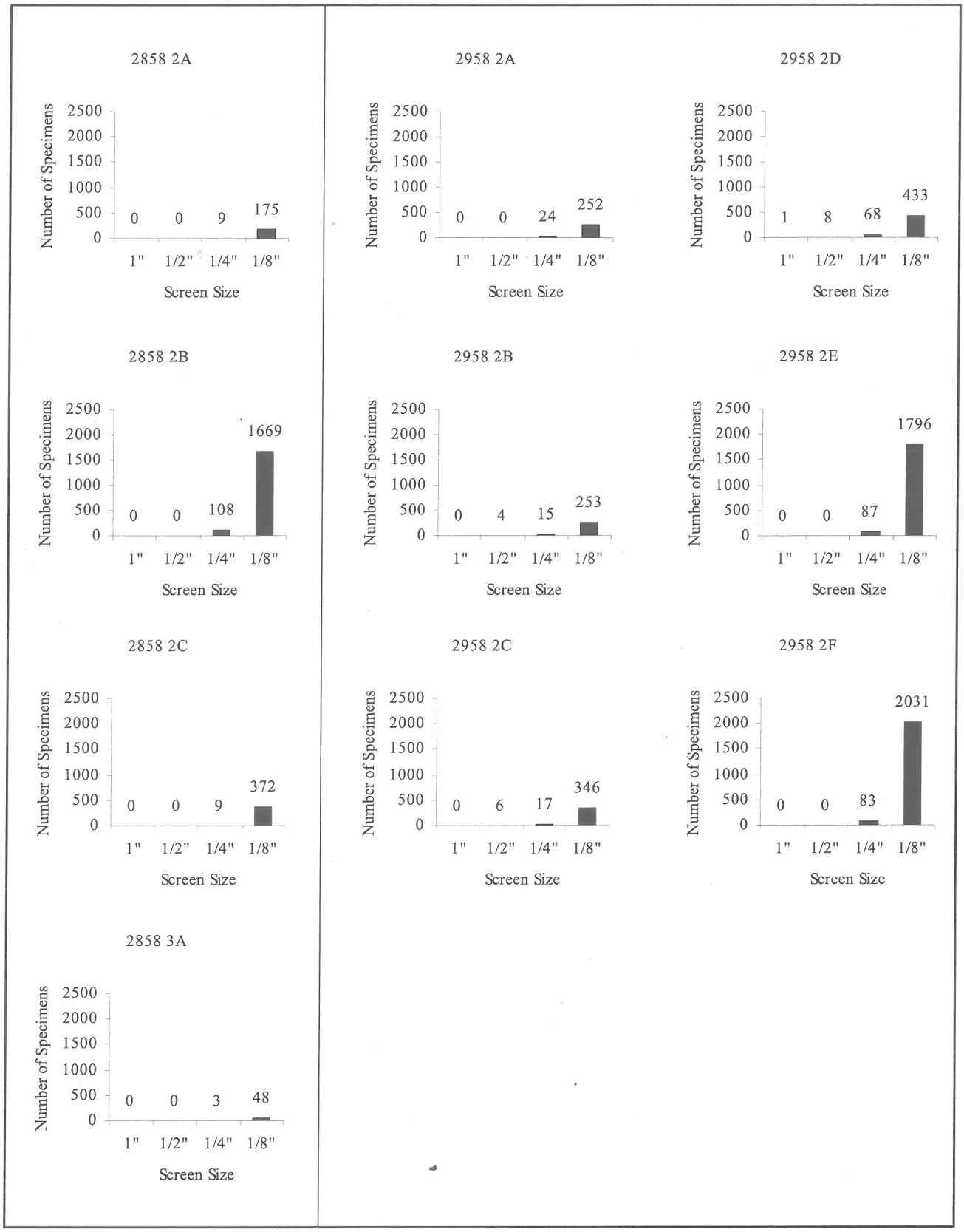

Figure 10.1 Number of fish remains found in each screen size displayed by layer and excavation unit. Numbers above bars represent counts.

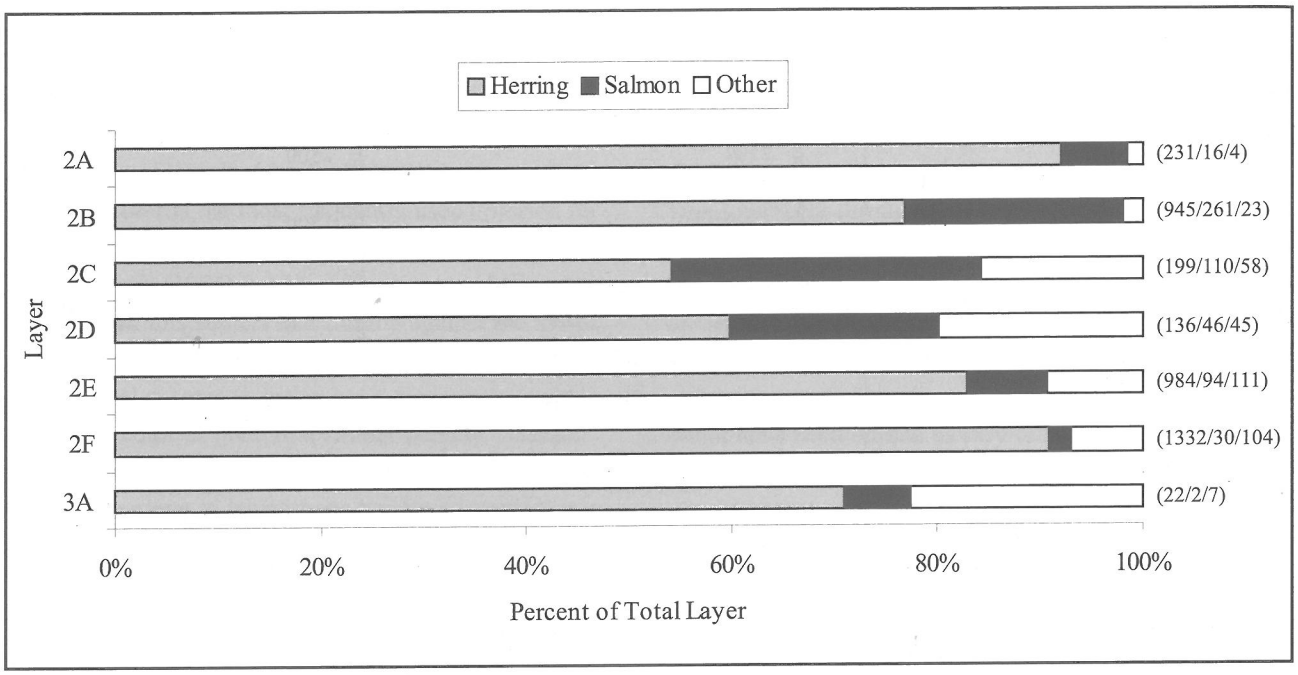

Figure 10.2 Number of herring, salmon, and other kinds of fish in each layer of Units 28/58 and 29/58 (combined). Numbers in parentheses represent NISP of herring/salmon/other.

inch screen, while 94.3% of the specimens are from the 1/8 inch screen. There was only one specimen in the 1 inch fraction: a cabezon (*Scorpaenichthys marmoratus*) fragment in Unit 29/58, Layer 2D. There were 20 specimens in the 1/2 inch fraction, 18 of which were in Layers 2B, 2C, and 2D of Unit 29/58. They were large herring cranial elements, salmon vertebrae, and six specimens that may be part of the cabezon, as they were found in the same bucket, but cannot be identified positively to that taxon. The other two specimens found in the 1/2 inch mesh were a flatfish (*Pleuronectiformes*) posttemporal and a rockfish (*Scorpaenidae*) abdominal vertebra found in Unit 22/58 Layer 2E (not shown in Figure 10.1). The majority of 1/8 inch specimens is not surprising given the abundance of taxa that are of small sizes (e.g. herring, surfperch).

Variability Over Time

Units 28/58 and 29/58 at the Burton Acres Shell Midden contain material spanning perhaps the last thousand years (see Chapter 5). Although the two other excavation units contain fish bone, their sample sizes are much smaller than these two units. Also, Units 28/58 and 29/58 are adjacent and have comparable stratigraphy, therefore the fish bone composition in these units will be analyzed for change over time.

The change in fish bone taxonomic composition can be seen stratigraphically in these two units (Figure 10.2) by examining the changing proportion of herring, salmon, and other fish taxa. These three categories are represented proportionally in each bar. The bars represent the fish bone assemblage sampled in each layer of Units 28/58 and 29/58 combined. Layer 2A is stratigraphically the younger layer.

The graph shows that herring is consistently the most abundant taxa in each layer, representing approximately 50% of the assemblage in Layer 2C to over 90% in Layer 2A. Salmon usually comprises the second most abundant category. It is proportionally the most abundant in Layer 2C, when herring is at its minimum. The other fish taxa found at the site, combined into one analytic category, comprise over 20% of the assemblage in Layer 2D and almost 20% in Layer 2C, when salmon is relatively abundant and herring is less abundant. In the densest layers, 2E and 2F, herring is maximally abundant, and salmon is less abundant than the other taxa found at the site. Although these other taxa were not differentiated in the graph, there is a marked increase in flatfish and surfperch in these layers (see Table 10.2). The layers towards the bottom are dominated by herring, despite an increase in other taxa. This increase in the number of other taxa found is most

likely the result of the larger size of the assemblages towards the bottom. Grayson (1984) notes that greater taxa richness can be expected with larger sample sizes.

Based on the fish taxa composition shown in Figure 10.2, there is a change stratigraphically in the fish being deposited at the Burton Acres Shell Midden. Herring were being deposited in much greater quantities in the bottom of these units, in layers associated with denser shells and shell fragments (see Chapter 11). The upper layers of Units 28/58 and 29/58, containing fewer fish bones, still contain proportionally more herring specimens than other taxa, although salmon is present in higher numbers in these upper layers relative to the lower layers.

CONCLUSIONS

Fish bones are the second most abundant type of faunal remains, next to shell, at Burton Acres Shell Midden. A sample of slightly over 25% of the fish bone at the site is analyzed. Almost 9000 individual specimens are examined. Of these, 5326 (approximately 60%) are identified taxonomically to at least family level (or order, in the case of some flatfish). They represent 20 fish taxa, all of which are common in the Quartermaster Harbor and Vashon Island area (Miller and Borton 1980).

Most of the fish bone came from the 1/8 inch screen size fraction, which is not surprising due to the abundance of herring in the assemblage. One element was found in the 1 inch fraction, belonging to cabezon, the largest taxa found at 45KI437. Based on the presence of herring cranial elements, the bones seem to be preserved quite well, a common occurrence at shell middens. Slightly less than 10% of the fish bone was burned, mostly salmon remains in Unit 28/58.

The fish bone assemblage at 45KI437 provides a record of changing patterns in fish use on Vashon Island. Fish utilization at Burton Acres Shell Midden included a variety of fish commonly available in the local area and seasonally restricted resources such as herring and salmon. Herring was the most abundant fish taxa, especially in the lower layers of the site. Although herring continued to be the most abundant taxa over time, the upper layers, most notably 2D, 2C, and 2B associated with historic artifacts exhibit a relatively greater proportion of salmon and other taxa.

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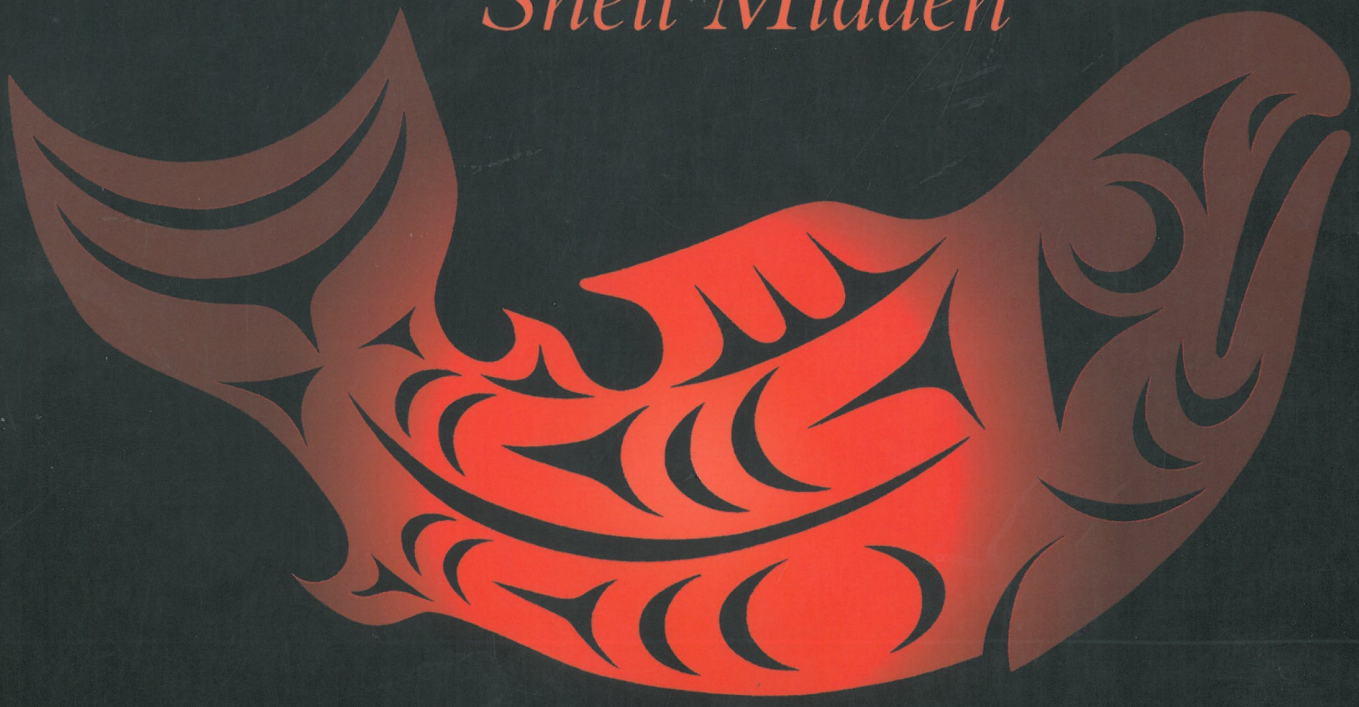
Vashon Island Archaeology

A View from Burton Acres Shell Midden



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