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COMPOSITION OF CALIFORNIA SHELLMOUNDS

BY
EDWARD WINSLOW GIFFORD

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UNIVERSITY OF CALIFORNIA PUBLICATIONS

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CONTENTS

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COMPOSITION OF CALIFORNIA SHELLMOUNDS

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EDWARD WINSLOW GIFFORD

CONTENTS

INTRODUCTION

The study of the composition of California shellmounds for the present paper was begun in August, 1913, at the suggestion of Dr. A. L. Kroeber. The paper has also had the benefit of his advice.

The first portion of the work was to find by analysis the quantity of the various constituents entering into the mound composition, the relation of quantity and depth in the occurrence of these constituents, and the amount of disintegration to which they have been subjected. The second portion of the work has been to consider the facts brought out by the analyses and see, first, whether they gave any insight into the environment of the shellmounds during their growth, and hence, whether they threw any light on the daily life of the shellmound dwellers; second, whether they offered any evidence as to the age of the mounds, either directly or relatively.

The results of the analyses of eighty-four samples (all part of the collection of the University of California Museum of Anthropology) are embodied in the present paper. These samples total in weight 10,003.15 grams, and range in weight from 31.47 to 832.9 grams (average 119.08 grams). In each case the sample is typical of the mound at a particular level and does not merely represent the contents of a pocket of any kind, for example a fireplace. Such pockets and their contents have been purposely avoided as not being typical.

Each sample was sifted through three square-mesh screens. The largest screen had meshes twelve millimeters square, the intermediate had meshes four millimeters square, and the smallest meshes two millimeters square. The material caught by each of these three screens, beginning with the coarsest, was separated by the eye and the various constitutents weighed. The fine material passing through the two-millimeter screen was analyzed chemically, by Mr. C. A. Harwell of the University of California, for the proportion of shell and of ash. All matter not proving to be either shell or ash in this chemical analysis has been called residue wherever mentioned in this paper.

Samples were examined from mounds, shown on the accompanying map, in the vicinity of San Francisco Bay, as listed below. The mound numbers refer to a manuscript map[1] and, in part, to a published map,[2] both by Mr. N. C. Nelson.

Sausalito (Mound No. 3)	6	samples
Greenbrae (Mound No. 76)	8	"
San Rafael (Mound No. 86*c*)	6	"
Carquinez (Mound No. 236)	2	"
Ellis Landing (Mound No. 295)	10	"
West Berkeley (Mound No. 307)	8	"
Emeryville (Mound No. 309)	19	"
Castro (Mound No. 356)	5	"
San Mateo (Mound No. 372)	4	"
San Mateo Point (Mound No. 418)	2	"
San Francisco (Mound No. 417)	1	sample
Half Moon Bay (Mound No. 407)	4	samples

Samples were also examined from three mounds outside of the San Francisco Bay region. The first two of these, listed below, are on the shores of Humboldt Bay in northern California, and are numbered as shown below on a manuscript map of that region by Mr. L. L. Loud.[3] One, Eureka mound, is a mile and a half east of the county courthouse at Eureka. The other, Gunther Island mound, is a mile north of the waterfront of Eureka and is on an island which lies in front of the town. The third mound (Point Loma) is on the west shore of San

[1] Univ. Calif. Mus. Anthrop., No. 13–1065.

[2] N. C. Nelson, Shellmounds of the San Francisco Bay Region, Univ. Calif. Publ. Am. Arch. Ethn., VII, map 1, 1909.

[3] Univ. Calif. Mus. Anthrop., No. 13–994.

Diego Bay in southern California. Its exact location is also shown on a manuscript map.[4]

Eureka (Mound No. N59)	1 sample
Gunther Island (Mound No. N67)	7 samples
Point Loma (Mound No. S49)	1 sample

The two samples obtained from Carquinez mound, and likewise the five from Castro, have not yet been catalogued with the Museum's collection. The remaining samples, arranged in order of depth of sample from top to bottom of each mound, are catalogued as follows:

Sausalito mound: 1–14817 to 1–14822.
Greenbrae mound: 1–14906 to 1–14913.
San Rafael mound: 1–14968 to 1–14973.
Ellis Landing mound: 1–11406, 1–11403, 1–11399, 1–11407, 1–11400, 1–11404, 1–11408, 1–11401, 1–11405, 1–11402.
West Berkeley mound: 1–7312, 1–7313, 1–17003, 1–7314 to 1–7318.
Emeryville mound: 1–9869, 1–9870, 1–9872, 1–9874, 1–9876, 1–9878, 1–9880 to 1–9884, 1–9890 to 1–9893, 1–7941, 1–7963, 1–7964, 1–7967.
San Mateo mound: 1–18586 to 1–18588, 1–16758.
San Mateo Point mound: 1–17331, 1–18585.
San Francisco mound: 1–17031.
Half Moon Bay mound: 1–17320, 1–17322 to 1–17324.
Eureka mound: 1–17978.
Gunther Island mound: 1–18546, 1–18547, 1–18553, 1–18556, 1–18576 to 1–18578.
Point Loma mound: 1–17366.

All depths were measured in feet from the surface of the mound. Often the samples from a given mound, however, were not all taken in one vertical plane. Such is the case with the samples from Carquinez, Ellis Landing, West Berkeley, Emeryville, Castro, San Mateo, San Mateo Point, Half Moon Bay, and Gunther Island.[5] The samples from

[4] Univ. Calif. Mus. Anthrop., No. 13–960.

[5] Of the Ellis Landing samples, those taken at 1.5, 4.5, and 7 (second seven in tables) feet are all in the same vertical plane (70 feet from the center); those taken at 2, 7 (first seven in tables), and 11 feet are all in another vertical plane (35 feet from the center); and those taken at 3, 6, 10, and 17 feet are in a third vertical plane (the center). Of West Berkeley samples the one marked 4.5 feet was not taken in the same vertical plane as the other samples. The first fifteen Emeryville samples (.5 to 19.5 feet deep) are from a vertical shaft sunk on the eastern side of the mound. The remaining four samples are from various places at the bottom of an excavation on the western side of the mound, and represent the mound at its very base. The first three Castro samples (1, 2, and 3 feet deep) were taken in one vertical plane; so also were the first three San Mateo samples (3, 6, and 8 feet deep). The first Half Moon Bay sample (1 foot deep) was not taken in the same vertical plane with the other three. The last three Gunther Island samples (6, 6.5, and 8 feet deep) came from one vertical plane.

Sausalito, Greenbrae, and San Rafael were taken from one vertical plane in the case of each mound.

Where only the approximate and not the absolute depths are given in the Museum's catalogue, the average depth is given in this paper. For example, three to six feet in the catalogue is here given as four and a half feet to serve better the purposes of comparison.

The listing of the mounds in most of the tables is in a series beginning at Sausalito on the north side of the Golden Gate and following the bay shore around to San Francisco on the south side of the Golden Gate. Then come the mounds located at Half Moon, Humboldt, and San Diego bays.

The species of shells from the Point Loma mound are entirely foreign to the San Francisco Bay and Humboldt Bay mounds. For that reason the shell of the single Point Loma sample has not been separated specifically, being of no use for comparison.

The records of the analyses are stated in terms of *weight* and not of volume.

SHELLMOUND CONSTITUENTS

The seven main constituents into which each sample of shellmound material was separated were fish remains (bones and scales), other vertebrate remains (chiefly bones), shell (almost entirely molluscan, but including also barnacles, crab shell, and sea-urchin), charcoal, ash, rock, and residue (earth, sand, charcoal dust, etc.). Of these constituents, shell is the most abundant, the average mound containing over fifty-two per cent by weight. Then follow residue with nearly twenty-eight per cent, ash with over twelve per cent, rock with over seven per cent, and charcoal, fish remains, and other vertebrate remains with less than one per cent combined. Table 1 gives the average per cent of these constituents in the fifteen mounds.

The percentage for fish remains, other vertebrate remains, charcoal, and rock should undoubtedly be higher than given in the tables. All of the very minute pieces of these constituents passed through the fine or two-millimeter screen, and, as they were not separated chemically, are included in the shell, ash, and residue. The percentages for these three are therefore too high, but there is no practical method of making the adjustment, so that this slight error in the results will have to stand.

In the second table the seven constituents of the first table have been combined so as to form only three groups. Fish remains, other vertebrate remains, and shell are included under material derived from animal sources; charcoal and ash under products of combustion; and rock and residue under material derived from inorganic sources. The percentages in table 1 for shell and ash differ but little from the corresponding percentages in table 2 under animal and combustion. This is due in the first case to the uniformly small amounts of fish and other vertebrate remains found in the mounds, and in the second case to the uniformly small quantity of charcoal. The average mound is composed by weight of over fifty-two per cent of material derived from animal sources, of thirteen per cent of material produced by combustion, and of thirty-five per cent of material derived from inorganic sources. For the average San Francisco Bay mound the figures are a trifle different, being fifty-six, fifteen, and twenty-nine, respectively.

The seven main constituents are presented in detail in the third to the ninth tables. The quantities are stated as percentages of the weight of each sample. It will be noted that the percentages for fish remains, other vertebrate remains, and charcoal are all very low, while those for shell, ash, rock, and residue range widely. In the case of fish remains (table 3) the two high percentages (2.11 and .9) for Emeryville are due to extraordinarily large fragments of bone. Considering the rapidity with which fish bones disintegrate, especially when cooked, it seems rather remarkable that any were preserved at all. Inasmuch as there are found in some of the mounds, and at all levels, grooved stones considered to be net sinkers, it is evident that fishing was a regular means of procuring food.[6]

In the material examined remains of other vertebrates were found in slightly larger amounts than those of fish (cf. tables 3 and 4). If these samples are typical, one of two conclusions must be true: either the shellmound people ate very few vertebrates outside of fish, or some destroying agency (possibly a domestic dog) has been a factor in obliterating the evidence.[7]

In the eighth table it will be noted that specimens of rock were retained by the screens from all but two of the eighty-four samples. The records of the amounts caught by each screen demonstrate that in the average mound eighty-three per cent passed through the twelve-

[6] Cf. N. C. Nelson, Shellmounds of the San Francisco Bay Region, Univ. Calif. Publ. Am. Arch. Ethn., VII, p. 339, 1909.

[7] Cf. N. C. Nelson, *op. cit.*, p. 339.

millimeter and was caught by the four-millimeter and two-millimeter screens. From this it is evident that eighty-three per cent of the rock consists of very fine fragments and pebbles. Mounds such as Sausalito and San Mateo Point probably derive the high average percentage of rock (see table 1) from the stony land on which they are laid. In many cases, however, the pebbles and small fragments of rock doubtless were attached to roots and bulbs dug elsewhere for food. Some of the ordinary earth or dirt in the shellmounds must have been brought there in a similar adventitious fashion.

Mussel (*Mytilus edulis*), clam (*Macoma nasuta*), and oyster (*Ostrea lurida*) are the most prominent molluscan species, at least one of them being of importance in each of the mounds except Half Moon Bay and Castro. In the eleven San Francisco Bay mounds, with the exception of Ellis Landing and Castro, mussel predominates above all other species. In Ellis Landing clam and in Castro horn-shell (*Cerithidea californica*) are the commonest species. In the tenth table are shown the records for the San Francisco Bay region. The amount of each species is mentioned as a percentage of the total amount of shell.

The mounds of Half Moon and Humboldt bays naturally yield, at least in part, shell species different from those typical of the San Francisco Bay mounds. These species are listed in the eleventh table. That the sources of shellfish supply of the Eureka and Gunther Island mounds, although less than two miles apart, were not the same, is made apparent at a glance by the species found in Gunther Island and not in Eureka, and furthermore, where they have species in common, by the widely divergent percentages. Gunther Island savors strongly of the ocean as well as the bay; Eureka only of the bay.

As stated in the introduction, three sizes of screens were used as aids in segregating the various constituents. At the same time record was kept of the amount of each constituent caught by these screens, and likewise of the amount of material passing through the fine screen. There proved to be a considerable variation in regard to this last point. Eighty-seven per cent of the Gunther Island and only forty-one per cent of the San Mateo material passed through the fine screen. Castro with eighty-five per cent and Point Loma with eighty-two per cent are similar to Gunther Island in this respect. This is owing to the abundance of earth in Castro and of sand in Gunther Island and Point Loma. The remaining mounds treated in this paper are more typical than the above four, ranging from sixty-six per cent in the case of San Rafael to forty-three per cent in Ellis Landing. Sixty per cent of the material composing the average mound passed through the fine, or two-millimeter, screen.

That all shell species do not break up alike was definitely demonstrated by keeping a record of the amount of mussel, clam, and oyster caught by the three screens. Of mussel, two per cent was caught by the coarse screen, twenty-eight per cent by the medium, and seventy by the fine; of clam fifteen per cent by the coarse screen, fifty-one by the medium, and thirty-four by the fine; of oyster thirteen per cent by the coarse screen, sixty by the medium, and twenty-seven by the fine. It is very clear that the mussel breaks far more readily than either clam or oyster, a fact which will have a bearing later in explaining the difference in the size of shell fragments in the upper and lower portions of Ellis Landing mound.

SHELLMOUND ENVIRONMENT

No evidence of change of environment is afforded by the results of the analyses. The definite facts established point the other way: that is, towards the continuity throughout shellmound times of the conditions as they were at the coming of the white man. This continuity of conditions is demonstrated by the shell species found in the mounds. It may be taken as almost axiomatic that the species in a mound reflect the molluscan fauna of the vicinity, and hence the environment during the period of growth of the mound. A very clear case in point is that of the small San Francisco mound located in a swamp in the Presidio on the south shore of the Golden Gate. This mound, as one can see by consulting the accompanying map, is situated in a position favorable for the hunting of both bay and ocean species of mollusks. The fact that the mound dwellers sought both forms regularly is shown in table 10 by the nearly equal percentages of *Mytilus californianus* and *Mytilus edulis*. The former is an ocean species frequenting surf-beaten rocks; the latter lives in the quieter bay waters.

The presence of large quantities of oyster shell (*Ostrea lurida*) in the shellmounds of the central San Francisco Bay region—West Berkeley, Emeryville, San Mateo, and San Mateo Point—points to the similarity between the conditions during the period of their growth and the conditions during modern times. This abundance of *Ostrea lurida* is made manifest in table 10. Generally speaking, these four mounds lie in the region which has been largely utilized at the present day for the raising of the introduced Atlantic coast oyster (*Ostrea virginiana*) for the market. The introduced oyster has in part displaced the native oyster of shellmound days.

Many examples of the occurrence throughout mounds of other species might be added as further proof of the absence of sweeping physiographic changes in the environment of the shellmounds. However, I will be content with mentioning two others, which are particularly interesting because they not only show continuity of conditions but also the advantages and disadvantages of the locations of the mounds involved. These two cases hinge on the occurrence of the horn-shell (*Cerithidea californica*), a small univalve with a great many spirals, and of another univalve (*Phytia myosotis*), which is minute.

In Castro mound near the southern end of San Francisco Bay, the horn-shell proves to be the commonest species (see table 10). Almost invariably it is found with the apex of the spiral broken off, evidently to aid in extracting the animal without crushing the entire shell. This species inhabits salt marshes, where it is usually found by thousands in shallow pools on top of the marsh. Its occurrence from top to bottom of the Castro mound proves the existence of salt marsh near by from the very beginning of its accumulation. This salt marsh with its deep sloughs, lying between the mound and the bay, must have been a fairly effective barrier against the mound-dwellers reaching the bay shore. This conclusion is further warranted by the comparative scarcity here of ordinary shellmound species, which is very well shown by the column for Castro in table 10. Further negative proof of the difficulty that the Castro people had in obtaining the usual molluscan food is also shown in table 10 by the scarcity or absence of *Cerithidea californica* in other mounds, in spite of the fact that it is a common species in the San Francisco Bay region. Thus it appears that the people of Castro, on account of the difficulty of obtaining the ordinary shellmound species, were forced to make use of the small and unsatisfactory *Cerithidea californica*. Conversely, the people of the other San Francisco Bay mounds appear to have neglected it because of the bountiful supply of other molluscan food.

The deduction that the Castro people lived under conditions differing from those at Ellis Landing, for example, is obvious. It is supported, moreover, by the fact that nearly seventy per cent of Ellis Landing mound is composed of shell, while Castro mound contains only about twenty-six per cent (see table 1).

The next species to be considered in connection with the matter of environment is the tiny *Phytia myosotis*. Its distribution in certain of the San Francisco Bay mounds is indicated by crosses in table 12. Like the last species, it also lives in salt marshes, where it occurs on the underside of driftwood which has lain in the marsh for a considerable time. Briefly then, the presence of *Phytia myosotis* in a mound indicates that there must have been salt marsh close by; which, furthermore, supplied the inhabitants with some of their firewood. An examination of table 12 shows therefore that salt marsh existed in the vicinity of some of the mounds throughout the period of their growth.

Mr. N. C. Nelson inclines to the theory that some of the San Francisco Bay shellmounds may have been "begun, if not actually abandoned, prior to the building up of the now broad belt of reclaimable marsh."[8] The absence of salt marsh during shellmound days would mean a very remote antiquity for the mounds and a great difference in the physical geography of the San Francisco Bay region. There is no evidence for either. The salt marsh doubtless grew rapidly enough to offset the general subsidence of the region as a whole and thus kept the conditions practically unchanged for countless centuries. Only a very sudden and extensive elevation or subsidence could obliterate the salt marsh of the bay. This would have meant a great difference in the habits of life of the people. The contents of the mounds certainly offer no indication of such a condition, while the presence of the two mollusks discussed give positive proof that such was not the case.

Mr. Nelson directs attention "to the noticeable variation of the preponderating shell species represented in the section wall of the Ellis mound (see pl. 49, fig. 1). The lower portion of this accumulation is composed almost exclusively of mussel shells, and it is only in the upper eight feet that the clam shells become at all plentiful."[9] Table 13 bears out Mr. Nelson's statement. In it, the amount of clam (*Macoma nasuta*) in each sample is compared with the amount of mussel (*Mytilus edulis*), each species being given as a percentage of the combined quantities of both. It will be noted that below ten feet the amount of *Macoma* drops to less than ten per cent by weight of the

[8] Nelson, Shellmounds of the San Francisco Bay Region, p. 328; see also p. 317.

[9] N. C. Nelson, The Ellis Landing Shellmound, Univ. Calif. Publ. Am. Arch. Ethn., VII, p. 376, 1910. The reference in the above quotation is to plate 49 in the paper cited.

combined species. It would be interesting to test by samples the extent to which Mr. Nelson's assertion holds true below the depth of seventeen feet.

Similar variations of the preponderating shell species are found in Sausalito mound between mussel and clam (table 14); in Emeryville mound between mussel, oyster (*Ostrea lurida*), and clam (table 15); in Castro mound between mussel, horn-shell (*Cerithidea californica*), and oyster (table 16); in San Mateo mound between mussel and oyster (table 17); in Half Moon Bay mound (table 18) between the large coast mussel (*Mytilus californianus*) and the black turban shell (*Tegula funebralis*); and in Gunther Island mound between all four of its chief food species (table 19). The twentieth table for West Berkeley mound shows variations less extensive than in the preceding. Tables 21 and 22 show that in Greenbrae and San Rafael mounds clam (with one exception) and oyster in no case amount to over ten per cent of the total of mussel, clam, and oyster. Moreover, mussel varies but little.

All of these cases, where not merely accidental, are to my mind nothing but instances of the mound-dwellers' overtaxing the supply of one particular shell species and thus being forced to rely more on other species. I consider that this explanation covers the case of Ellis Landing as well as of the other mounds. I have actually seen a modern instance of this sort. Several years ago clams (*Mya arenaria*) became very scarce in the mud flats at the east end of the city of Alameda on the eastern shore of San Francisco Bay, owing to a few Chinese clam diggers becoming too persistent in their work in such a small area. Why could not such a case have occurred in ancient times? With Ellis Landing mound, I fail to see where it is necessary to postulate changes in physiography to account for the abundance of clam shell in the upper portion of the mound and its scarcity in the lower portion.[10] A further consideration of table 13 will show that in part mussel is more abundant than clam in the upper portion of the mound. This recurrence of mussel in abundance perhaps represents a recovery from the drain to which it had been subjected. It is perfectly natural that a primitive people should prefer mussels, for they can be obtained without tools and merely for the effort of pulling them off the rocks or wood on which they grow. Clams, on the other hand, have to be dug, requiring more labor.

[10] Cf. N. C. Nelson, The Ellis Landing Shellmound, pp. 376–378.

The very different manner in which mussel shell and clam shell break up has been already pointed out. In Ellis Landing an average of seventy-one per cent of all the mussel (see table 23) stopped by the screens was caught by the fine or two-millimeter screen, while only fifteen per cent of the clam was caught by the same screen. Speaking of the difference in structure of the upper and lower portions of Ellis Landing mound, Mr. Nelson states that "the upper six or eight feet of the deposit is comparatively coarse material," while "below it the material is of an almost uniformly fine and compact nature."[11] Two pages farther on in the same paper, he says that "the lower portion of this accumulation is composed almost exclusively of mussel shells, and it is only in the upper eight feet that the clam shells become at all plentiful." These two statements seem to dovetail with the facts mentioned above as to the average size of the fragments of mussel and clam shell in the mound. It is obvious that the peculiarity of structure, to which Mr. Nelson calls attention, is due merely to the different manner in which the preponderating species in the two portions of the mound break up.

Besides the cause just mentioned, another has been operative in producing layers and streaks of finely broken shell at various depths in the shellmounds. This second cause, which operated constantly while the mounds were inhabited, was the people themselves. In their excursions for fuel, food, water, and other necessities, the mound-dwellers must in time have formed more or less well-defined trails. Not only must we consider trails, but also the places frequented by people around their houses. Then, too, dances and other ceremonies, which attracted a large number of visitors, were certainly instrumental in breaking up the shell. On the other hand, pockets of unbroken shell probably represent refuse heaps where people were not in the habit of walking. The occurrence of the sort of streaks and layers mentioned above is shown in table 23 for Sausalito, Greenbrae, San Rafael, Ellis Landing, and Emeryville mounds. Mussel shell is used to demonstrate this point, a high percentage representing a large amount of finely broken shell, a lower percentage indicating the reverse.

It is just possible that the favorable location for shellfish at Ellis Landing mound (note in table 1 that it has a higher percentage than any other mound) may have made it not only the metropolis but also a sort of ceremonial center for the region. This would be an additional

[11] Nelson, The Ellis Landing Shellmound, p. 374.

factor, in helping to exhaust the mussel supply and enforce the more extended use of clams.

AGE OF THE SHELLMOUNDS

Mr. N. C. Nelson estimates the volume of Ellis Landing mound at 1,260,000 cubic feet,[12] in other words 35,649 cubic meters. By actual test of shellmound material before it had been broken up or disturbed, I have found that its specific gravity is about 1.3. This makes the total weight of the Ellis Landing shellmound about 51,085 short tons. The shell entering into the mound would be about 69.43 per cent (see table 1) of this, or 35,468 tons. If we take Mr. Nelson's estimate of thirty-five hundred years as the age of the mound, the shell must have been laid down at the average rate of 10.13 tons a year, or fifty-six pounds a day. This amount of shell a day certainly seems reasonable enough, if we accept one hundred people as the average population of the mound throughout its growth. Both Dr. Kroeber and Mr. Nelson consider this figure to be the most probable, the former basing his opinion on his knowledge of California Indian life, the latter on his findings at Ellis Landing.

Turning to table 1 it is found that 13.99 per cent of Ellis Landing mound consists of ash. The actual weight of ash in the mound is therefore about 7147 short tons. Again employing Mr. Nelson's estimate of thirty-five hundred years as the age of the mound, we find that ash accumulated at the rate of 2.04 tons a year, or 11.2 pounds a day. If we adopt .009[13] pound of ash as the average amount produced by one pound of wood, then it appears that the Ellis Landing people used 1240 pounds of wood a day. If the assumed population of one hundred individuals was distributed among fifteen families, this would mean an average of eighty-three pounds of wood per family per day. This is a moderate amount if one considers that they had an abundance of driftwood close at hand. The two great rivers which drain the interior of California, the Sacramento and the San Joaquin, empty into San Francisco Bay through the adjoining Suisun and San Pablo bays. They must have given the shellmound people of the region a great variety of driftwood as well as a great quantity.

[12] Nelson, Shellmounds of the San Francisco Bay Region, p. 346.

[13] This approximate figure was derived by averaging the percentages of ash for the trees likely to have been accessible to the shellmound dwellers. The percentages were obtained from Romeyn Beck Hough, *American Woods*, 1888 ff.

These results accordingly corroborate Mr. Nelson's figure of thirty-five hundred years as the age of Ellis Landing mound. Of course they are dependent primarily on the acceptance of his assumption of one hundred people as the average population day in and day out.

Dr. Max Uhle estimated the volume of Emeryville mound at 39,000 cubic meters.[14] Again using 1.3 as the specific gravity of shellmound material, the weight of the entire mound proves to be about 55,885 short tons. Of this mass I assume that 59.86 per cent by weight is shell and 13.47 per cent is ash, as shown in table 1. Then in actual figures the shell in Emeryville mound would weigh 33,455 tons and the ash 7528 tons.

Let us suppose that the average population at Emeryville mound was one hundred as at Ellis Landing, for the two mounds approximate each other in volume. If we allow that these hundred people ate shellfish at the same rate as the Ellis Landing people, it then took thirty-three hundred years to accumulate the shell in Emeryville mound. Assuming that thirty-three hundred years is the correct age, the amounts of wood burned daily by the two populations were slightly different, though in virtual agreement. In Ellis Landing with an average population of one hundred and an age of thirty-five hundred years, it was shown that the rate of accumulation of ash was 11.2 pounds a day. In Emeryville mound, however, the people burned more wood, and ash accumulated at the rate of twelve pounds a day or 2.2 short tons a year. The Emeryville people used about 1333 pounds of wood a day.

Of course the results for Emeryville could be reversed by assuming that the amount of wood burned per day was the same as at Ellis Landing. In that case the amount of shellfish consumed per day would be less and the age of the mound would be thirty-seven hundred years instead of thirty-three hundred. This is really a further confirmation of the probable age of the mound rather than a contradiction. By age I mean, of course, the number of years during which accumulation took place; not the number of years the mound has been in existence.

It is plain that results depend upon what we assume our unknown quantities to be, and unfortunately there are many of these. Nevertheless, the period of thirty-three hundred or thirty-seven hundred years for Emeryville mound may be claimed to be a reasonable length

[14] The Emeryville Shellmound, Univ. Calif. Publ. Am. Arch. Ethn., VII, p. 10, 1907.

of time for the accumulation of the mound. In fact, it is substantiated by Mr. Nelson's figures for Ellis Landing. His estimate and the present one for Emeryville really corroborate each other.

This method of ascertaining the age of the mounds might be applied to all treated in this paper, were it not that the precarious factors are too numerous. The percentages of shell and ash in table 1, however, afford evidence that all shellmounds did not grow at the same rate. The mode of accumulation for the average mound was one part of ash to four parts of shell. In Ellis Landing the ratio is one to five and in Emeryville one to four. Emeryville matches the average mound, while Ellis Landing exceeds it on the side of shell. San Francisco and Emeryville mounds are the only ones that show the average ratio of ash to shell.

Considering the entire list of fifteen mounds, four have exceptionally large amounts of ash compared to shell: San Rafael, Carquinez, and West Berkeley with the ratio of one to two; and Castro with the ratio of one to three. In the majority of mounds the amount of ash is below the average when compared to the amount of shell: Greenbrae, Ellis Landing, and San Mateo with the ratio of one to five; Eureka with one to six; Point Loma with one to seven; Gunther Island with one to nine; San Mateo Point with one to ten; and Sausalito and Half Moon Bay with one to thirteen.

Differences of this sort have a very direct bearing on calculations with regard to the age of the mounds. Where the amount of ash is exceptionally high in proportion to the shell, it does not mean merely that the inhabitants burned more than the usual amount of wood; but it undoubtedly means that the mound was built up more slowly than others with a less amount of ash. The inhabitants, instead of depending to the usual extent on shellfish, lived more on vegetable foods which would leave no trace. The only thing to tell the tale would be the unusually high percentage of ash compared to shell. Therefore one cannot estimate the accumulation of shell in a mound of this sort at the same rate as in an average mound like Emeryville.

The puzzle of the age of the shellmounds requires for its solution every scrap of information bearing on the mounds. A knowledge of shellmound composition, of population, of artifacts, of skeletal remains, of environment, or of food alone will not solve the puzzle. The proper combination of all of these is necessary to gain the end.

Transmitted December 4, 1914.

TABLE 1

THE MAIN SHELLMOUND CONSTITUENTS IN AVERAGES OF THE PERCENTAGES IN THE SAMPLES FROM EACH MOUND

Mound	Fish remains	Other vertebrate remains	Shell	Charcoal	Ash	Rock	Residue
Sausalito	.008	.015	54.44	.055	4.21	23.5	17.77
Greenbrae	.008	.004	65.4	.108	12.73	8.9	12.61
San Rafael	.008	......	53.93	.047	24.66	6.1	15.26
Carquinez	.01	.025	55.34	.175	26.5	3.8	14.2
Ellis Landing	.034	.043	69.43	.294	13.99	5.1	11.05
West Berkeley	.069	.069	52.53	.123	23.76	4.9	18.51
Emeryville	.186	.031	59.86	.237	13.47	8	18.26
Castro	.008	.076	25.99	.898	9.47	8.8	54.72
San Mateo	.005	.11	59.09	.173	11.2	18.5	10.98
San Mateo Point	......	.185	58.5	.05	6.04	16.2	19.06
San Francisco	.1	.15	57	.02	15.9	1.4	25.43
Half Moon Bay	.003	.033	56.46	.01	4.19	5.2	34.06
Eureka	.01	......	68.47	.21	12.08	....	19.23
Gunther Island	.016	.077	15.62	.3	1.81	.88	81.29
Point Loma	......	......	28.94	.6	4.09	1.2	65.19
Average mound	.031	.055	52.07	.22	12.27	7.5	27.84
Average S. F. Bay mound	.04	.064	55.59	.198	14.72	9.6	19.8

TABLE 2

Shellmound Composition in Percentages of Material Derived from Animal Sources, from Combustion, and from Inorganic Sources

Mound	Animal	Combustion	Inorganic
Sausalito	55	4	41
Greenbrae	65	13	22
San Rafael	54	25	21
Carquinez	55	27	18
Ellis Landing	70	14	16
West Berkeley	53	24	23
Emeryville	60	14	26
Castro	26	10	64
San Mateo	59	11	30
San Mateo Point	59	6	35
San Francisco	57	16	27
Half Moon Bay	57	4	39
Eureka	69	12	19
Gunther Island	16	2	82
Point Loma	29	5	66
Average mound	52	13	35
Average S. F. Bay mound	56	15	29

TABLE 3

FISH REMAINS IN PERCENTAGES OF EACH SAMPLE

Depth	Sausalito	Greenbrae	San Rafael	Carquinez	Ellis Landing	West Berkeley	Emeryville	Castro	San Mateo	San Mateo Point	San Francisco	Half Moon Bay	Eureka	Gunther Island	Point Loma
.5	....	——	——	....	....	....	.01	....	....	——	....	....	.01	....	——
1	.02	....	....	——	....	....	....	.01	....	——	....	.01	....	.05	....
1	....	....	....	....	....	....	....	....	....	....	....	——	....	....	....
1.5	....	....	....	....	.02	....	2.11	....	....	....	.1	....	....	....	....
2	....	.03	——	....	——	.01	....	.01	....	....	....	....	....	.05	....
2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	.01	....
3	....	....	....	.02	.17	....	.01	.01	.01	....	....	——	....	——	....
3.5	.01	....	....	....	....	.1	....	....	....	....	....	....	....	....	....
4	....	——	.01	....	....	....	....	——	....	....	....	....	....	....	....
4.5	....	....	....	....	.01	——	....	....	....	....	....	....	....	....	....
5	.01	....	....	....	....	.05	.22	.01	....	....	....	....	....	....	....
6	....	.01	.03	....	.04	....	....	....	.01	....	....	——	....	——	....
6.5	....	....	....	....	....	.1	....	....	....	....	....	....	....	——	....
7	....	....	....	....	.01	....	.02	....	....	....	....	....	....	....	....
7	....	....	....	....	——	....	....	....	....	....	....	....	....	....	....
8	——	.02	.01	....	....	.2	.05	....	——	....	....	....	....	——	....
9	....	....	....	....	....	....	.02	....	....	....	....	....	....	....	....
9.5	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....
10	....	——	——	....	.05	.08	.08	....	....	....	....	....	....	....	....
10.5	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....
11	....	....	....	....	.02	....	.01	....	....	....	....	....	....	....	....
12	.01	——	....	....	....	.01	....	....	....	....	....	....	....	....	....
12.5	——	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....
14	....	——	....	....	....	....	....	....	——	....	....	....	....	....	....
15.5	....	....	....	....	....	....	.02	....	....	....	....	....	....	....	....
17	....	....	....	....	.02	....	....	....	....	....	....	....	....	....	....
17.5	....	....	....	....	....	....	——	....	....	....	....	....	....	....	....
19.5	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	.9	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	——	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	——	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	.05	....	....	....	....	....	....	....	....
Average	.008	.008	.008	.01	.034	.069	.186	.008	.005	——	.1	.003	.01	.016	——

TABLE 4

Other Vertebrate Remains in Percentages of Each Sample

Depth	Sausa-lito	Green-brae	San Rafael	Car-quinez	Ellis Landing	West Berkeley	Emery-ville	Castro	San Mateo	San Mateo Point	San Fran-cisco	Half Moon Bay	Eureka	Gunther Island	Point Loma
.5	......	—	—	......	......	......	.03	......	......	.32	......	......	—	......	—
1	—	......	......	.03	......	......	......	.37	......	.05	......	.12	......	.48	......
1	......	......	......	......	......	......	......	......	......	......	......	—	......	......	......
1.5	......	......	......	......	.04	......	—	......	......	......	.15	......	......	......	......
2	......	—	—	......	.05	.08	......	.01	......	......	......	......	......	.05	......
2.5	......	......	......	......	......	......	......	......	......	......	......	......	......	.01	......
3	......	......	......	.02	—	......	.01	—	.2	......	......	.01	......	—	......
3.5	—	......	......	......	......	.1	......	......	......	......	......	......	......	......	......
4	......	—	—	......	......	......	......	—	......	......	......	......	......	......	......
4.5	......	......	......	......	—	.1	......	......	......	......	......	......	......	......	......
5	.01	......	......	......	......	.01	.02	—	......	......	......	......	......	......	......
6	......	—	—	......	.1	......	......	......	.15	......	......	—	......	—	......
6.5	......	......	......	......	......	.15	......	......	......	......	......	......	......	—	......
7	......	......	......	......	.01	......	—	......	......	......	......	......	......	......	......
7	......	......	......	......	.03	......	......	......	......	......	......	......	......	......	......
8	—	—	—	......	......	—	.01	......	—	......	......	......	......	—	......
9	......	......	......	......	......	......	.01	......	......	......	......	......	......	......	......
9.5	......	......	......	......	......	......	—	......	......	......	......	......	......	......	......
10	......	—	—	......	.1	.11	.08	......	......	......	......	......	......	......	......
10.5	......	......	......	......	......	......	—	......	......	......	......	......	......	......	......
11	......	......	......	......	.1	......	—	......	......	......	......	......	......	......	......
12	.08	—	......	......	......	—	......	......	......	......	......	......	......	......	......
12.5	—	......	......	......	......	......	......	......	......	......	......	......	......	......	......
13	......	......	......	......	......	......	.01	......	......	......	......	......	......	......	......
14	......	.03	......	......	......	......	......	......	.09	......	......	......	......	......	......
15.5	......	......	......	......	......	......	.02	......	......	......	......	......	......	......	......
17	......	......	......	......	—	......	......	......	......	......	......	......	......	......	......
17.5	......	......	......	......	......	......	.01	......	......	......	......	......	......	......	......
19.5	......	......	......	......	......	......	.02	......	......	......	......	......	......	......	......
Bottom	......	......	......	......	......	......	.03	......	......	......	......	......	......	......	......
Bottom	......	......	......	......	......	......	—	......	......	......	......	......	......	......	......
Bottom	......	......	......	......	......	......	—	......	......	......	......	......	......	......	......
Bottom	......	......	......	......	......	......	.12	......	......	......	......	......	......	......	......
Average	.015	.004	—	.025	.043	.069	.031	.076	.11	.185	.15	.033	—	.077	—

TABLE 5

SHELL IN PERCENTAGES OF EACH SAMPLE

Depth	Sausalito	Greenbrae	San Rafael	Carquinez	Ellis Landing	West Berkeley	Emeryville	Castro	San Mateo	San Mateo Point	San Francisco	Half Moon Bay	Eureka	Gunther Island	Point Loma
.5	....	50.14	48.41	....	....	....	53.44	....	....	55.87	....	....	68.47	....	28.94
1	58.96	....	....	74.37	....	....	....	19.4	....	61.13	....	78.08	....	9.07	....
1	....	....	....	....	....	....	....	....	....	....	....	65.95	....	....	....
1.5	....	....	....	....	70.6	....	63.63	....	....	....	57	....	....	....	....
2	....	71.88	49.37	....	73.13	51.61	....	17.9	....	....	....	....	....	4.18	....
2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	29.11	....
3	....	....	....	36.3	72.94	....	75.56	25.86	61.05	....	....	63.22	....	3	....
3.5	74.17	....	....	....	....	54.68	....	....	....	....	....	....	....	....	....
4	....	65.22	49.81	....	....	....	....	30.01	....	....	....	....	....	....	....
4.5	....	....	....	....	56.06	72.8	....	....	....	....	....	....	....	....	....
5	55.15	....	....	....	....	48.06	72.15	36.78	....	....	....	....	....	....	....
6	....	70.77	78.14	....	90.8	....	....	....	65.23	....	....	18.6	....	11.99	....
6.5	....	....	....	....	....	53.86	....	....	....	....	....	....	....	28.15	....
7	....	....	....	....	89.9	....	68.38	....	....	....	....	....	....	....	....
7	....	....	....	....	55.82	....	....	....	....	....	....	....	....	....	....
8	61.39	65.12	50.6	....	....	57.39	74.7	....	55.37	....	....	....	....	23.86	....
9	....	....	....	....	....	....	53.9	....	....	....	....	....	....	....	....
9.5	....	....	....	....	....	....	69.98	....	....	....	....	....	....	....	....
10	....	67.9	47.23	....	64.61	53.75	72.93	....	....	....	....	....	....	....	....
10.5	....	....	....	....	....	....	71.82	....	....	....	....	....	....	....	....
11	....	....	....	....	63.98	....	76.36	....	....	....	....	....	....	....	....
12	48.6	63.91	....	....	....	28.09	....	....	....	....	....	....	....	....	....
12.5	28.37	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	....	....	....	....	....	....	40.98	....	....	....	....	....	....	....	....
14	....	68.27	....	....	....	....	....	....	54.7	....	....	....	....	....	....
15.5	....	....	....	....	....	....	52.92	....	....	....	....	....	....	....	....
17	....	....	....	....	56.5	....	....	....	....	....	....	....	....	....	....
17.5	....	....	....	....	....	....	43.75	....	....	....	....	....	....	....	....
19.5	....	....	....	....	....	....	45.88	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	43.49	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	62.8	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	61.55	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	33.13	....	....	....	....	....	....	....	....
Average	54.44	65.4	53.93	55.34	69.43	52.53	59.86	25.99	59.09	58.5	57	56.46	68.47	15.62	28.94

TABLE 6

Charcoal in Percentages of Each Sample

Depth	Sausalito	Greenbrae	San Rafael	Carquinez	Ellis Landing	West Berkeley	Emeryville	Castro	San Mateo	San Mateo Point	San Francisco	Half Moon Bay	Eureka	Gunther Island	Point Loma
.5	....	.01	.02	....	....	....	.01	....	....	——	....	....	.21	....	.6
1	.12	....	....	.3	....	....	....	.54	....	.1	....	.02	....	.2	....
1	....	....	....	....	....	....	....	....	....	....	....	.01	....	....	....
1.5	....	....	....	....	.01	....	.05	....	....	....	.02	....	....	....	....
2	....	.25	.07	....	.1	——	....	.41	....	....	....	....	....	.01	....
2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	.1	....
3	....	....	....	.05	1.5	....	.02	1.84	.4	....	....	.01	....	.5	....
3.5	.09	....	....	....	....	——	....	....	....	....	....	....	....	....	....
4	....	.17	.06	....	....	....	....	.7	....	....	....	....	....	....	....
4.5	....	....	....	....	.75	.01	....	....	....	....	....	....	....	....	....
5	.01	....	....	....	....	.01	.4	1	....	....	....	....	....	....	....
6	....	.14	.1	....	.1	....	....	....	.11	....	....	——	....	.24	....
6.5	....	....	....	....	....	.2	....	....	....	....	....	....	....	.65	....
7	....	....	....	....	.22	....	——	....	....	....	....	....	....	....	....
7	....	....	....	....	.03	....	....	....	....	....	....	....	....	....	....
8	.1	.02	.01	....	....	.35	.6	....	.12	....	....	....	....	.4	....
9	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....
9.5	....	....	....	....	....	....	——	....	....	....	....	....	....	....	....
10	....	.08	.02	....	.22	.41	1.2	....	....	....	....	....	....	....	....
10.5	....	....	....	....	....	....	.02	....	....	....	....	....	....	....	....
11	....	....	....	....	.01	——	——	....	....	....	....	....	....	....	....
12	.01	.17	....	....	....	....	....	....	....	....	....	....	....	....	....
12.5	——	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....
14	....	.02	....	....	....	....	....	....	.06	....	....	....	....	....	....
15.5	....	....	....	....	....	....	.22	....	....	....	....	....	....	....	....
17	....	....	....	....	——	....	....	....	....	....	....	....	....	....	....
17.5	....	....	....	....	....	....	.02	....	....	....	....	....	....	....	....
19.5	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	.7	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	.6	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	.32	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	.31	....	....	....	....	....	....	....	....
Average	.055	.108	.047	.175	.294	.123	.237	.898	.173	.05	.02	.01	.21	.3	.6

TABLE 7

Ash in Percentages of Each Sample

Depth	Sausalito	Greenbrae	San Rafael	Carquinez	Ellis Landing	West Berkeley	Emeryville	Castro	San Mateo	San Mateo Point	San Francisco	Half Moon Bay	Eureka	Gunther Island	Point Loma
.5	....	19.64	31.72	....	....	....	7.19	....	....	3.04	....	....	12.08	....	4.09
1	——	....	....	15.6	....	....	....	16.48	....	9.04	....	2.91	....	.9	....
1	....	....	....	....	....	....	....	....	....	....	....	4.64	....	....	....
1.5	....	....	....	....	12.84	....	7.79	....	....	....	15.9	....	....	....	....
2	....	9.86	32.57	....	10.11	19	....	5.53	....	....	....	....	....	——	....
2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	——	....
3	....	....	....	37.4	6.73	....	19.31	7.27	12	....	....	5.19	....	——	....
3.5	.62	....	....	....	....	22.3	....	....	....	....	....	....	....	....	....
4	....	11.88	29.37	....	....	....	....	4.29	....	....	....	....	....	....	....
4.5	....	....	....	....	26.47	15	....	....	....	....	....	....	....	....	....
5	5.14	....	....	....	....	29.19	10.04	13.8	....	....	....	....	....	....	....
6	....	12.78	11.56	....	2.88	....	....	....	11.7	....	....	4	....	4.77	....
6.5	....	....	....	....	....	26.91	....	....	....	....	....	....	....	2.81	....
7	....	....	....	....	5.39	....	24.5	....	....	....	....	....	....	....	....
7	....	....	....	....	23.76	....	....	....	....	....	....	....	....	....	....
8	4.91	15.25	26.06	....	....	23.8	6.2	....	13.24	....	....	....	....	4.21	....
9	....	....	....	....	....	....	28.11	....	....	....	....	....	....	....	....
9.5	....	....	....	....	....	....	25.2	....	....	....	....	....	....	....	....
10	....	14.43	16.65	....	18.3	23.47	11.93	....	....	....	....	....	....	....	....
10.5	....	....	....	....	....	....	8.53	....	....	....	....	....	....	....	....
11	....	....	....	....	13.32	....	6.61	....	....	....	....	....	....	....	....
12	11.85	14.74	....	....	....	32.39	....	....	....	....	....	....	....	....	....
12.5	2.72	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	....	....	....	....	....	....	3.37	....	....	....	....	....	....	....	....
14	....	5.28	....	....	....	....	....	....	7.86	....	....	....	....	....	....
15.5	....	....	....	....	....	....	6.52	....	....	....	....	....	....	....	....
17	....	....	....	....	20.13	....	....	....	....	....	....	....	....	....	....
17.5	....	....	....	....	....	....	7.23	....	....	....	....	....	....	....	....
19.5	....	....	....	....	....	....	9.35	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	16.67	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	17.52	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	18.43	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	21.44	....	....	....	....	....	....	....	....
Average	4.21	12.73	24.66	26.5	13.99	23.76	13.47	9.47	11.2	6.04	15.9	4.19	12.08	1.81	4.09

TABLE 8

ROCK IN PERCENTAGES OF EACH SAMPLE

Depth	Sausalito	Greenbrae	San Rafael	Carquinez	Ellis Landing	West Berkeley	Emeryville	Castro	San Mateo	San Mateo Point	San Francisco	Half Moon Bay	Eureka	Gunther Island	Point Loma
.5	....	11.7	4.8	....	....	....	3.4	....	....	25	....	....	——	....	1.2
1	26.5	....	....	3.8	....	....	....	13	....	7.3	....	1.4	....	.6	....
1	....	....	....	....	....	....	....	....	....	....	....	3.9	....	....	....
1.5	....	....	....	....	.9	....	3.5	....	....	....	1.4	....	....	....	....
2	....	9.2	1.6	....	8.8	6.2	....	2.4	....	....	....	....	....	.1	....
2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	.1	....
3	....	....	....	3.7	12.7	....	3.8	21.3	14.8	....	....	5.6	....	.1	....
3.5	16.9	....	....	....	....	5.8	....	....	....	....	....	....	....	....	....
4	....	6.5	5.5	....	....	....	....	5	....	....	....	....	....	....	....
4.5	....	....	....	....	5.1	5.4	....	....	....	....	....	....	....	....	....
5	25.5	....	....	....	....	6.4	2.1	2.4	....	....	....	....	....	....	....
6	....	7.1	4.1	....	.4	....	....	....	15.2	....	....	10.1	....	.1	....
6.5	....	....	....	....	....	5.6	....	....	....	....	....	....	....	5.15	....
7	....	....	....	....	1.1	....	5.2	....	....	....	....	....	....	....	....
7	....	....	....	....	6.1	....	....	....	....	....	....	....	....	....	....
8	24	4.7	6.8	....	....	3.1	3.4	....	15.2	....	....	....	....	——	....
9	....	....	....	....	....	....	3.9	....	....	....	....	....	....	....	....
9.5	....	....	....	....	....	....	2.1	....	....	....	....	....	....	....	....
10	....	7.9	13.8	....	6.8	3.3	.8	....	....	....	....	....	....	....	....
10.5	....	....	....	....	....	....	3.7	....	....	....	....	....	....	....	....
11	....	....	....	....	4.3	....	7.1	....	....	....	....	....	....	....	....
12	27.1	11.4	....	....	....	3.7	....	....	....	....	....	....	....	....	....
12.5	21	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	....	....	....	....	....	....	15.2	....	....	....	....	....	....	....	....
14	....	12.6	....	....	....	....	....	....	28.6	....	....	....	....	....	....
15.5	....	....	....	....	....	....	8.3	....	....	....	....	....	....	....	....
17	....	....	....	....	5.2	....	....	....	....	....	....	....	....	....	....
17.5	....	....	....	....	....	....	29.7	....	....	....	....	....	....	....	....
19.5	....	....	....	....	....	....	22.3	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	14.4	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	1.1	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	3.8	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	18.5	....	....	....	....	....	....	....	....
Average	23.5	8.9	6.1	3.8	5.1	4.9	8	8.8	18.5	16.2	1.4	5.2	——	.88	1.2

TABLE 9

Residue in Percentages of Each Sample

Depth	Sausalito	Greenbrae	San Rafael	Carquinez	Ellis Landing	West Berkeley	Emeryville	Castro	San Mateo	San Mateo Point	San Francisco	Half Moon Bay	Eureka	Gunther Island	Point Loma
.5	....	18.51	15.05	....	....	....	35.93	....	....	15.74	....	....	19.23	....	65.19
1	14.4	....	....	5.9	....	....	....	50.13	....	22.38	....	17.46	....	88.7	....
1	....	....	....	....	....	....	....	....	....	....	....	25.5	....	....	....
1.5	....	....	....	....	15.59	....	22.92	....	....	....	25.43	....	....	....	....
2	....	8.78	16.39	....	7.81	23.1	....	73.74	....	....	....	....	....	95.61	....
2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	70.67	....
3	....	....	....	22.5	5.96	....	1.29	43.71	11.54	....	....	25.97	....	96.4	....
3.5	8.21	....	....	....	....	17.01	....	....	....	....	....	....	....	....	....
4	....	16.23	15.25	....	....	....	....	60	....	....	....	....	....	....	....
4.5	....	....	....	....	11.61	8.69	....	....	....	....	....	....	....	....	....
5	14.18	....	....	....	....	16.28	15.07	46.01	....	....	....	....	....	....	....
6	....	9.2	6.07	....	5.67	....	....	....	7.6	....	....	67.3	....	82.9	....
6.5	....	....	....	....	....	13.18	....	....	....	....	....	....	....	63.24	....
7	....	....	....	....	3.34	....	1.9	....	....	....	....	....	....	....	....
7	....	....	....	....	14.26	....	....	....	....	....	....	....	....	....	....
8	9.6	14.89	16.52	....	....	15.15	15.05	....	16.07	....	....	....	....	71.53	....
9	....	....	....	....	....	....	14.05	....	....	....	....	....	....	....	....
9.5	....	....	....	....	....	....	2.71	....	....	....	....	....	....	....	....
10	....	9.69	22.3	....	9.9	18.88	12.98	....	....	....	....	....	....	....	....
10.5	....	....	....	....	....	....	15.92	....	....	....	....	....	....	....	....
11	....	....	....	....	18.27	....	9.92	....	....	....	....	....	....	....	....
12	12.35	9.78	....	....	....	35.81	....	....	....	....	....	....	....	....	....
12.5	47.9	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	....	....	....	....	....	....	40.42	....	....	....	....	....	....	....	....
14	....	13.8	....	....	....	....	....	....	8.71	....	....	....	....	....	....
15.5	....	....	....	....	....	....	32	....	....	....	....	....	....	....	....
17	....	....	....	....	18.13	....	....	....	....	....	....	....	....	....	....
17.5	....	....	....	....	....	....	19.29	....	....	....	....	....	....	....	....
19.5	....	....	....	....	....	....	22.43	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	23.81	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	18.98	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	15.89	....	....	....	....	....	....	....	....
Bottom	....	....	....	....	....	....	26.45	....	....	....	....	....	....	....	....
Average	17.77	12.61	15.26	14.2	11.05	18.51	18.26	54.72	10.98	19.06	25.43	34.06	19.23	81.29	65.19

TABLE 10

AVERAGE SPECIFIC COMPOSITION (IN PERCENTAGES)* OF THE SHELL FROM SAN FRANCISCO BAY MOUNDS

	Sausalito	Greenbrae	San Rafael	Carquinez	Ellis Landing	West Berkeley	Emeryville	Castro	San Mateo	San Mateo Point	San Francisco	Average
Mytilus edulis	24	47	44	68	35	41	35	X	33	34	19	36
Macoma nasuta	23	1	X	X	36	4	18	Z	X	....	12	9
Ostrea lurida	X	1	X	Y	X	19	8	3	31	22	X	8
Barnacles (Balanus)	3	3	5	1	1	2	2	Y	3	5	6	3
Mytilus californianus	2	Z	Z	....	....	Z	Z	Y	Y	....	18	1
Schizothaerus nuttallii	1	Z	Z	....	Z	....	Z	....	....	....	3	X
Cerithidea californica	....	....	....	....	Z	....	Z	9	....	....	....	X
Thais lamellosa	2	....	Z	....	X	Z	Z	....	....	....	....	X
Cardium corbis	X	X	....	....	Z	X	X	....	X	....	Y	X
Crab shell	X	Y	....	Y	Y	Y	Y	2	....	Y	X	Y
Pholas pacificus	....	....	....	....	X	X	X	3	X	....	....	Y
Paphia staminea	X	....	....	....	Y	....	Y	....	....	....	X	Y
Littorina scutulata	Y	....	....	....	X	Y	Y	....	....	....	....	Y
Phytia myosotis	Y	Y	Y	....	Y	Y	Y	....	Y	....	Y	Y
Zirphaea crispata	....	....	....	....	....	....	Y	....	....	....	....	Y
Acmaea pelta	....	....	....	....	Z	....	Y	....	....	....	....	Y
Unidentified shell	41	46	48	29	25	32	34	80	31	37	39	38

* Where the amount of a species is less than one per cent, but more than one-tenth of one per cent, an X has been substituted for the actual figure; where less than one-tenth of one per cent, a Y has been substituted. Z represents the occurrence of a species in a specimen other than one of the eighty-four analyzed for this paper.

TABLE 11

Average Specific Composition (in Percentages)* of the Shell from Half Moon Bay and Humboldt Bay Mounds

Species	Half Moon Bay	Eureka	Gunther Island
Mytilus edulis	X	58	X
Barnacles (Balanus)	X	3	X
Crab shell	Y	....	Y
Cardium corbis	Y	....	14
Paphia staminea	1	....	12
Schizothaerus nuttallii	X	2	23
Macoma nasuta	....	3	17
Mytilus californianus	25	....	....
Littorina scutulata	Y	....	....
Sea urchin	X	....	Y
Tegula funebralis	35	....	....
Tegula brunnea	X	....	....
Chitons	X	....	....
Limpets	Y	....	....
Platyodon cancellatus	Y	....	....
Pholadidea penita	Y	....	....
Saxidomus nuttallii	X	....	....
Crepidula adunca	Y	....	....
Saxidomus giganteus	....	....	1
Cardium californiense	....	....	Y
Paphia tenerrima	....	....	1
Zirphaea crispata	....	....	Y
Unidentified shell	32	34	28

* Where the amount of a species is less than one per cent, but more than one-tenth of one per cent, an X has been substituted for the actual figure; where less than one-tenth of one per cent a Y has been substituted.

TABLE 12

OCCURRENCE OF *Phytia myosotis* (indicated by ×)

Depth	Sausalito	Greenbrae	San Rafael	Ellis Landing	West Berkeley	Emeryville	San Mateo	San Francisco
.5	....	×	—	....	....	—	....	....
1	×	....	....	....	....	....	....	....
1.5	....	....	....	×	....	—	....	×
2	....	×	×	×	×	....	....	....
3	....	....	....	×	....	×	×	....
3.5	—	....	....	....	×	....	....	....
4	....	—	—	....	....	....	....	....
4.5	....	....	....	×	—	....	....	....
5	—	....	....	....	—	×	....	....
6	....	—	—	—	....	....	×	....
6.5	....	....	....	....	×	....	....	....
7	....	....	....	—	....	×	....	....
7	....	....	....	×	....	....	....	....
8	—	×	—	....	—	—	—	....
9	....	....	....	....	....	—	....	....
9.5	....	....	....	....	....	×	....	....
10	....	—	—	×	×	—	....	....
10.5	....	....	....	....	....	—	....	....
11	....	....	....	×	....	×	....	....
12	—	—	....	....	—	....	....	....
12.5	—	....	....	....	....	....	....	....
13	....	....	....	....	....	—	....	....
14	....	×	....	....	....	....	×	....
15.5	....	....	....	....	....	×	....	....
17	....	....	....	×	....	....	....	....
17.5	....	....	....	....	....	—	....	....
19.5	....	....	....	....	....	×	....	....
Bottom	....	....	....	....	....	—	....	....
Bottom	....	....	....	....	....	×	....	....
Bottom	....	....	....	....	....	—	....	....
Bottom	....	....	....	....	....	—	....	....

TABLES 13 TO 22

Tables 13 to 22 show the relative abundance in each sample of the species included in the table. This relative abundance is expressed in percentages of the sum of the species.

TABLE 13

ELLIS LANDING

Depth	Mytilus edulis	Macoma nasuta
1.5	43	57
2	55	45
3	98	2
4.5	87	13
6	2	98
7	7	93
7	85	15
10	53	47
11	91	9
17	96	4

TABLE 14

SAUSALITO

Depth	Mytilus edulis	Macoma nasuta
1	41	59
3.5	37	63
5	38	62
8	79	21
12	69	31
12.5	57	43

TABLE 15

EMERYVILLE

Depth	Mytilus edulis	Macoma nasuta	Ostrea lurida
.5	74	14	12
1.5	62	25	13
3	43	49	8
5	87	6	7
7	49	46	5
8	42	51	7
9	79	18	3
9.5	57	34	9
10	40	56	4
10.5	80	19	1
11	50	47	3
13	81	13	6
15.5	71	18	11
17.5	71	19	10
19.5	58	22	20
Bottom	34	—	66
Bottom	31	5	64
Bottom	42	4	54
Bottom	63	—	37

TABLE 16

CASTRO

Depth	Mytilus edulis	Cerithidea californica	Ostrea lurida
1	6	65	29
2	10	78	12
3	10	81	9
4	6	61	33
5	1	84	15

TABLE 17

SAN MATEO

Depth	Mytilus edulis	Ostrea lurida
3	62	38
6	41	59
8	54	46
14	50	50

TABLE 18

HALF MOON BAY

Depth	Tegula funebralis	Mytilus californianus
1	78	22
1	59	41
3	32	68
6	28	72

TABLE 19

GUNTHER ISLAND

Depth	Schizothaerus nuttallii	Macoma nasuta	Cardium corbis	Paphia staminea
1	1	71	—	28
2	33	67	—	—
2.5	54	7	11	28
6	58	28	14	—
6.5	10	30	42	18
8	45	34	16	5

TABLE 20

WEST BERKELEY

Depth	Mytilus edulis	Macoma nasuta	Ostrea lurida
2	73	3	24
3.5	74	2	24
4.5	57	26	17
5	77	2	21
6.5	60	2	38
8	58	1	41
10	54	1	45
12	73	—	27

TABLE 21

GREENBRAE

Depth	Mytilus edulis	Macoma nasuta	Ostrea lurida
.5	81	13	6
2	96	4	—
4	96	1	3
6	91	9	—
8	97	2	1
10	99	1	—
12	99	—	1
14	90	1	9

TABLE 22

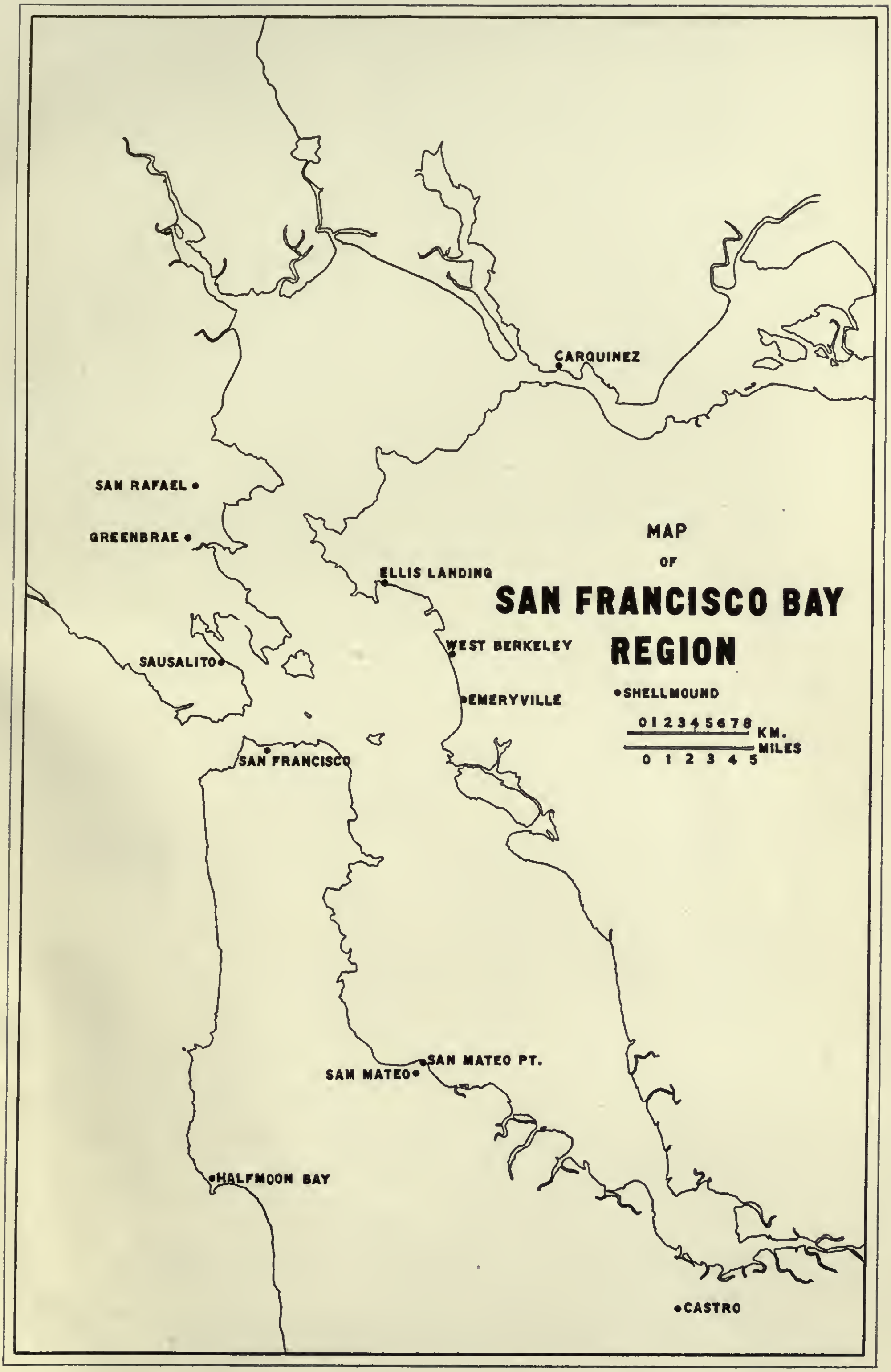
SAN RAFAEL

Depth	Mytilus edulis	Macoma nasuta	Ostrea lurida
.5	97	3	—
2	99	1	—
4	99	—	1
6	99	—	1
8	95	2	3
10	97	2	1

TABLE 23

MUSSEL SHELL (*Mytilus edulis*) CAUGHT BY THE FINE, OR TWO-MILLIMETER, SCREEN IN PERCENTAGES OF THE AMOUNT OF ALL MUSSEL CAUGHT BY SCREENS

Depth	Sausalito	Greenbrae	San Rafael	Ellis Landing	Emeryville
.5	....	77	97	....	90
1	88	....	....	....	....
1.5	....	....	....	86	62
2	....	65	86	61	....
3	....	....	....	41	55
3.5	68	....	....	....	....
4	....	82	91	....	....
4.5	....	....	....	80	....
5	92	....	....	....	66
6	....	70	67	63	....
7	....	....	....	54	71
7	....	....	....	82	....
8	79	76	86	....	67
9	....	....	....	....	75
9.5	....	....	....	....	67
10	....	71	95	71	62
10.5	....	....	....	....	85
11	....	....	....	90	73
12	93	83	....	....	....
12.5	91	....	....	....	....
13	....	....	....	....	96
14	....	81	....	....	....
15.5	....	....	....	....	88
17	....	....	....	87	....
17.5	....	....	....	....	92
19.5	....	....	....	....	90
Bottom	....	....	....	....	84
Bottom	....	....	....	....	83
Bottom	....	....	....	....	95
Bottom	....	....	....	....	97
Average	85	76	87	71	79


MAP
OF
SAN FRANCISCO BAY
REGION
CARQUINEZ
SAN RAFAEL
GREENBRAE
ELLIS LANDING
WEST BERKELEY
SAUSALITO
EMERYVILLE
SHELLMOUND
0 1 2 3 4 5 6 7 8 KM.
0 1 2 3 4 5 MILES
SAN FRANCISCO
SAN MATEO PT.
SAN MATEO
HALFMOON BAY
CASTRO

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