SHELLFISH FOODS OF THE CALIFORNIA INDIANS

Robert E. Greengo

INTRODUCTION

The relationship of Man to his environment involves problems of great significance in the study of culture. Much progress has been made in working out some of these complex, often subtle adjustments. Still, as with most bodies of knowledge, many questions remain that are unanswered.

Aboriginal California was characterized by a hunting and gathering type of culture. Within this area certain distinctions may be made, however, with reference to the kinds of foods upon which the people mainly subsisted. Among the many plant foods eaten, the acorn was the most important over a large part of the state. Documentation of the use of this distinctly aboriginal California food has been well summarized by E. W. Gifford (1). The Indians also consumed a great variey of animals—but few of these actually served as staple supplies of meat. Outstanding as a source of animal protein in much of California were the salmon which periodically ascended the great river systems of the state in enormous numbers to spawn. Substantial quantities of other types of fish were procured from the ocean—especially by the Indians of the Santa Barbara Channel, who fished from plank canoes; and by the natives of northwestern California, who caught and dried surf fish (2). In the latter area, where sea-going canoes of a different type were used, the taking of sea-mammals also provided more than an occasional meal of meat.

Shellfish formed another most important source of animal protein (3). This was particularly true along the coast, although certain inland bodies of water held molluscan fauna in sufficient numbers to be gathered profitably for food. The study presented herein is an attempt to assess the importance of shellfish in the diet of the Indians of California, and to analyze some of the cultural factors involved.

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For marine species, scientific names of shellfish follow the usage of Keen (1937) as the first authority, then Ricketts and Calvin (1948), and MacGinitie and MacGinitie (1949). Names for inland species are taken from Keep and Baily (1947).

The abbreviation UCMA is used to designate the University of California Museum of Anthropology. Numbered site designations are those in UCAS files.

KINDS AND DISTRIBUTION OF SHELLFISH

Coast

An understanding of the problems of Man in gathering and using shellfish might be elucidated by a consideration of the broader aspects of littoral habitat in which the animals are found. Two main categories may be set up, viz: exposure to wave shock, and type of bottom (4). In the first category, distinctions can be made between an open coast, a protected outer coast, or a relatively quiet bay or estuary. The main types of shore bottom conditions with which we will be concerned are: rocky shore, sand flats and mud flats. Further distinctions can be made concerning tidal horizons, these being segregated into low, middle, and high tide zones.

There is a fair correlation between habitat, as outlined here, and the range of various species of shellfish. This fact is important when dealing with the problem of locating and analyzing aboriginal littoral sites, as will be discussed below.

Along the Californian coast the shellfish most eaten were various species of the bivalve mollusks. One exception to this generalization was the abalone, formerly very abundant at certain places along the coast southward from Monterey Bay.

Open Coast

Of the bivalves, the most important food species was the sea mussel, Mytilus californianus. The factors accounting for the popularity of this species are not hard to find. In the first place it is one of the most numerous mollusks on the coast, being found attached to rocks on the open coast, often in such numbers as to form beds acres in extent. Occupying the mid-tide zone and swept by the surf, the sea mussel has a constant, fresh supply of planktonic food. This species ranges also up into the high-tide zone, but it is less numerous there and individual specimens are, on the average, of smaller size (5). The thick beds of large mussels which have been known to attain a length of nine inches are found on rocks that are exposed only during low tide, or on those seldom uncovered by the water. This latter factor—size—is the second element accounting for the popularity of mussels as food by the Indians. Another feature recommending this particular invertebrate as food is its "meatiness"—that is to say, it is anatomically composed of a large proportion of muscular and fibrous constituents. This, the factors of abundance and size already mentioned above, and a pleasant taste, help to explain the economic importance of Mytilus californianus—since it presented to the coastal dweller an almost inexhaustible food supply which could be obtained with a minimum of effort (6).

Next in importance perhaps, at least along the south-central and southern California coast, was a large marine snail, the abalone (7). Members of this genus inhabit an ecological niche very similar to that of the species discussed above. However, abalones range down to a depth of one hundred feet (8). Quite often they are found, not on rocks as are the mussels, but rather under rock ledges or in crevices.

While Keen recognizes eleven species of Haliotis, only two were of any great importance to the Indians (9). These were Haliotis cracherodii and Haliotis rufescens (10).

Unlike the mussel, which has been of little commercial importance on this coast, the red abalone (Haliotis rufescens) was exploited almost to the point of extinction, until rigid laws were passed for its protection. But like Mytilus californianus, it offered to the Indian a plentiful supply of meat which could be had with a minimum of effort. Far more than that of the mussel, the shell of the abalone was utilized for a variety of utilitarian and ornamental purposes.

Another open coast species which attained considerable importance, both aboriginally and in later times, is the Pismo clam (Tivela stultorum). This bivalve ranges from near Halfmoon Bay south to Socorro Island off the coast of Mexico at the latitude of 18° 46' N (11). It is found slightly below the surface on exposed sandy beaches near the mean low tide mark. Formerly this clam occurred in great numbers, especially at Pismo Beach on the southern San Luis Obispo County coast. Specimens are known to have reached a length of over seven inches and a weight of nearly four pounds (12). Again the advantages of abundance, size, and ease of gathering were

found in combination, offering the Indians another important source of food.

It might be noted that the abalone (especially Haliotis rufescens) and the sea mussel may often be found near each other in their rocky habitat, particularly in the vicinity of Monterey Bay, thus supplementing one another as food sources. Such a situation does not occur with the Pismo clam, however, for it fully dominates its ecological niche.

While two other forms of bivalves occur in similar habitats along the Californian coast they do not fulfill the criteria necessary to insure their popularity as a regular, staple source of food. These are the razor clam (Siliqua patula) and the bean clam (Donax gouldii). The former does answer our requirements on the coast of Oregon and Washington, however (13). The latter, though a small species (up to one inch long), was at one time canned commercially at Long Beach, California (14). The writer has been unable to find evidence of this species having been used by the Indians either in pre-historic or recent times.

Of minor importance, but evidently consistently eaten by aboriginal inhabitants up and down the coast, were various species of limpets, turban or top shells, and chitons—all of which are found attached to rocks in the inter-tidal zones. The largest and most important species of limpet were Megathura crenulata and Lottia gigantea on the south coast, while various species of Acmaea, especially Acmaea pelta and Acmaea mitra, are found in archaeological sites north of San Francisco. Turban or top shells are represented most often by two species: by Tegula funebrale, a dominant species of the high-tide horizon on rocky shores, where it often occurs in huge colonies; and, further down in the mid-tide horizon, by a closely related but less abundant species, Tegula brunnea.

Although there are many species of chitons on the west coast, only two were used as food to any great extent by the Californian Indians. One of these, Cryptochiton stelleri, popularly called the "gumboot," is the largest species of chitons known, sometimes reaching a length of thirteen inches (15). A northerly ranging species, the gumboot reaches as far south as San Nicholas Island in the Santa Barbara Channel, though very few are found south of Monterey. The other, somewhat more abundant and perhaps somewhat more relished by the Indians, is Katherina tunicata, which is the second largest species of chiton. It, too, is more abundant in northern waters, but ranges farther south than the larger form. Both of these animals favor the low-tide horizon on rockbound coasts, though Cryptochiton seems to prefer not to be exposed directly to the surf.

Included here under the term shellfish are several crustaceans, and at least one echinoid. These are all open coast forms and may be found in the inter-tidal zones.

Of these, various species of barnacles were relatively important in the diet of many coastal gatherers. Balanus nubilus and Balanus cariosus are two of the largest barnacles and were probably the most important for food. Another barnacle, the goose barnacle (Mitella polymerus), most often

associated with Mytilus californianus, was also eaten.

Crabs (Cancer antennarius and Cancer productus) were taken when possible from pools among the rocks at low tide—as ample ethnographic and archaeological evidence indicates (16).

Along the California coast the species of sea urchin occurring in greatest abundance—and most evident in middens—was Strongylocentrotus purpuratus. These animals with their brittle shells or "tests" are found on the open coast in the low-tide zone, nestled in small depressions in the rocks.

Bay and Estuary

The bounteous shellfish resources of the open coast of California derive from relatively few species. By contrast, the bays and estuaries offer—not only an abundance of shellfish—but also a much greater spectrum of forms. One of the more prominent of these is Mytilus edulis, or the "bay mussel," which is distributed all along the California coast (and, in fact, around the world in the North Temperate Zone), but which was important aboriginally only at San Francisco and Humboldt Bay. Differing from its allied form Mytilus californianus not only in habitat but also in size (rarely being over two inches long), the bay mussel too prefers to attach itself to rocks. When these are lacking, as they often are in bays and estuaries, the mussels will establish themselves on gravel beaches. These colonies are sometimes so closely intertwined by their byssal threads that they form great solid masses that can be torn away from the gravel in chunks or sheets.

Ranging all along the Californian coast is the bent-nosed clam, Macoma nasuta, of which the Indians ate a great many. It burrows only six or eight inches into mud, and thus is relatively easily procured.

A popular bivalve, aboriginally as well as today, is the rock clam, Protothaca staminea (also called rock cockle, little neck clam, hardshell clam, and the Tomales Bay clam). It can be found at low tide in packed mud or in a gravel and sand bottom, usually less than eight inches below the surface.

The gaper or horse-neck (Schizothaerus nuttallii) was fairly consistently used by the Indians north and south on the coast. It grows to eight inches in length, sometimes weighing up to four pounds. As it lives in soft muck or in fairly loose sand in the low tide horizon at a depth of from eighteen inches to three feet, this clam is gathered with no little effort. Most of the edible part is contained in the long muscular siphon which is the only part eaten by present day clammers. That the prehistoric coastal dwellers considered the effort to dig this species worthwhile, is evidenced by its presence in middens from Puget Sound down to the Ventura County coast.

More important in some respects than the horse-neck, but used to a lesser extent aboriginally for food, was the Washington clam (Saxidomus nuttallii). It is found in the same habitat and range as the above species, but at a depth of only eight to ten inches. This is a large clam, though not so large as Schizothaerus, averaging between three and five inches long. Its importance resulted from the nature of its shell, which, because of its thickness and lasting quality, was worked into small perforated discs which were used as a medium of exchange by the later Californian Indians.

Certainly one of the easiest clams to procure is the basket or heart. cockle (Clinocardium nuttallii) formerly called Cardium corbis), which is either found lying on the surface of the coarse sand flats in bays and estuaries or slightly below. It occurs in greatest abundance in the north, but California middens indicate that it was eaten by the Indians at least as far south as Halfmoon Bay.

In the more protected indentations of the coast southward from Monterey are found the West Coast scallops, of which one—Pecten circularis—was of some importance as food. It inhabits sand flats and is widely known for its fine taste.

Another southern ranging form is the hard-shell cockle (Chione spp., californiensis, fluctifraga, and undatella)—occurring archaeologically in a shell mound near Santa Barbara.

Widely known for its aboriginal decorative usage, and probably eaten to some extent by the aborigines, is the olive shell (Olivella biplicata). Ranging all along the California coast, it can be found in greater or lesser numbers on sand flats in bays and estuaries.

The native West Coast oyster, Ostrea lurida, was important for food in aboriginal California only in San Francisco Bay. This oyster is small, but like the members of its genus from other parts of the world it grows prolifically on beds of its own shells in shallow, protected water.

Inland

Unlike the tributaries of the Mississippi which flow over limestone formations conducive to the growth of mollusk shells, the freshwater bodies of California do not contain a great abundance of pearly clams (17). This is not to say, however, that many of the Indians of inland California did not from time to time enjoy the benefits of this nutritious food resource.

A very distinctive variety found in clear, swift streams, partially buried in sandy or gravelly bottoms, is the pearly naiad, Margaritifera margaritifera falcata. While there are few data as to what extent this species was utilized in California, it is known to occur in Indian sites in at least small quantities (18).

Another conspicuous member of the family Unionidae is Gonidea angulata, the angular anodon. It ranges from the northern border of the state down into San Diego County and across the Sierras to Idaho.

A species having a thin, trianguloid shell and named Anodonta nuttalliana may be found in most rivers and lakes in California. Two other forms, Anodonta californiensis and Anodonta oregonensis, have sometimes been considered separate species, and at other times merely as varieties of Anodonta nuttalliana.

While the above are now all classified taxonomically in the family Unionidae, a distinction has been made between the Unios and the Anodons. The former seem to prefer running water in rivers and streams, whereas the latter can be found in greatest abundance in quiet lakes and ponds, though the two habitats are not mutually exclusive (19). Although the literature on their distribution in California is meager, this distinction seems to be verified by the finding of Anodonta oregonensis as the only bivalve present in a shell midden on an island in Buena Vista Lake (20).

Land snails and slugs may possibly have been eaten to some extent in aboriginal California. Shells of the former occur in archaeological sites—but never in large enough quantities to indicate importance as a food item (21). They sometimes occur quite deep, but in most cases the numerous rodent burrows might explain this fact. The species mentioned in connection with Indians seem to have been largely of the family Helicidae (genera Helix and Helminthoglypta).

SHELLFISH IN ABORIGINAL LIFE

The Seasonal Round

Before entering into a discussion of shellfish gathering in California, it might be well to consider briefly the seasonal round as exemplified by a number of well known groups. We may first consider the seasonal gathering activities engaged in by a coastal group; for this purpose we will discuss the Coast Yuki, who have been excellently described by Gifford (22). This group, which consumed a large number of marine shellfish, may be taken as an example of an exposed, outer coast, kitchen-midden population (as differentiated from those who left remains on protected inner bays such as Humboldt, Bodega, or San Francisco Bays). These people lived in more or less temporary camps in the hills in the winter, and occupied the beach from about April to October. The period between the latter part of January and the first of March was the worst time of the year, for the food supply was then low, the stored food was largely used up, and the streams were too swollen by rains to permit salmon fishing. By March, however, excursions were being made to the coast for mussels and other shellfish. In April some people constructed dwellings at the beach, although the food quest still had an inland orientation, for in May clover leaves were ready

to eat, and by June clover flowers and seeds, grass seeds, bulbs and corms were plentiful. More time was spent at the beach in July, and such things as mussels, abalone, and surf fish were dried. Seafood drying activities continued through August; the diet being augmented by such food as berries and hazel nuts, and perhaps an occasional deer. By September short trips were made into the hills for acorns and other seeds. In October, winter houses were erected in the hills; these were occupied in November. Salmon were largely caught and dried in December, but toward the end of this month the rains intensified and salmon fishing terminated.

Thus, it appears that among this group the main protein supply in the diet was shellfish, especially mussels, for salmon could not have been very important if the greatest quantity of them was caught in December, and if the food supply was running low by the end of January (23).

A brief sketch is available of the annual food cycle of the Tolowa. Shellfish here figure prominently in the diet, though not to the extent that they did among the Coast Yuki (24). The most important food resources were salmon and acorns; these were followed by smelt, shellfish, and sea mammals (25). Unlike the Coast Yuki and very much in the pattern of the Yurok, who also relied on salmon to a great extent, the Tolowa congregated along the Smith River for the spring salmon run. During this time the roots and berries began to ripen and could be gathered. From the river the people moved to the beach in order to gather, hunt, and dry seafood. In the late summer when the salmon were again running they returned to the river, and from there moved to the hills to gather acorns. The Tolowa spent the winter in their villages along the river, around Lake Earl, and on the coast.

The general pattern along the coast must have been similar to the two cases described above, though groups living on the coast probably gathered a goodly quantity of shellfish in the winter as well as during the rest of the year (26).

Inland peoples apparently made frequent excursions to the coast to gather shellfish—probably mostly during the summer. The Coast Yuki and their inland neighbors developed this practice to a formal pattern (27). Freshwater shellfish were evidently more sought for in the summer by the Eastern Pomo (28). In the south, the Yokuts, and probably other valley groups, are also known to have made excursions to the coast to procure shellfish. An instance recorded in historic times took place in May (29).

The most important reason, apparently, for the decrease in shellfish gathering during the winter is to be found in the climate. The northern California coast can be very unpleasant at times during the summer, and even more so in the winter when gales whip down out of the northwest. Indians whose territory adjoined the open coast, such as the Coast Yuki, retreated before the storms to more pleasant climates. Those living on relatively protected bays such as Humboldt, Bodega, and San Francisco most probably occupied sites the year around, however.

Gathering Techniques

As one specialized aspect of the hunting and gathering types of subsistence, the procuring of shellfish is one of the simplest means of obtaining food known to man. There are, however, certain facets to the problem of collecting these unobtrusive animals that require skill and ingenuity. The simplest and most direct method of gathering shellfish is to pick them up by hand. This is possible with only certain species, and even with these it is often necessary to resort to some kind of implement. The more important factors governing the methods of gathering are the physical characteristics of the animals, their numbers, and their ecological relationships.

An animal fulfilling the requirements of ease of handling, occurrence in substantial numbers, and exposed habitat at low tide is the sea urchin (30). This species was probably usually gathered by hand, though this practice is not mentioned specifically in the literature. One might conclude that they were not gathered with the aid of an implement since the use of implements usually attracts the attention of the observer, and no such connection is cited for sea urchins along the California coast (31). This point can be illustrated by referring to the Kwakiutl who used a multi-pronged spear for sea urchins (sea eggs). It was constructed of a hemlock shaft three and one-half fingers thick, with yew wood prongs two spans and four fingers widths long, and bound to the squared end of the spear by split spruce roots (32). This invention was similar to the one used in gathering Dentalium, a mollusk which had a direct and powerful influence on California Indians through its use in trade (33).

It is possible through a slow and painful process to take mussels by hand. The only specific mention that the writer has found of such a practice is of the Wappo picking mussels off rocks by hand (34). The authority does not specify whether these are sea or bay mussels. The latter might be easier to deal with in some cases (35).

Since most of the clams live below the surface they usually have to be dug out with the aid of some sort of implement. There are a few instances on record of the Indians having dug for various species of clams with their hands. According to Nomland, not only clams, crabs, and river crawfish were taked by hand by the Sinkyone, but also the abalone—although she indicates that the latter was also pried off the rocks with a stick sharpened at one end (36). A Tolowa man said that the razor clam (Siliqua patula) was seized by hand in the mornings at low tide (37). The Lower Chinook at the mouth of the Columbia River sometimes used their hand to remove the sand from around clams. This group also used implements—in this case of a rather specialized kind.

Evidence as to how the native west coast oyster (Ostrea lurida) was gathered is meager (38). The Coast Miwok dug a few with digging sticks at the mouth of Valley Ford Creek (39). For San Francisco Bay, where this species is most in evidence archaeologically, there is no ethnographic material to indicate how it might have been procured. Very

likely they were dealt with in a manner analogous to the Seri practice. This group would gather oysters "with the hands, aided perhaps by a stone or stick for dislodging the shells either from the extended offshore beds at extreme low water, or from the roots of a mangrove-like shrub at a médium stage" (40).

The main types of crustaceans represented in aboriginal menus were crabs and barnacles. Both of these were perhaps more often taken with the aid of tools of greater or lesser complexity, but in some instances they were taken by hand. Crabs were caught in such a manner by the Coast Yuki (41). One of the most ingenious methods of procuring any shellfish was practiced by the Pomo, who, according to Loeb, would at low tide build a fire over a bed of barnacles living on the rocks (42). This was kept going, cooking the barnacles, until the incoming tide extinguished the fire and cooled the meal which was eaten the next day. This practice would very probably give rise to an underestimate of the amount of barnacles eaten by the Pomo groups in question if that estimate were based upon an analysis of their refuse sites alone. However, Loeb notes that barnacles were also gathered and cooked in hot ashes at their camps, while the writer has seen barnacle shells on Pomo sites as far as four miles in from the coast (43). The trait of cooking barnacles before they were removed from the rocks or gravel is also recorded for the Kwakiutl. Boas writes that barnacles (probably Balanus cariosus or glandula) were roasted by building a fire over a large bed of barnacles which were then peeled off in sheets (44). These people would also gather stones with many barnacles on them, and cook the animals by steaming (45).

In the interior where river and lake mussels were eaten, gathering was apparently most often accomplished without the aid of a tool. However, an American explorer who ascended the Sacramento River as far as the territory of the Northern Wintun observed that "these Indians had small fishing-nets, somewhat resembling the size and shape of a lady's reticule. These they made use of when diving for mussels, and in a short time procured half a bushel of them" (46). Repeated references have been made to the practice of diving for mussels by the Wintun (47). Powers says of the Wintun on the Sacramento River, "They would dive many feet for clams — and rise to the surface with one or more in each hand and one in the mouth" (48).

Land snails were probably most often merely picked up by hand, although references to their use by Californian Indians do not usually include the method of taking them. One ethnographer specifically states that the Pomo women picked up snails from the ground and water (49).

Specialized Techniques

The type of artifact employed to the greatest extent by the Indians

of the state for the purpose of obtaining shellfish was most likely some sort of wooden implement resembling, and in many cases identical with, the digging stick (50).

A stick was sometimes used to locate the shell of clams living in sand or mud flats. The sand or mud would then be loosened and scooped away by hand until the clam could be seized. Kelly's notes contain a good description of digging for a long neck clam (probably Schizothaerus nuttallii) by the Coast Miwok at Bodega Bay: "Dug at low tide on flats-with stick [51], or with stick for this particular animal. Sharp on end, but not very sharp. Thrust stick in to locate shells. Then go with fingers. Gathered by both men and women. Found above elbow depth. Gathered in conical burden basket" (52). The employment of a special instrument in collecting this clam may have a long history at Bodega Bay, for the popularity of the species at site Son-299 (with Middle Horizon affiliations) is shown by the relatively large proportions of Schizothaerus shells among those of other species (53). Driver gives a similar description for the digging of clams by the Wappo (54).

The famous money shell clam (Saxidomus nuttallii) was also dug with a stick by the Bodega Bay Indians. "'Rock clams' (Lupu-guta) are the ones from which thick beads are made, have to have a hard wood stick for these clams. They are in the rocks. Pretty good eating too. Just like the Washington clams" (55).

Apparently these people distinguished between specimens of Saxidomus on the basis of thickness of shell, for there is fair range of variation in this particular (from two to three millimeters), as observed by the writer. In several places in her manuscript, Kelly gives the native name of the Washington clam (Saxidomus nuttallii) as, Ku.ta, guta, or Kuta (56), while the so-called "rock clam" is repeatedly referred to as lupu-guta (57) or Lupu-Kuta (58). The form Kuta or guta is apparently the root word referring to the species, and the prefix lu.pu (lupu) qualifies the thickness of shell and its concomitant utilization for disc beads.

The name "rock clam" is misleading, however. Saxidomus thrives in mud flats, as well as in fairly coarse gravel. The latter is probably what is meant by the ethnographer.

The most important single component of site Son-299 at Bodega Bay was the sea mussel (Mytilus californianus). As with Schizothaerus the mussel was important enough in late times also, to merit a special name for an implement used in its procurement. Kelly tells how these people gathered mussels: "Found only in salt water. Principally on island at mouth of bay and on Bodega Head (ocean side). Get mussels at low tide off rocks. Hammer off with hardwood stick (hoiyo'n). Only men got mussels. Got to watch the water all the time. Carry basket to put them in" (59).

The manufacture of this tool (also used in taking abalone) is

described thus; "Use a pretty sharp stick (hoiyo'n). Sharpen it good and put it in the fire to dry. Don't burn it too much. Make it sharp by rubbing on a rock" (60). Other instances of the employment of a sharp stick have been recorded for the Wiyot who used it to get abalones as well as sea anemones (61).

Abalones (Haliotis rufescens) were sparsely represented in Són-299 but may have been more important during the later period.

To this day the type of implement used in procuring the abalone has retained the form employed by coastal dwellers at the time of contact. It consists of a rod-like instrument with a fair degree of fractural strength, sharpened, and often flattened at the working end. The present day "tire-iron" made of a section of automobile leaf spring serves the purpose well, whereas the Indian used a hardwood stick as described above or one with a spatulate end (62). The function of the instrument is to insert the end under the edge of the shell of the animal and quickly flip it off the rock to which it adheres by its strong muscular foot. Failure to perform the act in one quick motion gives the abalone time to draw its shell down tight against the rock with such strength that it is sometimes very difficult to remove the tool, much less loosen the animal. It has been suggested that the strength with which an abalone adheres is due in part to the secretion of mucus on which this sea snail slides. The mucus would aid in creating a vacuum (63).

The difficulties presented to the Indians by the characteristics of abalones and the nature of their habitat is vividly described in the following excerpts:

"Bodega Head is a bad place to get abalone. Got to climb up rocks with a big load. Got to go through tunnel to get abalone there" (64).

"Get on ocean side. Hang down under rocks. You got to feel for them. Dangerous. Catch your finger and you got to stay there.—Use a pretty sharp stick (hoiyo'n) [65]. Hit them quick not slow" (66).

The Coast Yuki also used a specialized tool for abalones and mussels. It was made of a hard wood, rhododendron or Garrya elliptica (a species of dogwood) one yard in length with a flat chisel-like end. When broken off in use the end was resharpened with a musselshell knife. After the stick became very short it was driven under the abalone shell with a stone. The instrument was made to last longer by hardening in the fire. It was also used to remove abalone meat from the shell (67).

On the Northwest Coast the Kwakiutl, who specialized in woodworking, had at least two different types of spatulate prying implements to aid in gathering shellfish. A mussel stick which was probably used as a blade to scrape mollusks off rocks is described as being made of a broken yew-wood paddle, four spans long with a round handle, the flat end being four fingers wide (68). What must have been a similar looking instrument was employed to peel chitons off rocks (69). This was made of a

hemlock branch three spans long and had a flattened point (70). A sharpened, flattened instrument of ironwood, three to four feet long and seasoned over the cooking fire for several months was used by the Coast Yurok to pry loose mussels, abalones, and chitons (71), while a similar form is described for the Tolowa who used it for mussels, horse-neck clams, and sea anemones (72). This type of instrument probably had a continuous distribution along the Northwest Coast as far south as the Lower Chinook, who employed an even more specialized tool. This was from two to four feet long including a handle and a blade which was cupped and tapered to a point (73).

Among the Wappo who lived somewhat more distant from the abalone habitat than the above mentioned groups, abalones were pried off rocks with sticks, or, "shell crushed and meat taken out without removing the shell from the rock" (74).

In extreme southern California the Diegueno took abalones with hardwood bars (75).

Except for the above citation our information as to gathering techniques refers to groups north of San Francisco Bay. For most of the species discussed thus far, the gathering techniques were probably similar on the south central and southern Californian coasts. Certainly more data are necessary, on the Chumash especially, before the picture can be completed. There is, for example, little or no information as to how the famous Pismo clam was located and gathered aboriginally. Today a rather specialized clam fork is often used to locate these clams. It is sometimes possible to find this species by looking for its siphons which protrude slightly out of the sand. Once the siphon is located it is a relatively simple matter to dig the animal out by hand. Quite possibly the Indians probed for the Pismo with sticks, as the Coast Miwok did for another species (76). Another manner of locating and gathering these clams was that employed by the Seri in the Gulf of California. McGee designated the Pacific Coast clam (probably Tivela stultorum) as the most important species in the shellfish class of the Seri diet (77). The method of procuring them was as follows: "The clams are usually taken at low tide without specialized apparatus. They are located by feeling with the feet in shallow water, and caught either with toes or with fingers, to be tossed into any convenient receptacle. When the water is entirely withdrawn from the flats, they are located by means of their holes, and are extricated either with a shellcup or with some other improvised implement"(78).

Of the many species of crabs along the California littoral only two were eaten to a substantial extent by the aborigines. Many of the shore species are too small to provide enough gastronomic reward for the effort of capturing them. Two species answer the criteria necessary to insure their use as an important food source, viz: Cancer antennarius and Cancer productus (79). These two species are to be found among rocks at low tides on the protected outer coast (80). To collect crabs a number of methods have been used by Californian Indians.

The Sinkyone caught crabs and crawfish by hand (81), as did the Coast Yuki (82), while the Wappo are said to have swum after them as well as picked them off the beach (83). Another simple method was to poke a stick or pole through the carapace of the animal. This practice is described for the Indians along southern Oregon Coast (84), the Yurok (85), and for the Wiyot (86). The Tolowa would merely thrust a stick down into a tide pool. The stick, which was seized by the crab, was then drawn back together with the animal. Octopi are said to have been caught in this manner also (87).

Together with the simple techniques for catching these crustaceans, more elaborate ones were used on the northern Californian coast. The Pomo used an intricate combination to catch crabs as illustrated by the following excerpt: "Crabs were caught on the coast with a piece of string, using meat as bait. The fisherman summoned the crabs with the cry of 'Pe pe pe pe.' Then the crab came out from his place of concealment. A hand net was used for the purpose of removing the crab from the water. Lobsters (K'i, Central Pomo) needed no enticing, but were netted out of the water at low tide"(88).

Stewart mentions that the Central Pomo caught crabs with dip nets at low tide (89), but says nothing about catching them on baited strings (90). Also he gives the Central Pomo name for crabs as "Ki" (91). This is almost identical with the word Loeb gives (above) for lobsters. Since the only lobster on the West Coast is the "spiny lobster" (Panulirus interruptus), which does not range north of Point Conception (92), Loeb was in error in referring to the crustacean as a lobster. What was probably meant was another species of crab.

On the northwestern coast of California at least two types of crab pots were used. One was a circular frame netted across, used by the Karok (93), Yurok, Wiyot, and Mattole. The latter group made the mesh of the inner bark of willow, and baited the pot with mussels; the Karok, on the other hand, used salmon viscera for bait (for crayfish). In addition, the Karok and Yurok employed an openwork twined form of pot for crabs and their freshwater relatives. The Bear River Athabascans probably used a contrivance similar to that first described above, for, although it is called a dip net, it functioned as a crab pot (94).

Methods of Preparation

The modes of preparation and consumption of shellfish by the California Indians were—like their technique of gathering—direct and unspecialized. The entrees were often, perhaps more so than actually recorded, eaten raw. This seems to have been especially true in the case of the sea urchin, Strongylocentrotus purpuratus, whose only edible portions, the eggs or gonads, were eaten raw by the Tolowa (95), Wiyot (96), and Central Pomo (97). This species was also exploited by the peoples of the Mediterranean area, and even today Californians of Italian descent

can be seen during low tide at Pacific Grove collecting this Frutta de Mare, washing the eggs in the sea water, and placing them in two-quart jars (98).

According to Jochelson (99), the gonads of a closely related species are fully developed only from April to June and from September to October (100). During the rest of the year the eggs are absent or very rare.

The Wiyot also ate limpets (Acmaea sp.) raw upon occasion (101). The writer's Wiyot informant declared that he has seen a descendant of the Mattole people eating limpets raw near Petrolia.

Undoubtedly clams were sometimes devoured with more preparation than removing them from the shell, as with the Wappo (102). This practice was also observed among the Seri (103).

Perhaps the main problem with shellfish that had been gathered was that of preparing for storage those that had been caught and were not to be eaten immediately. As far as is known this was always done by drying them in the sun or smoking them in a fire.

Non-coastal groups would sometimes travel half the width of the state in order to enjoy the benefits and delights of fresh sea food as well as to preserve some for transportation to their homes (104). On these trips trade was carried on for shells and other articles between the coastal and inland groups. The impracticality of transporting fresh sea food over long distances is reflected in the taboo by the Hupa against bringing any fresh sea foods into the valley, all such products had to be dried (105).

In many cases the food was cooked before drying, as with the Tolowa who, when they had a large quantity of mussels, clams, or barnacles to be dried, would build a large fire on the beach, scoop out the hot coals and bury the shellfish in the hot sand which was re-covered with the coals. When a portion of the dried product was to be eaten, it was soaked over night in fresh water, then boiled a bit and consumed along with acorn mush (106). The Yurok are known to have used this "pre-cooking" method for the pig's foot barnacle (107).

The Yurok cooked mussels before drying them by placing the live animal directly on the fire or on hot rocks in the fire, where they simmered in their own juices (108). They were done when the shell opened. Some were eaten freshly cooked; others were dried in the sun, the small children brushing away the flies with branches. When the mussels were dry they were stored in baskets between layers of fine grass. These were stone boiled in baskets after being soaked over night in fresh water (109).

Further light on mussel drying may be derived from data on the Wiyot—who not only broiled fresh mussels on an open fire but also boiled them fresh. The meat was dried and smoked in a twined, open-work basketry tray set on a frame over a fire of myrtle or alder wood. This process lasted for three days. In historic times the smoked and dried mussels were stored in a sack, though aboriginally a storage basket was undoubtedly used as with the Yurok. Again the dried mussels are said to have been soaked over night in fresh water and recooked by boiling (110). Preservation of shellfish, especially mussels, by drying or smoking occurred among all the northwestern Californian coastal peoples—the elements forming a complex of traits: cooking, drying, storing, soaking in fresh water and re-cooking by boiling the dried product before eating.

Nomland mentions this process for the Bear River Athabascans in the vicinity of Cape Mendocino (111). The Sinkyone practice in this regard was not recorded (112), while the Coast Yuki varied the mussel drying complex only slightly. They regarded mussels quite highly but went about preparing them somewhat differently. The first part of the Coast Yuki process corresponds rather closely to that of the more northerly groups; the stored mussels, however, were eaten dry without further cooking (113). The Coast Yuki method is described thus by Gifford: "Mussels for drying were placed among hot coals to open shells. Then the meats were spitted on young hazel twigs to dry. These twigs with their loads of mussels were tied together so that they radiated like the spokes of a wheel. Usually the mussels were dried in the sun, though sometimes smoked too. If not thoroughly dried they spoiled. When ready for transport inland, the sticks of mussels were packed in the man's burden basket (olo). They were eaten dry without further cooking. People were never poisoned by dried mussels, as they were sometimes by fresh mussels" (114).

Farther south, the Pomo followed the practice of the northwestern groups—boiling or roasting the mussels on hot coals to open them, sun-drying them, transporting them home, and sometimes stringing them on grass fiber (115). The dried mussels were made ready for eating by being soaked in fresh water until they were swollen, after which they were boiled (116).

South of San Francisco Bay our knowledge of mussel drying must be largely inferred. The Costanoans dried food by both sun and smoke, while the Chumash admitted sun drying but denied the smoking process. The Serrano and Gabrielino also said they dried food in the sun (117). Mussels were definitely eaten by the Costanoans (118), Salinans and Chumash (119).

In general the emphasis in coastal activities was laid upon the ubiquitous mussel. At various times and in certain localities, however, other forms of shellfish and sea food were the foci of attention. Among the shellfish, the abalone, in Monterey Bay and to the south, was almost

equally important (though specific citations as to drying of them for future use are lacking). Woodward stipulates that the most plentiful and most useful species on the coast of Southern California was the black abalone (Haliotis cracherodii), and that this species was one of the most prevalent at the important Chumash village site of Muwu (120). Another very important mollusk at this site was the present day market variety of cockle, Protothaca staminea, of which the author says that there were, "solid layers of cockle shells, unmixed with earth or other debris, evidently the remains of ancient feasts or a heavy catch prepared for future use" (121).

Though abalones were less frequent to the north, they were at least occasionally dried along with mussels and clams. The same method used for mussels was evidently extended to other kinds of shellfish—and to fish as well. At the seashore the Yurok took—besides shellfish—various types of sea mammals (including stranded whales)(122), surf fish, and seaweed (123). All of these were dried in greater or lesser quantities. Indeed, dried smelt were apparently a staple among the Tolowa, for one informant declared that they were eaten at almost every meal along with acorn mush (124). The taking of smelt in fair sized quantities extended at least as far south as the Coast Yuki, for Gifford includes them along with mussels, abalones, chitons, bullheads, kelp fish, and rock cod as foods dried at the seashore and taken inland to winter sites in the fall (125). Not much abalone was dried and taken inland, however, because the small supply was usually eaten immediately. In the process of preparation, "an abalone [which was] to be dried was cooked in coals, removed from the shell, and the meat cut into three broad horizontal slices with a flint knife. In cutting into small pieces for eating, a mussel shell was used" (126).

Sea mammals were generally less important south of northwestern California until the Chumash area was reached. Here, another sea-going people took them as evidenced by remains in archaeological sites (127). The coastal Gabrielino, too, are said to have subsisted principally on fish, whales, seals, sea otters, and shellfish (128).

Two species of smelt—Spirinchus starksi and Allosmerus attenuatus—comprise the bulk of present day surf fish catch, and probably did so in aboriginal times also. The former species is the most abundant and ranges as far south as Monterey Bay; the latter ranges only to San Francisco Bay. For both species, however, the largest recent landings were made at Eureka (129). This fact reflects the aborignnal distribution of this food.

Of shellfish other than mussels and abalone that were dried or smoked for later use, specific mention may be made of chitons (Cryptochiton stelleri and Katherina tunicata) for the Wiyot. These were cooked in hot ashes, the plates and viscera then being removed, and the foot only eaten. The drying process was similar to that used for mussels (130). The initial cooking process was essentially the same for the Coast Yuki. However, "the white and blue 'intestinal parts' were dried for use later, when they were parched, or soaked in water and eaten. The meat was washed and eaten at once" (131). What appears to be a survival of an ancient

Pomo practice in treating the "gumboot" was recorded recently at the Ukiah Rancheria. The informant was drying a couple of dozen chitons (Cryptochiton stelleri) on a table covered with newspapers in the yard. She said that "they are collected on the coast. They are boiled and then the shells are removed, then they are dried in the sun for about a week. When they are desired for a meal, they are again boiled and then sliced and served, ...not many of the Indians eat these any more" (132).

The northern Pomo formerly made trips to the coast lasting at least four to five days in order to gather and dry mussels, abalone, sea fish, kelp, and seaweed. They gave abalone feasts, and also dried them in the sun to be stored in baskets for relatively great lengths of time (133).

The process of stone boiling in baskets was widely distributed in aboriginal California—and where shellfish were eaten this was one of the means of preparing them. It has been pointed out above that boiling was the usual method of preparing dried shellfish, and probably other dried products also, for eating, being done with stones in most of California. In northwestern California all groups, except the Nongatl, Kato, and Coast Yuki, boiled meat (134), nevertheless, all are said to have dried meat and fish (135). In this area the most common method of preparing fresh meat or fish (and shellfish) was that of roasting or broiling the animal on hot coals (136). However, river mussels were boiled, for a species of "Unio" found along the Klamath River (137) in Karok country moved an early traveler to record the following: "These form a favorite article of food with the Indians, who boil them in baskets by means of hot stones" (138). From these and the few other statements that can be found relating to the utilization of freshwater mussels, it might be concluded that the manner of preparing them differed little from that employed by the coastal peoples for salt w ater species. Both boiling and roasting were resorted to by the River Wintu. If a surplus was accumulated over what could be consumed immediately, they would be dried on flat basketry trays for winter use (139), and for trade with the mountain people (140). Powers also states that the Washo boiled a bivalve—which he calls "Onondonta," but which may now be called generically Anodonta or Gonidea—found in the Owens River and in many other parts of California (141).

Freshwater lake mussles (probably Anodonta sp.) are reported roasted in a strikingly similar manner in both north central California among the Lake Pomo and by Yokuts around Buena Vista Lake in the southern Central Valley. Kniffen says of the Pomo: "Freshwater clams (xala) were well distributed about the lake. In summer they were taken in some numbers and cooked near the shore. They were placed on the ground in a flat spiral, hinge upward. Over the top a light fire was built with small sticks so that when cooked the shells were easily opened" (142). Latta records that the Chunut and Wowol Yokuts prepared large quantities of lake clams in the following way: "First they put on the ground a layer of tules four or five inches thick. They put the clams on top, with the open edges down as thick as they could, so they would not roll over. They piled tules on top of the clams. Then they set fire to them. When the tules burned, the water ran out of the clams and steamed them so they

cooked nice. My people ate lots of them that ways. They were good with salt from salt grass. Sometimes they baked lots of fires of them" (143).

The quite simple and efficient method of cooking food in hot sand was employed to some extent by the Tolowa (144). Hot sand was also employed to loosen the tough hides of such animals as chitons and octopi. The loosened hides were then scraped off—the meat of the former being broiled on live coals, the arms of the latter being chopped into six inch pieces and stone boiled in baskets (145).

Crabs are said to have been boiled by the Wiyot and Hupa; the latter also baked them in hot sand (146). Further up the coast the Yurok either baked them in hot sand or broiled them on the open fire (147). The Tolowa, again, cooked them in sand. Other shellfish said to have been prepared by this method include Washington clams (Saxidomus nuttallii) by the Hupa, and pig's foot barnacles (Mitella polymerus) by the Yurok (148).

Although the information is incomplete, it seems that the technique of baking food in hot sand seems to have occurred only on the northwest coast of California. Here, its use was confined to the preparation of shellfish. Broiling or roasting on the open fire or in hot ashes appears to have had a general distribution along the entire coast, however. In fact, this latter method is the only one reported for the Coast Yuki, who applied it even to the sea urchin (149). Elsewhere, sea urchins were raw, with the possible exception of the Bear River people, who sometimes placed them on hot stones. They did not, apparently, place sea food in direct contact with a fire (150). Their closely related neighbors to the south, the Mattole, broiled all meats and fish on the fire (151). Pomo practice was apparently equally divided between preparing sea food by boiling and cooking it in hot ashes or live coals. The Northern Pomo prepared even the seaweed for their feasts by cooking in hot ashes, as well as their abalone (152).

Another food which was gathered along with shellfish, and which has not been previously mentioned, was a sea anemone (Cribrina xanthogrammica). The fact that this animal was utilized was first pointed out by Loeb in 1926 (153). Stewart's description of its utilization by the Northern Pomo bears quoting: "...although extremely soft when removed from the water, they were found to keep several days without spoiling and were wrapped in leaves and tied with grass and transported fresh into the interior valleys. When cooked and dried they became very hard, but soften when soaked and warmed again. As prepared by my informant they had a texture like calves' brains and, except for the usual 'sea flavor' and the sand which could not be removed, might have been mistaken for them. Loeb noted their use by the Pomo, but they have not been reported for other California Indians and I find no reference to their use in other parts of the world" (154).

Although this description is excellent, Stewart is in error on the last point, for the Coast Yuki usage had also been noted by Gifford in 1939. This latter author describes these people as removing sea anemones from

the rocks with a wedge-like abalone spatula, cleaning the mussels, barnacles, and other hard objects from their exteriors and interiors (155), and cooking them in hot ashes (156). Further up the coast, the modern Wiyot slice and fry sea anemones. At least one informant doubted, however, if his people used them in the old days (157). The Tolowa seem to have eaten sea anemones since before the coming of the white man. At present they have to remove them from rocks with mussel bars, after which they wash them in fresh water, scrap them clean, and broil them on beds of live coals.

Still another cooking device which was used extensively in California was the so-called earth oven. This device consisted of a pit in the ground measuring between one or two feet in depth and one or two feet in diameter, which was filled with alternate layers of hot stones, leaves, and live stones. The food was protected from the heated stones by leaves, which also served to prevent the heat from escaping. Water was often poured over the stones before the live coals were put on; this served to steam the food as well as to prevent the leaves from burning (158).

In northwestern California the Yurok (159), Nongatl, Mattole, Kato, Coast Yuki, and Sinkyone used the earth oven for preparing meat or fish, and, presumably, shellfish (160). The Tolowa cooked only shellfish in the earth oven, never mammals or fish. This was largely true for the Wiyot also, while the Karok used the earth oven especially for bear meat (161).

Other specific references to the use of the earth oven for shellfish are rare or entirely lacking. One clue for the Pomo is given in an account which states that shell food was baked covered with leaves, coals and hot rocks (162). That other tribes along the coast possessed the earth oven and probably used it for shellfish seems to be a reasonable assumption. Harrington (163) lists the earth oven as present for seventeen Costonoan, Salinan, Chumash, Serrano, Fernandeno and Gabrielino groups, but in only four instances are the foods cooked in the device recorded (164).

Dietetic Factors

In the course of evaluating the importance of shellfish to the Californian Indian, let us consider briefly some of the most essential nutrient requirements of Man and the extent to which the consumption of shellfish might satisfy these.

Among the various requisites in the diet, two stand out as being particularly necessary in a qualitative sense — namely, proteins and vitamins (165). This fact is especially true with regard to peoples living on a rather narrow margin of subsistence — as was the case with the hunting and gathering aborigines of California. That is, "narrow" in a relative sense — the food potential was, to all appearances, well above that actually realized, but the habits of the Indians were generally

not conducive to storing foods for more than a few months in advance of what was needed from day to day. Consequently the greater portion of their time was spent in procuring food which was usually abundant enough in its many forms so that Kroeber could state, "Both formulated and experiential tradition are nearly silent on actual famines, or refer to them with rationalizing abstraction." Furthermore, the only known cases (to Kroeber) of famine aside from a few truly desert hordes, were among the agricultural Mohave living in an oasis, and the Indians of the lower Klamath who depended primarily on salmon (166).

In discussing the population of pre-conquest central Mexico, Cook emphasizes the importance of proteins by restating Linton's thesis, "... it is the protein level, not the total bulk or calorific level which limits the growth of populations" (167). Cook further points out the significant difference between vegetable protein with its high cost of utilization and lack of essential amino acids, as against animal protein, a relatively small quantity of which can, "so supplement the vegetable as to render the diet quite suitable for maintenance and even growth" (168). This contention can be illustrated by consulting tables of nutritional values of food, in which it can be seen that slightly larger than normal portions of various kinds of shellfish would satisfy the daily nutritional requirements of an average man (169). While it is not suggested that any Californian group subsisted exclusively on shellfish, reference to such tables indicates that it is well within the realm of possibility to do so, on a nutritional basis. Taking into account the known consumption of various plant foods it can be seen that those who gathered shellfish on the coast had a well rounded diet, even by the most rigid modern standards.

Because mussels were the most numerous shellfish eaten along most of the Californian coast, we might discuss their utilization at somewhat greater length. In Bradley's table (170), the mussels listed are probably the east coast mussel (Mytilus edulis, which is the same species as the west coast bay mussel). A portion consisting of a scant one-half cup of meat and liquor (or canned or cooked solids) is listed as weighing 100 grams. Since the east coast variety of Mytilus edulis is of a size comparable to the average of the west coast Mytilus californianus (171), which we can estimate to have a mean weight of about 4 grams for the meat, this would be equal to about 25 west coast sea mussels (172). According to Bradley, 100 grams of cooked mussel meat yields 18.2 gm. of protein. As a daily minimum protein requirement can be set at 30 grams (173) — or about twice that yielded by one portion of cooked mussels — only 50 sea mussels or 200 bay mussels (25 mussels per portion in the table) would be sufficient to fill the daily protein needs of a moderately active man. The food tables also indicate that much less than 100 grams of mussels would be required to supply vitamins B_1, B_2, and C if, by reasonable expectation, the vitamin content of mussels is similar to that of clams or oysters (174).

An estimate of the number of clams required to fill the daily protein

wants is somewhat difficult because of the variation in size among different species. Quite often the calculations of food values of clams have been made for such forms as the east coast round clam, Venus mercenaria or the long (soft shell) clam, Myarenaria (175). The former belongs to the same family as the west coast cockle or hard shell clam, Protothaca staminea, though somewhat larger, while the latter may average three to four inches in length or somewhat smaller than the west coast Saxidomus nuttallii. On the whole we might estimate the mean weight of clam meat consumed by the Indians as comparable to that of mussels, taking into consideration the large forms such as the Pismo, Gaper, and Washington clams, as well as the smaller forms such as the hard shell and the bent-nose clams (176).

The protein values given by Bradley for clams are slightly smaller than those given for mussels; therefore, the mean weights being of the same order, from one to several more clams than mussels per day (about 55), would be required to provide the 30 grams of protein needed.

Certainly the most valuable shellfish of all is the abalone. This was true generally of the shell as well as the meat (177). For cooked meat, the protein value of abalone is nearly ten per cent higher than that of its nearest rival, the mussel. Assuming the amino acids of abalone to be of the same nature as those given for clams and oysters, one large or several small abalones would be enough to maintain health and growth. Thus, one would expect that wherever abalone occurred in sufficient quantity it would be the main item in the shellfish diet (and probably in the total diet of the permanent coast dwellers). That this was the case at Monterey Bay and south is indicated by the predominance of abalone shells in many middens left by the former inhabitants (178).

Shellfish Poison

Paralytic shellfish poison (179) has been known on the West Coast approximately one hundred and sixty years. About 1790 Baranoff is said to have lost nearly one hundred of his Aleut hunters at once through poisoning by mussels at Peril Strait (180). Calvin, in analyzing historical data at Sitka found frequent references to mussel poison in translating the papers of Veniaminov and other early Russian explorers (181). Vancouver lost one man in this manner while others were severely affected (182).

When modern investigators turned to the problem brought to their attention by a severe outbreak in 1927, they found evidence that the phenomenon was not new, but rather, a more severe manifestation among human beings than had been formerly experienced. Various accounts of animal and human fatalities after eating shellfish previous to 1927 were brought together, and certain regularities among these accounts were found to fall into a pattern of symptoms we now know are characteristic of the poisoning (183).

In the past twenty-three years there has been no little concern by west coast inhabitants over the occurrence in shellfish of a most potent poison (184). This agent had caused 243 reported cases of human poisoning up to 1936 of which sixteen of the victims died (185).

Cognizance of the possible importance of shellfish poisoning to the Indians was taken in the first modern scientific report dealing with the problem (186). The importance of that reference is such that it is well worth quoting in full: "From time immemorial it has been the custom among coast tribes of Indians, particularly the Pomo, to place sentries on watch for Kal ko-o (mussel poison). Luminescence of the waves, which appeared rarely and then only during very hot weather, caused shellfishing to be forbidden for two days; those eating shellfish caught at such times suffered sickness and death (personal communication from Dr. John W. Hudson, Ukiah). According to a report, a band of Indians died about fifty years ago from eating mussels gathered on the Mendocino Coast during the month of August"(187). The first ethnographic report to contain information gathered from Indians on the subject was the Culture Element Distributions on the Pomo, published in 1937 (188). This was followed in 1939 with a paper on the Coast Yuki by Gifford, who reported not only the results of interrogation of informants, but also gave a summary of the latest scientific data on shellfish poison obtained directly from the late Dr. Herman Sommer, the foremost authority on the subject. In 1939 Driver's Culture Element Distribution list on Northwest California appeared with notes about the poison in that area. That inquiry into the problem had become somewhat standardized in the culture element checklists is evidenced in the two which were published in 1942 (189).

In order better to evaluate the ethnographic data regarding shellfish poisoning it might be well to inquire into the nature, distribution and possible antidotes to this lethal peril.

The toxic substance in shellfish has been identified as being closely associated with a species of marine plankton (dinoflagellata) Gonyaulax catenella, which the shellfish ingest as food (190). The nature of the association between this dinoflagellate and the poison it contains has not yet been entirely worked out. Apparently all organisms of the species contain the toxin, and when the species multiplies to a sufficient population in the water the concomitant amount ingested by plankton feeders grows (191). These latter animals are not in the slightest affected by the toxin, but apparently thrive on the increase of their food supply, store the poison in their livers, and excrete it slowly back into the water.

If the shellfish should be consumed by a warm-blooded animal before the poison has been excreted, symptoms of poisoning are liable to follow (192).

A concentration of Gonyaulax reaching approximately 1,000,000 per liter causes the surface of the water to assume a reddish brown coloration,

and "when the concentration reaches 20 to 40 million cells per liter, the ocean is a deep rust-red by day and brilliantly luminescent by night. High concentrations of certain non-poisonous marine plankton organisms may also appear as 'red water'" (193).

The toxin itself is described as " a highly poisonous amorphous product of basic nature"(194). Choline and trimethylamine are two of the known constituents, while a third has been isolated but not identified (195). About one millionth of a gram (i.e. one microgram) of the extracted poison is sufficient to kill a twenty gram mouse (196), while a few milligrams are fatal to man. In California a quarantine on shellfish is effected when a toxicity reaches two milligrams per 100 grams of whole shellfish meat (197). In Canada where paralytic shellfish poison has occurred on both the east and west coasts, the toxicity is measured in terms of "mouse units"(198). One mouse unit is defined as that amount of the pure poison which will kill a twenty gram mouse, (or about one microgram; cf. above). The quarantine level was set in 1944 at 400 mouse units per 100 grams of whole shellfish meat, this amount being comparable to the two mg. level set for California (199). That this quarantine level is perfectly safe is proven by the fact that it takes 2000 mouse units to produce symptoms of the poison in a human being, while 10,000 produce mild symptoms, an intake of 25,000 mouse units will cause severe paralytic indications in the victim (200).

Repeated observations as to the manifestation of shellfish poison in man and other mammals all concur in that the characteristic reaction is similar to that described by Kellaway (201). It reacts as, "a powerful neurotoxin with both central and peripheral actions. In sufficient dosage it paralyzes the respiratory center...The respiration rate is slowed but there are increased motor discharges from the center similar to those occurring in asphyxia, due partly to the fall of blood pressure caused by the poison and partly to its powerful cuarizing action...The poison paralyzes motor and sensory nerve endings and is active in very high dilutions. In stronger concentrations it abolishes conductivity in nerves" (202).

That the poison is most often concentrated in livers of shellfish has been repeatedly demonstrated (203), although some is found in organs in the viscera such as the gills (204). Most of the investigators have found that, "the muscular tissue (white meat) of the shellfish does not contain much poison" (205). One notable exception to this general case was found by a Canadian investigator who demonstrated that the poison was concentrated in the siphons of butter clams (Saxidomus, probably Saxidomus giganteus)(206).

When diligent research on the problem of shellfish poison got under way it was soon found that most of the species affected were to be found on the open coast and that clams and mussels in enclosed bays could be considered safe for human consumption. While this is generally true, species living in bays near the entrances are susceptible, for evidently

the Gonyaulax is carried in by the tidal currents. In Bodega Bay, for example, where some of the best clam beds are not far from the entrance, at least four species have been shown to contain the toxin, (i.e. Saxidomus nuttallii, Schizothaerus nuttallii, Protothaca staminea and Macoma, spp.) (207). There is only one case on record of an inner bay mollusk being affected by paralytic poison, viz., Modoilus demissus, an introduced form; a sample from near San Raphael in San Francisco Bay showed the toxin present in this mussel (208).

Open west coast mollusks other than Mytilus californianus that have been noted as containing the poison are the razor clam, Siliqua patula, the Pismo clam, Tivela stultorum, and a rock boring clam only occasionally used for food, Pholadidea penita (209). Species which have not been affected include the abalone, the west coast oyster, Ostrea lurida (as well as introduced species of oysters), the basket cockle, Clinocardium nuttallii, and the introduced soft shell clam Mya arenaria (210). It might also be added that, "clams become dangerous only when mussels reach exceptionally high toxicity" (211).

With the demonstrated virulence of paralytic shellfish poison in mind the question arises as to how the Californian Indians dealt with the danger. The fact that most of the people who subsisted largely on shellfish ate a preponderance of sea mussels must, somohow, be reconciled with the fact that this mollusk was also the most consistent carrier of the fatal toxin.

Although scientific knowledge of the phenomenon has been accumulated only recently, the occurrence of shellfish or mussel poisoning has long been known to the inhabitants of both the East and West coasts (212), and probably to the Indians of California.

The ethnographic information of Californian Indians with regard to the subject is quite meager and inadequate, although most coastal tribes are covered. In the north the Tolowa, Yurok, Wiyot, Chilula, Mattole, Sinkyone and Coast Yuki were found to admit knowledge of mussel poisoning (213). The Tolowa ate woodpecker tongues to cure it while the Wiyot supposed that long cooking would remove the poison which was never severe but usually left a rash. The latter also believed that mussels taken high up on rocks when the sun and moon shone were the only poisonous ones (214), and that mussels were not very good when there was "fire on the water," i.e., when it was luminescent (215).

Several interesting beliefs of the coastal Yurok regarding mussel poisoning were recently recorded. One informant said that mussel poisoning was thought to be a disease which comes toward the fall of the year when salal berries get ripe (216). When there was "lots of light" (luminescence) on the breakers, then they knew that mussels were bad. Clams and crabs were also regarded as unfit at such times. What is more, salal berries facing the ocean could not be eaten although those on the landward side of a hill away from the ocean were all right. If they heard about mussel poisoning but did not see any luminescence on the waves, they would test the mussels by rubbing the meat of fresh mussels on their hands.

If the hands grew numb, they knew that the poison was present (217).

Salal berries are featured in an account of mussel poisoning by another Coast Yurok informant. One time some people came to the mouth of the Klamath to gather mussels. This was when the salal berries were ripe. During the night one of the children got sick and died. The people knew that the death was caused by mussel poison for the water glowed at night (218).

In another story it was related that there had formerly been a belief that if a person died from mussel poisoning, mussels would grow from his mouth. However, the custom was to bury the dead on the day they succumbed so that this belief could not be verified. The informant's mother had seen only one person die of mussel poisoning, and had gone to the funeral of the deceased, at which she was able to get a view of the corpse. There were no mussels growing from the dead person's mouth, which fact was duly related to the rest of the people, thus exploding the myth (219).

The Mattole said that poisonous mussels occurred only in certain localities and never at the mouth of the Mattole River. One of the Sinkyone informants reiterated the opinion that mussels low on the rocks were not poisonous, and the Coast Yuki thought them toxic only in the month of August. Besides this latter view (220), the Coast Yuki also believed that the deeper occurring mussels which had to be dived for were safe, and people would never be poisoned by dried mussels (221). One informant told the ethnographer, "there was more poison in mussels formerly than today, and that Indians often died of mussel poisoning" (222). The basis for this statement was pointed by Gifford in his comment that probably the poison was more manifest formerly because of a greater per capita consumption of mussels then than there has been by recent inhabitants of the area.

Gifford and Kroeber found various Pomo informants differing on the question of knowledge of mussel poisoning (223). While four Northern Pomo informants affirmed such knowledge, one denied it. One of those answering affirmatively said, "When clouds turned red at sundown, ocean mussels were poisonous" (224). Stewart records that a Northern Pomo admitted knowledge of mussel poisoning but denied any deaths from it because the only mussels gathered were well washed by waves, and never exposed even at low tide (225). Of the Central Pomo, two informants knew of the phenomenon, but another did not (226). One of the former added that they were poisonous only when exposed to the sun, but those in a lower, shaded or underwater position at low tide were thought to be nonpoisonous (227). The Southwestern group of this people knew of its occurrence but the three eastern bands were not aware of the toxin (228). The latter peoples lived quite far from the ocean and undoubtedly visited the coast but infrequently. However, the Kato and Yuki, also inland groups, had knowledge of mussel poisoning (229).

Along the south central coast the only ethnographic information is the culture element list of Harrington which contains uniformly negative

replies about mussel poisoning and these only from one Salinan, and five Chumash informants out of a total of eighteen (230). While it is true that more of the recently recorded cases of this poisoning occurred on the central and northern California coasts, a few outbreaks have been noted as far south as Ventura County (231), so there is some reason to believe that the phenomenon must have visited the southern coast in aboriginal times a also.

One theme in particular seems to recur in the Indians' accounts of this poisoning, that is, even during times when mussels were known to contain poison, they were gathered from below the low tide mark by diving for them. While we must assume the veracity of the data, it is difficult to reconcile these accounts with the facts as brought out by modern scientific investigation. Sommer and Meyer (232) pointedly dispel some of the popular fictions regarding the toxin; in particular they state, "Temporary exposure to the sun does not harm living mussels nor does it make them poisonous," again, "Mussels below the tide line are, if anything, more poisonous than those above the water."

From these statements we can only conclude that there is no known means of gathering shellfish from Gonyaulax infested waters that will lessen the danger from the poison.

We have seen that in shellfish the toxic substance is concentrated in the digestive organs, especially the liver. If these organs are removed and only the muscular tissue consumed, chances are usually good that no ill effects will be suffered. But, there is no evidence whatsoever that the Indians separated the viscera from the muscle tissue in shellfish, for even modern Caucasians eat mussels and other shellfish whole. Although it is possible to destroy the poison by boiling it with an alkali (233), again there is no evidence that the Indians ever treated shellfish by such a process. Of course drying in no way affects the poison, and we have seen that the usual way of preparing fresh shellfish was probably by broiling them on an open fire or by simple stone boiling (234).

As for the possibility of an acquired immunity to shellfish poisoning, pharmacological evidence indicates that it is impossible for human beings to build up immunities to alkaloid poisons. Furthermore, in experiments performed in the course of analyzing paralytic shellfish poison, some animals were injected with non-fatal doses and recovered. They were again injected, but with fatal doses and showed all the symptoms which could be anticipated for animals not previously subjected to the toxin.

The observation that apparently coastal dwellers were less affected by toxic shellfish than were inland people who ate them less frequently was made by a pair of Canadian investigators. They suggested that the coastal people had built up immunities to the toxin, but such evidence was negated by their own data. Speaking of people of fishing communities on the east coast of Canada, Gibbard and Naubert (235) tell that inhabitants know from old traditions of the dangers of eating poisonous mussels and that they know the poison is confined to certain localities (geographically). "They have even acquired food habits that afford a certain degree

of protection. They will eat, for instance, only the adductor muscle of scallops, the rim being considered poisonous. Others eat the 'red roe' or 'coral' as the ovary is called, and regard all other parts of the rim as unfit for food. The allergic form of mussel poisoning has occasionally added confusion in identifying outbreaks...More frequent illness among human beings is apparently prevented by the food habits of the people in the fishing communities and their traditional knowledge of the dangers involved...It was also found that there were many who ate toxic shellfish without ill effects. These cases were of particular interest since they indicated a degree of human resistance to the poison (236). This was found especially among inhabitants of shore communities. Most of the sufferers were among nonresidents of these communities such as picnickers, for whom shellfish were not a habitual item of diet."

The conclusion reached by the authors seems unwarranted in the face of the evidence that the permanent coastal inhabitants knew how to eat dangerous shellfish, whereas inland, occasional shellfish eaters did not have this knowledge. The authors themselves have shown that by removing the viscera, practically all of the poison would be removed from the shellfish.

A similar situation is mentioned by Sommer and Meyer (237) which corroborates the point made here: "On the week-end of July 4, 1932 at Bodega Bay there were in the possession of various eating places in this neighborhood large quantities of strongly poisonous Washington clams, which were served to the week-end guests without ill effects. Poisoning occurred in two visitors from the interior valleys who dug and prepared their own clams and probably were not too familiar with the proper preparation of such sea food. The third victim was a local resident who ate three raw clams while digging."

The relationship of shellfish poisoning to the food habits of the Californian Indians can be summarized as follows: The seasonal gathering pattern of most of the inhabitants of the coast and hinterland brought them to the shore largely during the months of April through October. It was within this period that toxic shellfish were a serious threat, especially during mid-summer and early fall. Apparently some groups rightly correlated presence of the fatal toxin with luminescence of the water and refrained from eating shellfish at such times. However, it is equally apparent that, although they may have recognized the presence of the poison, a large number of Indians falsely believed that mussels gathered from below the low water mark were safe. This belief was bolstered by the fact that shellfish were safe most of the year. Gonyaulax multiplies to dangerous proportions only once each summer and then only for a short period in quite localized areas. During such occurrences, those Indians who did not refrain from eating shellfish must have succumbed from the effects of the toxin.

SUMMARY AND CONCLUSIONS

Ethnological and archaeological evidence indicate that all coastal Indians partook freely of shellfish, an abundant and easily gathered food. There were, however, differences in emphasis on shellfish by various groups up and down the coast. For some, such as the Coast Yuki, Bokeya Pomo (of Point Arena), Coast Miwok, and probably most of the Costanoans, this resource was a staple. Others, among whom were the Tolowa, Yurok, Wiyot, Mattole and the Chumash, ate large amounts of shellfish but did not depend on them to the extent that the above mentioned tribes did. These differing emphases have both cultural and ecological explanations. All of the latter groups had larger food resources open to them because they possessed sea-going canoes which enabled them to hunt sea mammals as well as to visit outlying rocks for mussels. In addition the Chumash in the south practiced marine fishing from their plank canoes.

On the northwestern coast the bulk of the population was concentrated along the excellent salmon streams including the Smith, Klamath, Mad, Eel, Bear and Mattole rivers. There were a few permanent villages scattered along the coast between the mouths of these rivers, and their inhabitants probably ate as much shellfish as other meat for their protein requirements. The Pomo speaking groups considered as a whole shared as wide a variety of ecological conditions as any other Californian people. Probably those along the Gualala and Russian rivers concentrated mostly on salmon. We have evidence that at the mouth of the Garcia River (near Point Arena), the Bokeya Pomo depended mostly upon shellfish, although salmon were taken when available.

Molluscan fauna in inland bodies of water was utilized to its fullest extent, but nowhere did this supply occur in the abundance nor assume the importance that it did on the coast.

Techniques utilized in gathering shellfish were not very involved. The tool most employed in gathering clams, mussels and abalones was essentially the digging stick, sometimes modified by flattening the end. Crabs and crayfish were, at some places, captured in basketry traps very similar to modern crab pots. Often many of the species of shellfish were taken by hand without the aid of implements.

Methods of preparation too were very simple. Much of the shellfish gathered was preserved for future use by drying, either precooked or raw. Dried shellfish meat was usually soaked in fresh water and boiled before being consumed. Raw shellfish were mostly broiled on an open fire. Stone boiling and baking in hot sand were also often resorted to. The earth oven was employed for preparing these animals to a significant extent in northwestern California.

Shellfish are so high in nutrient value that as few as fifty medium sized sea mussels would fill the daily protein requirements of a moderately active man. Somewhat larger quantities of clams or crabs would fill these needs.

Paralytic shellfish poisoning was most likely fatal to a good number of Indians who ate shellfish at the places and during the times that the toxin was present.

ENDNOTES

1. Gifford (1936).

2. See Rostlund (1952) for a study of primitive fishing in California.

3. The word "shellfish" is here used because some echinoderms and crustaceans are included as well as mollusks.

4. Following Ricketts and Calvin (1948).

5. See pages 82-84 for further discussion of size, numbers, and nutritional value.

6. A very similar species, Mytilus edulis, which has been used extensively along the Atlantic shore, as well as in sheltered bays on the Pacific coast, is discussed in Field (1924).

7. According to Bonnot (1948, p. 146), specimens of Haliotis rufescens sometimes attain a diameter of twelve inches.

8. Bonnot (1948, p. 143).

9. Keen (1937, p. 36).

10. Bonnot (1948, p. 143) discusses seven species as having commercial or sport value at the present time.

11. Fitch (1950, p. 286).

12. Fitch (1950, p. 290).

13. Ricketts and Calvin (1948, p. 38).

14. Ricketts and Calvin (1948, p. 38).

15. Ricketts and Calvin (1948, p. 62).

16. These two species can be reached at low tide. Cancer magister, the present-day market species, may have been taken occasionally, but rarely occurs in the inter-tidal zone.

17. After Keep and Baily (1947, pp. 66-71).

18. Such an occurrence has been recently noted in a cave in the Sierra Nevada foothills (Ama-3) by R. F. Heizer.

19. Stearns (1882, p. 3).

20. Gifford and Schenck (1926, p. 42).

21. One exception might be noted—since an archaeological site at Shelter Cove, Humboldt County, is reported to contain great quantities of land snails (Helminthoglypta arrosa). Personal communication from Allyn G. Smith.

22. Gifford (1939, pp. 329-330).

23. Gifford (1939, p. 326). See below for a discussion of the dietetic factors (pages 82-84).

24. Drucker (1937, p. 232).

25. Drucker (1937, p. 231) and Greengo (ms., p. 20).

26. That this was the case was stated to the writer by both a Wiyot and a Pomo informant (Greengo, ms., pp. 12, 10).

27. Gifford (1939, pp. 304-306). This pattern involved a notice of intention to visit, an acceptance of notice or invitation, and a reciprocal visit by the coastal people to the inland people.

28. Kniffen (1939, p. 365).

29. Pilling (1950, p. 438).

30. See page 67.

31. Californian groups on record as having taken sea urchins include: the Bear River people (Nomland, 1938, p. 113); the Coast Yuki (Gifford, 1939, p. 328);the Pomo (Loeb, 1926, p. 164; and Stewart, 1943, p. 60); and the Coast Miwok (Kelly, ms.).

32. Boas (1921, pp. 154, 488).

33. Drucker (1950, p. 204).

34. Driver (1936, p. 184).

35. See pages67.

36. Nomland (1935, p. 154).

37. Greengo (ms., p. 18).

38. See page 68.

39. Kelly (ms., T-2, 15b).

40. McGee (1898, p. 195).

41. Gifford (1939, p. 325).

42. Loeb (1926, p. 164) and Stewart (1943, p. 60).

43. Loeb (1926, p. 164).

44. Boas (1921, p. 505).

45. Boas (1921, p. 500).

46. Wilkes (1845, pp. 188-189).

47. Powers (1877, p. 233), Kroeber (1932, pp. 278-279), Du Bois (1935, p. 18).

48. Powers (1877, p. 233).

49. Loeb (1926, p. 164).

50. Driver (1936, p. 184); Barnett (1939, p. 234).

51. Keok, generic of digging stick; Kulule, a stick for this particular animal.

52. Kelly (ms., section 2:31).

53. Greengo (1951, Table I, p. 24).

54. Driver (1936, p. 184).

55. Kelly (ms., section 2:30).

56. Kelly (ms., sections 2:30, 2:31, and 5:42).

57. As above, and in section 2:31.

58. Kelly (ms., section 5:42).

59. Kelly (ms., T-2, 15b).

60. Kelly (ms., T-2, 15b).

61. Greengo (ms., pp. 11, 13).

62. The chisel-like implements made of whale ribs described from the Santa Barbara area may have been used to loosen abalones; see Abbot and Putnam (1879, p. 229) and Heye (1921, pp. 80-81).

63. Ricketts and Calvin (1948, p. 60).

64. Kelly (ms., section 2:32).

65. See above for mussel stick.

66. Kelly (ms., section 2:32).

67. Gifford (1939, pp. 337-338).

68. Boas (1921, p. 181).

69. Probably Katherina tunicata.

70. Boas (1921, p. 480).

71. Greengo (ms., pp. 15, 16).

72. Greengo (ms., p. 19).

73. Ray (1938, p. 112, figs. 13a,b).

74. Driver (1936, p. 184).

75. Drucker (1941, p. 171).

76. See p. 73.

77. McGee (1898, p. 195). According to this author, shellfish were estimated to comprise 10% of the total food supply.

78. McGee (1898, p. 195). By shell-cup, the author means any handy shell that was used as a scoop.

79. See p. 67.

80. Ricketts and Calvin (1948, p. 80ff.).

81. Nomland (1935, p. 154).

82. Gifford (1939, p. 325).

83. Driver (1936, p. 185).

84. Barnett (1937, p. 165).

85. See Loeffelholz (1893, pp. 137-138, 163) for a good description of Yurok spearing crabs.

86. Greengo (ms., p. 11).

87. Greengo (ms., p. 19).

88. Loeb (1926, p. 165).

89. Stewart (1943, p. 60).

90. This trait is mentioned for the Chimariko of northwestern California (Driver, 1939, p. 379).

91. Driver (1939, p. 379).

92. Ricketts and Calvin (1948, p. 107).

93. Driver (1939, pp. 313, 379).

94. These pots were also used for crayfish.

95. Greengo (ms., p. 20).

96. Greengo (ms., p. 13).

97. Greengo (ms., p. 10) and Stewart (1943, p. 60).

98. Ricketts and Calvin (1948, p. 240).

99. Jochelson (1925, p. 106). This author gives a good description of how the present day Aleuts gather and prepare echini (pp. 106-107).

100. See page 71, footnote 31.

101. Greengo (ms., p. 12).

102. Driver (1936, p. 184).

103. McGee (1898, p. 195).

104. Sample (1950), Pilling (1950, pp. 438-439), Greengo (ms., p. 18), and Gifford (1939, pp. 304-306).

105. Driver (1939, p. 375) and Greengo (ms., p. 18). A present day Hupa informant declared all food from the sea had to be eaten cooked, not raw. This is not to say, however, that fresh shellfish were not carried long distances inland. The Godard Mound (Nap-1), for example, is almost ten miles from the nearest mussel habitat, yet contains a considerable quantity of Mytilus shells; this is also true in the Pomo area—personal observation.

106. Greengo (ms., p. 19). Drucker (1937, p. 232) states that in the summer the Tolowa gathered shellfish and smelt and hunted sea lions along the beach, and cured these in the sun.

107. Greengo (ms., p. 15).

108. That mussels were the staple food of at least one historic Yurok village, Tsurai (Hum-169), is well documented in Campa (1952, p. 43), Shaler (1808, p. 69), and Loeffelholz (1893, pp. 138, 140, 162).

109. Greengo (ms., pp. 13, 15).

110. Greengo (ms., p. 12).

111. Nomland (1938, p. 113).

112. Of the Sinkyone, Nomland says that among other types of seafood, clams, mussels, and abalones were sun dried for the winter, but he does not elaborate on the process involved—Nomland (1935, p. 154).

113. Gifford (1939, p. 315).

114. Gifford (1939, p. 315). See also the discussion of shellfish poison.

115. This latter element is mentioned by Stewart (1943, p. 60).

116. Greengo (ms., p. 10).

117. Harrington (1942, p. 9).

118. Kroeber (1925, p. 467). This author states: "Mussels, whose shells constitute so large a proportion of the mounds of San Francisco Bay and the coast, are specifically mentioned as an important food of the Costanoans." Dodge (1914, p. 120) mentions, in connection with a shell mound near Santa Cruz containing mostly mussel shells, that, "Old timers tell me that the Indians used to come from the hills to this place, gather and cook shellfish, and throw the shells on the heap; at this time the mound was about 20 feet high."

119. Harrington (1942, p. 8).

120. Woodward (1930, p. 106).

121. Woodward (1930, p. 106).

122. For accounts relating to sea mammals and their importance, see Spott and Kroeber (1942) and Kroeber (1925, p. 84).

123. Spott and Kroeber (1942), Kroeber (1925, p. 84), and Greengo (ms., pp. 13-17).

124. Greengo (ms., p. 20). They are also said to have been stored in baskets between layers of dry grass.

125. Gifford (1939, p. 315).

126. Gifford (1939, p. 315).

127. See data for "Hunting" and Canalino periods in Rogers (1929).

128. Reid (1852, letter No. 5).

129. Roedel (1948, p. 41).

130. Greengo (ms., p. 11).

131. Gifford (1939, p. 327).

132. Clement W. Meighan (personal communication). This is at variance with what Gifford and Kroeber (1937, p. 178) found among the Central Pomo at Ukiah, who asserted that only seaweed and no mollusks were dried. See also Stewart (1943, p. 61) for Pomo drying of chitons.

133. Loeb (1926, p. 192).

136. Driver (1939, pp. 315, 381) and Drucker (1937, p. 234).

137. These were probably Gonidea angulata—Allyn C. Smith, marine biologist (personal communication).

138. Gibbs (1860, p. 158).

139. Du Bois (1935, p. 18).

140. Powers (1877, p. 235).

141. Powers (1877, p. 430).

142. Kniffen (1939, p. 365).

143. Latta (1949, p. 253).

144. See page 77 for a description of the process as applied to mussels, clams, and barnacles.

145. Greengo (ms., pp. 18, 19).

146. Greengo (ms., pp. 11, 18).

147. Greengo (ms., pp. 13, 17).

148. Greengo (ms., p. 18).

149. Gifford (1939, pp. 315, 325-328).

150. Nomland (1938, p. 113). Apparently they were usually stone-boiled.

151. Driver (1939, p. 315).

152. Loeb (1926, p. 192) and Chestnut (1900, p. 299). See also page 80.

153. Loeb (1926, p. 164).

154. Stewart (1943, p. 60).

155. While their effect on man is not known, these animals have one of the fastest enzymic actions on their food known in the animal world. Ricketts and Calvin (1948, pp. 30-31).

156. Gifford (1939, p. 328).

157. Greengo (ms., p. 13).

158. A description of a Coast Yurok earth oven may be found in Greengo (ms., p. 22).

159. The Yurok used it for sturgeon roe (Greengo, ms., p. 15).

160. Driver (1939, p. 315).

161. Driver (1939, p. 382).

162. Kniffen (1939, p. 387).

163. Harrington (1942, p. 9).

164. These are vegetable.

165. Cook (1947, p. 46). Linton (1940, p. 33) emphasizes proteins and fats.

166. Kroeber (1925, p. 324).

167. Cook (1947, p. 46).

168. Cook (1947, p. 46).

169. Bradley (1942, pp. 24, 25, 144-148, table 37) and Faust (1947).

170. Bradley (1942, pp. 24, 25, 144-148, table 37) and Faust (1947).

171. About $3\frac{1}{2}$ to 4 inches long, as illustrated by Bonnot (1940, p. 218, fig. 84), and as determined by measurement of specimens from middens by the author.

172. The mean weight of the meat of the west coast bay mussel, as determined by Cook (1946, p. 52), is 1.065 grams. The weight of the meat of the west coast sea mussel can conservatively be estimated to average 4 times that of the bay species.

173. Personal communication from S. F. Cook.

174. Vitamin A is most abundantly supplied by such sources as fish liver oils or fish roe.

175. See Taylor (1942) or Winton and Winton (1937) for example.

176. The bent-nose clam (Macoma nasuta) averages about 2 inches in length, and was the most important clam in San Francisco Bay shell mounds. See Greengo (1951).

177. Except, of course, during the late Central California Horizon, when the shell of Saxidomus was made into disc money.

178. Jones (ms.), Fisher (ms.), and Pilling (1950, p. 439). Also personal observation.

179. This is its present name. It is also often referred to as mussel poison because these animals carry it in the greatest quantities.

180. Gibbard and Naubert (1948, p. 550) cite the Washington Exploration Quarterly (18, p. 284). See also Hrdlicka (1944, pp. 84-85) for translation of account of Davydov of Aleuts dying from this cause.

181. Ricketts and Calvin (1948, p. 120).

182. Vancouver (1798, pp. 285-286).

183. After Meyer, et al (1928, p. 365 ff.).

184. Muller (1935, p. 88). Shellfish poison belongs to the class of alkaloids including strychnine, muscarine, and aconitine (Sommer and Meyer, 1941, p. 621; Fowler, 1943, p. 228), and according to Muller "it is considered the most potent chemical poison."

185. Sommer and Meyer (1937, p. 561).

186. Meyer, et al (1928, p. 368).

187. Meyer, et al (1928, p. 368).

188. Gifford and Kroeber (1937).

189. Essene (1942, p. 4) and Harrington (1942, p. 8).

190. "Paralytic shellfish poison was definitely demonstrated for the first time in plankton residues in July 1933" (Sommer, et al, 1937, p. 553).

191. There is a direct correlation between increased water temperature in the summer and high plankton count. For an excellent discussion of plankton, see Ricketts and Calvin (1948, pp. 255-268).

192. Fowler (1943, p. 228).

193. Riegel, et al (1949, p. 7).

194. Muller (1935, p. 88). Also see endnote 184.

195. Riegel, et al (1949, p. 11).

196. Sommer and Meyer (1941, p. 621).

197. Gibbard, et al (1944, p. 91).

198. The Canadian east coast poisonings have been traced to another species, i.e., Gonyaulax tamerensis (Gibbard and Naubert, 1948, p. 552).

199. Gibbard, et al (1944, p. 91).

200. Gibbard and Naubert (1948, p. 551).

201. Kellaway (1936).

202. Kellaway (1936). Other descriptions of effects of the poison may be found in Meyer, et al (1928), Meyer (1931), Prinsmetal, et al (1932), and Covell and Whedon (1937).

203. See page 85, and also Sommer and Meyer (1937, p. 574), Gibbard and Naubert (1948, p. 552).

204. Gibbard and Naubert (1948, p. 552).

205. Sommer and Meyer (1941, p. 621) and Gibbard and Naubert (1948, p. 552). The latter found that for scallops (probably Pecten irradians), "there was never any trace of poison indicated in the adductor muscle," the only part of that species commonly eaten.

206. Gibbard and Naubert (1948, p. 552) refer to Pugsley (Fish. Res. Bd. Can. Prog. Rep. Pacific Station, Vol. 40, pp. 11-13, 1939).

207. Sommer and Meyer (1937, p. 575) and Smith and Gordon (1948, p. 164).

208. Sommer and Meyer (1937, p. 575) and Smith and Gordon (1948, p. 164).

209. Sommer and Meyer (1937, p. 575) and Smith and Gordon (1948, p. 164).

210. Sommer and Meyer (1937, p. 575).

211. Sommer and Meyer (1937, p. 577).

212. Gibbard and Naubert (1948, p. 550), and page 84 above.

213. Driver (1939, p. 310).

214. Driver (1939, p. 310).

215. Greengo (ms., p. 12).

216. They ripen about the first of August.

217. This informant was born at ĕspĕw (Gold Bluff), and has lived between there and Stone Lagoon all her life. She and her husband were encamped at the bar across the mouth of Redwood Creek, drying surf-fish and consuming shellfish in what was apparently a survival of the old summer pattern. See Greengo (ms., p. 16).

218. Greengo (ms., p. 14).

219. Greengo (ms., p. 14).

220. Driver (1939, p. 376), corroborated by Gifford (1939, p. 326). See also page 85 for the Pomo traditions in this regard.

221. Gifford (1939, p. 315).

222. Gifford (1939, p. 315).

223. Gifford and Kroeber (1937, p. 136).

224. Gifford and Kroeber (1937, p. 178).

225. Stewart (1943, p. 60).

226. Gifford and Kroeber (1937, p. 178).

227. Gifford and Kroeber (1937, p. 178). A more recent Pomo informant knew of one man having died from the poison (Greengo, ms., p. 10).

228. Gifford and Kroeber (1937, p. 178).

229. Essene (1942, p. 4).

230. Harrington (1942, p. 8).

231. Sommer and Meyer (1937, pp. 560-561).

232. Sommer and Meyer (1941, p. 655).

233. Sommer and Meyer (1941, p. 621).

234. On pages 77-79 above.

235. Gibbard and Naubert (1948, pp. 550-552).

236. Underlining mine.

237. Sommer and Meyer (1947, pp. 574-575).

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