A New Late Pleistocene Fauna from Humboldt County, California

BY

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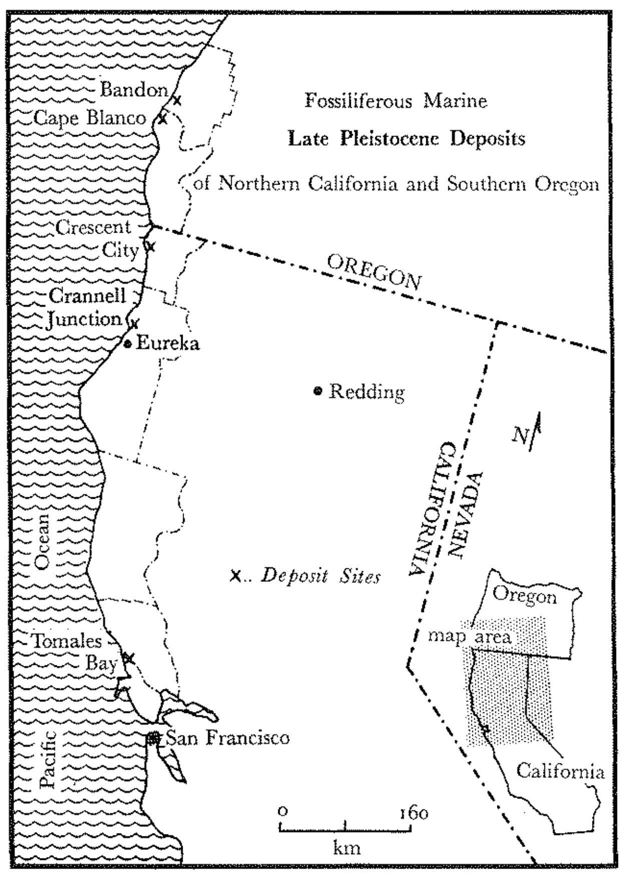
(2 Maps)

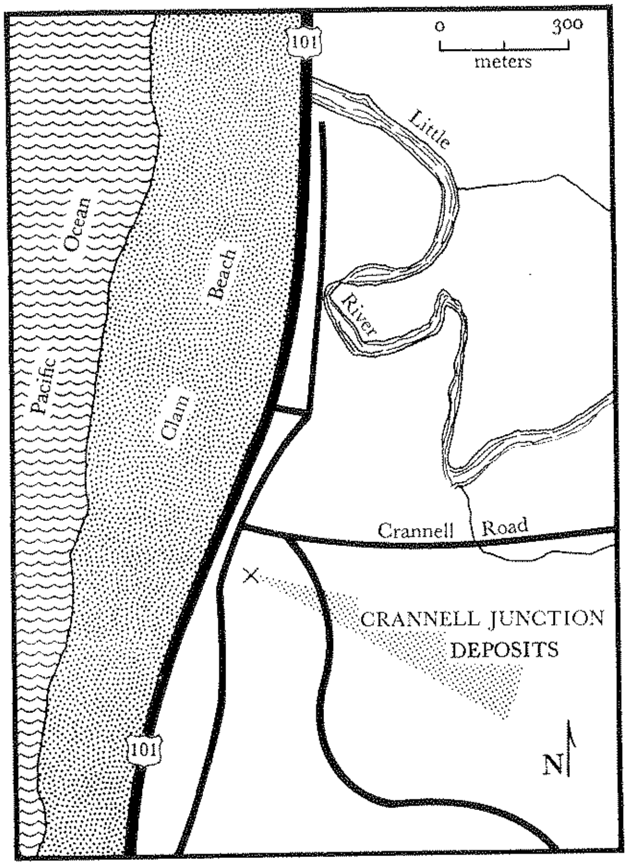
PREVIOUS INVESTIGATIONS

...SLY PUBLISHED STUDIES of the area in which the ...ell Junction deposit is located are few and none of ... refer to the abundantly fossiliferous strata described ... OGLE (1953) suggested that the high coastal ter... deposits which overlie the Crannell Junction deposit ... a northern extension of the Hookton Formation ... to late Pleistocene) exposed between Eureka and ... EVENSON (1958) traced the Carlotta Formation ... Pleistocene) of Ogle's Wildcat Group northward ... the Eel River Valley to the Mad River, about 6 km ... of Crannell Junction, by waterwell data. Evenson ... not trace the Carlotta Formation north of Mad ... however, he did recognize Ogle's Hookton Forma... there. Unconformably underlying the Hookton imme... north of the Mad River, Evenson recognized sedi... of marine origin as undifferentiated Wildcat Group ... based on molds and casts of *Clinocardium* and ...ma. This unit may be equivalent to the upper fos... ...ous clayey sands of the Crannel Junction deposit. ... Weed Sheet (State of California Division of Mines ... Geology, 1964) indicates that the Crannell Junction ... consists of undifferentiated Quaternary marine de... ... In this paper, the term Hookton Formation is re... ...ed for the non-fossiliferous, brown micaceous sands ...ing the Crannell Junction deposit.

FIELD TECHNIQUE

... present investigation is based upon systematic col... ...ng through some 24 m of section exposed at Crannel ...on. Collecting began in 1964 and continued through ... The fossiliferous, friable sands of the lowest 6 - 8 m were especially suitable for screening and were passed through a wide range of mesh openings, beginning with ½", ¼", 1/16" (12 mm, 6 mm, 1½ mm), followed by standard 16, 30, 60, 100, 120, 140, 200, and 400 meshes.





In the lower unit, the larger fossils are relatively fragile and in some cases could not be removed from the matrix without first being treated with a cementing agent made by dissolving strips of clear, flexible plastic in acetone. This yielded better results than Glyptal (General Electric Cement No. 1276) or shellac. In the usual circumstance, the fossilbearing layer was revealed by brushing an area of about a square meter. The individual specimens were then cleaned in place with brushes and probe, and allowed to dry for a short time. Before removal was attempted, the dissolved plastic solution was applied to each specimen in several coats by brush with a period of about 15 minutes interval between each coat to allow the cement to penetrate and thoroughly dry.

The clayey sands of the highest 18 m of exposed section were soaked in water and then passed through screens as in the lower unit. Specimens preserved in fossiliferous concretions were exposed by hammer and chisel method.

STRATIGRAPHY AND PALEONTOLOGY

Lower Unit

The lower unit consist of about 6 m of friable, [illegible] sorted, massive, lithic quartz sand and pebble gravels. The thickness of this unit is not known because the base is not exposed at Crannell Junction. Sand grains are generally of medium size and range from angular to subangular in shape. The gravels are concentrated in the lower [illegible] of this unit. They consist of well-rounded pebbles [illegible] chert, quartz, and sandstone in layers 2 - 25 cm in thickness and are interbedded with sand beds. The principal fossil bed occurs just above the uppermost gravel bed. The bed is about 15 cm in thickness and consists of densely packed fossils, the long axes of which are generally [illegible]ed parallel to bedding. Most of the fossils from the [illegible] unit are from this bed. Fossils also occur in the gravel-[illegible] interval below the principal fossil bed as well as [illegible] massive sand above it.

The fauna of the lower unit is composed principally [illegible] molluscan species, including 48 gastropods, 25 bivalves, 6 chitons, as well as 2 echinoderms and 7 arthropods. [illegible] represented are bryozoans, annelids, foraminifers, [illegible] plants, and vertebrates.

Particularly abundant molluscan forms are: *Clino-cardium aff. C. meekianum, Macoma nasuta, M. expansa, Siliqua patula, Tellina bodegensis, T. modesta, Amphissa versicolor, Cylichna attonsa, Epitonium indianorum, Man-gelia barbarensis, Mitrella gouldi, Nassarius fossatus, N. perpinguis, Olivella biplicata, O. pycna, Polinices lewisii, Thais lamellosa, T. lima*. Other abundant invertebrates are *Dendraster excentricus* and *Balanus hesperius laevidomus*.

The gastropods and bivalves are generally well-preserved and show little sign of abrasion. *Entodesma* [illegible] *Tellina bodegensis, T. modesta, Siliqua patula, Macoma nasuta, M. inquinata, M. expansa, Saxidomus nuttalli, Tresus capax*, and *Modiolus flabellatus* are often found articulated with ligament preserved. In contrast, valves of *Clinocardium aff. C. meekianum, Axinopsida serricata, Cryptomya californica, Mytilus edulis, Ostrea lurida, Psephidia lordi*, and *Tellina salmonea* are always disarticulated and *Tresus nuttallii* and *T. capax* generally are represented by fragments. *Hinnites multirugosus* and *Protothaca staminea* occur only as single immature valves while *Mytilus californianus* occurs as immature single valves or worn mature individuals.

Table 1

Late Pleistocene Fossils from the Crannell Junction Deposit, Humboldt County, California

	Lower Unit	Upper Unit	Millerton Fm. (Johnson, 1962)	Battery Fm. (Addicott, 1963)	Cape Blanco Fm. (Addicott, 1964)	Bandon Fm. (Zullo, 1969)
INVERTEBRATES						
MOLLUSCA						
Bivalvia						
…*californiensis* (Philippi, 1847)	R					
…*opsida serricata* (Carpenter, 1864)	F					
…*cardium* aff. *C. meekianum* (Gabb, 1866)	C	F				
…*omya californica* (Conrad, 1837)	F	N	X			
…*desma* sp.	F					
…*ites multirugosus* (Gale, 1928)	R					
…*ma expansa* Carpenter, 1864	N					
…*ma inquinata* (Deshayes, 1855)	N	F		X	X	X
…*ma nasuta* (Conrad, 1837)	C	C	X	X		
…*dus flabellatus* Gould, 1850	R					
…*us californianus* Conrad, 1837	F	F	X	X		
…*us edulis* Linnaeus, 1758	N		X			X
…*a lurida* (Carpenter, 1863)	N					X
…*desmus macroschisma* (Deshayes, 1839)	R					X
…*thaca staminea* (Conrad, 1837)	F		X	X		
…*ndia lordi* (Baird, 1863)	F				X	X
…*domus nuttalli* Conrad, 1837	R					
…*a patula* (Dixon, 1788)	C					
…*icarius* Gould, 1850		F				
…*a bodegensis* Hinds, 1845	C					
…*a modesta* Carpenter, 1864	C					
…*a salmonea* (Carpenter, 1864)	F					
…*lo* sp.		N				
…*s capax* (Gould, 1850)	F			X	X	X
…*s nuttallii* (Conrad, 1837)	R		X			
…*ia* sp.		F				
Gastropoda						
…*aea mitra* Rathke, 1833	R				X	
…*maea patina* Rathke, 1833	F					
…*cocina* sp.	R					
…*ohissa versicolor* Dall, 1871	C				X	
…*planes* aff. *A. perversa* (Gabb, 1865)	R					
…*um* sp.	R					
…*ium* cf. *B. strigillatum* Dall, 1891	R					
…*llostoma canaliculatum* (Lightfoot, 1786)	R					
…*lostoma ligatum* (Gould, 1849)	F				X	
…*atostoma foliatum* (Gmelin, 1791)	F					
…*sella digitalis* (Rathke, 1833)	F					X
…*ndula nummaria* Gould, 1846	F				X	X
…*hna attonsa* Carpenter, 1864	C	R				
…*iora aspera* (Rathke, 1833)	R				X	X
…*onum indianorum* (Carpenter, 1864)	C	F				
…*ton oregonense* (Redfield, 1848)	R				X	X
…*ana carinata* Gould, 1849	F					

…: R = less than 10; Few: F = 11-50; Numerous: N = 51-150; Common: C = more than 151 specimens.

Table 1 (Continued)

	Lower Unit	Upper Unit	Millerton Fm. (Johnson, 1962)	Battery Fm. (Addicott, 1963)	Cape Blanco Fm. (Addicott, 1964)	[illegible]
Littorina planaxis Philippi, 1847						
Mangelia barbarensis Oldroyd, 1924	F					
Mangelia sp.	C					
Margarites pupillus (Gould, 1841)	R					
Megasurcula carpenteriana (Gabb, 1865)	F				X	
Megatebennus bimaculatus (Dall, 1871)	R					
Mitrella gouldi (Carpenter, 1856)	R					
Moniliopsis incisa (Carpenter, 1864)	C					
Nassarius rhinetes Berry, 1953	F					
Nassarius fossatus (Gould, 1850)	F	R				
Nassarius mendicus (Gould, 1850)	C	C	X			
Nassarius perpinguis (Hinds, 1844)	F		X			
Neptunea aff. *N. phoeniceus* (Dall, 1891)	C					
Neptunea tabulata (Baird, 1863)	R					
Ocenebra interfossa Carpenter, 1864	F					
Ocenebra lurida (Middendorff, 1849)	F				X	
Odostomia sp.	F		X			
Olivella biplicata (Sowerby, 1825)	N					
Olivella pycna Berry, 1935	C	F	X			
Polinices draconis (Dall, 1903)	C					
Polinices lewisii (Gould, 1847)	N					
Rectiplanes thalea (Dall, 1902)	C	F				
Tegula brunnea (Philippi, 1848)	F					
Thais emarginata (Deshayes, 1839)	R					
Thais lamellosa (Gmelin, 1791)	F					
Thais lima (Gmelin, 1791)	C	C		X	X	X
Trophonopsis dalli (Kobelt, 1878)	C	F				
Trophonopsis fleenerensis Martin, 1914	F					
Turbonilla sp.	F					
Velutina sp.	F					
Amphineura						
Ischnochiton aff. *I. heathiana* (Berry, 1946)	R					
Mopalia ciliata (Sowerby, 1840)	N					X
Mopalia lignosa (Gould, 1846)	F					
Mopalia muscosa (Gould, 1846)	R					
Placiphorella sp.	R					
Tonicella lineata (Wood, 1815)	R					X
ECHINOIDEA						
Dendraster excentricus (Eschscholtz, 1831)	C					X
Stronglyocentrotus sp.	F					
ARTHROPODA						
Cancer magister Dana, 1852 (carapaces)	R					
Cancer magister Dana, 1852 (chela)	N					
Cancer sp. (appendages)		N				
Pugettia sp. (appendages)	R					
Mantis shrimp (appendages)	F					
Indeterminate chela	N					
Balanus nubilis Darwin, 1854	F	F		X		X
Balanus hesperius laevidomus (Pilsbry, 1916)	C	F				

Table 1 (Continued)

	Lower Unit	Upper Unit	Millerton Fm. (Johnson, 1962)	Battery Fm. (Addicott, 1963)	Cape Blanco Fm. (Addicott, 1964)	Bandon Fm. (Zullo, 1969)
Coronula diadema (Linnaeus, 1754)	R					
Mitella polymerus (Sowerby, 1833)						
BRYOZOA						
Bryozoan (colonial bulbous form)	R	R				?
Bryozoan (encrusting form)	R					
ANNELIDA						
Calcareous worm tubes	F					
Calcareous worm tubes (smaller colonial var.)	F					
PROTOZOA						
Eponides frigidus (Cushman, 1931)	F					
Nonion basispinata (Cushman, 1939)	R				X	
PORIFERA						
Sponge spicules		R				
VERTEBRATES						
PISCES						
Otoliths (Fitch, 1970)	C				X	
Teeth	C					
Vertebrae	C	F				
Misc. unidentified fragments	C	F				
MAMMALIA						
Enhydra macrodonta (Kilmer, 1973) (jaw)		R				
Enhydra sp. (milktooth and post cranial el.)	R					
Eumetopias jubata (Schreber, 1776) (premolar)	R					
Antilocaprid cf. *Capromeryx* (distal phalanx)	R					
AVES						
Gavia immer (pedal phalanx)	R					
Podiceps grisegena (distal end of humerus)	R					
Anas crecca (distal humerus and 2 humeri)	R					
Bucephala clangula (partial right caracoid)	R					
Clangula albeola or *Histrionicus histrionicus* (humerus frag.)	R					
Mancalla diegense (complete humerus)	R					
Melanitta perspicillata (carpometacarpus)	R					
Chendytes (?)	R					
Phalacrocorax (humerus frag.)	R					
Synthliboramphus cf. *S. antiquus* (carpometacarpus)	R					
PLANTS						
PLANTAE						
Alnus sp.	F					
Angiosperm not *Alnus* sp.	R					
Carbonized cones		F				
Unidentified Gymnosperm sp.	R					
Carbonized wood		C				
Silicified wood	R					

Gastropods generally occur as complete well-preserved shells. *Thais emarginata* and *Olivella pycna* have retained some original coloration and design. A few gastropods, however, are often abraded or broken. These include: *Collisella digitalis, Acmaea patina, Ceratostoma foliatum, Fusitriton oregonense, Neptunea tabulata, Rectiplanes thalaea, Thais emarginata, Megasurcula carpenteriana,* and *Buccinum* cf. *B. strigillatum. Antiplanes aff. A. perversa,* and *Neptunaea aff. N. phoeniceus* are represented by single fragmentary elements.

Clinocardium aff. C. meekianum, while larger in overall size, closely resembles *C. meekianum,* an extinct cockle from the Scotia Bluffs (Pliocene) and Rio Dell (Pliocene) formations of the Eel River Valley and is closely related to it. It differs significantly from the Recent *C. nuttallii* in (1) possessing significantly fewer ribs; (2) having stronger lateral and cardinal teeth, and larger sockets; (3) possessing a more anteriorly-directed beak, and (4) having an umbo which rises significantly higher above the hinge plate.

The following bivalves frequently show funnel-shaped holes, evidently drilled by predaceous gastropods, near their umbo: *Cryptomya californica, Macoma nasuta, M. expansa, M. inquinata, Ostrea lurida, Tellina bodegensis,* and *T. modesta.* Many of the gastropod tests have also been drilled, especially *Nassarius fossatus, N. perpinguis, N. rhinetes, Polinices lewisii,* and *P. draconis.*

The occurrence of *Megasurcula carpenteriana* and *Nassarius rhinetes* merits special comment. The record of *M. carpenteriana* is a significant northward extension of its late Pleistocene distribution. Previously, the northernmost known late Pleistocene occurrence of *M. carpenteriana* was in the Cayucos Formation, San Luis Obispo County (Valentine, 1958). The species previously was believed to live off the California coast between (Tomales) Bodega Bay and San Diego at depths ranging from 15 to 91m (Burch, 1945). Recently, however, *M. carpenteriana* has been found off the Humboldt County coast in the following circumstances: (1) one dead specimen at 640m (CSUH Paleo. Coll. No. 715), and (2) one live juvenile and one dead adult in 183m (Robert Talmadge, personal communication, 1971). *Nassarius rhinetes* has previously been known only from Recent collections, ranging from Squaw Creek, Oregon, to Magdalena Bay, Baja California, Mexico (Addicott, 1965).

Chitons are represented by single plates, most of which show some wear on the edges. *Mopalia ciliata* is by far the most abundant of the chitons. *Tonicella* sp., although worn, has retained its characteristic color pattern. Plates resembling *Ischnochiton* sp. and *Placiphorella* sp. were also found.

Two echinoderms, *Dendraster excentricus* and *Strongylocentrotus* sp., occur in the lower unit. *Dendraster excentricus* is represented by large, well-preserved, complete tests generally lacking spines. The spines are found in abundance in the surrounding sediment, and 2 specimens were found with spines intact. Specimens range from immature individuals 2 - 3mm in diameter to mature individuals attaining a diameter of more than 130mm. *Strongylocentrotus* sp. is represented by worn plates and spines.

The crab *Cancer magister* is represented by 2 complete immature carapaces and a fragment of the carapace of a mature individual. Numerous chelae resembling those of *C. magister* and *Pugettia* occur in this unit. Several crustacean appendages were identified as belonging to a type of Mantis shrimp (John E. Fitch, personal communication, 1970).

Balanus hesperius laevidomus is the most abundant barnacle. It is often found attached near the apex of several of the gastropod species. Encrusting masses of what appear to be this species are also found on some gastropods. *Balanus nubilis* is represented by juvenile and mature individuals attaining as much as 10cm in height. *Coronula diadema* is represented by a single well-preserved rostrum. The gooseneck barnacle *Mitella polymerus* occurs as isolated, worn, opercular plates. No barnacles were found attached to any part of bivalve tests.

An encrusting bryozoan was recognized in a valve of *Macoma nasuta* (Lloyd Barker, personal communication, 1970). Another bryozoan, a worn bulbous form, was also found.

Isolated sections of single calcareous tubes about 5mm in diameter and about 25mm long were found along with a few isolated colonial worm tubes of which the latter revealed worn surfaces. These probably belong to the family Serpulidae.

Protozoans are rare in this unit. Mr. David Parker, formerly at California State University, Humboldt, collected a few poorly preserved foraminifers. These were identified as *Eponides frigidus* and *Nonion basispinata* (Dr. Frank Kilmer, personal communication, 1973).

Fish otoliths, teeth, vertebrae, and bone fragments are abundant in this unit. Fitch (1970) identified 42 species of fish based upon otoliths from the Crannell Junction deposit. The most abundant in the lower unit are Pacific Tomcod, night smelt, shiner perch, English sole, scaly-fin sole, and Pacific staghorn sculpin. Most of the teeth belong to the skate *Raja* sp. Others appear to be those of lingcod and soupfin shark (Fitch, *op. cit.*) Twelve of the 42 species of fish recorded from this site are first occurrences as fossils.

Mammalian remains from the lower unit include a milktooth and various post-cranial elements of the sea otter, *Enhydra* sp., a single premolar inseparable from the sea lion, *Eumetopias jubata,* and a bone believed to be a distal phalanx of the antilocaprid *Capromeryx* sp. (C. A. Repenning, *in litt.*, 1970 and 1971).

Aquatic birds tentatively identified by Hildegarde Howard (written communications, 1969 and 1973) include common loon (*Gavia immer*), grebe (*Podiceps grisegena*), green-winged teal (*Anas crecca*), golden-eye duck (*Bucephala clangula*), bufflehead (*Clangula albeola*) or harlequin duck (*Histrionicus histrionicus*), surf scoter (*Melanitta perspicillata*), cormorant (*Phalacrocorax*), and murrelet (*Synthliboramphus* cf. *S. antiquus*). A well-preserved humerus of the flightless auk, *Mancalla diegense* Miller, was identified by H. HOWARD (1970). The unusually good preservation of this specimen suggests that it has not been reworked from older sediments and may represent the first Late Pleistocene occurrence of *M. diegense.* Two other vertebrae may belong to the extinct "diving goose," *Chendytes* (H. Howard, *in litt.*, 1969). All of the other avians recorded are presently living in the Humboldt area.

Scattered small, discoidal, clayey nodules 3 - 8 cm in diameter in the upper part of the lower unit contain poorly-preserved leaf imprints of *Alnus* sp. and an unidentified angiosperm. In the gravels of the lower part of the unit, silicified wood was found as well-rounded pebbles and cobbles.

Upper Unit

The contact between the upper and lower unit appears to be gradational. It is best exposed about 1 m above the base of the excavated slope where unconsolidated sediments of the lower unit tend to erode faster than the more consolidated upper unit, forming a steeper slope at this point. The upper unit is approximately 18 m thick and is composed of massive, gray, fine to medium grained quartz and with clay in sufficient quantities to make the sediment more consolidated than the lower unit. It contains a molluscan fauna of 16 species, evenly divided between gastropods and bivalves. Also represented are arthropods, annelids, sponges, bryozoans, vertebrates, and land plants.

Two fossiliferous intervals, each approximately 46 cm in thickness occur 3 m and 9 m above the base of the unit. These intervals tend to contain less clayey material than the surrounding sediments. Bivalves are abundant in these intervals and occur as disarticulated, well-preserved valves while gastropods are few, but also well-preserved. The long axis of the fossils tends to be parallel to the bedding. Fossils in the alternating massive units are scattered and less abundant. Concretions often contain crab appendages or mollusks.

Macoma nasuta, Cryptomya californica, Thais lamellosa and *Nassarius fossatus* are the most abundant mollusks. In general, bivalves are much more abundant than gastropods. In the massive parts of the upper unit, most of the bivalves are articulated, often with the ligament intact. In both the more fossiliferous and massive sections, some of the *N. fossatus, T. lamellosa,* and many of the bivalves have holes drilled into their test. Two bivalves, *Yoldia* sp. and *Solen sicarius,* found in this unit, do not occur in the lower unit. Specimens of *Mytilus californianus* are almost always articulated with ligament intact.

Crustacean appendages of *Cancer* sp. occur in concretions, although no carapaces were found. Barnacles are represented by *Balanus nubilis* and a more abundant, smaller balanid that may completely encrust tests of *Polinices lewisii, Nassarius fossatus* and *Thais lamellosa.*

A few colonial worm tubes and a bulbous form of colonial bryozoan were found in the concretions. Sponge spicules occur in the soft, clayey sand, but are not abundant.

Fish are represented by vertebrae and other skeletal elements, but no otoliths were recovered.

The left and right rami of a new species of sea otter, *Enhydra macrodonta,* were found in this unit (KILMER, 1973).

Plant material includes abundant carbonized wood fragments, some of which range from 30 to 90 cm in length. Most show signs of abrasion. Several large limbs, honeycombed by *Teredo* borings, were found in the lower part of this unit. Carbonized cones of *Alnus* sp. (?) are scattered throughout the unit.

DEPOSITIONAL SITE

Lower Unit

The present configuration of bedrock exposures (Franciscan Formation) along the Humboldt County coast suggests that the Crannell Junction deposit was laid down at the north end of a long, shallowly-indented, exposed bay which was partially protected by a reef or rocky headland to the north. It seems likely that the molluscan assemblage originally lived within or adjacent to the bay. The general lack of abrasion exhibited by most of the fossils suggests that they were transported relatively short distances to the site of deposition.

The occurrence of abundant, mature specimens of *Dendraster excentricus* and articulated *Siliqua patula* suggests that at least a portion of the bay was a broad, sandy, exposed coast with a fairly heavy surf. Epifaunal mollusks including *Calliostoma ligatum, Ceratostoma foliatum, Thais lamellosa, Mytilus californianus, M. edulis, Ostrea* *lurida,* etc. probably lived in the intertidal and subtidal zones of the rocky reef or headland to the north. The majority of the mollusks, including *Macoma nasuta, M. expansa, Clinocardium aff. C. meekianum, Psephidia lordi, Tresus capax, T. nuttallii, Tellina bodegensis, T. modesta, T. salmonea, Nassarius fossatus, N. rhinetes, N. perpinguis, Olivella biplicata, O. pycna, Polinices lewisii, P. draconis,* etc., probably lived on or beneath the sand or mud of the bay at depths ranging from intertidal to perhaps as deep as 50m.

All molluscan species except *Clinocardium aff. C. meekianum* in the lower unit have Recent ranges that include the Humboldt County area. A plotting of the midpoints of the geographical ranges of 61 molluscan species in the lower unit for which reasonably good ranges could be attained indicates a midpoint at the present latitude of Eureka (41° N). This would indicate that the temperature range may not have been greatly different from that found along the coast of northern California today.

The coarse, pebbly sand associated with the fauna of the lower unit suggests a near-shore depositional site with considerable turbulence. The abundance of articulated bivalves such as *Siliqua patula, Macoma nasuta, M. expansa,* and *Tellina bodegensis,* and complete tests of both immature and mature *Dendraster excentricus* suggests that the depositional site was not greatly distant from the optimum living sites of these species. *Dendraster excentricus,* which is presently living offshore of the Samoa area of Humboldt Bay (16km south of Crannell Junction), is abundant at 15m and is rarely found deeper than 27m (Dr. J. DeMartini, personal communication, 1971). Analysis of the mid-points of depth ranges of 37 molluscan species for which reasonably good depth data could be obtained indicates a median depth of 29m. This depth estimate excludes species restricted to the intertidal zone (*Collisella digitalis, Acmaea patina, Tegula brunnea,* and the chitons) and those species with a very broad depth range (*Epitonium indianorum, Neptunea tabulata,* and *Polinices draconis*) as well as those species with incomplete depth data. This depth estimate is in general agreement with the fish habitat interpreted by Fitch (1970), who concluded that of the 27 species of teleost fish found in the lower unit, 25 could be taken at depths of less than 37m. A depositional site of 29m or less appears consistent with the invertebrate and vertebrate, as well as lithologic evidence indicated above. The gastropods *Trophonopsis dalli, T. fleenerensis, Megasurcula carpenteriana,* and *Buccinum* cf. *B. strigillatum* are suggestive, however, of greater living depths than the bulk of the fossils indicated above. All of these species are presently known to be living off the Humboldt County coast and have been collected at the following depths: (1) *Trophonopsis dalli* – 2 dead specimens at 293m (CSUH 1104), 1 specimen at 365m (CSUH 766), and 1 at 549m (R. Talmadge, personal communication, 1970); (2) *Trophonopsis fleenerensis* – 7 live specimens at 183m (CSUH 779), 2 live specimens from 329m (CSUH 1155), 1 live specimen at 366m (CSUH 717); (3) *Megasurcula carpenteriana* – 1 dead specimen at 549m (CSUH 715), 1 live juvenile and 1 dead adult in 183m (R. Talmadge, personal communication, 1971); (4) *Buccinum* cf. *B. strigillatum* – abundant from 150 to 732m (CSUH 715, 716, 764, 781, and 888). The apparent discrepancy between the interpreted depositional site (29m or less) for the bulk of the lower unit fauna and the known living depths for these 4 species may be explained by one or more of the following: (1) incomplete data of the depth distribution of living species; (2) inshore transport of dead shells by currents or by hermit crabs or by both; and (3) evolutionary changes in these 4 species requiring them to live in deeper (cooler) waters now than in the Late Pleistocene.

Upper Unit

The abundance of articulated shallow-water bivalves, including *Macoma nasuta, Cryptomya californica, Mytilus californianus, Solen sicarius,* and *Yoldia* sp. associated with clayey, fine-grained sand and abundant fragments of carbonized wood suggests that a shallow, semi-protected bay replaced the more exposed bay environment of the lower unit. A slowly developing offshore bar well to the west of the Crannell Junction deposit might have produced such a gradual change in the depositional environment. The two thin beds of concentrated shells in this unit suggest that some transport occurred along the bay floor. In the intervening massive clayey sand intervals, however, paired valves of *Macoma nasuta* occur in living position, suggesting that these fossils have been preserved in place. *Thais lamellosa, T. lima,* and *Mytilus californianus* indicate a rocky substrate nearby. The remains of *Enhydra macrodonta* suggest that a population of sea otters lived nearby, possibly outside the bay along a kelp-lined rocky coast. Analysis of the depth ranges of 12 molluscan species in this unit suggests a median of 26m, although it seems possible that the assemblage from this unit may have lived at a somewhat shallower depth.

AGE AND CORRELATION

The faunas of the upper and lower units of the Crannell Junction deposit are treated as a single unit in this section. This seems appropriate because there is no evidence of significant evolutionary change in the fauna as a whole.

A youthful age for the deposit is suggested by the following evidence: (1) no extinct molluscan species have been recognized (except possibly *Clinocardium aff. C. meekianum*); (2) the presence of a single premolar inseparable from the sea lion, *Eumetopias jubata,* suggests an age no older than Rancholabrean; (3) the fauna as a whole is excellently preserved to the point of retention of original coloration and markings; (4) the lithology consists of semi-consolidated to unconsolidated sediments; (5) the bedding is nearly horizontal.

Another paleontologic approach to the age of the Crannell Junction fauna may lie in correlation of the fish remains (otoliths). FITCH (1970) reports that 14 species of fish recognized in the fauna are also found in the Palos Verdes sand which is of Late Pleistocene age and suggested that the Crannell Junction deposit was a northern equivalent to that deposit.

In conclusion, the Crannell Junction fauna appears to be very young geologically. Although here considered of Late Pleistocene (Rancholabrean) age, the Crannell Junction fauna may not be precisely the same age as the Late Pleistocene faunas of Bandon (ZULLO, 1969), Cape Blanco, Oregon (ADDICOTT, 1964), Battery Formation at Crescent City (ADDICOTT, 1963) and the Millerton Formation of Tomales Bay, California (JOHNSON, 1962) because: (1) the species in common have relatively long geologic ranges; (2) the composition of the molluscan fauna from the other deposits differs on a gross basis from that of the Crannell Junction deposit, because of different environmental histories; and (3) variable states of preservation and collection techniques are involved with each deposit.

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Literature Cited

ADDICOTT, WARREN OLIVER
1963. Interpretation of the invertebrate fauna from the upper Pleistocene Battery Point Formation near Crescent City, California. California Acad. Sci., Proc., (4) **31**: 341 - 347
1964. A late Pleistocene invertebrate fauna from southwestern Oregon. Journal of Paleontology, **38**: 650 - 661, text figs. 1 - 3, plts. 107 - 108
1965. Some Western American Gastropods of the Genus *Nassarius.* United States Geological Survey, Prof. Pap. **503-B**: 1 - 23

BURCH, JOHN QUINCY, Ed.
1942 - 1946. Distributional list of the West American marine mollusks from San Diego to the Polar Sea. Conch. Club So. Calif., minutes; 2 parts; pag. by issue; 3 plts.

EVENSON, ROBERT EDWARD
1959. Geology and ground water features of the Eureka area, Humboldt County, California. U. S. Geol. Surv. Water Supply Paper **1470**: 1 - 79

FITCH, JOHN E.
1970. Fish remains, mostly otoliths and teeth from the Palos Verdes Sand (Late Pleistocene) of California. Los Angeles Co. Mus., Contrib. in Sci. no. **199**: 1 - 41

HOWARD, HILDEGARDE
1970. A review of the extinct avian genus *Mancalla.* Los Angeles Co. Mus., Contrib. in Sci. no. **203**: 1 - 12

JOHNSON, RALPH GORDON
1962. Mode of formation of marine fossil assemblages of the Pleistocene Millerton Formation of California. Geol. Soc. America, Bull. **73**: 113 to 130; fig. 1

KEEN, A. MYRA
1937. An abridged checklist and bibliography of west North American marine mollusca. Stanford Univ. Press, Stanford, Calif. 87 pp.; 3 text figs. (29 September 1937)

KILMER, FRANK H.
1972. A new species of sea otter from the Late Pleistocene of Northwestern California. South. Calif. Acad. Sci. **A71** (3): 150 - 157

OGLE, BURDETTE A.
1953. Geology of the Eel River Valley area, Humboldt County, California. Calif. Div. Mines Bull. **164**: 1 - 128; 6 plts; 14 figs.

VALENTINE, JAMES WILLIAM
1958. Late Pleistocene megafauna of Cayucos, California, and its zoogeographic significance. Journ. Paleo. **32** (4): 687 - 696; 2 text figs. (22 July 1958)

ZULLO, VICTOR AUGUST
1969. A late Pleistocene marine invertebrate fauna from Bandon, Oregon. Proc. Calif. Acad. Sci. 4th ser., **36** (12): 347 - 361; 39 figs.