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LA JOLLA
NATURAL RADIOCARBON MEASUREMENTS IV*

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INTRODUCTION

During 1963 and 1964 the La Jolla Radiocarbon Laboratory continued to follow essentially the same techniques as in previous years. The three counters described in La Jolla III have continued to yield measurements in virtually complete agreement. As before, we add, except for the measurements of apparent age on organisms collected alive (see below), ca. 100 yr to the one-sigma statistical counting error. Dates are still computed on the basis of the half-life estimate of 5570 yr.

In this list 191 measurements are discussed. These cover all analyses from LJ-565 to 993, inclusive, except as indicated below:

(1) Additional measurements, numbering 156 (LJ-704-729, 731-737, 741-752, 754-778, 780-816, 819-864, 866, 867, and 870), have dealt with secular changes in the concentration of atmospheric radiocarbon, as determined by measurements of annual rings of modern wood, such as were reported by Suess (1955, 1961) and by Bien and Suess (1959). These will be reported elsewhere.

(2) Measurements LJ-650, 657, 659-700, and 876-883, totalling 58, also not included herein, and also to be reported elsewhere, continue those reported by Bien, Rakestraw, and Suess (1960, 1963) on the age of sea water. Additional measurements in this series are continuing.

(3) Four measurements (LJ-203, 738, 740, and 875) on the radiocarbon activity of dissolved CO_2 in thermal waters, also not treated herein, were run for Harmon Craig, in continuation of series LJ-246-252, reported in La Jolla II. Again, the activity is minimal.

(4) Background and instrumental checks were run 14 times (LJ-614, 646, 702, 730, 865, 868, 869, 871, 874, 891, 898, 921, 940, and 941) on oxalic acid, coal, and lampblack, and thrice on material previously run: LJ-739 and 872 confirmed the essentially "dead" nature of the tar of the LaBrea tar pits, as previously indicated (LJ-89, >28,000, La Jolla I); LJ-873 similarly confirmed the essentially "dead" character of shredded wood from the basin of Lake LeConte (cf. LJ-532, >45,000, La Jolla III).

The headings adopted in this report, with further, geographic subdivisions, are as follows:

I. Apparent age of organisms taken alive
II. Sealevel changes and shore processes
III. Deep-sea sediments
IV. Ancient and modern lakes
V. Pedogenesis and alluviation
VI. Geochemical processes

* Contributions from the Scripps Institution of Oceanography, University of California, San Diego.

VII. Paleozoogeography
VIII. Archaeology

This classification of the measurements does not adequately indicate the multiple bearings of many tests—a defect that is partly obviated by cross references under the headings and by the following references under subjects not included in the main categories.

Submarine erosion and submarine canyons—LJ-607 (entered under II B) and LJ-920 (II C).

Uplift and downwarping in Colorado River delta region—LJ-928, 954, and 959 (IV C).

Effects of 1964 and earlier Alaskan earthquakes on coastal forests and land movements—LJ-939-945 (II A).

Paleoclimatology (measurements bearing more or less definitely on past changes of rainfall and/or temperature, and on persistence of faunas)—Most tests under III, IV, and VIII.

Palynologic record, Northern Ireland—LJ-647 (VII A), and LJ-903-908 (II F).

Antiquity of certain Mexican and African fresh waters notable for richness of fauna and high incidence of endemism—LJ-565 and 566 (II C), LJ-884-886 (IV A), and LJ-992 (IV B).

Habitation by early man of shorelines of ancient lakes—LJ-895, 902, 929-935, 958, 960, 965, and 977 (IV D), and LJ-992 (IV B).

Long continued habitation or visitation by man of favorable locations—For coastal sites of southern California and Baja California (VIII B and VIIII C): LJ-592, 593, and 600 (cf. LJ-210, 211, and 336, La Jolla II); LJ-594 (cf. LJ-382, La Jolla II, and LJ-448, La Jolla III); LJ- 595, 926, and 927 (cf. LJ-453 and 454, La Jolla III); LJ-909, 914, and 915 (cf. LJ-136, La Jolla I, and LJ-202, La Jolla II); LJ-912, 918, and 919 (cf. LJ-31, 35, and 36, La Jolla I, and LJ-242, 243, 256, 333, and 381, La Jolla II); LJ-922-925 (cf. W-26 and 27, USGS I, LJ-5, La Jolla I, and LJ-216 and 231, La Jolla II); LJ-961, 966, and 967 (cf. LJ-335, La Jolla II). For ancient lakes of southern California (IV D): LJ-895 and 958 (cf. LJ-269, La Jolla II, and UCLA-121, UCLA I); LJ-928 (and 20 other measurements of less than 10,000 yr therein listed).

The operation of the La Jolla Radiocarbon Laboratory continues under support from the National Science Foundation. Additional support has again come from the California State Water Resources Board. Both agencies have also provided research grants to the senior author, for studies that involve the Radiocarbon Laboratory.

Technical assistance in the operation of the Laboratory has been furnished by Sylvia F. Chillcott and others, and the electronics have been maintained by Everett R. Hernandez. The senior author's staff has included Laura C. Hubbs, Charmion McMillan, Jacquelin N. Miller, Betty N. Shor, and Priscilla A. Sloan.

Unless otherwise noted all collectors and submitters are from Scripps Institution of Oceanography.

TESTS BEARING ON RELIABILITY AND PRECISION OF DATES

Evaluation of the reliability and precision of C^{14} measurements based on different materials, on different provenance, and by different methods is still in order. Pertinent tests are collated below. To permit location of the cited measurements, which are not sequentially arranged by number in this list, we include, in parenthesis, after the laboratory number(s), the section of the report as listed in the Introduction and as further subdivided in the text.

1. Sea-water and lake-water controls: LJ-701 (I); 817 and 818 (VI C). (See also LJ-127 (I) and sea-water measurements, for surface water, to be published elsewhere.)

2. Limited apparent age of modern organisms: LJ-648, 894, 896, 957, 978, and 988 (I).

3. Essential agreement among measurements by various laboratories: LJ-930 and 932 (IV D), also LJ-200, La Jolla II (cf. I-444, Isotopes, Inc., reported under LJ-200); LJ-933 (IV D) (cf. I-443, Isotopes, Inc., reported under LJ-200).

4. Essential agreement between measurements based on different species of molluscs: LJ-565 and 566 (II C); LJ-961 and 966, and LJ-962 and 968 (VIII B).

5. Measurements in close to moderate agreement based on different types of material: Marine shells *vs* carbonized wood and charcoal: LJ-568A and 568B (II C); LJ-592 and 600 (VIII B); LJ-611 and 645, LJ-922 and 925, and LJ-923 and 924 (VIII C) (cf. W-26 and 27, USGS I). (See also p. 69.) Freshwater shell (*Anodonta*) *vs* charcoal and tufa (see below).

6. Measurements in essential agreement based on samples with similar parameters: LJ-565 and 566 (II C) (cf. LJ-280, La Jolla II, and LJ-520, La Jolla III); LJ-604 and 605 (IV D) (cf. LJ-503, La Jolla III); LJ-606, 610, and 649 (IV D) (cf. LJ-501, La Jolla III); LJ-973, 981, and 985 (IV D).

7. Measurements inconsistent, or interpretable as contrary to expectation: LJ-517 (La Jolla III) *vs* LJ-280 (La Jolla II), LJ-520 (La Jolla III), and LJ-565 and 566 (II C); LJ-516 (La Jolla III) *vs* LJ-567 (II E); LJ-570 (II D) *vs* LJ-205, 206, 253, 254, 322, and 323 (La Jolla II) and LJ-597, 598, 899, 910, 916, 937, 946, and 948 (II D); LJ-608 (IV D) *vs* LJ-503 (La Jolla III) and LJ-604 and 605 (IV D); LJ-526 (La Jolla III) *vs* LJ-634-636 (II C); LJ-953 (II B) (error in premises?).

8. Measurements in essential agreement with sequential expectation based on stratigraphy and ancillary evidence: LJ-579 and 589, LJ-581 and 582, LJ-583 and 584, LJ-585 and 586, and LJ-587 and 588 (III C); LJ-595, 926, and 927 (VIII B) (cf. LJ-453 and 454, La Jolla III); LJ-618 and 620, LJ-619 and 621, LJ-623 and 626, LJ-624 and 627, LJ-625 and 626, and LJ-629 and 630 (VI C); LJ-631-633 (III B); LJ-637-643 (III C); LJ-884-886 (IV A); LJ-888 and 889 (V B); LJ-903-908 (II F); LJ-909, 914, and 915 (VIII B); LJ-912, 918, and 919 (II B) (cf. LJ-333, 381,

La Jolla II); LJ-922-925 (VIII C) (cf. W-26 and 27, USGS I, LJ-5, La Jolla I, and LJ-216 and 231, La Jolla II); LJ-929-935 (IV D); LJ-975 and 976 (VIII D) and 978 (I); LJ-983 cf. LJ-973, 979, and 991 (IV C); LJ-989 cf. LJ-985 (IV C); LJ-984 cf. LJ-981, 986, and 987 (IV D).

9. Measurements discordant with expectation based on stratigraphic sequence: LJ-590 *vs* LJ-591 (III C) (transposition of material or data suspected); LJ-592 and 593 *vs* LJ-600 (VIII B) (inversion plausibly explicable); LJ-594 (VIII B) *vs* LJ-382, La Jolla II, and LJ-448, La Jolla III (inversion similarly explicable); LJ-615 *vs* LJ-618 and LJ-616 *vs* LJ-619 (VI C) (measurements unexpectedly similar); LJ-643 *vs* LJ-644 (III C) (transposition of material or data suspected); LJ-892 *vs* LJ-969 (VIII B) (slight discrepancy); LJ-893 *vs* LJ-972 (VIII B) (possible error or inversion); LJ-980 *vs* LJ-982 (IV D) (transposition suspected).

Limitations on the adequacy of dates based on caliche are discussed by Arrhenius and Bonatti (1965), in relation to LJ-601 and 602, this list (VI B), LJ-510, La Jolla III, and other measurements.

DATES BASED ON SHELLS OF FRESHWATER MOLLUSCS

Serious doubts have been raised lately on the validity of measurements based on the shells of freshwater mussels, including *Anodonta* (Keith and Anderson, 1963, 1964; Rubin and Taylor, 1963; Berger, Horney, and Libby, 1964; and papers therein cited; also Lamont VI and VIII and Michigan IV and VIII). Empirical data lead us to place considerable reliance, at least as approximations, on dates based on *Anodonta* when solid, lustrous shell is used and when any powdery, chalky coating is removed by initial treatment with weak acid. One cross-checking with charcoal gave a discrepancy of only 170 yr (charcoal LJ-7, La Jolla I, 1000 ± 200, cf. *Anodonta*, LJ-965, 830 ± 140, this list; both based on hearth area of one desert site). One cross-check between *Anodonta* and tufa on a narrow Lake LeConte beachline involved a discrepancy of 500 yr (tufa, LJ-530, 1510 ± 180, La Jolla III, cf. *Anodonta*, LJ-960, 1010 ± 220, this list). Essential agreement between *Anodonta* and tufa in two shoreline streaks of Lake Mohave, and plausible sequence of dates based on both, are detailed on p. 97. Dates at least roughly consistent with expectation were obtained by measurements on *Anodonta* from a presumably recent stage of Lake Manix (LJ-958, 13,800 ± 600, this list), and for 2 obviously ancient stages of Lake LeConte, represented by remnants of beachline (LJ-928 and 954, each >50,000; this list, IV C).

Measurements on freshwater snails and on tufa are compared on p. 95.

I. APPARENT AGE OF ORGANISMS TAKEN ALIVE

In response to a long-felt need we have run 6 additional measurements of the radiocarbon activity of the shells of molluscs, both pelecypods and gastropods, taken alive, and one control test on sea water. These tests, along with 5 run earlier in the La Jolla Laboratory, and an ancillary test of the carbonate carbon in sea water from the end of Scripps Institution Pier, were omitted from La Jolla I, but were reported briefly by Bien, Rakestraw, and Suess (1960, p.

440). All these are presented in the following tabulation (with some minor corrections on tests previously run):

LJ-No.	Group	Species	Locality	Coll.	C^{13}‰ PDB	C^{14}‰ ±10	Apparent Age
48	Siphonophora	*Velella velella*	SW of Farallon Ids., Calif.	1957	−23	−80	680 ± 80
65	Dinoflagillata	*Gonyaulax polyedra*	Off La Jolla, Calif.	1958	−18	−35	500 ± 60
70	Phaeophyceae	*Macrocystis pyrifera*	Vic. La Jolla, Calif.	1957	−16	−60	580 ± 70
86	Pelecypoda	*Mytilus californianus*	SIO Pier, La Jolla, Calif.	1953	−8.3	−35	720 ± 90
97	Pelecypoda	*Mytilus californianus*	do.	1959	+0.6	−37	300 ± 40
127	(Sea water)	(Carbonate)	do.	1959	−2.3	−88	840 ± 100
648	Pelecypoda	*Mulinia coloradoensis*	Golfo de California	1962	—	—	210 ± 10
701	(Sea water)	(Carbonate)	do.	1963	—	—	210 ± 10
894	Pelecypoda	*Mytilus californianus*	Pta. Banda, Baja Calif.	1959	—	—	186 ± 20
896	Pelecypoda	*Mytilus californianus*	do.	1959	—	—	240 ± 20
957	Pelecypoda	*Chione fluctifraga*	Golfo de California	1962	—	—	270 ± 20
978	Gastropoda	*Strombus gigas*	Yucatán Peninsula	1963	—	—	<100
988	Gastropoda	*Tegula gallina*	Vic. Pta. Baja, Baja Calif.	1956	—	—	270 ± 25

Whole organism used for LJ-48, 65, and 70; shell only used for others.

The apparent age of the mussels (shells only) run in 1959 were 300 (coll. 1953) and 720 (coll. 1959), and the values for 3 other organisms run in 1959 were in the same time range; but the 6 values for the 5 species of molluscs run in 1963 and 1964, including 2 runs on the same species of mussel, ranged from <100 to 270. The essential reliability of datings from shells of marine molluscs is further indicated by cross-checking with charcoal and carbonized wood (see above, under Tests Bearing on Reliability and Precision of Dates).

For all these samples error cited is unaugmented standard deviation of actual count.

LJ-648. Modern organisms—6 Apparent Age 210 ± 10

Clams, *Mulinia coloradoensis* (30 valves, 1.9 to 2.5 cm long), coll. alive from top 0.1 m of offshore tidal mudflat, near mean sealevel, 300 to 400 m E of S end of El Chinero Barrier Island, ct. 45 km N of San Felipe, Baja California Norte (31° 28.4′ N Lat, 114° 50′ W Long). Coll. 1962 and subm. 1963 by D. L. Inman and W. R. Gayman (sample 13 Nov 1962—2A). *Comment*: La Jolla measurements utilizing old shells of *Mulinia coloradoensis* are LJ-220, 1180 ± 250, La Jolla II; LJ-522, 2190 ± 200 and LJ-525, 690 ± 130, La Jolla III; LJ-572, 2460 ± 200, and LJ-956, 1420 ± 160, this list, II C). Apparent age of a sample of sea water from upper Golfo de California (next measurement) yielded identical apparent age.

LJ-701. Sea-water control **Apparent Age 210 ± 10**

Sample (178 L) of water from just outside breakers at El Moreno, NW Golfo de California, 18.5 km N of San Felipe, Baja California Norte (31° 11.5′ N Lat, 114° 54′ W Long). Coll. 1500 hrs April 25 and subm. April 29, 1963 by D. L. Inman and W. R. Gayman (sample 25 Apr 63). *Comment*: sample taken to represent water from which molluscs tested build their shells; specifically to tie in with measurement of apparent age of intertidal clam *Mulinia coloradoensis* (LJ-648, 210 ± 10, above). Dates agree.

LJ-894. Modern organisms—7 **Apparent Age 186 ± 20**

California mussel (*Mytilus californianus*) shells coll. alive intertidally at Tres Hermanas on the relatively warm NE side of Punta Banda, Baja California Norte (31° 42.1′ N Lat, 116° 41.3′ W Long). Coll. 1959 for C. L. Hubbs and subm. 1964 (sample 1959—IX:15). *Comment*: to check apparent C^{14} age of modern shell, of species commonly used for C^{14} dates; to tie in with prospective dates and paleotemperature measurements on mussel shells from middens on two sides of Punta Banda; and to determine whether present great temperature differential is of long standing. Temperature seemingly has little or no effect on apparent age of *Mytilus*.

LJ-896. Modern organisms—8 **Apparent Age 240 ± 50**

California mussel (*Mytilus californianus*) shells coll. alive intertidally at Nuevo Arbolitos on the relatively very cold SW side of Punta Banda, Baja California Norte (31° 42.2′ N Lat, 116° 41.3′ W Long). Coll. 1959 for C. L. Hubbs and subm. 1964 (sample 1959—IX:1). *Comment*: same as for LJ-894, above.

LJ-957. Modern organisms—9 **Apparent Age 270 ± 20**

Clam (*Chione fluctifraga*) valves (2, 7.5 cm long) coll. alive 60 to 150 m E of beach toe in small basins, 0.1 to 0.2 m below sediment surface in mud at El Moreno beach, ca. 18 km N of San Felipe, Baja California Norte (31° 11.5′ N Lat, 114° 54′ W Long). Coll. 1962 and subm. 1964 by D. L. Inman and W. R. Gayman (sample 7 Apr 62—20). *Comment*: La Jolla and UCLA measurements utilizing old shells of *Chione* are—In La Jolla I: LJ-3, 6510 ± 200; LJ-31, 3900 ± 200; LJ-35, 3500 ± 200; LJ-36, 7300 ± 200; LJ-96, 1370 ± 200; LJ-136, 4720 ± 160. In La Jolla II: LJ-215, 1970 ± 240; LJ-242, 870 ± 200; LJ-243, 825 ± 200; LJ-245, 1075 ± 150; LJ-277, 4740 ± 200 (*Chione* in part); LJ-335, 1030 ± 200; LJ-381, 3400 ± 240. In La Jolla III: LJ-520, 16,490 ± 600 (*Chione* in ptrt); LJ-523, 4830 ± 260; LJ-524, 1060 ± 300. In this list: LJ-571, 2600 ± 200; LJ-573, 1750 ± 200; LJ-574, 2420 ± 200; LJ-576, 780 ± 200; LJ-636, >42,000; LJ-892, 7100 ± 300; LJ-893, 6600 ± 300; LJ-912, 4750 ± 200; LJ-964, 7130 ± 350; LJ-966, 7450 ± 370; LJ-969, 7480 ± 400; LJ-972, 7040 ± 350. In UCLA I: UCLA 119, 980 ± 80. In UCLA II: UCLA 191, >34,000.

LJ-978. Modern organisms—10 **<100**

Large conch (*Strombus gigas*) shell from specimen coll. alive from sea near site of midden behind beach on sea (E) side of Isla Cancún, S of Isla

Mujeres, on Yucatán Peninsula (ca. 21° 05′ N Lat, ca. 86° 45′ W Long). Coll. and subm. same as for LJ-975 and 976 (this list, VIII D) (sample A, lot no. 2). *Comment*: test bears on reliability of date for LJ-132, 1700 ± 150, La Jolla I, and LJ-976, 2080 ± 150. Apparent age of *Strombus gigas*, from Key Largo, Florida, is somewhat higher but still low (M-1220, 300 ± 75, Michigan VIII, p. 228; see also Keith and Anderson, 1963).

LJ-988. Modern organisms—11 Apparent Age 270 ± 125

Snails, *Tegula gallina* (4 shells, 44.4 g), coll. alive on intertidal rocky reef ca. 3.2 km E of base of Punta Baja, Baja California Norte, at Temperature Station 46 (29° 57.0′ N Lat, 115° 46.4′ W Long; H. O. Chart 1149, 1948). Coll. 1956 by C. L. Hubbs and subm. 1964 (sample 1956—V:28A).

II. SEALEVEL CHANGES AND SHORE PROCESSES

Most measurements herein reported pertain to changes in sealevel and related shore processes. In addition, most of the tests on coastal middens (sec. VIII) bear significantly on sealevel estimates.

A. Alaska

The 6 measurements on sealevel change in Alaska were all made on trees (5 on stumps) killed by a previous submergence of the land. Dates bear on amount and time of submergence. All samples subm. by Erk Reimnitz, who will report findings. An extensive submerged forest re-emerged as a result of the 1964 earthquake.

LJ-938. Submerged forests, uplifted by earthquake, Alaska—1 700 ± 130
A.D. 1250

Wood from *in situ* tree stump, ca. 0.3 m diam, in forest horizon 3.2 m below high marsh (ca. 0.8 m above pre-1964 MLLW); along W bank, Cudahy Slough, ca. 275 m above its mouth, on Copper River Delta (60° 16′ 31″ N Lat, 144° 42′ 45″ W Long; USGS Cordova B-2 Quadrangle, Alaska, 1953). Coll. 1964 by Erk Reimnitz (sample no. 2). *Comment*: 1.8 m of uplift during the 1964 Alaskan earthquake exposed this forest horizon along sloughs in marsh of Copper River Delta. Forest is overlain by marsh deposits consistently 2.7 to 3.0 m thick. Forest, represented by close-set stumps and interdigitating roots, was traced ca. 64 km in E–W direction. Indications are that it formerly extended S as far as barrier islands. Assuming that soil in which trees grew was at least 1 m above level reached by highest tides, or at ca. 5.5 to 5.8 m above pre-1964 MLLW, an earlier submergence of 4.9 m is indicated. Since marsh vegetation survived, submergence must have been gradual. Uniform depth of forest horizon rules out compaction as a cause. Thus, emergence along Gulf of Alaska coast, including recent seismic uplift, was interrupted by submergence of recent date.

LJ-939. Submerged forests, uplifted by earthquake, Alaska—2 725 ± 130
A.D. 1225

Wood from *in situ* tree stump, ca. 0.5 m diam, in forest horizon 3 m below high marsh (ca. 1.1 m above pre-1964 MLLW); along steep W bank of upper

Alaganic River, ca. 2.4 km S of Copper River Highway (60° 26′ 07″ N Lat, 144° 17′ 21″ W Long; USGS Cordova B-4 Quadrangle, Alaska, 1951). Coll. by Erk Reimnitz (sample no. 5). *Comment*: same as for LJ-938.

LJ-942. Submerged forests, uplifted by earthquake, Alaska—3 **ca. 0 ± 100**

Wood from spruce tree, ca. 0.5 m in diam, on surface ca. 2.7 m above pre-1964 MLLW; on a spit near abandoned Cronx Cannery, N of Hawkins Island Cutoff, Prince William Sound (60° 28′ 48″ N Lat, 146° 22′ 52″ W Long; USGS Cordova B-7 Quadrangle, Alaska, 1953). Coll. 1964 by Erk Reimnitz and N. F. Marshall (sample no. 4). *Comment*: trees killed by salt-water intrusion due to submergence of land are common along shores of Prince William Sound, in area that emerged during 1964 Alaska earthquake. This stand of trees is protected against wave action from the Sound by a high gravel embankment. Assuming trees grew at least 1 m above spring-tide level, *i.e.*, at ca. 5.5 to 6.0 m above pre-1964 MLLW, a recent pre-1964 submergence of ca. 2.7 m is indicated.

LJ-943. Submerged forests, uplifted by earthquake, Alaska—4 **1360 ± 150**
A.D. 590

Wood from *in situ* tree stump in forest horizon ca. 3 m below high marsh (ca. 0.8 m above pre-1964 MLLW); along steep W bank of Eyak River, ca. 18 m N of the fishing cabins, on Copper River Delta (60° 28′ 46″ N Lat, 145° 40′ 48″ W Long; USGS Cordova B-5 Quadrangle, Alaska, 1953). Coll. 1964 by Erk Reimnitz and N. F. Marshall (sample no. 1). *Comment*: same as for LJ-938, above, which lies ca. 64 km W, apparently in same re-emerged forest horizon.

LJ-944. Submerged forests, uplifted by earthquake, Alaska—5 **550 ± 120**
A.D. 1400

Wood from *in situ* tree stump in forest horizon ca. 4.5 m below high marsh, and ca. 1.5 m below forest horizons sampled for LJ-938, 939, 943, and 945 (ca. 0.5 m below pre-1964 MLLW); along steep bank of "Copper Cutoff" on Copper River Delta (60° 24′ 40″ N Lat, 145° 23′ 45″ W Long; USGS Cordova B-4 Quadrangle, Alaska, 1951). Coll. 1964 by Peter Shepherd, Alaska Dept. of Fish and Game (Reimnitz's sample no. 6). *Comment*: the 2 submerged forest horizons in this area (see also LJ-938, above) indicate that at different times the forest extended much farther seaward than now. Occurrence of rootlets and grassy material at all levels from surface of marsh to lower forest horizon indicates slow submergence.

LJ-945. Submerged forests, uplifted by earthquake, Alaska—6 **380 ± 120**
A.D. 1570

Wood from *in situ* tree stump, ca. 0.6 m in diam; at base of layer of marsh deposits, 1.8 to 2.7 m thick, overlying medium-grained sands at least 18 m thick; in lee of E end of Egg Island, near blinker on Copper River Delta (60° 23′ 19.5″ N Lat, 145° 44′ 40″ W Long; USGS Cordova B-5 Quadrangle, Alaska, 1953). Coll. 1963 (before earthquake) and subm. 1964, by Erk

Reimnitz and N. F. Marshall (sample no. 3). *Comment*: this then-submerged stump on one of the barrier islands may have belonged to same forest horizon as those used for LJ-938, 939, 943, and 944. Other tree stumps at about same level were reported by Rae Baxter, Alaska Dept. of Fish and Game, for E end of delta on tidal flats near barrier islands.

B. W Coast, United States

LJ-607. Root from La Jolla Submarine Canyon **8270 ± 500** **6320 B.C.**

Fibrous root (ca. 0.5 m long and 6 to 9 cm diam) dug out of cliff on S side of canyon, off La Jolla, California, 270° true from large buoy off Beach and Tennis Club, at depth of 23 m (32° 51′ 30″ N Lat, 117° 16′ 00″ W Long). Coll. and subm. 1962 by R. F. Dill, U. S. Navy Electronics Lab. (sample 1330 —Nov 20, 1962). *Comment*: date was obtained on Brussels Counter; a run on Bern Counter gave 8100 ± 500. Sample was regarded as having been laid down in place by fresh water earlier than deposit of overlying fine-grained blue clay, but after deposit of a highly calcareous, silty, light-gray clay layer. Root is thought to have been exposed by submarine erosion. See Dill (in press). For La Jolla Submarine Canyon see Shepard and Emery (1941), Limbaugh and Shepard (1957), and Emery (1960). Lower sealevel in the area during early Holocene time was discussed by Shumway, Hubbs, and Moriarty (1961).

Batiquitos Lagoon core series, California

Shells from 3 different depths in test boring, 10 cm in diam, NE of Leucadia, San Diego Co.; 48 m SSW of dirt road bordering N margin at ca. mid-length of this now sediment-filled lagoon, directly in line from large 3-forked eucalyptus and old pilings in lagoon flat (33° 05′ 26″ N Lat, 117° 17′ 34″ W Long; USC&GS Air-Photo Compilation T-5411, 1934). Coll. 1961 by J. N. Miller and party; subm. by her 1964 (sample 1961—I:30A).

LJ-912. Batiquitos Lagoon, California—10 **4750 ± 200** **2800 B.C.**

Clam (*Chione californiensis* and/or *undatella*) valves from depth of 7.24 to 7.31 m.

LJ-918. Batiquitos Lagoon, California—11 **3700 ± 200** **1750 B.C.**

Olympia oyster (*Ostrea lurida*) valves from depth of 2.84 to 3.33 m.

LJ-919. Batiquitos Lagoon, California—12 **1000 ± 200** **A.D. 950**

Scallop (*Plagioctenium circulare aequisulcatum*) valves from depth of 1.64 to 1.91 m.

General Comment: these and 2 other measurements of shells from this boring (tabulated below) were run in a study (Miller and Hubbs, ms. in preparation) of history of this coastal lagoon and its fauna, with special reference to trophic support of aboriginal inhabitants (measurements for adjacent middens, LJ-31, 35, and 36, La Jolla I, and LJ-242, 243, 245, and 256, La Jolla II, gave dates ranging from 825 to 7300 B.P.). Data are consonant with idea that lagoon, now completely unproductive of shellfish, remained baylike and productive of utilized shellfish for at least 6 millenia, during a period of continuing rise of sealevel (see Shepard, 1961b, 1963, 1964), while alluvial fill increased rather uniformly. Shellfish supply was no doubt a major factor in the long-continued occupation by man of lagoon margin. These problems were discussed by Shumway, Hubbs, and Moriarty (1961). Data appear to be inconsistent with hypothesis of C. N. Warren (1964; Warren, True, and Eudey, 1961, p. 25) that about 3000 or 4000 yr ago this and to a variable degree other coastal lagoons of N San Diego Co. became so filled with sediment as to become deficient in shellfish production and to cause aboriginal populations to abandon lagoon margins.

Sequential Dates on Batiquitos Lagoon Core

LJ-No.	Depth in Core, m	Date, B.P.	Shell Utilized (All Pelecypods)
919	1.64-1.91	1000 ± 200	*Plagioctenium*[1]
918	2.84-3.23	3700 ± 200	*Ostrea lurida*
381	5.24-5.61	3400 ± 240	*Chione*[2]
912	7.24-7.31	4750 ± 200	*Chione*[2]
333	10.01-10.45	6320 ± 250	*Plagioctenium*[1]

[1] *Plagioctenium circulare aequisulcatum*, formerly listed as *Pecten circularis aequisulcatus.*
[2] *Chione californiensis* and/or *undatella.*

LJ-953. Shells, off California — 1970 ± 200 / 20 B.C.

Scallop (*Pecten diegensis*) valves from sands now submerged to depth of 46 m, off Tijuana River area, southern California (32° 34′ N Lat, 117° 14′ W Long). Coll. 1963 and subm. 1964 by F. P. Shepard (sample F.P.S. no. 1). *Comment*: since shells are interpreted as part of an old beach and since area is regarded as probably having been stable, measurement was expected to add to data on eustatic changes in sealevel. Depth for indicated age is so far beyond expectation (Shepard, 1961b, 1963, 1964) as to suggest error, perhaps in geologic or biologic premises. Further measurements are anticipated.

LJ-971. Pleistocene beach, California — >50,000

Pismo clam (*Tivela stultorum*) valves from shell-pebble basal layer of poorly consolidated Pleistocene beach deposit that rests on Eocene sediments beside lip of hanging valley on cliff face of Torrey Pines State Park, San Diego, ca. 0.2 km N of Flat Rock ("Bathtub Rock"); alt of deposit ca. 12 to 18 m; this is U.C.L.A. loc. 3457 (32° 54′ 56″ N Lat, 117° 15′ 27″ W Long; USGS Del Mar Quadrangle, 7.5′ series, 1953, and USC&GS Air Photo Compilation T-5375, 1934). Coll. 1963 and subm. 1964 by D. L. Inman and W. R. Gayman (sample 30 June 63—4). *Comment*: collectors stated "deposits appear to be the most recent known elevated beach deposit along the California coast." One of us (C. L. H.), however, has regarded this and most other Pleistocene beaches of roughly same alt along open coasts of area as representing one Pleistocene stage older than lower terrace deposits that generally seem to have been destroyed except where protected from waves; on this theory age would be expected to be far beyond C^{14} potential. Lower and presumably younger terrace fills of the region, which also extend to ages beyond C^{14} dating, are only ones showing evidence of localized fires of questioned human origin (see, *e.g.*, W-142, 21,500 ± 700, USGS II, and LJ-217, >34,000, La Jolla II). See Stephens (1929, p. 254-255) and Valentine (1960).

C. W Coast, México

Pleistocene delta series

Shells dredged from depth of 104 m off W coast of mainland México on beachline of Pleistocene delta of Río Grande de Santiago (21° 40.7′ N Lat, 106° 15.0′ W Long). Coll. 1961 and subm. 1962 by J. R. Curray and R. H. Parker.

LJ-565. Shells, off W coast of México—4 **17,850 ± 700**
15,900 B.C.

Pelecypod (*Anomia adamas*) valves (sample C-658B).

LJ-566. Shells, off W coast of México—5 **16,800 ± 700**
14,850 B.C.

Clam (*Arca pacifica* and *A. mutabilis*) valves (sample C-568C). *General Comment*: since living range of the species is regarded by them as ranging from intertidal to 9 m, collectors thought that date of sealevel at –104 m might approximate 18,000 B.P. Agreement with expectation is perfect and close to dates provided by tests on other samples of similar environmental and depth parameters, namely LJ-280, 19,300 ± 400 (La Jolla II); LJ-520, 16,490 ± 600 (La Jolla III). Disagreement with LJ-517 (1480 ± 150, La Jolla III) is striking, although that measurement was made on shells (*Vermicularia pellucida*) from same dredge haul and of species supposedly of similar depth range; misidentification, mistaken living depth range, or transport is suspected. See Curray and Moore (1964, p. 208). Existence of an ancient beach in the vicinity of collections for this series of measurements was confirmed through observations by J.R.C. from the Diving Saucer in 1965. Measurements bear on antiquity of Río Grande de Santiago (correlated with its highly distinctive fish fauna), as noted under LJ-280.

Beach ridge series, S of Mazatlán

Material from 5.22 to 5.32 m below MSL, from boring with Ostenberg core on strand plain 7.7 km from W coast of mainland México (22° 22.9′ N Lat, 105° 37.0′ W Long). Coll. 1961 and subm. 1962 by J. R. Curray (sample C-512).

LJ-568A. Beach ridge, W coast of México—2 **5430 ± 300**
3480 B.C.

Carbonized wood (3.6 g).

LJ-568B. Beach ridge, W coast of México—3 **5000 ± 300**
3050 B.C.

Mollusc shells (mostly *Polymesoda* sp., with some fragments of *Donax*, *Natica*, and *Mitrella*). *Comment*: *Polymesoda* shells regarded as of lagoon origin; others, as from beach.

General Comment: should date this beach ridge. Estimated age 3000 B.P. Agreement between dates from carbonized wood and shell is fair. Believed not to be midden material.

Beach ridge and bar series, Golfo de California

Nine additional measurements were run on beach ridges and bars along W shore of gulf (E shore of Baja California Norte). Coll. and subm. by R. W. Thompson and by D. L. Inman and W. R. Gayman.

LJ-571. Shore of Golfo de California—10 **2600 ± 200**
650 B.C.

Clam (*Chione fluctifraga*) valves from abandoned beach ridge isolated from present shoreline by 13 km of recent mud-and-salt flat; 5 km E of Km 133 on Mexicali to San Felipe Highway (31° 30.5′ N Lat, 115° 01′ W Long). Coll. 1961 and subm. 1962 by Thompson (sample S-2). *Comment*: expected age 5000 yr +.

LJ-572. Shore of Golfo de California—11 **2460 ± 200**
510 B.C.

Clam (*Mulinia coloradoensis*) valves from abandoned beach ridge isolated from present shoreline by 4.5 km of recent mud; 5.5 km E of Km 157 on Mexicali to San Felipe Highway (31° 17′ N Lat, 114° 57′ W Long). Coll. 1961 and subm. 1962 by Thompson (sample S-3). *Comment*: expected age ca. 3000 yr.

LJ-573. Shore of Golfo de California—12 **1750 ± 200**
A.D. 200

Clam (*Chione fluctifraga*) valves from gravel bar representing former Gulf shoreline, isolated from present shoreline by 20 km of recent mud-and-salt flat; 1.5 km E of Km 108 on Mexicali to San Felipe Highway (31° 43′ N Lat, 115° 02.5′ W Long). Coll. and subm. 1962 by Thompson (sample S-9). *Comment*: date may represent brief transgressive period, when Gulf flooded previously deposited mud flats.

LJ-574. Shore of Golfo de California—13 **2420 ± 200**
470 B.C.

Clam (*Chione fluctifraga*) valves from gravel bar representing former Gulf shoreline, isolated from present shoreline by 22 km of recent mud-and-salt flat; 0.5 km E of Km 105.5 on Mexicali to San Felipe Highway (31° 44′ N Lat, 115° 03′ W Long). Coll. and subm. 1962 by Thompson (sample S-10). *Comment*: same as for LJ-573.

LJ-575. Shore of Golfo de California—14 **2950 ± 200**
1000 B.C.

Clam (*Glycymeris* cf. *maculata*) valves from abandoned beach ridge isolated from present shoreline by 3 km of recent mud flat; from same beach ridge as LJ-572, but 6.5 km to NE; 9 km E of Km 153 on Mexicali to San Felipe Highway (31° 20.5′ N Lat, 114° 54.5′ W Long). Coll. 1961 and subm. 1962 by Thompson (sample S-11). *Comment*: expected age 3000 yr; thought to represent period of low supply of Colorado River mud (perhaps when Colorado River was diverted into LeConte basin), allowing reworking of mud flats and formation of beach ridge.

LJ-576. Shore of Golfo de California—15 **780 ± 200**
A.D. 1170

Clam (*Chione fluctifraga*) valves from abandoned beach ridge isolated from present shoreline by 1 km of recent mud flat; 18 km E of Km 139 on Mexicali to San Felipe Highway (31° 27.5′ N Lat, 114° 51.5′ W Long). Coll. and subm. 1962 by Thompson (sample S-13). *Comment*: expected age 1000 yr.

LJ-603. Shore of Golfo de California—16 **530 ± 130**
A.D. 1420

Clam (*Protothaca grata*) valves from surface at top of modern pebble beach ridge on protected side of tombolo of Punta La Gringa, at N end of Bahía de los Ángeles; 2.1 m above mean sealevel, 81 m SW of bench mark on surveyed range and 21 m SW of LJ-213, 2190 ± 160, La Jolla II (29° 02.5′ N Lat, 113° 34.3′ W Long). Coll. 1960 and subm. 1962 by Inman and Gayman (sample 9 April 60—55B). *Comment*: shell deposit is interpreted by coll. as Indian midden.

LJ-936. Shore of Golfo de California—20 **1170 ± 150**
A.D. 780

Charcoal from upper 0.15 m of shell mound on 2nd beach ridge from present beach, 0.8 to 1.0 km N of El Moreno range, ca. 18 km N of San Felipe (31° 12.5′ N Lat, 114° 54′ W Long). Coll. 1961 and subm. 1964 by Inman and Gayman (sample 14 May 61—27). *Comment*: date bears on period of human occupation as well as on sealevel stability and rates of longshore transport.

LJ-956. Shore of Golfo de California—21 **1420 ± 160**
A.D. 530

Clam (*Mulinia coloradoensis*) valves from surface to depth of 0.2 m in 2nd ridge from sea 400 m behind modern beach at El Moreno, ca. 18 km N of San Felipe; ca. 35 m N of road; ca. 5.0 m above MSL (31° 11.5′ N Lat, 114° 54′ W Long). Coll. 1960 and subm. 1964 by Inman and Gayman (sample 28 Aug 60—24). *Comment*: modern shell of same species (LJ-648, this list), gave an apparent age of 210 ± 10 yr.

General Comment: through these measurements attempts are being made to obtain maximum age for old beach ridges and bars, and to establish rate of progradation of coastal plain by influx of Colorado River muds, rate of filling of N Gulf, and rate of longshore transport; mollusc species dated are believed to be intertidal and to be satisfactory indices of old shorelines. Dates fluctuate considerably but seem to indicate that Gulf level has been rather stable for several thousand yr. Previous La Jolla measurements in same series are LJ-213-215 and 220, La Jolla II, and LJ-522-526, La Jolla III.

Golfo de California terrace series

Three measurements were run on shell from beach deposits on terraces along W shore of Golfo de California in Baja California Norte. Coll. 1962 and subm. 1963 by T. R. Walker and R. W. Thompson.

LJ-634. Shore of Golfo de California—17 **>42,000**

Barnacles (not id.) from ancient cobble beach cropping out in terraces at Playa Ensenada Blanca 4.0 km NNE of San Felipe; 7.6 m vertically above any living representatives of same barnacle in this area (31° 03.3′ N Lat, 114° 49.5′ W Long). Sample WD-5.

LJ-635. Shore of Golfo de California—18 **32,800 ± 1600**
30,850 B.C.

Oyster (*Ostrea angelica*) valves from ancient beach on wave-cut bench around N end of small embayment immediately adjacent to Puertecitos, 77 km SSE of San Felipe; highest level of deposit is 0.6 to 0.9 m above modern beach berm, ca. 4.5 m above MSL (30° 20.8′ N Lat, 114° 38.5′ W Long). Sample Al-27-A.

LJ-636. Shore of Golfo de California—19 **>42,000**

Clam (*Chione gnidia*) valves from ancient, cemented beach exposed in terrace scarp along modern beach, ca. 4.6 m above MSL and ca. 0.6 m above modern beach berm, at Punta Estrella, 13.7 km SE of San Felipe (30° 56′ N Lat, 114° 42.5′ W Long). Coll. and subm. as for LJ-634 (sample Al-24-D).
General Comment: species are regarded as intertidal and hence indicative of changes in relative sealevel. The 3 deposits seem correlative. Dates far exceed expectation of ca. 8000 yr based on LJ-526, 7840 ± 250, La Jolla III, apparently from same formation. Samples probably date inception of major uplift and pedimentation.

LJ-920. Submarine canyon, Cabo San Lucas, Baja California **710 ± 150**
A.D. 1240

Shells (mixed species) from San Lucas Submarine Canyon at depth of 192 m (ca. 23° 16.5′ N Lat, ca. 109° 25′ W Long). Coll. 1963 and subm. 1964 by F. P. Shepard (sample San Juan #40). *Comment*: to determine time span of material transgressing from shore to deep water in submarine canyons (in this canyon by spectacular sand flows, including sand falls, documented by motion pictures); it is assumed that shells, along with sand, are of beach origin (Shepard, 1961a).

LJ-974. Shore of Golfo de California—22 **>50,000**

Pelecypod (*Codakia distinguenda*) valve from basal conglomerate covering uplifted terrace and extending ca. 30 km back of beach for at least 3 km; ca. 6 m above present sealevel, ca. 4 km S of Buena Vista in Cape region of Baja California Sur (23° 45′ N Lat, 109° 45′ W Long). Coll. and subm. 1964 by R. F. Dill, U. S. Navy Electronics Lab., San Diego. *Comment*: possibly representative of an Interglacial high sea stand. Beachrock found at depth of ca. 50 m in submarine canyon of same region indicates considerable sealevel fluctuation.

D. Hawaii

Emerged reel series, Hawaii[1]

Eleven additional measurements have been obtained on carbonate material from emerged reefs around Hawaiian islands. Except as noted, all coll. and subm. by F. P. Shepard.

[1] Nos. 1-6 of this series (see General Comment) were each labelled "Raised reef, Hawaii."

LJ-569. Emerged reef, Hawaii—7 **>40,000**

Mollusc shells (including *Conus abbreviatus*, *C.* cf. *marmoratus*, *Arcinella thaanumi*?, *Venus reticulata*, and unidentified fragments) from Kahe Point Quarry on Kona Coast of Oahu S of Nanakuli; in either beach conglomerate or reefrock (near a 3.7-m terrace of reefrock); alt 2.7 to 3.1 m (21° 21′ 15″ N Lat, 158° 07′ 50″ W Long; USGS Ewa Quadrangle). Coll. and subm. 1962 (sample no. 1).

LJ-570. Emerged reef, Hawaii—8 **7540 ± 300**
5590 B.C.

Limpets (unidentified) from beachrock overlying stranded coral reef (A-1) at alt 1.5 m on Kahuku Point, Oahu, N of airfield (21° 42′ 45″ N Lat, 157° 58′ 40″ W Long; USGS Kahuku Quadrangle). Coll. and subm. 1962 (sample A-2). *Comment*: measurement discordant with comparable measurements (see General Comment below).

LJ-597. Emerged reef, Hawaii—9 **>40,000**

Clam (*Venus reticulata*) valves from near contact bewteen reef and underlying basalt, near Waimea Bay, Oahu, W of sample 8 (LJ-598); alt 3.4 to 3.7 m (21° 39′ 18″ N Lat, 158° 03′ 52″ W Long; USGS Waimea Quadrangle). Coll. and subm. 1962 by F. P. Shepard, H. H. Veeh, and Ben Oostdam (sample no. 1).

LJ-598. Emerged reef, Hawaii—10 **>40,000**

Cowry (*Cypraea tigris*) shell from alt 2.1 to 2.4 m above low tide on sloping end of reef that rises to +3.7 m farther W; from just W of Pupukea Beach near Waimea Bay, Oahu (21° 39′ 30″ N Lat, 158° 30′ 52″ W Long; USGS Waimea Quadrangle). Coll. and subm. 1962 as for LJ-597 (sample no. 8). *Comment*: algae and coral occur in this reef.

LJ-899. Emerged reef, Hawaii—11 **18,000 ± 600**
16,050 B.C.

Cone (*Conus* cf. *sumatrensis*) shells from alt 3.5 m on emerged algal and coral reef at Puu O Hula Kai, on coast S of Waianae, on Kona side of Oahu (21° 24′ 17″ N Lat, 158° 10′ 47″ W Long; USGS Waimea Quadrangle). Coll. 1962 and subm. 1964 by F. P. Shepard, H. H. Veeh, and Ben Oostdam (sample no. 9).

LJ-910. Emerged reef, Hawaii—12 **>50,000**

Snail ("buccinid type") shells from alt 2.7 m at top of emerged coral reef at Kahuku Point, Oahu (21° 42′ 45″ N Lat, 157° 58′ 15″ W Long). Coll. 1962 and subm. 1964 (sample B).

LJ-937. Emerged reef, Hawaii—13 **>42,000**

Coral from emerged reef, alt 15 m, Kahuku Pt., Oahu (21° 41′ N Lat, 157° 57′ W Long). Coll. 1961 and subm. 1964 (sample no. 5).

LJ-946. Emerged reef, Hawaii—14 **>50,000**

Shells (mixed species) from top of emerged coral reef, at alt 1.5 m, Kahuku Pt., Oahu; N of airfield (21° 42′ 45″ N Lat, 157° 58′ 40″ W Long; USGS Kahuku Quadrangle). Coll. 1962 and subm. 1964 (sample A-1).

LJ-947. Emerged reef, Hawaii—15 **>50,000**

Shells (mixed species) from near top of emerged reef, at alt 3.7 to 4.0 m. 0.8 km E of Kaena Pt., Oahu (21° 34′ 30″ N Lat, 158° 16′ 00″ W Long). Coll. 1962 and subm. 1964 (sample no. 13).

LJ-948. Emerged reef, Hawaii—16 **39,100 ± 1500**
37,150 B.C.

Gastropod (buccinid and *Cypraea* sp.) shells from emerged coral reef with surface 1.5 m above low tide, on Popaia Island (21° 24′ 10″ N Lat, 157° 43′ 20″ W Long; USGS Kailua Quadrangle). Coll. 1962 and subm. 1964 (sample no. 14).

General Comment: to test possible eustatic sealevel rise as shown by Hawaiian terraces. Dates agree with Shepard's expectation. Measurements in series, with the exception of LJ-570, 7540 ± 300, indicate that terraces in question are pre-Holocene:

Reported in La Jolla II	In This List	
LJ-205, 28,200 ± 1300	LJ-569, >40,000	LJ-916, 15,000 ± 600
LJ-206, 18,070 ± 450	LJ-570, 7540 ± 300	LJ-937, >42,000
LJ-253, 24,140 ± 800	LJ-597, >40,000	LJ-946, >50,000
LJ-254, 31,540 ± 1300	LJ-598, >40,000	LJ-947, >50,000
LJ-322, 26,640 ± 1100	LJ-899, 18,000 ± 600	LJ-948, >40,000
LJ-333, 31,840 ± 1000	LJ-910, >50,000	

Related measurements follow:

LJ-753. Submarine terrace, Hawaii **8370 ± 250**
6420 B.C.

Coral (*Porites*) from "10-fathom" (18-m) submarine terrace, Kaheko Reef, Kauai (22° 08.3′ N Lat, 159° 45.7′ W Long). Coll. 1962 and subm. 1963 by D. L. Inman and H. H. Veeh (sample 18 Sept 62—6). *Comment*: has bearing on sealevel changes related to worldwide occurrence of "10-fathom terrace." Since *Porites* is a shallow-water coral, this indication that sealevel ca. 8400 B.P. was 18 m lower than now fits recent curves (Shepard, 1961b, 1963, 1964). Has bearing also on continuity of tropical fauna. Unaltered aragonitic portion was mechanically separated from bulk sample by autosonic vibration (sample still contained 1% calcite, probably algal, as estimated by peak ratios from X-ray diffraction, but no other contaminants were noted; presumably the small amount of calcite did not introduce a serious error).

LJ-916. Sea-cave deposit, Hawaii **15,000 ± 600**
13,050 B.C.

Cemented sandstone with aspect of beachrock, from large sea cave, from 4.6-m block 0.9 to 1.8 m above mean sealevel; from NW (Napali) coast of Kauai, 200 m N of mouth of Kauhoa Valley (22° 07.3′ N Lat, 159° 44.3′ W Long). Coll. 1962 and subm. 1964 by Inman and Gayman (sample 18 Sept 62—11). *Comment*: to date sealevel change, sedimentation rate, and erosion of Napali cliff.

LJ-917. Beachrock, Hawaii **1600 ± 160**
A.D. 350

Beachrock (about 45% $CaCO_3$), from upper foreshore of exposed Oomano Pt., Kauai (21° 57.7′ N Lat, 159° 43.5′ W Long). Coll. and subm. as for LJ-

916 (sample 19 Sept 62—15). *Comment*: to date sealevel change and rates of formation of beachrock, sedimentation, and coastal accretion.

E. Indonesia and Australia

LJ-567. Shell, off coast of Australia—2 **>40,000**

Gastropod (*Tudicula spinosa*) shell dredged at depth of 132 m on terrace at edge of Sahul Shelf, off NW coast of Australia (11° 57.5′ S Lat, 123° 50.4′ E Long). Coll. 1961 and subm. 1962 by J. R. Curray (sample V-229B). *Comment*: expected to give age of sealevel at ca. –130 m in this area, supposed to be tectonically stable. Another measurement of shell from sample V-229 (LJ-516, 16,910 ± 500, La Jolla III) was based on a pelecypod, *Chlamys senatorius*, with a less restricted depth range. In submitting sample for LJ-516 Curray commented that "it is quite possible that this is early Wisconsin."

LJ-913. Shells, off coast of Timor **23,800 ± 900**
21,850 B.C.

Pelecypod (*Lima persquamifer*) shell from small terrace at –293 m, off S coast of Timor (11° 00′ S Lat, 125° 33.6′ E Long). Coll. 1961 and subm. 1964 by Tj. H. van Andel (sample V-260). *Comment*: since shell is regarded as of shallow-water origin, measurement was assumed possibly related to late Pleistocene low sealevel. Measurement is so far below extrapolation of Shepard's (1963) curve that subsidence as well as sealevel rise may have occurred.

Emerged reef series, Australia

Shell (or shell and beachrock) from slightly emerged reefs on coast of Australia. All, except LJ-911, subm. 1964 by F. P. Shepard.

LJ-911. Emerged reef, Australia—1 **Modern—5% higher than 1850 wood**

Shell, of littoral origin, from beach on bench of *Thalassina* estuarine mudstone at 3.0 m above Indian Low Water Springs, on coast of Joseph Bonaparte Gulf, NW Australia (14° 50′ S Lat, 128° 52′ E Long). Coll. 1963 and subm. 1964 by Tj. H. van Andel (sample V-386).

LJ-949. Emerged reef, Australia—2 **1000 ± 140**
A.D. 950

Pelecypod (*Anadara trapezia*) valves from 3.0 to 3.7 m above present high-tide level, on southern shore of Deception Bay. Queensland (27° 08′ S Lat, 153° 04′ E Long). Coll. 1964 by P. J. Conaghan, Univ. of Queensland and F. P. Shepard (sample G.B.R. 1258).

LJ-950. Emerged reef, Australia—3 **1500 ± 160**
A.D. 450

Mixed shell and beachrock (remaining shell fragments id. by E. P. Chace, San Diego Nat. History Mus., as oyster, *Chama* cf. *fibula*, *Hipponyx australis*, *Cypraea* sp., and *Ricella* sp.), from high-tide level just S of N end of Facing Island, Gladstone, Queensland (23° 46′ S Lat, 151° 20′ E Long). Coll. 1963 by P. J. Conaghan (sample G.B.R. 1228; no. 8289).

LJ-951. Emerged reef, Australia—4 **1510 ± 170**
A.D. 440

Pelecypod (*Notospisula trigonella*) valves from emerged shell bed, 2.4 to

3.0 m above high-tide level, on Deception Bay, Queensland (27° 08′ S Lat, 153° 04′ E Long). Coll. 1964 by P. G. Conaghan and F. P. Shepard (sample G.B.R. 1257).

LJ-952. Emerged reef, Australia—5 **760 ± 140** **A.D. 1190**

Pelecypod (*Anadara trapezia*) valves taken at extreme high-tide level on Deception Bay, Queensland (27° 08′ S Lat, 153° 04′ E Long). Coll. and subm. same as for LJ-951 (sample G.B.R. 1256).
General Comment: subm. to test possible eustatic rise in sealevel, as claimed by Fairbridge (1958), largely on basis of data from Australia. Other C^{14} dates by La Jolla Lab. for reefs in Australia are: LJ-128 and 130, each 900 ± 150, La Jolla I and LJ-451, 3980 ± 150, La Jolla III. It is possible that the shells, taken at and near high-tide level, are adventitious, due to storm or human action.

F. Northern Ireland

Six samples of organic material from 2 uncompacted 12.7-cm cores (Monoliths II and III) through Postglacial deposits at Woodgrange, Co. Downs, near mouth of River Quoile, close to highest tide limit (54° 20′ 10″ N Lat, 05° 45′ 30″ W Long). Coll. and subm. 1963 by Gurdip Singh, then of Queen's Univ., Belfast.

Late Quaternary series, Northern Ireland

LJ-903. Late Quaternary, Northern Ireland—2 **6550 ± 300** **4600 B.C.**

Organic content in clay from depth of 0.89 to 0.94 m in Monolith II (sample 1). *Comment*: section of core interpreted as "marine clay from Transgression Contact."

LJ-904. Late Quaternary, Northern Ireland—3 **7650 ± 400** **5700 B.C.**

Peat from depth of 1.19 to 1.21 m in Monolith II (sample 2). *Comment*: peat contained 1st diatoms and histichospheres; interpreted as at Transgression Contact.

LJ-905. Late Quaternary, Northern Ireland—4 **270 ± 150** **A.D. 1680**

Fen peat from depth of 0.56 to 0.58 m in Monolith III (sample 3). *Comment*: interpreted as from Regression Contact.

LJ-906. Late Quaternary, Northern Ireland—5 **290 ± 150** **A.D. 1660**

Fen peat from depth of 0.58 to 0.60 m in Monolith III (sample 4). *Comment*: also interpreted as from Regression Contact.

LJ-907. Late Quaternary, Northern Ireland—6 **2710 ± 150** **760 B.C.**

Top of brackish clay, with fragments of shells, from depth of 0.68 to 0.78 m in Monolith III (sample 5).

LJ-908. Late Quaternary, Northern Ireland—7 **3380 ± 180**
1430 B.C.

Bottom of brackish clay, with fragments of shells, from depth of 1.00 to 1.02 m in Monolith III (sample 6).
General Comment: three additional samples, which proved insufficient for C^{14} measurement, are significant for interpretation of the column represented by Monolith III: sample 7, depth 1.14 to 1.16 m, middle of shell matrix; sample 8, depth 1.26 to 1.28 m, brackish clay-mud with abundant shells and organic matter; sample 9, 1.28 to 1.30 m, brackish clay-mud, with shells. Series date Transgression and Regression contacts of marine incursion in Co. Down. Singh indicates pollen results show that during Boreal time general sealevel rose by ca. mid-Atlantic time to within few m of present stand and that, during mid-Atlantic, rise apparently was very slow. However, pollen dates throw little light on when rise ceased or regression set in (if indeed regression occurred). Present tests suggest that marine influence has continued in Woodgrange basin ever since Boreal time. Lack of evidence of marine incursion above present highest tide level in area rules out higher sealevel here during any Postglacial time. Dates also bear on whether tides receded from basin (highest in River Quoile mouth area) simultaneously as from lower basins or whether recession preceded closure of river in 1775 by a dam that has caused formation of a fen-peat layer ca. 60 cm deep. Reindeer antler from lower horizon in same area dates 10,250 ± 350 (LJ-647, this list, VII). For another sealevel date in same region, for wood from a raised beach nearby on open coast, see Q-214, 8120 ± 135 (Cambridge II, p. 70); see also Morrison and Stephens (in press).

G. Brazil

LJ-970. Emerged reef, Brazil **4800 ± 250**
2850 B.C.

Oyster (*Ostrea arborea*) shells cemented to granitic rock 4.80 m above mean sealevel, 650 m from present coast, at Grotto de Morcega, Baia da Ribeira, Creek of Bracui, W of Rio de Janeiro (22° 57.0′ S Lat, 44° 25.6′ W Long). Coll. 1963 and subm. 1964 by J. R. Curray and F. Danciger (sample C-730, 2). *Comment*: species believed to live in intertidal to shallow water. Shells obviously not of midden origin. Sealevel stand higher than now is therefore indicated. Measurement appears to fall in line with 4 other dates, ranging from 1190 ± 130 to 3660 ± 170, on biogenous limestone and shell from 2.2 to 3.4 m above MLLW from near Recife, Brazil (van Andel and Laborel, 1964), and with evidence on Postglacial (Altithermal?) high sealevel stands suggested by other geologists (cited by van Andel and Laborel). Coastal instability is an alternative hypothesis. Replaces LJ-887 (gas sample inadvertently largely lost).

III. DEEP-SEA SEDIMENTS

A. Off Baja California

LJ-578. Sediment sample, Zapotec Expedition **>40,000**

Organic material from 30 cm of clay immediately overlying, at 5 to 6 m below surface, a sound-reflecting stratum consisting of quartz silt; taken in a sedimentary core in E Pacific Ocean, near Isla Guadalupe, Baja California Norte, México, at depth of 3530 m (28° 45′ N Lat, 117° 38′ W Long). Coll. 1960 by Gustaf Arrhenius and Enrico Bonatti on Scripps Inst. of Oceanography Expedition Zapotec; subm. by them 1962 (sample ZAPIP—Bottom). *Comment*: the extensive silt layer, thought to be eolian (Bonatti and Arrhenius, 1965), possibly equivalent to pre-Wisconsin loess (Arrhenius and Bonatti, 1965). Although younger loess layers occur on adjacent levels the date demonstrates that the silt, if equivalent to a loess, belongs to the older group, Mesa Verde >30,000 yr old. See LJ-601 and 602, this list (VI C).

B. Gulf of Alaska

Gulf of Alaska series

Samples dated from 3 depth levels (see General Comment) in a core (total length 142 cm) from depth of 3730 m on Tuft Abyssal Plain ca. 644 km W of Astoria, Oregon (47° 59.3′ N Lat, 134° 00.1′ W Long). Coll. and subm. 1963 by Y. R. Nayudu, Dept. of Oceanography, Univ. of Washington.

LJ-631. Globigerina ooze, Gulf of Alaska—1 **15,500 ± 600**
13,550 B.C.

LJ-632. Globigerina ooze, Gulf of Alaska—2 **21,950 ± 700**
20,000 B.C.

LJ-633. Globigerina ooze, Gulf of Alaska—3 **26,950 ± 1000**
25,000 B.C.

General Comment: dates test expectation of correlation with stages in Vashon glaciation of Puget lowlands. Results (Nayudu, 1964) follow:

LJ-No.	Level in Core, cm	Expected Correlation with Vashon Glaciation	Expected Date, B.P.	Measurement, B.P.
631	10-20	Close to end	ca. 11,000-12,000	15,500 ± 600
632	50-60	Middle stage	ca. 18,000	21,950 ± 700
633	130-140	Possibly beginning	ca. 26,000	26,950 ± 1000

C. Golfo de California

Bottom-sediment series, Golfo de California

Organic carbon (LJ-577, 579-591, 641, and 643), or organic plus carbonate carbon in gravity cores in sediments of Golfo de California, México. LJ-577 and 580 coll. 1961 and subm. 1962 by Tj. H. van Andel and S. E. Calvert; LJ-579 and 581-591 coll. 1961 and subm. 1962 by van Andel; LJ-637-644 coll. 1961 and subm. 1963 by Calvert.

LJ-577. Sediments in Golfo de California—1 **3560 ± 200**
1610 B.C.

Top 40 cm of core no. L-190P, 357 cm long, from depth of 1873 m in Guaymas Basin (27° 11.0′ N Lat, 111° 23.9′ W Long).

LJ-579. Sediments in Golfo de California—2 **2200 ± 150**
250 B.C.

Top 30 cm of mud core, no. R-79, 86 cm long, from depth of 1618 m (25° 07.7′ N Lat, 110° 25.1′ W Long).

LJ-580. Sediments in Golfo de California—3 **4670 ± 250**
2720 B.C.

Sec. at depth of 297 to 350 cm from core described under LJ-577.

LJ-581. Sediments in Golfo de California—4 **2730 ± 150**
780 B.C.

Top 20 cm of mud core, no. R-190, 104 cm long, from depth of 850 m (29° 39.0′ N Lat, 113° 56.0′ W Long).

LJ-582. Sediments in Goldo de California—5 **3260 ± 200**
1310 B.C.

Bottom 20 cm of core described under LJ-581.

LJ-583. Sediments in Golfo de California—6 **6270 ± 300**
4320 B.C.

Top 30 cm of core no. R-16, 89 cm long, from depth of 1372 m (22° 54.2′ N Lat, 106° 52.5′ W Long).

LJ-584. Sediments in Golfo de California—7 **17,250 ± 700**
15,300 B.C.

Bottom 25 cm of core described under LJ-583.

LJ-585. Sediments in Golfo de California—8 **5850 ± 250**
3900 B.C.

Bottom 25 cm of mud core, no. R-47, 100 cm long, from depth of 2820 m (23° 45.3′ N Lat, 108° 28.0′ W Long).

LJ-586. Sediments in Golfo de California—9 **2590 ± 125**
640 B.C.

Top 25 cm of core described under LJ-585.

LJ-587. Sediments in Golfo de California—10 **2250 ± 200**
300 B.C.

Top 75 g (dry weight) of core no. R-82 (top of core broken up), of layered diatomite, 85 cm long, from depth of 3164 m (25° 26.6′ N Lat, 109° 58.5′ W Long).

LJ-588. Sediments in Golfo de California—11 **3530 ± 170**
1580 B.C.

Bottom 20 cm of core described under LJ-587.

LJ-589. Sediments in Golfo de California—12 **4080 ± 200**
2130 B.C.

Bottom 25 cm of core described under LJ-579.

LJ-590. Sediments in Golfo de California—13 **5040 ± 250**
3090 B.C.

Top 25 cm of mud core, no. R-85, 170 cm long, from depth of 732 m (25° 40.0′ N Lat, 109° 41.0′ W Long).

LJ-591. Sediments in Golfo de California—14 **1430 ± 150**
A.D. 520

Bottom 25 cm of core described under LJ-590.

LJ-637. Sediments in Golfo de California—15 **3300 ± 150**
1350 B.C.

Top 39 cm (sample A) of core no. L-181P, of laminated sediment, 231 cm long, from depth of 787 m in N Guaymas Basin (28° 06′ N Lat, 112° 08′ W Long).

LJ-638. Sediments in Golfo de California—16 **3660 ± 150**
1710 B.C.

Sec. (sample B) at depth of 94 to 127 cm in core described under LJ-637.

LJ-639. Sediments in Golfo de California—17 **3710 ± 150**
1760 B.C.

Bottom 36 cm (sample C) of core described under LJ-637.

LJ-640. Sediments in Golfo de California—18 **2000 ± 200**
50 B.C.

Top 40 cm (sample A) of core no. L-66P, of laminated sediment, 440 cm long, from depth of 1604 m in S Guaymas Basin (26° 50′ N Lat, 110° 48′ W Long).

LJ-641. Sediments in Golfo de California—19 **5400 ± 200**
3450 B.C.

Sec. (sample B) at depth of 100 to 140 cm in core described under LJ-640.

LJ-642. Sediments in Golfo de California—20 **10,130 ± 400**
8180 B.C.

Sec. (sample C) at depth of 200 to 220 cm in core described under LJ-640.

LJ-643. Sediments in Golfo de California—21 **14,150 ± 600**
12,200 B.C.

Sec. (sample D) at depth of 300 to 340 cm in core described under LJ-640.

LJ-644. Sediments in Golfo de California—22 **11,500 ± 500**
9550 B.C.

Bottom 40 cm (sec. E) of core described under LJ-640.

General Comment: when samples are arranged from shallow to deep within cores and the cores are listed from north to south, age increases with depth within each core (with 2 exceptions, LJ-590 or 591 and LJ-643, perhaps due to inadvertent error) and this age differential decreases northward, reflecting more rapid sedimentation toward Colorado River:

Dated Sediment Cores from Golfo de California

N Lat, W Long	Depth, m	Core No.	Depth in Core, cm	LJ-No.	Date, B.P.
29° 39.0′ 113° 56.0′	850	R-190	0-20 84-104	581 582	2730 ± 150 3260 ± 200
28° 06′ 112° 08′	787	L-181P	0-39 94-127 195-231	637 638 639	3300 ± 150 3660 ± 150 3710 ± 150
27° 11.0′ 111° 23.9′	1873	L-190P	0-40 297-350	577 580	3560 ± 200 4670 ± 250

26° 50′ 110° 48′	1604	L-66P	0-40	640	2000 ± 200
			100-140	641	5400 ± 200
			200-220	642	10,130 ± 400
			300-340	643	14,150 ± 600
			400-440	644	11,500 ± 500
25° 40.0′ 109° 41.0′	732	R-85	0-25	590	5040 ± 250
			145-170	591	1430 ± 150
25° 26.6′ 109° 58.5′	3164	R-82	top 75g	587	2250 ± 200
			65-85	588	3530 ± 170
25° 07.7′ 110° 25.1′	1618	R-79	0-30	579	2200 ± 150
			61-86	589	4080 ± 200
23° 45.3′ 108° 28.0′	2820	R-47	0-25	586	2590 ± 125
			75-100	585	5850 ± 250
22° 54.2′ 106° 52.5′	1372	R-16	0-30	583	6270 ± 300
			64-89	584	17,250 ± 700

For the laminated diatomite (with one light, diatom-rich lamina coupled with one dark, clay-rich lamina), dates support the hypothesis that the paired laminations are annual varves (see thesis by Calvert, 1964).

IV. ANCIENT AND MODERN LAKES

A. Africa

Lake Nyassa sediment series

Organic-rich argillaceous sediment from dark-green gravity core taken near center of lake, both N–S and E–W (12° 18′ S Lat, 34° 23′ E Long). Coll. 1963 and subm. 1964 by R. P. Von Herzen (sample NY-3).

LJ-884. Sediments, Lake Nyassa, Africa—1 **2400 ± 200**
450 B.C.

Depth in core 0 to 7.6 cm.

LJ-885. Sediments, Lake Nyassa, Africa—2 **2540 ± 140**
590 B.C.

Depth in core 46 to 53 cm.

LJ-886. Sediments, Lake Nyassa, Africa—3 **2670 ± 200**
720 B.C.

Depth in core 86 to 94 cm.

General Comment: sample coll., in connection with heat-flow measurements, to determine rates of sedimentation. Samples from 3 different depths in the core were cut, sealed, and shipped in plastic core liner; when prepared for measurement 4 to 5 months later samples were still damp though probably somewhat dehydrated. Measurements are in correct sequence, but so close, and so old at top of core, as to raise questions about validity and significance of dates.

B. Coahuila, México

LJ-992. Cuatro Ciénegas Basin, Coahuila, México **2070 ± 250**
120 B.C.

Fibrous peat from depth of 2.25 to 2.35 m in core in Ojo de la Becerra, a spring-fed pond in W arm of interior-drainage portion of this desert basin

(26° 55.6′ N Lat, 120° 08.1′ W Long; Carta Geográfica de la República Mexicana, 1:500,000, sheet Jiménez 13 R-VI, 1958). Coll. and subm. 1964 by P. S. Martin, Geochronology Lab., Univ. of Arizona (sample 15 June 64, no. 1). *Comment*: this limestone basin is remarkable for high incidence of endemism among fishes and other aquatic organisms (Hubbs and Miller, 1965, and references therein) and for long period of human occupation (Taylor, 1956; see also Michigan III). Hence, date bears on evolutionary and archaeologic problems as well as on rate of pond filling. Martin regards date as roughly median for this pool.

C. Lake LeConte Basin, California and Baja California

LJ-928. Lake LeConte, Baja California Norte—2 >50,000

Freshwater mussel (*Anodonta californiensis*) valves from fragment of Pleistocene shoreline around tiny marble hillock barely outside contact between steep base of Sierra Cucopa and gently sloping bajada, ca. 20 km SW of Mexicali and ca. 29 km WNW of Cerro Prieto; alt ca. 22.0-24.5 m (32° 31.1′ N Lat, 115° 35.3′ W Long). Coll. and subm. 1964 by G. M. Stanley, Fresno State College, and C. L. Hubbs (sample 1964—III:24D). *Comment*: since this beach of a very ancient stage of Lake LeConte (Lake Cahuilla, Lake Coahuila, Blake Sea) lies higher than present sill of basin at Volcano Lake on low point of crest of Colorado River Delta, subsidence of delta and/or upthrust of marginal terrain has taken place since the lake existed here. Stanley (oral commun.) found southward downwarping of the fragmentary beaches (provisionally described by Thomas, 1963). Sedimentary and erosional features, as well as plentiful occurrence of *Anodonta* along with an occasional *Physa*, clearly stamp the horizon as a lake strand. Fragmentary and largely obscured nature of the beachline is consonant with age estimate. See LJ-954, also >50,000. Validity of dates based on *Anodonta* is considered on p. 69. The history of Lake LeConte is complex. The 30 measurements from the basin and tributary and adjacent areas are as follows (in chronologic sequence):

Date, B.P.	Lab. No. (Report)	Material	Lake Water
120 ± 200	M-598 (Michigan III)	Charcoal	Fresh
130 ± 200	M-597 (Michigan III)	Charcoal	Fresh
<200	LJ-17 (La Jolla I)	Charcoal	Fresh
220 ± 100	LJ-102 (La Jolla I)	Charred tules	Fresh
270 ± 60	UCLA-192 (UCLA II)	Charcoal	Fresh
300 ± 100	LJ-15 (La Jolla I)	Charcoal	Fresh
450 ± 200	M-596 (Michigan III)	Charcoal	Fresh
700 ± 150	LJ-16 (La Jolla I)	Charcoal	Fresh
760 ± 100	LJ-99 (La Jolla I)	Charcoal	Fresh
890 ± 140	LJ-965 (this list)	*Anodonta*	Fresh
960 ± 100	LJ-106 (La Jolla I)	Charcoal	Fresh
1000 ± 200	LJ-7 (La Jolla I)	Charcoal	Fresh
1010 ± 200	LJ-960 (this list)	*Anodonta*	Fresh
1440 ± 100	LJ-105 (La Jolla I)	Charcoal	Fresh
1510 ± 180	LJ-530 (La Jolla III)	Tufa	Fresh
1580 ± 200	LJ-101 (La Jolla I)	Charcoal	Fresh
1800 ± 200	LJ-513 (La Jolla III)	Tufa	Fresh
1890 ± 500	LJ-458 (La Jolla III)	Tufa	Fresh
3970 ± 100	UCLA-190 (UCLA II)	*Tagelus*	Salt
4980 ± 100	UCLA-117 (UCLA I)	Charcoal	Fresh?
9630 ± 300	LJ-528 (La Jolla III)	Gastropods	Fresh

13,040 ± 200	LJ-457 (La Jolla III)	Tufa	Fresh
24,900 ± 800	UCLA-116 (UCLA I)	Wood	Fresh?
32,200 ± 2000	UCLA-189 (UCLA II)	*Rangia*	Brackish
37,100 ± 2000	LJ-504 (La Jolla III)	*Physa*	Fresh
37,400 ± 2000	LJ-959 (this list)	Tufa	Fresh
>35,000	LJ-450 (La Jolla III)	Tufa	Fresh
>45,000	LJ-532 (La Jolla III)	Wood	Fresh?
>50,000	LJ-928 (this list)	*Anodonta*	Fresh
>50,000	LJ-954 (this list)	*Anodonta*	Fresh

LJ-954. Lake LeConte, Baja California Norte—3 >50,000

Freshwater mussel (*Anodonta californiensis*) valves (mostly fragmentary) from gentle N slope of bottom draw of alluvial sill of LeConte Basin on W side of Colorado River Delta desert region, between Cerro Prieto and Sierra Cucopa, a few m below summit of sill; alt 26 to 27 m (ca. 32° 15′ N Lat, ca. 115° 20′ W Long). Coll. and subm. 1964 by G. M. Stanley, Fresno State College, and C. L. Hubbs (sample 1964—III:25C). *Comment*: occurrence of *Anodonta* (with traces of *Physa* sp. and *Helisoma ammon*) and of gravel rounded and polished by current or wave action suggests great antiquity for shells and very different morphology in the Pleistocene. Stanley (oral commun.) is testing hypothesis that the sill represents ancient deposits of Colorado River, which may have discharged through this region prior to downwarping of delta (sill of LeConte Basin on E side of Cerro Prieto, in Volcano Lake area, now has alt of only ca. 13 m). Whole Delta area appears to have been very active tectonically, and volcanism continues. Around LeConte Basin many remnants are being found (Thomas, 1963; Stanley, ms.) of now elevated beachlines of Pleistocene stages of Lake LeConte (see LJ-928, above). Occurrence of beach remnants higher than present alt W of Cerro Prieto suggests that Pleistocene sill of LeConte Basin may have been farther S and that Delta region has been markedly downwarped toward the S.

LJ-959. Lake LeConte, California—14 37,400 ± 2000
35,450 B.C.

Tufa from shoreline of Lake LeConte, in SW corner of Sec. 27 a little E of W 1/4 post, T 16 S, R 11 E, Imperial Co.; alt 43.05 m (32° 44.85′ N Lat, 115° 49.75′ W Long; USGS Yuha Basin Quadrangle, 7.5′ series, 1957). Coll. 1963 and subm. 1964 by G. M. Stanley (sample no. 10 tufa at Observation 6). *Comment*: another C^{14} measurement for a remnant of one of several Pleistocene strandlines of Lake LeConte (see LJ-928, above, for summary treatment). Tufa coats the large rounded beach stones on foreslope of a Pleistocene gravel bar. Stanley is preparing a report on paleohydrography of Colorado River Delta region, including LeConte Basin.

LJ-960. Lake LeConte, California—15 1010 ± 220
A.D. 940

Freshwater mussel (*Anodonta californiensis*) valves from Lake LeConte shoreline, at alt ca. 13 m, ca. 2.4 km W of Truckhaven, Imperial Co. (ca. 33° 17′ 30″ N Lat, ca. 116° 00′ 00″ W Long; W border of USGS Truckhaven Quadrangle, 7.5′ series, 1956). Coll. 1954 by C. L. and L. C. Hubbs and B. E. McCown; subm. 1964 (sample 1954—X:17E). *Comment*: to establish another date for a late high (outlet) stage of the lake, and to cross-check measurements on *Anodonta* and tufa. Correspondence is moderately close (LJ-530, 1510 ± 180, La Jolla III, was based on associated compact, nodular tufa thinly covering upper surface of cobbles). For review of Lake LeConte datings see LJ-928. See also discussion (on p. 89) of datings based on *Anodonta*. This lake level is associated with abundant evidence of human occupation.

LJ-965. Fish Creek, San Diego Co., California—2 **830 ± 140**
A.D. 1120

Freshwater mussel (*Anodonta californiensis*) valves from hearth site in angle of headwater forks of Fish Creek, in arid Fish Creek Mts., in drainage basin of Salton Sea (USGS Carrizo Mountain Quadrangle, 15′ series, 1952). Coll. 1954 by C. L. Hubbs, B. E. McCown, and party and subm. 1964 (sample 1954—XI:27B). *Comment*: subm. to cross-check dating from *Anodonta* and charcoal (LJ-7, 1000 ± 200, La Jolla I); see also p. 89, this list. Inferences on past habitation, greater rainfall, and past fauna stated under LJ-7 are pertinent to this measurement.

D. California

Tree stump series, Lake Tahoe

Samples from 3 of the many stumps in water along SW shore of lake, which at time of collection had alt 1897 m (ca. 38° 56′ N Lat, ca. 120° 04′ W Long). Coll. 1961 by J. F. Hannaford, L. A. Mullnix, and R. T. Bean; subm. 1962 by M. B. Andrew (all of California Dept. of Water Resources).

LJ-604. Tree stump, Lake Tahoe, California—2 **4460 ± 250**
2510 B.C.

Wood (Specimen A, from Stump 5), id. by R. A. Cockrell, School of Forestry, Univ. of California, Berkeley, as apparently a type of cedar, from stump ca. 1.1 m in diam (age by superficial ring count ca. 250 yr), in water ca. 35 cm deep, just off Kiva Picnic Area of Baldwin Beach. Stump, one of 11 in group, had weathered bottom portion imbedded in lake sediments; the sharp tip barely emerged.

LJ-605. Tree stump, Lake Tahoe, California—3 **4250 ± 200**
2300 B.C.

Pine wood (Speciment C, from Stump 6, described in detail under LJ-503, 4790 ± 200, La Jolla III). *Comment*: inadvertent re-run of same sample. Younger date now obtained seems more precise, because measurement of 4250 ± 200 run on the Bern Counter was duplicated by one of 4243 ± 200 run on the Brussels Counter (see discussion in Introduction to La Jolla III), because both counters were stable at the time, and because the counter was less than optimally stable when LJ-503 was run.

LJ-608. Tree stump, Lake Tahoe, California—4 **<300**
Since A.D. 1650

Wood (Specimen B, from Stump 2), readily pulled, above water surface, from submerged stump standing in ca. 30 cm of water just off SW shore of lake at Old Tallac Resort. *Comment*: specimen was assumed to be a knot, but

the squared-off (sawed?) end suggests that the knot was driven into the trunk; date confirms this view.
General Comment: submergence is implied, but cause is unclear. Except for LJ-608 (wood adventitious) the dates are consistent. Significance is discussed under LJ-503, 4790 ± 200, La Jolla III. Staff of California Dept. of Water Resources is preparing for publication a paper on submerged stumps of Lake Tahoe (M. B. Andrew, personal commun.). For similar measurement for Lake Mono, California see UCLA-118, 920 ± 90 (UCLA I).

Tree stump series, Eagle Lake

Wood from stranded stumps along shore of Eagle Lake, Lassen Co., California (ca. 40° 33′ N Lat, 120° 47′ W Long). Coll. 1961 by J. F. Hannaford and R. T. Bean, and subm. 1962 and 1963 by M. B. Andrew.

LJ-606. Tree stump, Eagle Lake, California—2 **<300**
Since A.D. 1650

Wood (Specimen Z) removed from another portion, probably from the root, of Stump 1, described under LJ-501, 440 ± 110, La Jolla III, one of many stranded on S and W shores of Eagle Lake. *Comment*: discussion under LJ-501 (*q. v.*) pertains to same trunk.

LJ-610. Tree stump, Eagle Lake, California—3 **<300**
Since A.D. 1650

Wood (Specimen X) from Stump 3, 0.9 m diam, 6.1 m above water surface at time of collection; vicinity of Gallatin Beach at S end of lake.

LJ-649. Tree stump, Eagle Lake, California—4 **<300**
Since A.D. 1650

Wood (Specimen W) from Stump 5, 0.6 m in diam, 4.9 m above water surface at time of collection; vicinity of Gallatin Beach at S end of lake. *Comment*: replaces LJ-613 (gas sample inadvertently lost).
General Comment: see LJ-501, 440 ± 110, La Jolla III, *re* stranding of stumps around Eagle Lake, following period of flooding within last few hundred yr. Excellent state of preservation of wood, despite long flooding, and stranding for ca. 35 yr, is consistent with date.

LJ-902. Pluvial Lake Mono, California **21,900 ± 600**
19,950 B.C.

Lithoid tufa from highest sharply marked beachline (here at alt 2055 m) in Mono Basin, close to route into Adobe Valley near low point on rim between the basins; Inyo Co. (ca. 38° 03′ N Lat, 118° 46′ W Long; USGS Trench Canyon Quadrangle, 7.5′ series, 1958). Sample from surface of caprock, 1.5 m thick and comprising strata, ca. 1 dm thick, with many freshwater shells. Coll. and subm. 1964 by Ruth D. Simpson, Southwest Mus. *Comment*: Putnam (1949, p. 1295-1296) correlated this shoreline with the Tioga glacial unit; date suggests shoreline is early Tioga, as interpreted by Flint and Gale (1958) for Lake Searles, in same Pluvial drainage system (Miller, 1946). This shoreline, according to Putnam, is only slightly lower than one that he correlated with the Tahoe stage and that appears to represent an outlet from Pluvial Lake

Mono (for which Putnam accepted a preoccupied name, Lake Russell) into Adobe Valley, site of the shallow Pluvial Lake Adobe, which discharged into the Lake Owens system (Hubbs and Miller, 1948, p. 78-79, fig. 20). Date may bear on human occupation of Lake Mono shoreline, suggested by occurrence of crude artifacts.

Pluvial Lake Panamint series

Fourteen carbonate samples from Pleistocene shorelines in N (blind-end) part of basin of Lake Panamint, Inyo Co., California. Positions determined from USGS Panamint Butte and Maturango Peak quadrangles, 15′ series, 1951. Coll. 1963 by E. L. Davis, Univ. of California, Los Angeles, C. L. Hubbs, *et al.*; subm. 1964.

LJ-973. Lake Panamint, California—1 **>50,000**

Freshwater snail (*Carinifex newberryi*) shells sifted from almost pure $CaCO_3$ marly silt underlying bench fragment topped with tufa-containing beach material (subsample A, LJ-983), on steep E slope of N basin of Panamint Valley at estimated alt 565 m; ca. 2.0 km NNE of N end of Lake Hill (36° 25′ 04″ N Lat, 117° 23′ 50″ W Long). Sample 1963—III:22E, subsample B.

LJ-977. Lake Panamint, California—2 **13,000 ± 700**
11,050 B.C.

Fine-grade, highly vescicular, and coarsely fibrous tufa from lowest shoreline of N basin; near base of W side, near S end, of Lake Hill (just above present playa); alt ca. 475 ± 5 m (36° 22′ 43″ N Lat, 117° 24′ 12″ W Long). Sample 1963—III:22D. *Comment*: this, the most recent lake stage encountered, represents a slight refilling of only the smaller, N basin, almost surely contemporaneously with occupation of shoreline by man using stone implements (smaller and more finely flaked than those attributed by some to earlier shoreline occupants of such lakes as Panamint and Manix) comparable to those fashioned by apparently contemporaneous folk around Coyote Embayment of Lake Manix (see LJ-958, 13,800 ± 600, this list) and around Lake Mohave (see below). Well-preserved though delicate structure of tufa appears to have been formed from a *Chara* base (itself calcareous).

LJ-979. Lake Panamint, California—3 **24,750 ± 1300**
22,800 B.C.

Unconsolidated marly silt (>99% $CaCO_3$), from which shells used for LJ-973 were sifted (identical data; same sample and subsample). *Comment*: marl appears to be much younger than shells (LJ-973, >50,000), as though shells represent a reworking of an older lake stage at about the same level, as indicated under General Comment. See also LJ-983 and 991, from same station.

LJ-980. Lake Panamint, California—4 **>35,000**

Lithoid tufa, labelled as from outermost part of a broken-off piece ca. 0.2 m thick, on E side of Panamint Valley 7.5 km SE of S end of playa of N basin, on lower slope of NE bajada at alt 615 m (36° 15′ 14″ N Lat, 117° 18′ 36″ W Long). Sample 1963—III:23E. *Comment*: sample was selected, with LJ-982, to obtain date(s) for highest clear-cut strandline and to measure rate of tufa formation. Confusion in data may have led to transposition that would explain the gross apparent inversion of dates for LJ-980 and 982 (see tabulation under General Comment). Alternatively perhaps the inner and outer surfaces were misinterpreted. The thick tufa deposit used for these measurements may well have been formed during 2 or more separate lake stages, as hypothesized for similar tufa on Travertine Rock in Lake LeConte (LJ-457, 13,040 ± 200; LJ-458, 1890 ± 500; and LJ-513, 1800 ± 200, La Jolla III).

LJ-981. Lake Panamint, California—5 >50,000

Freshwater snail (*Carinifex newberryi*) shells from beach of Lake Panamint on E slope of N basin, in Panamint Valley at alt ca. 549 m, in NE 1/4 Sec. 27, T 17 S, R 24 E (36° 25′ 47″ N Lat, 117° 24′ 25″ W Long). Sample 1963—III:23C. *Comment*: confirmation of the great antiquity and probable reworking of this and other mollusc shells of the ancient lake (see LJ-973); as also for LJ-985, >45,000, below. At this Station (4), as for Station 2 (see LJ-973), tufa on overlying beach stones (LJ-984, 32,300 ± 1600) yields a younger date.

LJ-982. Lake Panamint, California—6 18,600 ± 1000
16,650 B.C.

Lithoid tufa, labelled as from innermost part of same piece described under LJ-980. *Comment*: possible transposition of material or data offers only reasonable explanation for apparent inversion, as noted under LJ-980.

LJ-983. Lake Panamint, California—7 17,100 ± 900
15,150 B.C.

Lithoid tufa, mixed whitish and slaty, with a few shells in each type, from same Station (2) as LJ-973 (same data); from surface of small level bench ca. 5 m higher than a larger level area, at estimated alt of 570 m; overlying LJ-973 and stratigraphically above LJ-979 and 991, below (see comparison in General Comment). Sample 1963—III:22E, subsample A. *Comment*: suggests Lake Panamint was filled at least once during Tioga glacial stage. Tufa is logically dated younger than underlying marl and shell.

LJ-984. Lake Panamint, California—8 32,300 ± 1600
30,350 B.C.

Lithoid tufa from surface at Station 4, described above under LJ-981 (same data; same sample). *Comment*: as for LJ-983, tufa yields a younger date than underlying marl and snails, but this tufa was seemingly derived from a Tahoe rather than a Tioga glacial age. Each lot of tufa represents a deep but intermediate lake stage, well below an outlet stage, represented by Station 1 (LJ-980 and 982).

LJ-985. Lake Panamint, California—9 >45,000

Freshwater snails (*Carinifex newberryi*) from Pleistocene beach on E slope of Panamint Valley near S end of N basin, at alt ca. 565 m (36° 14′ 54″ N Lat, 117° 19′ 16″ W Long). Sample 1963—III:24A. *Comment*: another indication of the great antiquity of at least this species, among the several highly variable snails of the lake (see also LJ-973, >50,000 and LJ-981, >50,000).

LJ-986. Lake Panamint, California—10 **>40,000**

Marly silt (almost entirely $CaCO_3$) from Station 4, described above under LJ-981 (same data; same sample). *Comment*: as indicated in tabulation in General Comment marly silt agrees with associated compacted marl (LJ-987) and shells (LJ-981) in being too old to date by C^{14}, although closely overlying and obviously younger tufa (LJ-984) maintained enough activity to indicate a probable date (32,300 ± 1600).

LJ-987. Lake Panamint, California—11 **>40,000**

Compacted marl with a few shells from Station 4, described above under LJ-981 (same data; same sample). *Comment*: same as for LJ-986.

LJ-989. Lake Panamint, California—12 **22,530 ± 1200**
20,580 B.C.

Red tufa from surface of Panamint Valley, at Station 3, E side near S end of N basin; alt ca. 549 m (36° 14′ 54″ N Lat, 117° 19′ 16″ W Long). Sample 1963—III.24B. *Comment*: another date for Lake Panamint based on tufa; somewhat older than other dates for what is thought to be Tioga glacial age, but younger than those thought to represent Tahoe glaciation (see tabulation in General Comment). Again, surficial tufa dates younger than *Carinifex* (see LJ-985, above) from immediately underlying, and therefore older, beach deposit.

LJ-990. Lake Panamint, California—13 **31,480 ± 1600**
29,430 B.C.

Lithoid tufa from near S end of N basin of Panamint Valley on S side of former outlet of N basin, ca. on Sec. 20–29 line, T 19 S, R 43 E; alt ca. 503 m (36° 15′ 39″ N Lat, 117° 20′ 20″ W Long). Sample 1963—III:23D. *Comment*: provides a date probably near the termination of Tahoe time.

LJ-991. Lake Panamint, California—14 **32,900 ± 1700**
30,950 B.C.

Pure, whitish, compacted marl from narrow stratum buried ca. 5 m in beach bar truncated by remnant of a beach bench (stratum dips ca. 10° to W; ca. 5 m lower than LJ-973 and 979, ca. 10 m lower than LJ-983; estimated alt 560 m; location as described above, under LJ-973. Sample 1963—III:22E, subsample C. *Comment*: another Panamint date attributable to Tahoe stage. Dip of the bed is not surprising as location is just SW of a prominent fault trench.

General Comment: these 14 measurements were designed to date the obviously multiple stages of this Pluvial lake, in the ancient Death Valley drainage system, intervening between Lake Searles and sump basin of Lake Manly (Miller, 1946; Hubbs and Miller, 1948; Smith and Pratt, 1957; Feth, 1961, 1964; Snyder, Hardman, and Zdenek, 1964). Pluvial history of this lake seems to, and should, agree with that of Lake Searles (Flint and Gale, 1958), because Lake Panamint presumably filled only when Lake Searles overflowed. There should also be correlations with Lake Manly. Lake Panamint dates, arranged first by stations, from high to low alt; then, within localities, from old to young:

Station	Approx. alt, m	Material	LJ-No.	Date, B.P.
1	615	Lithoid tufa[1] Outer (?)	980	>35,000
		Lithoid tufa[1] Inner (?)	982	18,600 ± 1000
2	565	Snails (*Carinifex*)	973	>50,000
	560	Firm marl; a few shells	991	32,900 ± 1700
	565	Unconsolidated marl (>99% $CaCO_3$)	979	24,750 ± 1300
	570	Lithoid tufa	983	17,100 ± 900
3	565	Snails (*Carinifex*)	985	>45,000
	549	Red tufa	989	22,530 ± 1200
4	549	Snails (*Carinifex*)	981	>50,000
		Carbonate silt	986	>40,000
		Compacted marl	987	>40,000
		Lithoid tufa	984	32,300 ± 1600
5	503	Lithoid tufa	990	31,480 ± 1600
6	475 (±5)	Vesicular tufa (*Chara* base?)	977	13,000 ± 700

[1] The 2 samples from Sta. 1 were likely somehow transposed (see LJ-980).

Tabulated dates confirm multiplicity of stages (fillings) of Lake Panamint, extending from beyond C^{14} dating (LJ-973, etc.) to subterminal Glacial and Pluvial time (LJ-977). High, presumably outlet stages continued until ca. mid-Vashon time (LJ-979, 982). If dates based on snails (*Carinifex* used) and tufa approach validity, as appears probable, these molluscs represent rewash and redeposit from earlier stage(s). Dwight W. Taylor, U. S. Geol. Survey, an authority on Quaternary molluscs of Western lakes, concurs in this view (personal commun.). At Station 2 the marly silt is intermediate in age between shells and younger overlying tufa. At Station 4 tufa dates later than either snails or silt. The small and thin yet still nacreous shells were thoroughly broken to facilitate removal of all adhering silt, internal as well as external. They were then treated briefly with dilute HCl to remove powdery shell material and finally boiled in NaOH, as were tufa samples.

LJ-895. Lake Manix shoreline, California—2 **30,950 ± 1000**
29,000 B.C.

Wave-rounded tufa fragments within 10 m of top of Afton bar of ancient Lake Manix, in Mohave Desert of San Bernardino Co., where the level sharp ridge becomes disrupted very close to S end of bar, ca. 1.5 km N of Afton Canyon, in N-central part of Sec. 17, T 11 N, R 6 E; alt ca. 535 m (35° 02′ 40″ N Lat, 116° 22′ 05″ W Long; USGS Cave Mountain 15′ Quadrangle. 1948). Coll. 1963 by R. D. Simpson, Southwest Mus. and C. L. and L. C. Hubbs; subm. 1964 (sample 1963—I:18B). *Comment*: top of bar represents an older lake stage, and lies ca. 30 m higher than a flat bench on slope of bar. On the bench the clasts are coated with tufa, probably correlative with the tufas dated by LJ-269, 19,500 ± 500, La Jolla II and UCLA-121, 19,300 ± 400, UCLA I. The new evidence may counter the indication (Blackwelder and Ellsworth, 1936) of a lake stage higher and *later* than the one probably represented by LJ-269 and UCLA-121. Date may represent termination of a Tahoe stage of Lake Manix (on the basis of the suggested pluvial chronology of Lake Searles, as proposed by Flint and Gale, 1958). It is possible that the high lake stage(s) seemingly associated with the Paleo-Indian Manix Lake Lithic Industry (Simpson, 1958) may be much older than ca. 19,000 to 20,000 yr; however, it may be younger (a relatively late lake stage, associated with less massive and more refined Pinto type implements, but at approx. same alt, is treated below under LJ-958). The hydrographic and archaeologic data were treated more extensively in LJ-269, La Jolla II.

LJ-958. Lake Manix shoreline, California—3 **13,800 ± 600**
11,850 B.C.

Freshwater mussel (*Anodonta californiensis*) valves from shoreline of Pleistocene Lake Manix at alt ca. 536 m, NE of Coyote Lake (playa), near S border near middle of Sec. 8, T 11 N, R 3 E, San Bernardino Co. (35° 03′ 13″ N Lat, 116° 41′ 02″ W Long; USGS Alvord Mountain Quadrangle, 15′ series, 1948). Coll. 1963 by R. D. Simpson; subm. 1964. *Comment*: first C^{14} measurement for a stage of Lake Manix presumably later than those previously dated (see LJ-269, 19,500 ± 500, La Jolla II; UCLA-121, 19,300 ± 400, UCLA I; and LJ-895, 30,950 ± 1000). Stage represented by LJ-958 is associated in region of Coyote Lake embayment of Lake Manix with the refined "Pinto Basin type implements" that contrast with massive, crude, Paleolithic-type artifacts that elsewhere occur above ca. 545 m, in presumed relation with earlier lake stages (Simpson, 1958). Probably during at least two stages Lake Manix provided a habitat favorable for aboriginal populations, supplying not only abundance of water but also food: freshwater mussels were probably consumed; cyprinid fishes and waterfowl no doubt abounded. Validity of measurements based on *Anodonta* is discussed on p. 69.

Pluvial Lake Mohave series

Tufa beachline near NW corner of this Pleistocene lake, now represented by a playa (Silver Lake); near middle of E side of a small gravel pit within tip of ancient lava promontory, 2.35 km slightly S of W from Silver Lake Station, in SW ¼ Sec. 21, T 15 N, R 8 E, San Bernardino Co. (35° 22′ 00″ N Lat, 116° 08′ 23″ W Long; USGS Baker Quadrangle, 15′ series, 1956) (specifications corrected from those given under LJ-200, La Jolla II). Coll. 1963 by R. D. Simpson and C. L. Hubbs; subm. 1964 (sample 1963—I:18A). Smooth base of the quarry area is close to the 920-ft (280-m) contour of the topographic sheet. At point of collecting, several successive, close-set beachline strata are exposed in the subvertical quarry wall, including the 2 streaks rich in *Anodonta californiensis* referred to under LJ-200, La Jolla II. Upper streak, running 1 to 2 m above quarry floor and 0.5 to 1.0 m below lip of borrow pit cut, was fixed as baseline for sighting-level determinations, from near middle of length of exposed section. The exposed beach strata, totaling 1.3 m, provided subsamples 2 to 6, utilized for LJ-930-935; subsample 1, of tufa, for LJ-929, came from 3.0 to 4.5 m above stated base, on lower part of steepening slope; such tufa abounded from the 3.0-m level to lip of exposed strata, but only traces remained at 6 m above base (at higher levels deposits seemed to be caliche). The 7.5-m level approximated a wave-cut notch that seemed to represent highest water-line. In exposed area the strata seem to form a gentle anticline (in cross-section of a bar?); exposure is thickest and highest toward the S and each stratum drops ca. 0.6 m in 10 m.

LJ-929. Pluvial Lake Mohave, California—2 **8350 ± 300**
6400 B.C.

Comment: subsample 1 (see above description of site) was interpreted as the youngest and as representing a previously unrecognized late high stage (refilling?) of Lake Mohave.

LJ-930. Pluvial Lake Mohave, California—3 **10,870 ± 450**
8920 B.C.

Subsample 2, of tufa, representing upper of the 2 exposed beachline streaks with a thick accumulation of freshwater mussels (*Anodonta californiensis*); the stratum, 1 to 2 cm thick, also contains beach-rolled tufa and a few *Physa* shells. Above and below, soil is largely of gravel. This stratum truncates and covers gravel and in turn is covered by tufa-coated gravel and cobble containing only scattered *Anodonta* shells. *Comment*: *Anodonta* from same stratum is dated 10,260 ± 400 (LJ-932). Two other runs on *Anodonta* from the same streak have yielded dates in fair agreement (see General Comment).

LJ-931. Pluvial Lake Mohave, California—4 **13,190 ± 500**
11,240 B.C.

Subsample 3, of tufa, from stratum ca. 1.0 m below upper and ca. 0.3 m below lower *Anodonta* stratum. Tufa was chipped from abundant *in situ* coating on cobbles of fanglomerate-like bar material. *Comment*: this lowest and oldest beach stratum was truncated above by the lower *Anodonta* stratum, apparently of almost the same age.

LJ-932. Pluvial Lake Mohave, California—5 **10,260 ± 400**
8310 B.C.

Subsample 2, of *Anodonta californiensis* (for data see LJ-930, above). *Comment*: shells for LJ-932 and 933 were carefully cleaned and were treated to remove any powdery material overlying the nacreous aragonite. See General Comment.

LJ-933. Pluvial Lake Mohave, California—6 **13,670 ± 550**
11,720 B.C.

Subsample 4, of *Anodonta californiensis* shells, which represent, along with some shells of *Gyraulus* and *Helisoma*, the thin, sandy lower *Anodonta*-rich streak that truncates a cobble layer (see LJ-929), from which it is separated by an eroded surface; it is covered by a gravel-cobble deposit (see LJ-934), which in turn was later truncated and covered by the upper *Anodonta* layer (see LJ-930, 932, etc.). *Comment*: this streak seemingly represents a brief lake stand. Date agrees with I-443, 13,150 ± 350, reported for same layer under LJ-200 (La Jolla II).

LJ-934. Pluvial Lake Mohave, California—7 **11,630 ± 500**
9680 B.C.

Subsample 5, of tufa, representing the gravel-cobble stratum intervening between the 2 beach levels rich in *Anodonta*. *Comment*: intermediate date is consonant with stratigraphy.

LJ-935. Pluvial Lake Mohave, California—8 **9160 ± 400**
7210 B.C.

Subsample 6, of tufa, overlying upper *Anodonta* stratum (see LJ-930 and 932), and consisting largely of gravel and cobbles, with only scattered *Anodonta* shells. *Comment*: wave-rounded tufa fragments (sampled ca. 0.3 m above the *Anodonta* streak) showed tufa growth all around the nuclei, obviously because the pieces were rolling. This was uppermost of exposed strata, and date, consistent with stratigraphy, is youngest except for higher tufa that represents a later and higher stand (see LJ-929).
General Comment: dates obtained to supplement 3 previous measurements of terminal or subterminal stage(s) of Lake Mohave, a dilation of Pluvial Mohave River (one of the 3 main feeders of Lake Manly—see Miller, 1946, Hubbs and Miller, 1948, Warren and De Costa, 1964, and references cited under LJ-200, La Jolla II). Each of the largely sandy *Anodonta* streaks represents a brief lake stand, but, as Warren and De Costa (1964) claimed, does not represent a mass mortality associated with terminal desiccation of Lake Mohave. Dates obviously comprise a sequence, with the lowest the oldest; whether mere fluctuations in lake level or successive fillings were involved is not evident. Datings so far obtained confirm field interpretations and form a consistent series between one another and between those based on tufa and on *Anodonta*:

Age Sequence	Test No. (& subsample)	Reported in	Material	Date, B.P.
1	LJ-931(3)	This list	Tufa	13,190 ± 500
2	I-443 (Isotopes, Inc.)	La Jolla II (under LJ-200)	*Anodonta*	13,150 ± 350
	LJ-933(4)	This list	*Anodonta*	13,670 ± 550
3	LJ-934(5)	do.	Tufa	11,630 ± 500
4	LJ-930(2)	do.	Tufa	10,870 ± 450
	LJ-200	La Jolla II	*Anodonta*	9640 ± 240
	LJ-932(2)	This list	*Anodonta*	10,260 ± 400
	I-444 (Isotopes, Inc.)	La Jolla II (under LJ-200)	*Anodonta*	10,000 ± 300
5	LJ-935(6)	This list	Tufa	9160 ± 400
6	LJ-929(1)	do.	Tufa	8350 ± 300

Validity of dates based on *Anodonta*, here and elsewhere, is discussed on p. 69. See further remarks under LJ-200 (La Jolla II), with special reference to associated archaeology and paleoclimatology.

V. PEDOGENESIS AND ALLUVIATION

Several of the measurements entered in sections II, VI B, and VIII bear on these processes.

A. California

LJ-612. Buried tree, Siskiyou Co., California **450 ± 200**
A.D. 1500

Wood from near top of pine (*Pinus ponderosa*) stump buried in mudflow from Mt. Shasta, 3.2 km E of McCloud Lumber Co. Sawmill along McCloud

River Railroad, then 457 m directly N; Sec. 33, T 40 N, R 2 W (41° 16′ N Lat, 122° 05′ W Long). Coll. 1960 and subm. 1963 by Hans Jenny, Soils and Plant Nutrition Dept., Univ. of California, Berkeley (sample 1). *Comment*: age of mudflows previously estimated at 60 yr from dendrochronology. C^{14} date is preferred because it agrees with amount of nitrogen accumulated in the soil. Mudflows from Mt. Shasta were studied from standpoint of development of soil profiles and ecosystems by Dickson and Crocker (1953 a–b, 1954). "Further studies by Jenny and Glauser have cast doubt on the validity of the ages of the mudflows given by the above authors in 1953 . . . . the tree sampled grew on a surface older than flow B. From its position we conclude that the tree was killed by the deposition of flow B." Date yields "valuable information on the rates of soil formation."

B. México

Soil series, Sonora

Buried wood from soil in coastal plain of NW Sonora. Coll. and subm. 1964 by J. R. Curray and T. R. Walker.

LJ-888. Coastal plain, NW México—1 **320 ± 150**
A.D. 1630

Twigs from depth of 30 to 35 cm in gravel pit on NW side of Kino–Hermosillo Highway, 8.9 km NE of junction with Calle 4 (28° 52.8′ N Lat, 111° 19.8′ W Long). Sample C-727. *Comment*: horizon with twigs was thought to antedate deposition of Holocene silt widely covering lower Costa de Hermosillo, and to represent the "A_O" horizon of underlying soil, which probably continued to form until inundation by the silt.

LJ-889. Coastal plain, NW México—2 **190 ± 120**
A.D. 1760

Wood from depth 0 to 5 cm in gravel pit described under LJ-888 (same sample no.). *Comment*: from silt layer thought to be Holocene, but pre-modern. Dates for the two levels are in correct sequence, but younger than expected.

LJ-890. Coastal plain, NW México—3 **290 ± 130**
A.D. 1660

Wood from log buried in gravel pit 16 km NW of Santa Ana, on N side of Highway 2 (30° 35′ N Lat, 111° 19′ W Long). Sample C-725. *Comment*: believed possibly early Wisconsin, covered by widespread, supposedly mid-Wisconsin soil.

General Comment: dates show soils are much younger than expected. Findings are consonant with data indicating rapid, recent aggradation of other lowlands along the Pacific Coast, as of the Colorado River Delta (UCLA 116, 24,900 ± 800, UCLA I), Los Angeles Basin (LJ-240, 255 ± 150 and LJ-241, 1160 ± 200, La Jolla II; also UCLA 119, 980 ± 80 and UCLA 120, 9650 ± 150, UCLA I), and Central Valley of California (LJ-314, 4250 ± 200, La Jolla II).

VI. GEOCHEMICAL PROCESSES

A. Off Baja California

LJ-779. Phosphorite, Baja California—6 **>50,000**

Carbonate apatite from fossil phosphatic brachiopod (*Disciniscus* *cumingii*) shells, from continental shelf at depth of ca. 80 m off W coast of Baja California (25° 45′ N Lat, 112° 34.3′ W Long). Coll. and subm. 1963 by B. F. d'Anglejan (sample DAT-4). *Comment*: run to test possibility of exchange or adsorption of carbonate in apatite (shells of this genus comprise lamellae of carbonate-fluorapetite and chitin). Such exchange or adsorption in marine phosphatic deposits would tend to invalidate measurements on rate of formation of phosphorites, such as LJ-268 (19,300 ± 600) and LJ-399 (9860 ± 200), La Jolla II, and LJ-500 (17,660 ± 450), LJ-509 (19,440 ± 600), and LJ-515 (26,640 ± 600), La Jolla III. Date indicates that the carbonate present in the apatite is not being exchanged with modern carbonate. The ground shells were treated with 0.1 N acetic acid to remove any associated $CaCO_3$ differentially. As the apatite had about 0.4% C the 525-g sample had ca. 2.1 g C. See d'Anglejan-Chatillon (1965).

B. Colorado

Mesa Verde caliche series

Calicum carbonate from slightly calified zones in loess from the NGP ("New Garbage Pit") section on Chapin Mesa, Mesa Verde Nat. Park (ca. 37° 03′ N Lat, ca. 108° 05′ W Long). Coll. 1962 by Douglas Osborne, Supervisory Archeologist, Weatherill Mesa Archeolo. Proj., Nat. Park Service; subm. 1963 by Gustaf Arrhenius and Enrico Bonatti.

LJ-601. Caliche, Mesa Verde, Colorado—2 **2880 ± 150**
930 B.C.

Caliche A, $CaCO_3$ from slightly calcified Zone A in Loess 1 (sample A).

LJ-602. Caliche, Mesa Verde, Colorado—3 **2380 ± 150**
430 B.C.

$CaCO_3$ from slightly calcified Zone B in Loess 2 (sample B).
General Comment: these measurements give only minimal estimates of age of caliche formation (see Arrhenius and Bonatti, 1965). See also LJ-510, 21,000 ± 600, La Jolla III. LJ-578, >40,000, this list (III B) also deals with deposit regarded as loess.

C. California

Dolomite formation series

Carbonate, chiefly dolomite, in some samples mixed with calcite and aragonite, and surface and interstitial water, from near surface of playa of Deep Spring Lake (a spring-fed pond) in Deep Spring Valley, Inyo Co. (ca. 37° 17′ N Lat, ca. 118° 03′ W Long). Coll. and subm. 1962 and 1963 by M. N. A. Peterson.

LJ-615-630. Dolomite, Deep Spring Lake, California—5-20 **See below**

The 16 new measurements on the carbonate particles are tallied below, with pertinent ancillary data; for comparison the 4 previously run tests (from La Jolla III) are included.

No.	LJ-No.	Sta.	Depth, cm	Size,[1] μ	Miner-alogy[2]	Growth,[3] $\mu/10^3$yr	Date,[4] B.P.
1	527	1	0-3	—	D	0.086	290 ± 150
4	564	1	0-3	0.1	D	0.064	390 ± 150
3	563	1	0-3	0.3	D	0.052	1440 ± 400
2	562	1	0-3	0.5	D	0.046	2700 ± 500
7	617	2	0-3	0.1	D	0.048	610 ± 100
6	616	2	0-3	0.3	D	0.057	1310 ± 160
5	615	2	0-3	0.7	D (+tr. C?)	0.080	2200 ± 220
9	619	2	30-35	0.3	D	—	1270 ± 160
8	618	2	30-35	0.7	D (+tr. C)	—	2200 ± 200
12	622	2	71-76	0.2	D	—	1470 ± 100
11	621	2	71-76	0.3	D	—	1960 ± 160
10	620	2	71-76	0.7	D	—	2520 ± 300
15	625	3	0-3	0.1	D	0.054	530 ± 100
14	624	3	0-3	0.3	D	0.056	1350 ± 200
13	623	3	0-3	0.7	D	0.077	2260 ± 300
18	628	3	30-35	0.1	D, C	—	5600 ± 500
17	627	3	30-35	0.3	A, D, C	—	8000 ± 500
16	626	3	30-35	0.8	A, D, C	—	9160 ± 700
19	629	3	60-65	0.6	A, D, C	—	9500 ± 800
20	630	3	60-65	1.0	A, C, D	—	10,000 ± 1000

[1] Average length of rhombohedral edge as measured directly on electron photomicrograph; no. 1 was run on whole sample prior to fractionization.
[2] By X-ray diffraction; A=aragonite, C=calcite, D=dolomite.
[3] For growth model: $t=T-kx$.
[4] These age measurements deviate slightly, chiefly in respect to the error, from preliminary figures published by Peterson, Bien, and Berner (1963). The differences resulted primarily from further counting.

Comment: "age determinations of growing dolomite crystals in this lake have been used to determine rates of crystal growth" (Peterson, Bien, and Berner, 1963). "The newly formed dolomite is calcium-rich, has only weakly developed ordering of cations, and is of variable composition within single crystals such that the most calicum-rich material is on the outsides of the crystals. A crystal growth model, assuming the rates of growth of the rhombohedral edge to be constant with time, fits the data well. A growth rate of hundreds of Ångstroms per thousand years is found. This very slow growth is probably necessary for the ordered phase to be forming at low temperatures and pressures. Interstitial solutions [LJ-818, −184 ± 50, this list] have been dated and give the effective age of the solutions from which the crystals are growing. The solution is, in this regard, a crystal of 0 size in the growth curve. Extrapolating these growth rates back for the larger crystals in the sediments indicates that the dolomite crystals nucleated shortly after the close of the pluvial period, about 10.000 yr B.P., and have been growing, perhaps intermittently, ever since. Ground waters leaching through the valley sediments and ascending along the boundary faults contribute ions to the playa lake slowly enough to be incorporated into the ordered dolomite." Surface water from this spring-fed playa was also measured (see below). Within each station and depth unit the age sequence is consistently correlated positively with depth (except for LJ-615 *vs* 618 and LJ-616 *vs* 619).

LJ-817. Dolomite, Deep Spring Lake, California—21 **Apparent Age −384 ± 50**

Surface water from same spring pond. *Comment*: apparent age of spring water in a closed graben basin was desired, for research on time and rate of formation of dolomite, indicated as still continuing in the spring water (Peterson, Bien, and Berner, 1963). Interstitial water from the dolomite deposits yields a closely similar apparent age (LJ-818, −184 ± 50). In both tests the unaugmented statistical error of counting is presented. Computational values for the two measurements are:
LJ-817—δC^{14}, 97.4 ± 10‰; δ^{13}, −5.73‰; δC^{13}, 19.3‰; ΔC^{14}, 62.5 ± 6‰.
LJ-818—δC^{14}, 71.8 ± 8‰; δ^{13}, −5.78‰; δC^{13}, 19.2‰; ΔC^{14}, 36.5 ± 5‰.
The CO_2 from these samples (supplied by Peterson) was converted to C_2H_2, which was counted.

LJ-818. Dolomite, Deep Spring Lake, California—22 **Apparent Age −184 ± 50**

Interstitial solutions from the dolomite deposits. *Comment*: see above, under series LJ-615-630 and under 817.

VII. PALEOZOOGEOGRAPHY

Considerable paleozoogeographic data are also involved in sections II, III, and VIII.

LJ-658. Late Quaternary, Northern Ireland—1 **10,250 ± 350**
8300 B.C.

Reindeer (*Rangifer* sp.) antler fragment from Late-glacial bed at Roddans Port, from Allerød clay-mud immediately above Zone I light-gray unctuous clay (54° 30′ 30″ N Lat, 05° 28′ 20″ W Long). Coll. by Cyril Cavan and subm. 1963 by Gurdip Singh, then of Queen's Univ., Belfast. *Comment*: stratigraphy and pollen strongly indicate that antler pertains to basal Zone II. Evidence favors occurrence of reindeer in Ireland as early as beginning of Allerød (Singh, 1963). Date is ca. 2000 yr younger than expected from other C^{14} measurements (Q 358-371, Cambridge VI). Other antlers gave dates (USGS III, p. 447) younger than anticipated. See LJ-903-906, under sec. II F of this paper, for other dates in same area, all tied in with pollen sequence. Because sample for LJ-647 proved insufficient, it was combined with another portion of the antler fragment to be run as LJ-658.

VIII. ARCHAEOLOGY

A. Oregon

LJ-609. Midden, Cape Arago, Oregon—4 **2120 ± 300**
170 B.C.

California mussel (*Mytilus californianus*) valves from Layer 2 (3rd dm) of midden at island end of footbridge leading to Cape Arago Light, at E end of residual ridge (43° 20′ 27″ N Lat, 124° 22′ 23″ W Long; USC&GS Chart 5984, 1957). Coll. by C. L. Hubbs and party (sample 1957—VII:10A); subm. 1963. *Comment*: date barely exceeds that of LJ-235, 2090 ± 200, La Jolla II, for lower Layer 5 (6th dm) of same pit, based on same species. Dates indicate rapid accumulation of lower part of midden, with a later superficial deposit (LJ-111, 1500 ± 100, La Jolla I, based on charcoal). See also LJ-235, La Jolla II; also M-904, Michigan V, p. 42 (indicating rise in sealevel during last 550 yr).

B. Southern California

Rancho Carrillo Site series

Further tests on this archaeologic site on sand spit between San Diego Bay and ocean, all from pit at Station C, on narrow, sandy cross ridge ca. 1.0 m high in bottom of swale along base of sand dunes, adjacent to highway, E of S extension of Silver Strand State Park (32° 37′ 29″ N Lat, 117° 08′ 11″ W Long; USC&GS Air Photo Compilation T-5371, 1933). Station C lies 0.1 km NW of Station B (LJ-210, 270 ± 150, La Jolla II; corrected location, 32° 37′ 27″ N Lat) and 0.15 km SW of Station A (LJ-211, 4020 ± 300 and LJ-336, 4520 ± 220, La Jolla II). Coll. by C. L. Hubbs and L. G. Jones (sample 1962—VII:21B).

LJ-592. Silver Strand, Coronado, California—4 **305 ± 150**
A.D. 1645

Pismo clam (*Tivela stultorum*) valves from depth of 90 to 108 cm in pit.

LJ-593. Silver Strand, Coronado, California—5 **3470 ± 175**
1520 B.C.

Pismo clam (*Tivela stultorum*) valves from depth of 5 to 15 cm in pit.

LJ-600. Silver Strand, Coronado, California—6 **460 ± 150**
A.D. 1490

Charcoal from depth of 90 to 108 cm in pit.

General Comment: dates from shell and charcoal from depth of 90 to 108 cm are in essential agreement, but much younger than date on shell from depth of 5 to 15 cm. Inversion is plausibly explained by hypothesis that after lower layers were deposited, with human occupation, older shell washed down with sand from the steep sandy ridge immediately E (this slope abounds in shells similar to those used for LJ-593 and contains some stone artifacts of La Jollan type, but no pottery—thus indicating considerable antiquity). Small size of Pismo clams indicates that ca. 300 and 3000 yr ago coastal sea temperatures were warmer than now. Greater past rainfall is suggested by fact that the water source presumably utilized is now hardly potable.

LJ-594. SIO Cliff Site, La Jolla, California—4[1] **4620 ± 200**
2670 B.C.

California mussel (*Mytilus californianus*) valves from midden on grounds of Scripps Inst. of Oceanography; from Dm 6 (from top) of pit recorded in detail under LJ-382, La Jolla II, and LJ-448, La Jolla III (32° 52′ 00″ N Lat, 117° 15′ 09″ W Long). Coll. by J. N. Miller and party (sample 1960—XI:21A); subm. 1961. *Comment*: see LJ-382, 3240 ± 240 (La Jolla II), for Dm 12-14, and LJ-448, 1050 ± 150 (La Jolla III), for Dm 1 (top). Irregular dating sequence (1050—4620—3240) seems to indicate redeposition of midden

[1] No. 3 of this series (LJ-448, La Jolla III) was inadvertently labelled 2.

material, with older shells washed down to overlie younger material. Ancient La Jollan middens lie just back of cliff along this coastal stretch (see, *e.g.*, LJ-454, 7530 ± 140, La Jolla III, and LJ-927, 4870 ± 200, this list). Measurement bears on history of coastal lagoons, rise in sealevel, past faunas, etc. (see Shumway, Hubbs, and Moriarty, 1961). Related measurements in this list: LJ-595, 892, 893, 900, 901, 918, 919, 926, 927, 969.

SIO Upper Cliff Site series

Three further measurements from pit on site on grounds of Scripps Inst. of Oceanography, immediately NW of present building of Inst. of Geophysics and Planetary Physics; ca. 6 to 7 m from lip of cliff, immediately back of eroded sec. (32° 52′ 07″ N Lat, 117° 15′ 09″ W Long; USGS La Jolla Quadrangle, 7.5′ series, 1953). Coll. by K. W. Radford and party (sample 1961—XII:3A); subm. 1962 and 1964.

LJ-595. SIO Upper Cliff Site, La Jolla, California—3 **4090 ± 200**
2140 B.C.

California mussel (*Mytilus californianus*) valves from Dm 8 (from top).

LJ-926. SIO Upper Cliff Site, La Jolla, California—4 **1510 ± 200**
A.D. 440

Pismo clam (*Tivela stultorum*) valves from Dm 4.

LJ-927. SIO Upper Cliff Site, La Jolla, California—5 **4870 ± 200**
2920 B.C.

California mussel (*Mytilus californianus*) valves from Dm 12.

General Comment: 5 dates are now available from the m² column (including LJ-453 and 454, La Jolla III):

LJ-No.	Material	Decimeter	Date, B.P.
453	*Tivela*	1	1620 ± 160
926	*Tivela*	4	1510 ± 200
595	*Mytilus*	8	4090 ± 200
927	*Mytilus*	12	4870 ± 200
454	*Mytilus*	16	7530 ± 140

Except for the 2 upper layers, which may have been disturbed, sequence is correct. Prolonged occupation, presumably in part intermittent, is confirmed. Past occupation and present aridity suggest more adequate freshwater supply in the past. Composition of the mollusc fauna suggests past temperatures at least about as warm as now.

LJ-599. Midden, Santa Rosa Island, California—3 **7330 ± 360**
5380 B.C.

Red abalone (*Haliotis rufescens*) shell (large and solid) from Survey Point on N shore of island, at collector's loc. 131.5; alt 23 m (34° 00′ 25″ N Lat, 120° 10′ 55″ W Long). Coll. and subm. 1962 by P. C. Orr, Santa Barbara Mus. of Nat. History (field no. 1/62; cat. no. 290). *Comment*: shell sample was requested from collector in view of measurement of 12,620 ± 200 (UCLA-141, UCLA I) based on fragmentary "charcoal" thought to be possibly contaminated with asphalt fragments (see UCLA I, p. 110; collector disagrees). Shell was not available from same locality and level, but red abalone furnished was indicated to have come from same stratigraphic level ca. 30 m E. The 7330 date is consistent with many others based on the older California coastal middens, for which the oldest dates, with the exception of UCLA 141, 12,620 ± 200, UCLA I and of UCLA 661, 11,900 ± 200, this list (both on Santa Rosa Island), are LJ-454, 7530 ± 140, La Jolla III, and LJ-967, 9020 ± 500, this list. Orr (personal commun.) now interprets the shell used for LJ-599 as not contemporaneous with the midden for which UCLA-141 provided date of 12,620 ± 200, but as representing rewash from a higher midden; he states that "UCLA-661 . . . . comes from a very dark line containing some shell at this point, but near by, considerably more shell. The charcoal is associated with red-burned earth, indicating a very hot fire, and is overlain by waterlaid silts, then another layer of black silt and shell, more waterlaid silts, and then 30 feet of dune sand. There are 3 or 4 of the black lines, but no more than 3 are ever directly superimposed; the youngest of these appears to be about 7400 and the oldest about 12,500 (L-290-T [Lamont IV] and UCLA-141) . . . . We have a date [UCLA-669B, this list] of 6500 ± 210 on the conchiolin portion of a red abalone, and a date of 6550 ± 150 on the carbonate (UCLA-659-C)." (This last matter has been discussed by Berger, Horney, and Libby, 1964, p. 1001). Orr (1964) described a percussively flaked implement and other evidence of human occurrence on Santa Rosa Island in strata dated in subterminal Pleistocene time, but most evidence points to hunters rather than gatherers. When shellfish gathering originated along southern California coast is still an open problem; culmination now seems to be authenticated as the period from ca. 7500 to ca. 4000 B.P.

Cardiff, California midden series

Clam (*Chione californiensis* and/or *C. undatella*) valves from a midden in Cardiff, San Diego Co., just S of junction of Kilkenny Drive with San Elijo Ave., on rather flat terrace, alt ca. 7 m, 0.25 km from beach, between bends of N channel of San Elijo Lagoon (33° 00′ 52″ N Lat, 117° 16′ 40″ W Long; USGS Encinitas Quadrangle, 7.5′ series, 1948, and USC&GS Air Photo Compilation T-5411, 1934). Coll. 1959 by J. N. Miller; subm. 1964 (sample 1959—XI:20A).

LJ-892. Midden, Cardiff, California—1 **7100 ± 300**
5150 B.C.

Shell from bottom layer, 73 cm below surface (in 4th dm below surface clearing 5 to 25 cm thick).

LJ-969. Midden, Cardiff, California—2 **7480 ± 400**
5530 B.C.

Shell from Dm 1 below discarded contaminated surface layer.

General Comment: date bears on history of San Elijo Lagoon, now sterile but at time of occupation shown by food remains to have supported marine molluscs and therefore to have been in open connection with sea; inclusion of many rocky-shore molluscs is consonant with hypothesis of a then lower but rising sealevel with resulting rocky foreshore nearby. This first date for the vicinity of San Elijo Lagoon fills an hiatus in the known coastal area occupied by La Jollan people. Dates suggest a possible, fortuitous inversion of midden contents, but topography of area and consistency of midden seem to rule out this possibility. More probably the midden represents rapid accumulation (very uniform proportion between the 4 main mollusc species in the 4 dm levels sampled is consonant with this idea). Predominance of lagoon species indicates baylike conditions. Other inferences are like those suggested for the San Diego Co. coast by Shumway, Hubbs, and Moriarty (1961). Two other midden deposits adjacent to same lagoon (LJ-893 and 972, below) yield dates in same cultural period, and similar inferences. See also LJ-594 above.

Solana Beach, California midden series

Clam (*Chione californiensis* and/or *C. undatella*) valves from small knoll just NW of Solana Beach Refuse Area, San Diego Co.; near crest of ridge S of San Elijo Lagoon, 3.1 km from coast; ca. 1.0 m W of dirt road, ca. 100 m N of road to dump; alt ca. 65 m (33° 00′ 15″ N Lat, 117° 14′ 58″ W Long; USGS Encinitas Quadrangle, 7.5′ series, 1948). Coll. 1960 and subm. 1964 by J. N. Miller.

LJ-893. Midden, Solana Beach, California—1 **6600 ± 300**
4650 B.C.

Shell from 1 to 4 cm below Dm 3, at bottom of midden (sample 1960—II:25A).

LJ-972. Midden, Solana Beach, California—2 **7040 ± 350**
5090 B.C.

Shell from Dm 1, just below discarded disturbed surface (sample 1960—II:24A).
General Comment: older date for top dm suggests error or inversion; closeness of dates indicates, as for LJ-892 and 969, rapid accumulation. Dates are usual for a La Jollan midden, and as usual charcoal is very scarce. Lagoon molluscs predominated, as in other La Jollan sites near a lagoon.

LJ-897. Witch Creek Site, California **360 ± 120**
A.D. 1590

Charcoal from funerary olla found at depth 1.0 m; on Sawday Ranch, Collier Flat, San Diego Co. (33° 03′ N Lat, 116° 43′ W Long). Coll. 1963 and subm. 1964 by J. R. Moriarty (sample U.C.L.J.—M-18). *Comment*: dates most sophisticated funerary practice of the Diegueño, who occupied the San Diego region when Spaniards arrived.

LJ-900. Scripps Estates Site, California—5 **5680 ± 250**
3730 B.C.

California mussel (*Mytilus californianus*) valves from "A" soil horizon, alt ca. 110 m on Lot 18 of Scripps Estates Associates, just N of grounds of Scripps Inst. of Oceanography; near S edge of Sumner Canyon (32° 52′ 23″ N Lat, 117° 14′ 55″ W Long; USGS La Jolla Quadrangle, 7.5′ series, 1953). Coll. and subm. 1964 by C. L. Hubbs (sample 1964—IV). *Comment*: renewed exploration of this La Jollan site confirms inferences of Shumway, Hubbs, and Moriarty (1961) regarding rising sealevel, warm temperature, extensive habitation requiring freshwater supply, etc. Bones of pelagic fishes (*Thunnus* and

Sphyraena) associated with the shell indicate early use of boats or rafts and advanced fishing technique. Other dates for site are: LJ-79, 6700 ± 150, LJ-109, 7370 ± 100, and LJ-110, 5460 ± 100, La Jolla I; and LJ-221, 5740 ± 240, La Jolla II.

LJ-901. Scripps Estates Site, California—6 **4100 ± 160**
2150 B.C.

California mussel (*Mytilus californianus*) valves from "A" soil horizon at alt ca. 105 m on grounds of Scripps Inst. of Oceanography 75 to 100 m S of S line of Scripps Estates Associates (32° 52′ 17″ N Lat, 117° 14′ 57″ W Long; USGS La Jolla Quadrangle, 7.5′ series, 1953). Coll. 1963 and subm. 1964 by C. L. Hubbs (sample 1963—XII). *Comment*: same purpose and general inferences as for LJ-900, above. Finding pond snails (*Helisoma ammon*) here indicates past occurrence of at least temporary pond(s), which present rainfall and topography would not support. Associated artifacts indicate more protracted occupation of this site by the La Jollans than previously thought and at least intermittent occupation through more than 3 millenia. Better preservation of shell suggested a later date here than elsewhere on site.

C. W. Harris Site series

Site on S slope of San Dieguito River valley close to type locality of San Dieguito Culture, at site SDi-149 of Univ. of California Archaeol. Survey; ca. 4 km E of Rancho Santa Fe (33° 20′ 00″ N Lat, 117° 09′ 30″ W Long; USGS Rancho Santa Fe Quadrangle, 7.5′ series, 1949). Coll. and subm. 1964 by P. R. Ezell, San Diego State College, and J. R. Moriarty.

LJ-909. C. W. Harris Site, San Diego Co., California—2 **4650 ± 200**
2700 B.C.

Scallop (*Plagioctenium circulare aequisulcatum*) valves from Trench 2, Sec. G, Level 10 (1.5 to 1.7 m below datum). Shell (rare at this site) was taken from middle part of La Jollan stratum, which overlies a stream-laid alluvium of cobble and boulders containing San Dieguito stone artifacts and underlies surficial strata containing Diegueño material. Sample was taken at top of a thin wedge of coarse alluvial sediment that bisects La Jollan stratum. *Comment*: this level is definitely referable to La Jollan.

LJ-914. C. W. Harris Site, San Diego Co., California—3 **3550 ± 150**
1600 B.C.

Charcoal from roasting pit in Trench 1, Level 7, B-3, 1.1 m below datum plane. *Comment*: this test, along with LJ-915, brackets level between typical La Jollan and Yuman (Diegueño) periods of occupation.

LJ-915. C. W. Harris Site, San Diego Co., California—4 **3850 ± 150**
1900 B.C.

Charcoal from Trench 1, Level 10, B-7, 1.5 m below datum plane. *Comment*: somewhat greater age is consistent with lower stratigraphic level.

General Comment: site provides only known complete stratigraphic sequence of San Dieguito—La Jolla—Diegueño. Long occupation or visitation of site by La Jollans and by Indians perhaps transitional between La Jollans and

Diegueño, all following San Dieguito and preceding Diegueño occupation, is indicated by these tests and by LJ-136, 4720 ± 160, La Jolla I (first wrongly thought to date San Dieguito) and LJ-202, 6300 ± 290, La Jolla II. Impoundment of water by a dyke across stream bed immediately below this site may have conditioned its long utilization.

LJ-955. Midden, San Miguel Island, California—3 **575 ± 125** **A.D. 1375**

California mussel (*Mytilus californianus*) valves from large, dense midden, deeply buried in sandy cliff near middle of Cuyler Harbor on N coast of the island (34° 03′ 17″ N Lat, 120° 21′ 37″ W Long; USC&GS chart 5116, 1945). Coll. 1954 by C. L. Hubbs and party; subm. 1964 (sample 1954—IX:16A). *Comment*: paleoecologic inferences were drawn in report on LJ-25, 1750 ± 200, La Jolla I, based on charcoal from same midden. Since stratigraphic control was inadequate discrepancy between dates based on charcoal and on shell may be overlooked. This favorable site—on a calm bay, in area of abundant marine food—was probably occupied for many centuries. Shell dated primarily to tie in with current paleotemperature measurements.

Agua Hedionda midden series

Shell samples from excavated block (A12) on property of A. O. Kelly on N shore near mudflat head of lagoon, ca. 2.5 km in straight line from lagoon entrance; ca. 1.2 to 2.4 m above level of lagoon, on low terrace around base of upland spur (33° 08′ 32″ N Lat, 117° 18′ 57″ W Long; USGS San Luis Rey Quadrangle, 7.5′ series, 1949). Coll. 1963 and subm. 1964 by J. R. Moriarty (site U.C.L.J.—M-15).

LJ-961. Agua Hedionda Lagoon, California—2 **7420 ± 350** **5470 B.C.**

Pecten (*Plagioctenium aequisulcatum circulare*) valves from depth of 13 to 14 dm.

LJ-966. Agua Hedionda Lagoon, California—3 **7450 ± 370** **5500 B.C.**

Clam (*Chione californiensis* and/or *C. undatella*) valves from depth of 13 to 14 dm. *Comment*: agrees in date with LJ-961.

LJ-967. Agua Hedionda Lagoon, California—4 **9020 ± 500** **7070 B.C.**

California mussel (*Mytilus californianus*) valves from base (depth 16 to 17 dm).

General Comment: LJ-967 provides a "breakthrough" date for the inception of shellfish gathering along mainland coast of California. Oldest (by a slight margin) of the many previous pertinent dates is LJ-454, 7530 ± 140 (La Jolla III). Earlier dates have been obtained for middens on Santa Rosa Island, California (see LJ-599, above). Because green felsite implements of the San Dieguito type increased as base level was approached Moriarty concluded that he had finally encountered a transition between San Dieguito and La Jollan cultures; indicated antiquity is consistent with that hypothesis. Transitional complex may be related to "Pauma complex" of True (1958), from farther in-land in San Diego Co. Most of the column (as expected from dates and coastal location) proved typically La Jollan. See Shumway, Hubbs, and Moriarty (1961, p. 117-125) and the following discussions: LJ-225 (6370 ± 210), La Jolla II; LJ-448 (1050 ± 150), LJ-449 (4770 ± 160), LJ-453 (1620 ± 160), LJ-454 (7530 ± 140), LJ-512 (4650 ± 260), and LJ-529 (5020 ± 250), La Jolla III; and in this list LJ-593 (3470 ± 175), LJ-594 (4620 ± 200), LJ-595 (4090 ± 200), LJ-599 (7330 ± 360), LJ-611 (1800 ± 300), LJ-645 (1660 ± 200), LJ-892 (7100 ± 300), LJ-893 (6600 ± 300), LJ-900 (5680 ± 250), LJ-901 (4100 ± 160), LJ-909 (4650 ± 200), LJ-914 (3550 ± 150), LJ-915 (3850 ± 150), LJ-922 (2200 ± 200); LJ-923 (5480 ± 200), LJ-924 (6140 ± 250), LJ-925 (2600 ± 200), LJ-926 (1510 ± 200), LJ-927 (4870 ± 200), LJ-955 (575 ± 125), LJ-962 (2300 ± 150), LJ-963 (1490 ± 200), LJ-964 (7130 ± 350), LJ-968 (2140 ± 150), LJ-969 (7480 ± 400), and LJ-972 (7040 ± 350). Paucity of charcoal in midden and lack of cold-water molluscs suggest temperatures about as warm, ca. 7500-9000 B.P., as now, or warmer. The presence today of flowing water within 3 km up Agua Hedionda Creek precludes need to postulate local change in precipitation, and helps explain long occupation of lagoon and creek (another site on N shore of lagoon, LJ-335, La Jolla II, gave date of 1030 ± 200, and typical Diegueño sites abound along upper part of lagoon and along lower part of creek). Total lack of indication of submergence of this midden area argues against any Postglacial sea stand more than a meter or two above that of present.

Torrey Pines Park midden series

Midden shells from depth of 1.5 m on steep SW slope of Soledad Valley on E side of Park opposite railroad tracks, 1.0 km back from beach (32° 55′ 28″ N Lat, 117° 14′ 52″ W Long; USGS Del Mar Quadrangle, 7.5′ series, 1953). Coll. 1963 and subm. 1964 by J. R. Moriarty (site T.P.S.P.—M-6).

LJ-962. Midden, Torrey Pines Park, California—2 **2300 ± 150**
350 B.C.

Clam (*Chione californiensis* and/or *C. undatella*) valves.

LJ-968. Midden, Torrey Pines Park, California—3 **2140 ± 150**
190 B.C.

Olympia oyster (*Ostrea lurida*) valves.

General Comment: these dates from 2 species of pelecypods, in essential agreement, extend upward the verified record of occupation of Torrey Pines Mesa and adjacent area. General status of ancient man in Torrey Pines Reserve has been briefly discussed by Hubbs and Moriarty (1964). The following dates are now available for this area:

2140 ± 150 (LJ-968, this list)
2300 ± 150 (LJ-962, this sample)
3700 ± 200 (LJ-19, La Jolla I)
4740 ± 200 (LJ-277, La Jolla II)
4840 ± 200 (LJ-276, La Jolla II)
4970 ± 200 (LJ-274, La Jolla II)
6400 ± 200 (LJ-275, La Jolla II)

These and various other dates of lagoon-side middens in southern California (see Shumway, Hubbs, and Moriarty, 1961, p. 117-125 and preceding dates), virtually all with an abundance of lagoon shells, tend to negate the indication of C. N. Warren (1964; Warren, True, and Eudey, 1961, p. 25) that there was "such a constant decrease in the supply of shellfish after about 3000 to 4000 years ago as a result of the silting of the lagoons" as to cause human populations to move away from the lagoons. Hypothesis is also inconsistent with data on the filling of Batiquitos Lagoon with sediment (see p. 74). Date bears on rate of accumulation of alluvium, as 1 m of sterile alluvium overlay midden proper.

LJ-964. Midden, Pt. Loma, California **7130 ± 350**
5180 B.C.

Clam (*Chione californiensis* and/or *C. undatella*) valves, from depth of 70 to 80 cm in Block 1, Level 3 at base of excavated site on W lip of summit ridge, on grounds of Natl. Cemetery, alt ca. 110 m (32° 40′ 32″ N Lat, 117° 14′ 31″ W Long; USGS Point Loma Quadrangle, 7.5′ series, 1942). Coll. 1963 and subm. 1964 by J. R. Moriarty (site U.C.L.J.—M-24). *Comment*: subm. to measure inception of occupation of this early La Jollan midden (with few milling stones), first to be dated for Point Loma.

LJ-993. Newberry Cave, California **2970 ± 250**
1020 B.C.

Fragments of split wooden figurines from depth of 0.45 to 0.6 m in Room 3 of this cave site in San Bernardino Co. (ca. 34° 45′ N Lat, ca. 116° 40′ W Long; USGS Newberry Quadrangle, 15′ series, 1955). Coll. 1950 by San Bernardino Co. Mus.; subm. 1964 by R. D. Simpson, Southwest Mus. (sample no. 3; cat. no. 3-102-19). *Comment*: cultural features in this previously undated cave site are described by Smith *et al.* (1957).

C. Baja California, México

LJ-596. Midden, La Paz, Baja California **3120 ± 150**
1170 B.C.

Lower valve of large rock oyster (*Chama buddiana*) from shore of Ensenada de los Aripes, at Radio Station of La Paz, W of town proper; in indurated sand (beachrock?) below high-tide level, and below level of adjacent midden (ca. 24° 09′ N Lat, ca. 110° 19.5′ W Long). Coll. 1960 and subm. 1962 by P. C. Orr, Santa Barbara Mus. of Nat. History (sample 289, field no. 1P 3588). *Comment*: collector, who reported associated artifacts and human skeletons with very dolichocephalic skulls, suspected an ancient date. The tropical mollusc used, as well as several organisms encrusted and bored into the shell, indicates warm climate. Only vitreous part of shell was used. Slightly negative sealevel is indicated.

San Antonio del Mar midden series

Midden in low sea cliff at S side of 1st canyon ca. 1 km S of S side of river mouth at San Antonio del Mar (Johnson's Ranch of older maps); ca. 50 m S of N end of cliff (ca. 31° 15′ N Lat, ca. 116° 19′ W Long; H. O. Chart 1149, 1948). Coll. 1962 by C. L. Hubbs and subm. 1963 (sample 1962—

XII:30M). Both samples from a definite clam bake 1.2 to 2.0 dm below ancient land surface, which lay ca. 1.5 m above berm of sand beach and below ca. 2.0 m of loose, gray sand with small Pismo clams at top; in redder and more consolidated of 2 generations of sand. Clam bake extended 36 cm along cliff face, was ca. 1.5 cm thick at center and gently concave downward; some valve pairs intact; much charcoal intermixed.

LJ-611. San Antonio del Mar, Baja California—1 **1800 ± 300** **A.D. 150**

Pismo clam (*Tivela stultorum*) valves.

LJ-645. San Antonio del Mar, Baja California—2 **1660 ± 200** **A.D. 290**

Charcoal from same clam bake.

General Comment: dates on shell and charcoal agree. Expectation of greater antiquity based on pedology is not verified. Higher water temperatures than now are indicated by small size of Pismo clams, contrasting with large sizes prevailing now on adjacent beach and elsewhere in cold, upwelling areas: 670 whole valves from clam bake (a nearly total sampling) varied from 24 to 46 mm in length. No signs of older occupation in area were discovered, but more recent surficial middens abound (represented by W-31, 300 ± 160, USGS II).

Punta Minitas Site series, Baja California

Four additional measurements from excavation in deep cliff-edge midden about midway between Punta Cabras and "Punta San Isidro" (=Punta Piedras Blancas) (31° 18′ 50″ N Lat, 116° 26′ 05″ W Long; H. O. Chart 1149, 1948). Coll. by C. L. Hubbs and party 1957 and subm. 1964 (sample 1957—VI:28A).

LJ-922. Punta Minitas Site, Baja California—4 **2200 ± 200** **250 B.C.**

Charcoal from Layer 4 (3 to 4 dm below surface).

LJ-923. Punta Minitas Site, Baja California—5 **5480 ± 200** **3530 B.C.**

Charcoal from Layer 10 (9 to 10 dm below surface).

LJ-924. Punta Minitas Site, Baja California—6 **6140 ± 250** **4190 B.C.**

California mussel (*Mytilus californianus*) valves from Layer 10 (9 to 10 dm below surface).

LJ-925. Punta Minitas Site, Baja California—7 **2600 ± 200** **650 B.C.**

California mussel (*Mytilus californianus*) valves from Layer 4 (3 to 4 dm below surface).

General Comment: this midden has been shown (W-26 and 27, USGS I; LJ-5, La Jolla I; and LJ-216 and 231, La Jolla II; Hubbs and Roden, 1964, p. 145, fig. 1) to represent prolonged, at first likely intermittent accumulation. The 9 available measurements, all from the same excavation, range as follows, in stratigraphic sequence:

Test No.	Layer	Dm below Surface	Material	Date, B.P.
LJ-216	2	1-2	Charcoal	1510 ± 150
LJ-922	4	3-4	Charcoal	2200 ± 200
LJ-925			*Mytilus*	2600 ± 200
W-26	Same layer, between 4 and 8		Charcoal	2500 ± 200
W-27			*Mytilus*	2540 ± 200
LJ-5	8	7-8	Charcoal	3100 ± 300
LJ-923	10	9-10	Charcoal	5480 ± 200
LJ-924			*Mytilus*	6140 ± 250
LJ-231	12	11-12	*Mytilus*	7020 ± 260

Below Layer 8 shell content becomes less dense through Layer 12, which lies unconformably on sterile dense reddish clay; seemingly occupation, at least early, was intermittent. Above Layer 8, to the disturbed Layer 1, shell content is very dense. Vertical extent of midden increases ca. 50% at a slight knoll, about 10 m N, under which a coarse cobble wedge separates midden from reddish clay (precipitation greater than at present is suggested by the cobble alluvium, and by the abundance of a minute land snail, *Pupilla sterkiana*, in Layers 9 to 12). Artifacts indicate culture equivalent to La Jollan (Shumway, Hubbs, and Moriarty, 1961; Warren, True, and Eudey, 1961). The flexed burial mentioned under LJ-216 (La Jolla II) was slightly embedded in the reddish clay and top of the overlying metate was stratigraphically opposite middle of Layer 10; absence of any apparent disturbance over the metate would seem to place burial ca. 5500-7000 yr B.P. (about the period when such burials were common in southern California). Further inferences conform with those offered under LJ-5 (La Jolla I) and LJ-216 and 231 (La Jolla II).

Moderate discrepancy appears between the 2 cross-datings of shell and charcoal (LJ-922 and 925 and LJ-923 and 924) from same decimeter levels (in contrast with agreement between previous tests, W-26 and 27, USGS I, from same pit). The new dates from shell are 400 and 660 yr higher than those from charcoal. Other comparable cross-checkings (from USGS II and La Jolla I) are as follows:

Test No.	Material	Date, B.P.
W-155	Charcoal	600 ± 200
W-154	*Mytilus*	580 ± 200
LJ-85	Charcoal	960 ± 150
LJ-84	*Mytilus*	1060 ± 150

With one exception, estimate from shell (*Mytilus*) is of insignificantly to considerably greater age than that from charcoal. Account needs be taken of apparent age of shells of *Mytilus* and other molluscs taken alive (see p. 69).

LJ-963. Midden, Punta Banda, Baja California **1490 ± 200**
A.D. 460

California mussel (*Mytilus californianus*) valves from lowest coastal terrace at fishing camp known as Nuevo Arbolitos on SW side of Punta Banda (31° 42.2′ N Lat, 116° 41.3′ W Long). Coll. 1959 by C. L. Hubbs and subm. 1964 (sample 1959—VIII:14A). *Comment*: from top 0.4 m of uniformly friable, rather sooty midden soil, in which *Mytilus* was dominant shell. Midden seems representative of surficial deposits on the now very cold SW side of this point. Fauna of these middens, with *Mytilus californianus* and *Haliotis cracherodii* particularly abundant, suggests past temperatures at least as warm as now. Collection was one pertinent to survey of present and past temperatures (Hubbs and Hubbs, ms.). Mussels collected alive on Punta Banda gave apparent ages of 186 ± 20 yr, LJ-894, and 240 ± 50 yr, LJ-896 (this list).

D. Yucatán Peninsula

Isla Cancún series, Quintana Roo, México

Shells from midden a few m back from Caribbean Sea shore on Isla Cancún, on E shore of Yucatán Peninsula S of Isla Mujeres (21° 07′ 30″ N Lat, 86° 46′ 15″ W Long; Carta Geográfica de la Republica Mexicana, Cozumel 16Q-IV, 1:500,000). Shell midden 40 to 65 cm deep, is exposed at tip of point; it is separated by archaeologically sterile white sand (full of natural shell) from underlying rock, which cuts across 10 km of white-sand beach; it is overlain by 1.5 m of "sterile" sand and humus. Coll. 1963 and subm. 1964 by E. W. Andrews, Middle American Research Inst., Tulane Univ.

LJ-975. Isla Cancún, Yucatán Peninsula—1 **2580 ± 130**
630 B.C.

One large gastropod (*Busycon contrarium*) shell from sterile white sand (sample E.W.A. Q-505). *Comment*: thought to antedate cultural period at site, because no artifacts were found in "sterile layer" and the shells were wave-worn and none showed signs of having been broken to remove meat. Date bears on sealevel changes (see sec. II).

LJ-976. Isla Cancún, Yucatán Peninsula—2 **2080 ± 150**
130 B.C.

One large gastropod (*Strombus gigas*) shell from sealed archaeologic stratum (sample E.W.A. Q-504). *Comment*: "this is a one-period occupation, lying atop a layer of sterile white sand full of natural shell heavily mixed with ash; a well-sealed archaeologic deposit consisted largely of shell, pottery, and burned hearth-stones, and was entirely of the last phase of the Formative period (possibly 300 ± 200 B.C.). Date for this remote Maya area is important because no accurate dating has ever been done here." Uniformity of pottery and no great abundance of molluscs (many of them the small *Nerita*) suggest brief time span for the whole occupation. Charcoal sample from the midden is being run. Previous La Jolla dates for the Maya of Yucatán are: LJ-87 (1140 ± 200), La Jolla I; LJ-272 (1090 ± 200), LJ-273 (1090 ± 200), and LJ-279 (2200 ± 200), La Jolla II; and LJ-505 (2925 ± 340), LJ-508 (2130 ± 200), and LJ-531 (1520 ± 200), La Jolla III.

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La Jolla III	Hubbs, Bien, and Suess, 1963
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Lamont VI	Broecker and Olson, 1959
Lamont VIII	Broecker and Olson, 1961
Michigan III	Crane and Griffin, 1958
Michigan IV	Crane and Griffin, 1959
Michigan V	Crane and Griffin, 1960
Michigan VIII	Crane and Griffin, 1963
UCLA I	Fergusson and Libby, 1962
UCLA II	Fergusson and Libby, 1963
UCLA IV	Berger, Fergusson and Libby, 1965
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