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LA JOLLA NATURAL RADIOCARBON MEASUREMENTS II*

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INTRODUCTION

Since the publication of the last list of C^{14} measurements (La Jolla I), covering the period from mid-1957 through 1959, the La Jolla Radiocarbon Laboratory has continued to use essentially the same technique. In the summer of 1961 a second Oeschger-Houtermans counter (Houtermans and Oeschger, 1958), purchased from Manufacture Belge de Campes et de Matériel Électronique, S. A., was installed. It has a somewhat higher background (3.1 counts/min at a filling pressure of 880 mm) than the counter obtained from Bern—a point of little significance in the measurements herein reported. Of the tests included in this report only those following LJ-380 were run with the new counter; the others, with the Bern counter.

The errors listed with each result are larger by ca. 100 yr than the one-sigma statistical counting errors, to take into account the uncertainties in calibration, the drift in sensitivity of background, and other parameters.

About one-third of the measurements carried out by the Laboratory since the completion of the first list are reported here. Not reported are the measurements carried out in connection with certain special investigations, as follows:

(1) C^{14} concentration in ocean water (reported in part by Bien, Rakestraw, and Suess, 1960).

(2) Secular changes in the concentration of atmospheric C^{14} (reported in part by Suess, 1961).

(3) C^{14} content of atmospheric methane (LJ-201, reported by Bainbridge, Suess, and Friedman, 1961).

(4) Terrestrial age of meteorites (being reported by Suess and Wänke, in press).

Further results of these special investigations will be published in various journals.

As in our first report we list the measurements serially, with a subject index for ready reference. Particular attention has again been paid to past changes in the environment, not only for their own significance but also for their bearings on the past distribution and abundance of organisms, including, and emphasizing, man. In turn, dates of organisms are brought to bear on the environmental changes. Some of the environmental inferences have been expanded (Shumway, Hubbs, and Moriarty, 1961) and will be elaborated in further publications.

Some new applications of the C^{14}-dating technique by the La Jolla Laboratory concern the terrestrial age of meteorites, the age of hot-spring waters,

* Contributions from the Scripps Institution of Oceanography, New Series, and from Department of Chemistry, University of California, San Diego (La Jolla, California).

time of formation of marine phosphorite, and (with negative evidence) the hypothesized origin of petroleum from terpenes. One of the more notable measurements (LJ-204) bears on the antiquity of man in Australia, in association with a Pleistocene fauna including giant marsupials. Some highlights from the C^{14} measurements of the La Jolla Laboratory were presented at the Autumn, 1961 meeting of the National Academy of Sciences (Hubbs, 1961).

ACKNOWLEDGMENTS

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Technical asistance in the operation of the Laboratory was furnished by Sylvia F. Chillcott, Paula Sandoval, and Jacquelin N. Miller, and the electronics were maintained by Everett Hernandez. We appreciate the advice and help of Arnold E. Bainbridge. Some O^{18} paleotemperature measurements were run by Robert N. C. Bowen, in the laboratory of Harold C. Urey. Hubbs has been assisted by many technicians and volunteers, notably by his project officer Jacquelin N. Miller and by Laura C. Hubbs, James R. Moriarty, Laurence G. Jones, Richard E. Casey, Allan J. Stover, Jr., Keith W. Radford, John A. Bollinger, and David L. Yoon. Valued advice and information has come from Robert F. Heizer, Clement W. Meighan, Ruth D. Simpson, the late Malcolm J. Rogers, and other archaeologists; from Francis P. Shepard and associates in marine geology; from Emory P. Chace, our consultant in malacology; and from various colleagues who have submitted samples.

CORRECTION

In our first report (La Jolla I), for LJ-27, the longitude should read 120° 10′ 22″ and the location should read ca. 0.65 km E of Arlington Canyon.

SUBJECT INDEX

Many of the C^{14} measurements by the La Jolla Laboratory reported here bear on diverse events and processes, geologic, oceanographic, zoogeographic, ecologic, climatologic, and archaeologic. Ready reference to entries, especially to those of significance in several fields, is facilitated not only by this index, but also by the strict numerical sequence of the measurements.

I. GEOLOGIC INFERENCES:

1. Quaternary Changes of Sealevel:

Raised beaches, Hawaii: LJ-205, 206, 253, 254, 322, 323; Ceylon: LJ-207.

Peat, wood, and natural shell deposits below present sealevel, southern California: LJ-208, 240, 241, 333, 381; Bermuda: LJ-228-230; W Mexico: LJ-280.

Midden with lower part below present high-tide line, San Francisco Bay: LJ-199.

Recent rise of sealevel in San Diego Co., Calif., inferred from silta-

tion of coastal lagoons and subsequent extirpation of bay molluscs after prolonged period of abundance, and from changes in molluscan fauna along open coast: LJ-221, 225, 242, 243, 245, 256, 274-277, 333, 381.

Inferences drawn from morphology of beach ridges, Silver Strand, Coronado, California: LJ-210, 211, 336; Golfo de California: LJ-213-215, 220.

2. Longshore Transport, Sedimentation, etc., in Golfo de California: LJ-213-215, 220.
3. Quaternary History of Coastal Bays and Lagoons, California and Baja California: LJ-199, 208, 210, 211, 242, 243, 245, 256, 261, 274-277, 332-336, 381, 385, 386.
4. Pleistocene History of Coastal Terrace, Southern California: LJ-217.
5. Rapid Subsidence and Aggradation of Los Angeles Basin, California: LJ-240, 241.
6. Shallow Subsidence and Alluviation of Central Valley, California: LJ-314.
7. Quaternary History of Bermuda: LJ-228-230.
8. Recession of Shoreline, California and Oregon: LJ-208, 217, 235.
9. Continuity of Springs and Streams, Southern California, Baja California, and Nevada: LJ-202, 210, 211, 222, 236, 237, 246-252, 336.
10. Age of Quaternary Lakes: Lake Mohave, California: LJ-200; Lake Manix, California: LJ-269; Lake Menindee, Australia: LJ-204.
11. History of Rancho La Brea Tar Pits: LJ-344-346.
12. Successive Generations of Dunes on Beach Ridges, Australia: LJ-204; Southern California: LJ-210, 211, 256, 336; Baja California: LJ-332, 334.
13. Evidence of Pedogenesis, California: LJ-213, 214, 216, 231, 256, 314, 385, 386.
14. Age of Giant Marsupials, Australia: LJ-204.
15. Pleistocene Eruption of San Quintín Volcanos, Baja California: LJ-332, 334.
16. Time of Formation of Marine Phosphorite: LJ-268, 399.
17. Negative Evidence on Origin of Petroleum from Terpenes: LJ-270-271.
18. Age of Hot-spring Waters, California and Nevada: LJ-246-252.
19. Terrestrial Age of Meteorites: LJ-338-341, 352, 354, 356-358, 360-365, 367, 368, 371-372, 375, 378-380, 387-391 (being reported elsewhere, Suess and Wänke, in press).
20. Antiquity of Río Grande de Santiago, Mexico (correlated with the highly distinctive fish fauna): LJ-280.

II. OCEANOGRAPHIC, ZOOGEOGRAPHIC, ECOLOGIC, AND CLIMATOLOGIC INFERENCES:

1. Past Sea (and Air) Temperatures, W Coast of North America (Indicated by Faunal Changes and/or Paleotemperature Estimates): LJ-210, 211, 216, 217, 221, 223-227, 231, 232, 235, 237, 238, 242, 243, 245, 256, 261, 266, 338.
2. Past Rainfall and Water Levels (see also I-5, 6, 9, 10, 18). Inferences from former habitation in now-arid regions, Southern California and Baja California: LJ-200, 204, 210, 211, 216, 217, 221, 225, 227, 231, 232, 258-261, 274-277, 332-334, 336, 385, 386.
   Inference from occurrence of freshwater mussels: LJ-212.
3. Continuity of Oceanographic and Climatic Patterns, W coast of North America: LJ-202, 216, 226, 227, 232, 235, 236-238.
4. Age of Sea-water Masses (from Analyses of Dissolved CO_2): LJ-146, 147, 149-154, 157, 158, 282-286, 315-321, 324-330, 337, 339, 340, 342, 343, 349-351, 355, 359, 369, 374, 383, 392-398, 401-410 (tests to be reported elsewhere).

III. ARCHAEOLOGIC INFERENCES:

1. Pleistocene (Pluvial) Sites, California: LJ-200, 217, 269; Australia: LJ-204.
2. Early (7400-4700 B.P.) Coastal Sites of Shell-gatherers in Southern California and Baja California: LJ-202, 221, 225, 231, 256, 274-277, 332-334.
3. Later Coastal Sites, with no Record of Pottery, California: LJ-199, 208, 211, 227, 236, 242, 243, 245, 258-260, 263, 314?, 335, 336, 385, 386; Golfo de California: LJ-215, 220; W Baja California: LJ-216, 224, 226, 232, 261, 266; Oregon: LJ-235, 238.
4. Late Coastal Sites, with Pottery, Southern California and Baja California: LJ-210, 222, 223, 237.
5. Temporal Relation of San Dieguitan and La Jollan Cultures, Southern California: LJ-202.
6. Sites in Interior Drainage of North America: LJ-200, 203, 212, 269, 314?, 331.
7. Submarine Artifacts, Southern California: LJ-208.
8. Early Agriculture, Durango, México: LJ-331.
9. Mayan Chronology: LJ-272, 273, 279.
10. Ancient Australian Site: LJ-204.
11. Evidence on Conditions Affecting Population Density: LJ-199, 200, 204, 210-212, 216, 218, 221-227, 231, 232, 235, 237, 238, 242, 243, 245?, 256, 258-261, 269, 274-277, 333, 381, 382, 385, 386.

IV. TESTS BEARING ON RELIABILITY AND PRECISION OF THE DATES:

1. Orderly, Expected Sequences: LJ-254 and 323 compared with LJ-

205, 253, and 322; LJ-338, 211, and 210; LJ-231, LJ-5, W-26 and 27, and LJ-216; LJ-217, W-142, LJ-382; LJ-235 compared with LJ-111; LJ-245 compared with LJ-242 and 243; LJ-36, 256, 31; LJ-333 and 381; LJ-241 and 240, UCLA-120.

2. Datings More or Less Contrary to Expectation: LJ-206 (checked by LJ-254 and 323); LJ-222 (*vs* LJ-33), LJ-258 and 260?.
3. Agreement between Tests on Different Species of Molluscs: LJ-224 and 226.
4. Essential Agreement between Repeated Tests: LJ-205, 253, and 322; LJ-254 and 323; LJ-79, 109, 110, 202, 217, 221, 225, 256, and 275; LJ-332 and 334.
5. Agreement between Datings by Different Laboratories:
   General concordance with previous datings: LJ-199.
   Concordance between current datings: LJ-200 and an unpublished measurement by Isotopes, Inc.; LJ-269 and UCLA-121.
   Possible discordance: LJ-204.
6. Agreement between Dating and Indicated Contact with Europeans: LJ-223.
7. Measurements on Wood of Determined Age: LJ-155, 156, 159-162, 164-169, 171-177, 179-185, 188-196, 198, 281, 289-313, 347, 348, 366, 370, 376, 377 (designed primarily to test temporal fluctuations in radioactivity, but bearing on reliability of datings; to be reported elsewhere).

LJ-199. Emeryville shellmound, California **2310 ± 220**

Charcoal, collected with oyster (*Ostrea lurida*) shells, from a depth of 2.44 to 2.67 m below present (not the original) surface of the Emeryville shell-mound site Ala-309 of the Univ. of California Archaeol. Survey, Emeryville, Alameda Co., near the E shore of San Francisco Bay (37° 50′ 15″ N Lat, 122° 17′ 30″ W Long). Sample came from near base of mound, ca. 1.5 m below the level of ground water, which is definitely below high-tide level. Coll. 1959 and subm. by R. F. Heizer, Dept. of Anthropology, Univ. of California. *Comment*: sample bears on changes in sealevel (in an area where there is evidence of local subsidence). This archaeologic site was described by Uhle (1907) and Schenck (1926), with different inferences regarding its relation to changes in sealevel. Because of the alteration of topography in past 30 yr, Heizer is unable to say how much midden soil originally overlay the present surface, or which quarter of the original mound would have contained the new excavation, but he believes that the new section was near the center of the mound. Age of this sample is generally concordant with dates of lower levels of other large San Francisco Bay shellmounds, for example L-187A, 2700 ± 350, and L-187B, 3150 ± 300 (Lamont III).

LJ-200. Pluvial Lake Mohave, California **9640 ± 240**

Freshwater mussel (*Anodonta*) shells from high shoreline near the NW corner of this Pluvial lake, which is now represented by a playa (Silver Lake);

alt 282 to 283.5 m; in NE corner of Sec. 29, T 15 N, R 8 E, 3.2 km W of Silver Lake Junction, San Bernardino County (35° 21′ 27″ N Lat, 116° 09′ 00″ W Long). The shells (sample 1) were taken from the upper of two shell layers exposed in a gravel quarry. Coll. and subm. 1958 by A. F. Woodward of Union Oil Co. of California and J. A. Woodward. *Comment*: it seems probable that the mussel shells were stranded *en masse* during the final recession of this Pluvial lake. Slightly higher terrace levels have been measured at 287.4 and 288.3 m, as well as one at 275.6 m (data from Univ. of California Archaeol. Survey). The occurrence of numerous crude stone artifacts along and near the ancient high shorelines implies that a hunting culture flourished here, though the age of the lake and the correlation between lake stage and human occupation have been doubted. The date confirms the view of Antevs (1952), who attributed the lake to what he termed the Provo Pluvial and believed that "the cultural remains probably derive from the last stage of the Pluvial, from about 9000 B.P." A general discussion of Lake Mohave was given, with references, by Wormington (1957, p. 161-167, etc.); a recent account was by Lawbaugh (1952). An unpublished measurement by Isotopes, Inc. on *Anodonta* shells from the same layer gave a date of 10,000 ± 300; *Anodonta* from the lower layer gave 13,150 (±350) (H. C. Smith, personal communication).

LJ-202. C. W. Harris Site, San Diego Co., California 6300 ± 290

Charcoal from a large accumulation of stones (Feature 5 of Warren and True, 1961) in exposure on S slope of valley of San Dieguito River, San Diego Co., close to type locality of San Dieguito culture, at site SDi-149 of Univ. of California Archaeol. Survey (33° 02′ 30″ N Lat, 117° 08′ 55″ W Long; USGS Rancho Santa Fe Quadrangle, 7.5′ series, 1949). Coll. and subm. 1959 by C. N. Warren, Univ. of California, Los Angeles. *Comment*: Feature 5 was stratigraphically associated with La Jollan artifacts and definitely overlay alluvial deposit containing typical San Dieguitan artifacts, with an intervening stratum 0.8 m thick of sterile river silt, thus securely establishing for the first time the chronological sequence of these cultures—hunting (San Dieguitan) followed by food-gathering (La Jollan). This test counterindicates the validity of evidence from LJ-136 (La Jolla I): the shell that was associated with San Dieguitan artifacts in stream alluvium within 0.5 km, downstream, from LJ-202, and was dated 4720 ± 160, presumably originated in a La Jollan midden and was either mixed by stream flow with artifacts eroded from a San Dieguitan level or was intrusive through rodent burrows (justifying the caution expressed in the description of test LJ-136). The presence of surface water in the streambed here in prehistoric (as also in historic) time may have conditioned the ancient occupation of the area. Archaeology is discussed by Warren and True (1961).

LJ-203. Rockshelter, Eastgate, Nevada 2930 ± 200

Charcoal sample (Ch-X3-T4) from bottom of midden (depth 0.9 m) in rockshelter at Eastgate, Churchill Co. (39° 48′ N Lat, 117° 52′ 30″ W Long). Coll. June 1958 and subm. by R. F. Heizer. *Comment*: dates earliest occupation of a series of cultures at this site (one of the few in this part of the Great

Basin providing stratified deposits), at a time when several distinctive projectile points (Elko Corner Notched, Elko Contracting Stem, and Elko Eared) were in use. Excavation results have been published (Heizer, 1961).

LJ-204. Lake Menindee, New South Wales 26,300 ± 1500

Charcoal from an apparent hearth in the top of the fossil-bearing Unit 4 (of Tedford, 1955; = Unit B of Tindale, 1955), just N of N end of Lake Menindee, a lake-plain flood basin (playa) on the W side of Darling River, in the W part of New South Wales (ca. 32° 20′ S Lat, 142° 20′ E Long). The charcoal was collected *in situ*, at the SW end of Site II. Associated with it were charred bone fragments and charred teeth of the giant gray kangaroo, *Macropus ferragus*; two stone artifacts were found *in situ* nearby, in presumably the same deposit. Coll. 1958 by R. H. Tedford, Univ. of California; subm. 1959 by R. A. Stirton and R. H. Tedford. *Comment*: dates an early human occupation of Australia and a rich assemblage of marsupials generally thought to be of Pleistocene age, including a number of giant species. The association of man with this fossil assemblage has been noted by Stirton (1954), Tedford (1955), and Tindale (1955; 1957). The artifacts associated with the extinct mammals have been regarded as correlative with the Tartangan Culture (Tindale, *l. c.*), which has been dated between 8700 ± 120 (NZ-69, New Zealand III, in which report (p. 747) Lake Menindee, New South Wales, is inadvertently printed "South Australia, Lake Merindee") and 6020 ± 120 or 6030 ± 120 (L-271E, Lamont III). Three samples (field numbers LFM 186, 188, and 189) of unionid shells were collected in 1954 at the Lake Menindee site; sample LFM 186 (NZ-67) from Site II comprising for the most part "float" (surface material of uncertain, likely recent provenance) but with "one or two in place," yielded a "modern" date, as did LFM 189 (NZ-68) of unionid shells from overlying Unit O, presumably "float," at Site IV; sample LFM 188, comprising again mostly "float" shell, but with "one or two shells in place in the B horizon" lying on and reportedly in Unit B of Site I, yielded the date of 6570 ± 100 (NZ-66, New Zealand III, where it is stated (p. 747) that the shells were "collected *in situ* and then broken out from the matrix," whereas the collector's field notes, quoted by Tindale (1957, p. 37), indicate that this was true only of one or two shells, and that the bulk was taken without digging). The date of 6570 ± 100 seemed sufficiently close to that obtained for the type Tartangan site on Murray River (6020 ± 120, L-271E, Lamont III) to allay suspicion that the Lake Menindee sample was biased. However, the fact that sample LFM 188 was not taken totally *in situ* caused Tedford to doubt its pertinence to Unit B, particularly in view of the result with LFM 186 and of the fact that modern unionid shells are common litter in this region. The new (LJ-204) date apparently indicates that the NZ-66 date of 6570 ± 100 does not apply to the fossil mammals of Unit B nor to the cultural remains associated therewith. Acceptance of the younger date as pertaining to the mammalian fossils would imply that an essentially Pleistocene fauna persisted in Australia until mid-Holocene time. The mammal faunas associated with the date of 6020 ± 120 (or 6030 ± 120) discussed above and with that of 8500 ± 250 (W-169, USGS II; Gill, 1955, p. 49-52) for the upper part of the

Keilor Terrace of Victoria are essentially modern. The youngest dating definitely applicable to a varied assemblage of giant marsupials is that for a presumably Pluvial period at the Lake Colongulac Site in W Victoria, 13,700 ± 250 or 13,725 ± 350 (Y-170, Yale III; Gill, 1955). It is therefore indicated that the extinction of most of the species of giant marsupials in Australia took place between ca. 13,700 and 8500 B.P., a time surprisingly similar to the average date for the extinction of the giant placental mammals in North America. The dating of man in Australia at 26,300 ± 1500 B.P. is also noteworthy. There is another date (NZ-207, New Zealand IV) of 18,000 ± 500 for charcoal from an Australian hearth. The mammalian fauna of Lake Menindee implies a somewhat greater rainfall and a more wooded environment, more like that now occurring ca. 300-500 km farther E: a circumstance more consonant with Glacial time than with the Hypsithermal Interval. Other faunal evidence supports the hypothesis of greater rainfall during the period represented by this date. (The charcoal was obtained by flotation with CCl_4, but any remaining trace was removed by drying *in vacuo*).

LJ-205. Raised reef, Hawaii—1 **28,200 ± 1300**

Cowry (*Cypraea* sp.) shells from raised coral reef at NE end of Waialua Bay (at Haleiwa), on the N coast of Oahu, at Locations 2 and 5, on the "5-ft" (1.5 m) terrace (ca. 21° 36.5′ N Lat, 158° 06.6′ W Long). Coll. 1960 by G. F. MacDonald and F. P. Shepard; subm. 1960 by Shepard, Scripps Inst. of Oceanography. *Comment*: see also LJ-206, 207, 253, 254, 322, and 323, this date list, for other data on relative sealevel. Referring to another measurement (LJ-253) for the same raised reef, with date given as 24,100 ± 800, Shepard (1961, p. 34) has stated: "At least the five-foot terrace looks very much like the present sea level reef and, therefore, may represent growth rather than erosion although this is a difficult point to determine. In either case it becomes clear that the sea stood relatively higher in Oahu during what is usually interpreted as a low sea level glacial time. Therefore, one can conclude that Oahu is unstable and not a good island to test for sea level changes. If it is really true that there are five-foot terraces all around these islands, which I personally doubt, the islands must either have become stable quite reecntly or must have been elevated very uniformly. Certainly the matter must be given more study."

LJ-206. Raised reef, Hawaii—2 **18,070 ± 450**

Cowry (*Cypraea* sp.) shells from raised coral reef ca. 0.5 km NE of Waimea Bay on the coast of Oahu, on "12-ft" (3.7 m) terrace (ca. 21° 39.1′ N Lat, 158° 04.1′ W Long). Coll. 1960 by G. F. MacDonald and F. P. Shepard; subm. 1960 by Shepard. *Comment*: this measurement is one of the series discussed under LJ-205. Suspecting an error or contamination, because it was expected that this "12-ft" terrace would prove older than the "5-ft" terrace dated 28,200 ± 1300 by LJ-205, further material from the two terraces was measured, as LJ-253 and 254, and as LJ-322 and 323. It appears from the essential consistency of the re-runs that this measurement of 18,070 ± 450 is indeed too young. An older date, represented by LJ-254 (31,540 ± 1300) and

LJ-323 (31,840 ± 1000) should apparently be accepted. Possibly some younger carbonaceous material contaminated the shell sample measured as LJ-206.

LJ-207. Raised reef, Ceylon **2990 ± 220**

Giant clam (*Tridacna*) shell from Hikkaidu ("Hikkaduwa") on SW corner of Ceylon; shell was embedded in a raised beach 0.9 m above low-tide level, in a region of very small tidal range (ca. 06° 09′ N Lat, 80° 05.5′ E Long). Coll. 1958 and subm. 1960 by F. P. Shepard. *Comment*: another test bearing on past changes in sealevel (see LJ-205). Shepard (1961) has charted and discussed this measurement, as providing the only date, except for a few from Australia, of past sealevels higher than the present during the last 5000 yr in relatively stable areas. The problem of late Quaternary changes in sealevel has been reviewed by Curray (1961).

LJ-208. Subtidal peat, La Jolla, California **4230 ± 200**

Peat, including fragmentary plant materials, mixed with subtidal beach sand off center of La Jolla Beach and Tennis Club, in La Jolla, San Diego; peat was exposed by erosion of overlying sand (an occasional occurrence); ca. 120 m seaward from mean lower low-water line and ca. 137 m seaward from Club; in water of low surf 1.3 m below MLLW, 2.0 m below mean sealevel (32° 51′ 16″ N Lat, 117° 15′ 33″ W Long; USGS La Jolla Quadrangle, 7.5′ series, 1953). Coll. and subm. 1960 by R. W. Thompson, Scripps Inst. of Oceanography. *Comment*: The freshwater pond on the Club grounds was transformed from a salt-water lagoon and the presence of the peat (usually buried in the subtidal part of beach) shows that a lagoon existed off the present shoreline when sealevel was lower. These circumstances confirm the view of Shumway, Hubbs, and Moriarty (1961) that the sealevel along this portion of the coast continued to rise during the last few thousand years, and indicate that the shoreline locally has receded considerably during this period. Such shoreline recession offers a plausible explanation for the occurrence just offshore, with the greatest known concentration off the Beach and Tennis Club, of great numbers of stone bowls and other artifacts (Tuthill and Allanson, 1955).

LJ-210. Silver Strand, Coronado, California—1 **270 ± 150**

Pismo clam (*Tivela stultorum*) shells from surface midden (Station B) on low sand dunes on Rancho Carrillo, on strand E of S extension of Silver Strand State Park; alt 6.4 m; ca. 600 m from State Park Monument No. 5 (32° 37′ 29″ N Lat, 117° 08′ 09″ W Long; Air Photo Compilation T-5371, 1933). Coll. and subm. by L. G. Jones (sample 1959—XII: 21B). *Comment*: occupational history and paleoecology of the Silver Strand are being reported (Jones and Hubbs, in press). Station B on the Rancho Carrillo Site represents a Diegueño camp on the light-colored, unconsolidated upper sand, with an abundance of pottery. Older occupation levels were dated by LJ-211 and LJ-336, this date list. As the ground water in the region is currently too brackish to drink, the occupation of the dune stations, perhaps seasonal or temporary, presumably occurred during a time of somewhat greater rainfall. The small

size of the pismo clams, which with clams and scallops from adjacent San Diego Bay apparently contributed the main food of the camp, suggests that the ocean surface (and air) temperatures were somewhat warmer than at present. An O^{18} paleotemperature of 20.6°C, obtained by analysis of these pismo clams, confirms this supposition (determination by R. N. C. Bowen, in the laboratory of H. C. Urey).

LJ-211. Silver Strand, Coronado, California—2 **4020 ± 300**

Pismo clam (*Tivela stultorum*) shells from Station A, in Level III (= Decimeters 9-11) below top of low bank exposed in lower stratum of somewhat consolidated sand exposed by borrow pit on Rancho Carrillo, on strand E of S extension of Silver Strand State Park; alt ca. 5.7 m; 370 m NW from "Silo Type Structure 1933" shown on map used (32° 37′ 33″ N Lat, 117° 08′ 09″ W Long; from Air Photo Compilation T-5371, 1933). Coll. by C. L. Hubbs and L. G. Jones (sample 1959—XI: 14A); subm. 1960. *Comment*: Station A on the Rancho Carrillo Site represents a distinctly older occupation than LJ-210, 270 ± 150 (this date list), and one probably referable to the La Jollan Culture. The great age difference is consonant with the indicated cultural difference (chiefly the lack of pottery in the earlier occupation) and provides an estimate of the rate of darkening and consolidation of sand. It seems improbable that this earlier occupational level has ever been below sealevel, for it would then probably have been eroded away on the narrow sand spit. The evidence for greater-than-present rainfall cited under LJ-210 presumably holds for this earlier date. The large size of the abundant pismo clams in Level III suggests cooler water (and air) than at the time of LJ-210, and the paleotemperature of 17.2°C provided by these clams supports the hypothesis. LJ-336, 4520 ± 220, this date list, came from a slightly lower level in the same exposure.

LJ-212. South Fork, Humboldt River, Nevada **3320 ± 200**

Sagebrush and willow charcoal from a large firepit at depth 1.83 m below surface of a rockshelter midden deposit (Site 26-El-11; Sample UC-59-1) at the mouth of S Fork of Humboldt River, Elko Co., ca. 19.3 km W of Elko (40° 44′ 08″ N Lat, 115° 51′ 40″ W Long). Total depth of midden is 2.69 m. Coll. July 1959 and subm. by R. F. Heizer. Charcoal (LJ-262) from same site, at a depth of 2.29-2.44 m, proved insufficient for measurement. *Comment*: date is of significance in the cultural chronology of the Great Basin (the report on this site will be published in the Univ. of California Anthropol. Recs.). An ample flow of cool water in the nearby river throughout the period of midden deposition is suggested by the circumstance that throughout most of the section, both above and below the firepit, midden shell is largely that of *Margaritifera margaritifera*, a northern relict in the Lahontan Basin. Earliest occupation can be calculated to have occurred ca. 4950 B.P., on the assumption that shelter deposit accumulated at a steady rate.

LJ-213. Shore of Golfo de California—1 **2190 ± 260**

Clam (*Protothaca grata*) shells from inner of two beach ridges on S side of tombolo of Pta. La Gringa, at N end of Bahía de los Ángeles, Baja Cali-

fornia Norte (29° 02.5′ N Lat, 113° 34.3′ W Long; HO Chart 620, 1943). From top 20 cm of a poorly cemented, iron-stained outcrop of pebbles and shells, 1.3-1.7 m above mean sealevel. Coll. and subm. 1960 by D. L. Inman and W. R. Gayman, Scripps Inst. of Oceanography (sample MEX 9 Apr 60—53B). *Comment*: beach morphology in the vicinity strongly suggested to the collectors that sealevel along the W coast of central part of Gulf has been fairly stable and not more than 1.0 m higher than at present since material of the beach ridge was deposited. Test was designed to provide estimates of rates of longshore transport, of sedimentation, of shoreline advance, and of cementation; also to bear on changes in ecologic conditions. There are midden deposits of *Protothaca* and other molluscs in the vicinity, but the shells submitted were presumably part of a natural deposit. See also LJ-214, 215, and 220, this date list.

LJ-214. Shore of Golfo de California—2 **2550 ± 220**

Shell fragments, probably of pelecypods, from innermost of six pebble-beach ridges forming NW rim of a marsh-enclosed tombolo at S tip of Isla San José, Baja California Sur (24° 52.6′ N Lat, 110° 34.3′ W Long; HO Chart 2181, 1918). From depth of ca. 0.3 m at summit of a beach ridge composed of granitic pebbles, 1.3-1.7 m above mean sealevel. Coll. and subm. 1960 by D. L. Inman and W. R. Gayman (sample MEX 15 Apr 60—84C). *Comment*: morphology of the beach ridge strongly suggests that sealevel on the W side of the S part of Gulf has been nearly stable and not more than 0.7 m higher than at present since material in the collection site was deposited. Test was designed to provide estimates of longshore transport, of sedimentation, of shoreline advance, and of weathering of granite (the granite pebbles composing the six ridges, of which the one sampled is the oldest, show an increasing degree of patination (desert varnish) with age); also to bear on changes in ecology. See also LJ-213, 215, and 220, this date list.

LJ-215. Shore of Golfo de California—3 **1970 ± 240**

Clam (*Chione fluctifraga*) shells from midden outcrop at E side of elongate tidal flat at base of Pta. San Jorge, Sonora (ca. 30° 59′ N Lat, 113° 08′ W Long; WAC 471, 1948). From a definite midden in an old soil horizon ca. 4.6 m above mean sealevel, on the face, being eroded by the tidal stream, of a sand-dune ridge ca. 12-15 m high. Coll. and subm. 1960 by D. L. Inman and W. R. Gayman (sample MEX 6 Apr 60—41). *Comment*: morphology of the collection site indicates that sealevel on the E side of N part of Gulf has probably been fairly stable and not more than 4-5 m higher than at present since the midden was deposited. Test was designed to provide estimates of rates of longshore transport, of sedimentation, and of shoreline advance; also to bear on changes in ecology and to date the occupation of the site by Indians who subsisted largely on seafood. See also LJ-213, 214, and 220, this date list.

LJ-216. Punta Minitas Site, Baja California—2 **1510 ± 150**

Charcoal from Layer 2 (1-2 dm below surface) of coastal midden about midway between Punta Cabras and "Punta San Isidro" (= Punta Piedras Blancas), Baja California Norte (31° 18′ 50″ N Lat, 116° 26′ 05″ W Long;

from HO Chart 1149, 1948). Coll. by C. L. Hubbs and party (sample 1957—VI: 28A); subm. 1959. *Comment*: as Layer 1 was disturbed, this date is the youngest reliably obtainable from this long occupied site. First datings were for near middle in densest part of midden: W-26, 2540 ± 200, *Mytilus* shells; W-27, 2500 ± 200, charcoal (USGS I); LJ-5, from Layer 8, gave 3100 ± 300 (La Jolla I); LJ-231, from Layer 12, gave 7020 ± 260, this date list. The occupation indicated was longer than previously assumed, and proves that the sea-food gatherers occupied the coastal sites for several millenia. Since the composition of shellfish species changed little, and no cold-water types such as *Cryptochiton* were utilized at any stage of midden deposition, the temperature probably remained warm throughout, though the time of occupation extended into the recent period of lower temperatures indicated by other tests, such as LJ-108 (La Jolla I). Abundance of such middens along the now very arid coast suggests prolonged period or periods of greater rainfall. Pedogenesis, as noted for LJ-5, has been very slow, except that variable amounts of lime (indurating soil or forming thick caliche) underlying these middens may be attributed to leaching of the shell deposits.

LJ-217. SIO Cliff Site, La Jolla, California—1 >34,000

Charcoal, apparently from a hearth, concentrated in a dark soil lens exposed by minor slide on receding face of cliff at Scripps Inst. of Oceanography, 104 m N of N pilings of Scripps Pier, 3.7-4.3 m above top of Eocene bedrock (which is at alt 2.65 m), 3.1-3.7 m above top of Pleistocene sand-beach deposit, 1.6-2.2 m below lowest of several buried land surfaces with darkened soil and reddened areas, 6.3-6.9 m below lip of cliff (32° 52′ 00″ N Lat, 117° 15′ 09″ W Long; USGS La Jolla Quadrangle, 7.5′ series, 1953). Coll. by C. L. Hubbs and party (sample 1960—VIII: 16A); subm. 1960. *Comment*: this test strengthens the hypothesis of Hubbs that the terrace-fill here represents alluviation throughout Wisconsin time, overlying a beach deposit of Sangamon Interglacial age. This sample came from approximately one-third the height of the cliff above the Eocene base; charcoal from a similar apparent hearth at a stratigraphically higher position in the same terrace fill, 4.9 m below surface of a superficial midden, gave 21,500 ± 700 (W-142, USGS II); shell from near the bottom of the midden on outer part of terrace, at decimeter levels 12 to 14 below undisturbed surface, gave 3240 ± 240 (LJ-382, this date list). Whether the darkened soil horizons containing shallow lenses of conspicuously fire-reddened soil (generally with more charcoal than elsewhere, and often with bone fragments), represent man-made fires is open to question, but seems highly probable to us. Such hearths or hearthlike indications occur at the level of this measurement and at various other levels, from the upper part of the underlying beach to just below the surface middens, and greatly resemble features in the cliff on the N side of Santa Rosa Island. Carter (1957, p. 243-245, fig. 19) and Sellards (1960) have discussed the SIO Cliff Site.

LJ-218. Midden, San Miguel Id., California—2 2120 ± 150

Giant chiton (*Cryptochiton stelleri*) valves from the upper, unconsolidated brownish level of the extensive midden in the sandy area extending NW from

the base of the high slope fronting Adams Cove for two-thirds of the distance to N shore, behind Pt. Bennett at W end of island (34° 01′ 57″ N Lat, 120° 26′ 18″ W Long; USC&GS Chart 5116, 1945). Coll. by C. L. Hubbs and party (sample 1954—IX: 18A); subm. 1960. *Comment*: great abundance in this midden of cold-water species, particularly *Cryptochiton stelleri* and *Tegula brunnea*, indicates that sea (and, no doubt, air) here were then cold, as at present (see also discussion under LJ-227, this date list). Indications of heavy occupation seem incompatible with degree of aridity obtaining at present.

LJ-220. Shore of Golfo de California—4 1180 ± 250

Clam (*Mulinia coloradoensis*) shells from midden deposit on surface of innermost and lowest of three parallel beach ridges bordering W shore of Gulf, near Pta. Sargento, ca. 32.5 km N of San Felipe, Baja California Norte (31° 18.7′ N Lat, 114° 53.3′ W Long; WAC 472, 1947). Ridge is ca. 4.3 m above mean sealevel and ca. 213 m landward from edge of extensive flat (at base of the most seaward and highest ridge, which rises 5.2 m above mean sealevel). Coll. and subm. 1960 by D. L. Inman and W. R. Gayman (sample MEX 4 Apr 60—19). *Comment*: morphology of the collection site indicates that sealevel on the NW coast of Gulf has probably been fairly stable since the shell was deposited. Test was designed to provide estimates of rates of longshore transport, of sedimentation, and of shoreline advance; also to bear on changes in ecology and on production of biogenous material, and to date occupation of this ridge by shellfish-gathering Indians (the evidence of human occupation of this ridge was clear, but little or no evidence was noted of occupation on the two more recent ridges). See also LJ-213-215, this date list.

LJ-221. Scripps Estates Site, California—4 5740 ± 240

California mussel (*Mytilus californianus*) shells from trench S—M—3, on Lot 16 of Scripps Estates Associates, La Jolla, San Diego, largely from the lower part of the A soil horizon; on high terrace at alt ca. 110 m (32° 52′ 22″ N Lat, 117° 14′ 53″ W Long; USGS La Jolla Quadrangle, 7.5′ series, 1953). Coll. and subm. 1960 by George Shumway. *Comment*: date fits nicely among others for the same site described and discussed with various inferences in La Jolla I (LJ-79, 6700 ± 150, LJ-109, 7370 ± 100, and LJ-110, 5460 ± 100) and, in greater detail, by Shumway, Hubbs, and Moriarty (1961). See also other measurements for the same (La Jollan) Culture, in San Diego Co. (LJ-202, 225, 256, 275-277, this date list). The species composition of the shells in this site suggests temperatures probably a little higher than at present. The extensive occupation of the area suggests more ample surface water in the past.

LJ-222. Rancho Cuevas, Baja California Norte—2 70 ± 180

Charcoal from 5-cm bottom level, below Decimeter 7 (from top), in Pit B, near center of the midden deposit, in rockshelter on Rancho Cuevas, between Rosarito Beach and Pta. Descanso, ca. 100 m upstream from low coastal terrace, in third canyon S of basaltic hill "Aguajito" (ca. 32° 17.0′ N Lat, 117° 02.0′ W Long; HO Chart 1149, 1948). Coll. 1959 by R. W. Holmes, Harold Berkson, and R. I. Clutter, Scripps Inst. of Oceanography; subm. 1960. *Comment*: in view of the date of 400 ± 200 obtained from Decimeter

2 in Pit A of the same rockshelter (LJ-33, La Jolla I) it was expected that this date would be older. The discrepancy is unexplained, and further checking is anticipated. The unexpected finding of a few *Cryptochiton* valves in the overlying midden debris poses another problem. These valves may have been brought in from an older midden or from a Pleistocene deposit. The whole site appears referable to the Diegueño Culture.

LJ-223. Presidio Site, San Diego, California **100 ± 150**

Pismo clam (*Tivela stultorum*) shells from old Spanish Presidio grounds adjacent to present Junípero Serra Museum, in the city of San Diego at S side of W end of Mission Valley, just above the original site of Misión San Diego de Alcala (32° 45′ 34″ N Lat, 117° 11′ 38″ W Long; Air Photo Compilation T-5373, 1935). Coll. by B. E. McCown, C. L. Hubbs, and party (sample 1956—VII: 11A); subm. 1959. *Comment*: this fort was occupied during the early years of the 19th century. The artifacts and midden remains that were excavated here indicate habitation by hunting and seafood-gathering Indians during a period of contact with the Spaniards. The date is consistent with this interpretation and confirms the validity of datings from littoral shellfishes. The small size of the pismo clams is consonant with other indications of a warm period (Hubbs, 1948).

LJ-224. Colonia Guerrero, Baja California—1 **630 ± 150**

Pismo clam (*Tivela stultorum*) shells from a superficial midden deposit in Colonia Guerrero, Baja California Norte, on low terrace near coast, near (S of) mouth of Río Santo Domingo, ca. 2.4 km WSW of main crossroad on Highway Mex. 1 (30° 42′ 52″ N Lat, 116° 02′ 28″ W Long; HO Chart 1149, 1948). Coll. by C. L. Hubbs and party (sample 1955—X: 24B); subm. 1960. *Comment*: see LJ-226.

LJ-225. University of California, La Jolla Site 1 **6370 ± 210**

California mussel (*Mytilus californianus*) shells from a depth of 1.25 m near bottom of midden on the high terrace on the La Jolla campus of the Univ. of California in San Diego Co.; taken 3.7 m from road, in Pit 4-A (32° 52′ 13″ N Lat, 117° 14′ 44″ W Long; USGS La Jolla Quadrangle, 7.5′ series, 1953). The sample was taken in the S section of the midden near its edge, in a region from which 13 burials were excavated. Coll. and subm. 1960 by J. R. Moriarty, Scripps Inst. of Oceanography, and party. *Comment*: this site is now regarded as an integral continuation of the Scripps Estates Site, described by Shumway, Hubbs, and Moriarty (1961), dates for which have ranged from 5460 to 7370 B.P.: LJ-79, 109, and 110 (La Jolla I); LJ-221 (this list). Other dates for the La Jollan Culture, of which this site (UCLJ M-1) appears to have been one of the major dwelling areas, are discussed by Shumway, Hubbs, and Moriarty; see also, in this date list, LJ-202, 208, 211, 256, 274-276, and 336, for other La Jollan or similar sites in San Diego Co., and LJ-231, 332, and 334 for similar sites in NW Baja California. Despite the indicated time span of more than 3000 yr, the known La Jollan sites are strikingly similar in lithic technology. Relations to past changes in sealevel, fauna, and climate are discussed in the previous sample descriptions, and, at greater length, by

Shumway, Hubbs, and Moriarty. The faunal composition of the midden suggests temperatures higher than at present.

LJ-226. Colonia Guerrero, Baja California—2 **660 ± 150**

Giant chiton (*Cryptochiton stelleri*) valves from same superficial midden as LJ-224 (30° 42′ 52″ N Lat, 116° 02′ 28″ W Long). Same collectors and sample no.; subm. 1960. *Comment*: in very close agreement with the date for pismo clams (LJ-224, 630 ± 150, this list) from the same midden, with species intermixed. Presence of the cold-water *Cryptochiton*, which is no longer extant in the area, indicates colder-than-present temperatures along the NW Baja California coast, as established particularly for the millennium between 1600 and 600 B.P.; see also C-659, 1063 ± 100 and 716 ± 130 (Chicago III); W-32, 650 ± 200 (USGS I); LJ-75, 1150 ± 150, LJ-83, 1600 ± 150, LJ-84, 1060 ± 150, LJ-85, 960 ± 150, and LJ-108, 1580 ± 100 (La Jolla I). Exceptional local persistence of this chiton is shown by LJ-232, 110 ± 150, and LJ-266, 160 ± 150, and possibly by LJ-222, 70 ± 180 (this date list). Abundance of shells and paucity of artifacts in this and similar middens suggest persistence of a degraded culture. Occurrence of *Cryptochiton* in middens of NW Baja California, in an area of present upwelling, is evidence of the continuity of climatic pattern.

LJ-227. Santa Cruz Island, California **600 ± 200**

Mussel (*Mytilus californianus*) shells, from a deep, unconsolidated midden at the E edge of the cove at Willows Anchorage, on S shore of island (33° 57′ 46″ N Lat, 119° 45′ 10″ W Long; USC&GS Chart 5115, 1945). Coll. by C. L. Hubbs and party (sample 1954—IX: 18B); subm. 1960. *Comment*: essentially warm-temperate fauna and rather warm sea (and air) temperatures are indicated, most strikingly by apparent absence of *Cryptochiton* (none disclosed by considerable search), at a time when this cold-water chiton occurred along the NW Baja California coast (see references under LJ-226) and between points Conception and Arguello in California (LJ-263, this date list), and when, presumably, it also occurred farther W in the northern Channel Islands (as it did earlier—see LJ-25, 1750 ± 200, La Jolla I, and LJ-218, 2120 ± 150, this date list). At present there is a sharp upward gradient in temperature from W to E along this island chain (unpublished records), and these datings indicate that the same pattern has likely held for centuries. Confirmatory evidence comes from the species composition of shells (essentially warm-temperate types, lacking *Cryptochiton*), reported from all middens studied on Anacapa Island, easternmost of the chain (McKusick, 1959, p. 98-100). The present extreme aridity of the S coast of Santa Cruz Id. seems incompatible with the past occupation.

LJ-228. Off southeast shore, Bermuda—1 **5970 ± 210**

Mangrove wood (Sample no. 1) protruding from top 5 cm of peat exposed on bottom at depth of 9 m below present sealevel (ca. 32° 20.2′ N Lat, 64° 39.7′ W Long). Coll. and subm. 1959 by H. A. Lowenstam, California Inst. of Technology. *Comment*: date and depth of deposit for this and the next

two tests agree well with other estimates of eustatic sealevels, as summarized by Shepard (1961).

LJ-229. Off southeast shore, Bermuda—2 **7030 ± 200**

Cedar wood (Sample no. 2) protruding from peat layer exposed 9 m below present sealevel at site of LJ-228 (ca. 32° 20.2′ N Lat, 64° 39.7′ W Long). Coll. and subm. 1959 by H. A. Lowenstam. *Comment*: see LJ-228. The agreement is only fair. L-111A, cedar log dredged in entrance to St. George's Harbor, Bermuda (Lamont I) gave 11,500 ± 700.

LJ-230. Off southeast shore, Bermuda—3 **5910 ± 210**

Peat from 15 cm below top of peat deposit exposed 9 m below present sealevel at site of LJ-228 (ca. 32° 20.2′ N Lat, 64° 39.7′ W Long). Coll. and subm. 1959 by H. A. Lowenstam. *Comment*: this measurement agrees very closely with that of 5970 ± 210 (LJ-228) for wood protruding from the same peat deposit, not quite so well with the second estimate (LJ-229) of 7030 ± 200 derived from another piece of wood associated in the same deposit. L-111B, peat dredged in entrance to St. George's Harbor, Bermuda, reportedly overlying drowned cedar forest (Lamont I) gave average of 6900 ± 150.

LJ-231. Punta Minitas Site, Baja California—3 **7020 ± 260**

California mussel (*Mytilus californianus*) shells from Layer 12 (11-12 decimeters below surface), near bottom of coastal midden described under LJ-216, this date list (31° 18′ 50″ N Lat, 116° 26′ 05″ W Long). Coll. by C. L. Hubbs and party (sample 1957—VI: 28A); subm. 1960. *Comment*: oldest of five dates for this midden; youngest, for LJ-216, is 1510 ± 150; the great time span now indicated for this rather uniform midden, with a paucity of artifacts, all crude, supports the hypothesis (Shumway, Hubbs, and Moriarty, 1961) that the old shellfish-gatherers of the La Jollan type continued to inhabit the coast for about six millenia. Other inferences drawn from the data for this site are presented under LJ-216.

LJ-232. Midden N of Punta Camalú, Baja California **110 ± 150**

Giant chiton (*Cryptochiton stelleri*) valves from surface of plowed field on low coastal terrace, at Temperature Station 34, ca. 1.6 km NW of Pta. Camalú, Baja California Norte (30° 49.2′ N Lat, 116° 06.4′ W Long; HO Chart 1149, 1948). The shells, from an underlying midden, were brought to surface through windblown sandy soil by burrowing rodents. Coll. by C. L. Hubbs and party (combined sample, 1954—V: 7C and 1955—X: 23A); subm. 1960. *Comment*: this was first recent dating of the cold-water *Cryptochiton*, which no longer persists in Baja California. Its persistence here and at Pta. Baja (see LJ-266, this date list) may be explained by the fact that these two places are shown by the long-continued coastal temperature survey (Hubbs and Hubbs, ms in preparation) to be among the coldest along the coast. At such points *Cryptochiton* may have resisted for several centuries the high temperatures following the cold period from ca. 1600 to ca. 600 B.P. (see LJ-226, this date list). The present aridity of the coast seems incompatible with the occupation indicated by many middens and by an extensive stone-working site just S of Pta. Camalú.

LJ-235. Midden, Cape Arago, Oregon—2 **2090 ± 200**

California mussel (*Mytilus californianus*) shells from Layer 5 (6th decimeter) of a midden at island end of footbridge leading to Cape Arago Light, at E end of a 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. 1960. *Comment*: date fixes an early period in the occupation of this site, for which ecologic and cultural inferences will be detailed in a later report. Charcoal from Layer 1 (upper 2 decimeters) of same midden yielded date of 1500 ± 100 (LJ-111, La Jolla I). It seems probable that this midden was occupied before the channel severed the very steep-sided island; the top decimeter of a midden on the mainland side of the channel gave a much younger date (250 ± 150, LJ-238, this date list). The shells indicate a northern fauna much like that of the present.

LJ-236. Whale Rock Reservoir, California **1620 ± 150**

Pismo clam (*Tivela stultorum*) shells from site SLO-157 of the Univ. of California Archaeol. Survey, along Cottontail Creek, tributary to Old Creek, near Cayucos, San Luis Obispo Co., in the area to be flooded when Whale Rock dam is built across Old Creek; sample from Pit K-6, depth 0.91 to 1.07 m, slightly below the level of Burials 1, 2, and 4 (ca. 35° 27.0′ N Lat, 120° 52.5′ W Long; USGS Cayucos Quadrangle, 1951). Coll. June 1960 by F. M. Reinman; subm. 1960 by C. W. Meighan (both of Univ. of California, Los Angeles). Two charcoal samples from the same location (LJ-255, from a depth of 0.58 m in the same Pit K-6, in site SLO-157, and LJ-257, from a depth of 2.59 to 2.90 m in Pit F-20 of site SLO-156) proved insufficient for measurement. *Comment*: no definite paleoclimatologic changes are indicated: the stream still maintains a permanent flow and the shellfishes represented in the excavations still live nearby. Archaeology of the site has been reported and the date discussed by Reinman (1961, p. 10, 13, 32).

LJ-237. Bahía de los Ángeles, Baja California—3 **300 ± 150**

Clam (*Glycymeris* cf. *gigantea*) shells on and just below surface midden on low dunes between airstrip and beach (within 100 m of high-tide line), on the Golfo de California side of Baja California Norte (ca. 28° 57.0′ N Lat, 113° 34.5′ W Long; HO Chart 0620, 1943). Where thickest, the midden forms low mounds, but the ground coverage is almost complete. Much material has been left like desert pavement at the surface, but in places some is buried *in situ*, with some charcoal. Crude blackish pottery is common. Coll. and subm. by C. L. Hubbs (mixed sample, 1959—II: 26A and 1960—II: 19). *Comment*: the midden suggests a relatively recent and rather dense population. On the basis of popular accounts it has been stated (La Jolla I, p. 206) that "the occupation of the area continued until historic time (Father Kino mentioned encountering a large ranchería on the bay)," but a search of the literature shows that Kino did not travel along the W side of the Gulf. However, "in the year 1746 Padre Fernando Consag . . . . came to the great Bay of Los Angeles where he found many Indians enjoying the beautiful beach and

living near a palm-shaded spring" (North, 1908, p. 37); there are other indications of Indians living in the region into historic time. Evidence of occupation abound in the region of the springs, ca. 1 km from LJ-237, the only source of drinking water for many miles along this very arid coast. That the habitation was prolonged is indicated by LJ-26, 6100 ± 200, and LJ-29, 2500 ± 300 (La Jolla I). Shellfish species in all the middens indicate the long persistence of a tropical fauna.

LJ-238. Midden, Cape Arago, Oregon—3 **250 ± 150**

California mussel (*Mytilus californianus*) shells from "Decimeter 1" layer (sod plus top decimeter below sod) of a midden on small point at E end of channel inside island of Cape Arago Light, on mainland side on cliff edge facing SE (43° 20′ 23″ N Lat, 124° 22′ 20.5″ W Long; USC&GS Chart 5984, 1957). The total layer, nearly two decimeters thick in an area of 1 m^2, yielded ca. 55 L of shell, with some fish bone. Coll. and subm. by C. L. Hubbs and party (sample 1957—VIII: 9A). *Comment*: the available datings indicate that Cape Arago was occupied for about two millenia, until almost historic time, and this mainland midden is younger, or lasted longer, than the one sampled (LJ-111, La Jolla I, and LJ-235, this date list) on the small island. The site will be described, with inferences on ecology and culture, in a later report. The fauna, as indicated by the midden shells, was much like that of the present in this area.

LJ-240. Magnolia Core Hole No. 1, California **255 ± 150**

Mussel (*Mytilus californianus*) shells from 3.96 to 7.01 m below sealevel in boring (DWR 55/13 W 1L- or 1M-) by Richfield Oil Corporation, on beachfront fill in city of Long Beach, California, 0.7 km W of Municipal Auditorium (33° 45′ 54″ N Lat, 118° 11′ 46″ W Long; USGS Long Beach Quadrangle, 7.5′ series, 1949, and USC&GS Chart 9147, 1959). Subm. 1960 by R. G. Thomas, then of California Dept. of Water Resources. *Comment*: according to a geologic cross-section, Terminal Island—Long Beach, dated 5-13-60, subm. with sample, ground surface was at alt +3.35 m, and the first shell zone encountered was from 0.67 to 3.66 m below present sealevel, well above the level of a questioned line of contact between Upper Plistocene and Recent and barely below recent fill compensating for modern subsidence (due to removal of oil and water). Other shell zones, to be dated later, were encountered between this level and the level marked on the cross-section, with a question, as the line between Upper Pleistocene and Lower Pleistocene; also below that level. "Horizons in this well should be corrected for ca. 6′ [1.83 m] of [modern] subsidence." This test and LJ-241 verify the interpretation of the upper part of the floor of the Los Angeles Basin as of Recent age, and since the shell samples seem to represent beach deposits, these tests indicate rapid subsidence and rapid aggradation. See also UCLA-119 and 120 (UCLA I).

LJ-241. Richfield Water Source Well No. 3, California 1160 ± 200

Clam (*Amiantis callosa*) shells from 19.81 to 21.34 m below sealevel in boring (DWR 55/13 W 11A-) by Richfield Oil Corporation, on beachfront fill 1.5 km SW of Long Beach Municipal Auditorium and 0.4 km E of E

breakwater of Long Beach Harbor (33° 45′ 23″ N Lat, 118° 12′ 03″ W Long; USGS Long Beach Quadrangle, 7.5′ series, 1949, and USC&GS Chart 5147, 1959). Subm. 1960 by R. G. Thomas. *Comment*: according to the geological cross-section referred to under LJ-240, ground surface is at alt ca. + 8.23 m, and the first shell zone encountered was 11.28 to 15.85 m below present sea-level (well below the modern fill and well above the level of a questioned line of contact between Upper Pleistocene and Recent); another thin shell zone was found below that line, at 32.61 m. "Horizons in this well should be corrected for ca. 8′ [2.44 m] of subsidence." Inferences same as for LJ-240.

LJ-242. Batiquitos Lagoon, California—4 **870 ± 200**

Clam (*Chione undatella*) shells from top (Decimeter 1) of midden along N shore, near middle of the now sediment-filled Batiquitos Lagoon, just NE of Leucadia, San Diego Co. (33° 05′ 28″ N Lat, 117° 17′ 33″ W Long; Air Photo Compilation T-5411, 1934). Coll. by J. N. Miller (sample 1960—III: 29A); subm. 1961. *Comment*: this measurement, along with those for LJ-243 and LJ-245, delimits a late stage in the extensive occupation around this lagoon, before its virtual elimination by sediment, and presumably during a continuation of the early Holocene rise in sealevel (Miller and Hubbs, ms in preparation). The species composition indicates a warm-temperate fauna, with no definite indication of temperatures different from those now prevailing. The shell-gathering culture seems to have persisted around the lagoon, at least intermittently, for ca. 7 millennia, in response to adequate food supply and water at or near the surface. The earlier dates are given and discussed under LJ-256 (this date list). Evidence of LJ-242, LJ-243, and LJ-245 negates the conclusion of Warren, True, and Eudey (1961, p. 25) that "from about 2500 to 3000 years ago it appears that Batiquitos lagoon could no longer support a supply of shellfish adequate to maintain a sizable aboriginal population."

LJ-243. Batiquitos Lagoon, California—5 **825 ± 200**

Clam (*Chione undatella*) shells from Decimeter 4 (below surface, of midden described and located under LJ-242; same coll. and same sample; subm. 1961. *Comment*: the significance of this measurement is discussed under LJ-242. The slightly older (nearly identical), rather than the earlier date that would be expected, presumably indicates accumulation over a very short period. The Decimeter 4 level is unique in the extremely high density of shells (65,000 in 0.05 m^3). Obviously conditions for human existence were very favorable.

LJ-245. Batiquitos Lagoon, California—6 **1075 ± 150**

Clam (*Chione undatella*) shells from Decimeter 7 level of midden described and located under LJ-242. Coll. by J. N. Miller (sample 1960—VI: 16B); subm. 1961. *Comment*: slightly older, as expected, than overlying levels of midden. Inferences as for LJ-242 and LJ-243.

LJ-246. Thermal water, The Geysers, California—1
<0.54% of modern

CO_2 gas from Thermal Power Co. Well no. 1, The Geysers, Sonoma Co. (38° 48′ N Lat, 122° 48′ W Long). Coll. September 16, 1960 by Harmon

Craig and A. E. Bainbridge; subm. by Craig, 1960. *Comment* (H.C.): "activity quoted represents the 3 standard deviation upper limit." See LJ-247.

LJ-247. Steamboat Springs, Nevada—1 **<0.54% of modern**

CO_2 gas from Nevada Thermal Well no. 3, Steamboat Springs, Washoe Co. (39° 23′ N Lat, 119° 45′ W Long). Coll. September 8, 1960 by Harmon Craig and D. E. White; subm. by Craig, 1960. *Comment* (H.C.): "activity quoted represents the 3 standard deviation upper limit. The radiation 'age' of the sample is from 30,000 to 300,000 years, taking into account the carbon and ground water penetrating the thermal area, and the types of circulation which may exist in the area." The problem was discussed at the December 1961 meeting of the Am. Geophys. Union.

LJ-248. Thermal water, The Geysers, California—2 **<0.54% of modern**

Same as LJ-246, except CO_2 gas from Thermal Power Co. Well no. 11, same location. Coll. September 15, 1960 (collectors and submitters date same). *Comment*: same as for LJ-246.

LJ-249. Steamboat Springs, Nevada—2 **<0.54% of modern**

Same as LJ-247, except CO_2 gas from Steamboat Spring no. 4, same location. Another CO_2 gas sample from Steamboat Springs (LJ-251, from Steamboat Rodeo Well, same location and collectors) proved insufficient for measurement. Coll. September 11, 1960 by Harmon Craig and Valerie Craig. *Comment*: same as for LJ-247.

LJ-250. Thermal water, The Geysers, California—3 **<0.54% of modern**

Same as for LJ-246, except CO_2 gas from Magna Power Co. Well no. 1, same location. Coll. September 16, 1960 (collectors and submitters date same). *Comment*: same as for LJ-246.

LJ-251. (See LJ-249)

LJ-252. Thermal water, The Geysers, California—4 **<0.54% of modern**

Same as for LJ-246, except CO_2 gas from Thermal Power Co. Well no. 7, same location. Coll. September 17, 1961 (collectors and submitters date same). *Comment*: same as for LJ-246.

LJ-253. Raised reef, Hawaii—3 **24,140 ± 800**

Cowry (*Cypraea* sp.) shells from same collection as for LJ-205 (a subsequent run, on other shells). Subm. 1960 by F. P. Shepard. *Comment*: this measurement agrees reasonably well with the two others for the same terrace of the same reef (LJ-205, 28,200 ± 1300, and LJ-322, 26,640 ± 100, this date list).

LJ-254. Raised reef, Hawaii—4 **31,540 ± 1300**

Cowry (*Cypraea* sp.) shells from same collection as LJ-206 (a duplicate run). Subm. 1960 by F. P. Shepard. *Comment*: this measurement from the

"12-foot" terrace is discordant with that of LJ-206, which seemed too low, but is consistent with expectation, as being older than the dates for the "5-foot" terrace on another reef in the same region (see LJ-205, LJ-253, and LJ-322, this date list), and agrees well with another date (LJ-323, 31,840 ± 1000, this date list) for shells in a new collection from the same terrace on the same reef.

LJ-255. (See LJ-236)

LJ-256. Batiquitos Lagoon, California—7 **6250 ± 150**

Charcoal from SDi-603, the Leucadia Site, of the Univ. of California Archaeol. Survey, on S shore of Batiquitos Lagoon, at W side of westernmost canyon on S side, San Diego Co. (33° 05′ 01″ N Lat, 117° 17′ 52″ W Long; Air Photo Compilation T-5411, 1934). From Feature 14, a concentration of broken and whole rocks (darkened by charcoal and by burning, as was the surrounding soil), containing a chopper, a mano, and a metate fragment. Coll. and subm. September 1960 by C. N. Warren, Dept. of Anthropology and Sociology, Univ. of California, Los Angeles. *Comment*: as interpreted by collector, sample came from soil Stratum A3 (a gray-brown, compact sand, containing relatively large quantities of shell, largely *Pecten* and *Chione*), within 5-10 cm of bottom of Stratum A2 (compact, light-brown sand containing small amounts of shell; 14-30 cm thick), which was overlain by Stratum A1 (humous, loose, lumpy, dark-brown sandy soil 8-15 cm thick, probably representing soil disturbed by plow; containing pottery, a few stone artifacts, and very few shells). According to the hypothesis presented by C. N. Warren and D. L. True (personal communication), Stratum A3 represents the climax of the La Jollan Culture and A2 represents its final stage. Stratum A1, with pottery, obviously represents the Diegueño Culture. Pit was within a few m of LJ-31, 3900 ± 200 (La Jolla I), which came from Warren's Stratum A2, and LJ-36, 7300 ± 200 (La Jolla I), which came from Warren's Stratum B1 (underlying his Stratum A3). Other tests from middens around Batiquitos Lagoon (LJ-35, La Jolla I, and LJ-242, 243, and 245, this date list) gave dates of 3500 ± 200, 870 ± 200, 825 ± 200, and 1075 ± 150, respectively. Shells from two levels in a core in the lagoon fill (LJ-333 and LJ-381, this date list) are dated 6320 ± 250 and 3400 ± 240, respectively. These dates, along with other pertinent evidence, suggest to us: (1) that the observed soil horizons were differentiated subsequent to the early occupation of site SDi-603, (2) that the lagoon long remained open to the sea, likely concurrently with a continued rise in sealevel, and (3) that shellfish-gatherers of different cultures long utilized this lagoon as a source of food.

LJ-257. (See LJ-236)

LJ-258. San Clemente Island, California—1 **<100**

Charcoal, sample no. 1, from hearth of Eel Cove House Site (SCll-118 of Univ. of California Archaeol. Survey) at depth of 0-33 cm (32° 54′ 48″ N Lat, 118° 32′ 18″ W Long; map 4 of McKusick and Warren, 1959, and USGS

San Clemente Central Quadrangle, 1950). Coll. September 1958 by M. B. McKusick and C. N. Warren, Dept. of Anthropology and Sociology, Univ. of California, Los Angeles; subm. 1958 by C. W. Meighan of that department. *Comment*: Meighan, on advice of C. N. Warren, who was on the field project, states that the samples for LJ-258 and LJ-260 "came out of archaeological contexts with fair abundance of aboriginal artifacts" and that "the site does not look particularly recent on cultural grounds." The site was described by McKusick and Warren (1959). Meighan adds that as the site is shallow, the sample may have been contaminated, possibly by a brush fire. He regards the date as meaningless archaeologically, but other recent deposits have yielded comparable dates that are not possibly correct if construed rigidly (no archaeologic remains on San Clemente Island can possibly be less than 100 yr old, because all Indians were removed from the island at least 150 yr ago).

LJ-259. San Clemente Island, California—2 **450 ± 150**

Charcoal from Univ. of California Archaeol. Survey Site SCll-67, from Seal Cove Midden (steatite site), T-67, Pit B′, depth 20 cm (32° 53′ 53″ N Lat, 118° 31′ 35″ W Long; map 5 of McKusick and Warren, 1959, and USGS San Clemente Island Central Quadrangle, 1950). Coll. September 1958 by M. B. McKusick and C. N. Warren; subm. 1958 by C. W. Meighan. *Comment* (C.W.M.): "The sample LJ-259 is out of known recent context and the date is presumably correct. However, in view of the other dates and the fact that LJ-259 charcoal is only 8 inches deep in the ground, some caution in using the date is probably indicated." Earlier, in submitting the samples, he had noted that this sample and the one for LJ-258 "are from fairly recent sites and might date anywhere from a few hundred to perhaps 2,000 or 3,000 years ago." The site was described by McKusick and Warren (1959), who noted in their reconnaissance study of the middens on the island that it "seems plausible that the climate has become somewhat dryer because there are large numbers of archaeological sites, representing fairly large populations, and no apparent water sources to support them." They indicated that the food remains in the archaeologic sites suggest "that the prehistoric populations subsisted largely on seafood." (The occurrence of land snails in the middens does not justify their conclusion that this land resource was eaten).

LJ-260. San Clemente Island, California—3 **<100**

Charcoal from a hearth from Midden 1 in Eel Cove Canyon Shelter, Site SCll-49 of the Univ. of California Archaeol. Survey (32° 54′ 40″ N Lat, 118° 33′ 18″ W Long; Map 4 of McKusick and Warren, 1959, and USGS San Clemente Central Quadrangle, 1950). Coll. September 1958 by M. B. McKusick and C. N. Warren; subm. 1958 by C. W. Meighan. A sample (LJ-265) of mussel (*Mytilus californianus*) shells from the same midden site, taken at a depth of 1.22-1.37 m, proved insufficient for measurement. *Comment*: Meighan's remarks under LJ-258 apply also to this measurement, as does some of the discussion under LJ-259. This site was described by McKusick and Warren (1959), who wrongly assigned it site number SCll-48, and the midden column sample from the site was analyzed by Wissler (1959).

LJ-261. Scammons Lagoon, Baja California Sur—3 200 ± 150

Charcoal from a midden on a low sand dune, ca. 1.5-4.5 m above high-tide line, along the W shore of the E arm of Scammons Lagoon (Laguna Ojo de Liebre), ca. 6.5 km NW of old pier of abandoned salt works (27° 44′ 36″ N Lat, 113° 58′ 00″ W Long; from MS Air-Photo Compilation Map by F. B Phleger). Midden shells and artifacts abound, mostly on the surface, approaching the characteristics of desert pavement in places (with some charcoal and a few shells as deep as ca. 1 m). Other low dunes in area show similar middens. Coll. by C. L. Hubbs and party (sample 1959—II: 22A); subm. 1960. *Comment*: the site is obviously rather recent, though free of contact material. The circumstances indicate rather extensive use of the lagoon by food-gathering people, though neither continuous nor prolonged habitation is indicated. The considerable distance (ca. 17 km) from Ojo de Liebre, the only spring on the extensive flat Desierto de Vizcaíno, and the much greater distance from springs reputed to exist in the mountains to the W, suggest that rainfall at the time was greater than at present. A warm-water mollusc fauna is indicated, as also for other samples of varying dates in the parts of Baja California that are now warm (LJ-12, 1900 ± 300, LJ-13, >25,000, LJ-21, >37,000, LJ-26, 6100 ± 200, LJ-28, 1000 ± 250, LJ-29, 2500 ± 300, LJ-30, 600 ± 150, LJ-96, 1370 ± 200, LJ-100, 200 ± 100, LJ-131, > 42,000, LJ-132, 1700 ± 150, all in La Jolla I; and LJ-200 ± 100, LJ-220, 118 ± 250, and LJ-237, 300 ± 150, this date list).

LJ-262. (See LJ-212)

LJ-263. Jalama Creek midden, California 600 ± 150

Giant chiton (*Cryptochiton stelleri*) valves from surface of midden on N side of mouth of Jalama Creek, Santa Barbara County (34° 30.9′ N Lat, 120° 30.1′ W Long; USC&GS Chart 5202, 1958). Coll. and subm. 1955 by R. S. Finley, Santa Barbara Mus. of Nat. History. *Comment*: dated to determine past distribution of the cold-water indicator. Measurements on this species from middens in Baja California are discussed above under LJ-226 (this date list); *Cryptochiton*-containing middens from the Channel Islands, California have also been treated under LJ-25 (La Jolla I) and LJ-218 (this date list).

LJ-265. (See LJ-260)

LJ-266. Midden, Punta Baja, Baja California 160 ± 150

Giant chiton (*Cryptochiton stelleri*) valves from surface of midden on uppermost terrace near middle of Punta Baja, Baja California Norte (29° 57.0′ N Lat, 115° 48.8′ W Long; HO Chart 1085, 1943). Coll. by L. C. Hubbs (sample 1954—IV: 12A); subm. 1960. *Comment*: dated to determine when this cold-water chiton, now extinct in Baja California, existed at Pta. Baja, which is now in a region of strong inshore upwelling. No *Cryptochiton* valves have been found on this point in the older buried middens, and the species composition of the shells in those middens, confirmed by one paleotemperature, indicates that relatively high temperatures prevailed prior to the relatively recent cold period (one sample, W-30, USGS I, gave a date of 4030 ± 200

and a paleotemperature of 17.1° C). *Cryptochiton* valves from a midden ca. 3.2 km E of Pta. Baja gave a C^{14} measurement of 1600 ± 150 and a paleotemperature of 13.6° (LJ-83, La Jolla I); dates for a *Cryptochiton*-containing thin midden in Valle de Rosario, also nearby, are 1060 ± 150 and 960 ± 150 (LJ-84 and LJ-85, La Jolla I); dates for other *Cryptochiton*-containing middens in Baja California are discussed under LJ-226 (this date list). LJ-266, like LJ-232 (this date list), seems to indicate that at points of maximal upwelling *Cryptochiton* persisted after ca. A.D. 1300 for some centuries into the recent warmer period.

LJ-267. (See LJ-331)

LJ-268. Phosphorite, Baja California—1 **19,300 ± 600**

Phosphorite, $Ca(PO_4, CO_3)$, from dunes on lagoon barrier, 1.6 km N of Boca Santo Domingo, Baja California Sur (ca. 25° 31′ N Lat, 112° 05′ W Long). Coll. 1959 by F. B Phleger; subm. 1960 by E. D. Goldberg, Scripps Inst. of Oceanography. *Comment*: the first attempt to date phosphorites of marine origin. The structural carbonate in the crystal lattice provided the datable fraction. Relatively recent formation is indicated by this measurement and, more strikingly, by that of LJ-399 (this date list). LJ-82 (La Jolla I), a phosphatized wood specimen from 510 m depth, gave an indefinite age, but the carbon was probably organic and genuinely old.

LJ-269. Lake Manix shoreline, California **19,500 ± 500**

Tufa with scattered shells, casts, and molds of freshwater mussels (*Anodonta*); ca. 150 m SW of the great NW-SE-trending Afton beachbar of Pluvial Lake Manix, ca. 1.5 km NNE from Afton, San Bernardino Co.; NW of the hill on the N side of the outlet channel (35° 02′ 54″ N Lat, 116° 22′ 30″ W Long; USGS Cave Mountain Quadrangle, 1951). The sample was taken at an elevation of ca. 521 m on a bearing of 5.45°W from the highest point on the mountain due W of Cave Mountain. The tufa deposit is roughly wedge-shaped and occupies a relatively flat area at the junction of two ephemeral streams. Exposures of the tufa extend upslope for ca. 50 m, where it becomes buried beneath the cobbles and gravels derived from the beachbar, which lies farther upslope. Coll. August 1959 and subm. 1960 by J. T. Scheliga, Jr., California Dept. of Water Resources. *Comment*: the elevation of the bar crest, according to R. D. Simpson (personal communication), is about the same as that (542.5 m) of the highest observed beach, on the hill to the SE. Just below this beach, encrusting tufa has yielded the virtually identical measurement (UCLA-121) of 19,300 ± 400 (UCLA I). According to Simpson, recent (Shoshonean) artifacts occur near the modern playas (bare remnants of the ancient lake); Playa Complex artifacts on the intermediate beaches, formed during the lowering of the lake; and the Manix Lake Lithic Industry (characterized by very crude stonework, resembling Early Paleolithic), just above the highest clear-cut stand of this lake and for some distance up the slopes of the surrounding hills. The several stages of Lake Manix were impoundments of Pluvial Mohave River (evidence reviewed by Hubbs and Miller, 1948, p. 87; by Simpson, 1958 and 1960, along with an abstract of the archaeologic data; and by Sellards, 1960).

The date fixes this high stand of Lake Manix (but possibly not the highest) as being well within the Wisconsin period and offers confirmatory evidence, though hardly a new demonstration, of the occurrence of man in the SW during Glacial time. However, a later but still probably Pleistocene date may prove to be involved, if verification should be obtained for the existence of the higher and later stage of Lake Manix postulated by Blackwelder and Ellsworth (1936) on the basis of "beach gravel" stratigraphically overlying the fan gravel that was deposited over the lake clays and beach gravel associated with the tufa here discussed.

LJ-270 and 271. Beach tar, Viet Nam and Australia >40,000

Tar coating beaches at Isles des Pecheures, near Nhatrang, Viet Nam (12° 02.0′ N Lat, 109° 19.2′ E Long), and in Australia at mouth of Jardine River, York Peninsula (11° 04′ S Lat, 142° 11′ E Long). Tar formed extensive blobs on these beaches, especially on the long sandy beach at York Peninsula. The two small samples were combined. Coll. and subm. 1960 by P. F. Scholander, Univ. of California, San Diego. *Comment*: experiment was designed by collector to test hypothesis of F. W. Went (1960) that terpenes exuded into the atmospheric mist by plants may be a factor in the origin of petroleum. Since the beaches where the tar was collected bound lush tropical vegetation, in regions where there is very little industry and limited shipping, Scholander thought it possible that the tar on the beaches, remote from shipping lanes, might have been derived in this way from terpenes that had originated in the nearby lush vegetation and had accumulated on the sea-surface, to be washed ashore. The infinite age, however, indicates an origin from a more ancient source. Further efforts will be made to collect plant-liberated terpenes to test Went's hypothesis.

LJ-272. Gruta de Balankanche, Yucatan—1 1090 ± 200

Charcoal from inside urns found in Chamber no. 2 far within this limestone cavern; ca. 4 km due E of Chichén-Itzá, Yucatán, México (ca. 20° 41′ N Lat, 88° 32′ W Long). The urns were in a recently discovered, previously sealed off part of the cave. Coll. 1959 and subm. 1960 by E. W. Andrews, Middle Am. Research Inst. *Comment*: sample submitted to provide first definite date by C^{14} of indicated "invasion of Yucatan by people from Tula in North of Mexico, and the following 'Period of Mexican Influence' now called 'Modified Florescent' . . . . The urns were among nearly 500 whole pieces of pottery and artifacts, all clearly offerings to the Highland Mexican Rain God, Tlaloc." The LJ-272 and LJ-273 measurements date the extensive key ceramic material in the cave. Since the cave had seemingly not been used prior to the "Toltec" period, and was apparently sealed off with masonry at the end of that period and never entered subsequently until the present excavation, there seems to be no chance of contamination with later archaeological material. The date is slightly earlier than "the rough period A.D. 900-1200" anticipated by Andrews in submitting the samples. Under date of June 21, 1961 he wrote that the dates are "somewhat early for the conventional dating of the Modified Florescent (Toltec), but they fit in well with the somewhat earlier chronology we are ad-

vocating." They correspond closely with the date of 1140 ± 200 (LJ-87, La Jolla I) obtained from a beam in "The Nunnery" at Chichén-Itzá (John Bolles, who excavated the Monjas group, has agreed with Andrews in the opinion that no beam fragments of the Pure Florescent (Classic) section of the Monjas would have been available to Shedlovsky and that the sample probably came from one of the Modified Florescent (Toltec) additions). The Balankanche explorations have been described briefly by Sartwell (1961) and by Andrews (1961); the then known parts of the cave had been described earlier, under the name Balaam Canche, by Pearse (1938). This sample (and that for LJ-273) was treated to conform with the collector's warning that since the cave is wet the charcoal may have been contaminated with lime. The collector offers evidence that when the cave was utilized the water table was lower than at present, which would presumably mean lesser rainfall. He feels virtually certain that a now-flooded portion of the cave (shown in black on the cave diagram published by Andrews, 1961, fig. 11) was dry at the time represented by LJ-272 and 273, for the entire floor was "spotted with archaeological offerings which were almost certainly left on dry land. Observation since our excavations has indicated that the present water level does not vary in depth more than a few centimeters from dry to wet season. So the change since the 'Toltec' habitation seems to have been a definitive one in terms of water level . . . . The surface of the water is approximately 21 meters below the ground surface above."

LJ-273. Gruta de Balankanche, Yucatan—2 **1090 ± 200**

Charcoal from hearth on which were set the urns containing charcoal measured as LJ-272, with identical data. *Comment*: it was thought that the charcoal from the hearth might antedate that within the urns, but they are indicated as being of the same age within 130 yr at the 67% level of confidence. The agreement adds confidence to the dating. See discussion under LJ-272.

LJ-274. Midden, Torrey Pines Grade, California—1 **4970 ± 200**

California mussel (*Mytilus californianus*) shells from Decimeter 5 (from top) of surface midden at top of road cut along Highway 101, near top of Torrey Pines Grade, San Diego; elevation ca. 76 m (32° 55′ 02″ N Lat, 117° 14′ 54″ W Long; USGS Del Mar Quadrangle, 7.5′ series, 1953). Coll. by J. N. Miller (sample 1960—II: 26A); subm. 1961. *Comment*: sample was thought to represent another of the many La Jollan sites of the region (see Shumway, Hubbs, and Moriarty, 1961; LJ-256, above), until at this decimeter level a well-formed spear-point was found. However, a few other large points have appeared in the upper layers of other La Jollan sites, and this site should probably be included in the La Jollan series. LJ-274 lies between LJ-19, 3700 ± 200 (La Jolla I) and LJ-275, 6400 ± 200, in both distance and age. Inferences for other La Jolla sites on the Torrey Pines Mesa (Shumway, Hubbs, and Moriarty, 1961), regarding rising sealevel, warm climate, and more rainfall than at present, seem to apply to this site.

LJ-275. Torrey Pines Mesa, La Jolla, California 6400 ± 200

California mussel (*Mytilus californianus*) shells from a depth of 0.75 m under Burial 3, near center of midden on the grounds of the U. S. Dept. of Agriculture Horticulture Station on Torrey Pines Mesa N of La Jolla, San Diego, California (32° 53′ 59″ N Lat, 117° 13′ 58″ W Long; USGS Del Mar Quadrangle, 7.5′ series, 1953). Coll. January 21, 1961 by J. R. Moriarty and party (site UCLJ-M3); subm. 1961. *Comment*: this midden represents a typical La Jollan occupation, with stone artifacts typical of the La Jollan Culture and a preponderance of lagoon species in the midden deposit (as would be expected, as the site is only 4 km distant from Los Peñasquitos (Sorrento or Soledad) Lagoon, which presumably was a baylike body of water during the occupation). The inferences derived from the investigation of this site fit into those derived from other studies of the La Jollan Culture regarding rising sealevel, warm climate, and more rainfall than at present (see discussion under LJ-225, above, and especially Shumway, Hubbs, and Moriarty, 1961).

LJ-276. Midden, Torrey Pines Grade, California—2 4840 ± 200

California mussel (*Mytilus californianus*) shells from Decimeter 2 (from top) of surface midden described under LJ-274, and from same pit. Same collector and same sample; subm. 1961. *Comment*: abundance of lagoon molluscs in this layer is indicative of a flourishing bay fauna in the adjacent Los Peñasquitos (Sorrento or Soledad) Lagoon, now quite devoid of living molluscs. At the time of occupation the lagoon was obviously in open communication with the ocean and deep enough to support the molluscs, and at that time it seems probable that the sealevel was still rising and that there was more fresh water in the region (see discussion by Shumway, Hubbs, and Moriarty, 1961).

LJ-277. Midden, Torrey Pines Grade, California—3 4740 ± 200

Shells of three pelecypods (*Mytilus californianus, Pecten circularis aequisulcatus*, and *Chione undatella*) from Decimeter 7, at base of a surface midden treated under LJ-274 and 276 (*q. v.*), and from the same pit. Coll. by J. N. Miller (sample 1960-VI: 16A); subm. 1961. *Comment*: it seems obvious that this particular midden, unlike some others left by shell-gathering people along the coast (see, for example, LJ-109 and 110, La Jolla I, and LJ-216 and LJ-231, this report), represents accumulation over a brief period. In fact, this date is slightly younger than those measured for Decimeters 5 and 2 in the same pit.

LJ-278. (See LJ-335)

LJ-279. Dzibilchaltún, Yucatán 2200 ± 200

Charcoal (sample M585) from Structure 450 in the extensive ruins of Dzibilchaltún, now being excavated in NE Yucatán, México, 16 km N of Mérida (ca. 21° 17.0′ N Lat, 89° 35.8′ W Long). Coll. 1960 and subm. 1961 by E. Andrews. *Comment*: see I(NGS)-171 (Isotopes II) for a similar date. Preliminary reports on the Dzibilchaltún excavations have been published by Andrews (1959; 1960; 1961).

LJ-280. Shells, off west coast of México **19,300 ± 400**

Conch (*Strombus granulatus*) shells dredged at depth of 114.5 m off San Blas, Nayarit (22° 06.7′ N Lat, 106° 17.8′ W Long). From a zone of shelly sand at outer edge of terrace near edge of continental shelf. The shelf in this area was shaped by the Pleistocene delta of Río Grande de Santiago, coalescing with several smaller deltas. Two whole shells and two fragments were used. Coll. March 11, 1960 by J. R. Curray (C-331-60) and R. H. Parker (P-152-60); material selected and identified by Parker; subm. 1961 by Curray and Parker. *Comment*: if, as is thought, the species lives no deeper than 18 m, and if the shells were deposited on the shoreline, sealevel stood at ca. –113 m 19,300 yr ago. This point agrees very closely with the curve of late Quaternary sealevel by Curray (1960), based chiefly on data for the Gulf of Mexico. Date has been plotted by Curray (1961) as indicative of sealevel changes on the Pacific Coast. According to Curray, bathymetric and sedimentologic studies suggest that the crust has been relatively stable in the region during the time involved. The occurrence of this tropical species at ca. 22° N Lat during a low period in Pleistocene temperature indicates that the southward displacement of the fauna then was probably not very striking at this latitude. The extensive, now flooded delta of Río Grande de Santiago (J. R. Curray, ms in preparation), with this date of nearly 20,000 yr at the surface, bespeaks a long history for this stream system, which is consonant with the circumstance that it harbors the most strikingly distinctive endemic fish fauna of any Middle American stream system.

LJ-314. South Kern County, California **4250 ± 200**

Charcoal from pit, 3.35 m below surface, in southern part of Kern Co., Sec. 9, T 11 N, R 21 W, in the drainage basin of Buena Vista Lake (35° 03′ 30″ N Lat, 119° 07′ 51″ W Long). Charcoal fragments and ash were mixed with clay and silt. Mudflow deposits were encountered above and below the sample. Coll. November 1960 by California Dept. of Water Resources (C-O-8959A); subm. 1961 by W. D. Fuqua, Senior Engineering Geologist of said department. *Comment*: according to Fuqua, dating bears on rates of deposition and recent tectonic movement as factors in the shallow subsidence in the San Joaquin Valley, being considered in relation to geologic and pedalogic studies currently being summarized. The interior drainage area formerly largely occupied by Buena Vista and Kern lakes resulted from damming by the Kern River alluvial fan, possibly accompanied by structural downwarping. Identification of the plants represented by the charcoal is being attempted. The date is within the period of known human occupation of the Valley, but there is no definite evidence that the indicated fire was produced by man. Soils containing the charcoal fragments have been identified as debris-flow deposits from suspended loads. Field evidence strongly suggests that the charcoal was not produced at the site, but was transported from the drainage area. Based on pedologic examination and logging by J. Glavinovich, there was little soil profile development in the depth ranging from the pit bottom of 4.9 m to within 1.06 m of the surface. Exhibiting slight development, very unusual in this area, the soil is logged in the Lynndyl series. The two profiles identified

in the upper 1.06 m were estimated to represent a period of 500-1500 yr each. Present inference is that the charcoal found at 3.35 m, and a trace found at 2.3 m, was laid down during a period of rapid deposition as indicated by lack of profile development. Changes in tectonic and probably climatic conditions subsequently contributed to very slow rate of deposition, permitting slight profile development in the upper 1.06 m. While other factors are involved, it appears that we have evidence of 2.4 m of fine-grained material deposited in the relatively short period of 1200 to 2500 yr. Other evidence indicates that greater rates of deposition have occurred in this area.

LJ-322. Raised reef, Hawaii—5 **26,640 ± 1100**

Cowry (*Cypraea* sp.) shells from same "5-foot" raised reef at same locality as LJ-205 and LJ-253. Coll. 1960 for F. P. Shepard by Ralph Moberly, Jr., Univ. of Hawaii; subm. 1961 by Shepard. *Comment*: this measurement is consistent with the two others run on the same cowry species from the same raised reef (see discussion under LJ-205).

LJ-323. Raised reef, Hawaii—6 **31,840 ± 1000**

Cowry (*Cypraea* sp.) shells and one pelecypod valve from same "12-foot" raised reef at same locality as LJ-206 and LJ-254. Coll. 1960 for F. P. Shepard by Ralph Moberly, Jr.; subm. 1961 by Shepard. *Comment*: this measurement agrees nicely with that for LJ-254 (*q. v.*) and appears to show that the measurement of 18,070 ± 450 for LJ-206 was too young.

LJ-331. Río Zape Site (Cave), Durango, México **1300 ± 200**

Uncharred wood fragment from within La Cueva Muertas Chiquitas, near the pueblo El Zape, in Municipio de Guanecevíi, near the upper course of Río Zape (tributary of Río Nazas); alt ca. 152 m (ca. 25° 45′ N Lat, 105° 55′ W Long). The wood was taken from the 61-71 cm level of Pit B4, mixed with loose, dry midden refuse (plant and animal), 10 cm above House Floor A. Other wood samples (LJ-267) from the same site proved insufficient for measurement. Coll. April 1957 by R. H. Brooks; subm. 1961 by T. W. Whitaker. *Comment*: date should approximate that of the house floor and should antedate the cultural refuse. The site represents an agricultural and hunting culture, described by Brooks, Kaplan, Cutler, and Whitaker (1962). There is no evidence of European contact. The wide variety of corn and beans and the lack of Chalchihuites-type material seemed to indicate a date of occupation around A.D. 1200-1300. The date points to an early agricultural development in the region.

LJ-332. Bahía San Quintín, Baja California—1 **6165 ± 250**

Pismo clam (*Tivela stultorum*) shells from a midden shell deposit 1.12 m from top of low terrace along E shore of Bay N of Old Mill (presently a cannery and motel); 105.8-108.1 m along cliff from N end of terrace (which is 1.0 km N of old causeway), 0-1.20 m into face of cliff (30° 29′ 27″ N Lat, 115° 59′ 03″ W Long; HO Chart 1043, 1940, and Air-Photo Compilation). Midden streak was near top of older generation of consolidated, reddened sand, overlain by sand, a few decimeters thick, so indurated by lime to approach the consistency of sandstone, and then by a younger generation of unconsolidated

sand containing a younger midden and much flaked stone. Coll. by C. L. Hubbs, L. C. Hubbs, J. N. Miller, and Eva Ewing (sample 1960—XI: 13A); subm. 1961. *Comment*: sample dated because of obvious antiquity (the lower, older sand rests on a Pleistocene deposit). The date gives a maximal estimate of the time required for the modification of the older sand. Present lack of surface water in whole area suggests that the time was one of greater rainfall (to provide water needs for the population). Other Baja California coastal habitations of about the same age (5020-7020 B.P.), are represented by LJ-6, 26, and 107 (La Jolla I), and by LJ-231 and 334 (this date list), all nearly devoid of lithic material.

LJ-333. Batiquitos Lagoon, California—8 **6320 ± 250**

Scallop (*Pecten circularis aequisulcatus*) shells from the depth of 10.01-10.45 m in a test boring, 10 cm in diam, just off the N side, near the middle, of the now sediment-filled Batiquitos Lagoon, just NE of Leucadia, San Diego Co. (33° 05′ 26″ N Lat, 117° 17′ 34″ W Long; Air-Photo Compilation T-5411, 1934). Coll. and subm. by J. N. Miller (sample 1961—1: 30A). *Comment*: this measurement, and that of 3400 ± 240 for shell from the depth of 5.24-5.61 m (see LJ-381, below), were run in a study (Miller and Hubbs, ms in preparation) of the history of this coastal lagoon and its fauna, with reference to the food of the Indians who inhabited the shores over what turns out to be the same period (see LJ-256, this date list). The data are consonant with the idea that the lagoon, now completely unproductive of shellfish, remained baylike and productive of shellfish for at least six millennia, probably in large part because of the continuing rise of sealevel, during which time the alluvial fill may have proceeded at a rather uniform rate. The shellfish supply was no doubt a major factor in the long-continued occupation by man of the region around the lagoon. These problems were discussed by Shumway, Hubbs, and Moriarty (1961).

LJ-334. Bahía San Quintín, Baja California—2 **6055 ± 250**

Pismo clam (*Tivela stultorum*) shells from a midden deposit less than one decimeter thick, in upper part of older generation of sand, in same coastal terrace as LJ-332, ca. 0.85 km N of mill; 250.6-251.9 m along cliff from N end of terrace (30° 29′ 23″ N Lat, 115° 59′ 03″ W Long; same maps). Midden streak was in a low stretch of cliff, here 2.60 m high with stratigraphy as follows: 1.30 m, Pleistocene; 0.70 m, old-generation soil, becoming indurated with lime and redder toward top, where the shells (and a small amount of charcoal and two fragmented cobbles) lay just below a hardpan with weakly columnar structure; 0.60 m, recent-generation sand. Same collectors as for LJ-332 (sample 1960—XI: 13B); subm. 1961. *Comment*: reasons for dating and inference same as for LJ-332. A different camp in same area of habitation is indicated. Some other shells, less concentrated, were observed in the same stratigraphic level, in the same small area of low terrace (surrounded by bay and marsh). There appear to be disconformities not only between the Pleistocene mudstone (which contains shells of bay molluscs mixed with lapilli from the eruptions of the nearby volcanoes) and the old sand, but also between the

two clear-cut generations of sand. The shell remains indicate that the bay existed in all three time periods represented.

LJ-335. Agua Hedionda Lagoon, California 1030 ± 200

Clam (*Chione undatella* and *Chione californiensis*) shells from Decimeter 7 (from top) of midden site exposed in road cut in bank above lagoon, near Carlsbad, San Diego Co. (33° 08′ 43″ N Lat, 117° 19′ 40″ W Long; USGS San Luis Rey Quadrangle, 7.5′ series, 1949). Charcoal (LJ-278) from the same site, at a depth of 82 cm, proved insufficient for measurement. Coll. by J. N. Miller (sample 1960—VIII: 25A); subm. 1961. *Comment*: shells, all of probable lagoon origin, indicate that this lagoon, like Batiquitos Lagoon (see LJ-242, 243, and 245, this date list) was in open communication with the sea and produced edible shellfish about a millennium ago. This is the first date for any of the several middens about Agua Hedionda Lagoon.

LJ-336. Silver Strand, Coronado, California—3 4520 ± 220

Pismo clam (*Tivela stultorum*) shells from Station A, Level IV (in Decimeter 13), in the same exposure (Station A) treated under LJ-211. Coll. by L. G. Jones (sample 1960—V: 10A); subm. 1961. *Comment*: see LJ-211, 4020 ± 300, this date list. The less dense shell deposit in this slightly lower, and lowest, level suggests transient occupation of this (La Jollan?) site. The smaller size of the pismo clams suggests a higher temperature than for LJ-211, and one almost as high as for the more recent levels. The paleotemperature data for the Rancho Carrillo site are as follows:

Station B, surface, midden shells small: 20.6°C at 270 ± 150 B.P. (LJ-210).

Station A, Level II (30 cm above III), shells small: 20.8°C at date presumably between 4020 and 270 B.P.

Station A, Level III, shells large: 17.2°C at 4020 ± 300 B.P. (LJ-211).

Station A, Level IV, shells rather small: 19.9°C at 4520 ± 220 B.P. (LJ-336).

LJ-344-346. La Brea Tar Pits, California—4 >34,000

Freshly erupted tar from tar boil at Rancho La Brea Tar Pits, Los Angeles Co. (ca. 34° 03′ 45″ N Lat, 118° 21′ 25″ W Long). Coll. February 25, 1958 by Mr. Kirby, caretaker at Rancho La Brea Park; subm. 1961. *Comment*: confirms LJ-89, La Jolla I, on tar extracted from a tree trunk (LJ-55, La Jolla I) dated 14,400 ± 300. It now seems reasonably safe to assume that the tar at the La Brea Pits is not of recent origin. Sample was run three times, and proved useful as a "dead" standard.

LJ-381. Batiquitos Lagoon, California—9 3400 ± 240

Clam (*Chione undatella*) shells from the depth of 5.24-5.61 m in test boring described and located under LJ-333. Same collector and sample; subm. 1961. *Comment*: see LJ-333 (this date list).

LJ-382. SIO Cliff Site, La Jolla, California—2 **3240 ± 240**

California mussel (*Mytilus californianus*) shells, from midden on minor terrace, surface alt 26.1 m, beside parking lot of Scripps Inst. of Oceanography; from bottom three decimeters (12-14) of pit 1 m^2, ca. 2 m from cliff edge; opposite point on beach 89 m N of N pilings of Scripps Pier (32° 52′ 00″ N Lat, 117° 15′ 09″ W Long). Coll. by J. N. Miller and party (sample 1960—XI: 21A); subm. 1961. *Comment*: this measurement provides one datum in the geologic and archeologic survey of the "lower campus" of Scripps Inst. being conducted by C. L. Hubbs and D. L. Inman. Site seems to be a continuation of the La Jollan Culture (see Shumway, Hubbs, and Moriarty, 1961). The midden caps a terrace fill containing hearths or hearthlike structures and occasional concentrations of charcoal, one of which, 4.9 m below the surface of this midden on the S, excavated side, 12 m distant at bearing of 140°T), has been dated at 21,500 ± 700 (W-142, USGS II), and the other, still lower, at >34,000 yr (LJ-217, this date list). The midden material obtained from this pit is being analyzed.

LJ-384. (See LJ-386)

LJ-385. Spindrift Site, La Jolla, California—1 **3190 ± 200**

California mussel (*Mytilus californianus*) shells from Decimeter 11 (from top) of midden on slope above ocean cliff, between La Jolla Beach and Tennis Club and the La Jolla Caves, on the property of Oliver Gill on Spindrift Drive (32° 51′ 02″ N Lat, 117° 15′ 38″ W Long; USGS La Jolla Quadrangle, 7.5′ series, 1953). This sample came from well within the lower, lime-indurated B soil horizon. Coll. and subm. 1961 by J. R. Moriarty and J. N. Miller (sample 1961—IX: 28A). *Comment*: Moriarty regards the lithic material as "La Jollan III" and notes its resemblance to the artifacts found underwater off the adjacent coast (Tuthill and Allanson, 1955). No pottery or projectile points were encountered at this level; they appear abruptly above a sharp break in soil texture and color (see LJ-386), which apparently represents a structural and perhaps cultural disconformity. The site lies in a coastal area of extensive and long-continued habitation, wherein various lines of evidence suggest equitable climate and rich food supply over the past several thousand years, with, at least in general, rather greater rainfall than at present. These questions are discussed by Shumway, Hubbs, and Moriarty (1961). The presence of bay molluscs in the midden, at both levels measured (LJ-385 and 386), indicates the probable long continuity of a salt-water lagoon here, either in the position of the present lagoon or farther off the present shoreline (see LJ-208, this date list).

LJ-386. Spindrift Site, La Jolla, California—2 **1270 ± 250**

California mussel (*Mytilus californianus*) shells from Decimeter 6 (from top) of midden described and located under LJ-385. This sample came from the lower part of the upper level of dark, friable soil. Charcoal from Decimeter 7, at the bottom of the upper soil, comprising sample LJ-384, proved insufficient for measurement. Coll. and subm. along with LJ-385 (same data, except

depth). *Comment*: probably approximates the time of introduction into this section of the coast of pottery and of more refined stonework, which are here diagnostic of the Diegueño Culture.

LJ-399. Phosphorite, Baja California—2 9860 ± 200

Marine apatite, $Ca_{10}(PO_4, CO_3)_6 F_{2-3}$ (within matrix of various heavy minerals, and perhaps 2-3% undigested carbonate left after treatment with triammonium citrate); dredged from the continental shelf off Baja California Sur at a depth of 78.6 m (26° 09′ N Lat, 117° 51′ W Long). Coll. and subm. 1961 by Bruno d'Anglejan, Scripps Inst. of Oceanography. *Comment*: date suggests present deposition of authigenic marine apatite in this area. The indicated age may deviate somewhat from that of the phosphorite, depending on the radioactivity of the residual enclosed carbonate. If this was young, the age of the phosphorite is slightly older than indicated, but by not much more than 10%. This measurement provides even stronger evidence than LJ-268 (19,300 ± 600, this date list) that the deposition of phosphorite along the Baja California coast has been continuing through recent Quaternary time.

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La Jolla I	Hubbs, Bien, and Suess, 1960
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Lamont III	Broecker, Kulp, and Tucek, 1956
New Zealand III	Fergusson and Rafter, 1957
New Zealand IV	Fergusson and Rafter, 1959
UCLA I	Fergusson and Libby, 1962
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