and a drop in the fall. Superimposed on these annual level changes are long term changes. The level reached its lowest point, 250.7 feet below sea level, in November 1924. During the next 11 years it rose to 243 feet and declined nearly to the 1925 level. It averaged 240 feet or a little lower throughout the 1940's, and in 1951 it began to rise again. On March 31, 1954, the level of Salton Sea was 234.75 feet below sea level.

Complete analyses of the water of Salton Sea are available for 1907 to 1916 inclusive (MacDougal, 1917, p. 466) and from 1946 to the present. For the intervening years there are two analyses for 1929 and the mean of four analyses from different parts of the sea in 1942. In the years prior to 1920 when inflow was small the total dissolved solids present in Salton Sea remained substantially unchanged, but as evaporation reduced the volume of water the salinity rose at a uniform rate from 3648 parts per million in 1907 to 16,472 parts per million in 1916. Some samples taken in 1911 (Ross, 1914, p. 43) show that the salinity in all parts of the sea was essentially uniform. Some salts must be added by mineral springs such as the mud pots at the southwest end of Salton Sea. The brine from wells on nearby Mullet Island is rich in chlorides (table 2, analysis 11). As will be shown, however, an increase in the relative proportion of chloride in Salton Sea has not occurred, and therefore additions of salts from mineral springs have not been significant.

After inflow became significant the salinity was much less uniform. The Imperial Irrigation District has established five sampling stations where samples have been taken one to three times a year and at the same day beginning late in 1945. At one station, near the mouths of Alamo and New Rivers, the salinity is substantially lower than the average, but at the other four stations the salinity differs by as much as 10 percent. This range of salinity, however, is of the same order of magnitude as that in different parts of the southern end of San Francisco Bay. Since 1945 the salinity has varied inversely as the volume of the sea. It reached a maximum of about 40,000 parts per million in the fall of 1948 when the surface was about 241 feet below sea level. At the end of 1953 when the level stood a little higher than 236 feet the salinity was 35,000 to 35,500 parts per million.

Prior to 1953 the level had been below 236 feet since the latter part of 1916. The salinity in 1916 and 1953 when the volume of the sea was equal would have been the same if the total quantity of dissolved solids present had remained unchanged, but, in fact, the salinity in 1953 was more than double that in 1916. Probably the additional dissolved solids have originated from the essentially fresh irrigation water that has been flowing into Salton Sea since 1920.

The total quantity of dissolved solids can be compared at all times when the level was the same. The increase in the total dissolved solids present is shown on the graph by a dashed line connecting the points for October 1942 and September 1948 when the level was between 241 and 242 feet. Projected backward to 1918 when the level was about the same, this line passes close to the extension of the salinity curve plotted from the 1907-1916 analyses; and it is in agreement with the 1929 analyses of 32,200 and 36,500 parts per million when the level was considerably lower.

Over the years the relative proportions of the dissolved solids have changed. Between 1907 and 1916 marked decreases in calcium and carbonate and smaller decreases in potassium and magnesium were noted. Although the water was not saturated with respect to calcium carbonate, lime was withdrawn by organisms to form calcareous deposits (MacDougal, 1917, pp. 467-469). The decrease in potassium has not been explained. During this period the proportion of chloride was noted to increase slightly, while that of sulfate decreased.

The 1945-1953 analyses are not identical, but no changes in the relative proportions of the dissolved solids are apparent in this short interval. Compared with the 1907-1916 analyses, however, they show that significant changes have occurred. The most pronounced change has been in the ratio of chloride to sulfate which in 1907-1916 was about 3.7 to one and increasing slowly. In 1929 it was nearly five to one, but in 1945-1953 it was only 2.2 to one. Quite possibly it reached a maximum at the end of 1919 when inflow of sulfate-rich irrigation water from the Colorado River water became significant and has been decreasing subsequently. It seems likely that if this trend continues, the proportion of sulfate will become so great within a relatively few years that the water of Salton Sea will deposit sodium sulfate rather than sodium chloride upon evaporation.

Regarding the other ions present in Salton Sea water, the relative proportion of sodium is about the same as it was in 1907-1916, and both calcium and carbonate seem to have become stabilized also. The relative proportions of potassium and magnesium have increased.

The accompanying table illustrates the changes of salinity and level of Salton Sea.

Changes in salinity and level, Salton Sea.

Date	Elevation of surface (feet below sea level)	Salinity (PPM)
June 3, 1907 (location not known)	195.9	3,648
May 25, 1908 "	199.9	4,372
June 8, 1909 "	204.7	5,194
May 22, 1910 "	208.8	6,038
June 3, 1911 "	213.8	7,180
June 10, 1912 "	217.8	8,465.5
June 18, 1913 "	220.0	10,025.6
June 12, 1914 "	226.0	11,796
June 8, 1915 "	230.1	13,774
June 10, 1916 "	234.3	16,472
March 21, 1929 (Fish Springs)	246.0	36,500
March 21, 1929 (center of sea)	246.0	32,200
October 1942 (mean of 4 samples)	241.7	36,713
December 12, 1945 (Salton Sea Beach)	240.6	37,073
December 20, 1946 "	240.5	37,191
December 17, 1947 "	240.6	38,536
September 20, 1948 "	241.0	41,637
December 15, 1948 "	240.8	39,234
September 19, 1949 "	240.6	40,461
December 15, 1949 "	240.3	38,521
September 20, 1950 "	240.1	39,520
December 22, 1950 "	239.7	38,308
September 25, 1951 "	238.9	39,558
November 19, 1952 "	237.2	36,228
November 23, 1953 "	236.0	35,545

* rounded up
** average of two locations

Table 1. California brines (lakes and playas).

	Percent of the dissolved solids																				
	Sea water, mean of 77 analyses (1)	Sea water bittern (2)	Salton Sea June 3, 1907 (3)	Colorado River at Yuma (4)	Hypothetical original Salton Sea (5)	Salton Sea June 10, 1916 (6)	Salton Sea March 21, 1929 (7)	Salton Sea Nov. 23, 1953 (8)	Dale Lake (9)	Danby Lake (10)	Cadiz Lake (11)	Bristol Lake (12)	Soda Lake (13)	Mojave River at Victorville (14)	Saline Valley (15)	Death Valley (16)	Mono Lake (17)	Deep Springs Lake, Inyo County (18)	Black Lake, Mono County (19)	Borax Lake, Lake County (20)	Searles Lake (21)	Owens River at Charlies Butte (22)
Cl	55.292	51.0	47.83	19.92	52.62	49.2	50.9	43.8	44.7	44.17	60.82	61.95	40.84	5.29	48.6	46.81	23.34	32.97	7.68	32.27	38.51	9.5
Br	0.188	0.5	Tr	---	Tr	---	---	---	---	---	---	---	---	---	---	---	---	---	Tr	0.04	0.25	---
SO_4	7.692	16.6	13.41	28.61	11.0	13.0	11.0	20.0	15.8	4.94	0.38	0.08	17.05	6.98	12.1	14.81	12.86	22.32	13.24	0.13	13.21	15.5
B_4O_7	---	---	---	---	---	---	---	---	Tr	---	---	0.01	0.68	---	Tr	0.44	0.32	0.42	Tr	5.05	3.66	---
CO_3	0.207	---	1.85	13.02	---	0.7	0.8	0.6	---	---	---	---	3.95	36.08	---	---	23.42	5.47	37.73	22.47	7.90	29.9
HCO_3	---	---	---	---	---	---			---	Tr	---	---	---	---	0.2	---	---	---	---	---	---	---
Na	30.593	16.8	31.29	19.75	33.14	33.0	31.2	30.0	36.7	50.73	30.71	20.55	37.43	13.21	36.4	36.5	37.93	33.18	39.05	38.10	28.72	19.8
K	1.106	3.3	0.65	2.17	0.30	0.4			0.02	---	1.41	1.18	Tr		1.2	1.35	1.85	5.64	2.03	1.52	7.73	
Ca	1.197	---	2.80	10.35	1.37	1.9	1.6	2.7	---	0.12	6.12	15.51	---	13.23	0.05	---	0.04	---	---	0.03	---	8.9
Mg	3.725	11.8	1.81	3.14	1.81	1.7	4.5	2.7	---	0.04	0.56	0.38	---	2.51	<0.01	0.05	0.10	---	---	0.35	---	3.4
Fe_2O_3	---	---	0.002	---	---	Tr	---	---	---	---	---	---	---	0.27	---	---	Tr	---	---	0.01	---	0.1
Al_2O_3	---	---	0.016	---	---	---	---	---	---	---	---	---	---	---	---	---	Tr	---	---		---	---
SiO_2	---	---	0.26	3.04	---	0.1	---	---	---	---	---	---	---	22.05	---	---	0.14	---	0.20	0.01	---	12.4
Misc. and organic	---	---	0.08	---	---	---	---	---	2.7	---	---	0.34 (Sr)	---	0.38 (NO_3)	1.4	---	---	---	Tr (Li, PO_4)	0.01 (PO_4)	0.02 (Li)	0.5 (NO_3)
Dissolved solids, ppm	35,000±	293,800	3,648	702	---	16,472	31,050	35,545	*298,000	271,200	73,500	279,149	305,137	113.4	*355,100	299,500	51,170	203,800	18,500	76,560	344,431	339
NaCl, % of dissolved solids	77.76	42.6	---	---	---	---	---	---	73.8	92.5	78.04	66.9	67.19	---	---	---	37.1	45.98	9.73	51.0	46.5	---

* Grams per liter.

(1) Sea water, mean of 77 analyses: Clarke, F. W., 1924a, The data of geochemistry: U. S. Geol. Survey Bull. 770, p. 127, analysis A.

(2) Sea water bittern: Recalculated from Seaton, M. Y., 1931, Bromine and magnesium compounds drawn from western bays and hills: Chem. and Met. Eng. vol. 38, no. 11, Nov.

(3) Salton Sea, June 3, 1907: Ross, W. H., 1914, Chemical composition of the water of Salton Sea and its annual variation in concentration, 1906-11, in MacDougal, D. T., and others, The Salton Sea: Carnegie Inst. Washington Pub. 193, p. 41, table 9.

(4) Colorado River at Yuma: Clarke, F. W., 1924b, The composition of river and lake waters of the United States: U. S. Geol. Survey Prof. Paper 135, p. 132, analysis 3.

(5) Hypothetical original Salton Sea: Ross, W. H., 1914, p. 45, table 15, analysis B.

(6) Salton Sea, June 10, 1916: Recalculated from MacDougal, D. T., 1917, A decade of the Salton Sea: Geog. Rev. vol. 3, no. 6, p. 468.

(7) Salton Sea, March 21, 1929, Sample from the center of the sea: Recalculated from Coleman, G. A., 1929, A biological survey of Salton Sea: California Div. Fish and Game, California, Fish and Game, vol. 15, pp. 221, 222.

(8) Salton Sea, Nov. 23, 1953, Salton Sea beach: Recalculated from analysis furnished by Imperial Irrigation District.

(9) Dale Lake: Recalculated from King, C. R., 1948, Soda ash and salt cake in California: California Jour. Mines and Geology, vol. 44, p. 190, table 1.

(10) Danby Lake, test well in sec. 22, T. 2N., R. 17E., SB: Recalculated from analysis furnished by Metropolitan Water District of Southern California.

(11) Cadiz Lake: Gale, H. S., and Hicks, W. B., 1920, Potash: U. S. Geol. Survey Min. Res. U. S., 1917, vol. 2, p. 418.

(12) Bristol Lake, sample from "canal" of National Chloride Co. of America: Recalculated from Durrell, Cordell, 1953, Celestite deposits at Bristol Dry Lake, San Bernardino County, California: California Div. Mines Special Rept. 32, p. 13, analysis II.

(13) Soda Lake: Clarke, F. W., 1914, Water analyses from the laboratory of the United States Geological Survey: U. S. Geol. Survey Water-Supply Paper 364, p. 33, analysis Q.

(14) Mohave River at Victorville: Clarke, F. W., 1924b, p. 132, analysis 3.

(15) Saline Valley: Recalculated from King, C. R., 1948, p. 190, table 1.

(16) Death Valley, well no. 200 at 38 feet: Gale, H. S., 1914, Prospecting for potash in Death Valley, California: U. S. Geol. Survey Bull. 540, p. 411.

(17) Mono Lake: Clarke, F. W., 1924a, p. 162, analysis A.

(18) Deep Springs Lake, Inyo County: Recalculated from Tucker, W. B., and Sampson, R. J., 1938, Mineral resources of Inyo County: California Div. Mines Rept. 34, p. 497.

(19) Black Lake, Mono County: Clarke, F. W., 1924a, p. 162, analysis F.

(20) Borax Lake, Lake County: Clarke, F. W., 1924a, p. 162, analysis H.

(21) Searles Lake, upper structure brine: Recalculated from Ryan, J. E., 1951, Am. Inst. Min. Met. Eng. Trans. vol. 190, p. 449, table 1.

(22) Owens River at Charlies Butte, mean of 36 10-day composite samples: Van Winkle, Walton, and Eaton, F. M., 1910, The quality of the surface waters of California: U. S. Geol. Survey Water-Supply Paper 237, p. 121.