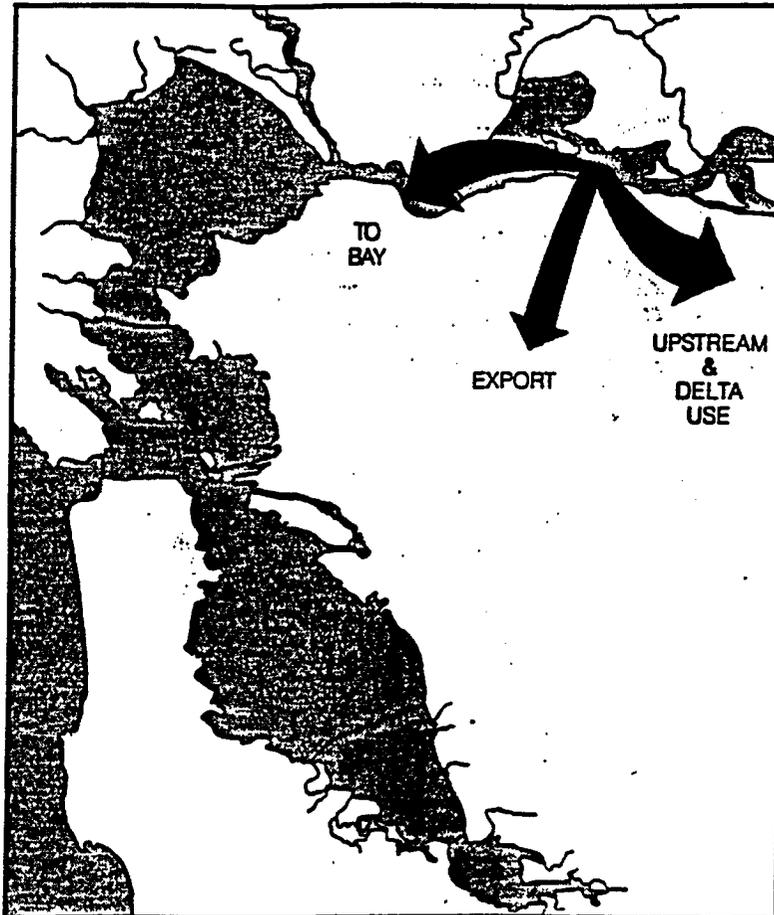


ANALYSIS OF THE INFLUENCE OF WATER WITHDRAWALS ON RUNOFF TO THE DELTA-SAN FRANCISCO BAY ECOSYSTEM (1921-83)



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historical past.

3. The most significant changes in the number of occurrences was for wet and critical dry years. For example, the number of wettest and wet months of April (Table II. 18) was reduced as much as 1.7-2.5 times under regulated conditions (i.e., RRI and RDO versus NRI and NDO), but for May and June the reduction in the numbers of wet and wettest months is 5.3-8 times and 3.6-5.7 times, respectively (Tables II. 19, 20).

At the same time, there were no significant changes in the number of sub-normal and dry years.

However, the number of critical dry months of April, May and June increased as much as 5.2-5.4, 3.5-3.7, and 2.2-2.4 times, respectively.

These ratios demonstrate that since the water diversions were intensified, which coincided in some years with the natural low wetness discussed earlier, the system has experienced a water supply deficit.

This shift in hydrological regime of the rivers from predominantly above normal and normal months to sub-normal and critical dry months for would-be natural runoff is well illustrated in Figs. II. 10, 11.

These figures show that this type of monthly shift predominantly natural runoff surplus ranges to regulated runoff ranges, can be characterized as conditions of deficit.

It is important to stress that this runoff redistribution is typical for many rivers located in semi-arid zones of the Northern Hemisphere which are under water regulation. It should also be emphasized that the impact of water supply redistribution and reduction has a similar pronounced effect on living and non-living resources of estuarine and coastal zone systems regardless of where they are. This is especially true for many rivers, like the Sacramento-San Joaquin, whose late winter-spring runoff usually accounts for 40-65% of their annual mean runoff, and therefore, an essential part of it is used for surface and ground water storage recharges, conveyance to other areas and local consumption.

It is interesting to note that as a rule, 30-85% of the natural spring runoff is diverted each year in many areas of the globe, despite the fact that spring runoff is the most vital part of any riverine-estuarine environment. It brings to the system more than 60% of the annual sediment load, more than 70% of organic and inorganic matter, provides for oxygen enrichment and flushing of the natural and man-induced wastes, and is entirely responsible for the estuarine salinity regime of the subsequent months of the year. As such, the spring runoff defines the productivity of the estuary and its adjacent coastal zone. Hence, if there is no such runoff, it is logical to expect that

Table II.18 The number of years of different wetness in relation to "normal" monthly runoff - April

Runoff Characteristics	Wettest and Wet Years	Years	Sub-normal and Dry Years	Years	Critical Dry Years	Years
Qnri	1927, 1935, 1938, 1940-43, 1952, 1954, 1958, 1963, 1965, 1967, 1969, 1974, 1978	15	1930, 1939, 1944, 1947, 1955, 1957, 1959, 1960, 1961, 1964, 1968, 1970, 1972	13	1924, 1929, 1931, 1934, 1976	5
Qrri	1935, 1938, 1940, 1941, 1952, 1958, 1963, 1974, 1982	9	1945, 1946, 1950, 1956, 1971, 1975	6	1924, 1929, 1930, 1931, 1932, 1933, 1934, 1939, 1944, 1947, 1949, 1951, 1953, 1955, 1957, 1959, 1960, 1961, 1962, 1964, 1966, 1968, 1970, 1972, 1973, 1976, 1977	27
Qndo	1927, 1935, 1938, 1941-43, 1940, 1948, 1952, 1954, 1958, 1963, 1965, 1967, 1969, 1974, 1978	17	1930, 1933, 1939, 1944, 1944, 1947, 1955, 1957, 1959-61, 1964, 1968, 1970, 1972	14	1924, 1929, 1931, 1934, 1976	5
Qrdo	1935, 1938, 1940, 1941, 1952, 1958, 1964, 1974	8	1945, 1946, 1950, 1956, 1971	5	1924, 1929, 1930, 1931, 1933, 1934, 1939, 1944, 1947, 1949, 1951, 1953, 1955, 1956, 1958, 1962, 1964, 1965, 1966, 1968, 1970, 1972, 1973, 1975, 1976, 1977	26

Note:

1. Wettest and wet years - the Qnri and Qrri and Qndo and Qrdo of any year are 25% or more above "normal" (4.14 and 4.10 MAF, respectively.)
2. Sub-normal and dry years of wetness - when the same runoff parameters are 25% or more below "normal."
3. Critical dry years of wetness - when the Qnri, Qrri, Qndo and Qrdo are 50% or more below "normal."

Table II.19 The number of years of different wetness in relation to "normal" monthly runoff - May

Runoff Character-istics	Wettest and Wet Years	Years	Sub-normal and Dry Years	Years	Critical Dry Years	Years
Qnri	1922, 1935, 1937, 1938, 1941, 1942, 1943, 1952, 1956, 1958, 1963, 1967, 1969, 1973, 1974, 1975, 1978	17	1926, 1929, 1930, 1933, 1947, 1960, 1961, 1964, 1966, 1968, 1970, 1972	12	1924, 1931, 1934, 1939, 1959, 1976, 1977	7
Qrri	1938, 1952	2	1928, 1932, 1942, 1943, 1945, 1946, 1950, 1951, 1953, 1965, 1975, 1978	12	1924, 1927, 1929, 1930, 1931, 1933, 1934, 1939, 1944, 1947, 1950, 1954, 1955, 1959, 1960, 1961, 1962, 1964, 1966, 1968, 1971, 1972, 1976, 1977	24
Qndo	1922, 1937, 1938, 1941, 1942, 1948, 1952, 1956, 1958, 1963, 1967, 1969, 1973, 1974, 1975, 1978	16	1926, 1929, 1930, 1933, 1947, 1960, 1961, 1964, 1966, 1968, 1970, 1972	12	1924, 1931, 1934, 1939, 1959, 1976, 1977	7
Qrdo	1922, 1938, 1952	3	1924, 1928, 1932, 1936, 1940, 1943, 1945, 1946, 1950, 1951, 1953, 1954, 1957, 1965, 1978	15	1924, 1926, 1929, 1931, 1933, 1934, 1939, 1944, 1947, 1949, 1955, 1959, 1960, 1961, 1962, 1964, 1966, 1968, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977	26

Note:

1. Wettest and wet years - the Qnri and Qrri and Qndo and Qrdo of any year are 25% or more above "normal" (4.26 and 4.15 MAF, respectively.)
2. Sub-normal and dry years of wetness - when the same runoff parameters are 25% or more below "normal."
3. Critical dry years of wetness - when the Qnri, Qrri, Qndo and Qrdo are 50% or more below "normal."

Table II.20 The number of years of different wetness in relation to "normal" monthly runoff - June

Runoff Character-istics	Wettest and Wet Years	Years	Sub-normal and Dry Years	Years	Critical Dry Years	Years
Qnri	1921, 1927, 1932, 1935, 1938, 1941, 1942, 1948, 1952, 1953, 1956, 1958, 1969, 1971, 1974, 1975, 1978	17	1929, 1930, 1946, 1947, 1949, 1951, 1954, 1960, 1961, 1964, 1972	11	1924, 1926, 1928, 1931, 1833, 1934, 1939, 1947, 1959, 1966, 1968, 1976, 1977	13
Qrri	1938, 1952, 1966	3	1932, 1936, 1937, 1940, 1943, 1945, 1950, 1953, 1963, 1965, 1971, 1974, 1975	13	1926, 1928, 1929, 1930, 1931, 1933, 1934, 1939, 1944, 1946, 1947, 1949, 1951, 1954, 1955, 1957, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1970, 1972, 1973, 1974, 1976, 1977, 1978	31
Qndo	1921, 1922, 1927, 1932, 1935, 1938, 1941, 1942, 1948, 1952, 1953, 1956, 1958, 1967, 1971, 1974, 1975, 1978	18	1928, 1929, 1930, 1944, 1946, 1949, 1951, 1954, 1960, 1964, 1972	11	1924, 1926, 1928, 1931, 1934, 1939, 1947, 1959, 1960, 1961, 1966, 1968, 1976, 1977	14
Qrdo	1922, 1938, 1942, 1952, 1967	5	1923, 1925, 1936, 1937, 1940, 1943, 1945, 1950, 1963, 1971, 1975	11	1926, 1928, 1929, 1930, 1931, 1933, 1934, 1939, 1944, 1946, 1947, 1949, 1951, 1954, 1955, 1957, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1970, 1972, 1973, 1974, 1976, 1977, 1978	31

Note:

1. Wettest and wet years - the Qnri and Qrri and Qndo and Qrdo of any year are 25% or more above "normal" (2.65 and 2.51 MAF, respectively.)
2. Sub-normal and dry years of wetness - when the same runoff parameters are 25% or more below "normal."
3. Critical dry years of wetness - when the Qnri, Qrri, Qndo and Qrdo are 50% or more below "normal."

the estuarine system may undergo a gradual transformation, insidious for the first ten to fifteen years but becoming noticeable later on.