# CHAPTER XI. ANALYSIS OF ALTERNATIVE STANDARDS

## A. DESCRIPTION OF ALTERNATIVES

This section describes alternative sets of fish and wildlife standards considered for adoption by the SWRCB. The standards for protection of agricultural and municipal beneficial uses are not being reviewed during this triennial review; therefore, the standards for protection of these beneficial uses are the same in all alternatives.

The SWRCB solicited alternative sets of fish and wildlife standards for its consideration at workshops on July 13-14, September 1, and October 19, 1994. Complete regulatory alternatives submitted include proposals by the USEPA, the DFG, David Schuster and Chuck Hanson, the Bay Institute, Jones and Stokes, and SWRCB staff, and a joint proposal by major agricultural and urban water agencies. (David Schuster and Chuck Hanson participated in the formulation of the joint proposal, which supersedes their individual proposals. SWRCB staff's proposal was not a formal recommendation to the SWRCB, but rather an attempt to ensure that a range of alternatives was evaluated.) Discussions with the federal agencies indicated that the NMFS may adopt a biological opinion for winter-run chinook salmon that imposes additional standards in the Estuary, and these draft standards were combined with the USEPA alternative to prepare an alternative characterized as the Club FED alternative.

DWRSIM operation studies were run for all of these proposals, five of which are analyzed in this report: the USEPA, the DFG, SWRCB staff, and the Club FED alternatives, and a modified version of the joint proposal (preferred alternative). The modified version was endorsed by representatives of the State and federal governments and urban, agricultural, and environmental interests, as documented in the "Principles for Agreement on Bay-Delta Standards between the State of California and the Federal Government".

The complete regulatory alternatives proposed by the participants include similar features. These similarities occur because the same principles are employed by all of the participants in formulating their alternatives. These principles include: (1) additional outflow in the Spring period (February through June) for general estuarine protection; (2) additional flow on the San Joaquin River during the peak salmon outmigration period; (3) export constraints to reduce entrainment; and (4) operation of barriers to reduce diversion of smolts and eggs from the main stems of the Sacramento and San Joaquin rivers. While the principles are the same, both the amount of water dedicated to these principles and the regulatory parameters used to address these principles are different. For example, outflow can be expressed as either flow or salinity in the western Delta, and export limits can be fixed or variable (QWEST, percent inflow, or restricted diversions below a particular outflow).

In most cases the alternatives suggested to the SWRCB include recommended actions that are beyond the scope of this plan. For example, all of the groups recommended that a barrier be installed at the head of Old River in the spring to reduce diversion of outmigrating salmon on the San Joaquin River to the export pumps. These recommendations are not included here, but they are discussed in Chapter IX.

### 1. Base Case or "No Action" Alternative

The base case used in Chapter VII for the water supply impact analysis of the preferred alternative is assumed to be the "no action" alternative in this chapter. This base case consists of D-1485 conditions, modified to account for upstream requirements on the Sacramento River imposed by the NMFS to protect winter-run chinook salmon. This base is chosen for the reasons discussed in Chapter VII, one of which is that it represents the SWRCB's current regulatory requirements that impact Bay-Delta water supplies. The conditions which define the base case for DWRSIM studies are discussed in section VII.A. Alternatives 1 through 5 are discussed below in terms of changes and additions to these base case conditions.

### 2. Alternative 1

Alternative 1 is the USEPA's final water quality standards for the Estuary, which were published in the Federal Register in January 1995 (60 FR 4664-4709). This alternative includes four sets of standards to be added to the flow and export standards for protection of fish and wildlife in D-1485 and the water quality standards in the 1991 Bay-Delta Plan: (1) estuarine habitat criteria (X2 isohaline standard); (2) fish migration criteria (salmon smolt survival standard); (3) fish spawning criteria for the lower San Joaquin River (salinity standard); and (4) narrative criteria for the Suisun Marsh.

a. Estuarine Habitat Criteria (X2 Isohaline Standard). For protection of the estuarine habitat and other designated fish and wildlife uses in the estuary, the USEPA adopted a set of criteria that the agency believes provides the same degree of protection as would have existed under the 1968 "level of development" (Herbold 1994). The criteria specify the number of days when the near-bottom salinity at Roe Island, Chipps Island and the confluence of the Sacramento and San Joaquin rivers must not exceed 2 ppt. (The USEPA defines "level of development" as the existing water diversion and storage facilities in the targeted period (Seraydarian 1994). However, the USEPA's standards exceed the targeted level of development in very dry periods because they require 150 days at the confluence. Also, the standards are less than the targeted level of development in wetter periods. In actuality, the standards replicate the number of days the 2 ppt isohaline would have been downstream of Chipps and Roe islands under various hydrologic conditions during the historical reference period, not the hydrology of the targeted reference period. The distinction is important because very different water supply impacts at the same historical reference period would have been obtained if the USEPA had selected a different isohaline or different compliance locations.)

The USEPA developed its estuarine habitat criteria by using a logistic equation to define a sliding scale for the number of days the 2 ppt isohaline was downstream of Roe and Chipps islands under 1968 conditions. The criteria are then calculated on a monthly basis from February through June based on the previous month's unimpaired flow index (PMI) for the Sacramento River and San Joaquin River basins. The criteria include a "trigger" for the Roe Island standards to be required for any given month only if the 14-day average salinity at Roe Island falls below 2 ppt on any of the last 14 days of the previous month. Lastly, the 2 ppt criteria are required at the confluence of the Sacramento and San Joaquin rivers from February 1 through June 30 for all year types.

The USEPA believes that the SWRCB could adopt an implementation program that allows compliance with the criteria in any one of three ways: (1) the daily salinity value meets the requirement; (2) the 14-day average salinity meets the requirement; or (3) the daily outflow is equivalent to the salinity requirement (Seraydarian 1994). In the third method, the equivalent outflow is approximately 7,100 cfs for the confluence, 11,400 cfs for Chipps Island, and 29,200 cfs for Roe Island.

The estuarine habitat criteria are modeled in DWRSIM as described below:

i) Salinity at the confluence of the Sacramento and San Joaquin Rivers must not exceed 2 ppt from February 1 through June 30.

ii) Salinity at Roe Island (when triggered) and Chipps Island must not exceed 2 ppt for a specific number of days each month from February through June. The specific number of days for each month is computed by the following formula (Herbold 1994):

$$NDR = TND * \left(1 - \frac{1}{1+e^{K}}\right) \qquad K = A + B * \ln(PMI)$$

where *A* and *B* are determined by Table XI-1 for each location, and

*NDR* = number of days required in the month
*TND* = total number of days in the month
*PMI* = previous month's eight river index

The eight river index is defined as the sum of the unimpaired runoff for the following locations: (1) Sacramento River flow at Bend Bridge, near Red Bluff; (2) Feather River, total inflow to Oroville Reservoir; (3) Yuba River flow at Smartville; (4) American River, total inflow to Folsom Reservoir; (5) Stanislaus River, total inflow to New Melones; (6) Tuolumne River, total inflow to Don Pedro; (7) Merced River, total inflow to Exchequer; and (8) San Joaquin River, total inflow to Millerton Lake. Table XI-2 contains calculated required number of compliance days, using the above equations, for a range of PMI values.

| TABLE XI-1<br>A & B Values for Calculating K | | | | |
|---|---|---|---|---|
| MONTH | CHIPPS ISLAND | | ROE ISLAND<br>(if triggered) | |
| | A | B | A | B |
| FEB | -- | -- | -14.36 | 2.068 |
| MAR | -105.16 | 15.943 | -20.79 | 2.741 |
| APR | -47.17 | 6.441 | -28.73 | 3.783 |
| MAY | -94.93 | 13.662 | -54.22 | 6.571 |
| JUN | -81.00 | 9.961 | -- | -- |

| TABLE XI-2<br>Number of Days when Salinity Must Not Exceed 2 ppt | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| PMI<br>(TAF) | CHIPPS ISLAND | | | | | ROE ISLAND<br>(if triggered) | | | |
| | FEB | MAR | APR | MAY | JUN | FEB | MAR | APR | MAY |
| 250 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 500 | 28 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 |
| 750 | 28 | 18 | 0 | 0 | 0 | 9 | 2 | 1 | 0 |
| 1000 | 28 | 31 | 2 | 0 | 0 | 13 | 4 | 2 | 0 |
| 1250 | 28 | 31 | 7 | 0 | 0 | 17 | 7 | 4 | 0 |
| 1500 | 28 | 31 | 15 | 0 | 0 | 19 | 10 | 8 | 0 |
| 1750 | 28 | 31 | 21 | 0 | 0 | 21 | 13 | 11 | 0 |
| 2000 | 28 | 31 | 26 | 1 | 0 | 22 | 16 | 15 | 0 |
| 2500 | 28 | 31 | 29 | 16 | 1 | 24 | 20 | 21 | 2 |
| 3000 | 28 | 31 | 29 | 29 | 7 | 25 | 24 | 25 | 5 |
| 4000 | 28 | 31 | 30 | 31 | 25 | 26 | 27 | 28 | 18 |
| 5000 | 28 | 31 | 30 | 31 | 29 | 27 | 29 | 29 | 26 |
| 6000 | 28 | 31 | 30 | 31 | 30 | 28 | 30 | 30 | 29 |

b. <u>Fish Migration Criteria (Salmon Smolt Survival Standard)</u>. To protect salmon smolts and other migratory species in the estuary, the USEPA has adopted salmon smolt survival criteria consisting of two sets of index values: the Sacramento River Salmon Index (SRSI) and the San Joaquin River Salmon Index (SJRI).

USFWS studies have shown that closure of the Delta Cross Channel gates is the most important controllable factor in the survival of smolts on the Sacramento River (USFWS 1992). Accordingly, the USEPA's target index values approximate experimental salmon survival index values observed in Sacramento releases during periods when the gates are closed, which is approximately double the historical survival measured at times when the gates are open. The criteria for the Sacramento River system are as follows:

i) At temperatures < 61 °F: SRSI = 1.35

ii) At temperatures ≥ 61 °F and ≤ 72 °F: SRSI = 6.96 - 0.092*Temperature ( °F)

iii) At temperatures > 72 °F: SRSI = 0.34 (the measured index approaches zero, but the USEPA believes that this value is appropriate in order to encourage efforts to protect salmon during periods of high temperatures)

The USEPA expects target index values to be attained through measures to be identified in the USFWS Sacramento salmon smolt survival model. The model relates the salmon survival index to four factors: temperature at Freeport, exports, proportion of water diverted into the Delta Cross Channel at Walnut Grove, and proportion of water remaining in the Sacramento River at Walnut Grove.

For the San Joaquin River system, the USEPA derived the target values from the modeled values associated with protective measures recommended by the USFWS (USFWS 1992), revised to provide additional protection in drier years. The USEPA believes that its criteria will increase wet year survival by a factor of 1.8 and dry year survival by a factor of four. The resulting San Joaquin salmon smolt survival criteria are based on the 60-20-20 San Joaquin Water Year Index (SJWYI) in MAF, and are as follows:

i) In years with SJWYI > 2.5: SJRI = (-0.012) + 0.184*SJWYI

ii) In other years: SJRI = 0.205 + 0.0975*SJWYI

The USEPA expects the revised USFWS San Joaquin salmon smolt survival model to be used in identifying measures to attain the above criteria. This model relates the survival of San Joaquin smolts migrating through the Delta to four factors: San Joaquin River flow at Vernalis, proportion of flow diverted from the mainstem San Joaquin River, exports, and temperature at Jersey Point. The salmon smolt criteria are modeled in DWRSIM as described below:

i) The Delta Cross Channel gates are closed from April 1 through June 30.

ii) Minimum flow requirements and export restrictions must be maintained as specified in Table XI-3. These values have been estimated by the USEPA to be necessary to achieve the survival index standard, based on the USFWS smolt survival model.

c. Fish Spawning Criteria for the Lower San Joaquin River (Salinity Standard). To address increased salinity levels caused by agricultural return flows in the San Joaquin Valley, the USEPA also adopted fish spawning criteria for the lower San Joaquin River. These salinity standards are intended to reduce the impacts of salt loadings on spawning habitat for sensitive species, including striped bass and Sacramento splittail, and protect other fish and wildlife uses of the lower San Joaquin River from Jersey Point to Vernalis. The criteria include the following requirements from April 1 through May 31:

i) In wet, above normal and below normal years, the 14-day running average of the mean daily EC must not exceed 0.44 mmhos/cm in the reach from Jersey Point to Vernalis.

ii) In dry and critical years, the 0.44 mmhos/cm EC standard is required in the reach from Jersey Point to Prisoner's Point.

These standards were not incorporated into the DWRSIM operation study.

d. Narrative Criterion for Suisun Marsh. To protect the tidal wetlands surrounding Suisun Bay, the USEPA adopted a narrative criterion that requires water quality conditions sufficient to support high plant diversity and diverse wildlife habitat and prevent conversion of brackish marsh to salt marsh. This standard was not incorporated into the DWRSIM operation study.

### 3. Alternative 2

Alternative 2 was developed by SWRCB staff from various recommendations received from workshop participants. This alternative includes flow, export and operational requirements to replace those for protection of fish and wildlife in the 1978 Delta Plan and D-1485.

a. Flow Standards. For protection of chinook salmon during the peak of smolt outmigration, flows on the San Joaquin River at Vernalis for four weeks from April 17 through May 14 must be at least 8,000 cfs in wet years, 7,000 cfs in above normal years, 6,000 cfs in below normal years, 5,000 cfs in dry years, and 4,000 cfs in critical years. To attract adult migrating chinook salmon into the San Joaquin River and its tributaries, flows on the San Joaquin River must be at least 2,000 cfs from October 18 through October 31.

b. Export Standards. During the spring pulse flow period from April 17 through May 14, exports must not exceed 1,500 cfs. Maximum exports for the rest of April through June are

| TABLE XI-3<br>Salmon Smolt Criteria for DWRSIM | | |
|---|---|---|
| **PARAMETER** | **SJWYI[1] (MAF)** | **CRITERION (cfs)** |
| EXPORTS (cfs)<br>4/1 - 4/15 and<br>5/16 - 5/31 | ≤ 2.5 | 1191.13 + 964.08*SJWYI |
| | >2.5 and <3.8 | 13.79 + 1432.41*SJWYI |
| | ≥ 3.8 | 6,000 |
| EXPORTS (cfs)<br>4/15 - 5/15 | All Values | 1,500 |
| EXPORTS (cfs)<br>6/1 to 6/30 | ≤ 2.8 | 4,000 |
| | > 2.8 and < 3.8 | 13.79 + 1432.41*SJWYI |
| | ≥ 3.8 | 6,000 |
| VERNALIS FLOW<br>(cfs) 4/15 - 5/15 | ≤ 2.5 | 832.52 + 1749.08*SJWYI |
| | >2.5 and <4.2 | -1972.43 + 2864.82*SJWYI |
| | ≥ 4.2 | 10,000 |

1 Where SJWYI = the 60-20-20 San Joaquin Water Year Index in MAF

set at 4,000 cfs in critical years, 5,000 cfs in dry years, and 6,000 cfs in below normal, above normal, and wet years. In July, exports must not exceed 9,200 cfs. These fixed export constraints in April through July are eliminated when the Delta Outflow Index exceeds 50,000 cfs. Additionally, total CVP and SWP exports must be less than 30 percent of Delta inflow from February 1 through June 30, and 60 percent of Delta inflow from July 1 through January 30.

c. Operations. The Delta Cross Channel gates must be closed from February 1 through April 30, and they are operated on a real-time basis from November 1 through January 31 and May 1 through June 30. For modeling purposes the gates are assumed to be closed throughout the period.

e. X2 Isohaline Standard. This requirement is based on the California Urban Water Agencies' (CUWA's) proposed estuarine habitat standard (CUWA 1994). The standard is derived using the same methodology as used by the USEPA, but the standard replicates the number of days the 2 ppt isohaline was downstream of the three locations under conditions that existed in year 1971.5 instead of year 1968. Additionally, the number of days the 2 ppt isohaline must be downstream of the confluence is derived using the sliding scale methodology instead of the USEPA's recommendation that the 2 ppt isohaline be downstream of the confluence at all times from February through June.

Compliance with the standard can be achieved by meeting at least one of three alternative criteria at each of three locations for the number of days during each month of February through June, as determined from the eight river index, defined on page XI-3, for the previous month (PMI):

- i) Average daily salinity at the compliance point; or
- ii) 14-day average salinity at the compliance point; or
- iii) Maintenance of Delta outflow calculated to maintain desired salinity at steady-state.

Table XI-4 contains calculated required number of compliance days for a range of PMI values.

**4. Alternative 3**

The DFG developed three sets of alternative Bay-Delta standards in 1992, and it recommended that the SWRCB consider adoption of one of the alternatives during the SWRCB's draft D-1630 proceedings (DFG 1992). During the SWRCB's hearings to develop alternatives for this plan, the DFG recommended that the SWRCB consider alternative B in the above reference. This alternative is extracted from that source.

The DFG developed these standards by examining the needs of fall-run chinook salmon, winter-run chinook salmon, striped bass and a series of estuarine species. These standards

| PMI (TAF) | CONFLUENCE | | | | | CHIPPS ISLAND | | | | | ROE ISLAND | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FEB | MAR | APR | MAY | JUN | FEB | MAR | APR | MAY | JUN | FEB | MAR | APR | MAY | JUN |
| 250 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 |
| 750 | 28 | 8 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 8 | 2 | 0 | 0 | 0 |
| 1000 | 28 | 31 | 0 | 0 | 0 | 28 | 12 | 2 | 0 | 0 | 12 | 4 | 0 | 0 | 0 |
| 1250 | 28 | 31 | 24 | 0 | 0 | 28 | 31 | 6 | 0 | 0 | 15 | 6 | 1 | 0 | 0 |
| 1500 | 28 | 31 | 30 | 31 | 0 | 28 | 31 | 13 | 0 | 0 | 18 | 9 | 1 | 0 | 0 |
| 1750 | 28 | 31 | 30 | 31 | 0 | 28 | 31 | 20 | 0 | 0 | 20 | 12 | 2 | 0 | 0 |
| 2000 | 28 | 31 | 30 | 31 | 0 | 28 | 31 | 25 | 1 | 0 | 21 | 15 | 4 | 0 | 0 |
| 2500 | 28 | 31 | 30 | 31 | 5 | 28 | 31 | 29 | 11 | 1 | 23 | 19 | 8 | 1 | 0 |
| 3000 | 28 | 31 | 30 | 31 | 25 | 28 | 31 | 30 | 27 | 4 | 25 | 23 | 12 | 4 | 0 |
| 4000 | 28 | 31 | 30 | 31 | 30 | 28 | 31 | 30 | 31 | 23 | 26 | 27 | 20 | 15 | 0 |
| 5000 | 28 | 31 | 30 | 31 | 30 | 28 | 31 | 30 | 31 | 29 | 27 | 28 | 25 | 25 | 4 |
| 6000 | 28 | 31 | 30 | 31 | 30 | 28 | 31 | 30 | 31 | 30 | 27 | 29 | 27 | 29 | 16 |
| 7000 | 28 | 31 | 30 | 31 | 30 | 28 | 31 | 30 | 31 | 30 | 27 | 30 | 28 | 30 | 26 |
| 8000 | 28 | 31 | 30 | 31 | 30 | 28 | 31 | 30 | 31 | 30 | 27 | 30 | 29 | 31 | 29 |
| 9000 | 28 | 31 | 30 | 31 | 30 | 28 | 31 | 30 | 31 | 30 | 28 | 30 | 29 | 31 | 30 |
| 10000 | 28 | 31 | 30 | 31 | 30 | 28 | 31 | 30 | 31 | 30 | 28 | 31 | 30 | 31 | 30 |

TABLE XI-4: Number of Days When Salinity Must Not Exceed 2 ppt would replace the flow and operational constraints for protection of fish and wildlife in D-1485.

a. Flow Standards. For protection of fall-run chinook salmon, average Sacramento River flows at Rio Vista should exceed 4,000 cfs from April 1 through June 30; and average San Joaquin River flows at Vernalis from April 15 through May 15 should be greater than: 10,000 cfs in wet years; 8,000 cfs in above normal years; 6,000 cfs in below normal years; 4,000 cfs in dry years; and 2,000 cfs in critical years. For protection of striped bass eggs and larvae, the minimum daily flow on the Sacramento River at Freeport should exceed 13,000 cfs.

b. Export Standards. During the spring pulse flow on the San Joaquin River from April 15 through May 15, limit exports to the following: 6,000 cfs in wet years; 5,000 cfs in above normal years; 4,000 cfs in below normal years; 3,000 cfs in dry years; and 2,000 cfs in critical years. For April through July, maximum average monthly exports must be maintained as follows: 6,400 cfs in wet years; 5,400 cfs in above normal years; 4,400 cfs in below normal years; 3,400 cfs in dry years; and 1,600 cfs in critical years. For August through March, maximum average monthly exports must be maintained as follows: 7,900 cfs in wet years; 7,100 cfs in above normal years; 6,500 cfs in below normal years; 6,000 cfs in dry years; and 5,000 cfs in critical years.

The DFG also proposes that exports in excess of 1,500 cfs and diversion to storage be prohibited unless the outflows in Table XI-5 are met.

c. QWEST Standards. QWEST must be greater than zero cfs from February 1 through June 30. From April 15 through May 31, QWEST must be at least 1,500 cfs, 2,000 cfs, 2,500 cfs, and 3,000 cfs in dry, below normal, above normal, and wet years, respectively. QWEST must be greater than 1,000 cfs for the rest of the April 1 through June 30 period.

d. Operations Standards. The Delta Cross Channel gates should be closed from February 1 through June 30.

e. Outflow Standards. In critically dry years, the Delta Outflow Index must be greater than 8,700 cfs, 7,800 cfs, 7,000 cfs, 6,200 cfs, 5,600 cfs, and 5,000 cfs in February, March, April, May, June, and July, respectively. For protection of striped bass, the outflow standards in Table XI-6 must be met in the fall.

**5. Alternative 4**

This alternative adds requirements to the USEPA's standards described in Alternative 1 (described in section XI.A.2). These additional requirements are proposed by the NMFS for the protection of winter-run chinook salmon.

| TABLE XI-5<br>Outflow Below Which 1,500 cfs Export Restriction and Diversion Prohibition Apply | | | | |
|---|---|---|---|---|
| MONTH | DELTA OUTFLOW INDEX | | | |
| | WET | ABOVE NORMAL | BELOW NORMAL | DRY |
| FEB | 50,000 | 50,000 | 22,000 | 19,200 |
| MAR | 45,000 | 50,000 | 15,400 | 15,000 |
| APR | 18,000 | 13,600 | 9,500 | 9,500 |
| MAY | 24,400 | 15,000 | 9,500 | 9,500 |
| JUN | 17,500 | 12,000 | 8,600 | 7,900 |
| JUL | 12,500 | 9,900 | 8,300 | 7,600 |
| OCT | 14,200 | | | |
| NOV | 16,300 | 12,900 | 9,500 | |
| DEC | 28,000 | 27,000 | 26,000 | 20,000 |

| TABLE XI-6<br>14-Day Running Average Delta Outflow Requirement | | | | | |
|---|---|---|---|---|---|
| YEAR TYPE | AUG | SEP | OCT | NOV | DEC |
| Wet | 5,800 | 7,300 | 7,300 | 7,300 | 7,300 |
| Above Normal | 5,600 | 4,200 | 4,500 | 4,500 | 5,400 |
| Below Normal | 5,300 | 4,200 | 4,500 | 4,500 | 4,900 |
| Dry | 5,000 | 4,000 | 4,500 | 4,500 | 4,700 |
| Critical | 3,300 | 3,000 | 3,600 | 3,600 | 4,700 |

a. <u>QWEST Standards</u>. QWEST must be greater than -2000 cfs from November 1 through January 31. In the months of February through April, QWEST must be at least 2000 cfs for 6 weeks, with exact dates to be determined through monitoring, and greater than 0 cfs for the rest of the February 1 through April 30 period. For modeling purposes, QWEST requirements are assumed to be -2000 cfs in November through January, 0 cfs in February, 2000 cfs in March, and 1000 cfs in April.

b. <u>Operations</u>. The Delta Cross Channel gates must be closed from February 1 through June 30, and they are operated on a real-time basis for 45-day closure based upon monitoring during November 1 through January 31. In modeling the latter, the gates are assumed to be closed 15 days in each of the three months, for a total of 45 days.

### 6. Alternative 5

Alternative 5, which incorporates the "Principles for Agreement on Bay-Delta Standards between the State of California and the Federal Government," is the consensus proposal by major agricultural and urban water users, and is the SWRCB's preferred alternative. The fish and wildlife standards, modeling assumptions, and potential impacts of the preferred alternative are described in detail earlier in this report and are not repeated here. For additional information on the standards, modeling assumptions and water supply impacts, and environmental impacts, refer to Chapters II, VII and VIII, respectively.

## B. WATER SUPPLY IMPACTS OF ALTERNATIVES

This section compares the water supply impacts of alternative sets of fish and wildlife standards considered for adoption by the SWRCB. The analysis focuses on the water supply impacts, and not on their distribution to responsible water users. The SWP and the CVP serve as surrogates in the modeling studies in order to determine the overall water supply impacts of each alternative. Following adoption of the draft plan, the SWRCB will initiate a water right proceeding to identify responsible water users and allocate responsibility.

Water supply impacts are determined by comparing DWRSIM studies for each alternative with the base case described in section VII.A. Complete characterization of the water supply impacts requires consideration of three parameters: total exports, Sacramento River Basin storage changes, and San Joaquin River Basin water supply impacts. Table XI-7 summarizes the water supply impacts of the alternatives relative to the base case.

### 1. Exports

For this analysis, exports are defined as SWP exports at Banks Pumping Plant, CVP exports at Tracy Pumping Plant, Contra Costa Canal exports, North Bay Aqueduct exports, and diversions by the City of Vallejo. Water supply impacts discussed below for both the 71-year hydrology and critically dry period do not include adjustments due to additional flows in excess of New Melones releases required to meet flow requirements in the San

| TABLE XI-7<br>Summary of Comparative Water Supply Impacts Relative to Base Case<br>(TAF/yr) | | | | |
|---|---|---|---|---|
| Proposed Fish & Wildlife Standards | Critical Dry Period Average (May 1928-Oct 1934)[2] | 71-Year Average (1922-1992)[3] | Average Annual Carryover Storage in Sacramento River Basin[1] | Average Annual Carryover Storage in New Melones Reservoir |
| Alternative 1 | -1079 | -495 | -175 | -730 |
| Alternative 2 | -1389 | -573 | -253 | -680 |
| Alternative 3 | -2428 | -2893 | 1244 | -320 |
| Alternative 4 | -1411 | -865 | -61 | -730 |
| Alternative 5 | -987 | -300 | 17 | -666 |

1. Includes Clair Engle, Whiskeytown, Shasta, Folsom and Oroville reservoirs, with total storage capacity of 11.7 MAF.
2. Change in total exports (Banks, Tracy, Contra Costa and North Bay/Vallejo diversions) from base case plus adjustments due to upstream reservoir storage used (Clair Engle, Whiskeytown, Shasta, Folsom, Oroville and New Melones) and additional flows in excess of New Melones releases required to meet flow requirements in the San Joaquin River at Vernalis.
3. Change in total exports (Banks, Tracy, Contra Costa and North Bay/Vallejo diversions) from base case plus adjustments due to additional flows in excess of New Melones releases required to meet flow requirements in the San Joaquin River at Vernalis.

Joaquin River at Vernalis. Critical period impacts also do not include adjustments due to Sacramento River Basin reservoir storage used.

Figure XI-1 shows the average annual exports for the 71-year hydrology under the base case and all alternatives. The figure shows the highest, lowest and average annual exports for each set of standards. Average annual exports for the base case are 6.1 MAF. Alternative 3 has the lowest average annual exports at 3.2 MAF. For other alternatives, annual exports range from 5.3 MAF (under Alternative 4) to 5.9 MAF (under Alternative 5). Figure XI-2 shows the maximum, minimum, and average changes in exports under each alternative from that of the base case. Exports are reduced from 230 TAF (under Alternative 5) to 2.9 MAF (under Alternative 3), with maximum annual reductions of 1.4 MAF, 1.6 MAF, 4.1 MAF, 2.3 MAF, and 1.1 MAF under Alternatives 1 through 5, respectively.

Figure XI-3 shows the average annual exports during the critically dry period of May 1928 through October 1934 for the base case and all alternatives, and Figure XI-4 shows the corresponding export reduction for each alternative from the base case. In the base case, the average annual exports are 5.2 MAF. Average annual exports for the alternatives range from 2.4 MAF (under Alternative 3) to 4.3 MAF (under Alternative 5). Average impacts range from 830 TAF (Alternative 5) to 2.7 MAF (Alternative 3) per year on average.

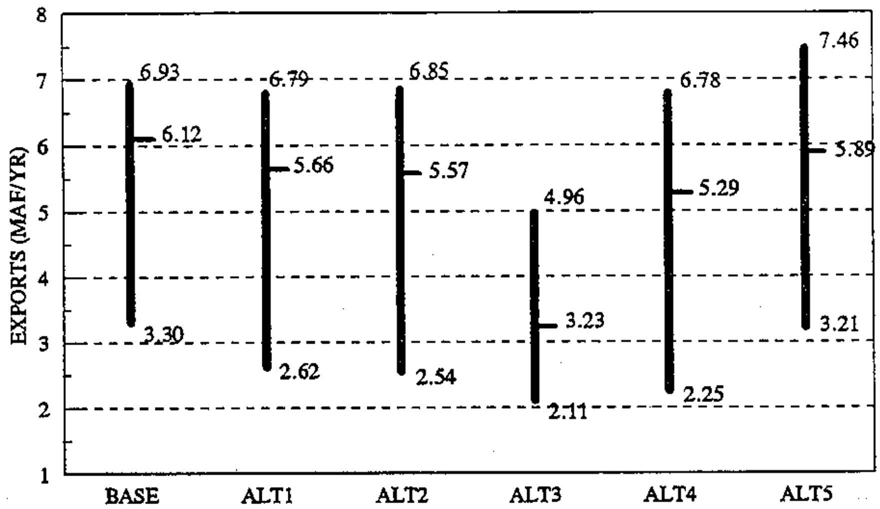
**2. Sacramento River Basin Storage Impact**

To evaluate potential impacts on reservoir storage in the Sacramento River Basin, combined storage in Clair Engle, Whiskeytown, Shasta, Oroville and Folsom reservoirs under the various alternatives is compared with that under the base case.

For the 71-year hydrology, Figure XI-5 shows carryover (end-of-September) storage under the base case and all alternatives. Change in storage from the base case for each alternative is shown in Figure XI-6. For Alternatives 1, 2, and 4 the reductions in carryover storage from the base case are 175 TAF, 253 TAF, and 61 TAF, respectively. Under Alternative 3, exports are restricted until reservoir inflows reach designated levels. This restriction results in an increase in carryover storage of 1.24 MAF. Alternative 5 also results in an increased carryover storage of 17 TAF from the base case.

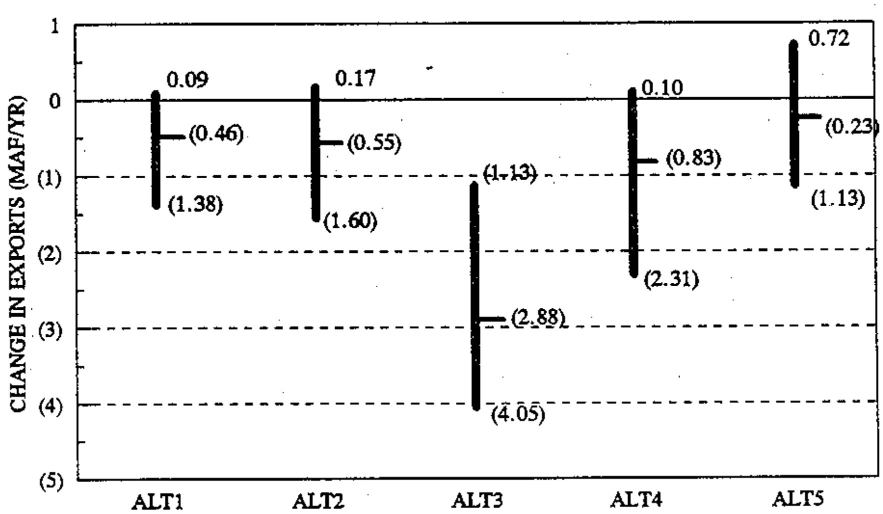
For the critically dry period of May 1928 through October 1934, the combined impact on upstream reservoir storage in the Sacramento River Basin and on New Melones Reservoir storage in the San Joaquin River Basin is characterized as the change in upstream storage during this period (derived by subtracting storage at the end of the critical period from storage at the beginning of the period, dividing by 6.5 for an annual average, and subtracting losses due to evaporation). The changes in upstream storage for the base case and all alternatives are shown in Figure XI-7. Figure XI-8 shows the net change in annual upstream storage used under Alternatives 1 through 5 from the base case.

FIGURE XI-1
AVERAGE ANNUAL EXPORTS
OVER 71-YEAR HYDROLOGY



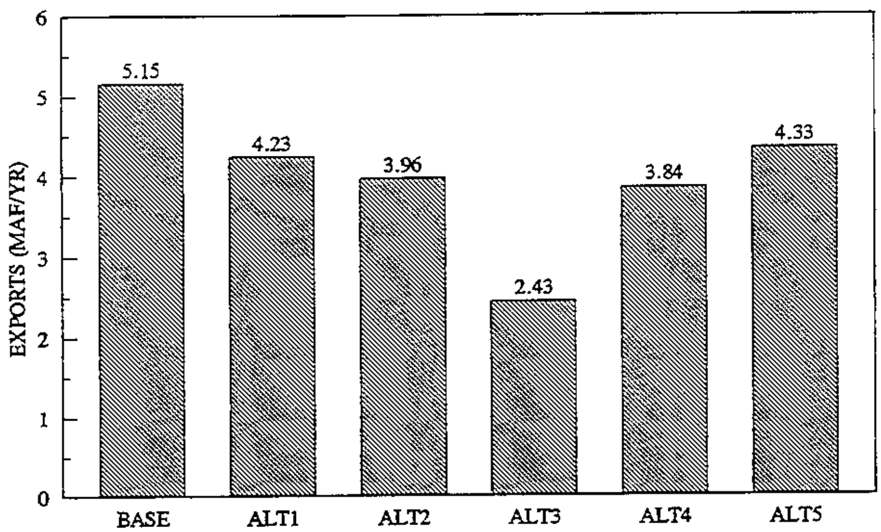

Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo
Top of bar = maximum, bottom of bar = minimum, marker = average

FIGURE XI-2
AVERAGE ANNUAL CHANGE IN EXPORTS FROM BASE CASE
OVER 71-YEAR HYDROLOGY



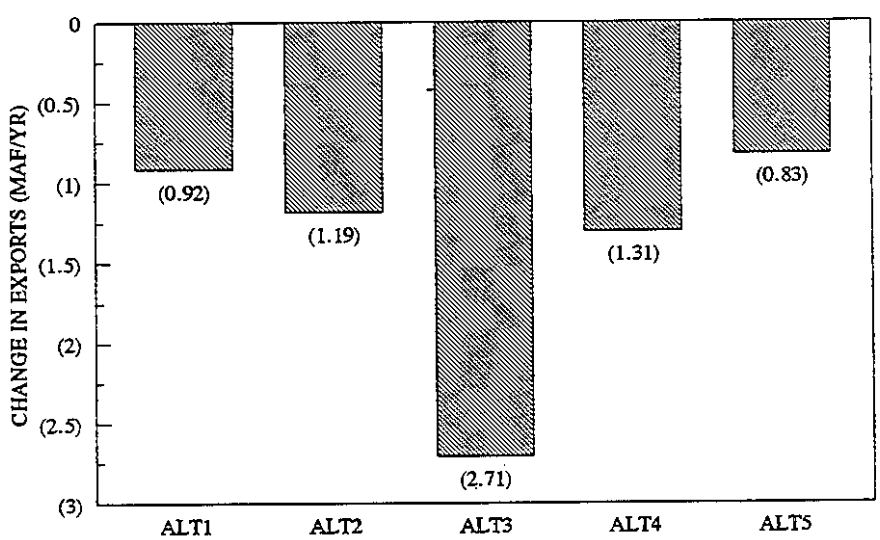

Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo
Top of bar = minimum, bottom of bar = maximum, marker = average

FIGURE XI-3
AVERAGE ANNUAL EXPORTS
FROM MAY 1928 - OCTOBER 1934



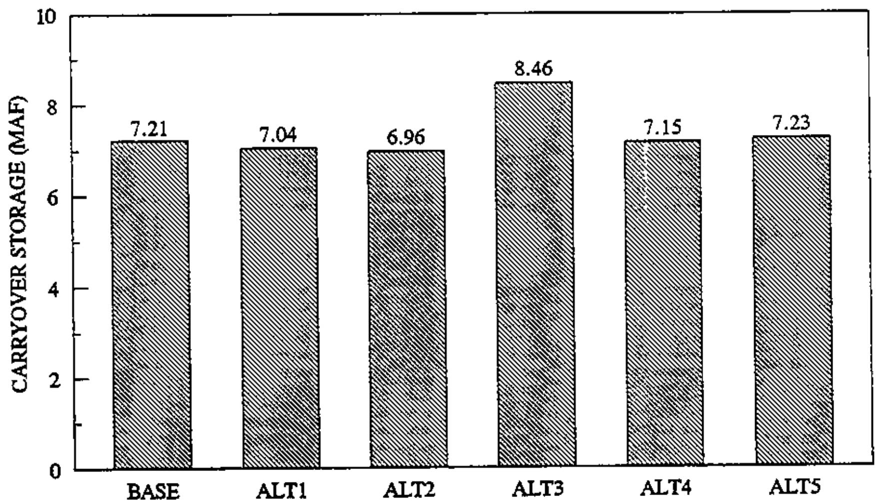

Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo

FIGURE XI-4
AVERAGE ANNUAL CHANGE IN EXPORTS FROM BASE CASE
FROM MAY 1928 - OCTOBER 1934



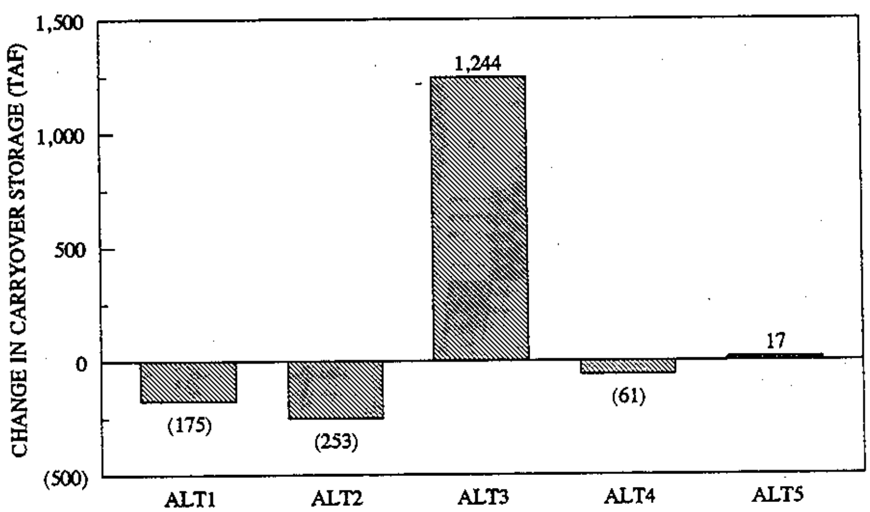

Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo

FIGURE XI-5
AVERAGE END-OF-SEPTEMBER CARRYOVER STORAGE
IN SACRAMENTO RIVER BASIN RESERVOIRS



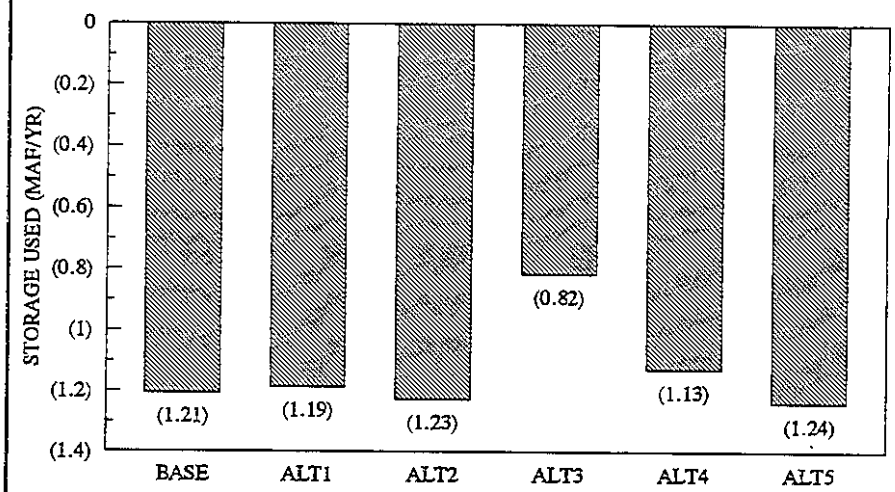

Includes Clair Engle, Whiskeytown, Shasta, Folsom and Oroville Reservoirs
Average carryover storage over 71-year hydrology

FIGURE XI-6
AVERAGE CHANGE IN END-OF-SEPTEMBER STORAGE
IN SACRAMENTO RIVER BASIN RESERVOIRS



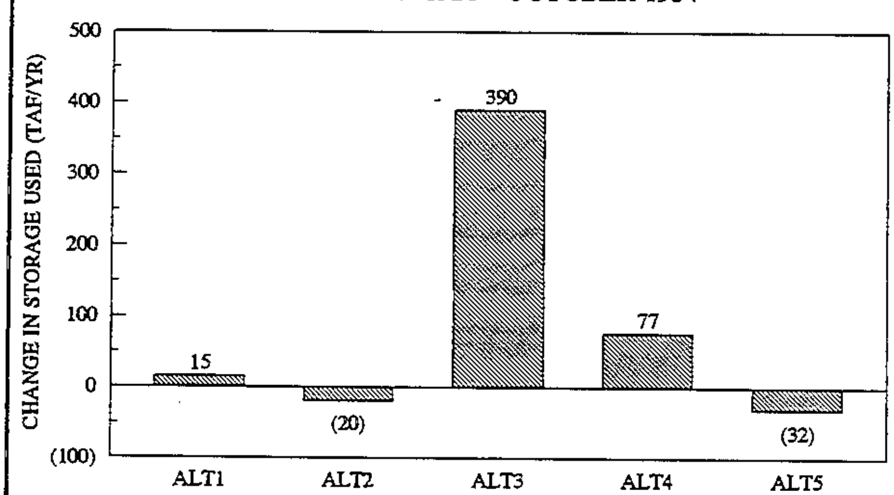

Average change in carryover storage from base case over 71-year hydrology
Includes Clair Engle, Whiskeytown, Shasta, Folsom and Oroville Reservoirs

FIGURE XI-7
AVERAGE ANNUAL UPSTREAM STORAGE USED
FROM MAY 1928 - OCTOBER 1934




Includes Clair Engle, Whiskeytown, Shasta, Folsom, Oroville and New Melones.
Average annual storage used = (May 1928 storage - October 1934 storage)/6.5 yrs
with adjustment for evaporation.

FIGURE XI-8
AVERAGE ANNUAL CHANGE IN UPSTREAM STORAGE USED
FROM MAY 1928 - OCTOBER 1934




Includes Clair Engle, Whiskeytown, Shasta, Folsom, Oroville and New Melones.
Annual storage used =(May 1928 storage - October 1934 storage)/6.5 years - evap
Change in net storage used from base case.

### 3. San Joaquin River Basin Impact

As discussed in Section VII.D, water supply impacts of the new flow standards at Vernalis are characterized by two limiting cases. The first limiting case assumes that water necessary to achieve the standards is obtained by reducing storage in San Joaquin Valley reservoirs, represented in DWRSIM studies by New Melones Reservoir. The second limiting case assumes that the water is obtained by reducing deliveries to customers, while increasing San Joaquin River flows. In actuality, water users are likely to meet the requirements through a combination of these two measures. The water supply impact in the first limiting case is determined by the change in New Melones storage from the base case. The water supply impact in the second case is determined by comparing the additional flow required on the San Joaquin River at Vernalis between the base case and the alternatives.

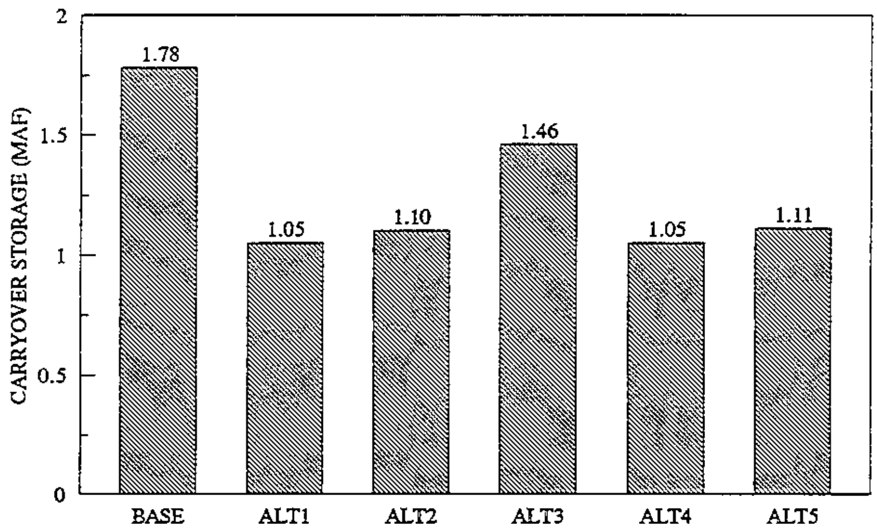
a. New Melones Reservoir Storage. Figure XI-9 shows carryover storage in New Melones under the base case and various alternatives. Figure XI-10 shows the changes in storage from the base case for the alternatives. Impacts on New Melones carryover storage under Alternatives 1 through 5 are 727 TAF, 672 TAF, 311 TAF, 727 TAF, and 666 TAF, respectively.

These impacts do not include adjustments due to additional flows in excess of New Melones releases required to meet the new flow requirements. This excess water from unspecified sources is required when New Melones reaches minimum operating storage. Water in excess of New Melones releases is required under Alternative 1 in 11 years (1927-1935, 1964 and 1992), resulting in an additional average annual impact of 35 TAF/yr over the 71-year hydrology; under Alternative 2 in 8 years (1928-1934 and 1992), with an average annual impact of 23 TAF/yr; under Alternative 3 in 7 years (1928-34), with an average annual impact of 13 TAF/yr; under Alternative 4 in 11 years (1927-1935, 1964 and 1992), with an average annual impact of 35 TAF/yr; and under Alternative 5 in 20 years (1926-1935, 1948-1949, 1963-1964, 1966, and 1974-1978), with an average annual impact of 71 TAF.

b. San Joaquin River Flow. All of the alternatives require minimum flows in the San Joaquin River at Vernalis in April and May for salmon smolts outmigration. Alternatives 2 and 5 require additional flows in October. Alternative 5 also includes minimum flow requirements at Vernalis in February, March and June. The flow requirements in Alternatives 1 and 4 are identical, and, thus, their impacts are the same.

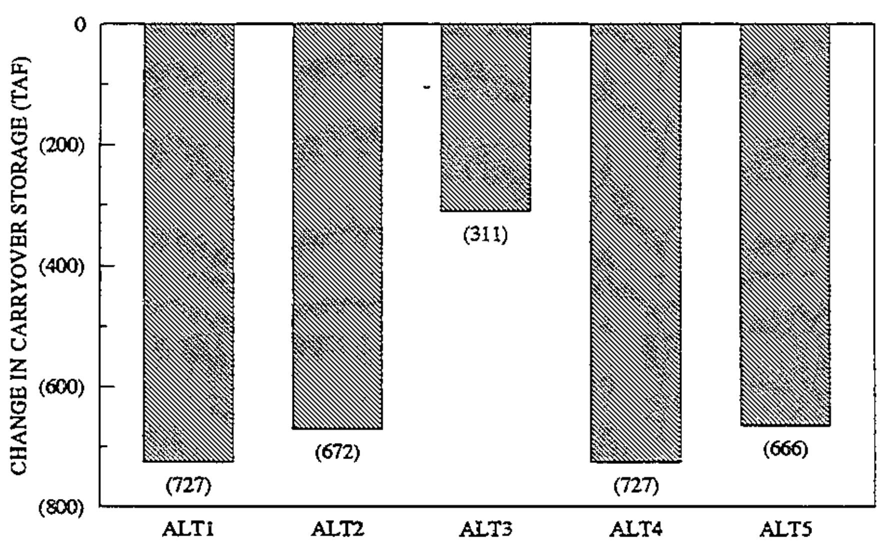
As shown in Figure XI-11, under Alternatives 1 through 5, the average annual additional San Joaquin River flows provided are 267 TAF, 232 TAF, 171 TAF, 267 TAF, and 266 TAF, respectively. Figure XI-12 shows the average monthly additional flows from the base case for the various alternatives in February through July. In November through January, and in August and September, the additional Vernalis flows provided are similar between all five alternatives. Under Alternatives 2 and 5, additional Vernalis flows of 10.4 TAF and 16.3 TAF, respectively, are provided to meet the October minimum flow requirements.

FIGURE XI-9
AVERAGE END-OF-SEPTEMBER CARRYOVER STORAGE
IN NEW MELONES RESERVOIR




Average carryover storage over 71-year hydrology

FIGURE XI-10
AVERAGE CHANGE IN CARRYOVER STORAGE FROM BASE CASE
IN NEW MELONES RESERVOIR




Average change in carryover storage over 71-year hydrology

FIGURE XI-11
AVERAGE ANNUAL ADDITIONAL SAN JOAQUIN RIVER FLOW AT VERNALIS FROM BASE CASE

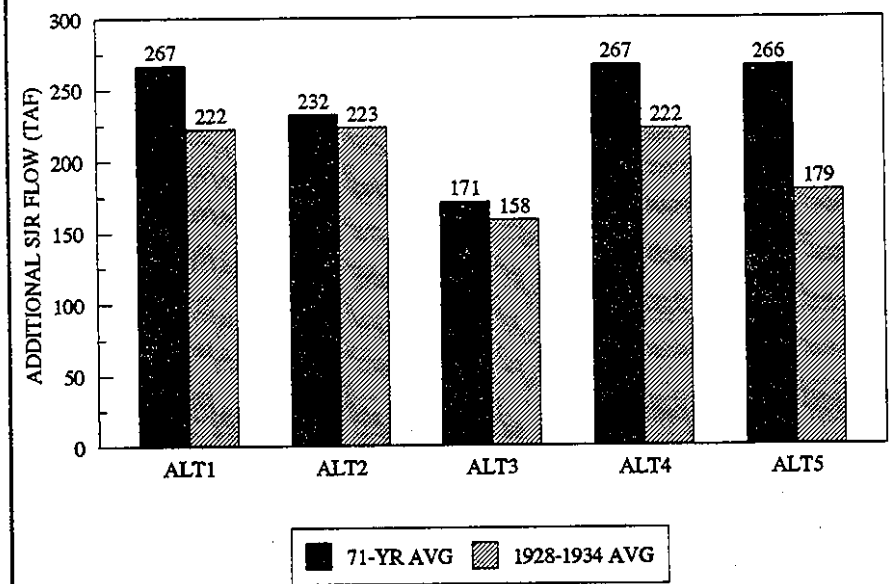
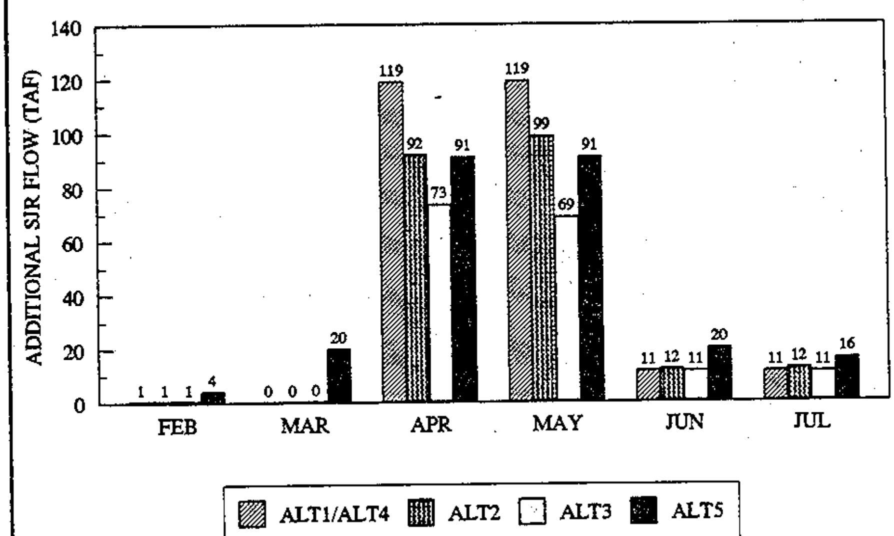



FIGURE XI-12
AVERAGE MONTHLY ADDITIONAL SAN JOAQUIN RIVER FLOW FROM BASE CASE OVER 71-YEAR HYDROLOGY




ALT 2 requires 10.4 TAF of additional water in October.
ALT5 requires 16.3 TAF of additional water in October.

## C. IMPACTS OF ALTERNATIVES ON AQUATIC RESOURCES

Major factors affecting aquatic resources in the Bay-Delta Estuary are reasonably well established, and although the alternatives analyzed by the SWRCB are different, they all address these major factors. Similar elements found in all of the alternatives include: (1) increased outflow, especially in the spring, for general estuarine protection; (2) export restrictions, especially in the spring, to minimize entrainment; (3) higher San Joaquin River flows during the most important salmon smolt outmigration period to improve smolt survival; and (4) barrier operation or construction to minimize straying from historic migratory routes.

A major difference among the alternatives is the period of the year over which regulatory controls are proposed. Alternatives 1 and 4 establish standards for the February through June, and October through June periods, respectively, while alternatives 2, 3, and 5 establish flow and operational requirements throughout the year. The SWRCB believes that operational requirements are needed throughout the year to ensure adequate protection for the Estuary.

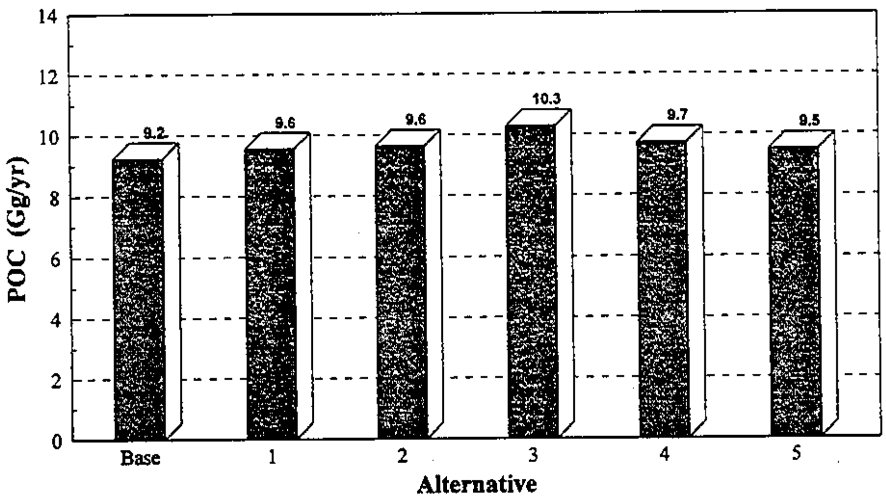
In general, the condition of aquatic resources in the Estuary improves as the hydrologic regime moves toward unimpaired conditions. (Such movement, however, comes at the expense of the consumptive uses of the waters of the Estuary.) Therefore, assuming similarly crafted standards, the water supply impacts of a set of alternative standards can provide a reasonable surrogate for the biological benefits of the alternatives at the present level of understanding. This simplistic approach cannot be used in this case because the alternatives are comprised of different elements.

The effects of each of the alternatives on aquatic resources (POC, *Crangon franciscorum*, Neomysis, longfin smelt, starry flounder, splittail, striped bass, and chinook salmon) are summarized in this section using the aquatic resource models described in Chapter VI and the DWRSIM-modeled 71-year hydrology. For purposes of discussion, the model results can be broken into three categories: (1) the abundance/outflow model results in Figures XI-13 through XI-18; (2) the striped bass model results in Figures XI-19 and XI-20; and (3) the salmon model results in Figures XI-21 through XI-23.

The abundance/outflow model results predict that none of the alternatives will result in major increases in the targeted resources. This result is expected because the abundance/outflow models predict that substantial increases in abundances occur due to large storm-driven outflows, which are well outside both the control of the CVP and the SWP, and the range of outflows required in these alternatives.

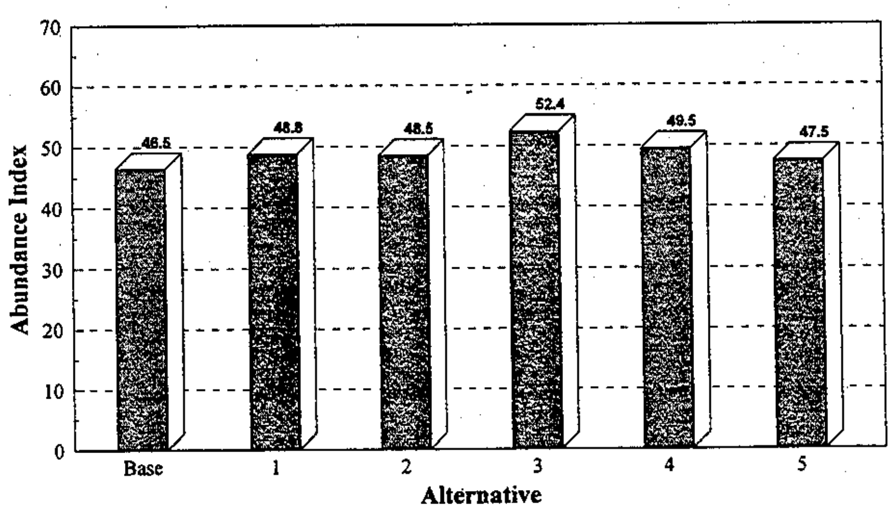
The striped bass model predicts that Alternative 3 will provide a substantial increase in both the young-of-the-year and the adult population. The model predicts that the other alternatives will improve the YOY index, but the adult population under these alternatives will not change markedly from the existing population of approximately 600,000 striped bass. The YOY is principally dependent on the export and outflow conditions in the April through July

## Figure XI - 13
## Particulate Organic Carbon (POC)



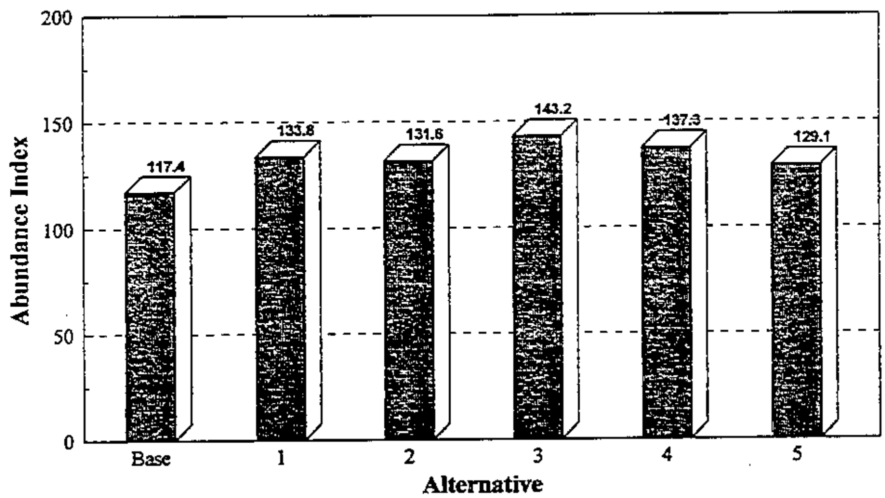

*Abundance index values are obtained using the modified Jassby model and DWRSIM model output for 1922-1992.*

## Figure XI - 14
## *Neomysis*



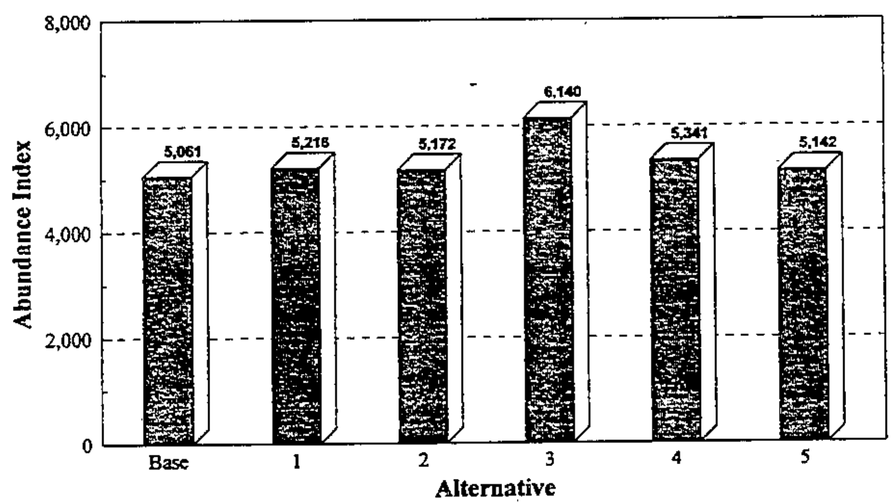

*Abundance index values are obtained using the modified Jassby model and DWRSIM model output for 1922-1992.*

## Figure XI - 15
## Immature *Crangon franciscorum*



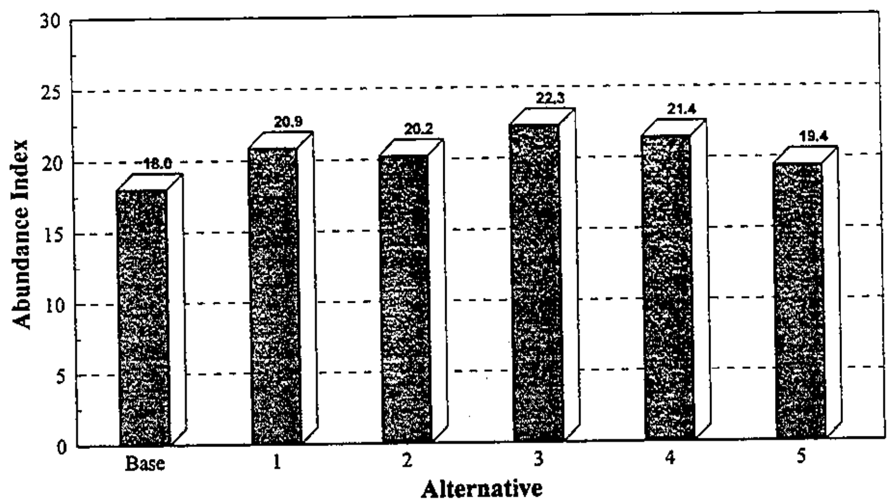

*Abundance index values are obtained using the DFG model and DWRSIM model output for 1922-1992.*

## Figure XI - 16
## Longfin Smelt



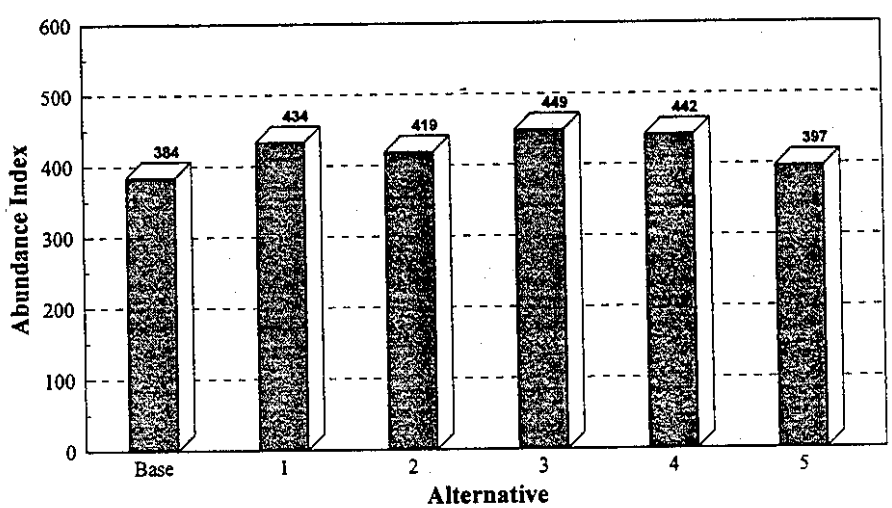

*Abundance index values are obtained using the DFG model and DWRSIM model output for 1922-1992.*

**Figure XI - 17**
## Sacramento Splittail




*Abundance index values are obtained using the DFG model and DWRSIM model output for 1922-1992.*

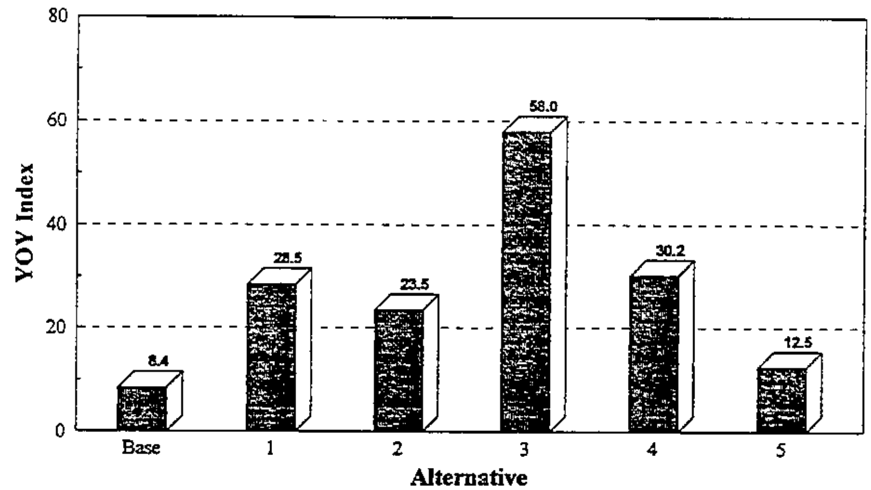
**Figure XI - 18**
## One-Year-Old Starry Flounder




*Abundance index values are obtained using the DFG model and DWRSIM model output for 1922-1992.*

Figure XI - 19

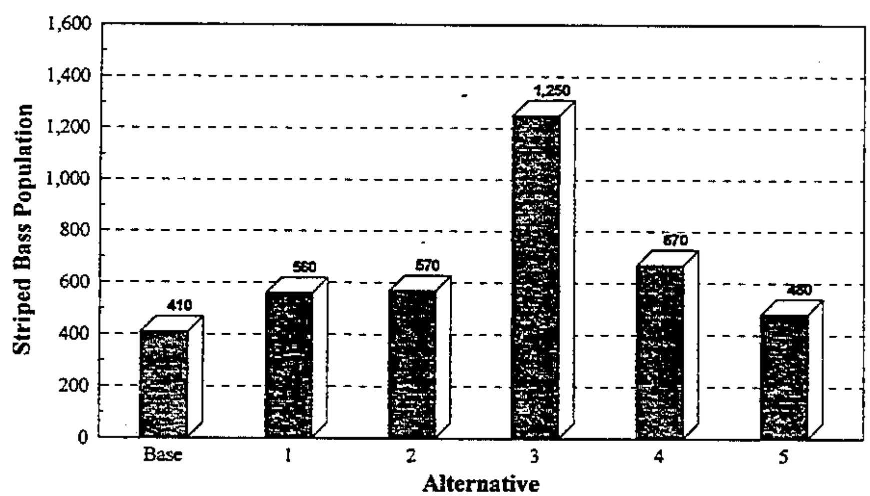
## Striped Bass YOY Index




*Abundance index values are obtained using the DFG striped bass model and DWRSIM model output for 1922-1992.*

Figure XI - 20

## Adult Striped Bass Population

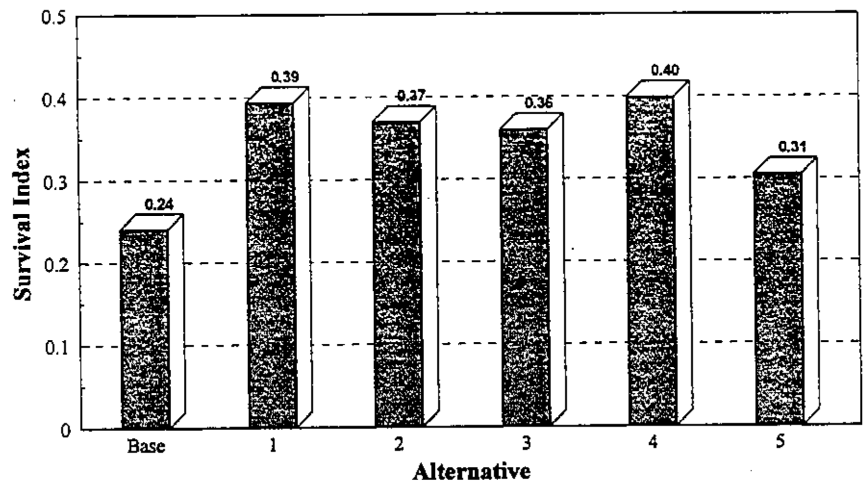



*Abundance index values are obtained using the DFG striped bass model and DWRSIM model output for 1922-1992.*

Figure XI - 21

## San Joaquin River Fall-Run Chinook Salmon Smolt Survival

**with the Old River barrier**

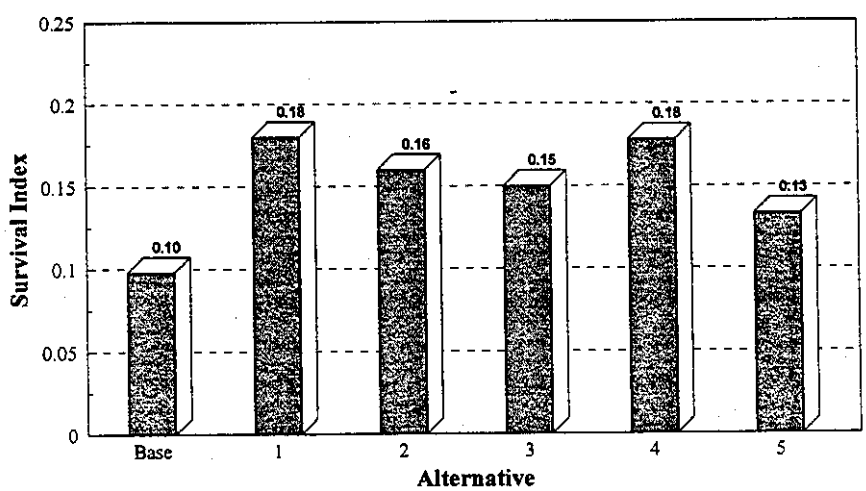



*Abundance index values are obtained using the USFWS salmon smolt model and DWRSIM model output for 1922-1992.*

Figure XI - 22

## San Joaquin River Fall-Run Chinook Salmon Smolt Survival

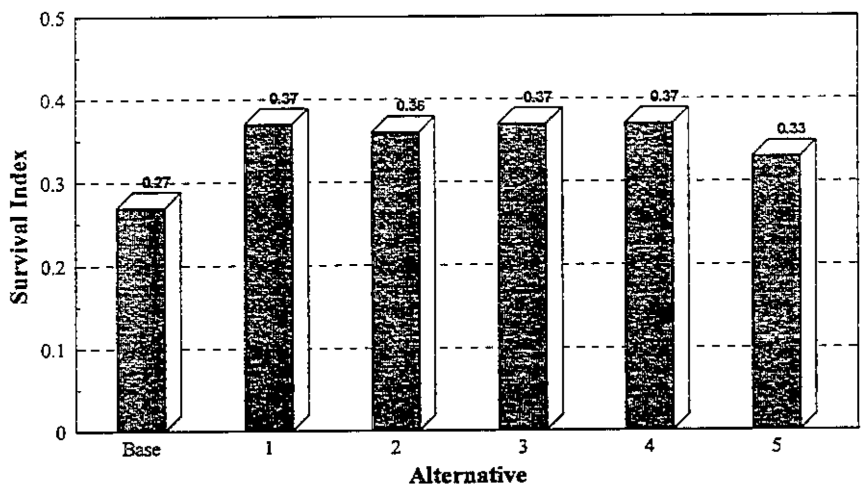
**without the Old River barrier**




*Abundance index values are obtained using the USFWS salmon smolt model and DWRSIM model output for 1922-1992.*

Figure XI - 23

**Sacramento River Fall-Run Chinook Salmon Smolt Survival**




*Abundance index values are obtained using the USFWS salmon smolt model and DWRSIM model output for 1922-1992.*

period, and these months receive substantial protection in all of the alternatives. The adult striped bass population is principally dependent on the YOY and export and outflow conditions from August through March. All of the alternatives, with the exception of Alternative 3, tend to shift export pumping out of the spring period, which is considered most critical for estuarine protection, and into the fall and winter. The striped bass model indicates that this shift will cause the benefits of increased YOY in the alternatives to be largely lost, probably through increased entrainment in the fall and winter.

The fall-run chinook salmon models predict increases in smolt survival during migration through the Delta for all of the alternatives. On the San Joaquin River, smolt survival for all of the alternatives more than doubles due to construction of the Old River barrier. The high flows at Vernalis combined with the export constraints of 1,500 cfs in Alternatives 1 and 4 cause these alternatives to have the highest predicted smolt survivals on the San Joaquin River. On the Sacramento River, the smolt survival increases are largely driven by the closure of the Delta Cross Channel gates. The model covers the period from April through June, and it predicts increased survival when the Delta Cross Channel gates are closed, as described in Chapter VI. Alternatives 1 through 4 require the gates to be closed throughout this period, and consequently these alternatives have very similar predicted survival indices. Alternative 5 requires the gates to be closed from February 1 through May 20 and for four days a week from May 21 through June 15. The base case assumes that the gates are open throughout the April to June period. Therefore, the base case and Alternative 5 have the lowest smolt survivals.

## D. RATIONALE FOR SELECTION OF PREFERRED ALTERNATIVE

The first step in setting objectives for the aquatic resources of the Bay-Delta Estuary is to develop a scientific understanding of the factors that have contributed to the decline of these resources and are subject to regulation. As discussed in section C of this chapter, all of the alternatives share similar elements, which are based on this scientific understanding. The principal elements consist of: (1) higher outflows in the February through June period for general estuarine protection; (2) higher flows in the San Joaquin River in the spring to improve migratory conditions for chinook salmon, and improve habitat conditions in the south Delta; (3) fixed or variable export constraints to reduce entrainment; and (4) construction and operation of barriers to minimize the movement of eggs, larvae, and smolts towards the export pumps.

The second step in setting objectives is to determine the level of protection that will ensure reasonable protection of the beneficial uses (aquatic resources) and will prevent nuisance. This step requires the SWRCB to consider the competing demands for the available water supply. Unlike objectives for parameters such as toxics, dissolved oxygen, or temperature, factors such as flow and export rates do not have identifiable threshold levels that limit the beneficial uses' viability. Instead, the available information indicates that a continuum of protection exists. (This statement is illustrated by the description of the aquatic resource models in Chapter VI.) Higher flows and lower exports provide greater protection for aquatic resources. Apparently, the maximum level of protection requires unimpaired flow conditions and elimination of exports, although natural conditions are not always optimal for all the species present in the Delta.

In the SWRCB's judgement, the set of objectives in Alternative 5 provides the most reasonable protection for the aquatic resources among the alternatives considered. This alternative includes the elements identified above, and it includes flow requirements and export constraints throughout the year. The SWRCB believes that low flows and entrainment to the export pumps are problems throughout the year.

The following four factors were important elements in the SWRCB's determination that Alternative 5 provides the most reasonable level of protection. First, the urban and agricultural sectors of the State are dependent on water supplies from the Bay-Delta Estuary watershed. Their uses are competing beneficial uses for the water supplies used by the aquatic resources. Second, the SWRCB will periodically review these objectives to determine whether the standards have stabilized and enhanced the condition of aquatic resources, as expected. This review will be based on information obtained through the extensive monitoring program in the Bay-Delta Estuary required by the SWRCB. Third, the objectives in this plan are only one part of the overall program to improve aquatic resource conditions. Substantial improvement will also be provided through implementation of the recommendations in the draft plan and through the long-term planning process for the Bay-Delta Estuary established in the Framework Agreement. Fourth, these standards were developed and agreed to by representatives of the urban, agricultural (principally urban and agricultural water exporters), and environmental communities together with State and federal fishery and water agencies. This agreement was signed on December 15, 1994, and marks a turning point in resolving the contentious issues that have surrounded the establishment of Bay-Delta standards.

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