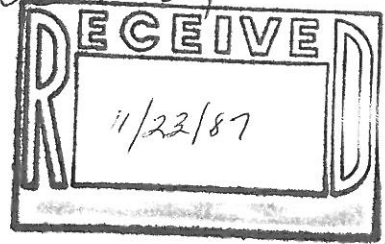C-WIN 5

SUMMARY

THE ROLE OF WATER DIVERSIONS IN THE DECLINE OF FISHERIES OF THE DELTA-SAN FRANCISCO BAY AND OTHER ESTUARIES*

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(with Preface by Joel W. Hedgpeth)

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Conclusions

1. The similarities in the correlations between seasonal and annual regulated Delta outflow for the three species of anadromous fish suggest that a specific range of mean flows during consecutive springs, as well as consecutive years, have both a predictable effect on reproduction, recruitment in stock and catch success, and thereby supports the argument that there are cumulative effects of flow on fish (and perhaps on other species as well) in this and other estuaries.

2. In sum, for all three of the most valuable species of anadromous fish of the San Francisco Bay ecosystem (Chinook salmon, striped bass and American shad), the highest correlations between commercial catch and average spring and annual regulated outflows of the pre-project period of 1915-1943 (characterized by predominant upstream diversion) were obtained for catch of a given year against seasonal and annual regulated Delta outflow averaged for the preceding 3-5 years (RDO_3RDO_5).

3. As a rule, the mean spring RDO of 2.3-3.5 MAF (38,653-58,819 cfs or 1,082-1,665 m^3/sec), which correspond to 64-97% of the normal (unimpaired) spring Delta outflow of 3.6 MAF (for 1921-1978), provided the optimal commercial catch.

Under these conditions the prevailing range of annual averaged regulated Delta outflow was equal to 19-22 MAF (or 70-81% of the normal unimpaired Delta outflow = 27.2 MAF for the period of 1921-1978).

4. The highest correlations between production indices (salmon fall run and SBI), as well as striped bass recreational catch, and averaged spring and annual regulated Delta outflow for

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several consecutive years of the post-project period of 1944-1985 may indicate that the range of 3- and 5-year running mean spring of 2.3-2.5 MAF (38,655-42,014 cfs) was able to maintain relatively tolerant ecological conditions for eggs, larvae and juvenile survival up to 1975. That is, total spring and annual RDO for the 3-5 years preceding the year of catch or index were 6.9-7.5 MAF and 17-19 MAF, respectively. (These ranges of spring and annual $RDO_{3,5}$ correspond to 64-70% and 62-70% of their normals, 3.6 and 27.2 MAF, respectively.)

When the gradual reduction of water supply exceeded these thresholds and reached mean spring and annual regulated volumes of 1.0-1.5 MAF and 11-15 MAF, respectively (or 27-40% and 40-45% of their normals), the signs of deterioration of environment of the riverine-estuarine system and its living resources became obvious.

It seems likely that the average spring water supply for several consecutive years contributes significantly to the adequate ecological conditions for eggs, larvae and juvenile survival. Therefore it is not surprising that these cumulative average regulated Delta outflows (with concomitant influence on nutrient level, salinity, temperature, dissolved oxygen, etc.) affect the overall estuarine environment and, as a result, the reproductive success of fish.

However, the predominant ranges of mean annual and spring water supply to the Bay for the 3- and 5-year periods were 1.5-2.5 times less (annual) and 2.5-3.5 times less (spring) than their normal levels for the last 10-15 years.

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Table 8-1 Regulated Delta outflow and living resources of the river-Delta-San Francisco Bay ecosystem: pre- and post project observed values and recommendations*

Pre-Project Period - Observed Values:

Parameter\Fish

Commercial Catch

	Salmon	Striped Bass	Shad
Total Spring Regulated Delta Outflow (RDO):			
MAF (km^3)	7.5-12.0 (9.2-14.8)	6.9-10.2 (8.5-12.6)	7.5-10.5 (9.2-13.0)
Mean Spring RDO:			
MAF cfs	2.5-4.0 42,014-67,222	2.3-3.4 38,653-57,139	2.5-3.5 42,014-58,819
(km^3) (m^3/sec)	(3.1-4.9) (1,189-1,904)	(2.8-4.2) (1,094-1,618)	(3.1-4.3) (1,189-1,666)
Annual RDO:			
MAF (km^3)	19.0-23.0 (23.4-28.4)	18.0-22.0 (22.2-27.1)	18.0-25.0 (22.2-30.8)

-------------------- All 3 Species --------------------

Total Spring RDO:

    MAF
    (km^3)

            6.9-12.0
            (8.5-14.8)

Mean Spring RDO:

    MAF
    cfs

            2.3-4.0
            38,653-67,222

    (km^3)
    (m^3/sec)

            (2.8-4.9)
            (1,094-1,904)

Annual RDO:

    MAF
    (km^3)

            18.0-25.0
            (22.2-30.8)

Table 8-1 continued

<u>Post-Project Period</u> - <u>Observed Values</u>:

Parameter\Fish

	<u>Salmon Fall Run</u>	<u>Striped Bass Index</u>	<u>Striped Bass</u> <u>Recreational Catch</u>
Total Spring Regulated Delta Outflow (RDO):			
MAF	6.9-8.9	6.0-7.5	6.0-9.0
(km^3)	(8.5-11.0)	(7.4-9.2)	(7.4-11.1)
Mean Spring RDO:			
MAF	2.3-2.8	2.0-2.5	2.0-3.0
cfs	38,653-47,056	33,611-42,014	33,611-50,417
(km^3)	(2.8-3.4)	(2.5-3.1)	(2.5-3.7)
(m^3/sec)	(1,094-1,332)	(952-1,189)	(952-1,428)
Annual RDO:			
MAF	17.0-19.0	18.0-21.0	17.0-21.0
(km^3)	(21.0-23.4)	(22.2-25.9)	(21.0-25.9)

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<u>Recommendations for all 3 species</u>:
<u>Recreational and Limited Commercial Catch</u>

Total Spring RDO:

    MAF   6.9-7.5
    (km^3)   (8.5-9.2)

Mean Spring RDO:

    MAF   2.3-2.5
    cfs   38,653-42,014

    (km^3)   (2.8-3.1)
    (m^3/sec)   (1,094-1,189)

Annual RDO:

    MAF   17-21
    (km^3)   (21.0-25.9)

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* Note:

The recommended total spring RDO for several years prior to migration and spawning of anadromous fish accounts for 63.9-69.4% of the normal spring Delta outflow of 10.8 MAF. The recommended total annual RDO accounts for 62.5-69.8% of the normal annual Delta outflow of 27.2 MAF. In this case, total

Table 8-1 continued

winter RDO of 8.5-9.5 MAF will account for 61.5-68.7% of the normal winter Delta outflow of 13.8 MAF; the total summer-autumn RDO of 1.6-2.0 MAF will account for 62.0-77.5% of the normal summer-autumn Delta outflow of 2.6 MAF.

The monthly redistribution of regulated outflows may differ from the seasonal averages (especially for winter and spring) provided that their volumes are able to maintain optimal balanced water quality conditions for the different water users.

Because, in our investigation, fish landings and indices are indicators of the health of the environment, the 3- and 5-year running mean RDO are assumed to be responsible for providing optimal conditions for:
- Landward migration, spawning and rearing,
- Seaward migration of juvenile fish,
- Physical, chemical and biological parameters of the entrapment zone (including nutrient supply) as well as its ultimate - spatio-temporal dynamics within the Suisun Bay - Carquinez Strait area,
- Adjustment of juvenile to salinity fluctuations in transition zones of the Delta-Suisun Bay subsystem,
- Water quality in the Delta suitable for different water users,
- Flushing intensity necessary to maintain adequate water quality in the esuarine system.

The recommended optimal range of Delta outflow discharges do not preclude the possibility of additional man-regulated releases, provided these releases will not result in the destabilization of the Delta levees (which have adjusted to impaired runoff and sediment load over the last forty years) or in the development of "shock" conditions for eggs, larvae and juvenile fish.

CONVERSIONS:

Cubic feet per second (cfs) x .028317 = cubic meters per second (m^3/sec)

Acre feet x 1.233 x 10^{-6} = cubic kilometers (km^3)