Attachment 2.

TECHNICAL COMMENTS

on

PROPOSED WATER QUALITY STANDARDS FOR THE SAN FRANCISCO BAY/DELTA

prepared by

California Urban Water Agencies
Sacramento, California

March 9, 1994

1. CALIFORNIA URBAN WATER AGENCIES TECHNICAL ANALYSIS OF THE PROPOSED EPA STANDARDS

1. PURPOSE AND SCOPE

California Urban Water Agencies (CUWA) represents California's eleven largest urban water agencies, serving over 20 million consumers and a large majority of the state's economic activity. CUWA is concerned with the decline of aquatic resources in the Sacramento-San Joaquin Bay/Delta and San Francisco Bay ecosystem (hereafter Delta). CUWA strongly supports development of a standard that protects Delta estuarine habitat. CUWA members have in the past supported efforts to address the causes of this decline and will continue to do so in the future. It is from this positive perspective that the CUWA Board submits these comments regarding the U.S. Environmental Protection Agency's (EPA) proposed rule: "Water Quality Standards for Surface Waters of the Sacramento River, San Joaquin River, and San Francisco Bay and Delta of the State of California," dated January 6, 1994 (40 CFR part 131 [OL-FRL-4783-6]).

California Urban Water Agencies has conducted a technical evaluation of the Environmental Protection Agency's proposed water quality standards for the San Francisco Bay/Delta (hereafter Bay/Delta). The objectives of this evaluation were:

a) To explain the proposed standards to the CUWA Board;

b) To investigate the scientific basis for the standards, including analysis of the scientific background to the standard and comparison of this background with the provisions of the standard itself. It was assumed that the science behind the standards was valid unless contradictory evidence was identified;

c) To evaluate the potential biological and water supply impacts associated with implementation of the standards, considering both direct and indirect impacts; and

d) To determine if these proposed standards were an appropriate response to the environmental problems in the Bay/Delta, and, to the extent they are not, to propose alternatives or refinements which would be as effective or more effective at meeting the goal of protecting estuarine habitat in Suisun, Honker, and Grizzly bays (hereafter Suisun Bay).

e) To specifically address the issues raised by the EPA in its Request for Comments.

CUWA assembled a technical team composed of CUWA member agency staff and consultants along with several independent consultants. Working under the general direction of Lyle Hoag, CUWA Executive Director, the team consisted of:

CUWA Staff and Consultants

Dr. Jud Monroe, Project Manager
Dr. Dudley Reiser, R2 Resource Consultants
Dr. Phyllis Fox, Analyst
Dr. John Rice, Statistics, UC Berkeley
Ms. Alison Britton, Analyst
Dr. John List, Consultant
Dr. Wim Kimmerer, Biosystems Analysis
Mr. Ed Conner, R2 Resource Consultants

CUWA Member Agency Staff and Consultants

Mr. Steve Arakawa, Metropolitan Water District
Mr. Randall Neudeck, Metropolitan Water District
Mr. Dan Steiner, Consultant to San Francisco Public Utilities Commission
Mr. Randy Bailey, Consultant to Metropolitan Water District
Dr. Jim Buell, Consultant to Metropolitan Water District
Mr. Jerry Cox, Consultant to Metropolitan Water District
Dr. B.J. Miller, Consultant to Santa Clara Valley Water District
Dr. Thomas Mongan, Consultant to Santa Clara Valley Water District

The San Luis and Delta-Mendota Water Authority cooperated in this technical study, with the following members of their team participating:

Dr. B.J. Miller, Consultant and Project Manager for SLDMWA
Dr. Thomas Mongan, Consultant
Dr. Carl Chen, Systek Engineering
Mr. Dan Nelson, SLDMWA
Mr. Lance Johnson, SLDMWA
Mr. Tom Boardman, SLDMWA
Ms. Francis Mizuno, SLDMWA

CUWA conducted a technical evaluation of the standards and the science behind the standards. Work products of the two organizations were exchanged for review and discussion The evaluation effort was a proactive response to the proposed standards: 1) an effort to understand them, 2) an effort to determine if they are based on the best available science and the most cogent analysis of this science, and 3) an effort to ensure that any standard, whether promulgated by EPA or by the State Water Resources Control Board (SWRCB), would be an appropriate response to the problems identified. The comments which follow, based on the advice of the technical team, are the consensus of the CUWA Board. Neither the work products, the representatives, or the comments of CUWA and SLDMWA should be assumed to represent the views of the other organization.

The comments below address each of the three elements of the proposed EPA standard separately:

- The Estuarine Habitat Criteria
- The Fish Migration and Cold-Water Habitat Criteria
- The Fish Spawning Criteria

These comments are focused on a series of specific issues that which form the basis of a CUWA recommendation regarding each of the three elements of the EPA-proposed standard. For each element, the summary conclusions are presented, followed by a discussion of the key findings which support the conclusion. Findings related to CUWA independent analysis of the data (not to literature review) are cross-referenced to brief appendices which present summary data and analysis in tabular and graphic form which support the findings, based on the technical findings of the technical team. The questions addressed are outlined below and answered, in sequence, in the analysis which follows.

The Estuarine Habitat Standard

1) Is there a sound scientific basis for an estuarine habitat standard with compliance based on measurement of average salinity at various locations in the Suisun Bay?

    a) Has there been a decline in estuarine habitat and aquatic resources?

    b) Is calculated average X2 a valid indicator of estuarine conditions?

2) What is an appropriate standard and how would it function to sustain the ecological health of the estuary?

    a) What physical and hydrologic conditions would implementation of a salinity-based standard create in the estuary and what water resources would be required?

    b) What would be the environmental benefits and impacts to the estuary of creating these physical conditions?

    c) Would these benefits and impacts result in a *net* environmental benefit to the estuary ecosystem?

d) What impacts to other species in the Bay/Delta could be reasonably expected from promulgation and implementation of the standard?

e) What is the probable net impact of implementation on Bay/Delta species?

3) What other actions need to be taken to ensure the health of the Bay/Delta ecosystem?

a) What other factors appear to affect estuarine health?

b) What is the response required to address these factors?

4) What are the potential water supply impacts associated with the proposed standard? How do they differ from those of the CUWA proposed alternative?

The Fish Migration and Cold-Water Habitat Criteria

1) Is there a sound scientific basis for the proposed Fish Migration and Cold-Water Habitat Criteria?

2) What is the appropriate approach to meeting the goals of the Fish Migration and Cold-Water Habitat Criteria?

The Fish Spawning Criteria

1) Is there a sound scientific basis for the Fish Spawning Criteria?

2) What is the appropriate approach to meeting the goals of the Fish Spawning Criteria?

2. THE EPA ESTUARINE HABITAT CRITERIA

2.1 Introduction

The proposed estuarine habitat criteria, involving a requirement for the number of days that the 14-day moving average bottom salinity of 2 ppt must be downstream of three locations in Suisun Bay, is primarily based on an analysis of the relationship of the abundance of 8 indicators of estuarine habitat and the calculated position of the 2-ppt isohaline (hereafter X2, measured in kilometers upstream from the Golden Gate Bridge)). The assumption behind EPA's analysis is that the average position of X2 is an appropriate indicator or index of estuarine habitat because it integrates a number of estuarine properties and processes (EPA Proposed Rule, Section C(1)(b and c). EPA cites Moyle (1992):

> ". . .while the exact mechanisms that account for the importance of having the [entrapment] zone in Suisun Bay (increased food supplies, physical concentration of organisms, association with higher flows, etc.) are being debated, there seems little doubt that many fish species depend on this location [of the entrapment zone] for their long-term survival."

EPA further states:

> "EPA is selecting the 2 ppt isohaline as the basis for its proposed criteria in part because that isohaline incorporates a whole range of factors relevant to the estuary's health, even though the operation of some of these factors is not fully understood."

Jassby (San Francisco Estuary Project (SFEP) 1993) developed a series of abundance vs X2 regression curves (hereafter the X2 series) which indicated that abundance levels increase as the average position of X2 is located further downstream. The motivation for the EPA salinity standard was the statistical relationship between abundance and the calculated average position of X2 for a specified period of time for each indicator. The standard was established for the period from February through June because EPA determined that this was a biologically important period for most of the 8 indicators.

Assuming that X2 is the appropriate regulatory parameter, EPA then established the number of days of required compliance at each of three locations based on an objective of achieving biologic conditions similar to those during the late 1960's and early 1970's.

To understand and evaluate the scientific basis for the proposed estuarine habitat criteria, CUWA first addressed the need for a standard. Second, CUWA evaluated the appropriateness of the proposed standard from the point of view of whether its various provisions would contribute to accomplishment of its stated purpose: to protect "water quality necessary to sustain the ecological health of the estuary." CUWA's conclusions and the findings in support of these conclusions are presented below.

2.2 Conclusions and Findings in Support of Conclusions

2.2.1 Is there a sound scientific basis for an estuarine habitat standard with compliance based on measurement of average salinity at various locations in the Suisun Bay?

First, CUWA review of the scientific basis for the estuarine habitat standard resulted in general concurrence that there has, indeed, been a serious decline in Bay/Delta aquatic resources and that reduction of spring outflow and resulting alteration of estuarine processes is one cause of that decline. To address this issue CUWA both reviewed pertinent literature and obtained the data bases used to develop the abundance indices and evaluated their method of calculation. Not all data bases were readily available to CUWA, and CUWA findings related to this question are primarily based on review of the indices calculated from California Department of Fish and Game (CDF&G) Fall Midwater Trawl surveys, Summer Townet Surveys, and a partial analysis of the CDF&G Bay Study data base.

Second, CUWA concurs with EPA that there is a relationship between the average position of the 2 ppt isohaline (which is a function of freshwater outflow from the Sacramento-San Joaquin rivers) and the processes necessary for a estuarine function. An estuarine habitat standard which provides for additional outflows to Suisun Bay is therefore justified. As EPA notes in its proposed rule, measurement of compliance with such a standard may be accomplished by measurement of salinity, as an indicator of estuarine function. This standard should be a feature of a program for recovery of the Bay/Delta ecosystem. However, CUWA believes that some of the relationships between the location of the X2 and estuarine functioning are more complicated and less certain than those proposed by the San Francisco Estuary Project (SFEP) and used as the basis for the EPA proposed rule. The uncertainties in the relationship between X2 and indicators of estuarine conditions are greatest for calculated average locations of X2 downstream of Chipps Island. The basis for these conclusions is outlined below.

A preponderance of the literature indicates that native aquatic resources of the Bay/Delta ecosystem, including anadromous species which traverse the Bay/Delta, have experienced declines in abundance or changes in distribution.

A. The March 1992 SFEP "Status and Trends Report on Aquatic Resources in the San Francisco Estuary" documents: 1) changes in the abundance and composition of primary producer communities; 2) long-term declines in some zooplankton such as *Eurytemora affinis* in San Pablo and Suisun Bays; 3) changes in abundance and community composition of benthic organisms; 4) significant declines in chinook salmon runs; 5) a continuous decline in striped bass populations; 6) a probable decline in sturgeon populations; 7) a general decline of planktivorous fishes in Suisun Bay and the Delta; 8) declines in numerous native fish species; 9) increases in populations of exotic species such as the chameleon goby and the Asian clam.

B. The SFEP "Status and Trends Report on Aquatic Resources in the San Francisco Estuary" further documents many fluctuations in the relative abundance of various species at all trophic levels, and suggests that 1) there is significant variation in the ecosystem and 2) there may be long-term changes in the ecosystem.

C. Similar findings by California Department of Fish and game (CDF&G), United States Fish and Wildlife Service (USF&WS), National Marine Fisheries Service (NMFS), and other resource agencies suggest that there have been significant changes in the Bay/Delta ecosystem's communities, and that some of these changes involve declines in native species.

D. CUWA (Appendix 1) recalculated several of the abundance vs X2 relationships used by EPA as a biological basis for the standard for several species, correcting for a number of statistical problems in the original calculations. CUWA determined that there is a significant relationship between the calculated average location of X2 during the proposed regulatory period and subsequent increases in many of the indicators of estuarine health used by EPA. Based on CUWA's adjustments, this relationship is not as strong as reported by EPA, and the statistics indicate that the calculated average location of X2 downstream of Chipps Island explains much less of the variability in the indices of estuarine health than suggested in previous work. Nevertheless, this analysis supports a general conclusion that there has been a continuing decline in Bay/Delta estuarine resources.

The relationships between estuarine conditions and X2 are more complicated and less certain than those proposed by the SFEP and used as the basis for the EPA proposed rule. As the calculated average location of X2 moves downstream from Chipps Island, uncertainties in the relationship increase. When outflows are higher, and the average X2 is therefore pushed to the western end of Suisun Bay, CUWA found that the uncertainty in the X2 vs abundance relationships increased dramatically, and the location of X2 explains less of the variability in the data. The basis for this conclusion is outlined in detail below.

A. The X2 vs abundance relationship is reliable for low outflow conditions.

When outflow is consistently low, and therefore the average location of X2 is consistently upstream of the confluence of the Sacramento and San Joaquin rivers, the relationships between X2 and abundance are reliable. The prediction of low abundance under low outflow conditions (or when X2 is above the confluence) is also substantiated by the X2 series as corrected by CUWA (Appendix 1).

CUWA (Appendix 2) found that measures of estuarine primary productivity such as concentration of particulate organic carbon (POC) increase with outflow, and that these measures are positively correlated with various indices of estuarine health. Specifically, when outflows are low and the average calculated position of X2 is above Chipps Island, the index of riverine POC is low. To the extent that riverine POC increases as a result of overland runoff, and therefore with outflow, the position of X2 (which is related to outflow) may therefore be an indicator of the condition of the base of the food chain in the estuary

B. Nevertheless, there is significant uncertainty in the abundance indices themselves (Appendix 4). CUWA found a *systematic* bias evident in the sampling upon which the abundance indices are based, in that the sampling effort may not sample the entire population of each species. However, it is not possible to correct for these potential problems and not possible to address the influence of this bias on the X2 series. CUWA notes, however, that the potential for sampling problems to influence the data, and therefore the abundance indices, increases the level of uncertainty regarding their usefulness as predictors of estuarine conditions.

CUWA re-calculated several of the abundance indices (primarily from Fall Midwater Trawl Data) to correct for potential biases in abundance indices recently identified by CDF&G and calculation problems such as those recently identified by Jassby, *et. al* (1994). Based on these corrected X2 series relationships (Appendix 1), CUWA concurs with Jassby *et.al.* (1994) that the abundance vs X2 relationships are less certain and less robust than indicated in the preliminary analysis done by SFEP. The average location of X2 therefore explains substantially less of the variation in abundance than postulated by SFEP. This suggests that 1) other factors have constrained the ecosystem health and 2) these other factors are more important than suggested by the preliminary SFEP analysis. Specific findings related to the uncertainties identified in the calculation of abundance indices themselves were:

1) The data from the Fall Midwater Trawl (FMWT) show some sampling biases (Appendix 4) which could potentially distort or confound the abundance indices, but (1) not all potential biases were investigated (including turbidity, tidal phase, and tidal velocity) and (2) the biases identified and evaluated by CUWA were not generally found to invalidate year-to-year trends in young-of-year calculated abundance and the relationships of the X2 series.

2) CUWA found considerable temporal and spatial variability in the data used to derive annual abundance indices for the species used to support the X2 standard. Therefore, there is a degree of uncertainty regarding how well the abundance indices reflect actual species populations. This level of uncertainty increases for species with moderate but widely dispersed populations including delta smelt, and (especially) Sacramento splittail.

3) CUWA found several sources of sampling bias for delta smelt, including time of sampling during the day, time of sampling during the year, depth, turbidity, and population dispersion. These biases appear to be strongest in drought years. These sources of bias may lead to population underestimation or overestimation, depending on conditions.

4) As an example of sampling bias, CUWA found that sampling results for delta smelt were influenced by the time of day when sampling occurs. Based on the analysis of this influence, delta smelt populations may be underestimated during a portion of the recent drought (1989-1990) due to decreasing catch efficiency related to time of day of sampling during drought conditions.

5) CUWA notes that there was obvious variation in delta smelt catch for a given salinity, suggesting there is a wide range of tolerance for the calculated location of X2.

6) CUWA also found that abundance indices for many species, including *Crangon franciscorum* (bay shrimp), delta smelt, longfin smelt, and starry flounder decrease when populations attain a wider spatial distribution, possibly reflecting movement of the fish out of the FMWT study area (for example, longfin smelt migrating into the central bay). This is indirect evidence that there may be sampling differences in the FMWT and Bay Study surveys and that the abundance indices may be influenced by distribution.

7) Certain species, notably Sacramento splittail, are so rare in the surveys that few conclusions can be reached regarding their relationship to salinity or the calculated position of X2.

8) Based on evaluation of species distribution in the FMWT catch, most of the species sampled in the FMWT are distributed over a wide range of salinity conditions both above and below the calculated X2 position.

9) CUWA notes that the FMWT abundance indices used by SFEP (Jassby 1993) to determine the relationship between X2 and indicators of estuarine condition have recently been corrected by CDF&G.

C. The methods used to calculate some of the indices and to relate them to average location of X2 lead to significant uncertainty about the predictive ability of the X2 series for values of X2 downstream of Chipps Island.

Regarding the methods used to calculate abundance indices themselves, and the calculation of X2 series relationships, CUWA found that, abundance index issues aside, Jassby's (SFEP 1993) analysis of the X2 series contained no obvious computational errors, but there were a number of other mathematical problems related to the calculated relationship of the X2 to abundance indicators of estuarine condition).

1) First, the biologically critical period used in the X2 series does not correspond to the proposed regulatory period.

2) Second, as noted above, CDF&G has discovered and since corrected an error in the FMWT indices that Jassby (SFEP 1993) used.

3) Third, SFEP (Jassby 1993) omitted 1967 and 1983 in their analyses. CUWA reanalyzed the X2 series with these two years added and found that including these two years in the analysis did not have the result anticipated by SFEP.

4) Fourth, SFEP (Jassby 1993) assumed the variance was constant for striped bass and was proportional to the mean for longfin smelt.

5) Fifth, SFEP (Jassby 1993) did not report a calculated uncertainty associated with the fitted equations.

6) Finally, SFEP used the total index for FMWT indicators, which, if abundance indices are used as measures of real population and trends in a population as they are in the X2 series, may alter the strength predicted increase in abundance achieved for a given X2 location.

7) Jassby *et. al.* (1994) indicate that, when they addressed the issue of other factors which may be influencing abundance, the uncertainty in the X2 regressions increased. They concluded that "the presence of unexplained variation is one signal that an existing model can lead to unacceptably biased management policies, and should result in a search for alternate and additional models."

D. Re-calculating the average indices, correcting for various calculation problems, and calculating in a manner more consistent with that used by the Bay Study, suggests that changes in abundance may be less dramatic than have previously been reported (Appendix 1). The analysis suggests that longfin smelt populations have not declined, and splittail populations may have increased. Further, delta smelt and striped bass populations may have declined at a lower rate than had previously been reported.

1) CUWA found that when the revised average indices for longfin smelt and striped bass are regressed against the location of X2, using Jassby's methods including the first five adjustments mentioned above, the percent of variability in abundance index explained by the location of X2 was significantly smaller than originally calculated by SFEP (Jassby 1993):

Species	Squared Correlation Coefficient (r^2)	
	SFEP	CUWA
Striped Bass	0.71	0.50
Longfin smelt (1)	0.74	0.27

2) CUWA (Appendix 5) found that the reported relationship between delta smelt abundance and the number of days that X2 is in Suisun Bay from February to June is not statistically valid because it fails to account for the nonuniform variance in the data. When this variance is corrected, the relationship is no longer statistically significant and X2 accounts for very little of the variability in abundance: the squared correlation coefficient for the X2 vs delta smelt abundance index relationship is only 0.13.

E. CUWA examined the abundance data to determine whether a non-continuous function could be fitted to the data. Although there are statistically significant differences in mean abundance and variability upstream and downstream of roughly 68-80 km, CUWA could not fit a discontinuous function to the data. However, there are biological reasons to indicate that there may be a discontinuity in the data, discussed in later comments.

F. CUWA found a positive relationship between salvage of Sacramento splittail at the SWP and CVP facilities and the abundance index for this species, suggesting that salvage may be a good indicator of splittail abundance within the Delta.

When outflow is 8,000 to 15,000 cfs, which places the calculated average location of X2 near Chipps Island, the X2 series shows that abundance increases. Although there is less certainty in the relationships between X2 and various indicators of estuarine condition, the uncertainties are not large (Appendix 1) for this reach of the estuary. CUWA performed a number of other analyses which suggest that estuarine processes in Suisun Bay are enhanced by outflows of this magnitude. CUWA found that habitat of a majority of estuarine species is greatest under these flow conditions.

The benefits of locating X2 at or near Chipps Island include: 1) placement of the 2 ppt to 10 ppt brackish water zone in the Suisun Bay region, 2) placement of the turbidity maxima in Suisun Bay, 3) helping to ensure transport of eggs, larvae, and nutrients into the shallow-water areas of Suisun Bay, 4) allowing for mixing of freshwater and saltwater in the estuary and dispersal of eggs, larvae, and nutrients, 5) reducing predation and competition which is affected by the density of fish, and 6) promotion of increased phytoplankton and zooplankton production by increasing the residence time of nutrients in the shallow-water estuary.

This finding is consistent with the preponderance of the scientific literature cited by EPA in the references to its proposed rule.

A. CUWA analysis of riverine productivity (Appendix 2) indicates that indicators of primary productivity increase when the calculated average location of X2 is near river kilometer 72, just downstream of Chipps Island. However, the supposition that primary productivity, the base of the food web, is *controlled* by the location of X2 is unfounded. Primary productivity in Suisun Bay, as represented by the POC series, is primarily influenced by upstream factors as represented by Delta outflow, not X2 (Appendix 3). Locally-derived POC declines marginally as flows increase and X2 moves downstream.

In short, riverine sources of organic carbon and other nutrients are the most important factor in establishing the base of the food chain. The origin of POC in riverine flows is related to unregulated flows over the watershed. To the extent that outflow and the location of X2 are indicators of these unregulated inflows carrying nutrients from the watershed not controlled by reservoirs, the location of X2, which is clearly related to such flow, may be a reasonable measure of riverine productivity input to the Suisun Bay.

B. A review of the literature upon which the SFEP based its conclusions indicates a preponderance of opinion that processes such as mixing of fresh and salt water; transport and distribution of eggs, larvae, and juveniles; transport and distribution of food supplies; and other processes necessary for estuarine function should be located in Suisun Bays, not in the narrow confines of main channels (Sacramento River, San Joaquin River, and Carquinez Strait). Maintaining this "entrapment zone" in Suisun Bay enhances the opportunity for shallow water euryhaline species to thrive, although the mechanisms which account for this are not fully understood.

C. CUWA, in its review of literature cited in the SFEP report, notes that Fullerton (1991) concluded that placement of the entrapment zone in Suisun Bay increases the residence time of phytoplankton in this favorable habitat. Fullerton indicates that this requires minimum flows, but that high flows decrease residence time and push phytoplankton out of Suisun Bay. Fullerton notes that the conjunction of the entrapment zone with the shoals of Suisun Bay is the dominant factor leading to high productivity of Suisun Bay.

D. Given that X2 correlates well with these estuarine processes (SFEP 1993), then X2 is a reasonable indicator of estuarine condition at low and moderate outflows.

However, when outflows are high enough to locate the average X2 at to the western end of Suisun Bay, CUWA found that the uncertainty in the X2 series increased dramatically, and the location of X2 explains less of the variability in the data.

A. CUWA (Appendix 1) found that the variance in abundance indices for some species increases exponentially as the index increases. This suggests that high indices are less reliable predictors of actual abundance than low indices.

B. CUWA (Appendix 1) found that the uncertainty in predicted abundance indices based on FMWT data increases significantly for values of X2 less than 70-75. Given that other factors are eliminated from consideration, this suggests that predictions of abundance indices may be reliably made from X2 for average locations of X2 upstream of Chipps Island, but that the predictive value of X2 declines rapidly when X2 is located downstream of Chipps Island.

C. Comparing the abundance indices vs X2 for Chipps Island and Roe Island, CUWA (Appendix 6) found that the amount of variability in abundance explained by X2 increases with downstream movement of X2 for some indicators (*Crangon franciscorum*, striped bass, starry flounder, and longfin smelt) but decreases for other indicators (*Neomysis mercedes*, POC, striped bass survival, and Sacramento splittail). Both the r^2 values and the upstream and downstream slopes of the regressions are statistically equal, except for longfin, suggesting that these species gain no benefit from locating X2 at Roe Island. In an additional comparison, there was no significant difference in variability for delta smelt. This suggests that X2 becomes a less reliable predictor of overall estuarine habitat conditions at the high outflows needed to place X2 at or downstream of Roe Island than for the moderate outflows needed to place X2 downstream of Chipps Island.

D. Comparing abundance indices of other estuarine species to the location of X2 (Appendix 5) also suggests that X2 does not universally predict abundance. No statistically significant model relating abundance indices and X2 could be fitted for delta smelt, threadfin shad, topsmelt, white croaker, and white sturgeon, suggesting that other factors control the abundance of these fish. X2 thus predicts less than 45% of the variance in abundance for chinook salmon ($r^2 = 0.36$), inland silversides ($r^2 = 0.16$), northern anchovy ($r^2 = 0.43$), and Pacific herring ($r^2 = 0.27$). For topsmelt and threadfin shad, the relationship between X2 and abundance appears to be negative; that is, downstream location of X2 is associated with a decline in abundance index.

The increasing uncertainty in the X2 series as the average location of X2 moves downstream of Chipps Island does *not* argue against use of salinity as an indicator of estuarine condition. Rather, it suggests 1) that the proposed standard should be based on those portions of the X2 series for which there is reasonable predictive certainty and 2) that the mechanisms potentially responsible for estuarine conditions need to be explored in order to determine the appropriate standard. In short, the X2 series is probably valid for a certain range of conditions. It is necessary to understand those conditions in order to develop an appropriate standard to protect beneficial uses in the Suisun Bay.

2.2.2 <u>What is the appropriate standard and how would it function to sustain the ecological health of the estuary?</u>

It is CUWA's view that there is a relationship between the location of X2, outflow, estuarine processes, and abundance of estuarine species and that this relationship varies with the location of X2.

The physical and biological mechanisms responsible for the X2 vs abundance relationships, and for the variation in this relationship, would appear to be related to transport; nutrient residence time in shallow-water habitat; mixing phenomena; reduced predation related to turbidity and other factors; dispersal of eggs, larvae and nutrients into shallow-water habitat; the presence of brackish water in the estuary; and within-year variability in conditions. The evidence for this conclusion is summarized below.

A. Transport of eggs and larvae out of the inhospitable river/delta channel complex into the Honker, Suisun, and Grizzly bays complex appears to be important to estuarine function. The evidence supporting this is:

1) Kimmerer, in a summary of 20 years of research (IESP Report 33, September 1992), suggests that transport of eggs and larvae downstream from spawning areas to the entrapment zone is necessary for striped bass.

2) USF&WS Designation of Critical Habitat for delta smelt concludes that flows are necessary to transport larval and juvenile fish downstream to rearing habitat in Suisun Bay.

3) In the USF&WS Delta Smelt Biological Opinion, during the spawning and rearing interval, from February 1 to June 30, adequate outflows of sufficient magnitude are necessary. These flows provide transport away from the CVP/SWP pumps, but also provide the necessary habitat rearing areas within Suisun Bay and Marsh. The entrapment zone needs to be downstream of the confluence.

4) Under current average water year conditions, survival is enhanced when eggs and larvae are transported out of the Delta, away from areas of entrainment in the Delta, downstream to nursery areas (IESP Annual Report, 1991).

5) Based on our statistical analysis of abundance vs X2 (Appendix 6), it appears that abundance of some species increases when outflows are adequate to move the entrapment zone out of the confluence and into Suisun Bay, but do not obtain significant benefit from a movement of X2 further downstream. For these species, transport beyond the confluence would appear to be important to egg and larval survival and subsequent recruitment.

   * Larval striped bass are most numerous in the western Delta and Suisun Bay (CDF&G 1985).

   * Moyle (1992) suggests that maintenance of net seaward flows in the lower San Joaquin River during the period when delta smelt larvae are present is related to maintenance of delta smelt populations.

B. Transport of nutrients, and nutrient residence time in the estuary appears to be important to estuarine function. The evidence supporting this is:

1) Both the 1990 and 1991 IESP Annual Reports discuss the importance of transport of nutrients and particulates into Suisun Bay, and residence time of nutrients in shallow-water estuary habitat.

2) In the Status and Trends Report on Aquatic Resources (SFEP 1992), Jassby states that the position of the entrapment zone relative to large expanses of shoal areas was the most critical factor regulating accumulation of phytoplankton in the zone.

3) In his "Synopsis of Evidence Presented to the State Water Resources Control Board in the Bay Delta Hearings on the Functioning and Benefits of the Entrapment Zone," Fullerton (1991) concurs that outflows necessary to place the entrapment zone in Suisun Bay increases the concentration of phytoplankton.

4) Abundance of entrapment zone species are highest at the location of highest concentration of chlorophyll.

5) High flows bring higher inflows of phytoplankton and nutrients to shallow-water habitat.

6) The U.S.G.S. two-dimensional model suggests that brackish-water habitat in Suisun Bay has a relatively long residence time under moderate flow conditions, due to tidal trapping in Grizzly Bay and Suisun Bay. Under higher flow conditions, nutrients, eggs, and larvae are transported out of the system into Carquinez Strait and San Pablo Bay.

7) In the Status and Trends Report (SFEP 1992), Moyle *et.al.* conclude that moderate flow levels are necessary to maximize biological productivity and that they increase the residence time and concentration of POC and the concentration of nutrients.

8) The SFEP 1992 Status and Trends Report indicates that riverine loading is the dominant source of organic carbon in Suisun Bay. Because reservoir releases are not nutrient-rich, overland runoff is probably the primary source of organic carbon.

9) Turner and Chadwick (1972) note that nutrients in the estuary increase with flow; CUWA notes that this may be a function of unregulated flows which bring nutrients from runoff, rather than reservoir releases.

10) Concentrations of chlorophyll are highest in the entrapment zone, for all outflows. Placement of the entrapment zone adjacent to shallow-water habitat therefore provides nutrients in this zone.

C. Mixing of salt and freshwater in the estuary, resulting in dispersal of nutrients, eggs, and larvae to shallow-water habitat is important to estuarine function. The evidence in support of this is:

1) Kimmerer (IESP Technical Report 33, 1992) states that the combined energy of tidal and stream flows is balanced at some intermediate point. This balance results in settlement of particles during slack water, and subsequent resuspension during tidal flows causing a turbidity maximum near the area of minimum kinetic energy. This area should be adjacent to the shallow-water habitat of the estuary.

2) The bathymetry of the SF Bay/Delta estuary is complex, and therefore circulation is complex (Kimmerer, 1991). In Suisun Bay, the topography interacts with tidal flows to produce a net counter clockwise flow that is strongest during the tides of the spring. This results in lateral dispersion. This counter clockwise circulation depends on a balance of outflow and tide. Very high outflows diminish the tidal influence. In addition, high outflows increase surface velocity and carry nutrients, eggs, and larvae of some species out of the estuary and out of the influence of this tidal circulation (except striped bass, where eggs are on the bottom).

3) According to Stevens (1985), when buoyant larvae of delta smelt and other estuarine fish species are carried by downstream flows into the upper end of the mixing zone of the estuary, the mixing currents at the upper end of the mixing zone keep larvae circulating with abundant zooplankton also found in this area.

4) Adult delta smelt are most abundant in low-salinity water associated with the mixing zone in the estuary, except when they are spawning. When the mixing zone is in Suisun Bay, a majority of fish are captured in shallow-water habitat, and there is more of this habitat available when the mixing zone is in Suisun Bay.

D. Reduced predation on juveniles and reduced competition due to more available habitat (dispersal) and more cover (turbid conditions) are important to estuarine function. The evidence in support of this is:

1) The preponderance of scientific evidence suggests that there is reduced predation when turbidity is higher.

2) Based on CUWA analysis of turbidity data (Appendix 7), there is maximum turbidity in Suisun Bay when outflows are from 10,000 to 20,000 cfs (CUWA). This is consistent with Arthur and Ball (1979), who found that flows of 9,000 to 13,000 cfs are required to maximize turbidity in Suisun Bay.

3) Midwater trawl catches are greater when turbidity is high; if the fish cannot see the net, then predators cannot see prey.

4) According to Stevens and Miller (1985), dispersal of young increases with increasing flow, which probably results in lower density-dependent mortality.

E. The presence of brackish water in the estuary is important. Evidence in support of this is:

1) In a recent Interagency Ecological Studies Program Newsletter, Herbold (1993) and the U.S. F&WS (Biological Opinion) show that delta smelt abundance is greatest when X2 is adjacent to Suisun Bay (not at the confluence or downstream in Carquinez Strait).

2) U.S. F&WS (1993) indicates that Sacramento splittail do best when X2 is located adjacent to Suisun Bay.

3) CUWA's analysis of the data suggests that adults of some species have preferences for brackish water; available habitat for these species may be greatest when the 2 ppt to 10 ppt zone is in Suisun Bay (Appendix 8).

F. Year-to-year, and within-year variation in outflow patterns. Evidence that variation in outflow patterns is important. Evidence in support of this includes:

1) CUWA analysis of abundance indices which shows that conditions which benefit one species may not benefit another (lack of coabundance, Appendix 9).

2) CUWA analysis of abundance of species other than those which were used to justify the proposed EPA rule that indicates that the habitat of 14 species (based on salinity preferences) may be reduced when the average calculated position of X2 is at or downstream of Roe Island (Appendix 8).

CUWA believes that the functions of 1) transport, 2) nutrient residence time in shallow-water habitat, 3) mixing phenomena, 4) reduced predation related to turbidity and dispersal, 5) the presence of brackish water in the estuary, and 6) within-year variability in conditions tend to be generally most favorable for the full range of aquatic biota in Suisun Bay when the upstream boundary of the 2 ppt to 10 ppt zone is, on average, located at or near Chipps Island during the proposed regulatory period. This is an appropriate basis for management provided that this condition is not imposed on a consistent basis from year-to-year; too much consistency in estuarine conditions, in an estuary which has historically had widely varying year-to-year conditions, could favor one suite of species over another. The exception to this caveat is that flows adequate to provide transport of eggs, larvae, and nutrients would appear to be required relatively more consistently to ensure that they are transported through the Delta and beyond the confluence. The evidence in support of this conclusion is outlined below.

A. It is clear that consistently low outflows do not deliver high volumes of nutrient rich flow to the estuary. Also the apparent decline in concentrations of locally-derived POC

(Appendix 3) as X2 moves downstream suggests that high outflows from reservoir releases (and therefore not carrying nutrients from unregulated watershed areas) may decrease nutrient residence time in the estuary by flushing locally-derived nutrients without supplying riverine-derived nutrients. Consistently high or low outflows might therefore have an adverse impact on nutrient loading in the estuary.

B. CUWA (Appendix 10) evaluated patterns of historic hydrology. From Appendix 10, it is clear that there is increasing year-to-year variation in the number of days that X2 is maintained at a given location during the proposed regulatory period (from February through June) as X2 is located further downstream. That is, X2 has historically been at or downstream of the confluence for extended periods of time during the regulatory period, except in drought conditions; from 1930 to 1992, X2 was at or downstream of the confluence more than 120 days during February through June in 52 out of 63 years. There is less consistency in year-to-year X2 location at Chipps Island (40 out of 63 years), and even less at Roe Island (17 out of 63 years). This trend is evident in pre-CVP and pre-SWP periods.

C. CUWA (Appendix 10) found that implementation of the standard, as proposed or as modified by EPA's proposed sliding scale, would result in a significantly greater number of days of average location of X2 at the given compliance points for a given water year type than would have occurred either during the EPA target period of 1968-1975 or during the period of record from 1968 to 1992.

D. Based on an analysis of habitat availability considerations as a function of salinity, CUWA evaluated the habitat preferences of 41 species, compared them to changing locations of X2, and found that total number of species with potential habitat impacts (either positive or negative) related to position of X2 was greatest when the calculated X2 would be at Roe Island as opposed to Chipps Island or the confluence (Appendix 8). Maintaining variation in habitat in downstream reaches of the estuary would therefore appear to be important to a variety of species.

Therefore, to address the need for transport and to place key estuarine processes in the Suisun Bay, CUWA recommends a "Suisun Estuary Standard" that provides for outflow which will place the brackish water zone (2 ppt to 10 ppt) downstream of the Confluence and Chipps Island for a specified number of days during the period from February through June, the number of days to be determined as follows:

- The Sacramento River Index for the period February through June will be updated at least monthly, or more frequently if desirable.

- For a given Sacramento River Index, the number of days of compliance at the Confluence and Chipps Island would be determined based on a weighted least squares regression of the hydrology during the period 1968-1975, a period for which salinity data are available. Extending the period to include the extreme events (such as flood alternating with drought from 1976 through 1992) is unnecessary because it does not appear to significantly alter the results of the 1968-1975 regression.

- The number of days of compliance at each point would be adjusted at each re-calculation of the Sacramento River Index, but would not exceed the number of days remaining in the February through June regulatory period. This approach is preferred because it will best reflect hydrology during the regulatory period, while other indices take into account other factors which may be unrelated to accomplishing the goal of providing transport and brackish water habitat during the critical winter-spring period.

- Compliance would be based on achieving any one of the following requirements at the compliance point: 1) average daily salinity of 2 ppt at the compliance point, or 2) 14-day average salinity at the compliance point, or 3) maintenance of an outflow calculated to maintain average X2 at a steady state condition. This will prevent short-term extreme wind or tide events from causing non-compliance, as long as the required outflow is provided.

CUWA does not recommend a Roe Island Standard because 1) the uncertainty in the relationships between X2 and indicators of estuarine increases significantly downstream of Chipps Island, suggesting that there are uncertain benefits from the standard and 2) there are potential adverse environmental impacts associated with the standard. The evidence for this conclusion is outlined below.

A. DWR has found that implementation of the standard could have significant impacts on carryover storage in the Sacramento River Basin. The Roe standard would account for a large portion of the loss of carryover storage. Of particular concern is the impact of the standard on carryover storage needed to ensure low-temperature releases to the upper Sacramento River for winter-run chinook salmon. Endangered Species Act consultation documents have not been available to address this issue. CUWA's analysis indicated that the incremental requirements of the Roe standard, as proposed by EPA, would be 800 thousand acre-feet (TAF) in wet years, 500 TAF in above normal and below-normal years, and 200 TAF in dry years; this water supply impact would probably affect carryover storage.

B. CUWA (Appendix 10) noted that the historical record shows only a few (very wet) years (such as 1969 and 1983) when there were sustained high outflows; the hydrologic record more frequently shows high variation in outflow, particularly following March. The result of implementation of the Roe Island portions of estuarine habitat criteria, as proposed, may reduce somewhat the within-year variability in hydrology in Suisun Bay which may have an impact on the biology of the estuary.

C. CUWA's coabundance analysis (Appendix 9) suggests that conditions which benefit some species do not benefit others. CUWA analyzed the relationship between abundance of several key estuarine species and found that when delta smelt and Sacramento splittail have high abundances, they do not occur in the same year; that is, when delta smelt abundance is high, splittail abundance tends to be low and vice versa. This lack of coabundance further suggests that conditions which favor one species may not favor the other. This analysis suggests that conditions which benefit Neomysis also benefit Crangon franciscorum but do not benefit longfin smelt, Sacramento splittail, and striped bass.

D. CUWA further found that several species not evaluated by EPA showed declines in abundance indices in response to increased outflow (and therefore to location of X2 further downstream from the confluence), including inland silversides and threadfin shad, while several other species showed virtually no response to the location of X2 (white sturgeon, white croaker, delta smelt and topsmelt).

E. As noted above, CUWA believes that analysis of habitat change is an effective approach for evaluation of potential impacts. Based on an analysis of habitat considerations and an analysis of all life history stages, CUWA (Appendix 8) found that the habitat of a number of species may be reduced when X2 is located at or downstream of Roe Island. Fourteen species were identified which could be adversely affected at one life history stage or another, due to changes in habitat. For delta smelt, the amount of habitat gained from a Roe Island standard is minimal. Based on an analysis of habitat requirements, CUWA (Appendix 8) found that the species which most benefit from extending X2 downstream from the confluence to Roe Island are the Sacramento splittail, inland silverside, and threadfin shad, even though the abundance indices for threadfin shad suggest otherwise. The inconsistency between the result of a habitat-based analysis and the X2 vs abundance based analysis suggests that the relationships may not have high predictive certainty.

F. CUWA further notes that EPA will close its comment period on the proposed regulations prior to publication of the results of its Section 7 Consultation with the U.S. F&WS regarding the potential for impacts to threatened and endangered species. It is difficult to evaluate the net environmental benefit of the proposed standards without the results of this consultation. Species which could be adversely impacted by changes in salinity, and therefore changes in marsh habitat, include Suisun song sparrow, Delta tule pea, black rail, clapper rail, and soft-haired bird's beak. However, a Confluence/Chipps Island standard would not have as much potential for adverse impacts to tidal marsh habitat.

Based on these considerations, CUWA believes its proposed Suisun Estuary Standard would have significant benefits, without the uncertainties and potential risks associated with a Roe Island standard. Implementation of a standard which benefits habitat in Suisun Bay would protect the beneficial uses of the estuary, by maximizing suitable habitat in the Suisun Bay. The proposed standard is an ecologically safe standard; it meets the needs of the estuary without extending management beyond the limits of our confidence in the data and data relationships. Finally, there will be lower water costs associated with the proposed approach.

2.2.3 What other actions need to be taken to protect the beneficial uses of the Bay/Delta ecosystem?

As corrected, the X2 series indicates that the location of X2 accounts for less of the variability in estuarine conditions than initially postulated by SFEP and EPA, suggesting that other factors may be more important to protecting beneficial uses of estuarine habitat in Suisun Bay and its aquatic, wetland, and upland species than initially thought by EPA and others. CUWA believes that there is substantial evidence that other factors must be addressed, concurrent with promulgation and implementation of an estuarine habitat standard, to ensure that these resources have an opportunity to recover.

CUWA is particularly concerned that adverse impacts caused by other factors could offset or mask the beneficial effects of its proposed Suisun Estuary Standard. If, for example, the Asian clam alters the basic food chain significantly, species abundance may be affected in spite of our best efforts to provide for better estuarine habitat conditions. Other factors, such as changes in pesticide and herbicide use, could have similar effects.

The literature cited by EPA in support of the proposed standard identifies some other factors which may have an influence on estuarine habitat and on the abundance and distribution of species in the Bay Delta. Monroe and Kelly (1992) noted that the Estuary Project recognized that no single factor was controlling existing populations of aquatic biota or was singly responsible for apparent declines in historic populations. The SFEP participants identified five broad issues which they believed the program should address:

1) Intensified land use
2) Decline in biological resources
3) Freshwater diversion and altered flow regimes
4) Increased pollutants
5) Increased dredging and waterways modification

The EPA Draft Proposed Standard addresses only one of these potential causative factors.

While CUWA concurs that water diversions and altered flow regimes have an impact on the aquatic biota of the Bay/Delta, it is useful to examine the *relative* impact of this factor, with respect to other potential causative factors, as a basis for evaluating the relative benefits and costs of the proposed standard. Given the potential water supply impacts of the proposed standard, justification of the standard is based on the premise that its implementation will make a substantial contribution to halting the decline of Bay/Delta aquatic resources. To the extent that this is true, then the water supply impacts of the standard may be justified.

CUWA reviewed the pertinent literature to identify factors which had been identified as having a potential impact on Bay/Delta resources. CUWA supplemented this review with an analysis of the potential impacts of several factors identified as potential causes of aquatic biota declines.

A. CUWA identified a number of categories of factors which may be to some extent responsible for the observed decline in Bay/Delta aquatic biota:

The introduction of exotic species
Alterations to the food chain
Long-term and continuing dam and upstream water development
Land development and loss of physical habitat
Pollution (pesticides, herbicides, metals)
Reductions in BOD and nutrient loading
Entrainment/impingement into diversion systems
Fishing and direct resource exploitation
Exports and water development in the Delta

B. CUWA notes that cumulative impacts from mining, loss of 90-95% percent of Central Valley wetlands and estuarine habitat, alteration of hydrologic regimes, exotic species introductions, loss of spawning habitat, resource exploitation, introduction of pesticides and other pollutants, and other factors have subjected the Bay/Delta to constant and significant changes which collectively impact the aquatic ecosystem.

C. CUWA notes that the period of documented decline in Bay/Delta aquatic resources corresponds to a period of extreme hydrology (two severe droughts and four severe flood years). Depending on particular habitat affinities, these conditions would be expected to have variable impacts to fish and invertebrate populations, absent all other developments.

D. CUWA notes that drought periods may have affected migration patterns for anadromous fish; reduced egg and larval survival; increased the concentration of toxics; increased the abundance of filter feeding organisms with high salinity tolerance, such as the exotic Asian clam which crops the food base at a high rate; decreased the influx of food to the Delta; increased fish vulnerability to parasites and diseases, by increasing stress; elevated water temperatures; increased vulnerability of some species to predation; and decreased phytoplankton blooms, because exotics favored by drought conditions filtered a greater percentage of the water column.

E. CUWA notes that wetland and habitat degradation are cited (Meiorin et. al. 1992) as the major reasons for the decline of the delta smelt and Sacramento splittail and the extinction of the thicktail chub and Sacramento perch.

F. CUWA (citing Moyle and others) notes that 27 species of fish have been introduced since the 1840's, with several significant introductions occurring during the period of decline defined by the EPA (1976-1991), including: the Asian clam (which may alter nutrient availability significantly), the inland silversides (which may compete with delta smelt), the chameleon goby (which may compete for habitat or resources with native species), and others. These exotic species may impact native species by direct competition for food or space, predation, habitat interference, and/or hybridization (Moyle 1976). CUWA notes that Herbold et. al. (1992) summarized the history of introduced species in the Bay/Delta and their widespread impact on ecosystem structure.

G. CUWA documents the changes in pollutant load in the Bay/Delta during the period and notes that there have been significant changes in the types of pesticides and herbicides used since the EPA began its activities to control use of persistent pesticides and herbicides in the early 1970's. As a result of environmental regulation, pesticides such as chlordane and DDT have been effectively eliminated from the pollutant load in the Bay/Delta but they have been replaced by chemicals such as rice herbicides. In particular, CUWA notes that recent U.S.G.S. studies indicate that diazinon levels in outflows may be greater than the minimum lethal dose for some species, particularly following the first significant runoff event following the summer.

H. CUWA evaluated the potential impacts of power plant operation on abundance of selected species in the Bay/Delta, but found that during the period of decline defined by EPA (1976-1991), power plant diversions from the Bay/Delta declined slightly. No simple statistical relationship could be found between diversions, discharge temperature and the overall abundance of the nine indicators used by Jassby (SFEP 1993).

I. CUWA notes the general concern in the scientific community regarding the impacts of the Asian clam on zooplankton productivity; the decline in zooplankton in the estuary may be a major factor affecting the ability of populations to rebound from recent drought conditions.

The CUWA analysis has not answered all of the questions concerning the factors influencing abundance of aquatic resources. CUWA comments raise more questions than are answered. What is clear is that there are substantial weaknesses in our understanding of the various factors affecting the health of the Bay/Delta. Data necessary to evaluate the potential impacts of other factors on the Bay/Delta ecosystem are dispersed in a variety of data bases and formatted in a variety of ways, making quantitative analysis of the available data difficult, especially in the limited time frame. Until a unified data base is established, and additional data are collected which measure the potential effects of other factors on the Bay/Delta aquatic biota, a reasonably quantitative understanding of the dynamics of the ecosystem will not be feasible.

The operation of these other factors on the condition of the estuary and its aquatic resources needs to be systematically addressed through a multi-agency comprehensive monitoring and research effort which will capture data about:

- Changes in the status of a wide range of biological resources in the Bay/Delta;
- Changes in the hydrology of the Bay/Delta;
- Changes in other factors potentially affecting aquatic, wetlands, upland species;
- Biological responses to the standard; and
- Responses to habitat modifications and improvements.

This broad focus is needed to ensure that the relative influence of the various factors affecting the estuary is defined and used as the basis for decision making in the future. Such a comprehensive monitoring and research program should be broad enough so that it can support development and evaluation of a long-term multi-species plan for the Bay/Delta which would address the many factors responsible for the decline in Delta resources. As the plan is implemented, outflow and/or water quality standards should be modified to reflect new habitat conditions. Any regulatory approach should allow for incorporation of the results of this program in the future. This is important because any standard must reflect changed conditions in the estuary to ensure that it continues to meet its goal of protecting beneficial estuarine habitat uses. This is important because the standard must reflect changed conditions in the estuary to ensure that it continues to meet its goal of protecting beneficial estuarine habitat uses.

2.2.4 The Water Cost Associated with the Estuarine Habitat Criteria

The EPA estimate of water costs associated with the proposed estuarine habitat criteria are described in its "Draft Regulatory Impact Assessment" dated December 15, 1993. The EPA estimated that the cost of implementing its standards would be 0.54 million acre-feet (MAF) on average and 1.1 MAF in dry or critical years. These additional outflows, necessary to locate X2 at the three proposed compliance locations, would result in reduced deliveries to urban and agricultural water users. EPA states that reductions would be implemented through negotiations with federal and state agencies and special districts. CUWA analyzed the potential water costs of both the EPA-proposed estuarine habitat criteria and the CUWA-proposed Suisun Estuary Standard.

CUWA analyzed potential water costs by calculating the outflow required to meet the proposed salinity standard at all three locations (Confluence, Chipps, and Roe) on a daily basis and then comparing this outflow with the estimated Net Daily Outflow for the period 1930 to 1991, based on the DWR DAYFLOW estimates. CUWA did not evaluate impacts of increased outflow requirements on project operations. CUWA's analysis indicated that the relationship between measured surface electrical conductivity (EC) and practical bottom salinity (2 ppt) used by EPA was inaccurate, and that a surface EC of 2640 μS/cm represents a practical bottom salinity of 1.5 ppt, instead of 2.0 ppt. CUWA's analysis suggests that a surface EC of 3406 μS/cm converts to a 2.0 ppt bottom salinity. CUWA therefore calculated water costs based on both a surface EC set at 3406 μS/cm and 2640 μS/cm.

The water cost estimates for the EPA-proposed estuarine habitat standard are summarized on Table 1. Note that CUWA calculated water costs for several implementation scenarios, including conversion of the X2 standard to an outflow standard, and several different periods of record. Key points are:

A. Implementation of an outflow standard would result in approximately 300 TAF/year greater outflow required on average than a 2 ppt salinity standard. This can be attributed to the salinity standard's greater ability to take advantage of wet antecedent conditions.

B. The estuarine habitat standard, as proposed, would have required additional outflows averaging 50 to 200 TAF per year during the period 1930-1950 (prior to operations of the CVP and SWP), 250 to 600 TAF during the period 1951-1967 (prior to operation of the SWP), and 850-1300 TAF during the period 1968-1991.

C. For any given year during the chosen period of record, the range of additional outflows required by the estuarine habitat standard for any given year during the chosen period of record were 0 to 1190 TAF for the period 1930-1950, 0 to 1880 TAF for the period 1951-1967, and 0 to 3090 TAF for the period 1968-1991, with the highest additional outflow in any given year generally produced by implementation of a steady state outflow standard, rather than a salinity standard.

D. The water costs of the standard, on average, are higher for critical (1500 TAF to 1850 TAF per year) than for wet years (1000 TAF to 1300 TAF per year), even though the Roe Island standard would not be triggered in critical years.

E. Although implementation of a standard based on the average daily location of X2 generally resulted in a lower additional water cost than implementation of an outflow standard, this general rule does not apply to all of the years analyzed. In several years, an equivalent outflow standard resulted in lower outflow requirements than an X2 standard.

F. Comparing additional outflows developed using CUWA's analysis with additional outflows estimated using DWR's model (DWRSIM) at two different levels of demand (6 MAF and 7 MAF) and assuming no buffer required shows only minor differences in the estimates of additional outflow required for critical and wet water year types, but more significant differences for dry, below-normal, and above normal year types. However, for the period 1968-91, the DWRSIM estimated average annual additional outflow required at a demand of 6000 TAF was about equal to the CUWA estimate of 1000 TAF/year. At a demand level of 7000 TAF, the difference between the two estimates was 10%.

G. CUWA, using the daily Kimmerer-Monismith equation, determined that the steady-state flow required to meet the X2 standard would be: 29,200 cfs for kilometer 64 (Port Chicago, representing Roe Island), 12,460 cfs for kilometer 75 (Chipps Island), and 6,860 cfs for kilometer 81 (Collinsville).

Table 1.
Potential Water Costs of the Proposed Estuarine Habitat Criteria
Average Annual Additional Outflow in Thousands of Acre Feet (TAF)
Contra Costa Water District Analysis

Period of Record	Year Type	Additional Outflow Required		
		2640 μs/CM Standard	3406 μS/cm Standard	Outflow Standard
1930-50	WET	0 TAF	0 TAF	0 TAF
	ABOVE NORM	0 TAF	0 TAF	0 TAF
	BELOW NORM	50 TAF	0 TAF	100 TAF
	DRY	150 TAF	100 TAF	350 TAF
	CRITICAL	350 TAF	250 TAF	450 TAF
	AVERAGE	100 TAF	50 TAF	200 TAF
1951-1967	WET	200 TAF	100 TAF	250 TAF
	ABOVE NORM	400 TAF	250 TAF	600 TAF
	BELOW NORM	800 TAF	500 TAF	1050 TAF
	DRY	500 TAF	300 TAF	900 TAF
	CRITICAL	--------	--------	--------
	AVERAGE	450 TAF	250 TAF	600 TAF
1968-1991	WET	900 TAF	700 TAF	1000 TAF
	ABOVE NORM	550 TAF	350 TAF	650 TAF
	BELOW NORM	1000 TAF	1250 TAF	1900 TAF
	DRY	1000 TAF	900 TAF	1600 TAF
	CRITICAL	1550 TAF	1200 TAF	1600 TAF
	AVERAGE	1000 TAF	850 TAF	1300 TAF

Implementing the EPA-proposed standard would require compliance for a specified number of days, depending on water year type. The hydrologic impacts of this compliance requirement were investigated.

A. Using DWR DAYFLOW data and the conversion for outflow to X2, with X2 based on a surface of 3406 μS/cm, CUWA determined that, during the EPA-chosen period of record from 1940-1975, the EPA requirement for Roe Island would have been met only about 50% of the time, for all water year types.

Year Type	EPA Requirement	Number of Times Requirement Was Met, 1940-1975
Wet	133 days	8 Wet years out of 15
Above-Norm	105 days	3 AN years out of 5
Below-Norm	78 days	4 BN years out of 9
Dry	33 days	5 Dry years out of 7
Critical	0 days	No critical years in this period

B. CUWA analyzed the number of days during various periods of record during which the proposed standard would have been met. This analysis indicates the proposed X2 standards tend to require a significantly greater number of days of compliance "than the least squares linear fit through the 1968-1975 data." CUWA analysis of other periods of record indicate that the tendency of the proposed X2 standard to require compliance for a greater number of days than has historically occurred is consistent for all post 1955 periods.

C. The inconsistency between the EPA's goal and the levels of compliance required is due to the method EPA used to calculate the standard.

a) Using essentially the same data set used by CUWA and DWR, and a daily version of the Kimmerer-Monismith equation, EPA calculated the average number of days of compliance, by water year type, for the period 1940-1975 and then determined that the average number of days would be the minimum number of days of compliance for each water year type.

b) Using the average as the minimum effectively eliminates much of the variability in outflow which EPA states is a purpose of selecting a longer period of hydrologic record.

D. The water year type index used by EPA in its analysis, the 40-30-30 index developed by the State Water Resources Control Board to define water year availability over a full water year does not represent the salinity regime for Suisun Bay for the regulatory period because it includes indices of runoff which do not affect salinity during February through June. Use of a February through June Sacramento River Index of unregulated flow provides a more relevant basis for determining water year type.

E. Using the Sacramento River Index and a least-squares linear fit to the historic outflow data as the basis for determining the number of days necessary to accomplish the EPA's goal of recreating conditions of the late 1960's and early 1970's results in a significant decline in the number of days of required compliance.

F. The average annual additional incremental Delta outflow required by a Roe Island standard, compared to a Chipps Island and Confluence standard, for the period 1968-1991, was calculated by CUWA to be:

Wet Year:	800 TAF	
Above-normal Year:	500 TAF	
Below-normal Year:	500 TAF	
Dry Year:	200 TAF	
Critical Year:	0 TAF	(Roe Island Standard not triggered)

Implementation of the EPA proposed standard will have significant water supply impacts, with the highest average Impacts occurring during dry and critical dry years. In any given year, water supply impacts may vary significantly from average annual water costs for that year type. Implementation of the standard as proposed would result in more days of the required outflow than would have occurred either during the EPA target period or during the period of hydrologic record used by EPA to develop its proposed rule.

A. The CUWA-recommended Suisun Estuary Standard would reduce average annual water requirements from approximately 700 TAF to approximately 300-500 TAF, although water requirements in dry and critical dry years would remain in the 1000 TAF range.

B. The CUWA-recommended Suisun Estuary Standard would maintain the variability in hydrology which supports biological diversity in the estuary, while maintaining flows adequate to provide transport of eggs, larvae, and nutrients through the Delta and into the estuary.

C. By reducing water requirements in wet years, the CUWA-recommended Suisun Estuary Standard will help address the concern that loss of carryover storage could adversely impact winter-run chinook salmon and delta smelt.

2.2.5 Additional Refinements and Implementation Considerations for the CUWA-Recommended Suisun Estuary Standard

CUWA stresses that its recommended standard should be promulgated in 1994. CUWA believes that this prompt and effective implementation of its recommended Suisun Estuary Standard would be facilitated by adopting the following refinements and implementation recommendations.

A. All parties involved in promulgation and implementation of the CUWA-recommended Suisun Estuary Standard, including EPA, SWRCB, NMFS, USF&WS, USBR, CDF&G and others should consult to ensure that implementation of the proposed standard does not have adverse impacts on threatened or endangered species. Of particular concern is the impact of the standard on carryover storage needed to ensure low-temperature releases to the upper Sacramento River for winter-run chinook salmon and flows required for the delta smelt.

B. Salinity should be measured near the surface, rather than at the bottom, because it is the standard measurement technique to reduce measurement difficulties. Surface electrical conductivity (EC) would be measured and these measurements would be converted to bottom salinity using well-established conversions. This recommendation not intended to affect the required position of the 2 ppt isohaline.

C. The appropriate agency(s) should develop a comprehensive monitoring and research program which would result in better understanding of how abundance and distribution of aquatic and marsh wetlands species are related to a full range of potential causative factors in the Delta and upstream areas. The purpose of the monitoring program would be to measure how the estuarine standard is meeting its objectives and how other actions, such as those to restore habitat, and contributing to estuarine health. Any regulatory approach should allow for incorporation of the results of this program in the future. This is important because any standard must reflect changed conditions in the estuary to ensure that it continues to meet its goal of protecting beneficial estuarine habitat uses.

D. A water supply impact threshold (cap) should be established, beyond which the standard would be met with purchased water paid for by an environmental fund established for this purpose and supported by payments by the basin water users. This will ensure that the goals of the Suisun Estuary Standard are met in an economically viable manner.

E. All parties involved in promulgation and implementation of the CUWA-recommended Suisun Estuary Standard, including EPA, SWRCB, NMFS, USF&WS, USBR, DWR, CDF&G and others should coordinate with USF&WS and NMFS to address issues such as QWEST and take limits to ensure that cross delta transfers are feasible. As EPA notes in the Regulatory Impacts Analysis, transfers are a critical element of reducing the water supply impacts of a standard.

F. To avoid confusion and thus ensure orderly and prompt compliance, a compliance schedule should be established which would phase in requirements in recognition of the need for operators to develop procedures for compliance, the need for the State Water Resources Control Board to address water allocation issues, and the need to equitably phase the water supply impacts of the standard among Bay/Delta watershed users.

G. All parties involved in promulgation and implementation of the CUWA-recommended Suisun Estuary Standard, including EPA, SWRCB, NMFS, USF&WS, USBR, CDF&G, BDOC, IESP, and others should develop and implement a long-term multi-species plan for the Bay/Delta, addressing the many factors responsible for the decline in Delta resources. As the plan is implemented, outflow and/or water quality standards should be modified to reflect new habitat conditions. As modifications are proposed, EPA should perform an ecological risk assessment before proposing modifications. EPA should then modify the standard as habitat improvements are made in the Delta and biological resources respond to these changes. This is important because the standard must reflect changed conditions in the estuary to ensure that it continues to meet its goal of protecting beneficial estuarine habitat uses.

H. Implementation of the CUWA-recommended Suisun Estuary Standard should be coordinated with other habitat enhancement and instream flow efforts in upstream areas to make it possible to concurrently meet both objectives whenever coordinated water releases are feasible.

I. A multi-species ecosystem approach to long-term Delta protections should be developed along with commencement of a joint State/Federal process, guided by the requirements of the California Environmental Quality Act and the National Environmental Policy Act, to develop a comprehensive water resources management plan for the estuary, addressing the many factors responsible for the decline in Delta resources including consideration of a full range of alternatives.

3.0 THE FISH MIGRATION AND COLD-WATER HABITAT CRITERIA

The Salmon Smolt Survival Index proposed under the Fish Migration and Cold-Water Habitat Criteria was developed by USF&WS, which has often noted that there are limits to its application. Consistent with the concerns of the USF&WS, CUWA analysis of the proposed Fish Migration and Cold-Water Habitat Criteria indicates that the proposed criteria is not the appropriate tool for accomplishing EPA's stated goals. The indices are not valid over a wide range of conditions and operational scenarios likely to occur; compliance with the standard would be impossible under some circumstances, regardless of CVP, SWP or other project actions. The findings in support of these conclusions are:

A. The proposed Sacramento River index predicts smolt survival on the basis of water temperature and measures related to flow. The San Joaquin Index considers only flow parameters.

B. According the U.S. Bureau of Reclamation, the temperature component of the smolt survival standard for the Sacramento River is almost entirely a function of ambient air temperature and therefore is outside of the control of CVP, SWP, or other water users.

C. CUWA determined that the equation used to derive the Sacramento River smolt survival index is statistically flawed. The mortality equations used to develop the Sacramento River index are based on probabilities of mortality occurring in a particular reach. However, since survival estimates using these equations with experimental data often exceed 100% (an impossible result), the USF&WS has divided all estimates by the <u>highest</u> experimental multiplier, 1.8. Scaling using this multiplier to bring survival estimates to unity (1.0) or less invalidates their use <u>as probabilities</u>, and they therefore cannot be used in the type of equations developed. In short, the correction factor applied is fundamentally inappropriate for the type of statistical equation being used. This invalidates all subsequent use of the indices, including their use in regression equations used to justify the proposed standards.

   There is also a lack of experimental data to validate the proposed San Joaquin River index. In order to relate index results with experimental data, USF&WS has applied the 1.8 scaling factor to the San Joaquin River relationship. The use of this correction factor, derived for the Sacramento River, has no basis within the San Joaquin River index and further invalidates the index as a measurement of biological response.

D. There are a number of other sources of potential mathematical error in the index equation for the Sacramento River. For example, adjusting the sampling width of the trawl used to collect data on smolt abundance, as discussed by U.S. F&WS in their testimony to the State Water Resources Control Board (Exhibit 31, Appendix 12) and placing 95% confidence intervals on the predicted smolt survival indices changes the resulting prediction by approximately 100%.

E. Application of the proposed Sacramento River standard, under a variety of operational scenarios, often results in biologically invalid results. For example, if State and Federal exports are set at zero and the proportion of flow through the Delta Cross Channel and Georgiana Slough is 0.3 and equations are solved for zero mortality, the results are biologically meaningless. Under these conditions, the temperature needed to reduce mortality to zero in Reach 1 (above Walnut Grove) is approximately 58 degrees. In Reach 3, the temperature required to accomplish zero mortality is approximately 50 degrees. In Reach 2, the temperature required to reach a calculated zero mortality is 30 degrees. Aside from the fact that the equation requires frozen water to achieve zero mortality in Reach 2, the variation in these results suggests that there are factors other than water temperature and proportion of flow diverted which are responsible for the observed mortality in the experimental data.

The U.S. Fish and Wildlife Service has cautioned that the results of their smolt survival analysis should not be used outside of the parameters from which they were developed. The EPA has not incorporated these limitations into the equation; as a result, the equation is used to predict smolt survival indices for conditions outside of its range of validity. At very high flows, for example, it is possible to be in violation of the standards under normal operating procedures simply because the equation does not behave predictably at this range of flows.

The EPA criteria only consider a Delta channel configuration which includes a barrier in Old River. Alternative criteria and compliance measurement formulae would be required if other potential Delta channel configurations are to be considered. The water supply impacts associated with these alternative Delta channel configuration have not been considered by EPA.

Because, as U.S. Fish and Wildlife Service points out, the index does not accurately predict survival under the full range of probable conditions, it is irrelevant to the measures which could actually improve salmon smolt survival.

CUWA notes that USF&WS and CDF&G have identified factors which they feel are responsible for the decline in winter-run chinook salmon and other runs of salmon in the Sacramento and San Joaquin Rivers, including loss of spawning habitat, diversion of outmigrating smolts into the central delta where they are subject to predation and where their migration to the ocean is delayed, and other factors. CUWA believes that the appropriate tool should be used to address salmon smolt survival issues. In lieu of the Fish Migration and Cold-Water Habitat Criteria, water management and other basin-wide management provisions for ensuring salmon smolt survival should be developed by the appropriate federal and state agencies.

4.0 THE FISH SPAWNING CRITERIA

4.1 Introduction

The EPA's proposed Fish Spawning Criteria is intended to establish water quality criteria to protect the historic spawning range of striped bass, an introduced species of value to recreational anglers. The EPA further states that it intends to "ensure the genetic diversity of the population as well as increase the size of the overall striped bass population." A literature review, including analysis of State Water Resources Control Board testimony, was conducted. The findings are summarized below.

A. CUWA notes that striped bass are predators on delta smelt, a species listed as threatened under the Federal Endangered Species Act, and winter-run chinook salmon, a species listed as endangered under the Federal Endangered Species Act.

B. CUWA further notes that there may be competition for the same water supply between the proposed EPA standard and standards intended to meet the requirements of other species. Water used to support striped bass spawning in the San Joaquin River may not be available to meet the requirements of either delta smelt or other species or habitats needing protection.

C. CUWA, citing the State Water Resources Control Board, notes that the cause of high salinity in the San Joaquin River reaches of concern is agricultural return flows, and the proposed criteria amounts to dilution flows to correct discharge pollution. The SWRCB has also made a similar finding.

D. CUWA cites an analysis by the State Board that finds the EPA proposed criterion will create an environment in excess of conditions that existed during the targeted period. CUWA provides data to confirm this finding.

E. Other proposed and existing criteria will substantially achieve the objectives of the Fish Spawning Criteria incidentally.

F. CUWA cites correspondence between EPA and DWR in acknowledging that the water supply analyses were performed without incorporating all of the modeling assumptions necessary to full comply with the Fish Spawning Criteria. Thus, the current water supply impact analysis does not indicate the full amount of water required by the standard.

G. According to the SFEP Status and Trends Report (SFEP 1992), "Increased loss of eggs and larvae into the hazardous Central Delta is the only well-documented and sufficiently powerful mechanism to explain the continuing destruction of the striped bass fishery." This report does not mention loss of spawning habitat as one of the limiting factors affecting striped bass populations, but instead addresses issues such as toxics, larval starvation, increased entrainment, and declining egg abundance. The report also notes that disease has been considered, but rejected, as a cause of the observed population decline.

The goal of the proposed rule is to increase striped bass spawning success by reducing electrical conductivity in the San Joaquin River, which would probably be accomplished by dilution of high salinity runoff from agricultural return flows using reservoir releases. Successful implementation of the standard would increase populations of a predator of several threatened and endangered species (winter-run chinook salmon and delta smelt). EPA should consider this potential conflict more carefully. There are broader ecological reasons for addressing the high salinity of flows in the San Joaquin River. At an appropriate time, EPA should develop and implement a standard keyed to preparation of a management plan for the various species in the river, and to solving the agricultural drainage problems which are the demonstrated cause of the problem.

5.0 RESPONSES TO EPA'S REQUEST FOR COMMENTS

Many of the issues raised in EPA's request for comments have been addressed by CUWA in the above comments. Many are related to the need for additional protections for Bay/Delta ecosystem resources. CUWA generally feels that its recommended Suisun Estuary Standard will address the hydrologic needs of Suisun Bay, but that other factors need to be addressed as well. Additional protections for the estuary should be developed which remedy other causative factors concurrent with implementation of the Suisun Estuary Standard.

5.1 Setting water quality criteria based on a smooth function.

CUWA has described a smooth function which it recommends be used to determine the required number of days of compliance at both locations specified in its recommended Suisun Estuary Standard. All parties involved in promulgation and implementation of the CUWA-recommended Suisun Estuary Standard should meet with CUWA interests and other interested parties to develop such a smooth function based on the Sacramento River Index for the period February through June. In these discussions, if CUWA's proposed smooth function is adopted, then it will be unnecessary to address the issues in 1(b) of the Requests for Comments.

5.2 Use of a 14-day rolling average.

Given that CUWA's recommendation for three-way compliance, a 14-day averaging period for measuring compliance is adequate and there will be no need for a longer averaging period to adjust for conditions beyond human control which cause short-term periods of non-compliance. CUWA therefore stresses that the most flexible approach to compliance, one which will ensure the goals of the Suisun Estuary Standard are met while giving project operators the most operational flexibility, is the three-way compliance standard under which compliance can be accomplished when 1) the average daily salinity is below 2 ppt, or 2) the 14-day average salinity is below 2 ppt, or 3) the net Delta outflow index is equal to or greater than the outflow calculated to be necessary to place the X2 location at the appropriate monitoring station, then this issue has lower priority to all parties concerned.

CUWA concurs with EPA that compliance should be measured independently at each compliance point and that non-compliance at one station should not affect compliance at other stations.

5.3 Use of a "confidence interval" or margin of safety.

The CUWA-recommended Suisun Estuary Standard will ensure protection of the estuary, without use of a confidence interval, because it provides for the three-way compliance methodology recommended in these comments, section 2.2.5. This methodology which will ensure the minimum outflow needed to place physical processes beneficial to the estuary at or downstream of Chipps Island. CUWA believes use of the flow calculated to result in maintenance of steady-state X2 at each compliance point is adequate, and that no additional margin of safety is needed to provide protection of the estuary.

5.4 Ability of the standard to protect low-salinity habitat conditions in wetter years.

EPA's concern about the proper level of protection which can be provided in wet years is based on a misunderstanding of the Kimmerer-Monismith equation, which is outside of its range of validity when addressing very high outflows. Also, the level of outflow which EPA appears to be concerned about is beyond the operational control of all water users in the Sacramento-San Joaquin Bay/Delta ecosystem. Outflows experienced in very wet years, such as 1983, are measured in 100,000's of cubic feet per second. It is beyond the physical capability of all water users in the basin combined to either control or significantly influence such flows. Development of a more protective standard than proposed would therefore ensure non-compliance. Further, CUWA believes that its recommended Suisun Estuary Standard will provide the base flows needed to protect the estuary, with unregulated outflows providing some of the natural variability in estuarine conditions EPA is concerned about.

5.5 The proper historical reference period for the standard

As CUWA analysis indicates, a number of different hydrologic periods of record may be used as the basis for the standard with only small differences in the number of days which would be required for compliance. CUWA has recommended that 1968 is an appropriate year to begin hydrologic analysis because salinity data are available for the period 1968-present. As CUWA indicates, the 1968-1975 period of hydrology may be chosen or extended to include the period 1968 to 1992 to allow several periods of dry and critical dry hydrology to be included in the analysis. This does not cause a significant change in the slope of the least squares fit of the relationship between the number of days at 2 ppt and the February-June Sacramento River Index.

5.6 A Trigger for the Roe Island Standard

CUWA does not recommend a Roe Island standard, for reasons described above; therefore no comments are provided by CUWA regarding recommendations for a trigger for a Roe Island standard.

5.7 Extended droughts

A special criteria to address problems associated with extended drought periods is speculative, but a coordinated state and federal process to address the issue of extended droughts should be developed. This process should be opened to all interested parties. This process should be focused on developing mechanisms to resolve the problems associated with extended droughts.

5.8 Tidal Marsh Protections

Management plans for the tidal marshes of Suisun Bay are more appropriately developed by the U.S. Fish and Wildlife Service under its authority and California Department of Fish and Game under its authority to develop Natural Community Conservation Plans. EPA and other interested agencies should coordinate with U.S. F&WS to develop such plans.

5.9 Delta Smelt Spawning

The specific requirements of any single species, such as delta smelt are best addressed by agencies with responsibility for their management. The focus of the EPA's regulatory efforts should be on protecting estuarine habitat conditions necessary to protect a wide range of beneficial uses of the Suisun Bay. CUWA found delta smelt were widely distributed in the Suisun Bay, the Delta, and the Sacramento River within a given month, suggesting that the response of adults to salinity is not entirely predictable. Data from the 1993 delta smelt sampling program indicate that in summer and fall of 1993 approximately 50% of the delta smelt population was found upstream of Suisun Bay and 50% was found in Suisun Bay. It is therefore premature to consider adjusting the estuarine habitat criteria to meet the, at present, poorly-defined habitat requirements of a single species. If the compliance period were extended into July for delta smelt spawning, this would have an impact on carryover storage and water supplies available for winter-run salmon.

5.10 Potential Water Temperature Criterion for Salmon Smolt Survival

While there is a scientific basis to explain the effects of temperature on outmigrating salmon smolts, such a criterion would not be attainable because ambient air temperature is the overriding determinant of water temperature in the reaches considered by EPA. Protection of outmigrating salmon smolts is a subject for a multi-species management plan for the Bay/Delta ecosystem, which CUWA encourages EPA and other agencies to develop in cooperation with State, regional, and local agencies.

5.11 Effectiveness of Barriers at the Head of Georgiana Slough

Barriers to prevent salmon smolts from entering the central delta, where they are subject to higher predation and where their migration to the ocean is delayed, are an important component of an overall management program for anadromous species in the Sacramento-San Joaquin River Basin. Action to provide barriers, particularly those which do not adversely affect water quality in the central delta (such as acoustic barriers), are, however, independent of target Fish Migration and Cold-Water Habitat Criteria values. Barriers are an appropriate subject for a multi-species management plan for the Bay/Delta ecosystem, which CUWA encourages EPA and other agencies to develop in cooperation with state, regional, and local agencies.

5.12 Old River Barrier Issues

As noted above, the salmon smolt survival indices are not a valid measure of actual smolt survival, and therefore they are irrelevant to the issue of the proposed barrier at the head of Old River during the migration of San Joaquin River smolts. Barriers to prevent smolts from being "lost" in the central delta are acknowledged by many to be useful management tools, but their construction and operation is irrelevant to the issue of the validity of salmon smolt survival indices. Barriers are an appropriate subject for a multi-species management plan for the Bay/Delta ecosystem, which CUWA encourages EPA and other agencies to develop in cooperation with state, regional, and local agencies.

5.13 Export Limits on the San Joaquin during Migration Periods

As noted above, the salmon smolt survival indices are not a valid measure of actual smolt survival. Further, the proposal to revise the San Joaquin River salmon smolt survival indices to account for potential operational scenarios points out how sensitive these indices are to changes in operational scenarios related to outflow. EPA should address the poor conditions in the San Joaquin River by promulgating regulations which regulate water quality of discharges from agriculture and industry. Management plans for specific species should be developed by USF&WS, NMFS, and CDF&G, as appropriate to ensure that a wide range of factors which may influence these species are addressed.

5.14 Impact of Proposed Standards on CVPIA Goal to Double Production of Anadromous Fish Throughout the Central Valley Project Watershed

The CVPIA goal of increasing anadromous fish populations is commendable. CUWA notes that carryover storage to provide for low-temperature releases to the upper Sacramento River may be important to accomplishing this goal, and the loss of carryover storage associated with implementation of the EPA-proposed standard could therefore have an impact on accomplishment of the CVPIA goal.

5.15 Kimmerer Salmon Population Model

CUWA has no comment on the Kimmerer salmon population model, but notes any model needs to be validated to represent the full range of factors affecting population abundance, distribution, behavior, and mortality.

5.16 Revisions to the Proposed Standards to Protect Estuarine Species in July to January Period

Revision of the proposed standards to cover the period July through January would be justified if strong causal relationships could be demonstrated between the proposed changes in outflow and biological variables known to affect abundance and distribution of fish.

Given the findings of Herbold and Moyle (1986) that fish abundance in the tidal marshes increases in the summer when salinity and temperature are higher, it is possible that extending the regulatory period could have some adverse as well as beneficial impacts to the estuary. This is an issue which should be addressed in a multi-species plan for the Bay/Delta ecosystem.

5.17 Need for Biological Resource Monitoring Data

As noted in Section 2.2.5, above, there is a strong need for additional research into the relationship between the abundance and distribution of aquatic and wetland marsh species in the Bay/Delta and a full range of potential causative factors. At present, as the SFEP report notes, regulatory efforts are being based on a relatively limited set of correlations and indicators, and no attempt has been made to establish causal relationships between X2 and abundance and distribution. The EPA, as participant in the Interagency Ecological Studies Program for the San Francisco Bay Estuary, should direct this program towards such basic scientific research so that the full range of problems facing the estuary can be explored and long-term recovery can be addressed.

APPENDICES

APPENDIX 1

Re-calculation of the abundance indices for longfin smelt, striped bass, delta smelt, and Sacramento splittail, as corrected and with the potential statistical error shown for longfin smelt and striped bass.

APPENDIX 2

Primary productivity vs abundance calculations. Note the general positive relationship between riverine particulate organic carbon and abundance, suggesting that nutrients in freshwater inflows may be in part responsible for the effects of outflows on the condition of the estuary, and therefore the usefulness of X2 as an indicator of estuarine condition.

APPENDIX 3

The relative contribution of riverine and locally-derived particulate organic carbon in Suisun Bay.

APPENDIX 4

Some representative indicators of sampling bias in the Fall Midwater Trawl sampling program: delta smelt.

APPENDIX 5

X2 vs abundance for a suite of estuarine and marine species in Suisun Bay and San Pablo Bay.

APPENDIX 6

Results of correlations between abundance indices and the number of days during which X2 was at or downstream of Chipps Island vs Roe Island

APPENDIX 7

Turbidity readings vs outflow for areas in the Suisun Bay.

APPENDIX 8

Analysis of potential impacts of the Chipps and Roe Island standards, based on the amount of preferred habitat for each of 41 species which utilize the estuary (some brackish water species, some marine species), based on habitat preference analysis from National Marine Fisheries Service.

APPENDIX 9

Comparison of the abundance of several estuarine species. Note that the shape of most of the graphs suggests that when one species is abundant, the other species evaluated is not. Conditions which favor one species may therefore be hypothesized to disfavor the other.

APPENDIX 10

Data from the CUWA water cost analysis.

APPENDIX 11

References

APPENDIX 1

Re-calculation of the abundance indices for longfin smelt and striped bass, adjusted and with the potential statistical variance shown (GLM = generalized linear model).

a. In Figures 1-1 and 1-2, note the location at which potential errors in the X2 vs abundance series increases. The predictive ability of the X2 vs abundance relationships shown is greatest when X2 is upstream of Chipps Island (low abundance) and lowest when X2 is downstream of Roe Island.

b. In Figure 1-3, note how the variance in abundance index for longfin smelt increases as the total index increases, suggesting uncertainty in the relationship for high indices.

c. In Figures 1-4 through 1-7, the total abundance index for four species has been re-calculated using the average index method used by the Bay Study. Note that the variance in annual index often approaches the mean value, suggesting low predictive value for the index. Use of total indices and omission of variance from the mean of the four monthly indices for each species obscures the uncertainties in these indices.

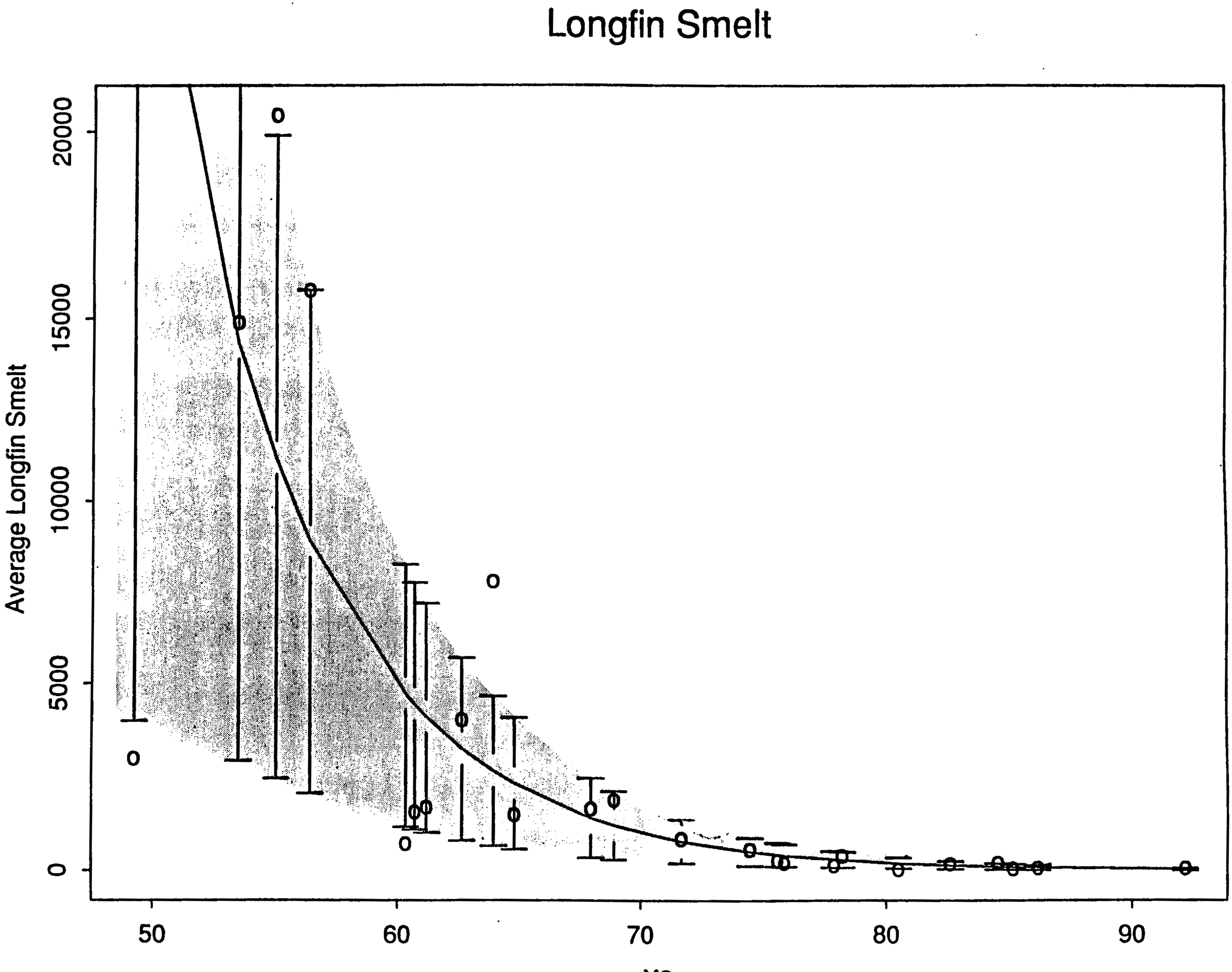


Figure 1-1 GLM fit with variance proportional to square of mean

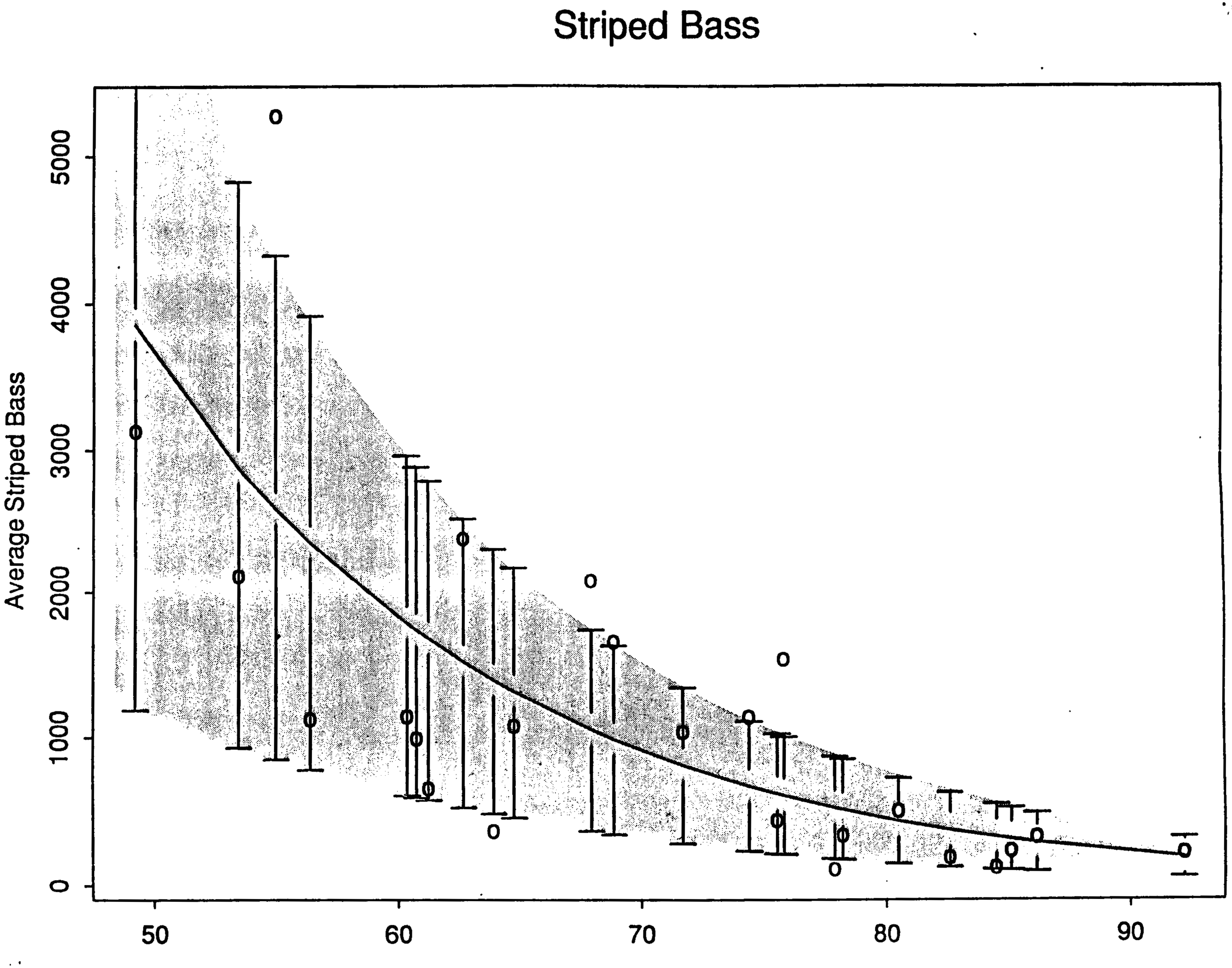


Figure 1-2
GLM fit with variance proportional to square of mean

Figure 1-3. Variance in the longfin smelt index.

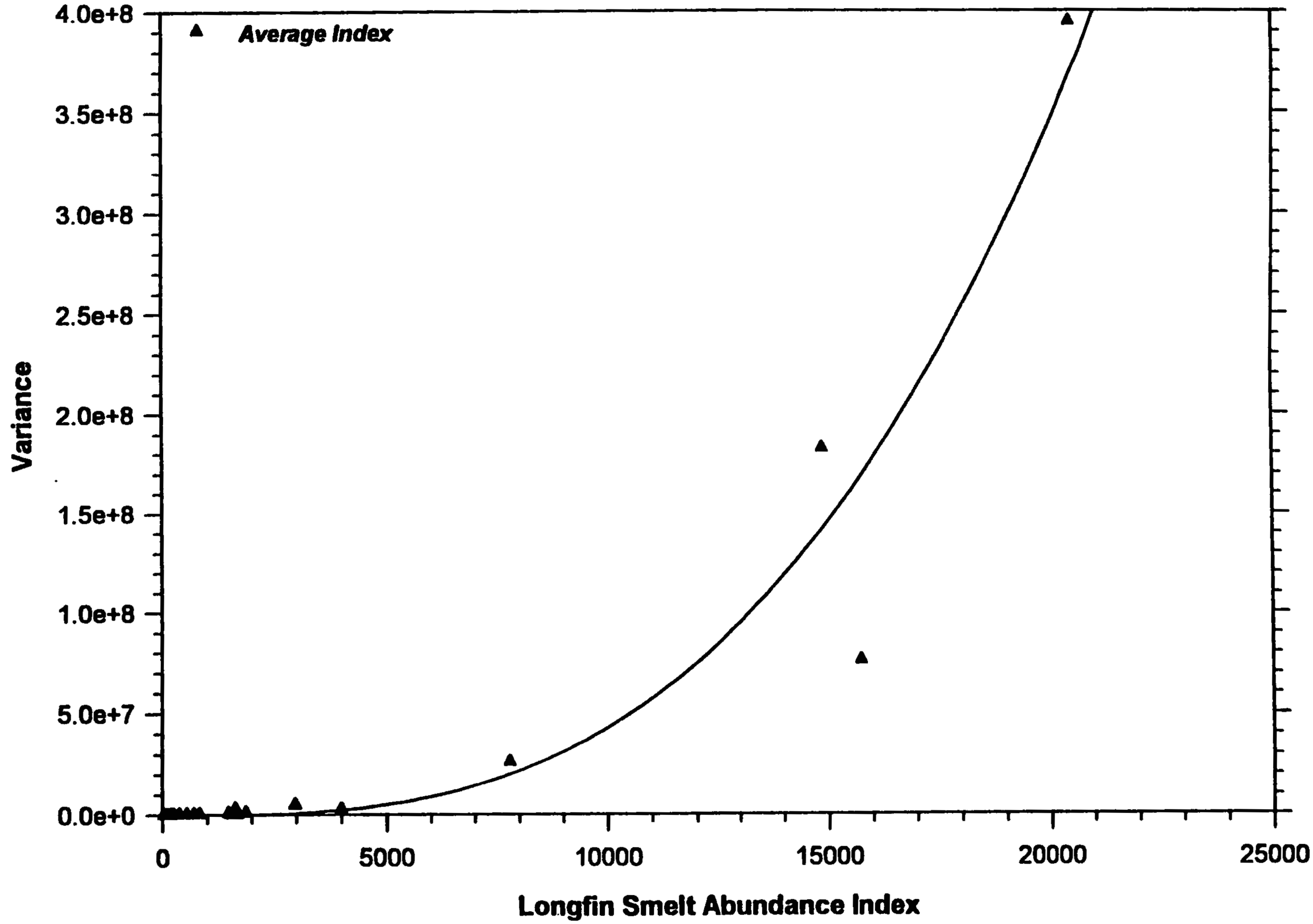


Figure 1-4. Total FMWT index for striped bass compared to average FMWT index, with variance in the 4 monthly indices shown.

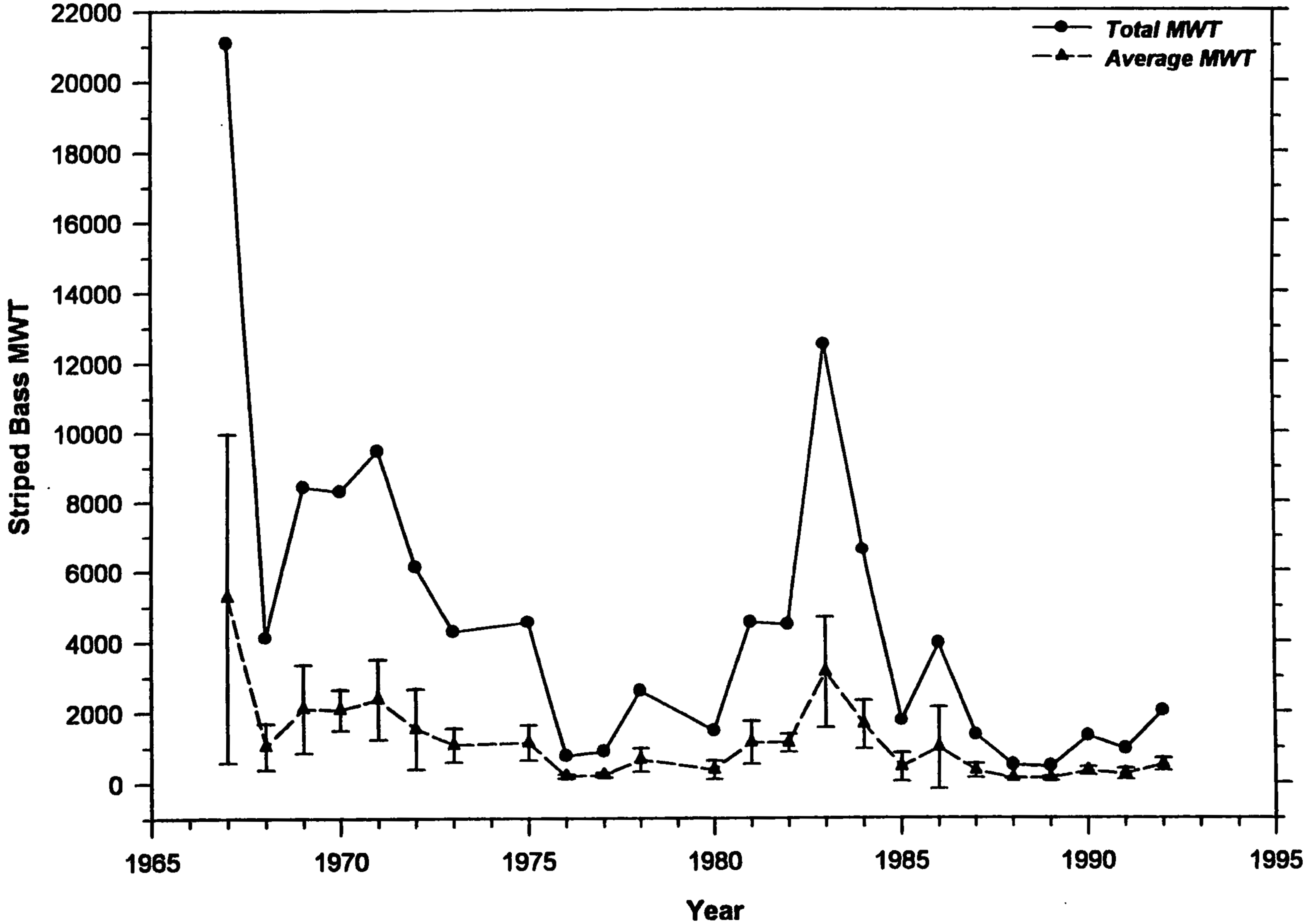


Figure 1-5. Total FMWT index for splittail compared to average FMWT index, with variance in the 4 monthly indices shown.

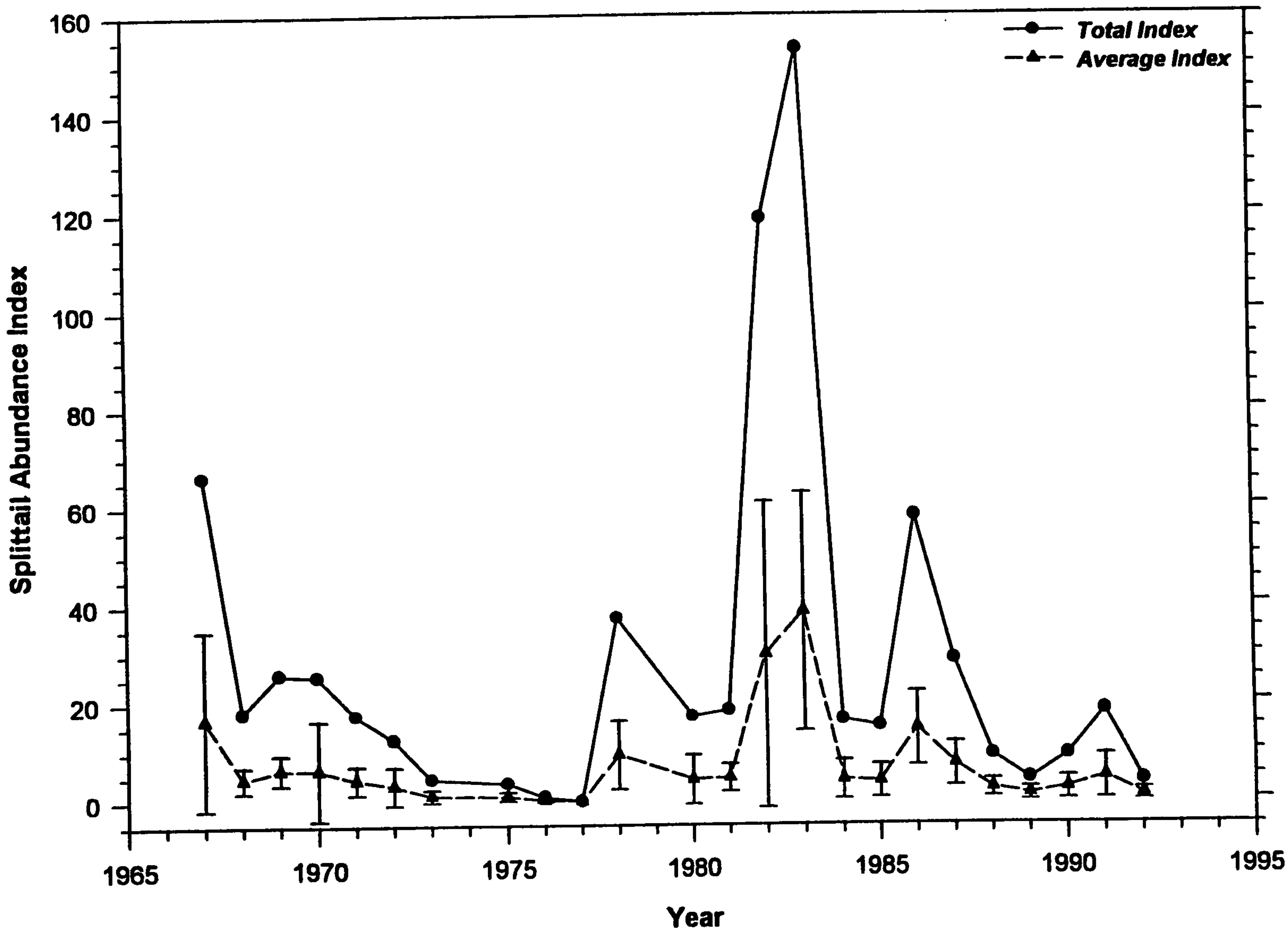


Figure 1-6. Total FMWT index for longfin smelt compared to average FMWT index, with variance in the 4 monthly indices shown.

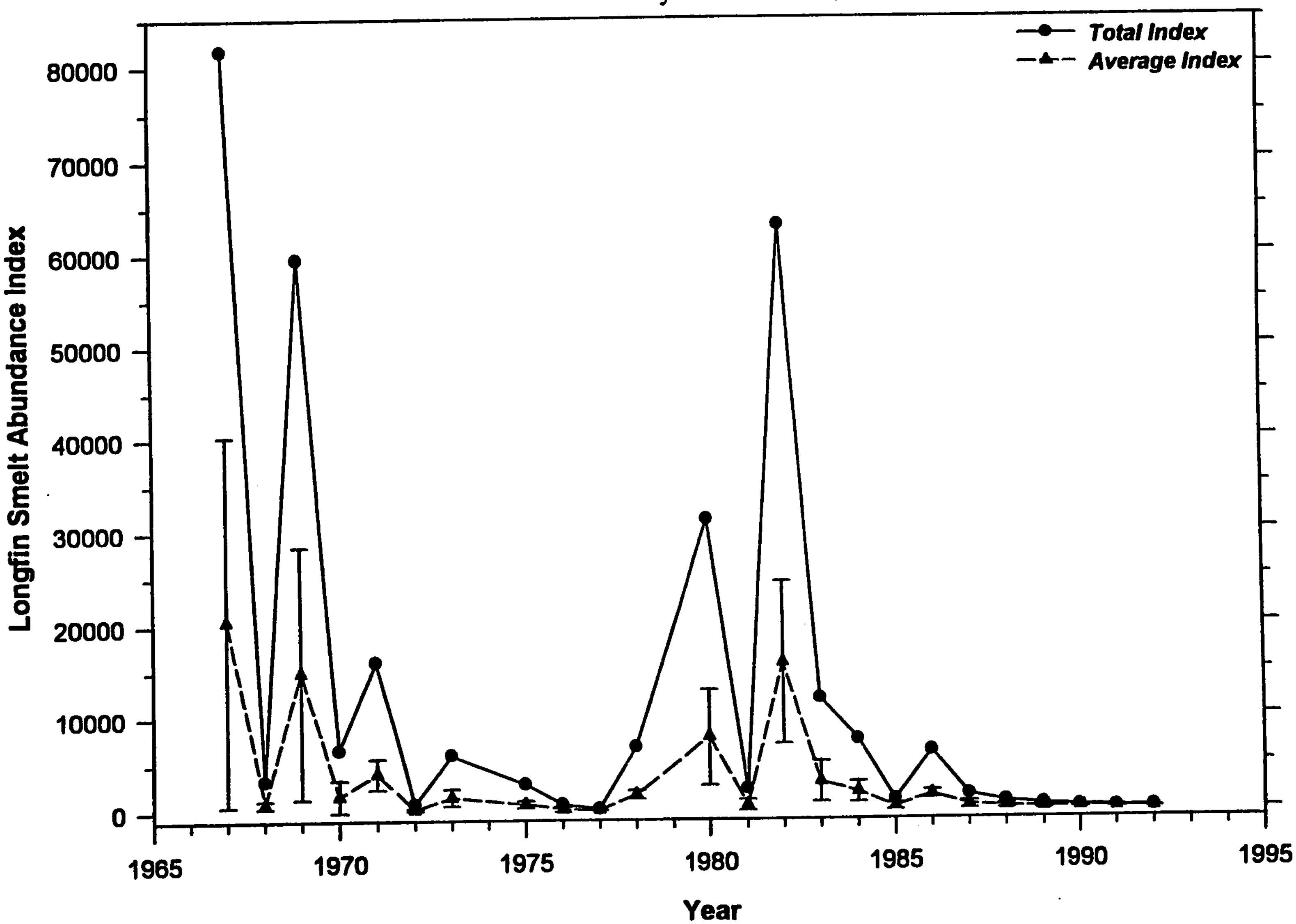
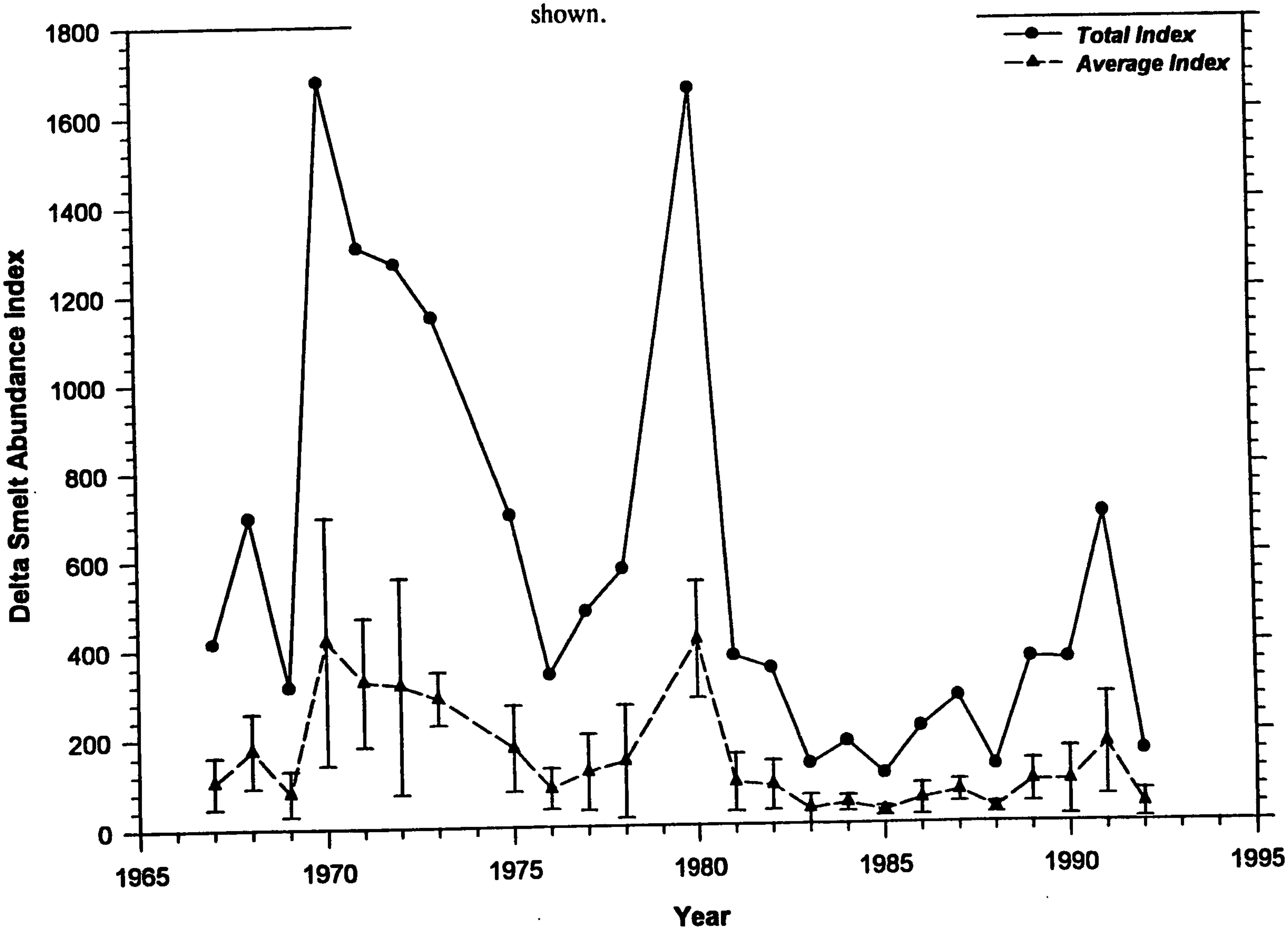


Figure 1-7. Total FMWT index for delta smelt compared to average FMWT index, with variance in the 4 monthly indices shown.



APPENDIX 2

Primary productivity vs abundance calculations. Note the general positive relationship between riverine particulate organic carbon and abundance, suggesting that nutrients in freshwater inflows may be in part responsible for the effects of outflows on the condition of the estuary, and therefore the usefulness of X2 as an indicator of estuarine condition.

Figure 2-1

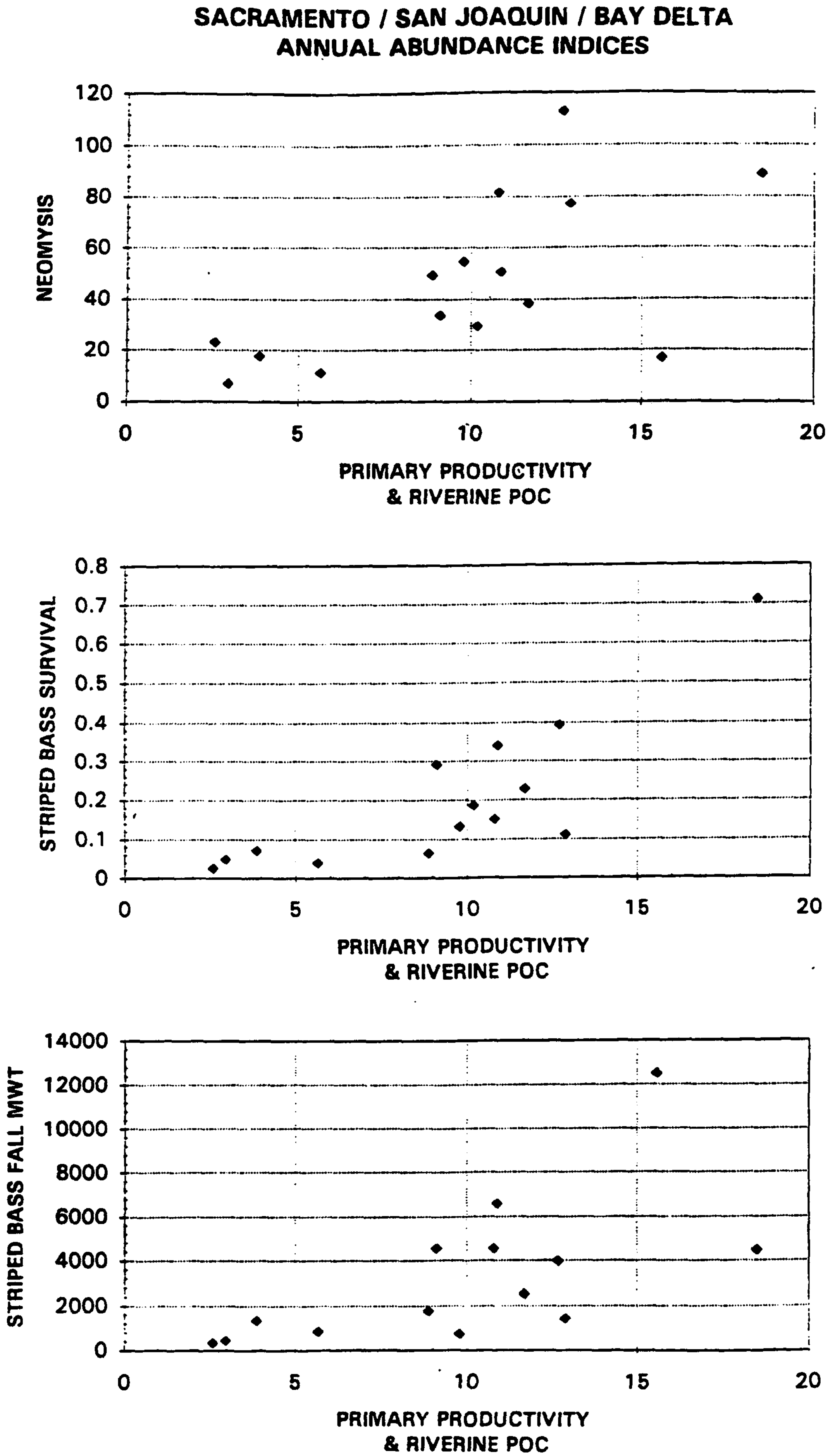

SACRAMENTO / SAN JOAQUIN / BAY DELTA
ANNUAL ABUNDANCE INDICES
NEOMYSIS
120
100
80
60
40
20
0
0
5
10
15
20
PRIMARY PRODUCTIVITY
& RIVERINE POC
STRIPED BASS SURVIVAL
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
PRIMARY PRODUCTIVITY
& RIVERINE POC
STRIPED BASS FALL MWT
14000
12000
10000
8000
6000
4000
2000
0
0
5
10
15
20
PRIMARY PRODUCTIVITY
& RIVERINE POC

Figure 2-2

SACRAMENTO / SAN JOAQUIN / BAY DELTA
ANNUAL ABUNDANCE INDICES

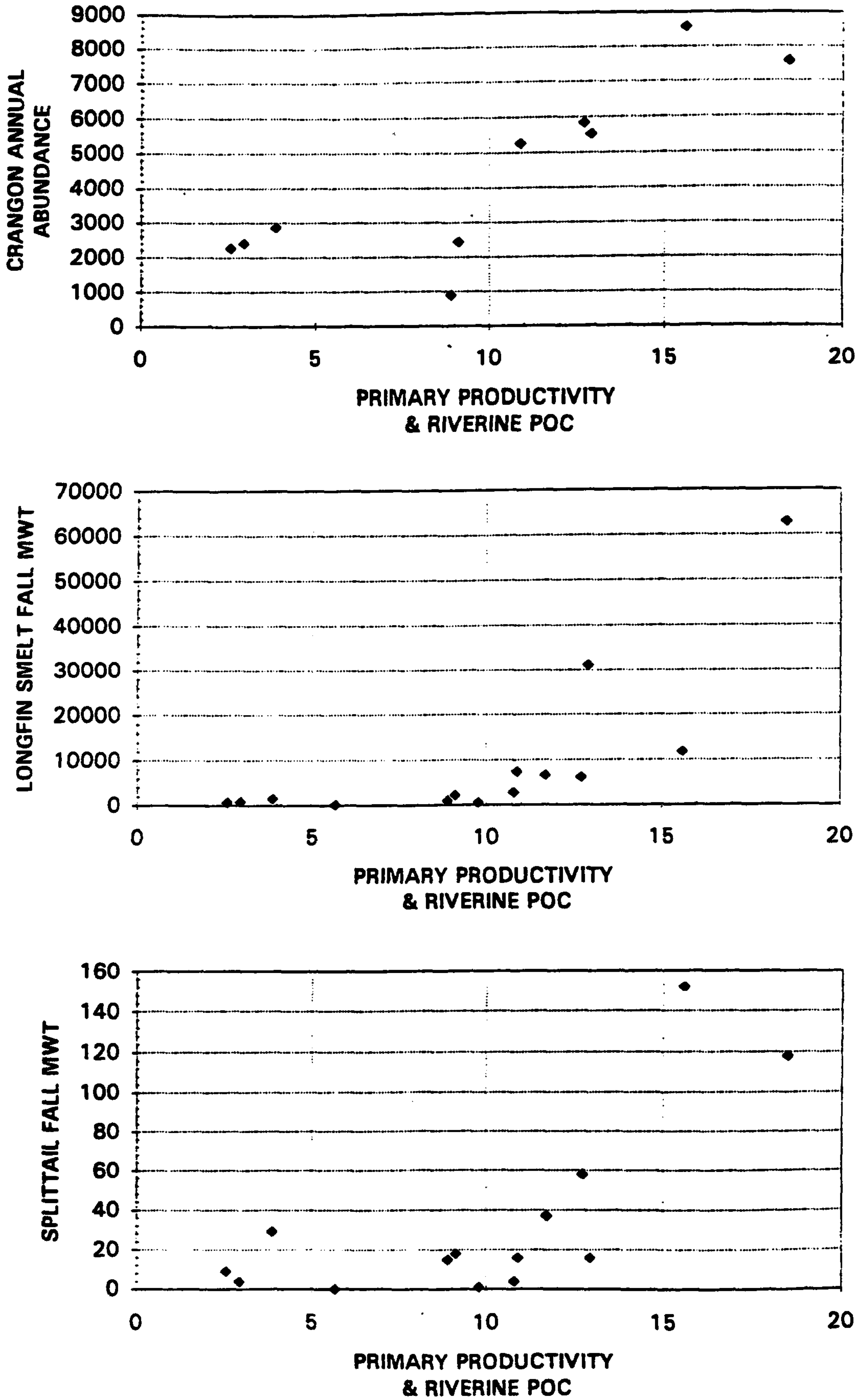
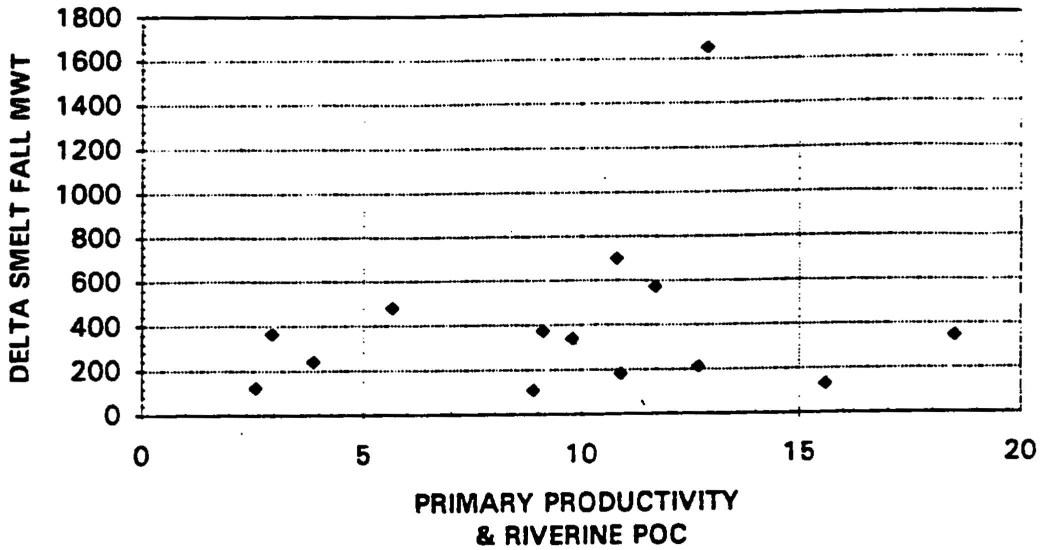
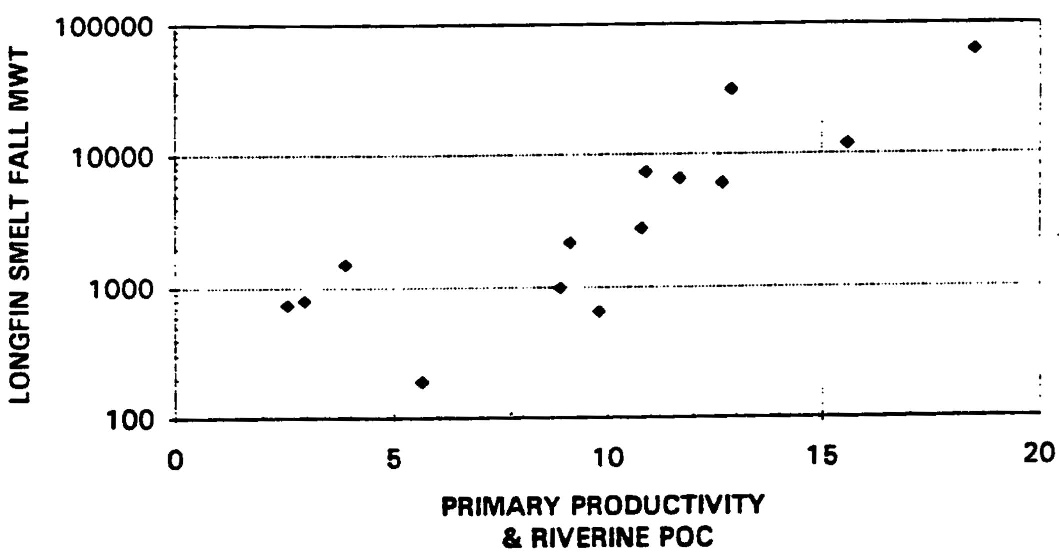


Figure 2-3

SACRAMENTO / SAN JOAQUIN / BAY DELTA ANNUAL ABUNDANCE INDICES





APPENDIX 3

The relative contribution of riverine and locally-derived particulate organic carbon in Suisun Bay. Note that riverine particulate organic carbon contributes less than 50% of organics to the estuary at flows under 10,000 cfs, but rapidly becomes the dominant source of organic carbon thereafter. This suggests that transport of nutrients is an important feature of higher outflows. Note also that locally-derived organic carbon declines with high outflows, suggesting a flushing of nutrients to San Pablo Bay at higher outflows.

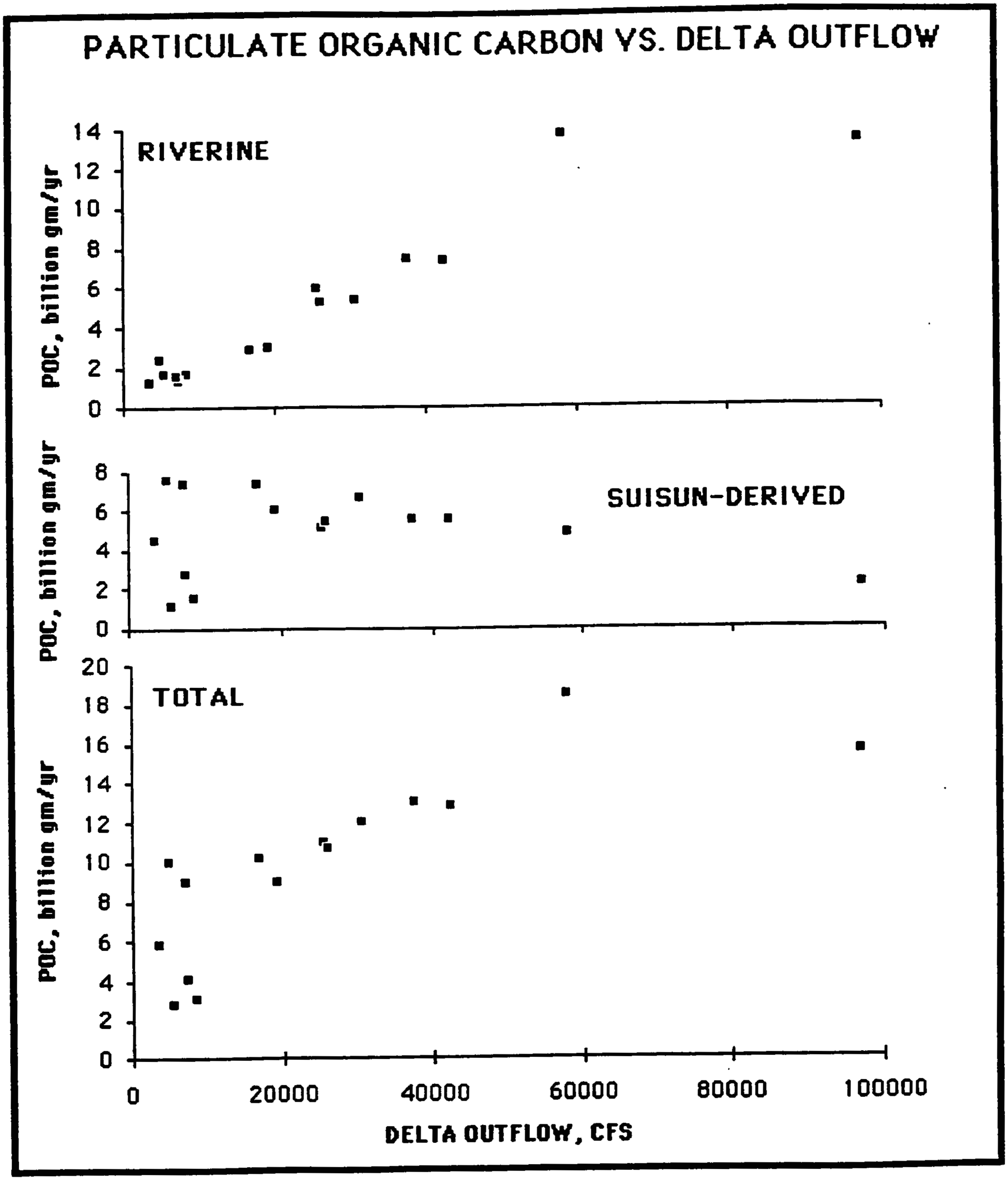


Figure 3-1

Relationship Between Particulate Organic Carbon ("POC") and Delta Outflow (Jassby et al., 1993)

APPENDIX 4

Some representative indicators of sampling bias in the Fall Midwater Trawl sampling program: delta smelt.

a. In Figure 4-1, note that there is a clear peak in catch efficiency when river discharge is at about 25,000 cfs. This suggests that catch can be influenced by outflow.

b. In Figure 4-2, note that there is an apparent bias in sampling of delta smelt in the river km 80 to river km 95 area; more smelt are caught in the morning.

c. In Figure 4-3, note that the relationship between surface electroconductivity and delta smelt catch changes when it is corrected for sampling effort.

These types of sampling bias may not be systematic enough to make their correction possible at this time, but they add to the uncertainty over the usefulness of the various abundance indices over a wide range of predicted conditions.

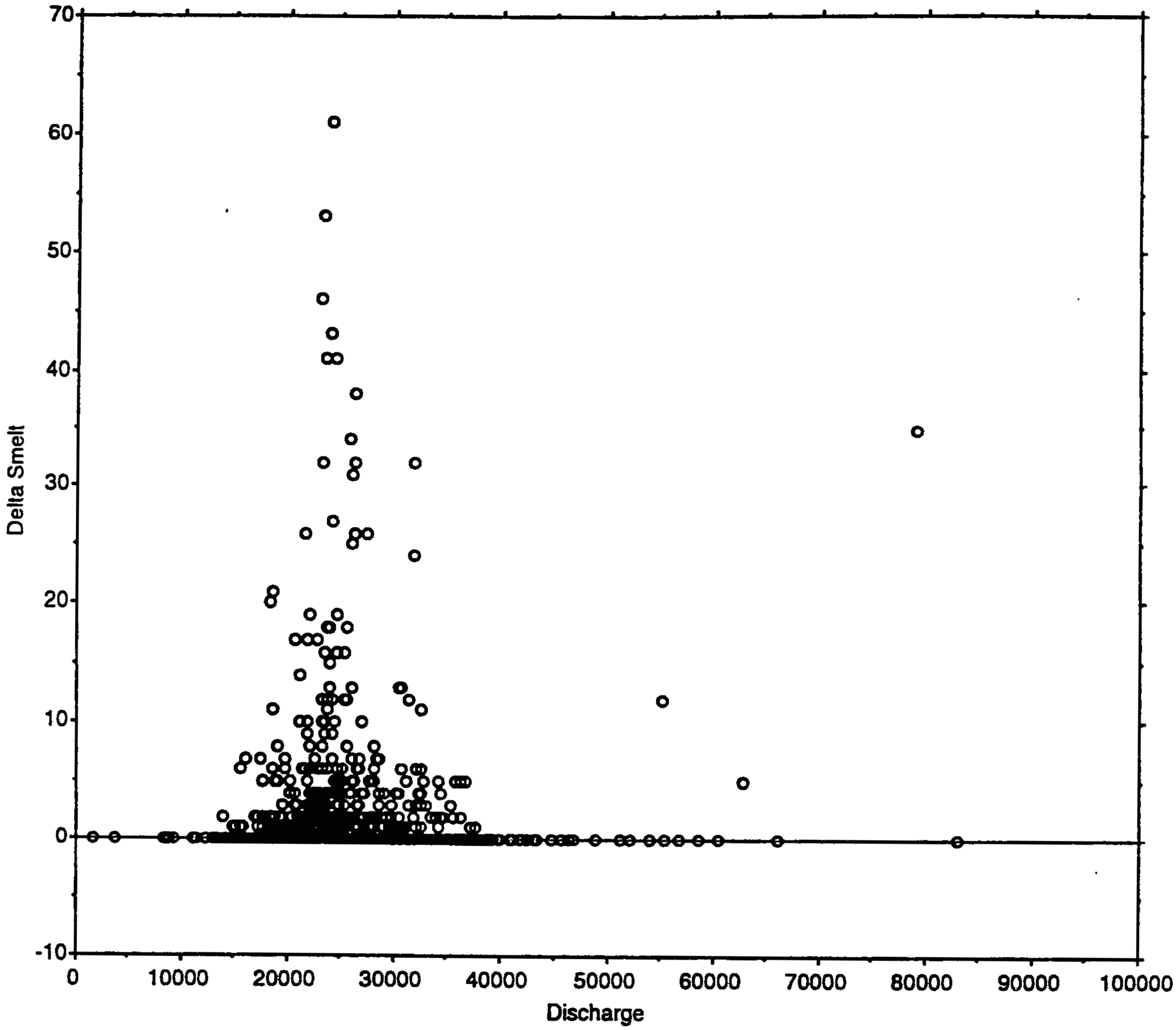


Figure 4-1. Catch abundance of delta smelt by volume of water (meter reading) sampled in midwater trawl (source: CFG midwater trawl study).

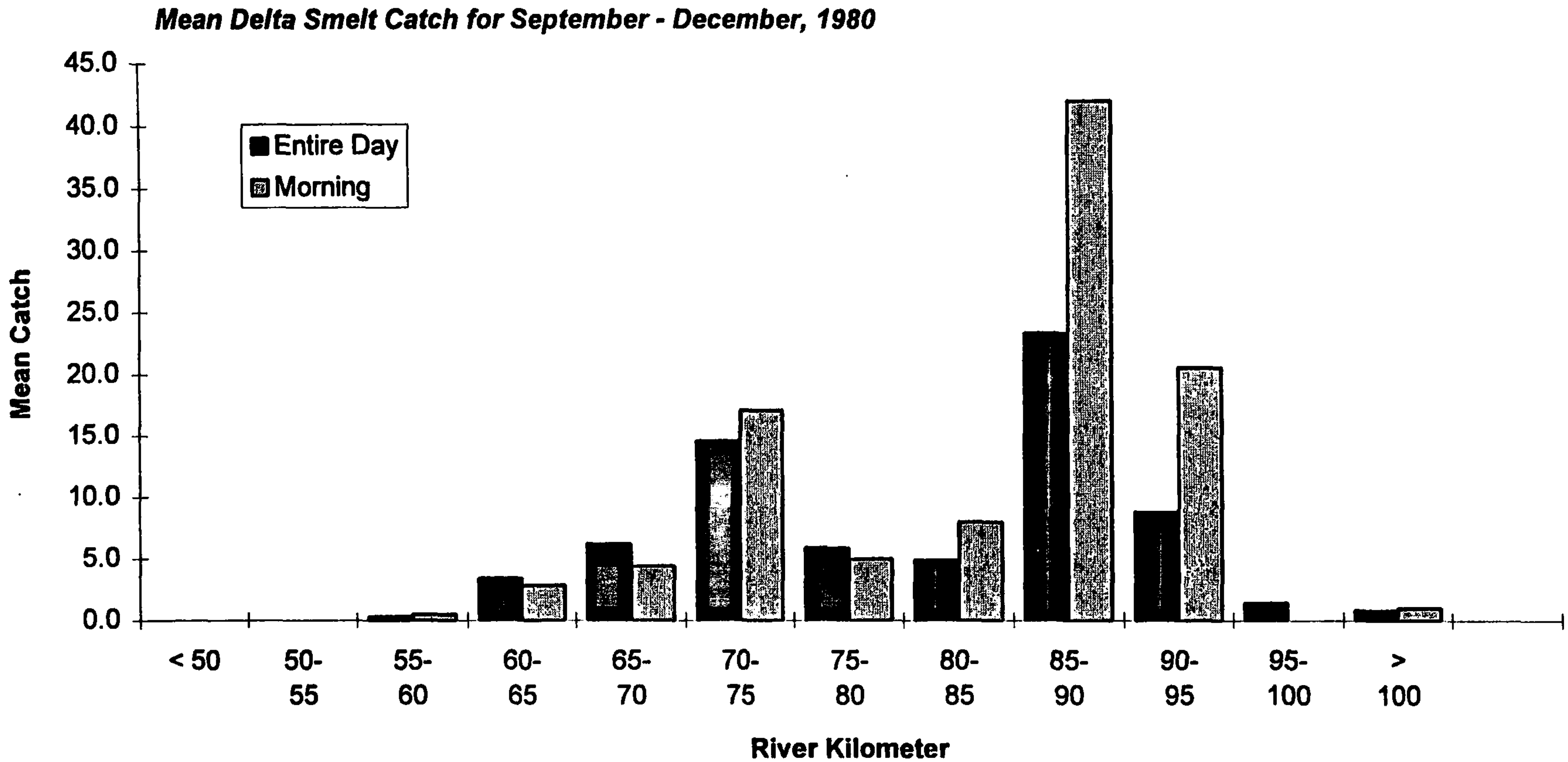


Figure 4-2. Mean delta smelt catch abundance for September, 1980 for entire day of sampling and for morning (before 10:00 am) only (source: CFG midwater trawl data).

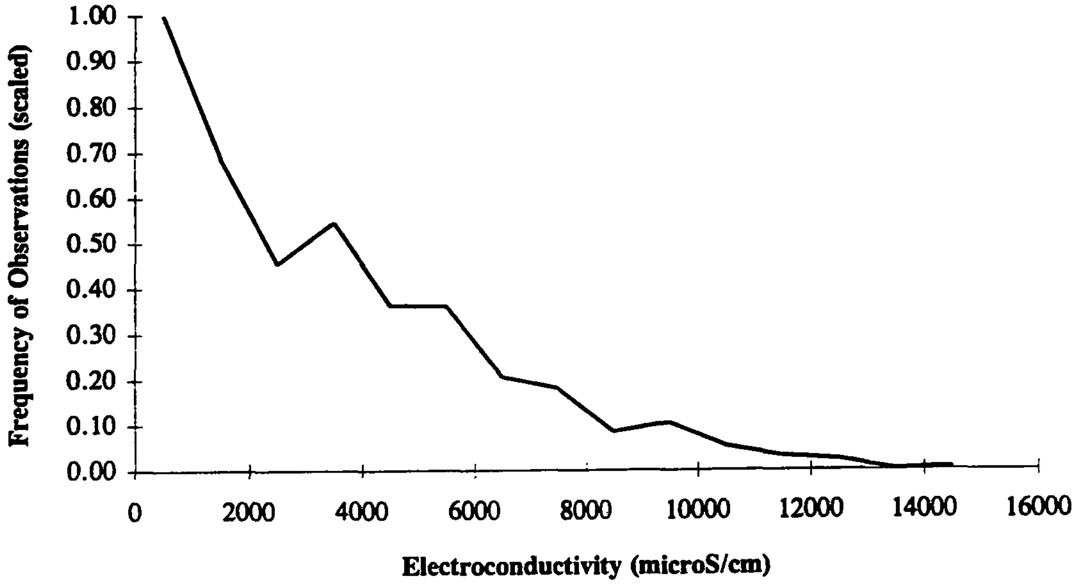


Figure 4-3. Delta smelt abundance frequency curve for electroconductivity prior to adjusting for sampling effort, September 1967-92 (source: CFG fall midwater trawl).

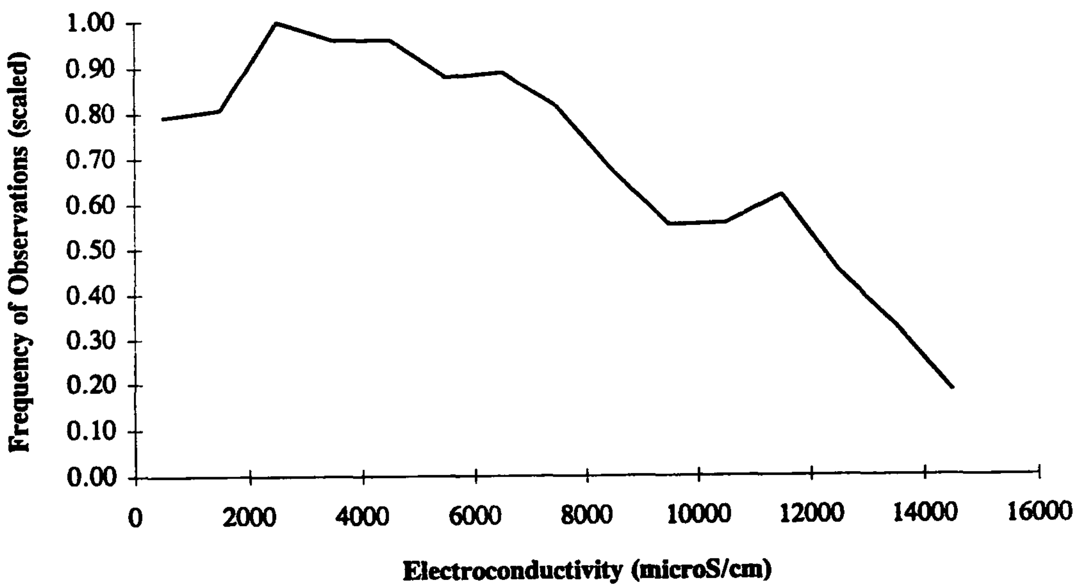


Figure 4-4. Delta smelt abundance frequency curve for electroconductivity after adjusting for sampling effort, September 1967-92 (source: CFG fall midwater trawl).

APPENDIX 5

X2 vs abundance for a suite of estuarine and marine species in Suisun Bay and San Pablo Bay (r^2 is a measure of how much variability in the dependent variable is accounted for by the independent variable). Note the low predicted response to X2 for species not considered by SFEP (Jassby 1993), the inability to fit a model to the X2/abundance relationship for 5 species (including delta smelt), and the inverse relationship between several estuarine species and movement of X2 downstream. This analysis suggests that X2 is not as strong a predictor of estuarine ecosystem conditions as it is of conditions favorable to the particular suite of indicators selected by the SFEP in their analysis.

Table 5. Summary Statistics for the Relationship Between Abundance Indices and the Location of X2 During the February to June Period

INDICATOR	R^2	SLOPE[1]
Jassby et al. 1994		
Bay Shrimp	0.86	
Longfin Smelt	0.79	
Opossum Shrimp	0.62	
POC	0.72	
Starry Flounder	0.58	
Striped Bass Survival	0.35	
Striped Bass MWT	0.72	
Others		
American Shad	0.36	
California Splittail	0.51/0.61[2]	
Chinook Salmon	0.36	
Delta Smelt	NM[3]	
Inland Silversides	0.16	—
Jacksmelt	0.17	
Northern Anchovy	0.43	
Pacific Herring	0.27	
Threadfin Shad	NM	—
Topsmelt	NM	—
White Croaker	NM	
White Sturgeon	NM	

[1] A minus sign (—) indicates that abundance decreases as X2 moves downstream. Otherwise, the reverse is true.

[2] The first-listed value was fit using weighted least squares in TableCurve and the second-listed value using generalized linear models.

[3] All fitted models and coefficients are individually statistically significant at the 0.05 level. NM indicates that a well-behaved model could not be fit to the data.

APPENDIX 6

Results of correlations between abundance indices and the number of days during which X2 was at or downstream of Chipps Island vs Roe Island (increases in r^2 from Chipps to Roe are an indication of a continuing benefit to be derived from moving X2 downstream; decreases suggest that there is no incremental benefit from moving X2 downstream). Note that only some of the indicators used by SFEP have an apparent incremental benefit from location of X2 at or downstream of Roe Island. In short, most of the benefit from an estuarine habitat standard may be gained by location of X2 at or downstream of Chipps Island.

Table 6-1. Comparison of biological benefits of locating X2 at or below Roe Island and Chipps Island.

	NUMBER OF DAYS X2 IS LOCATED			
	at or below Roe Island </= 64 km		at or below Chipps Island </= 74 km	
INDICATOR	Slope[1]	r^2	Slope	r^2
Crangon franciscorum	48	0.94*	38	0.76*
Delta Smelt	0.37	0.13	0.27	0.08
Longfin Smelt	12	0.56*	2.1	0.11
Neomysis mercedis	0.33	0.27*	0.35	0.39*
POC	0.065	0.56*	0.061	0.63*
Splittail	0.012	0.13	0.013	0.23*
Striped Bass MWT	7.1	0.40*	3.8	0.31*
Striped Bass Survival	0.0019	0.35*	0.0017	0.39*
Starry Flounder	0.34	0.37*	0.26	0.28

[1] AU/days = number of abundance units per number of days that X2 is downstream of the compliance point.

* An asterisk indicates that when a straight line is fit to the data, the overall regression is significant at the 0.05 level.

APPENDIX 7

Turbidity readings vs outflow for areas in the Suisun Bay (the lower the value of the Secchi disk reading, the more turbid the water). Note the highest turbidity occurs between 10,000 and 20,000 cfs, when X2 would be near Chipps Island; further note that turbidity in areas 12, 13, and 14 (Suisun Bay, see Figure 7-1) does not increase significantly for higher flows.

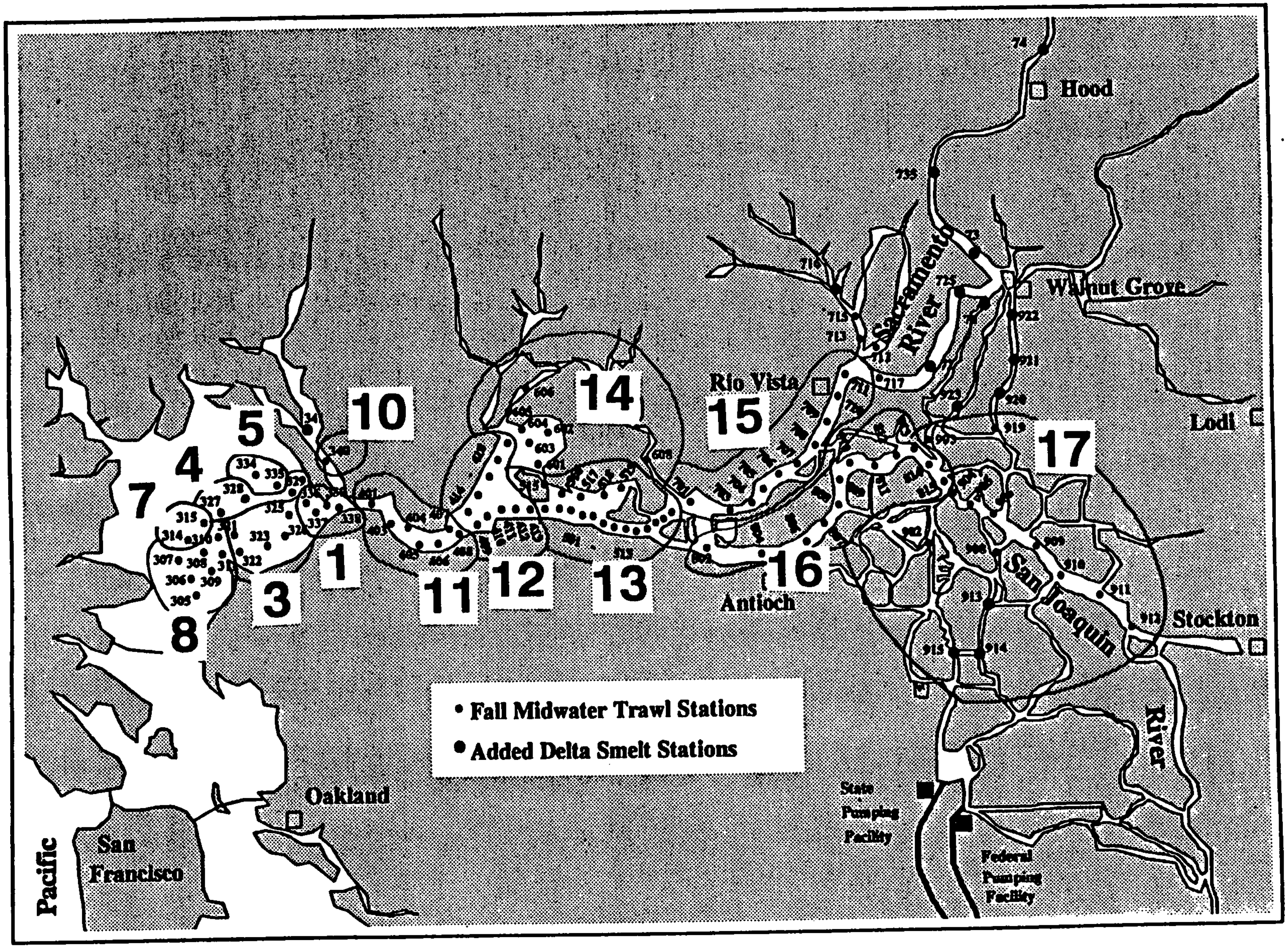


Figure 7-1 **Stations and Subareas Used in the Fall Midwater Trawl.**

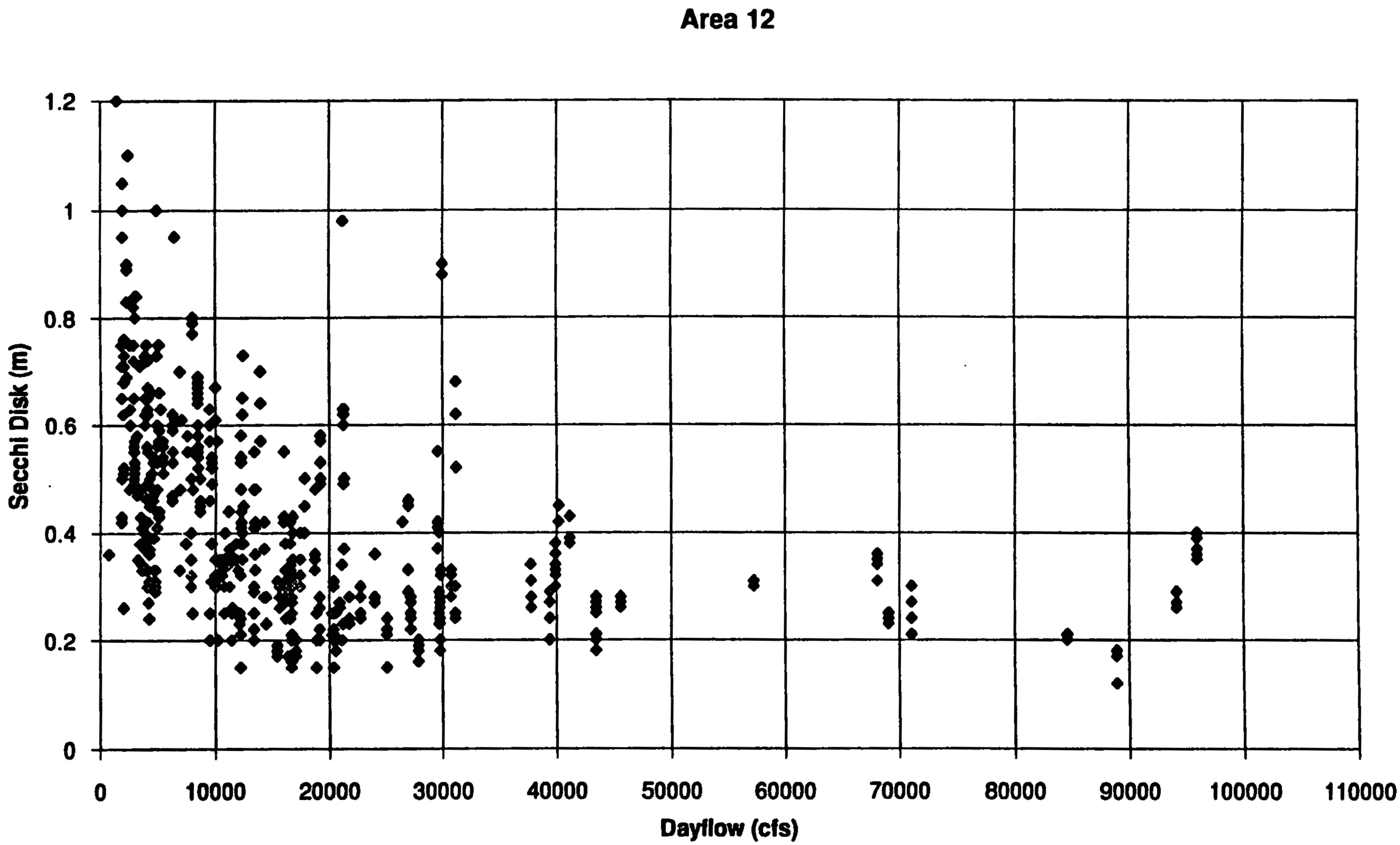


Figure 7-2. Turbidity vs dayflow, Area 12.

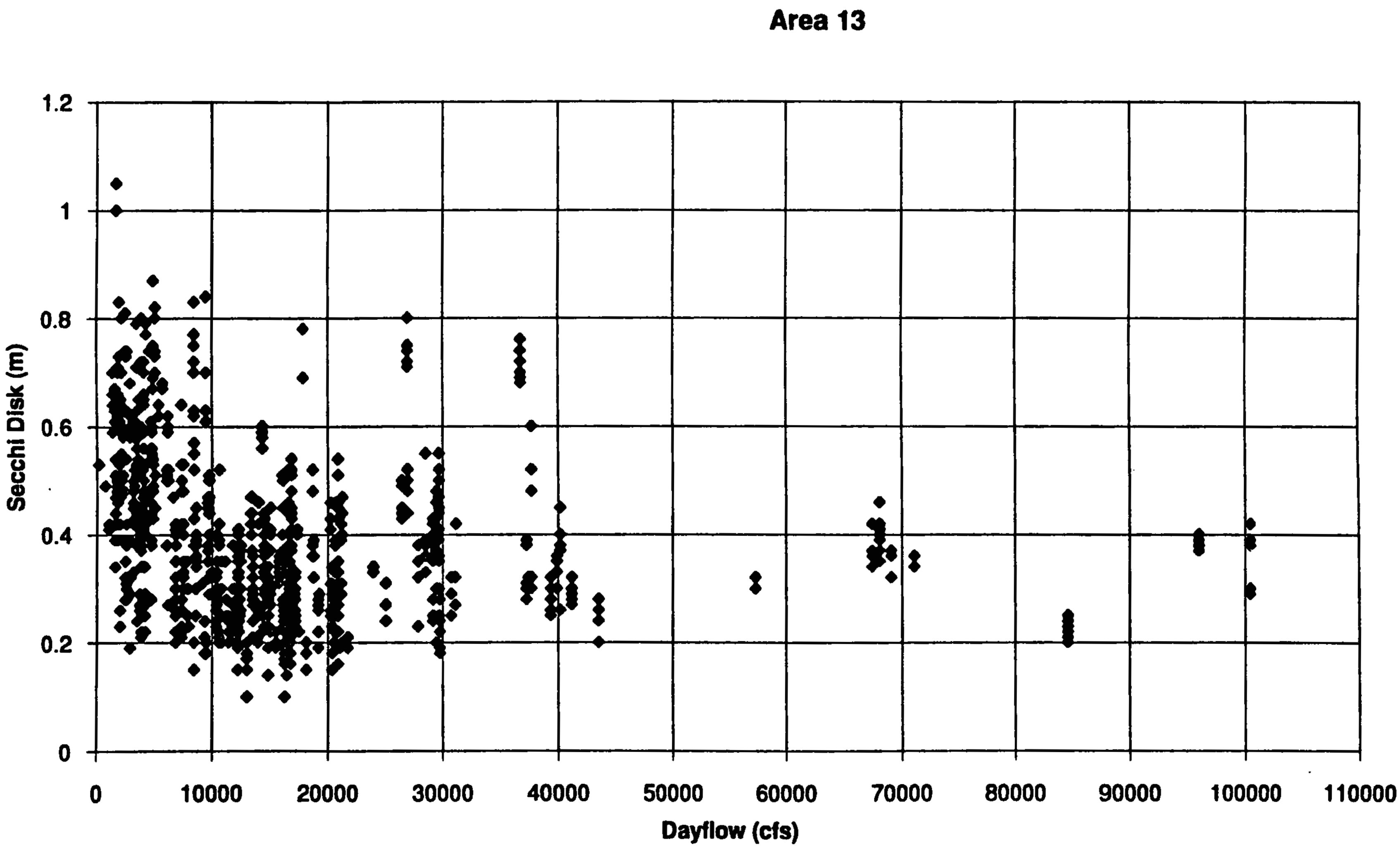


Figure 7-3. Turbidity vs dayflow, Area 13.

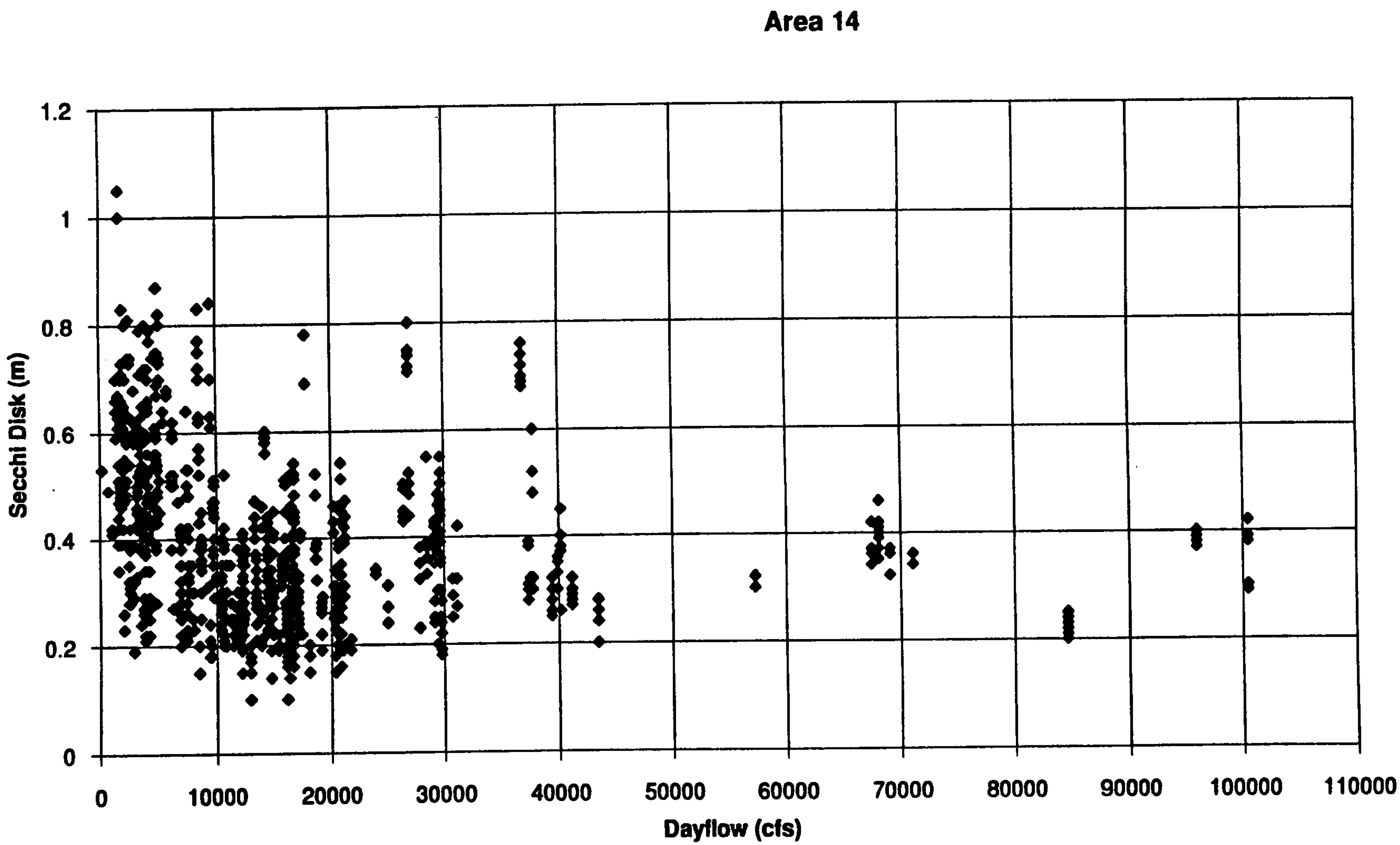


Figure 7-4. Turbidity vs dayflow, Area 14.

APPENDIX 8

Analysis of potential impacts of the Chipps and Roe Island standards, based on the amount of preferred salinity habitat, determined on a longitudinal basis, for each of 41 species which utilize the estuary (some brackish water species, some marine species), based on habitat preference analysis from National Marine Fisheries Service.

Note that the *potential* for adverse impacts, based on an analysis of habitat availability, increases for the Roe Island location of X2. This casts further doubt on the value of an X2 standard as a measure to protect the general condition of the estuary, further suggesting that the suite of species analyzed by SFEP was too narrowly defined to give a picture of general estuarine condition.

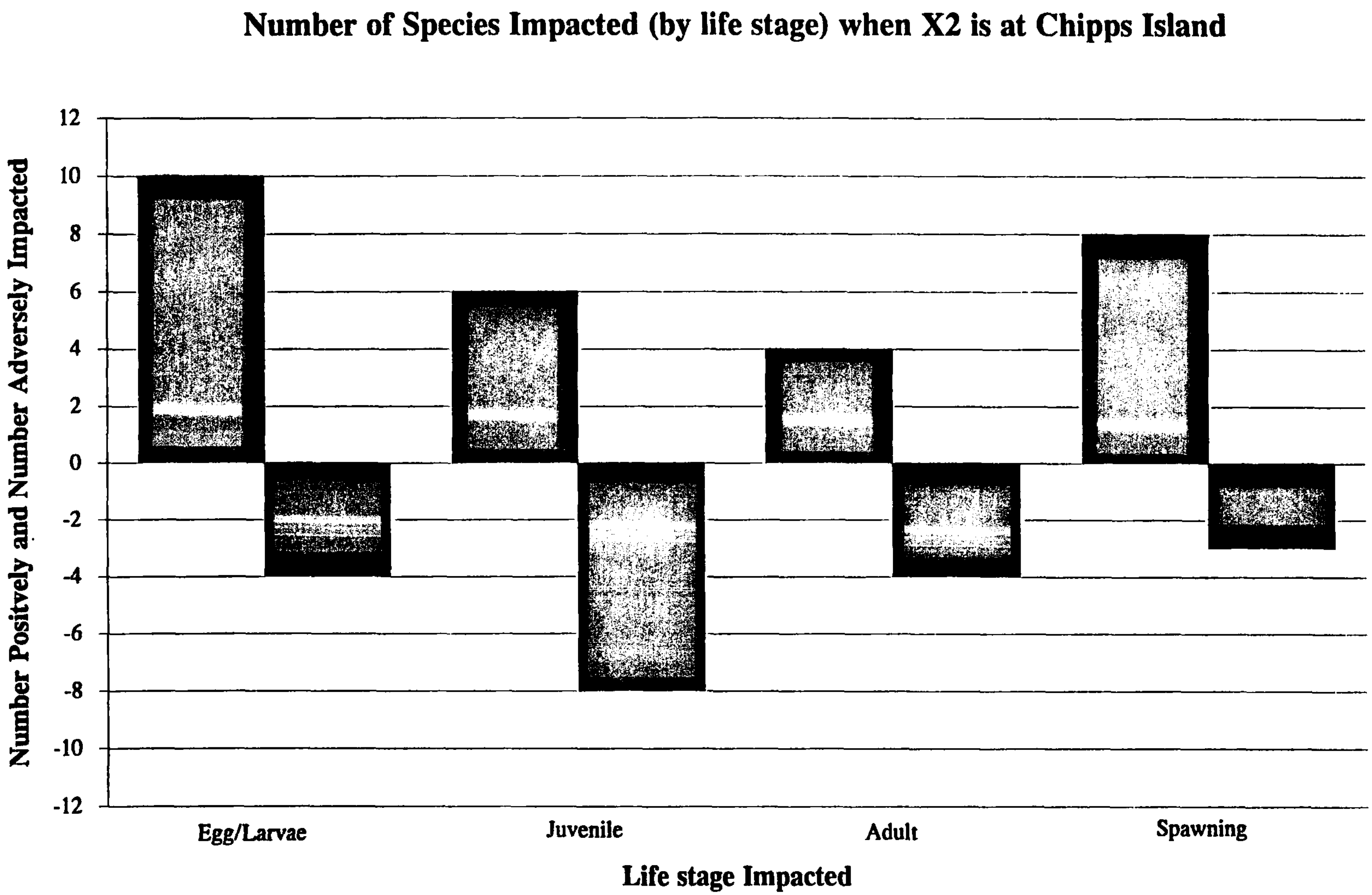


Figure 8-1. Number of species beneficially and adversely impacted (by life stage) under the Chipps Island Operational Scenario.

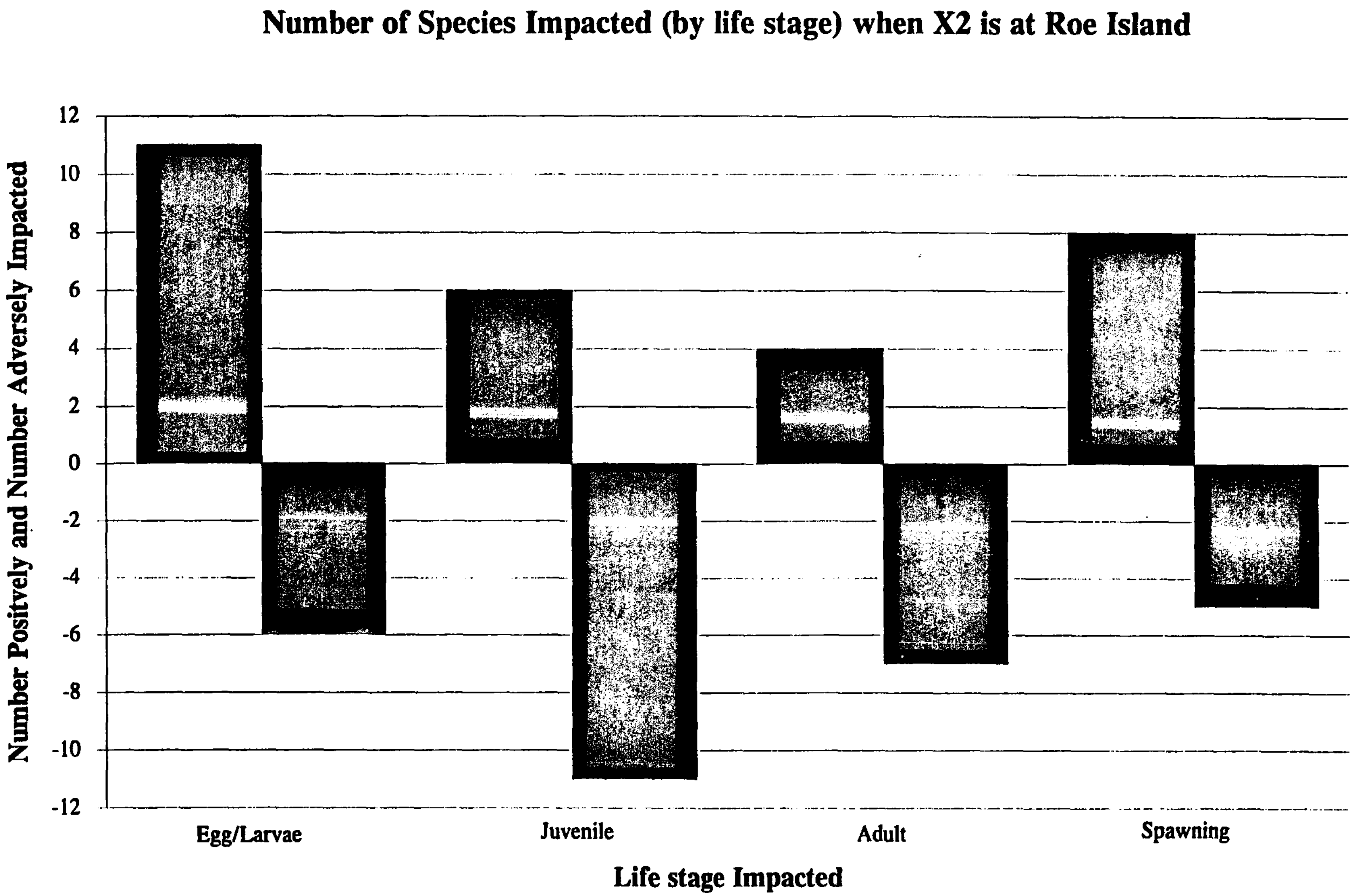


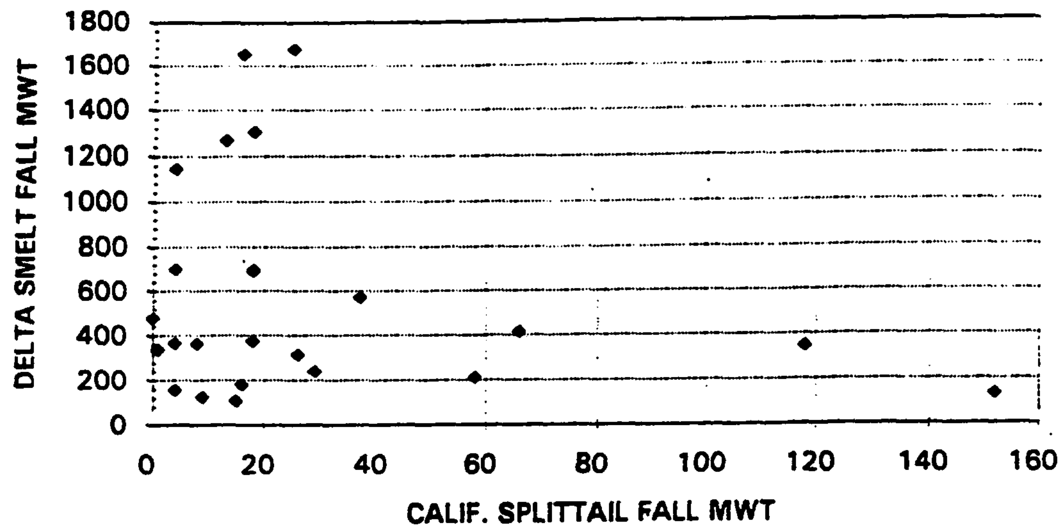
Figure 8-2. Number of species beneficially and adversely impacted (by life stage) under the Roe Island Operational Scenario.

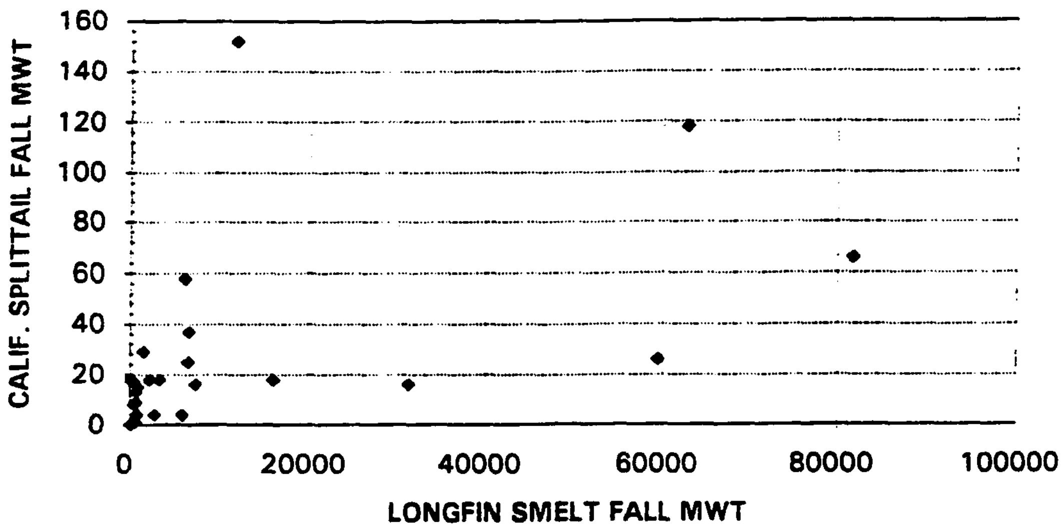
APPENDIX 9

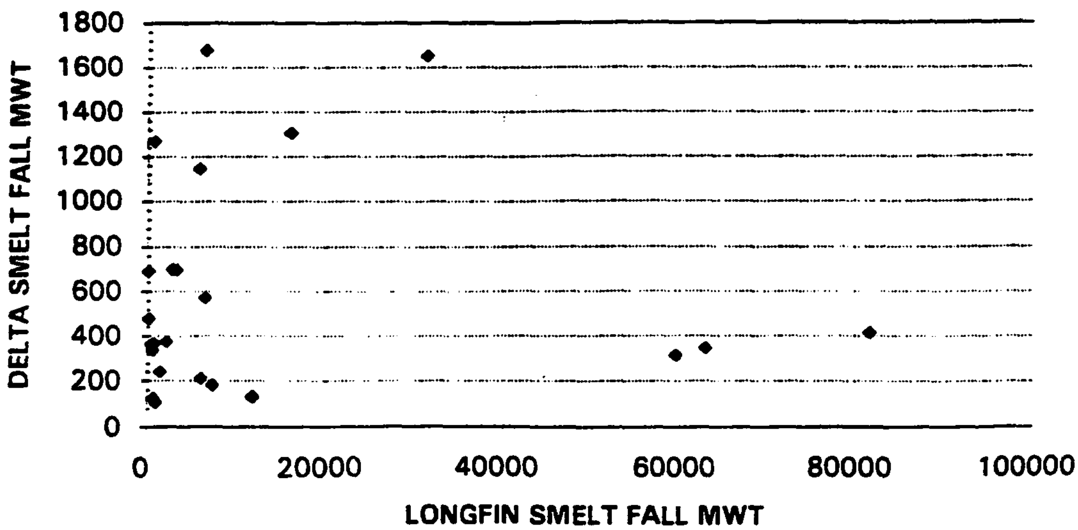
Comparison of the abundance of several estuarine species. Note that the shape of most of the graphs suggests that when one species is abundant, the other species evaluated is not. Conditions which favor one species may therefore be hypothesized to disfavor the other. This analysis suggests that variability in application of a standard which requires consistency in the location of X2 may favor one species over another, while a standard which permits greater within-year variability may provide a better balance of conditions.

Figure 9-1

SACRAMENTO / SAN JOAQUIN / BAY DELTA ANNUAL ABUNDANCE INDICES







APPENDIX 10

Data from the CUWA water cost analysis from Reference 13 (see references below):

a. Calculation of the number of days when X2 would have been at or downstream of the three compliance points proposed by EPA for the period 1930-1992.

b. Weighted least squares regression of days at X2 during various periods of record and the corresponding Sacramento River Index for the EPA-proposed regulatory period.

2.2. Historical Perspective on X2 Attainability

An analysis was performed using two different methodologies to determine the number of days the X2 standards (treated as an equivalent surface EC of 2640 μS/cm) were met historically for the period, 1930-1992, at Port Chicago, Chipps Island, and Collinsville. The first methodology used Denton's antecedent flow-salinity relations (discussed in chapter 4) to determine salinity as a function of time at the three stations. The second methodology used the X2 equation (discussed in chapter 4) to determine X2 as a function of time. In both cases, historical DAYFLOW estimates of net Delta outflow were used. The historical number of days the X2 standards were met are given in table 2.2.1.

	Port Chicago		Chipps Island		Collinsville		Annual
Water Year	Gave days	X2 days	Gave days	X2 days	Gave days	X2 days	40/30/30 Index
1930	72	91	144	143	150	150	5.90
1931	0	0	73	70	101	98	3.66
1932	127	145	151	151	151	151	5.48
1933	18	0	150	150	150	150	4.63
1934	19	16	101	100	120	113	4.07
1935	131	150	150	150	150	150	6.98
1936	140	149	151	151	151	151	7.75
1937	135	137	150	150	150	150	6.87
1938	150	150	150	150	150	150	12.62
1939	19	0	103	102	130	126	5.58
1940	132	141	151	151	151	151	8.88
1941	150	150	150	150	150	150	11.47
1942	150	150	150	150	150	150	11.27
1943	135	142	150	150	150	150	9.77
1944	41	22	143	142	151	151	6.35
1945	114	135	150	150	150	150	6.80

Water Year	Port Chicago Gave days	Port Chicago X2 days	Chipps Island Gave days	Chipps Island X2 days	Collinsville Gave days	Collinsville X2 days	Annual 40/30/30 Index
1946	127	132	150	150	150	150	7.70
1947	41	26	110	109	145	141	5.61
1948	91	81	146	139	151	151	7.12
1949	72	74	141	140	150	150	6.09
1950	103	119	150	150	150	150	6.62
1951	109	123	146	146	150	150	9.18
1952	151	151	151	151	151	151	12.38
1953	101	115	150	150	150	150	9.55
1954	113	117	139	139	150	148	8.51
1955	0	0	118	104	150	144	6.14
1956	142	151	151	151	151	151	11.38
1957	53	50	146	145	150	150	7.83
1958	150	150	150	150	150	150	12.16
1959	41	39	79	79	118	115	6.75
1960	33	34	121	111	137	132	6.20
1961	38	19	87	86	135	132	5.68
1962	67	68	143	137	150	150	6.65
1963	108	125	150	150	150	150	9.63
1964	7	8	74	71	142	140	6.41
1965	95	124	150	150	150	150	10.15
1966	20	33	113	110	129	123	7.16
1967	145	150	150	150	150	150	10.20
1968	54	49	81	81	122	120	7.24
1969	150	150	150	150	150	150	11.05
1970	58	68	91	97	148	144	10.40
1971	57	68	150	150	150	150	10.37
1972	0	0	64	62	93	88	7.29
1973	69	82	124	123	150	146	8.58
1974	96	119	150	150	150	150	12.99
1975	84	105	150	150	150	150	9.35
1976	0	0	0	0	63	52	5.26
1977	0	0	0	0	0	0	3.09
1978	114	125	141	142	150	150	8.65
1979	44	47	121	108	143	137	6.67
1980	77	93	151	151	151	151	9.04
1981	19	0	79	76	133	108	6.21
1982	137	150	150	150	150	150	12.72
1983	150	150	150	150	150	150	15.29
1984	60	68	92	89	151	151	10.00
1985	0	0	39	31	110	99	6.47
1986	84	85	139	138	150	150	9.93
1987	0	0	51	30	96	91	5.83
1988	0	0	7	0	52	28	4.63
1989	24	0	45	37	111	104	6.13
1990	0	0	0	0	38	9	4.81
1991	5	0	34	14	54	37	4.21
1992	11	0	48	41	83	78	4.07

Table 2.2.1. Number of days X2 standards were met using: (1) Denton's antecedent flow-salinity relations; (2) Kimmerer-Monismith X2 equation.

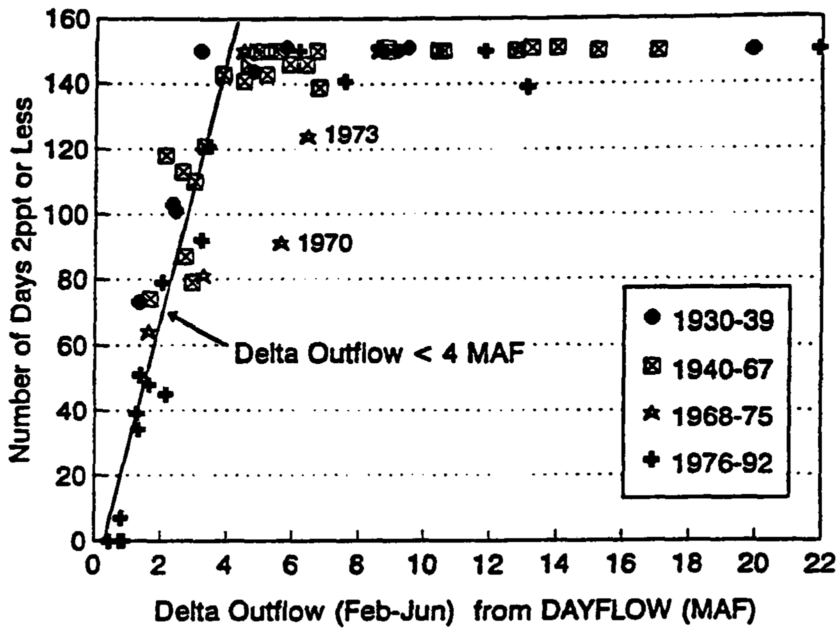


Figure 2.2.5. Relation between the number of X2 days at Chipps Island and the February-June net Delta outflow for the period, 1930-1992.

2.2.3 Sliding Scale Approach to X2 Standards

EPA has recommended a level of protection for San Francisco Bay and the Delta similar to that which existed during the late 1960s and early 1970s. In developing the X2 standards, however, EPA used a longer period, 1940-1975, to determine the X2 day requirements for specified year types. This longer period was deemed necessary to ensure sufficient data for the analysis. EPA used the 40-30-30 Sacramento River Index to categorize water years into one of five water year types (wet, above normal, below normal, dry, and critical) and averaged the data within each category. In essence, EPA's methodology reduced the data from 36 years to four points: the average number of X2 days during wet, above normal, below normal, and dry years (the period, 1940-1975, contained no critical years).

It is recognized that the 40-30-30 index, which was developed as part of the SWRCB D-1630 process to define water year availability over a full water year (October-September) may not be representative of the salinity regime in Suisun Bay for the period, February-June; e.g. the 40% component of the 40-30-30 index is the sum of monthly unimpaired runoffs for April-July and July runoff cannot affect salinity in the previous period, February-June. Similarly, unimpaired runoff in October, November, and December that is not stored in upstream reservoirs will not significantly effect salinity in the February-June period. EPA has considered using other indices than the 40-30-30 index to define the X2 day requirements (Issue #1, USEPA 1994, p.834). One alternative EPA has considered is to modify the 40-30-30 split of the April-July runoff, October-March runoff, and the previous water year's index. A somewhat better approach may be to use the sum of the monthly runoffs for the period, February through June, as this most directly affects salinity in the Delta and Suisun Bay. This index may be further refined by including January to account for antecedent effects of outflow on salinity and/or including an additional factor to account for carryover storage in upstream reservoirs at the end of January.

To determine appropriate X2 day requirements historical X2 attainability may be plotted versus the February-June runoff index. This enables analysis of periods such as 1955-1975 (21 points), 1964-1975 (12 points), or 1968-1975 (8 points) to address EPA's Issue #5 (USEPA 1994, p.839) which deals with the determination of the appropriate historical reference period for developing target number of X2 days. Figure 2.3.1 shows X2 days at Roe Island for a period compatible with the required level of protection, 1968-1975, along with a least squares linear fit. The data plotted in figure 2.3.1 and in figures 2.2.2 to 2.2.4 suggest that since a simple linear equation reasonably fits the data use of a higher order polynomial appears unwarranted. Also shown in figure 2.3.1 are the number of X2 days required under the proposed X2 standards. There is some overlap in required number of days because the water year types for the proposed standards are based on the 40-30-30 index rather than a February through June runoff index. The proposed X2 standards tend to require significantly greater number of days of compliance than the least squares linear fit through the 1968-1975 data.

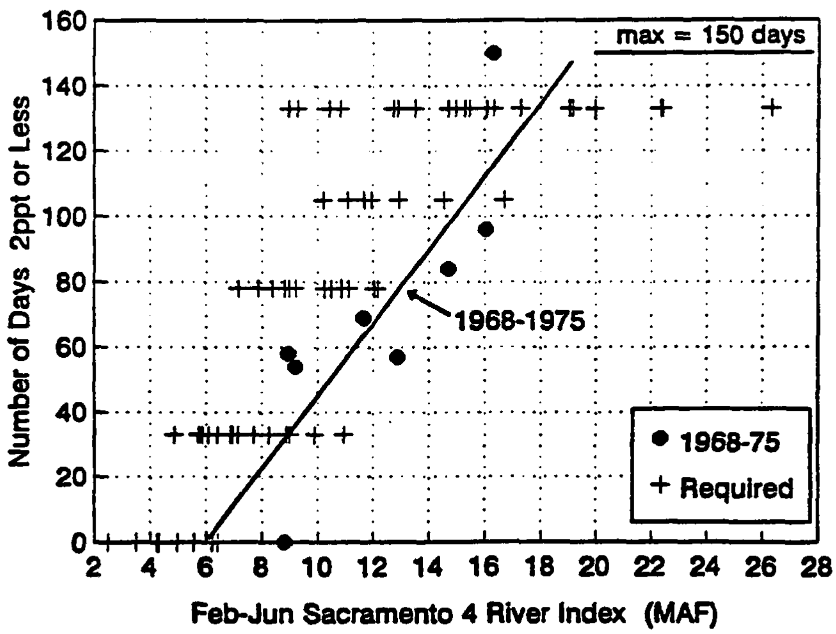


Figure 2.3.1. Number of X2 days at Roe Island for the period, 1968-1975. The solid line represents a least squares linear fit through the data. The crosses represent the required number of days under the EPA-proposed X2 standards.

Figure 2.3.2 shows the number of X2 days at Chipps Island for the period, 1968-1975, along with a least squares linear fit. Data for which the February through June index was greater than 14 MAF were not included in the least squares linear fit since they were at the maximum number of days (150 days). EPA's extrapolation to set a critical year standard (the period 1940-1975 used by EPA contains no critical years) appears to have overstated the necessary level of protection at Chipps Island. The linear fit through the 1968-1975 data shown in figure 2.3.2 suggests that very few days of 2 ppt or less would be required at Chipps Island during critical years for appropriate protection. The proposed below normal and above normal year X2 day requirements also appear to be overstated.

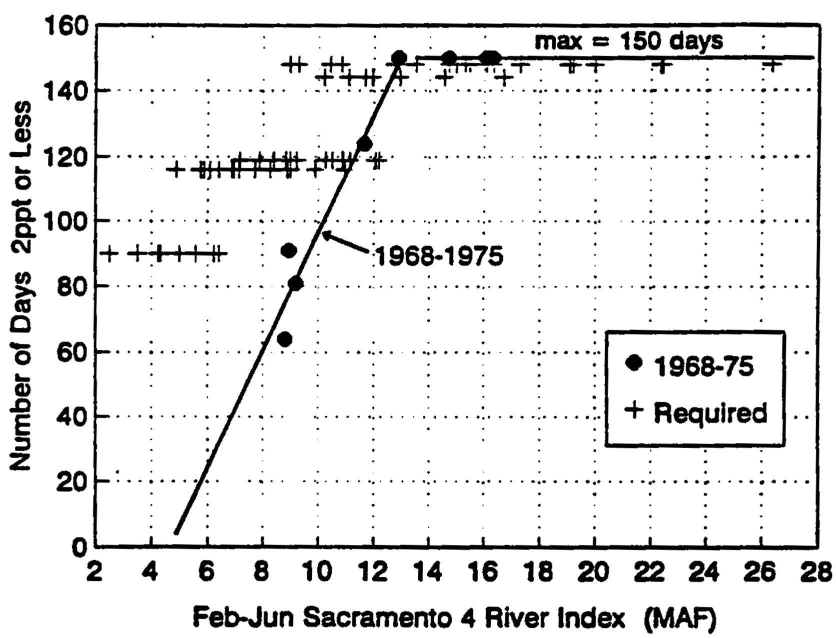


Figure 2.3.2. Number of X2 days at Chipps Island for the period, 1968-1975. The solid line represents a least squares linear fit through the data for values of the February-June Index less than 14 MAF. The crosses represent the required number of days under the EPA-proposed X2 standards.

Figures 2.2.2, 2.2.3, and 2.2.4 indicate that the least squares linear fits are sensitive to the choice of historical period. Figure 2.3.3 shows X2 days at Chipps Island for the period, 1955 through 1992, with linear fits for the periods, 1955-1976, 1968-1975, and 1968-1992. Prior to

1968 (pre-SWP) there were fewer diversions upstream of the Delta and less exports and the number of days of X2 compliance were correspondingly higher. The linear fit for 1955 through 1976 therefore reflects the correspondingly higher ratio of Delta outflow to unimpaired runoff relative to the period, 1968-1975. It is interesting to note that including the period, 1976 through 1992, with the period of desired level of protection, 1968-1975, results in only a small change to the least squares linear fit.

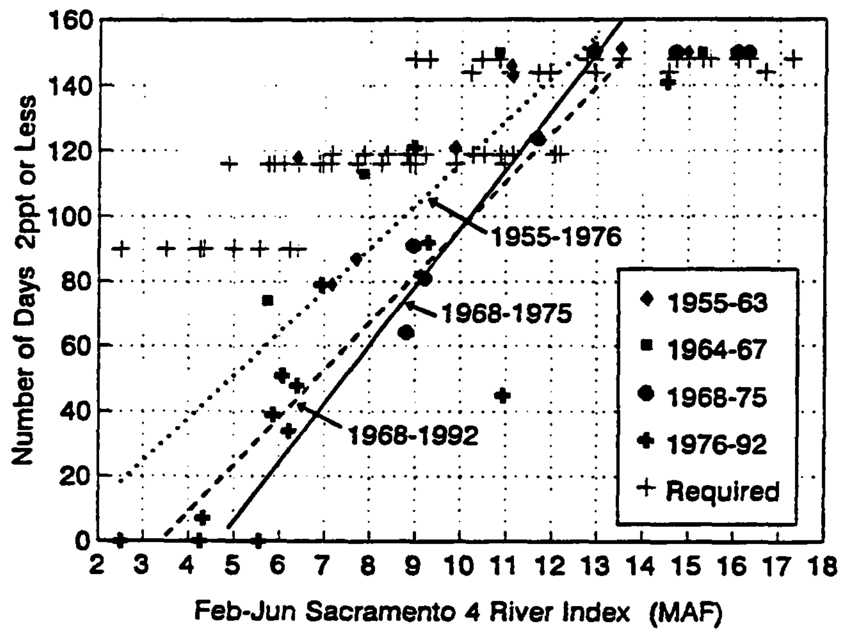


Figure 2.3.3. Number of X2 days at Chipps Island for the period, 1955-1992. The solid line represents a linear fit through the data for 1968-1975; the dashed line represents a linear fit through the data for 1968-1992; the dotted line represents a linear fit through the data for 1955-1976.

The proposed X2 day requirement at Collinsville is 150 days for all water year types. Figure 2.3.4 shows the number of X2 days at Collinsville for the period, 1964-1992. There were only two years during 1968-1975 when the number of X2 days was significantly less than 150 days. However, the data from the longer period, 1964-1992, suggest that in critical years (beyond the range of conditions in the 1968-1975 period) some relaxation in the proposed X2 day requirements may be warranted.

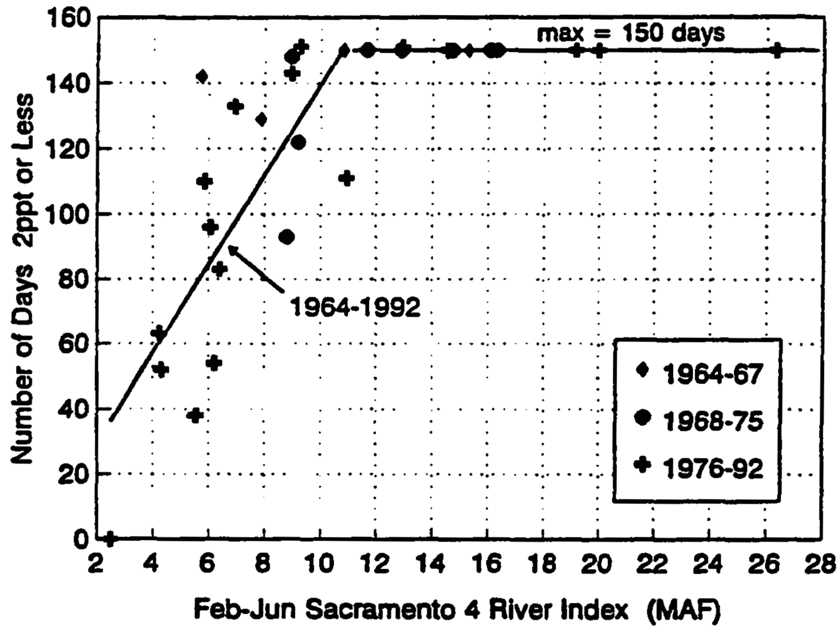


Figure 2.3.4. Number of X2 days at Collinsville for the period, 1968-1975.

In summary, the data presented in figures 2.2.1-2.2.5 and in figures 2.3.1-2.3.4 suggest that a sliding scale methodology based on linear fits to data for individual years provides an effective way to define day requirements for the X2 standard. An index based on the February-June Sacramento Four River Index appears to correlate well with the historical number of X2 days. Because the number of X2 days depends both on the runoff index and on the total amount of diversions from the system, an X2 standard based on a linear sliding scale equation would in effect impose a limit on the amount of total diversions from the whole watershed for the February-June period. While the period, 1968-1975, has been used to illustrate the sliding scale methodology, alternate periods may be selected, such as 1964-1976.

APPENDIX 11

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