Status and Protection Of The San Francisco Bay- Sacramento-San Joaquin Delta Striped Bass Population

Prepared by

Thomas Cannon
Four Pumps Committee

Prepared for

California Striped Bass Association

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Acknowledgements

Thomas Cannon, a member of and volunteer advisor to the California Striped Bass Association (CSBA), and CSBA's representative on the Four Pumps Mitigation Committee, performed this review. Mr. Cannon is an estuarine fisheries ecologist who began his study of striped bass in estuaries as the statistician and technical director of the Hudson River Estuary Ecological Studies from 1972-1977. He has been involved in the Bay-Delta from 1977 to the present. During his years on the Hudson River, he consulted on several occasions with CDFG scientists working on striped bass in the Bay-Delta. Pete Chadwick, DFG's lead Delta scientist, was a consultant to the Hudson River program. From 1977-1980 Mr. Cannon was project director of Bay-Delta ecological studies for PG&E's Bay-Delta power plants impact programs. From 1980-82, he was a consultant to the State Water Contractors, the National Marine Fisheries Service, the Electric Power Research Institute (ERPI), and State Water Resources Control Board determining the effectiveness of the D-1485 Bay-Delta Water Quality Standards in protecting the Bay-Delta ecosystem and striped bass population. From 1986-1987 he was a consultant to the State Water Contractors and US Bureau of Reclamation during the SWRCB hearings on water quality standards. From 1994-1995, he was a consultant to the State Water Contractors and the California Urban Water Agencies, working on the 1995 Bay-Delta Water Quality Standards and how the new standards would affect the Bay-Delta ecosystem and striped bass population. From 1995-2003 Mr. Cannon was a consultant to the CALFED Bay-Delta Program where he worked on various projects including the Ecosystem Restoration Program Plan (ERPP), the Delta Entrainment Effects Team (DEFT), the Tracy Technical Advisory Team (TTAT), the Environmental Water Account (EWA), and the Delta Cross Channel – Through Delta Facility (DCCTDF) evaluation team, where again potential effects on the striped bass population were a subject of interest. He prepared a comprehensive review of striped bass impacts from the south Delta pumping plants and potential effects on striped bass from a Through Delta Facility. In 2002 he participated in a DFG review of the status of the striped bass population. From 2002 to the present, Mr. Cannon has been involved in activities related to the Striped Bass Stamp Program including stocking and tagging striped bass, continuing coordination with DFG on striped bass issues, and most recently as CSBA's representative on the DFG/DWR Four Pumps Mitigation Committee.

Over the years Mr. Cannon has prepared numerous papers, reports, assessments, and presentations on Bay-Delta striped bass that were used as the basis of this review.

Preface

In the summer of 1959 the California Department of Fish and Game (DFG) began monitoring the abundance of fish and zooplankton invertebrates in Suisun Bay and the Delta. From the survey data DFG developed an index of abundance of young striped bass, which was the most important sport fish in the Bay-Delta then and to this day. Though the index and the supporting surveys were relatively crude and simple they proved to be effective measure as the proverbial canary in the coal mine when it came to the ecological health of the Bay-Delta estuary. DFG's Turner and Chadwick (1972) wrote a four-page paper published in the Journal of the American Fisheries Society that turned out to be a classic in estuary science because the authors were able to relate the simple index of the summer abundance of young striped bass to late spring and early summer freshwater flow through the estuary.

The paper had a profound effect on my colleagues and me studying the Hudson River, Chesapeake Bay, and other east coast estuaries in the native range of striped bass. Populations of striped bass in major coastal estuaries that numbered in the millions of adult fish that grew to over 50 lbs and 15 years or older were controlled in great part by the survival of the ¼ inch larvae in a small portion of the river estuaries in a short period of the late spring and early summer. Many of the surveys conducted by DFG in the Bay-Delta became the norm on east coast estuaries including the Hudson River where I was technical director of striped bass studies in 1974-75.

After several years of intense study on the Hudson River beginning in 1972 it became apparent that power plant entrainment of striped bass larvae was having a substantial effect on the striped bass population of the Hudson River and north Atlantic coast. Plans for new power plants on the Hudson River and other estuaries were soon scrapped and major alterations were made to existing plants' operations and facilities to reduce impacts to striped bass.

I came to California in 1977 to determine what role the PG&E power plants in the Bay and Delta had on the striped bass population. The Bay-Delta striped bass were unique in that they not only had major power plants in their nursery area to contend with, but the State Water Project (SWP) and the federal Central Valley Project (CVP) also controlled flows through the estuary especially in the spring and summer of drier years. The state and federal export pumps also diverted over half the water entering the Delta in some years.

My first observation at the PG&E power plants in the fall of 1977 was numerous tails of dead adult striped bass sticking out of dumpsters on the docks of the plants. It immediately brought back my experience on the Hudson River where pictures taken of similar dumpsters at Con Edison power plants by intrepid local environmentalists and New York Times reporters on night boat raids had contributed to the near collapse of Con Edison and the eventual change in the color of their service trucks from brown to blue. As PG&E already had blue trucks, I suggested that they find a better way (or at least less visible) to remove the striped bass collected on their trash screens. The striped bass collected on the trash screens, as was the case with Con Edison, had died long before reaching the scavenger trash screens. My first paper on the Hudson portrayed these adult fish as having a high incidence of parasites that indicated a weakened condition. It was obvious that a lot of what outwardly appeared to be healthy adult striped bass were dying in the Bay and Delta. Studies at the time indicated elevated levels of hydrocarbons like benzene from numerous Bay-area refineries collected in the tissues of the adult striped bass possibly affecting their immune systems and causing disease such as tape worm infestations and sores and lesions. DFG had observed this die-off in many years during the summer after fish returned from spawning in freshwater to saltwater. The State Water Resources Control Board and DFG's pesticide unit were looking into the problem. The National Marine Fisheries Service (NMFS) lab in Tiburon was also studying the phenomenon. The NMFS draft report came out a few years later indicating potential hydrocarbon pollution, but the report was never published and the lab was shut down. I had been working on testing striped bass for PCB's on the Hudson River. Tissue samples I collected in 1976-77 turned up high levels of PCB's and the Hudson's commercial and sport fisheries were subsequently shut down. To this day sportsmen cannot keep striped bass they catch in the Hudson because of the high level of PCBs in the flesh of the striped bass.

My focus in 1977 turned to the power plant entrainment effect on the young striped bass and putting that effect in perspective with similar effects from the south Delta pumping plants of the SWP and CVP, as well as thousands of unscreened agricultural diversions. Working closely with DFG over several years it became apparent that the loss of young striped bass to diversions was far greater than anything I had seen on the east coast. PG&E's plants were killing 10 percent or more. The south Delta plants were taking another 20-40 % and Delta agriculture was taking 10-20%. That was a lot for any population to sustain even for the prolific striped bass that each spawned 5 to ten times over as many years with 2 to 4 million eggs each time.

The following narrative and data synthesis picks up with the initial observed collapse of the striped bass population after the 1977 drought and the subsequent quest to determine what caused the collapse and efforts to improve water quality standards for the Bay-Delta to fix the problem. In the end after 25 years of study and debate, the story is a sad one for the striped bass and other fish populations for they are worse off with fewer protections today than in 1978. Though the ability to help the striped bass is severely limited by the Endangered Species Act, there are some protections mandated by law that are not being implemented that should be, within the restrictions of the striped bass biological opinion. Such protections could help maintain the small population remaining in the Bay-Delta, as well as the delta smelt and salmon populations.

Much of the review is presented in chronological order to give the reader a sense of the history behind management of the Bay-Delta striped bass population. Water management efforts in the 70's and 80's focused on the striped bass. More recently beginning with the 1995 Standards there has been less focus on striped bass, a reluctance to provide further striped bass protections despite laws that require it, and a subtle if not overt attempt to sacrifice striped bass protections for further protections for other species and increased water exports.

Summary

Striped bass, delta smelt, and San Joaquin tributary salmon populations that depend on the Sacramento-San Joaquin River Delta have declined as a consequence of spring and summer exports from the south Delta by State Water Project and Central Valley Project pumping plants. Evidence presented over the past 30 plus years by the California Department of Fish and Game and other federal and state resource agencies indicates that water quality standards (D-1485 and D-1641) for the Bay-Delta have not provided adequate protection for Delta fish populations. The California Bay Delta Authority (formerly CALFED) and the Central Valley Project Improvement Act (CVPIA) programs have also not provided sufficient protection for these fish populations. Biological opinions for pumping plant operations for the delta smelt and salmon have also not afforded adequate protection. Export losses of striped bass, delta smelt, and salmon have severely depressed young production and recruitment into adult populations, which has further resulted in lower adult population levels and lower subsequent young production. Annual exports have increased from 2 million acre-ft in the 1960's, to 4 million acre-ft in the 1970's, and to 6 million acre-ft in the 1980's. In 2001 and 2003 annual exports reached record annual levels of 6.3 million acre-ft. In 2003 June-July export reached a record 1.3 million acre-ft. Standard summer exports from the south Delta are now 10,000 cfs, the capacity of the two federal and state pumping plants. High spring-summer exports lead to reverse flows in the lower San Joaquin River, which results in the loss of over 50 % of larval and juvenile striped bass from the Delta. These losses directly affect recruitment of 3 yr-olds into the adult population and thus reduce subsequent adult spawning populations and egg production. Reductions in the spawning population directly translate into fewer young produced. Thus export losses are compounded as predicted by the Striped Bass Working Group enlisted by the State Water Resources Control Board in 1982 to study the striped bass decline. The 1986 Two-Agency Agreement between the Department of Fish and Game and the Department of Water Resources that governs the operation of the State Water Project pumping plant in the south Delta should be renegotiated to provide added protections to striped bass, delta smelt, and San Joaquin salmon. Export limitations as originally agreed upon by DFG and DWR in the 1982 Two-Agency Agreement but not adopted should be considered to protect the fish populations. Reverse flows in the lower San Joaquin River should not be allowed in spring and early summer. New fish protections facilities and improved salvage systems should be implemented at the south Delta pumping plants to reduce the loss of fish. Fish restoration funds should be focused more toward improving survival of Delta fishes. Finally, project operations and protection facilities once directed toward protecting striped bass and over the past decade redirected toward other fish and increased water export, should be redirected to provide protections guaranteed striped bass by the CVPIA and state laws. Such protections will also benefit the delta smelt and San Joaquin salmon populations.

Introduction

This review is a synthesis of existing information on the San Francisco Bay – Sacramento San Joaquin Delta striped bass population for the purpose of determining if the population is receiving adequate protections from existing water quality standards, water project operating agreements, and mandated ecosystem restoration and mitigation programs. The review picks up with the initial evaluations of the D-1485 Bay-Delta Water Quality Standards (1978 Standards) and continues through the more recent reviews of the 1995 Standards and restoration actions and protections of the Central Valley Project Improvement Act (CVPIA), California Bay Delta Authority (CBDA/CALFED), Tracy Mitigation Agreement, Striped Bass Stamp Program, and the California Department of Fish and Game (DFG) and California Department of Water Resources (DWR) 1986 Two-Agency Fish Agreement.

The review starts with information reviewed, evaluations, and arguments developed by the Striped Bass Working Group commissioned by the California State Water Resources Control Board (SWRCB) during 1981-1982. The review continues through similar evaluations in 1986-1987 and again in 1994-1995 during SWRBC hearings on water quality standards. The review includes later evaluations made by the CALFED Delta Entrainment Effects Team (DEFT) in 1998-1999, and Delta Cross Channel Through Delta Facility (DCCTDF) evaluations in 2000-2001. I also show that it is not just the striped bass population that has had problems, but also the delta smelt and San Joaquin salmon populations. Finally, I bring the review up-to-date with more recent survey and index information from 2002-2004 by the Interagency Ecological Program (IEP) and DFG Delta Fisheries Program. Throughout the review, papers, testimony, and reports published over the years are referenced. All the data included in this review was obtained from the website databases of IEP and DFG.

The recollections, data analysis, and opinions presented in this review are mine, and not the agencies or their scientific staff unless specifically referenced.

The Problem Becomes Apparent

A serious decline in the striped bass population became apparent by the end of the 1970's nearly a decade after the Banks Pumping Plant[1] of the State Water Project came on line in 1968. The Bay-Delta striped bass population was in period of sharp decline that appeared to begin in 1977 (Figures 1 and 2), though some scientists believed the decline had actually begun earlier in the 1970's coincident with the first high SWP exports particularly in June and July (Figure 3).

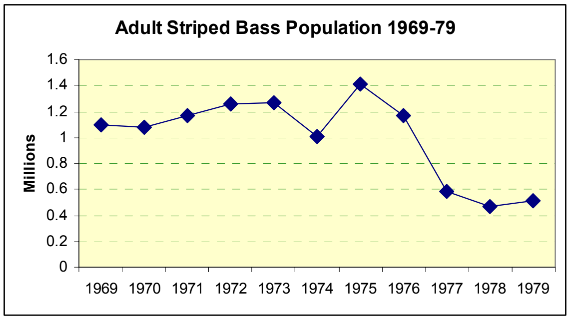

Figure 1. Adult striped bass population estimates from adult tagging study. Estimate includes 4 year old and older fish.

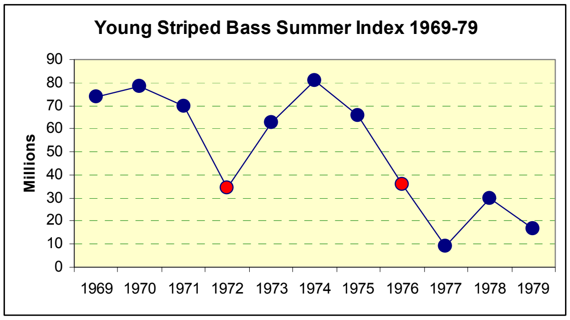

Figure 2. Young striped bass summer index from townet survey. Estimates approximate the relative abundance of 38-mm young. A popular explanation for the low 1972 index (red dot) was the Andrus Island break in June 1972. The 1976 index was considered low because of drought conditions. The 1977-79 indices were thought to be low because of a combination of drought and low adult abundance.

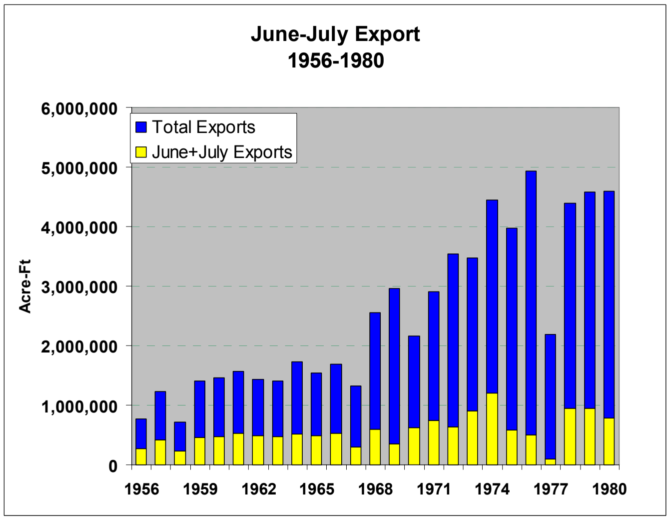

Figure 3. Delta exports from 1956-1980. The SWP came on line in 1968 with an initial doubling of exports to near 3 maf. From 1974-1980 the average was over 4 maf. June-July exports doubled from about 0.5 to near 1 maf (from an average of about 4,000 cfs to near 8,000 cfs).

[1] The Banks Pumping Plant was completed in 1968. With seven units, its pumping capacity is 6,400 cubic feet per second. In 1991, four more units were added, boosting total capacity to 10,300 cfs. The federal Tracy Pumping Plant constructed in 1954 has a 4,600 cfs pumping capacity.

D-1485 Standards – 1978

New water quality standards were adopted in 1978 to protect striped bass and other uses. The striped bass criteria were primarily minimum monthly-averages for Delta outflow (Table 1) and average monthly export limitations in spring and early summer (Table 2). In addition there were standards for April Delta salinity and outflow to protect striped bass spawning. To the surprise of many, the standards failed to provide expected benefits in the form of an improved striped bass production index based on DFG regression models (Turner and Chadwick 1972).

Table 1. Spring and summer minimum average monthly Delta outflow (cfs) for striped bass survival and Neomysis protection.

Year Type	May 6-31	June	July
Wet	14,000	14,000	10,000
Above Normal	14,000	10,700	7,700
Below Normal	11,400	9,500	6,500
Subnormal Snowmelt	6,500	5,400	3,600
Dry	4,300	3,600	3,200
Critical	3,700	3,100	2,900

Table 2. Spring and summer maximum average monthly exports (cfs) for striped bass survival and Neomysis protection.

Facility	May	June	July
SWP	3,000	3,000	4,600
CVP	3,000	3,000	4,500
Total	6,000	6,000	9,100

The Problem Appears Unresolved –1982

After the striped bass production index failed to respond as anticipated from 1978-1981 (Figures 4 and 5). DFG and the SWRCB became concerned that the D-1485 standards were not sufficient to protect the striped bass. DFG and DWR set their hopes on the Peripheral Canal to solve the problems, but attempted to improve upon D-1485 standards in the interim before the canal was built with a Two-Agency Agreement on the operation

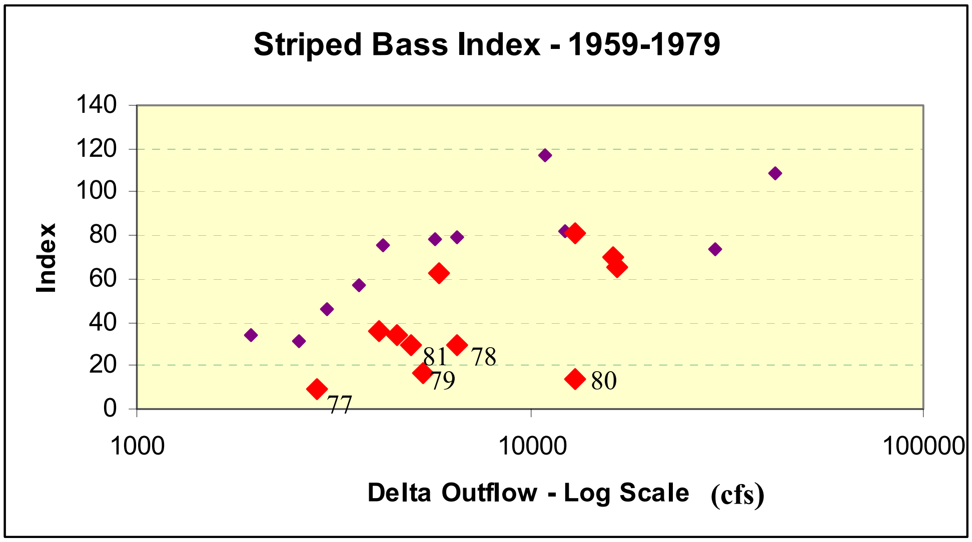

Figure 4. Striped bass summer townet index for the period 1959-1981 versus average June-July Delta outflow in cfs. Small diamonds are the original 1959-1970 Turner and Chadwick (1972) data on which the relationship was first developed. Large red diamonds are the 1971-1981 survey indices with 1977-81 indicated.

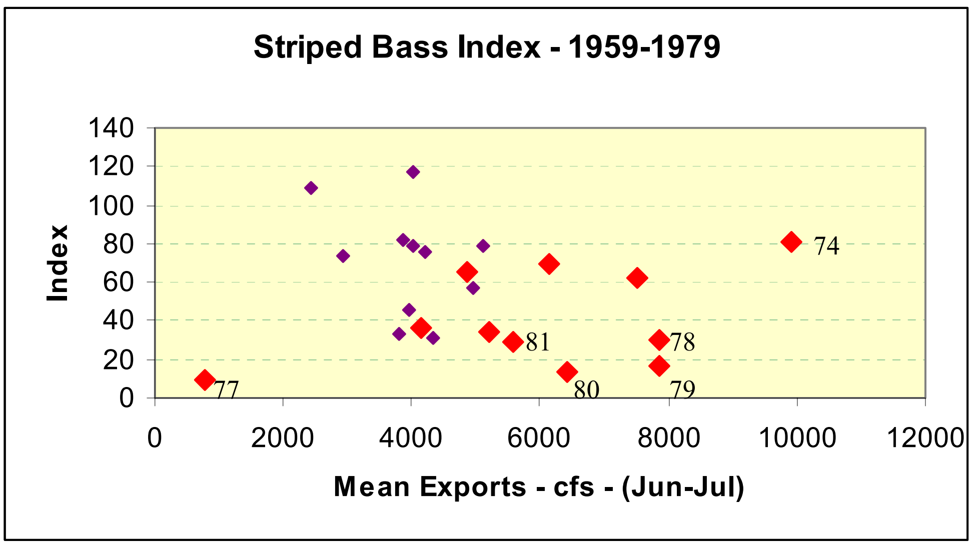

Figure 5. Striped bass summer townet index for period 1959-1981 versus south Delta exports. Small diamonds are the original 1959-1970 data (missing 1966). Large diamonds are for 1971-1981 period. Year 1977 was considered an outlier because of the extreme drought conditions. Year 1974 is an outlier as it had nearly 30,000 cfs Delta June-July inflow compared to 16,000-20,000 for 1978-1981.

of the SWP in 1982. The SWRCB assembled a team of scientists that had experience with striped bass in the Bay-Delta to review the available information and determine the cause of the decline. Summaries of these evaluations follow.

Draft Two-Agency Agreement – 1981-82

DFG and DWR began to negotiate an agreement to operate the SWP in such a way as to preserve and enhance fish and wildlife, and meet contractual responsibilities for the delivery of water. Their goals included maintaining fish populations at average 1970-1981 levels until such time that a Peripheral Canal could be built and the goal could be raised to historical levels. Their objectives included providing suitable environmental conditions for young fish and their food supply and minimize Delta SWP diversions of young fish and their food supply. While most of the agreement focused on defining "historical levels" for goals with the Peripheral Canal and operating constraints with a Peripheral Canal, there were Delta outflow and export provisions that applied to "existing" conditions that they hoped would improve upon D-1485 standards.

Minimum spring and summer Delta outflows for striped bass and Neomysis protection in the draft agreement were defined as in D-1485 with one important exception. DFG attempted to change the monthly average provision to a 10-day average provision because outflows tended to decline in spring months while exports increased (Figure 6), leaving potentially extreme high export rates and low outflow periods near the end of the months[2]. DWR agreed, if the 10-day average limit were 50 percent of the Delta outflow standard.

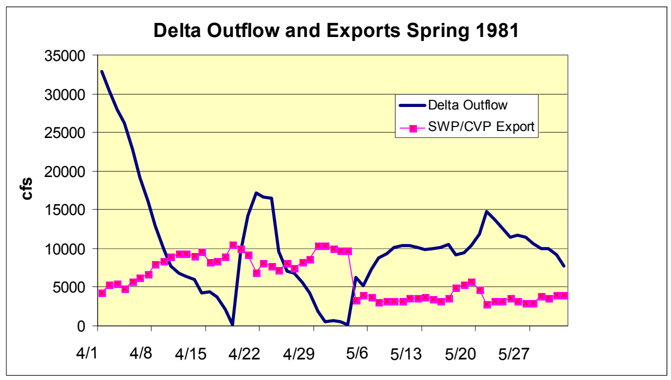

Figure 6. The standards for April under D-1485 were monthly average Delta salinity (EC) and outflow levels, which allowed the extremes of 1981 outflow and export. Uncontrolled outflow in early April could be averaged out by allowing virtually zero outflows under maximum exports later in April when flows were controlled by reservoir releases. The outflow standard increased on May 6 and the export standard dropped to 3000 cfs on May 1. The conditions before May 6 were likely devastating to the lower San Joaquin striped bass spawn for which the standards applied. For a more detailed review of these specific events see Appendix Figure A-1.

Instead of adopting the D-1485 export limits (Table 2), the draft agreement limited SWP exports to no more than 2000 cfs when Delta outflow was less than 15,000 cfs when some regulated supply was needed for export, nor more than 3,000 cfs when unregulated supply was available in May and June of all but wet years where the limit was raised to 5,000 cfs. The limit on July exports in D-1485 was dropped. Though complicated (and confusing) these criteria provided additional protections in specific cases (10-day average outflow specifications).

[2] This phenomenon had also occurred in 1978 and 1979 (Cannon 1982a) and subsequently continued until 1995 when the 1995 Water Quality Standards did away with monthly average export and outflow conditions.

The draft agreement included three additional changes to the D-1485 standards:

1. Critical year May outflow standard in Table 1 was changed to 3,300 from 3,700 cfs.
2. Dry years following dry or critical years were to have outflow standards defined for critical years.
3. Allow for closure of the DCC in May and June for short periods to reduce cross Delta movement of striped bass, **<u>but only if Delta outflow exceeded 12,000 cfs</u>**.

May and June export limitation in D-1485 (Table 2) would be changed from a monthly average 3,000 cfs to a weekly average pumping limit of 5,000 cfs in wet years unless DFG found this to cause excessive loss of young bass. When releases from storage (beyond minimum flows) are required to meet standards and exports in May and June, then the SWP export limit would be reduced from 3,000 to 2,000 cfs. The DFG/DWR (1982) report stated that this would lead to increased May exports and lower June exports, which they stated would be a net benefit for striped bass.

DWR and DFG prepared a draft and final environment impact report on their proposed Two-Agency Agreement in 1982 and final environmental report on the State Water Quality Control Plan to amend DWR and USBR water rights permits (DWR/DFG 1982). The draft agreement stipulated that because of future potential decreases in unregulated Delta outflow from the SWP <u>or other water developments</u> "*some reservation of presently unregulated flows may be necessary to accomplish the goals of this Agreement. Such reservations could be accomplished either by increasing minimum outflows or by limiting future exports and diversions to storage*." Both parties to the agreement recognized the potential value of unregulated flow in the controlling productivity of the estuary. Even the SWRCB in setting the D-1485 standards (SWRBC 1978) stated "*In view of the fact that no additional project facilities are expected to be completed for at least ten years, current levels of unregulated Delta outflow should not be appreciably reduced during the effective period of this plan*." All three parties seemed accepting that D-1485 with added protections provided by the Two-Agency Agreement would protect the striped bass and other estuary fish at the new 1980's export level of 4.5 million acre-feet (see Figure 3).

The parties stipulated that in recent years provisions in D-1485 like those proposed had not provided adequate protection to striped bass, and that the cause was being investigated. In the event goals were not achieved, they further stipulated that the agreement would be modified to achieve the prescribed goals.

The report also concluded that expansion of the SWP Banks Pumping Plant (four new pumps with a capacity of 6,000 cfs) would create additional adverse impacts on the striped bass. The draft agreement stated that expansion, beyond the existing US Army Corps of Engineers constraints that allowed some higher winter exports, would only occur if (1) <u>the parties agreed upon additional operational constraints; **and** (2) fish screens at the SWP Banks fish facility were upgraded.</u>

The EIR stated that the proposed agreement would provide greater protections than D-1485, but any increase in exports beyond the current level would cause further impacts.

NMFS Comments on Draft Two-Agency Agreement - 1981

The National Marine Fisheries Service (NMFS) commented on the 1981 draft Two-Agency Agreement (NMFS 1981). NMFS stated that the draft agreement failed to establish standards to restore and maintain fish and wildlife resources prior to completion of a Peripheral Canal. It was NMFS position that provisions beyond those of D-1485 were needed to reduce the decline in fish and wildlife resources. NMFS recommended adoption of a three-agency agreement (DFG, DWR, and USBR) that included both SWP and CVP operation limits. NMFS also stated that monthly average flow and export standards were inadequate and variable limitations or minimum mean weekly standards should be adopted.

NMFS stated that implementation of D-1485 failed to protect striped bass and other species, and that the proposed standards in the Two-Agency Agreement would allow continued degradation of the remaining fish and wildlife resources in the estuary. They also stated that the striped bass decline suggests that export standards were not adequately protecting the estuary, and additional limitations on exports were necessary to mitigate losses in the estuary.

They further stated that existing exports of approximately 3 maf had caused adverse impacts and **plans to export 4.3 maf posed the greatest of threats to remaining resources**. They further recommended screening Delta agriculture diversions, as such diversions would continue in the future with or without a Peripheral Canal.

Striped Bass Working Group – SWRCB 1982

In January 1982 the SWRCB asked a group of knowledgeable scientists (the group) to investigate the causes and recommend solutions to the striped bass decline. The group came up with three potential factors that might be involved in the adult decline:

1. Poor recruitment into the adult population since 1972 from increased losses of young fish at the Banks pumping plant.
2. High legal and illegal harvest of adults.
3. High adult and subadult mortality during the 1976-77 drought.

The group found only limited evidence for each of three factors. Estimated salvage[3] of striped bass juveniles at the fish facilities at the south Delta pumping plants increased sharply in the early 70's reaching a peak in 1974 and 1975. Harvest rates on adult striped bass in the fishery nearly doubled from around 10 % in 1970 to 20 % from 74 to 76, before dropping again in the late 70's. But some of the group felt that factor 3, high adult mortality during the drought, was most compelling in explaining the initial sharp drop in 1977 despite lack of available evidence. Many adult striped bass had indeed been found dead around the Bay and Delta in 1977, although the phenomenon was apparent to some extent in most years. Newspaper articles had attributed the die-off to a tapeworm

[3] Salvage numbers reflect the number of fish that are actually captured and trucked back to the Delta at the south Delta fish facilities. Salvaged fish generally have poor survival and represent only a portion of the fish that actually are pumped from the Delta.

parasite. The state-federal Cooperative Striped Bass Study found elevated hydrocarbons especially benzene and reduced liver condition, gonad condition, low weight per size, and low egg viability in striped bass sampled. Egg estimates from plankton surveys although highly variable were also down sharply in the 1977-79 period. However, nearly everyone in the group agreed that whatever the causal factor, the 76-77 drought was the precipitator. The high water temperatures, low flows, and poor food supply that were evident during the drought likely made the adult striped bass more susceptible to disease, toxins, starvation, and harvest. Investigations into growth, mortality, and fish condition by group members failed to turn up any smoking gun that would indicate stress in the adult population.

The group also found that the young bass index had fundamentally changed from its relationship with flow (Figure 3) and exports (Figure 4) developed originally for the 1959-1970 period by Turner and Chadwick (1972). The continuing poor young production index that remained below an index of 30 from 1978 and 1981 was the chief concern of the group because the drought had ended in 1977 and Delta outflows had improved from 1978-81. The low young production did not bode well for the future. Two questions became a prime focus of the group: (1) what was causing the continued low young production; and (2) were the D-1485 standards adequate to protect the population?

The group theorized various potential factors in the decline in the young striped bass production summer index:

<u>Low Adult Abundance</u> - Poor egg production based upon estimates from the plankton surveys indicated that the lower numbers of adults and corresponding egg production could be limiting young production. Simply put, the adult population had declined such that production of young was lower. Some in the group were skeptical of this theory because striped bass have a very high fecundity and high intrinsic rate of increase. Others thought it plausible that a 50% reduction in the adult population and egg production could result in a 50% decline in young production. Furthermore, the indicated greater loss of older females with their more viable eggs might be more significant.

<u>Reduced Estuary Productivity</u> – Another theory among the group was that some fundamental changes had occurred in the estuary such that it could no longer produce young striped bass and their food supply as in the past. Hypotheses varied from the loss of productivity from reduced inputs of nutrients and organic carbon from sewage treatment plants that had undergone conversion to tertiary treatment. Another hypothesis was that the higher export of water from the Delta with the addition of the SWP Banks pumping plant was reducing estuarine productivity directly or indirectly. The possibility that introduced invasive non-native species of fish and invertebrates had something to do with productivity decline was also discussed. There was also some speculation that young production was limited by a new lower carrying capacity and that density dependent mortality was limiting survival and production of young or older recruits. However, the group found no evidence of this factor (e.g., decreased growth rates or a negative relationship with stock and recruitment such as young versus three-year old

abundance). The group found a positive relationship between the young index and the catch rate of age 4 adults four years later, which would indicate that there was no density dependent mortality at least from 1965 to 1976 the period for which there was 4-year old bass catch data available. Furthermore, the available evidence and population modeling tools indicated that declining young production would translate to fewer adults. The group did find evidence that there was lower productivity during the 76-77 drought that could have led to fewer young produced, which was a density independent factor. Some of these changes were observed in 1974, 1975, 1978, and 1979 before and after the drought under the higher new export rates from the Delta by the SWP, which led some in the group to believe that high exports reduced Delta productivity and young striped bass production in a density independent way. Phytoplankton and Neomysis production continued low after 1977 into 1982, except during two periods of spring 1981 and 1982 when blooms occurred when export pumps were shut down for maintenance. The group concluded from the available data that exports controlled phytoplankton blooms and Neomysis production in the Delta. One possible explanation was thought to be lower residence time under higher exports, which reduced productivity.

<u>Increased Entrainment and Impingement of Young Striped Bass at Power Plants and Water Diversions</u> – The group acknowledged that the numbers of young striped bass lost at PG&E power plants and Delta water diversions had indeed increased sharply in the 1970's as more projects came on-line and increased diversions from the Delta. Estimates by the group indicated that export losses increased by 42% from the 1960's to the 1970's and that the average loss of young striped bass was 50% in the 1970's with peaks of 60-65% in 72, 73, 76, 79, and 81. Losses from PG&E power plants were estimated at 16% for 1978 and 1979. Much cruder estimates for Delta agricultural diversions were 3 to 4 times higher than the power plant estimates. With cumulative estimates of over 100% loss in some years from the combined effect of the three diversion types, the group concluded that a major portion of the eggs, larvae, and early juvenile production was being lost to diversions. A model used by the group to simulate future population levels with these levels of young mortality predicted the adult population would continue to decline and young production would further decline as a consequence of the declining adult population (we called this the death spiral or compound interest mortality). Without some sort of density dependent response such as increased fecundity or survival at the low densities, or stocking of substantial numbers of yearlings or subadults, the population would crash or possibly reach some very low equilibrium level.

Some of the group concluded that the young production index relationships developed in the 1960's by CDFG had fallen apart. Others believed the relationships behaved as intended by showing fewer bass were being produced per unit outflow and that the main culprit for the decline in production was the higher exports based on the strong negative relationship between exports and the index (Figure 4). The outflow and export extremes had simply widened beyond the range in the original regression equations first developed by Turner and Chadwick. Most of the group believed the combination of fewer adults (lower egg production) and higher exports (poor habitat leading to poor survival, and high diversion losses of eggs, larvae, and early juveniles) were the factors that were driving down both the production of young and adults. In short, the export portion of the striped bass index model was becoming dominant over the flow function in the model.

The group concluded that the combination of reduced adult survival and young recruitment drove the population down in the late 1970's and that higher exports meant lower productivity and higher entrainment mortality, which would translate into much lower young production. Lower young production from fewer eggs, lower food supply, and higher entrainment would translate into even fewer adults in future years unless these trends were reversed.

The group also concluded that D-1485 standards were not adequate to protect the striped bass population because the 6,000 to 9,000 cfs exports allowed under the standards would lead to indices below 30, which was far below the D-1485 target level of 71.

I developed a supporting theory while working on data for the group that was included in my 1982 paper (Cannon 1982a). The theory involved the location and movement of the two-parts-per-thousand salinity contour, which was generally considered the upper end of the so-called "entrapment zone" or high-productivity, low-salinity, zone of the estuary. This location, which was later termed X2, was prone to rapid movement upstream from the Bay into the Delta in the spring when the Delta "came into control". Essentially what happened in spring or early summer was before stored water was released from upstream reservoirs, the freshwater pool in the Delta remaining from uncontrolled winter-spring precipitation events was pumped out by the south Delta and interior Delta diversions within the criteria of the D-1485 standards or earlier standards. As X2 was pulled upstream toward the Delta, young striped bass that were generally concentrated in fresher water upstream of X2 were being drawn from Suisun Bay and the western Delta to the export pumps in the south Delta. This pool of freshwater including many of the larvae and early juvenile striped bass and their invertebrate food supply (Neomysis and Eurytemora) was literally exported south or diverted onto Delta fields.

The peak risk to striped bass from this phenomenon occurred in the early 1970's when the SWP Delta pumping plant came on line. This phenomenon occurred in either June or July of 1971-1974 and was highly exacerbated by the exports from the new SWP Delta pumping plant. The term "reverse" flows is synonymous with the upstream movement of the X2 zone. Egg and larvae and salvage survey data from 1968-1979 (which remains unpublished to this day) showed convincingly that the phenomenon did occur. Estimated losses from salvage surveys were highest in 1971-74 as compared to 1968-69 or 1975-1979. For July 1971 I estimated that 80 million juvenile striped bass were entrained and lost at the SWP Delta pumping plant. Delta outfall fell from 20,000 cfs near the end of June to 10,000 cfs by late July with lower San Joaquin River flows going negative in July under a record 7,000 cfs total export levels. In June 1972, I estimate 130 million juvenile bass lost, the highest monthly total since salvage records were kept (1968), which was coincident with 7,000 cfs exports in early June and negative lower San Joaquin flows, followed by the Andrus Island break in mid June that led to –28,000 cfs lower San Joaquin flows. In 1973 nearly 35 million juvenile bass were lost in June coincident with rising exports (new export records of 7,000 to nearly 10,000 cfs), the Delta outflow falling from 15,000 to 4,000 cfs, and lower San Joaquin flows falling from 3,000 cfs to a –6,000 cfs. In June 1974, an estimated 75 million young bass were lost at the SWP Delta pumping plant as lower San Joaquin River flows went from +8,000 cfs to a –4,000 cfs and Delta outflow went from 26,000 cfs to 5,000 cfs, while exports rose again to record levels from 8,000 cfs at the beginning of the month to an unprecedented 12,000 cfs near the end of the month. These were huge losses of juvenile striped bass and occurred prior to or during the period when surveys for the summer index of abundance were occurring. Because the estimates were made using conservative salvage efficiencies, the actual numbers lost were likely higher. Because the salvage events occurred coincident with the period when the X2 movement phenomenon described above was occurring, the general theory of the phenomenon has some credence. This was exactly the phenomenon referenced earlier and shown in Figure 6.

The water replacing the Delta pool that was exported (with the young striped bass and their food supply) was what we called "Shasta" water or unproductive reservoir water from Shasta (Sacramento River), Oroville (Feather River), or Folsom (American River) reservoirs. Reservoir water soon dominated the lower Sacramento River channel and the western Delta after these events, whereas the long-residence, higher productivity, higher turbidity Delta water (with the striped bass and their food supply) gradually moved up the lower San Joaquin River channel and on to the south Delta export pumps. The freshwater and low salinity nursery area was also confined to narrow Delta channels that were considered less productive compared to the shallow bays of Suisun Bay where the freshwater and low salinity pool had extended into earlier in the spring. The group had found a significant negative correlation between western Delta chlorophyll spring bloom levels and water exports from the south Delta. The spring and early summer of 1978 and 1979 turned out to be further examples of this X2 movement phenomenon and the loss of a considerable portion of the striped bass young production to diversions or poor habitat conditions. In addition to salvage surveys at the pumping plants, these events were documented by actual fish distribution changes in the 1978 and 1979 egg and larvae, and juvenile fish surveys (Cannon 1982a).

One of my findings from this analysis was that the monthly average provisions of the water quality control standards that were designed to protect the striped bass actually exacerbated the problem. The monthly average water quality standards for outflow and exports actually encouraged SWP and CVP operators to create the phenomenon. For example, in June 1978, a wet year, the uncontrolled (high) inflow-outflow and low export demands early in the month, operators were allowed to lower outflow and increase exports later in the month (Figure 7). These same conditions occurred in the above examples for 1971-74 and 1981 (see Figure 6).

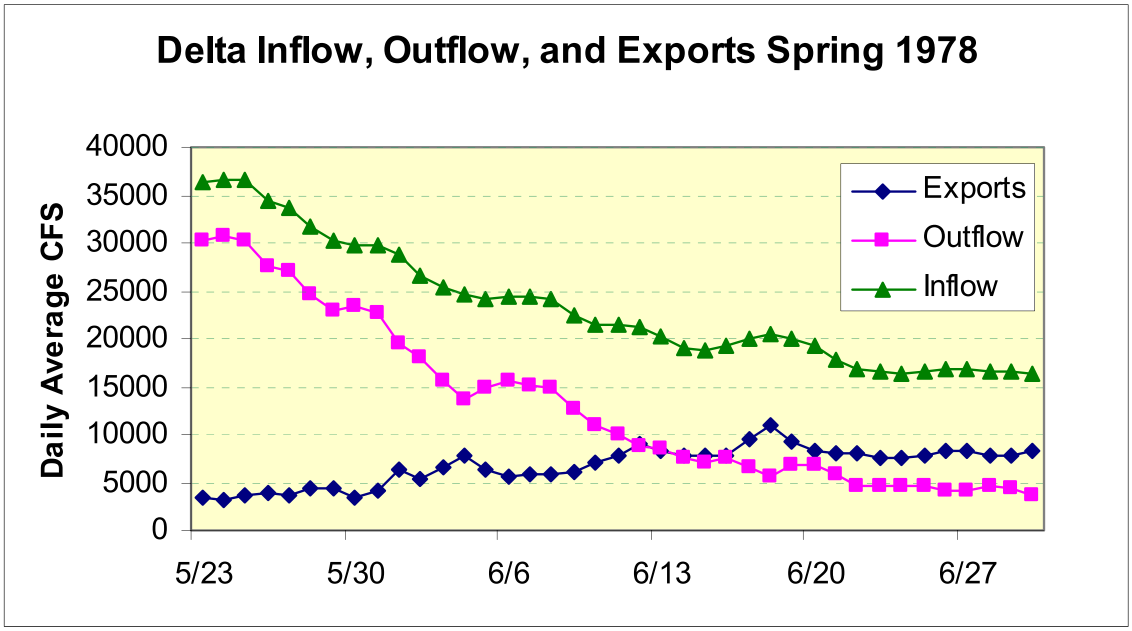

Figure 7. Delta hydrology in late spring 1978. Independent monthly average standards for export, inflow, and outflow allowed short-term conditions that were poor for striped bass and their food supply. High early June inflow-outflow and low exports allowed detrimental high exports and low outflow in late June.

Final Two Agency Agreement and Response to Draft Agreement Comments

The Draft Two-Agency Agreement was finalized with a final EIR in December of 1982. Hopes had hinged on passage of the Peripheral Canal referendum, which failed in the fall of 1982. The combination of the Two Agency Agreement and D-1485 now provided the only protection for the striped bass and other estuarine organisms.

State Water Contractors expressed strong opposition to the Agreement and did not see the need for the Agreement. They believed the Agreement seriously undermined DWR's ability to meet their obligations to the 30 State Water Contractors.

The Contractors contended that the Agreement would delegate responsibilities of DWR and the SWRCB to DFG. Furthermore, the Contractors expressed the opinion that striped bass were well adapted to changing conditions and did not need the extra protections provided in the Agreement that would lead to a reduction in the Project yield.

Other contentions included:

- The SWP did not have a mitigation responsibility for the salmon resource in the San Joaquin River tributaries.
- The Agreement provided better protection for striped bass than the D-1485 standards, but the potential benefits to angler catch had not been demonstrated.
- The Contractors disagreed with DFG and DWR contention that hatchery replacement could not sustain the striped bass population. (Eventually hatchery replacement

became the center-piece of the 1986 Agreement and limitations on exports and minimum outflow standards above those of D-1485 believed necessary by both DFG and DWR were eliminated.)

DFG **and DWR** responded in the FEIR to these concerns by reiterating that mitigation for the SWP for impacts on the estuary was required to preserve fish and wildlife resources:

- Fish screens at the Banks Pumping Plant
- Limitations on May-July exports as prescribed in the Agreement
- Minimum outflow standards as prescribed in the Agreement.
- Minimum flows at Rio Vista in the lower Sacramento River below the DCC
- Stocking of hatchery reared striped bass and salmon.

Without these mitigation measures, the two agencies agreed that the striped bass population could not survive over the long term. They added that by simply stocking striped bass into an estuary that did not have the capacity to support them let alone restore historic fishery levels because of lack of flow and high rates of diversion would not overcome these deficiencies.

DFG and DWR further stated that without an "isolated Delta Transfer Facility" they would not be able to restore historic fishery levels even with the provisions in the Agreement. Only 60-70 percent of the number of striped bass the estuary once supported could be sustained with the provisions in the Agreement.

The agencies also concluded that any changes in SWP operations and facilities in the future would require additional mitigation and that the Agreement included provisions for incorporating future planning and change to the SWP. They believed that a yield of 3 MAF for the SWP to go along with a yield of 2 MAF from the CVP could be sustained without jeopardizing fish and wildlife resources **if the proposed mitigation measures were adopted.** (Yields have exceeded 5 MAF in 13 years and 6 MAF in three years since 1982, while the proposed mitigation measures in this Agreement have not been fully implemented.)

Both agencies understood the ramifications of closure of the DCC. DWR was concerned about the effects on export water quality, while DFG understood the negative effects on the Delta striped bass. To protect the Sacramento River spawning populations of striped bass they agreed to close the DCC two days out of four when the Sacramento striped bass eggs and larvae were in the vicinity of the DCC in May and June, **but only if outflow was above 12,000 cfs**.

In comments on the DEIR, United Anglers brought up the need to reduce predation in Clifton Court Forebay, losses through the Fish Protection Facility louvers, and losses from handling and trucking.

Environmental groups unanimously took exception that the provisions of the Two-Agency Agreement adequately mitigated for the SWP and the new four pumps and that the SWP had improved fisheries in the Delta. The California Striped Bass Association further noted that the sportsmen's were already paying $3.50 for the striped bass stamp that paid for the hatchery program. They had been advocating reducing spring and early summer exports to protect the striped bass young and encouraged such provisions.

The 1982 Two Agency Agreement was not implemented, leaving D-1485 standards to protect Bay-Delta fishes.

The Problem Continues Unresolved – 1986

By 1986 it was obvious that the D-1485 standards were not protecting the striped bass population. The 1985 summer index of young striped bass was the lowest on record. The indices in 84 and 86 were also below expectations given the amount of outflow (Figure 8). Indices were however starting to appear realistic based upon an obvious negative relationship with export levels (Figure 9) that had not been so apparent in the previous decade. In 1984 exports reached 8,000-10,000 cfs in April, while 3,000 cfs was maintained in May and June at each facility, and July hit its limits of 4,600 cfs at each facility. The combined June-July export reached over 8,000 cfs. In 1985 April exports again reached the 8,000-9,000 level, while May, June, and July perfectly matched their legal limits of 3,000, 3,000, and 4600 at each plant, respectively. Based on 1984 and 1985 it appeared that the export limits were not protecting the striped bass, especially with new higher exports in April (Figure 10). D-1485 only restricted May-July exports. The 1986 striped bass index nearly reach target levels. Despite having nearly identical June-July exports and outflow as 1984, the 1986 index was nearly three times the index of 1984. The difference between 1986 and 1984 and 1985, was that flows were higher in spring 1986 and exports nearly 2,000 cfs less in April. The question remains as to how the population would have responded had the May-June restriction to 2,000 cfs in the 1982 Two-Agency Agreement been applied, because conditions in all three years met the criteria for this restriction.

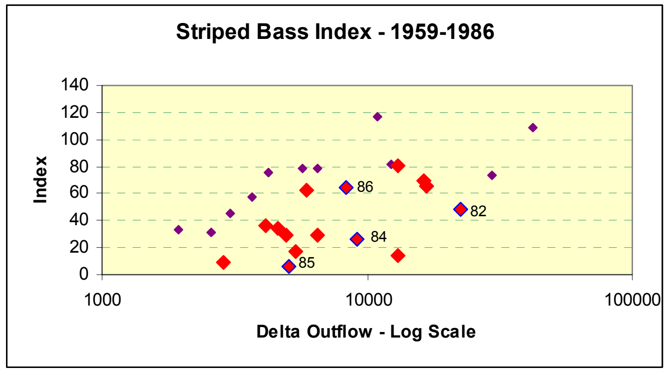

Figure 8. Striped bass summer townet index for the period 1959-1986 versus average June-July Delta outflow in cfs. Small diamonds are the original 1959-1970 Turner and Chadwick (1972) data on which the relationship was first developed. Large red diamonds are the 1971-1986 indices.

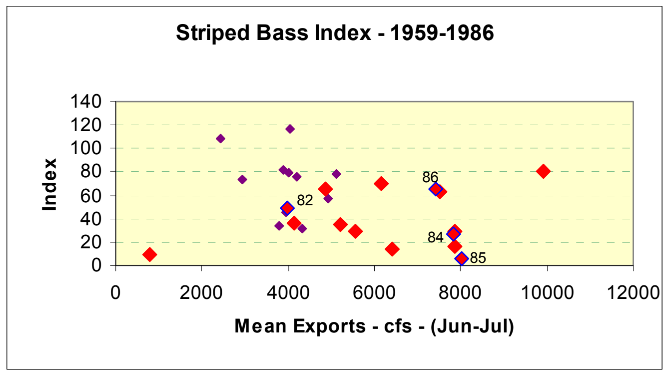

Figure 9. Striped bass summer townet index for the period 1959-1986 versus average June-July Delta export in cfs. Small diamonds are the original 1959-1970 Turner and Chadwick (1972) data on which the relationship was first developed. Large red diamonds are the 1971-1986 indices.

In 1986, DFG and DWR completed a new Two-Agency Agreement (that met the approval of the State Water Contractors) and the SWRCB initiated hearings to reconsider D-1485 standards. A new level of yield of 5.5 million acre-feet from the Delta was being achieved by the SWP and CVP with a record level in 1985 (Figure 11), which was a relatively dry year with exports frequently in the 10,000 to 12,000 cfs range. Average June-July export for 1984-1986 was near 8,000 cfs, the maximum allowed under D-1485.

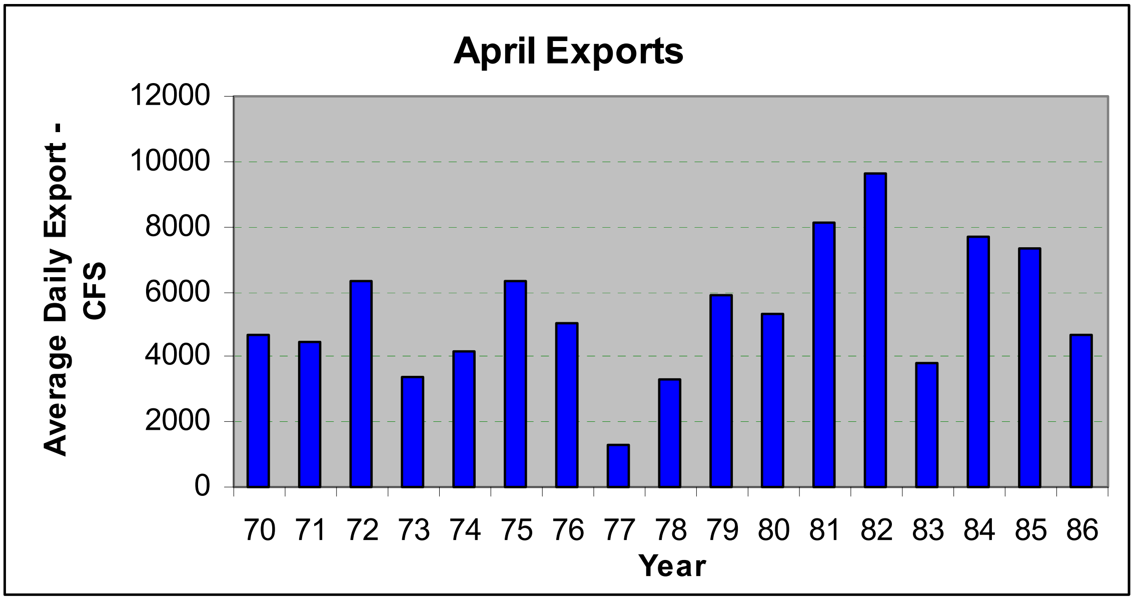

Figure 10. Total exports in April from 1970-1986.

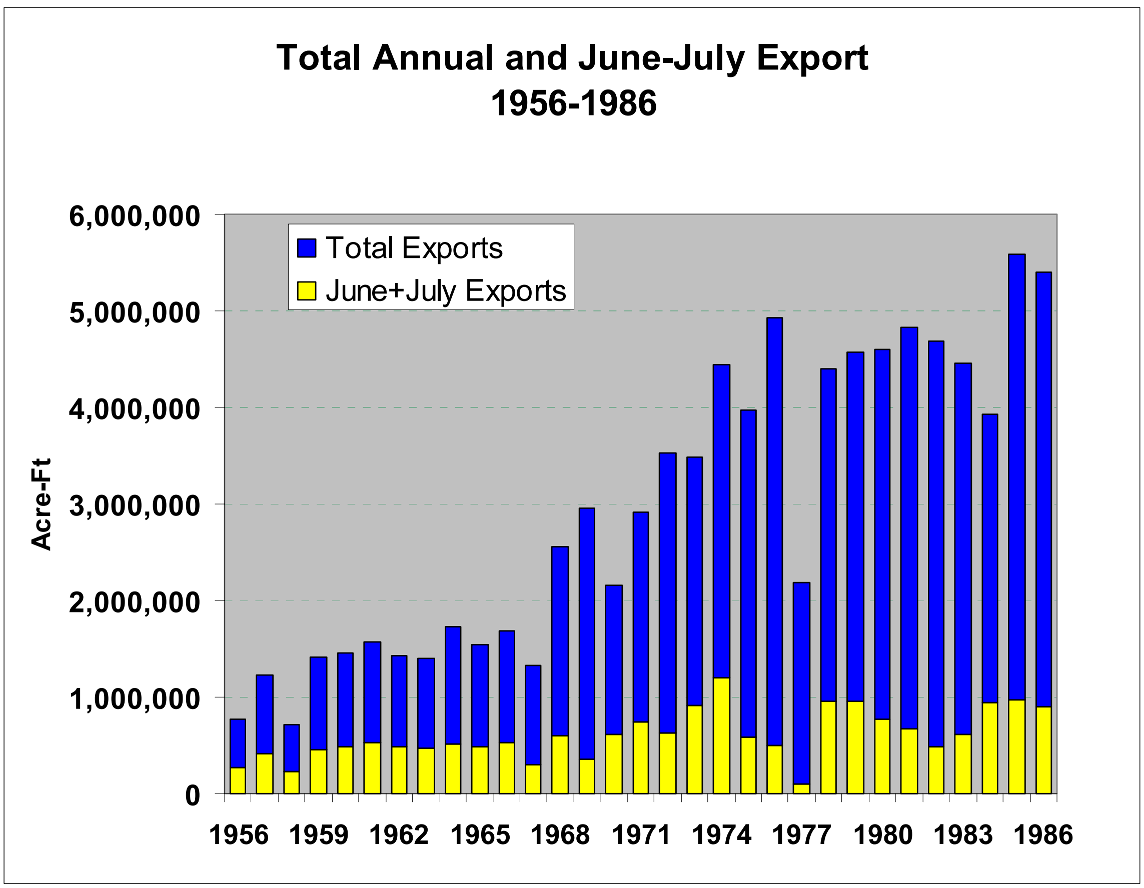

Figure 11. Delta exports from 1956-1986. The SWP came on line in 1968 with an initial doubling of exports to near 3 maf. From 1974-1984 the average was over 4 maf. In 1985 and 1986 export levels reached near 5.5 maf with June-July exports at nearly 1maf.

Two-Agency Agreement 1986

The new Two-Agency Agreement (Four Pumps Agreement) was consummated in 1986, but without most of the provisions in the 1982 Agreement that would have improved the protections of the D-1485 standards. The Agreement was fundamentally changed to a mitigation agreement with striped bass losses at the pumping plants being mitigated by grow-out of salvaged young striped bass and stocking of hatchery produced yearling and older striped bass. The purpose of the Agreement was to offset losses between the fish being drawn into Clifton Court Forebay (CCF) to their being returned in trucks to the Delta. These losses generally included young striped bass lost to predation by older bass and other fishes in CCF, young fish that died on the louvers and screen systems at the end of CCF, young fish that passed through the louvers and secondary screens and down the California Aqueduct, and those fish that were salvage but died before reaching the Delta release sites.

The Agreement also called for parties to begin discussion on developing ways to offset the impacts that were not covered in the Agreement. Additional measures were to be included in proposals by DWR before expanding the capacity of the Bank's pumping plant. Until such understanding was reached, DWR agreed not to increase its diversion (with the new pumps) except in wet winters with high San Joaquin River flow. "*Additional measures for impacts not covered in this agreement will have to be included in proposals by DWR to expand its diversions beyond the limitations contained in this agreement."* This is an important point because the Agreement still applies and DWR is presently seeking permission to increase exports using the additional pumps without the ability to stock striped bass.

The Agreement also called for a reduction of fish losses due to predation in CCF and an annual review of progress. The Agreement furthermore stipulates *"If the agreement is not successful in offsetting the direct effects of diversions by the Pumping Plant on fisheries dependent on the Delta**, it shall be renegotiated** to fulfill the SWP's responsibilities relating to the direct effects of diversions by the pumping plant."* Options that are to be considered if present measures were not successful included:

- new screens at the Bank pumping plant fish protection facilities
- improvements in the cross Delta conveyance of water to minimize reverse flows

Reverse flow in the lower San Joaquin River channel refers to negative net tidal flows caused by the increase in exports after the SWP Banks pumping plant came on line. Appendix Figure A-2 shows a schematic of the reverse flow phenomenon for years before and after the SWP came online.

1986-87 Hearings

With a continuing decline of the striped bass adult population and young production indices, and the obvious lack of protection provided by the D-1485 standards, the SWRCB opened hearings on the Bay-Delta standards again in 1986. Considerable testimony was prepared and taken over the one-year period that provided further insights into problems with the striped bass population. The Interagency Ecological Program including DFG, USBR, USFWS, and DWR, conducted a comprehensive study of the Delta in 1985-1986 in preparation of the hearings.

DFG Testimony

DFG's testimony (DFG 1986) stated that despite the efforts of the SWRBC working group in 1982, the cause of the striped bass decline " has remained a mystery". While that may have been DFG's official position in 1986, DFG's Turner, Chadwick, and Stevens who participated in the group's review in 1982 felt strongly as did most of the other contributors that higher export from the Delta beginning in the early 1970's from the addition of the SWP pumping plant was the cause of the decline. The root causes of the decline whether direct or indirect was the only issue debated, and even then most felt that all the factors were contributing to the decline.

The DFG testimony related that the striped bass decline continued through 1985 despite relatively wet years and the CVP and SWP meeting outflow and export standards set by D-1485 (monthly average criteria). DFG was unable to explain why their model based on flow and export failed to predict the lower abundance of young striped bass. DFG's testimony failed to state that the 1982 Working Group had concluded (1) the standards for exports were not sufficient to protect the young striped bass, and (2) the abundance index predicted by the model were likely to be overestimated. Furthermore they failed to acknowledge the obvious problems with monthly average standards for flow and exports in the D-1485 standards, despite their attempt to add weekly average conditions in the 1982 Two-Agency Agreement.

The DFG testimony concluded that the decline was likely attributable to four factors:

1. low egg production from low adult numbers
2. reduced plankton food in the Delta and Suisun Bay
3. large numbers of young striped bass lost to water diversions
4. toxic substances stressing the population in unknown ways.

DFG also concluded that among these factors, environmental factors were as important as spawning stock and egg abundance in explaining variability in young bass abundance. They also concluded that export losses had a "*substantial detrimental effect on the striped bass population*", and that the effect was most likely caused by a reduction in survival before the 8 mm larval stage. This later point was important as it meant that yearclass abundance was determined by the 8-mm larval stage and that mortality prior to this stage or low egg production was the major cause of the decline.

DFG was also in a conundrum about the merits of closing the Delta Cross Channel (DCC) to keep larval striped bass in the Sacramento River moving toward Suisun Bay or keeping it open to limit reverse flows in the lower San Joaquin River. They noted that reverse flows in the lower San Joaquin River from high exports and limited cross-Delta flow with closure of the DCC draws large numbers of young striped bass to the south Delta export pumps. They stated: "*Ideally, the gates (of the DCC) would be operated to minimize the direct entrainment of eggs and larvae from the Sacramento River and to* *minimize flow reversals."* CDFG also estimated that an increase in net lower San Joaquin flow from a negative 4000 cfs to a plus 1,000 cfs would reduce these estimated losses by approximately 40%. *"Although eliminating reverse flows is advantageous, it is obvious that this action is not the entire solution." "We suspect that mortality of larvae not flushed into Suisun/Grizzly/Honker bay area is higher." "Entrainment losses and, perhaps, a mismatch of food and larvae in time and space are the most likely reasons for the high mortality rates (of larval striped bass)."* In the 1982 Two-Agency Agreement DFG had included a criteria that the DCC could not be closed unless Delta outflow exceeded 12,000 cfs, and the criteria was not met in May-June 1985 when the DCC was closed.

DFG had other conclusions based upon their review and analysis:

- An increase in adult mortality rates could reduce egg production.
- Growth rates of adults had remained unchanged (changes in fecundity or natural mortality were not likely causes of lower egg production, whereas direct mortality from harvest or toxins would be a more likely cause).
- Habitat for spawning had not changed, which indicated that poor habitat for spawning was not the cause of lower egg production or survival to 8-mm size.
- Young survival rates had declined since 1975, which could be a major factor in fewer 8-mm and larger bass produced.
- Entrainment of young striped bass at Delta exports was 55% in 1985, which could be the major reason the indices of 8mm larvae and 38-mm juveniles were the lowest on record, and the principle cause of the striped bass declining young production and adult population recruitment.
- Even in the wet year 1986, entrainment at export pumps was 30%, which indicated striped bass were not protected from the new SWP exports.
- The significance of entrainment losses were underestimated when D-1485 was formulated – D-1485 allows for high entrainment losses – entrainment is substantially more important than previously realized.
- "*May-July export restriction in D-1485 kept exports at 1975 levels, thus not likely cause of the decline."* (I do not fathom this conclusion because DFG had believed that the higher levels of exports from 1972-1975 had contributed to the decline, which manifested itself beginning in 1977 in the adult population and subsequent young production indices.)
- "*The new Two Agency Agreement should benefit striped bass*." DFG appeared to be putting their hopes in the new stocking program, which they had stated in 1982 would not be sufficient because the numbers stocked did not even make up for the direct losses at the export pumps or the higher adult mortality rates. Furthermore, they had stated that the estuary could not sustain the stocked fish.

DFG had the following recommendations that could help reduce the striped bass decline:

- Screen Delta agriculture diversions to reduce losses (DFG acknowledged that screens could not protect striped bass smaller than about 20 mm including the important 8-mm size level).

- Make improvements to fish protection fish facilities at the south Delta pumping plants, which would save a lot of striped bass (but not any below the important 8-mm size level).
- Curtail exports in critical periods to reduce losses of larvae below and above 8-mm; however, DFG was not specific on when or how much reduction export reduction was needed.
- Continue evaluation of toxicity, which could lead to reductions in adult mortality.
- Investigate increased mortality rate of larvae striped bass, which could determine the most important factor in pre-8mm mortality be it entrainment or loss of food supply from exports or other factor.
- Minimize reverse flow in lower San Joaquin River channel below the mouth of Old River, which could greatly benefit food supply and reduce entrainment of pre and post 8-mm larvae.
- Stock striped bass to rebuild the population, which would help to mitigate adult and young losses.
- Consider short-term closures of DCC to protect Sacramento River striped bass larvae, which would reduce movement of larvae from the Sacramento River to the Central Delta, but could increase reverse flows. (DFG understood that closing the DCC would increase reverse flows.)

Supporting their testimony were several specific testimonies of analyses conducted by DFG scientists.

DFG's Turner and Miller (1986) prepared testimony on the food supply of striped bass. The results of their analyses supported the theory that striped young production from year to year is set by the amount of food available to early feeding larvae. Food uptake by striped bass was also found to be higher downstream of Collinsville at the terminus of the Sacramento and San Joaquin rivers, possibly as a result of the effect of south Delta exports. Copepods especially Eurytemora were the dominant food of larval striped bass. Selectivity for specific prey by young striped bass increased with increased prey abundance, usually in the form of a preference for larger zooplankton, which would be a mechanism for higher larval bass survival at higher prey abundance.

Turner (1986) in continuing his work with the striped bass working group in 1982 found a positive relationship between the post-yolk sac larvae about 8-9 mm, summer juveniles (38 mm), and the number of age 4 fish four years later, suggesting that recruitment into the adult population is primarily a function of survival of early larvae prior to their reaching 8-mm. He found high numbers of yolk-sac larvae with varying survival to 8-9 mm depending on location and year. He studied the unusually high summer index in 1986, which was the highest summer index since 1975, to determine what factors contributed to the high summer index. He found that survival was lower in the lower Sacramento River and San Joaquin River above the confluence upstream of Collinsville than downstream. He noted that this decline in the Delta portion of the population compared to eastern Suisun Bay began in the early 1970's. He also concluded with higher Sacramento River flows and high Delta outflow more larvae from the primary spawning grounds in the Sacramento River reached Suisun Bay where their chances of survival were higher compared to the Delta. Eggs and larvae spawned or reaching the lower San Joaquin River also had a greater potential survival if lower San Joaquin River flows flushed them into Suisun Bay. In 1986 many larvae were transported into Suisun Bay from both the lower Sacramento and San Joaquin river channels, leading to a high summer young bass abundance index, while in contrast few larvae were transported to Suisun Bay in 1985 (or 1984) and the result was a poor summer index. He noted that prior to the decline in abundance of striped bass, production and survival of young striped bass was higher in the lower Sacramento and San Joaquin river portions of the Delta. After the decline started the rate of larvae decline also increased in Suisun Bay, possibly as a consequence of lower larval survival in Suisun Bay, less input of juvenile bass produced from the Delta, or a combination of the two factors. He concluded that the decline in the summer index of striped bass was due to higher mortality of larvae since 1973. Estimates of total loss of eggs and larvae to exports for 1985 and 1986 were 55% and 15%, respectively. These estimates did not take into account losses to juvenile striped bass 15 mm and larger (which could have been derived from available pumping plant fish salvage survey data). Turner noted that high mortality in the Delta prior to the index size of 38-mm was caused by a combination of poor food supply and direct losses to diversions. Turner noted that Orsi and Mecum (1986) and Stevens et al. (1985) had detected a decline in the zooplankton concentrations in the lower rivers after 1972. All of these DFG biologists concluded that the likely cause of these declines was increased exports from the south Delta beginning in the early 1970's. Which factor was most important, poor survival from poor food supply or direct loss to exports, could not be determined, but likely each played a part in the decline (sort of a double wammy).

Turner also looked at the breakdown of the summer young bass index between the Delta and Suisun Bay components. Over a decade earlier he had noted that with higher flow more of the index-sized striped bass (1-2 inches long) were located upstream of Collinsville in the Delta than in Suisun Bay downstream of Collinsville (Turner and Chadwick 1972). In his 1986 testimony he noted that there had been a steady decline in the Delta portion of the index since 1959 (Figure 12) without much of a change in June-July outflow (Figure 8). Turner attributed the lower Delta index to higher mortality from a combination poor food supply and higher loss of young to the exports, which were both caused by higher exports (Figure 13). <u>The decline in the striped bass summer</u>

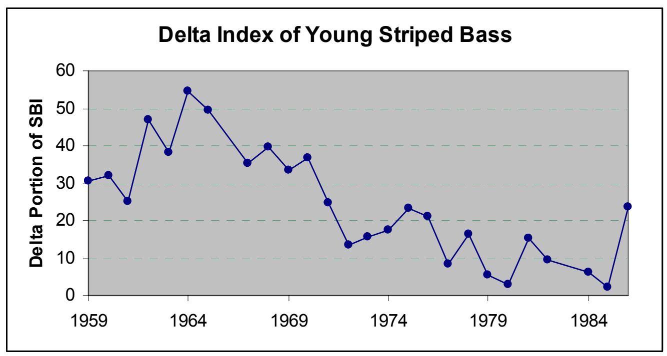

Figure 12. Delta portion of the striped bass summer townet index from 1959-1986.

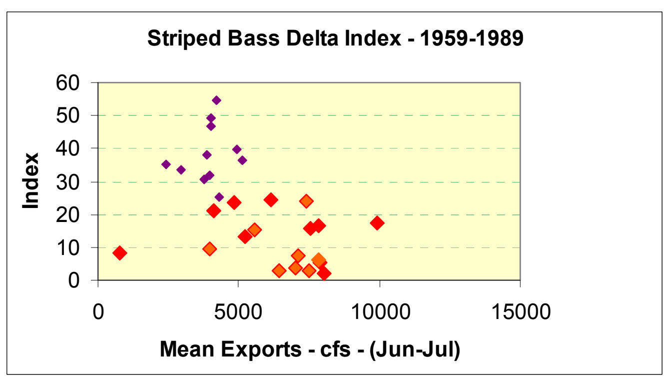

Figure 13. Delta portion of the striped bass summer townet index from 1959-1986 versus June-July Delta exports. Larger reddish diamonds are post 1970 years. Lighter orange diamonds are post 1980 years. Years 1974 and 1977 are the outliers as in Figure 5.

young abundance could be explained by the strong relationship between the Delta portion of the index and export level – **there was no mystery.**

USBR

USBR provided testimony in 1986 about the controlled flow study in the Delta in May 1985 (Arthur 1986). This was one of the few attempts to actually conduct an adaptive management experiment with project operations in 50 years of studying the Delta. The study involved maintaining relatively high exports (6,000-8000), a high cross-Delta flow (open DCC), relatively high lower Sacramento River flows, and near zero net flow in the lower San Joaquin channel for the month of May (Figure 14) for the purpose of determining whether plankton production in the Delta is related to residence time of water.

As a result of the experimental conditions in May, phytoplankton concentrations reached the highest level in the Delta since records were kept in the 1960's. Zooplankton reached similar high levels in the lower San Joaquin River. Arthur attributed the plankton bloom, which was confined primarily to the lower San Joaquin River channel, to the long residence time provided by the zero net flow in the lower San Joaquin River channel (Figure 14). Peak densities of striped bass 6-8 mm larvae also occurred in the latter half of May in the lower San Joaquin River, at levels similar to the 1960's and 1970's.

After the experiment ended at the end of May, the projects went back to normal operations. The Delta Cross Channel was closed on half the days of the first two weeks of June at outflows of only 10,000 and 5,000 cfs (Figure 14), resulting in lower cross-Delta flows and increasingly negative lower San Joaquin flows (a condition that would not have been allowed under the 1982 Two-Agency Agreement). Under these conditions the plankton bloom dissipated quickly, falling to less than 10 micro-grams per liter by mid June in the lower San Joaquin River channel. Zooplankton concentrations dropped sharply late in May. Coincident with the declining phytoplankton concentration in early June, Arthur noted a sharp increase in salinity at Jersey Point in the lower San Joaquin. Declining outflow and reverse flows were bringing brackish water upstream into the lower San Joaquin from Suisun Bay. (The pool of freshwater in the Delta built up during the May experiment was being exported.) Arthur noted also the index of older striped bass larvae had declined to the second lowest level on record during June, eventually leading to the record low summer index in July.

Arthur also noted that zooplankton concentrations were low in June and July in the lower San Joaquin River where young striped bass were concentrated. He attributed the low zooplankton production in June and July to short residence time in the lower San Joaquin River because of high exports and high cross-Delta flow. As noted by Turner, Delta outflow through May had been insufficient to transport larvae to Suisun Bay (regardless

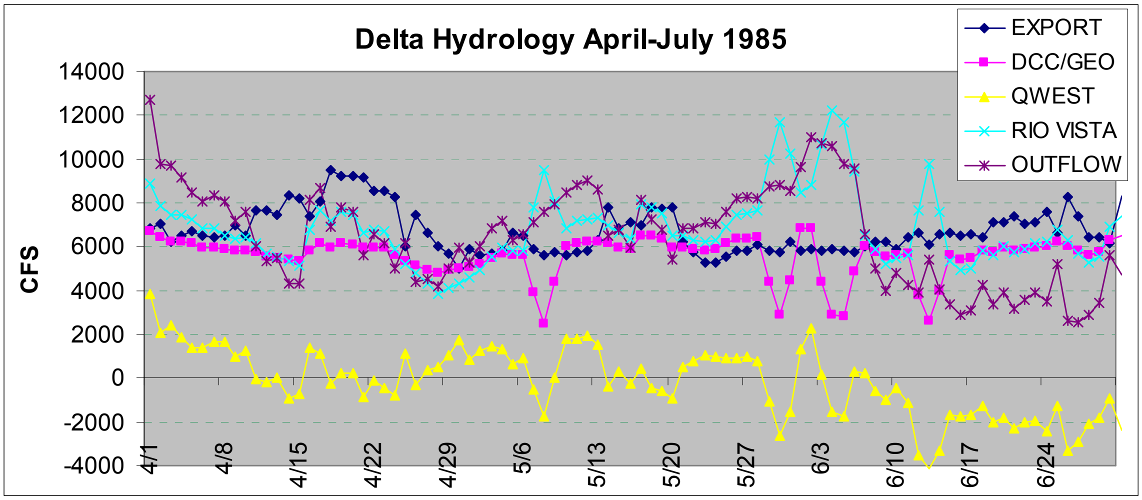

Figure 14. Hydrology in the Delta in May-June 1985. May water project operations were controlled so that net flow in the lower Sacramento River (Rio Vista) was kept generally in the 6,000-8,000 cfs range and near zero in the lower San Joaquin River (QWEST). The four dips in DCC/GEO, one in early May, one at the end of May, and two in early June were caused by short-term closure of the DCC, which caused greater flow down the lower Sacramento River and negative (reverse) flows in the lower San Joaquin River. Inflow/outflow had to be increased for several days at the beginning of June to keep brackish water from entering the Delta with the DCC closed. During the latter half of June, outflow was reduced to 3000-4000 cfs (the D-1485 level for a dry year) and exports increased from the 6,000 cfs D-1485 level to as high as 8,000 cfs (well above the allowed D-1485 level). As a consequence of low-inflow, low-outflow, and high exports, much of the freshwater pool in the lower San Joaquin including the striped bass young and their plankton food supply was exported from the Delta, resulting in the lowest young striped bass index on record in July. Sadly, the closure of the DCC in late May and early June was prescribed to keep striped bass larvae from being drawn out of the lower Sacramento River to the export pumps, when in reality the closure contributed to strong reverse flows, a breakup of the strongest phytoplankton bloom on record, and the eventual export of most of the plankton and young striped bass from the Delta. In hindsight, if the DCC could have remained open, negating the need for the inflow pulse to keep out brackish water out at the beginning of June, and exports kept no higher than the D-1485 standard of 6,000 cfs, with a little more outflow in the latter half of June, maybe some of the striped bass young could have been saved. Again, the problem with monthly-average standards under the D-1485 left little option for fish managers to control the situation.

as to whether the DCC was open or closed). Arthur attributed the poor survival of the larval striped bass to poor food availability and loss to the export pumps. Export pump entrainment of larval striped bass increased sharply in late May. He noted peak densities of newly hatched larvae striped bass at the export pumps in the south Delta in the third and fourth weeks of May. From his analyses he concluded that 40% of the striped bass larvae that had transported down the Sacramento River were diverted across the Delta and eventually lost in the export pumps. (DFG's estimate was 55%.) Arthur also noted that losses of larger young striped bass in June and July were high, and were "*probably as a result of reverse flows in the lower San Joaquin River drawing bass toward the water project export pumps.*" He added: ***"If our analysis of 1985 is correct, the SWRCB decision (D-1485) to have the Delta Cross Channel gates closed at flows <12,000 cfs may have been a significant factor in the post-1977 striped bass decline***. This was a prophetic statement about the effects of closing the DCC at low Delta inflow conditions, a factor that the 1982 Two-Agency Agreement addressed. Arthur had attributed the high losses at the export pumps to high cross-Delta flow of Sacramento River water within which were Sacramento produced striped bass larvae. In the end I believe he meant the high exports were going to cause high cross-Delta flow regardless of the DCC being open or closed, but that the closure of the DCC would result in reverse flows that would pull the striped bass and plankton upstream from the lower San Joaquin River channel to the export pumps.

DWR

In their testimony in 1986-1987, DWR concluded that a major cause of the striped bass decline was direct loss of young in exports. They noted that the 1986 Two-Agency Agreement and future planned actions (not specified) were designed to improve the striped bass population and reduce losses at the south Delta pumping plants. No actions were contemplated at that time that would reduce losses at the pumps. No mention was made of the multiple actions that had been in the 1982 Two-Agency Agreement that would have reduced the losses.

Water Contractor Position

A MWD memo distributed during the hearings succinctly states the water contractors' position on water supply and the Delta:

> *"The Delta transfer facilities remain the most important project for further development of the SWP. The channels of the Delta presently act as a bottleneck to the SWP and prevent it from delivering more water. Unless this bottleneck is removed, any future storage facility, either north or south of the Delta, will be prevented from operating efficiently to provide its full potential yield.*
>
> *The bottleneck affects the SWP in two ways. First, the yield of storage facilities north of the Delta is limited by the channels in the North Delta. These channels are presently too small to allow enough water during low flow periods to flow from the Sacramento River, across the Central Delta, and down to the export pumps. As a result, as exports are increased, some of the water must continue down the Sacramento River and around Sherman Island in the Western Delta on its way to the export pumps. When this water flows around Sherman Island, it mixes with ocean water. Extra water (carriage water) must be released from upstream reservoirs as Delta outflow to help repel the ocean salinity and protect the quality of export water. As demand levels increase in future, more carriage water must be released from upstream reservoirs and allowed to flow to the ocean to protect export quality. Any future storage facility north of the Delta would not be allowed operate to its maximum efficiency if a large portion of its storage would have to be released as carriage water.*
>
> *The second way in which the Delta acts as a bottleneck results from the channels in the southern Delta not being large enough to allow greater amounts of water to be exported during the winter months when surplus supplies are available and carriage water is not required. Any new storage facilities south of the Delta could not operate to provide full potential yield because the*

constraining channels limit pumping from the South Delta and prevents this storage from being filled.

As demands for water increase in the future, the SWP will transfer more water to storage south of the Delta in summer and fall months in order to increase available storage capacity north of the Delta during the winter months. This increase in summer and fall pumping will increase carriage water requirements. With this increase in future demands, along with South Fork Mokelumne River improvements and construction of a New Hope Channel, DWR estimates that future savings of carriage water would be about 400,000 acre-feet per year.

It is critical that the next step for development of the SWP be improved Delta transfer. Since the Delta is such a bottleneck, the precise allocations of water supply benefits in terms of firm yield for Delta transfer facilities is not as important as the fact that the bottleneck would be relieved, allowing for further development and efficient use of supplies north and south of the Delta.

The Problem Continues Unresolved – 1987-1994

With the old D-1485 standards and the new 1986 Two-Agency Agreement protecting the striped bass, the population had record low young production during the drought years of 1987-1992. Annual young production indices barely registered on the charts (Figure 15). Export levels reached 6 maf before the water supplies gave out in the middle of the 1987-1992 drought (Figure 16).

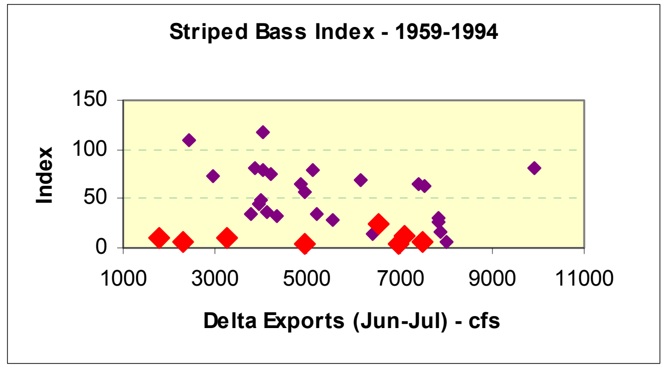

Figure 15. Striped bass summer townet index for the period 1959-1994 versus average June-July Delta exports in cfs. Small diamonds are the previous 1959-1986 indices. The large red diamonds are the 1987-1994 indices.

The Central Valley Project Improvement Act of 1992 (CVPIA) provided for specific support for the striped bass population of the Bay-Delta. CVPIA section 3406 b1 and b18 prescribed unspecified actions to protect striped bass. Section 3606(b)(2) included 800,000AF of CVP water for fishery resources of the Central Valley. The CVPIA called for doubling the striped bass population.

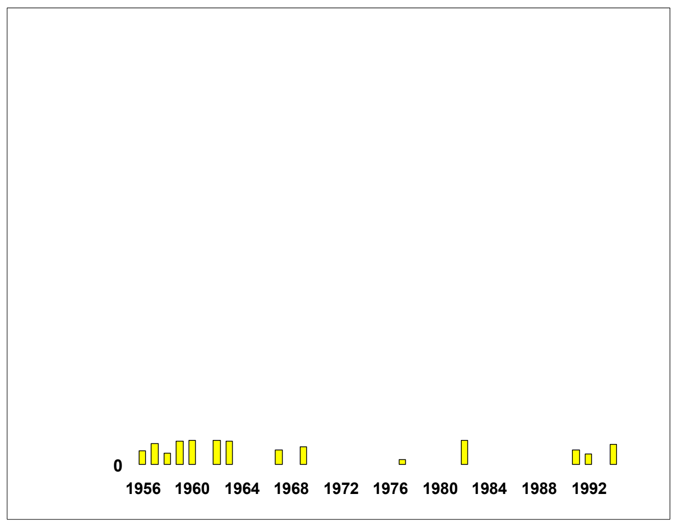

Figure 16. Delta exports from 1956-1994. Exports reached 6 maf in 1987-88, but declined with the full force of the drought through 1992. Exports rebounded to near 5 maf in 1993 after a wet winter.

The Bay-Delta Framework Agreement in December 1994 among the resource agencies, water projects, and water contractors committed the parties to finally resolve the "Delta problems".

The 1995 Water Quality Control Plan provided the standards called for in the CVPIA and Bay-Delta Agreement, as well as prescriptions mandated in the federal Biological Opinions for continued operation of the SWP and CVP.

Tracy Mitigation Agreement – Between USBR and DFG

In 1992 an agreement was reached between DFG and the USBR on mitigating the effects of the south Delta Tracy Pumping Plant of the CVP. Five years (1993-97) and 6.51 million dollars worth of unspecified mitigation were initially prescribed. (The Agreement was later renewed, expired in 2002, and reinitiated yet again.)

The Tracy Fish Collection Facility (TFCF) was constructed in the 1950's and operated to divert and salvage fish entrained at the Tracy Pumping Plant. The initial expected salvage efficiency was never achieved, so measures to reduce and offset or replace direct losses of Chinook salmon and striped bass in the Delta associated with the Tracy Pumping Plant and TFCF operation were instituted. The "*Agreement Between U.S. Bureau of Reclamation and the California Department of Fish and Game to Reduce and Offset Direct Fish Losses Associated with the Operation of the Tracy Pumping Plant and the Tracy Fish Collection Facility*" (Tracy Agreement) was signed in June 1992. The Agreement's intent was to reduce direct fish losses at the TFCF through (1) facility improvements or operational changes and (2) mitigating unavoidable losses. The Agreement guides TFCF operations and the mitigation fund administration.

The Agreement also initiated the Tracy Fish Collection Direct Loss Mitigation Program (Tracy Program), a CALFED ROD Category A Program. DFG administers the Tracy Program and develops the habitat restoration expenditures plan in collaboration with other ERP and cooperating agencies. The Tracy Program has spent approximately $3.72 million to-date. Tracy Program plans include funding 18 habitat enhancement projects within the ERP management zones during 2003-04.

1992 Hearings SWRCB Water Rights Hearings

In 1992 the SWRCB resumed hearings on proposed new Delta standards. DFG's testimony in 1992 describes a model they developed for evaluating the impacts of freshwater outflow and export on the striped bass population in the estuary (Kohlhorst, Stevens, and Miller 1992). The Two Agency Agreement uses model predation rates to scale up loss estimates from salvage surveys at the SWP's Banks Pumping Plant. Not only are salvage numbers scaled up based on the relative efficiency of the louver-screen system (based on efficiency studies from the 1950's), but also based on predation rates measured in the Clifton Court Forebay before the fish even reach the fish salvage facilities in front of the export pumps.

Predation Rate by striped bass size group:

21-25mm = 0.93	26-30mm = 0.83	31-35mm = 0.75	36-40mm = 0.68
41-50mm = 0.60	51-60mm = 0.50	61-70mm = 0.42	71-80mm = 0.35
81-90mm = 0.29	91-100 = 0.23	101-110 = 0.18	111-120 = 0.14
121-130 = 0.10	131-140 = 0.06	141-150 = 0.03	

DFG studies later indicated predation of 47-56 mm striped bass was considerably higher, in the 70-94% range, which is substantially higher than the 50-60% rate used in the Two-

Agency Agreement calculations to this date. In other words, the losses are even higher than estimated in the mitigation program.

DFG's model predicted the summer abundance of striped bass young based on the magnitude of exports from May-July and the Delta outflow from May-July.

One of the interesting results of the modeling exercise is that DFG's estimates of the rate of reduction in the entire young striped bass population from export loss **after the summer young index was set** substantially increased in the period 1985-1989 compared to earlier 1959 to 1984 period (Figure 17). Losses of young bass were apparently increasing during the summer. Though the rate rose significantly during the late 1970's, it rose substantially more during the late 1980's. What this meant was that the proportion of the juvenile striped bass that remained in the population after the index was set that was subsequently lost to exports rose dramatically beginning in 1985. The increase occurred coincident with the proportion of Delta inflow that was exported increasing dramatically during the striped bass summer rearing period in the Delta. More of the striped bass were vulnerable to export during the summer especially in the dry years of 1985, 1987, 1988, and 1989. Instead of the young striped bass being concentrated in Suisun Bay by July and August, they remained highly vulnerable to exports by being in the Central and Southern Delta during these dry years. From Figure 16 you can see that compared to the previous drought of 1976-1977, total exports and specifically summer exports more than doubled in the 1985, and 1987-1989 drought years. Higher demands and higher export capacity by the late 1980's was leading to a new and higher level of impact of the striped bass population. Where the summer young index had been a sufficient indicator of project impacts on striped bass production, the summer index was no longer an adequate indicator of the full project export losses on the population. The higher summer exports can be seen in Figure 16, and the specific mechanism of high export and low outflow is apparent in June of 1985 in Figure 14.

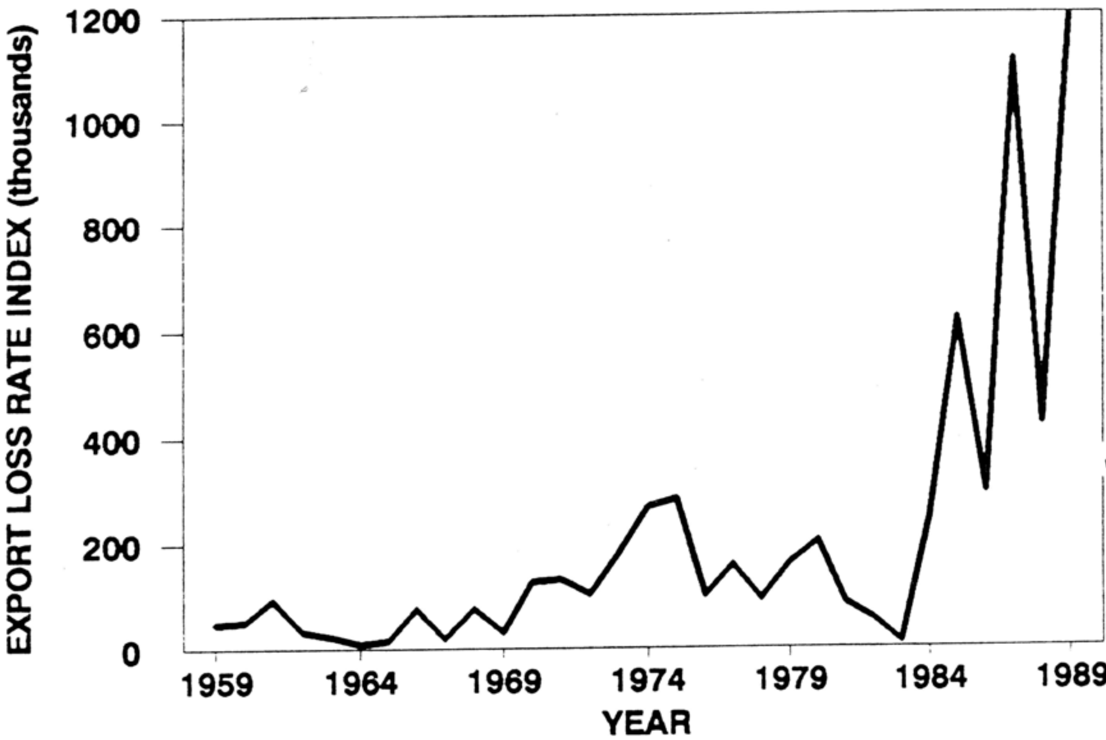

Figure 17. Trend in estimated export loss rate of 21-150 mm striped bass after the time when the young-of-year index is set. Loss rate is the estimated export loss divided by the YOY index and represents the number of young bass lost per index unit. (Source: DFG 1992)

Another result from the modeling exercise was that the percentage of younger striped bass age 3-7 in the adult population had risen from 80 % to 95-98 % in late 80's, which indicated age 8 and older striped bass important in egg production were no longer a significant component of the population. Like the 1976-77 drought, there appeared to be a die-off of older bass in the late 80's drought.

Bay-Delta Agreements – 1994

In 1994, state and federal agencies signed the Framework Agreement that would provide more reliable water supplies, protect fish and wildlife of the Bay-Delta ecosystem, and prohibit the listing of more endangered species. To help fulfill the Agreement, the CALFED Bay-Delta Program was established and charged with developing long-term solutions to problems in the Bay-Delta estuary. The Agreement was intended as a stopgap measure to limit the decline in health in the Delta ecosystem while a more comprehensive solution (e.g., something like the Peripheral Canal, which the voters rejected in 1982) was developed. New standards were designed to protect various fish species during the most critical seasons in their life cycles. Many of the new standards were required as conditions of federal biological opinions for the operation of the water projects. The Agreement included increased Delta outflows and further limits on water diversions.

The Agreement integrated the 1992-1995 ESA Biological Opinion requirements for delta smelt and winter run Chinook salmon into the water quality standards. The Agreement also included adaptive management of the water projects that would provide flexibility in operations and greater ecological protection at lower water cost. Institutions would also be developed that would ensure water management that maximizes environmental benefits. There was also a commitment to a non-flow habitat restoration program – a real one-two punch at saving the estuary.

On December 1, negotiators for DWR and the State Water Contractors reach an agreement, known as the Monterey Agreement, to modernize the way the State Water Project allocates, stores and sells water.

The SWP and CVP water contractors estimated the cost of the agreements in terms of project yield was 1.1 million acres feet in dry years and 0.4 maf on average in wet years. The water contractors were offering up some substantial help to resolve the Delta problems.

Bay-Delta Water Quality Standards – 1995

The 1995 Water Quality Standards modified or added to the D-1485 standards in many ways:

1. **April 15 to May 15 export limit of 1500 cfs plus added San Joaquin inflow** – this provision designed to save the San Joaquin salmon and delta smelt had some real benefits to the striped bass. The problem was that the already weak D-1485 protections were even further weakened before and after this period in early April and late May, as well as June and July.
2. **February through June 35% of Delta inflow export limit.** While this looked like improved protection it actually allowed for higher exports – to meet this standard, exports could be raised as long as inflow was high.
3. **July through January 65% of Delta inflow export limit.** This standard essentially took away all the summer striped bass D-1485 protections that limited July exports to a maximum 8000-9000 cfs. Now exports could be raised to the full capacity of 11,000 cfs simply by insuring inflow was 17,000 cfs or higher, which was about what was needed to meet carriage water and Delta outflow requirements.
4. **August – January minimum outflows 3000-4500 cfs.** This was a slight improvement on the 2000-3000 cfs normally provided in summers of droughts that was necessary to meet water quality salinity standards in the Delta (which generally control at low Delta inflow levels).
5. **July monthly average outflow of 8000 cfs in wet and above normal years, 6500 in below normal year; 5000 in dry, 4000 in critical (when 5000 cfs or below 7-day average must be within 1000 cfs of standard; above 5000 cfs 7-day average must be within 80% of standard).** This standard required a little extra outflow in wet years to allow export at capacity, but a monthly average standard is usually easy to get around. These flows were designed to get the young bass into Suisun Bay, but with exports higher than this, a majority of the

young bass (and delta smelt) were going to head to the south Delta pumps in any case.

6. **<u>May 6-30, June, and July monthly average outflows as in D1485</u>** (see Table 2).
7. **<u>Closure of Delta Cross Channel Gates February-May 20th unconditionally with remainder of November to mid June period conditional.</u>** This standard was to protect Sacramento River salmon, which are minimally impacted by exports in any case. What the standard did was doom striped bass, delta smelt, and San Joaquin salmon to the exports because of the strong reverse flows in the lower San Joaquin River that results from closure of the DCC, especially when outflow is less than 12,000 cfs. Despite the concerns about closure of the DCC on San Joaquin fish raised by DFG and USBR (and FWS) in 1986-87, closure of the DCC in late spring was again prescribed without low outflow limits on its use.
8. **<u>Winter-spring X2 standard for outflow to maintain location of X2 in lower estuary.</u>** This standard had major potential benefits to the estuary for those organisms that could get downstream of the influence of the pumps. For the striped bass it did not help because the new standards pretty much doomed them to the exports. This standard is worse than the D-1485 monthly standards in that it was a seasonally averaged standard and benefits derived are usually prior to the young bass appearing in the estuary.

Draft CVPIA Anadromous Fish Restoration Program 1995

The draft CVPIA Anadromous Fish Restoration Program (AFRP) Plan distributed by the US Fish and Wildlife Service (FWS) in December 1995 to meet CVPIA goals, had a number of measures that were designed to help striped bass:

- *Maximize DCC* (Delta Cross Channel) *closure in May and June* to protect salmon, but open the DCC when striped bass and other sensitive species are abundant in the lower San Joaquin River. (*later changed to May 21 – June 15)*

While this measure was designed to protect Sacramento River salmon, at least the FWS understood the potential ramifications to striped bass and other species (e.g., delta smelt and San Joaquin salmon) from closing the DCC and causing reverse flows under high exports. The problem was that striped bass and other species were always abundant in May and June in the lower San Joaquin because that is a major part of their nursery area.

- *Minimize fish losses and predation at facilities by operating state and federal pumps interchangeably.*

This measure would allow switching between the two pumping plants depending on the degree of fish loss at each plant. It generally proved infeasible as the CVP pumps went full out anyway and they had the least impact (at least this appears to be the case) being they were not connected to CCF.

The AFRP had other recommendations that would require water, a prescription not available under the jurisdiction of the AFRP (CVPIA Section 3406b1) but other CVPIA programs (3406b2 and b3).

- *Limit the combined SWP and CVP exports to 1,500 cfs for more than the 30 days* required by the 1995 Standards, when San Joaquin River chinook salmon smolts are abundant, or when large striped bass spawning events occur in the lower San Joaquin River. (*Later changed to 15 day ramping up after 30-day VAMP period.)* This too would provide additional protection in early April and late May, or even early June. But water costs are high and little can be done each year with limited available CVPIA b2 water or even the EWA account after it became available in 2001. Generally, while some benefit has occurred from this provision in late May, nothing has been done under this provision to help save the striped bass in June and July.
- *Increase the Vernalis (San Joaquin River Delta inflow) flow period to more than the 30 days required by the 1995 Standards when San Joaquin River salmon smolts are abundant and temperatures are below 68F.* This provision had some protection potential for striped bass as they spawn in the 60-65°F range; however, there is generally insufficient b2 or b3 water to accomplish this action.
- *Reduce exports and increase Delta outflow from April through July to begin restoration of striped bass population.* The final AFRP plan calls for limiting the average SWP and CVP exports to no greater than 35% of Delta inflow in July instead of the 65% in the 1995 WQCP standard. This provision recognized that striped bass would benefit from export reductions in the entire April-July period, and especially in July. There turned out to be no b2 or EWA resources to get this done in July, so it has never been accomplished.
- *Maintain at least 13,000* cfs daily flow in the Sacramento River at the I Street Bridge (City of Sacramento) during May. (*Final added 9000 cfs minimum at Knights Landing.)* This provision was to protect the striped bass spawn in the Sacramento River as the eggs and larvae drifted to the Delta. These flows are generally provided for by some other need or natural flows.
- *Supplement Delta outflow for migration and rearing of white sturgeon, green sturgeon, striped bass, and American shad by modifying CVP operations and using water available under the CVPIA (3406(b)(2) and (3).* This provision though vague could provide Delta inflow and outflow at key times for striped bass. However, it being vague and b2 and b3 water being gone by summer, it has not been used specifically for striped bass.
- *Minimize to the extent possible riparian diversions in the Delta during the April through May pulse flow period and at other times when anadromous fish are abundant.* Again this water would come from the b(2-3) programs or volunteer efforts by Delta agricultural diverters. As far as I know there have been no attempts to address this provision. Delta agricultural diversions remain for the most part unscreened and unregulated. Screening with high-tech, expensive systems would not reduce impacts to the important early larval stage, but would reduce losses to older larvae and juveniles that are lost in these diversions.
- *Develop and implement a program that provides for modified operations and new or improved control structures at the DCC and Georgiana Slough during times when high numbers of striped bass eggs, larvae, and juveniles are in these areas.* Nothing has been done with respect to this provision. Striped bass egg and larval abundance

and distribution in the lower Sacramento River are no longer monitored. If they were monitored the DCC could be closed (in combination with increased Sacramento Delta inflow) for short periods to allow concentrated patches of eggs and larvae to pass down to Suisun Bay.

- *Evaluate actions to reduce loss and entrainment of eggs, larvae, and juveniles of anadromous fish by screening or relocating riparian diversions in the Delta.* Only a small number of the Delta diversions have been screened.

The Problems Continue Unresolved - 1996-2003

The period 1996-2003 could be described as the initial stages of implementation of the CALFED and CVPIA programs under the 1995 Water Quality Standards. The negative relationship between the summer young striped bass abundance index and June-July exports remained apparent (Figures 18 and 19), although the index remained at record lows during the period with five of the seven years having exports higher than that allowed by the previous D-1485 standards (Figure 20). The total index (Figure 18) was significantly negatively related to June-July exports (r-square = 0.11, p = 0.04). Without the five drought years and 1974 the relationship was highly significant (r-square = 0.51, p = 0.000002). The relationship was stronger between the Delta portion of the index and June-July exports (Figure 19).

Total Delta exports in 2000 and 2003 reached record levels above 6 maf (Figure 21). Total June-July exports reached or exceeded 1 maf in six of the seven years. Year 2003 had a record export for June-July of over 1.3 maf (Figure 22).

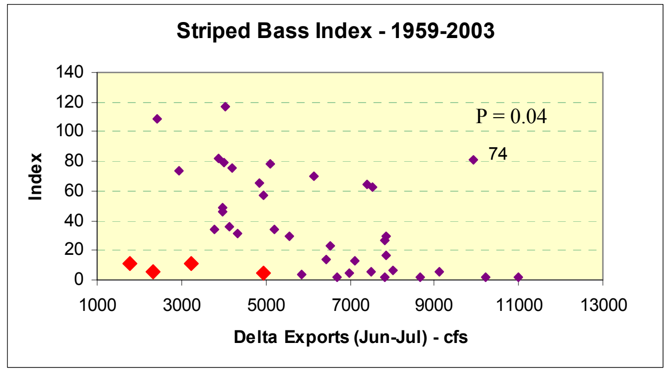

Figure 18. Striped bass young summer index versus average June-July Delta export from 1959-2003. Large red diamonds are critical drought years. Year 1974 was considered an outlier because it occurred at the beginning of the decline and high export losses that year may very well have contributed to the decline. Without these years the negative relationship between the index and exports is highly significant.

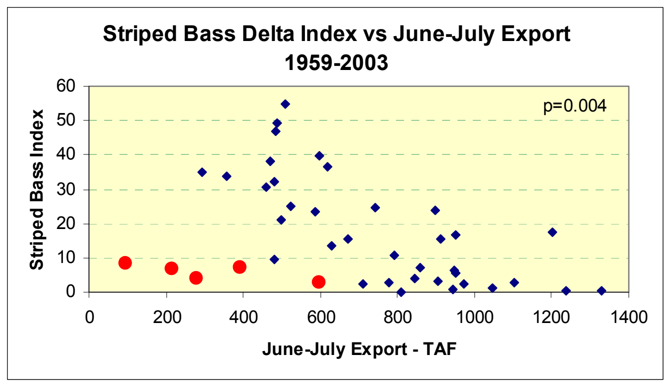

Figure 19. The portion of the striped bass young summer index for the Delta versus average June-July Delta export from 1959-2003. The five red dots are drought years 77, 90-92, and 94 when exports were curtailed from lack of water.

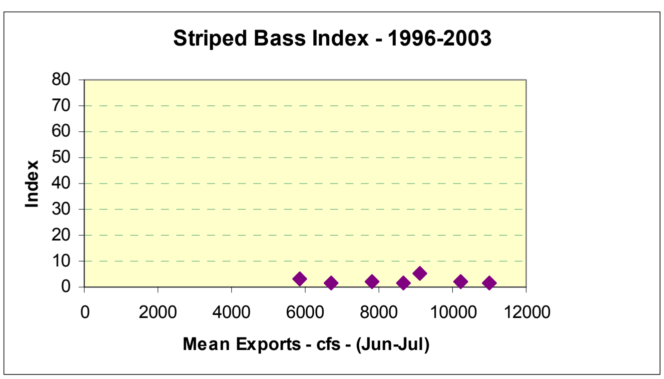

Figure 20. Striped bass young summer index versus average June-July Delta export from 1996-2003. (there was no index for 2002)

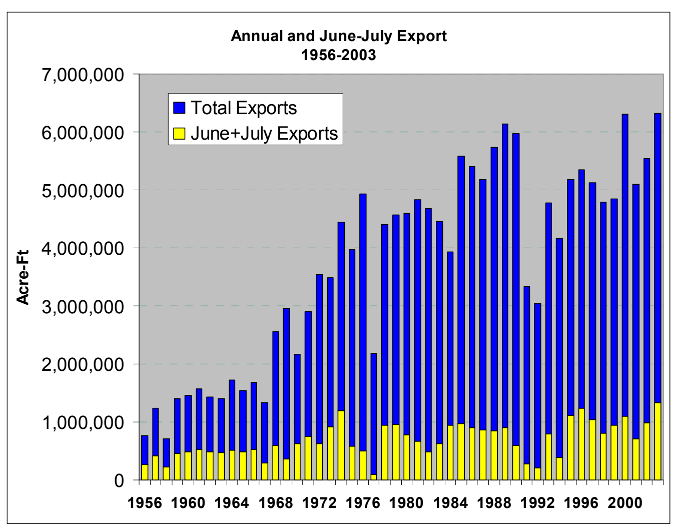

Figure 21. Total and June-July exports 1956-2003.

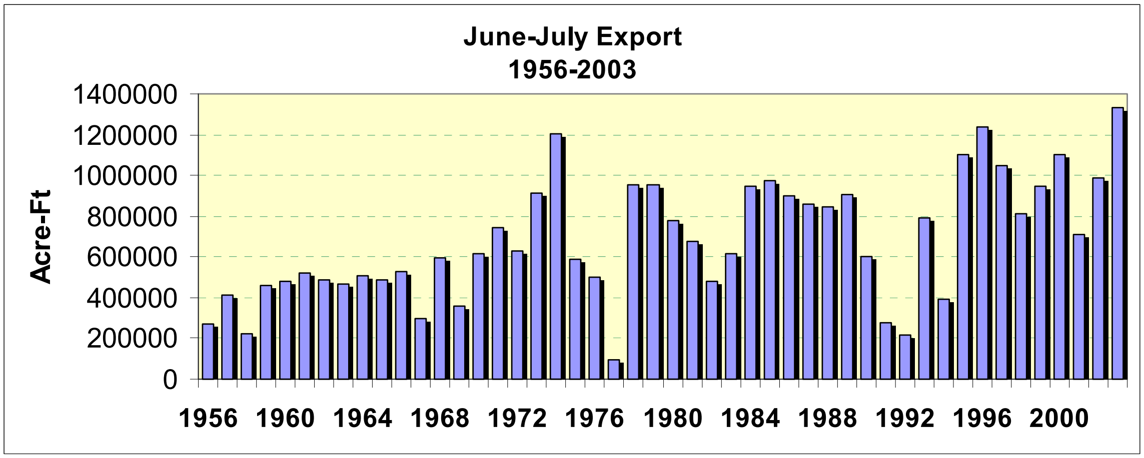

Figure 22. June-July export from 1956-2003 at the south Delta pumping plants of the SWP and CVP.

CALFED 1996-2004

The CALFED Bay-Delta Program (CALFED) got underway in 1995 in developing long-term solutions to problems in the Bay-Delta estuary. In 2000 CALFED published a plan to fix Delta water problems and address major water challenges over the next 30 years. Agreement on the plan was jointly announced on June 9, 2000, by California Governor Gray Davis, U.S. Secretary of the Interior Bruce Babbitt, and California Senator Dianne Feinstein. The plan was formalized in a Record of Decision issued on August 28, 2000. The CALFED program subsequently called the California Bay Delta Authority (CBDA) began a thorough review of Delta science in 1995 that continues to this day. In the documents supporting the Record of Decision, remaining key science questions and concerns were identified to help guide the program. One of these questions concerned diversion effects of the export pumps: *"It is not clear to what extent the entrainment of fish and other biota in the CVP and SWP pumps and agricultural water diversions in the Delta affect the population size and dynamics of any one species."*

Delta Entrainment Effects Team

One of the CALFED activities was the Delta Entrainment Effect Team (DEFT), which analyzed export effects in 1998. Some of the issues reviewed by the team included:

1. Direct effects of entrainment from south Delta pumping. Is the number of fish killed at the south Delta pumps significant – Will populations be impacted significantly by loss of fish at the pumps?
2. Indirect effects of south Delta pumping. Does pumping create greater impacts to habitats and species by changing hydraulics and source water composition in the Bay and Delta?
3. Other factors. Are other factors relating to project operations (hydrology, habitat, etc.) more important than entrainment at the south Delta pumping plants?

The DEFT report to CALFED recommended a series of actions to reduce fish losses in exports:

- Flexible operations – flexibility allow changes in project operations on short notice to protect fish.
- Expanded VAMP – The Vernalis Adaptive Management Program with its higher spring San Joaquin Delta inflows and lower exports was determined by the DEFT team to be highly effective at reducing fish losses at the export pumps. The DEFT team further recommended that extending the export reductions before and after the standard April 15 to May 15 period would provide valuable added benefits.
- Hood Diversion – the team determined that a Hood diversion from the Sacramento River to the Central Delta (often called a Through Delta Facility) would reduce reverse flows, which might benefit Delta fish, but exacerbate effects on Sacramento fish.
- HOR barrier – the team determined that a Head of Old River Barrier would be a benefit to San Joaquin salmon, but a possible detriment to delta smelt and striped bass.
- Fish screens at Delta pumping plants – improving fish screens at the SWP and CVP south Delta pumping plants would reduce fish losses.

Generally the actions taken by CALFED, CVPIA, and the new water quality standards were considered by the team to be good for salmon and delta smelt. The group thought striped bass would generally benefit except from higher summer exports. The team's formal position was that despite higher Delta outflow and lower exports in general from the new 1995 standards, striped bass had not responded positively because of some "unknown" cause.

Delta Cross Channel – Through Delta Facility Review Team

The CALFED Record of Decision prescribes a Delta Cross Channel – Through Delta Facility evaluation where a review team was charged with conducting scientific and analytical studies to determine optimal operation of the Delta Cross Channel (DCC) and the potential benefit of a new structure called the Through Delta Facility (TDF). The TDF would increase diversion of water from the Sacramento River across the Delta toward the south Delta pumping plants alleviating some or the a majority of the north Delta bottleneck.

Some of the questions the team was charged with addressing include:

1. Are there fish benefits or impacts to closure of the DCC?
2. What would be the potential benefits and impacts to fish populations from a TDF?
3. Is closure of the DCC necessary to protect Sacramento salmon, steelhead, splittail, delta smelt, and striped bass?
4. Is there a significant portion of the striped bass population subject to diversion to the Central Delta through the DCC or TDF?
5. Will a TDF add significantly to benefits or impacts of a DCC?
6. What would be the benefits and impacts of the DCC being open and the TDF pumping or diverting 4000 cfs?
7. What would be the effect on the lower San Joaquin portion of the striped bass population?

8. What would be the effects on the lower Sacramento River (below Georgianna), GS, lower San Joaquin, Mokelumne Forks, Snodgrass Slough, and Steamboat/Sutter Sloughs from an additional 4000 cfs diverted/pumped at a Hood TDF?
9. What would be the effects on striped bass eggs and larvae in the lower Sacramento River?

The DCCTDF team has released no formal findings.

2004 Operations Plan

The agencies plan for Delta operations no longer includes striped bass in their objectives:

- *Delta export pumping reductions in April and May to protect juvenile salmonids and juvenile delta smelt and splittail and implement VAMP.*
- *Delta export pumping reductions and/or ramping in June to protect juvenile delta smelt, splittail, and juvenile salmonids.*

2004 OCAP Biological Opinion

Non-jeopardy opinions have been issued on the existing operations and expansion of the Banks pumping to 8,500 cfs with the south Delta barriers. The USFWS issued a Biological Opinion on the operations of the State and Federal pumping plants in the Delta (July 30, 2004). NOAA Fisheries recently released a similar biological opinion.

My Analyses 1998-2004

I conducted extensive analysis of available information for both the DEFT and DCCTDF teams while a consultant for CALFED from 1998-2002. Additional information and analyses were added for this review. From my review it was apparent that the mystery behind the decline in striped bass over the past several decades as generally viewed in the summer townet index (Figure 23) and fall midwater trawl index (Figure 24) was really not a mystery at all – Turner had fundamentally documented the reasons in 1986. It had been explained over and over again by biologists close to the program beginning with Turner and Chadwick's 1972 paper that related the striped bass summer abundance index to outflow and export levels. The relationship simply shifted over the years as the regression model moved beyond its previous limits of outflows (lower) and exports (higher). The relationship developed on monthly average conditions also failed because the system could be manipulated far more within a month than previously thought possible (see Figure 6 and Figure 25). The decline in the index over the years was explained well by a highly significant negative relationship between the index and the level of exports from the south Delta (see Figures 18 and 19 above). Over the years the export component of the relationship simply became dominant over the outflow component except during drought years and some very wet years when outflow was the obvious controlling factor. Furthermore, where exports were restricted in specific time, they simply were allowed to increase at other times (e.g., high April exports in the early 1980's; and July exports post 1995). Another action being undertaken despite prophetic warnings in the 1982 Two Agency Agreement and the 1986 USBR testimony, was allowing closure of the DCC in the spring or early summer when outflows are less than 12,000 cfs.

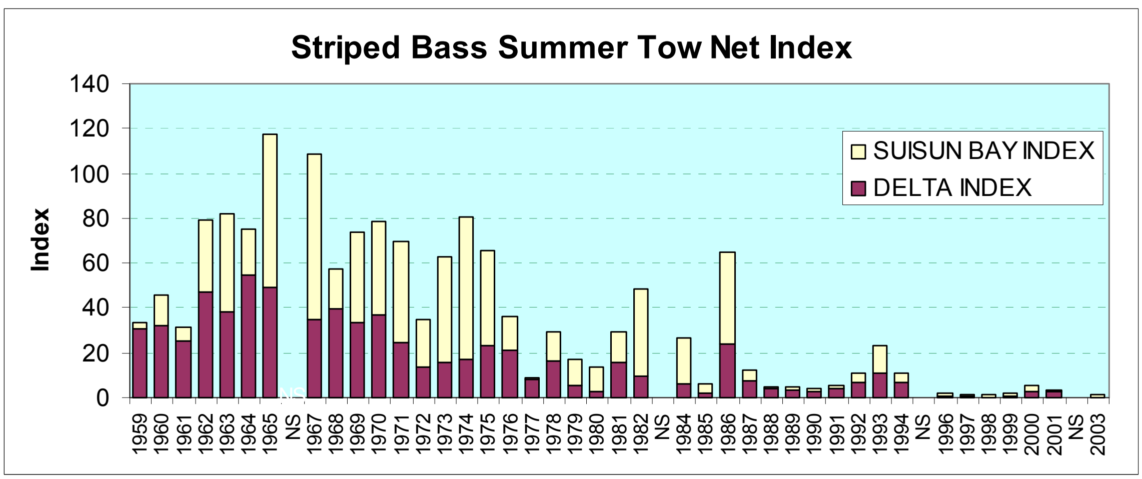

Figure 23. The striped bass summer townet index from 1959 to 2003. The index has two components: a Delta and Suisun Bay index. NS = no survey.

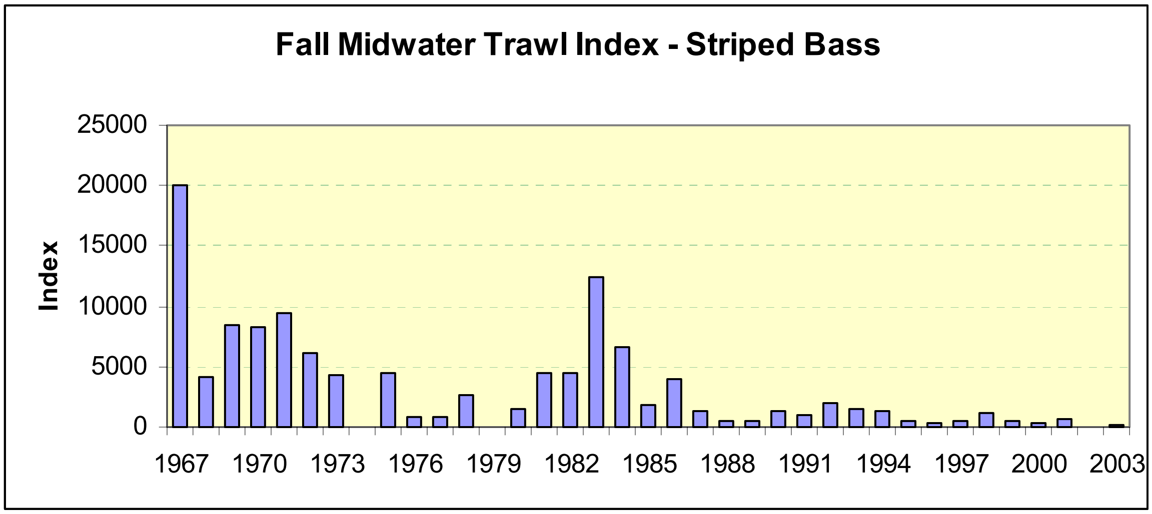

Figure 24. The striped bass fall midwater trawl index from 1967 to 2003. No index was determined for 1974 and 1979.

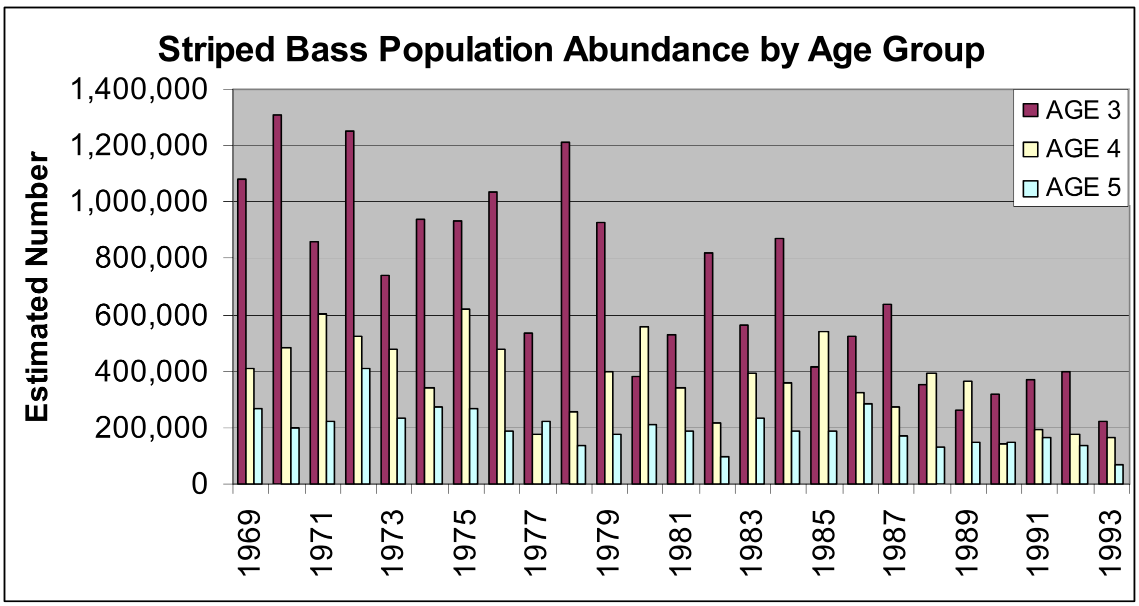

Figure 25. The striped bass adult population estimates from 1969 to 1993.

Export Losses of Young Striped Bass

Young striped bass are lost in the water diverted for export at the South Delta pumping plants of the SWP and CVP. The combined capacity of the two pumping plants is nearly 15,000 cfs with the SWP capacity at 10,300 cfs and the CVP at 4,600 cfs. Channel constraints in the south Delta generally limit exports to 11,000 cfs or less, but there have been opportunities to export more water during high winter flows. Losses occur in the form of eggs, larvae, juveniles, and yearlings. While there are few estimates of the number of eggs and larvae lost, the numbers of juveniles and older striped bass salvaged are estimated each day at the two pumping plants.

An analysis of salvage and hydrology data from 1980-1997 indicates the magnitude of striped bass salvage at south Delta pumping plants is related to export rate, outflow, net flows in the lower San Joaquin River, and adult population size and young production in the Bay-Delta system. Many of the specific salvage events in that period can be explained by these factors. Three major salvage periods occur each year: 1) late spring and early summer (usually late May to early July), 2) in the fall (usually November after the first pulse in Delta inflow), and 3) in early winter (usually January or February). The combination of seasonally decreasing outflow and increasing or high exports explains many of the major salvage events. Very high exports (10,000-14,000 cfs) in winter also lead to high salvage.

Spring-summer losses are generally considered most serious for striped bass because the young are not effectively screened out at the fish facilities at the two pumping plants, the distribution of the young make them more at risk to the pumping plants, and the young are less able to survive the salvage process. Though yearling and older striped bass can be salvaged in the tens of thousands per day in some years in winter, exports losses in late spring and early summer are generally considered a greater risk to the population, and thus are the subject of the summary of salvage losses in this section.

Salvage of striped bass young generally begins in late spring when young reached salvageable size at 1 to 2 inches in length. In this respect salvage numbers are only an indicator of what young bass are being lost that are not salvaged due to the lack of efficiency of striped bass young less than about 1.5 inches in length.

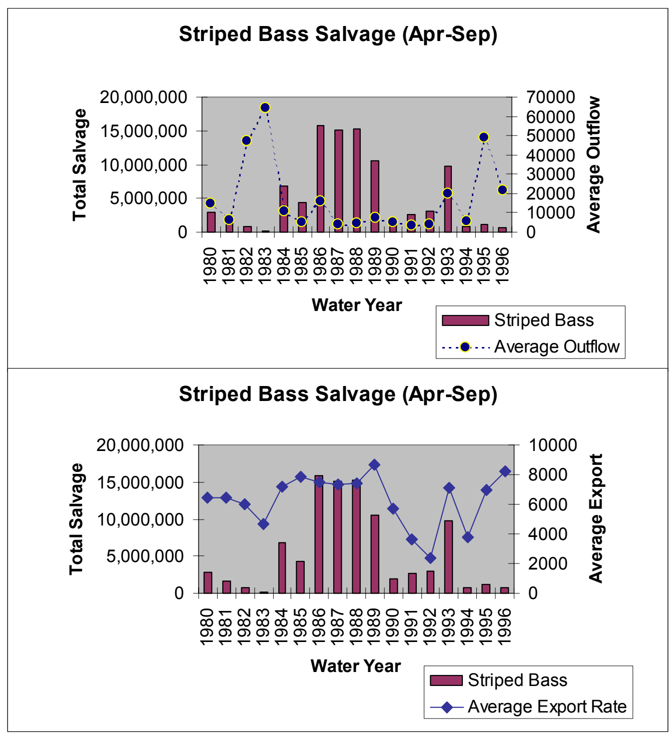

Figure 26. Spring-summer salvage of young striped bass versus outflow (a) and export (b) from 1980-1996.

Salvage of young striped bass reached 10-15 million from 1986 to 1989, which had relatively dry spring-summers with high export levels over the spring and summer (Figure 26). Years 1982, 83, and 95 with high average outflow over the spring and summer had low salvage regardless of export level. Salvage was also lower in dry years with relatively low exports (81, 90-92, and 94). Annual spring-summer salvage was greater in dry years with high exports (85, 87, 88, and 89) and wet years with dry spring-summers and high exports (84, 86, and 93).

Young striped bass begin appearing in salvage at the two Delta pumping plants in June and reach a peak usually in late June or July (Figure 27). Spring-summer salvage often peaked coincident with a sharp drop in inflow/outflow and rising exports (July 80, June

81, July 82, July and August 83, June and July 84, June 85, June and July 86, May and June 87, June 88, June 89, July 90, June and July 91, June 92, July 93, June 94, June and July 95, June and July 96, and June 1997). Often the drop in outflow was brought on by the export increase alone under stable inflows, especially in drier years (including wet years with low inflow spring and summers).

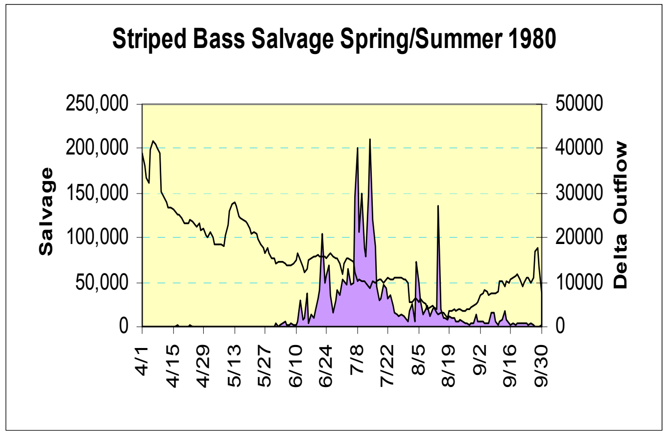

Figure 27. Salvage of young striped bass in spring and summer of 1980 a relatively wet year.

Salvage was often very high when inflow was dropping and exports were rising. Salvage reached the 200,000-800,000 per day range under these circumstances in June 1986 and June and July of 1993, both wet years. The June 1986 event (Figures 28 and 29) occurred as exports increased from 4,000 cfs to 8,000 cfs, while outflow was falling from about 15,000 cfs to 7,000 cfs. Conditions during the July 1993 event were very similar.

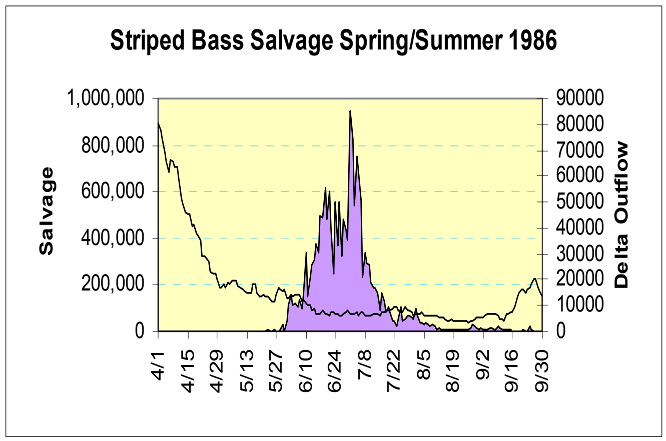

Figure 28. Salvage of young striped bass in spring and summer of 1986 versus Delta outflow.

Salvage was often very high when inflow was low and steady, and exports were increasing. Salvage rates exceeded 100,000 fish per day under these circumstances in June and July 1984, May and June 1987, June and July 1988, May-July 1989, June and July 1991, May and June 1992, and June 1994.

Some major salvage events occurred under falling outflow and steady or falling exports. Salvage rates exceeded 100,000 per day under these circumstances in July 1980, June 1981, and June 85.

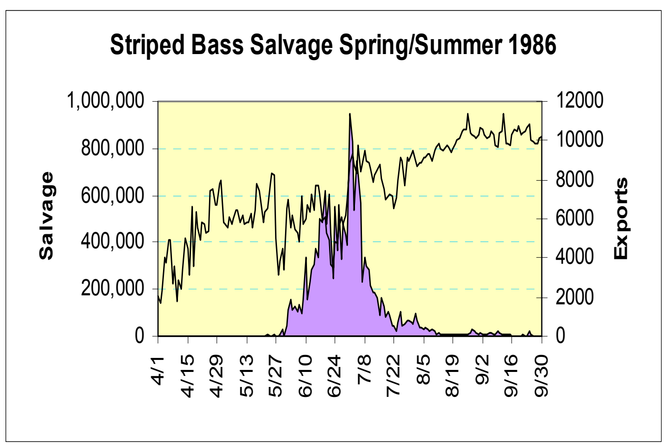

Figure 29. Salvage of young striped bass in spring and summer of 1986 versus Delta exports. The June and July export restriction under D-1485 were 6,000 cfs and 9,100 cfs, respectively.

Salvage occurred earlier in dry years as striped bass spawned earlier in spring with water warming earlier than wet years. In 1987 a critically dry

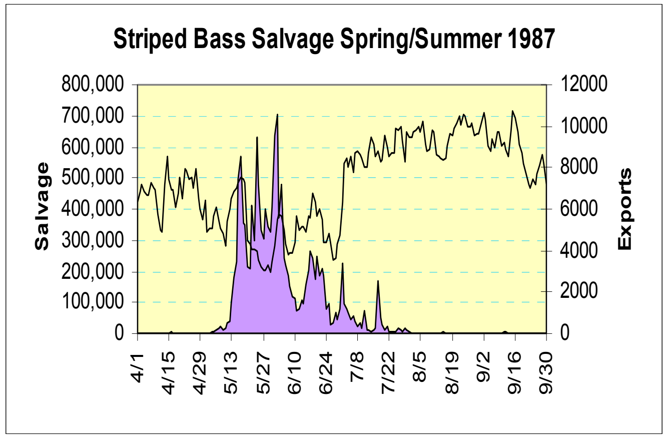

Figure 30. Salvage of young striped bass in spring and summer of 1987 versus Delta exports. The June and July export restriction under D-1485 were 6,000 cfs and 9,100 cfs, respectively.

year, salvage began and peaked a month earlier that most wet years (Figure 30).

Sharp drops in spring–summer salvage also help explain salvage patterns. Salvage fell sharply when exports dropped, inflow/outflow increased, or under stable export-outflow conditions.

Salvage also declined sharply in many years in mid summer despite continued drops in outflow and rising exports (Figures 29 and 30). This may be an indicator of young moving down estuary or simply growing to a size where they no longer move with the flow. Another possibility is population depletion. Regardless, this point may represent a reasonable trigger for when exports can be safely increased in summer without damaging the striped bass population. A similar pattern occurs for delta smelt. In dry years it may be possible to increase exports a month earlier than wet years.

Summer Young Striped Bass Production

My analyses focused on the production of young striped bass in the estuary and what factors controlled that production. The basic finding was that the declining index and especially the Delta portion of the index over the past 30 years was significantly related to increases in exports at the south Delta pumping plants (see Figures 18 and 19).

I also found the index was significantly related to the number of adults in the spawning population and June-July outflow (Figure 31). The spawning population explained 53% of the variation, while June-July outflow explained 14% of the variation. Years 1974 and 1986, both wet years, produced more young bass per numbers of spawners than the average, while years 1972 and 1976, both dry years, produced less young bass per number of spawners than average. Year 1972 young production was also affected by the June Andrus Island break. Wet years simply produce a lot more young bass than dry years, over twice as many as dry years. Higher indices in years 1982, 1986, and 1993 indicate that even when the spawning population is low young production can be significantly higher in wet years.

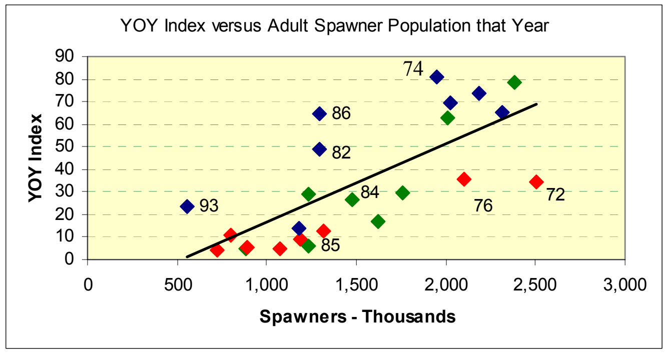

Figure 31. Young index versus number of spawners. Red dots signify low June-July outflow years. Blue dots indicate high June-July outflow years. Green dots indicate in-between years.

I was able to attribute further amounts of the variability in the index in the 1980's to high April exports (Figure 32). All the years with April exports higher than 5,000 cfs had lower than expected indices. Years 1984 and 1985 (green dots in Figure 31) had higher April exports than 1986, while May through July exports were nearly identical. Salvage patterns in 1984 and 1985 were more similar to dry years like 1987 (Figure 30) and thus spawning likely occurred in April, and thus April exports may have been more important than in a year with a wet spring like 1986.

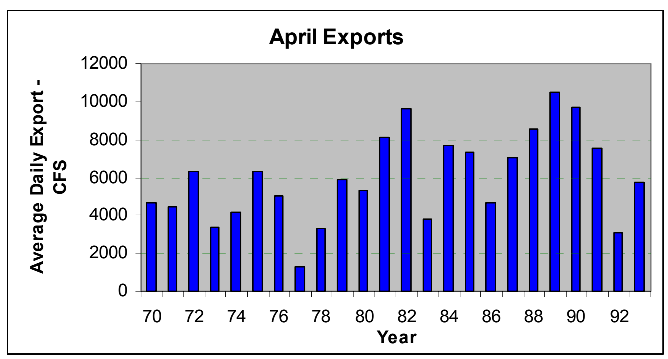

Figure 32. April exports from 1970-1993.

Overall, the production of young appears to have driven downward by a combination of reduced young recruitment in drier years, subsequent lower numbers of adult spawners from the lower young production, and from two periods of sharp reduction in the adult population in or immediately after droughts (1976-77 and 1987-1992). There appear to be three relationships in Figure 31 – one for wet years (blue dots) that provides more young produced per spawner, one for moderate years (green dots), and one for dry years (red dots). The lower production in non-wet years is likely a consequence of high export losses via direct loss of young in export pumps and a possibly a reduction in food supply in the Delta from exports and low outflows.

Fall Young Striped Bass Production

The fall midwater trawl index of young striped bass measured several months after the summer index is strongly positively related to the summer index (Figure 33). Year 1967 was high for both indices, but higher than expected from the linear regression line, which may be a consequence of the high outflow and low exports in summer 1967. Unlike 1967, years 1973, 1975, and 1986 had high exports in summer that may have caused high late summer and early fall mortality. Year 1976 was a drought year with low flows and moderately high exports in summer, which also may have resulted in higher late summer and early fall mortality. Higher mortality during the summer during the townet survey period also may not show until the fall midwater trawl survey.

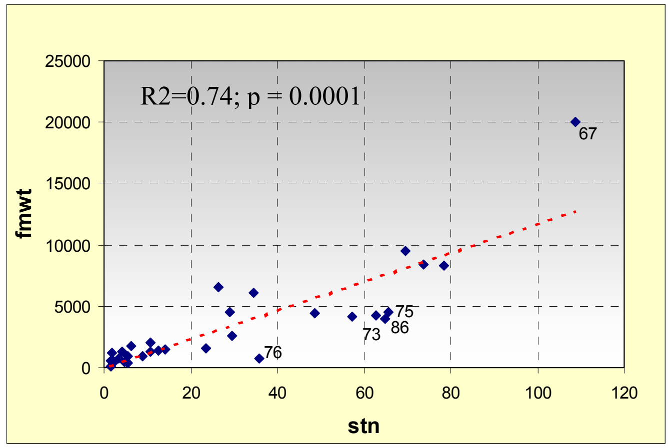

Figure 33. Fall MWT index versus STN Index. Year 67 had high flow and low exports in summer. Year 76 had very low flow and relatively high exports. Years 73, 75, and 86 had moderate flow and high exports.

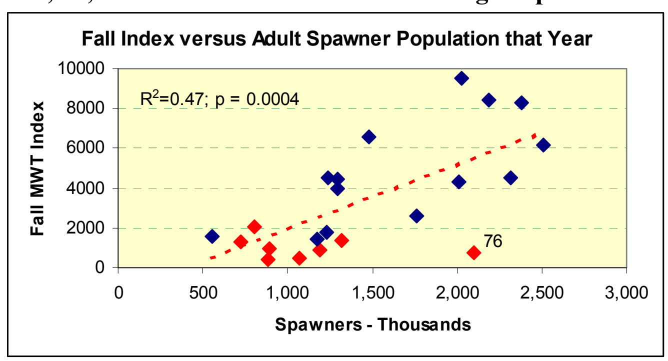

Figure 34. Fall MWT index versus number of spawners. Red dots signify drought years.

Like the summer index, the fall index was also significantly related to the size of the spawning population (Figure 34). Also as for the summer index, production was much lower per unit spawner in drier years (red dots).

Recruitment into the Adult Population

The number of young produced each year has a significant effect on recruitment of 3-yr-olds into the adult population. The number of 3yr-old striped bass is significantly positively related to the index of young produced three years earlier (Figure 35). The relationship appears curvilinear; however, I hypothesize that the outlier yearclasses 1974 and 1986 had poorer survival to age-3 because at least two

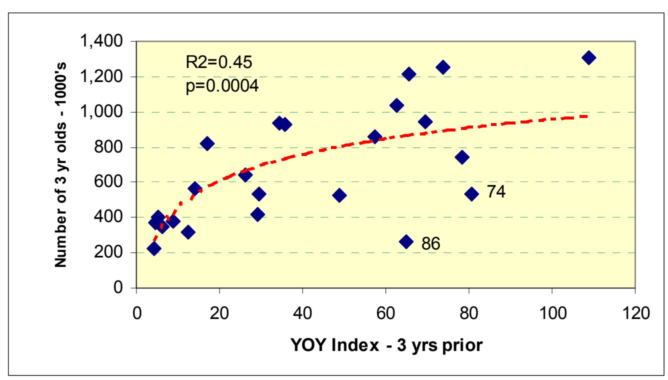

Figure 35. The striped bass 3yr olds estimate versus summer index three years earlier -1972 to 1993. Years designated were years in which the YOY index was determined – or the designated yearclass.

of the years between age 0 and age 3 were extreme drought years (1976-77, 1987-89). Without 1974 and 1986 the curvilinear shape of the relationship all but disappears and is replaced by a predominantly linear relationship with a significantly positive slope.

The estimated number of 3yr-olds is similarly related to the striped bass fall midwater trawl index of young three years earlier (Figure 36). Again, the 1986 yearclass produced fewer than expected three year olds, probably because that yearclass faced three years of drought. The three-year-old index for the 1983 yearclass was lower than expected, other than mortality was higher than normal in 1984 and 1985.

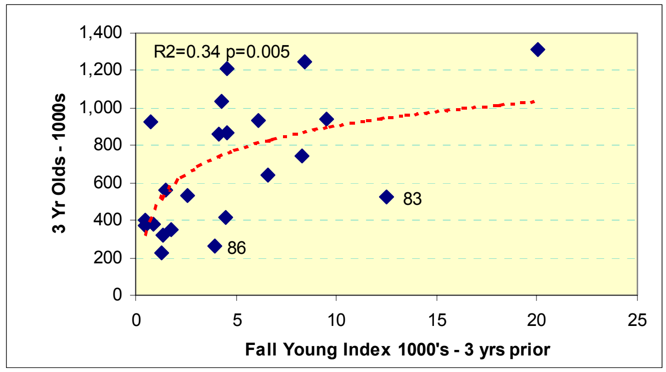

Figure 36. The striped bass 3yr olds estimate versus fall midwater trawl index three years earlier -1972 to 1993. Years designated are yearclasses – year born.

The number of 3 yr olds produced is strongly related to the number of adults in the spawning population three years earlier (Figure 37). Three of the negative outliers were 1977, 1989, and 1990, which were extreme drought years following another extreme drought year, which might explain lower survival to age 3. Year 1984 was a positive outlier possibly because that year and the two previous years were very wet years, which likely increased survival to age 3 per unit of spawners.

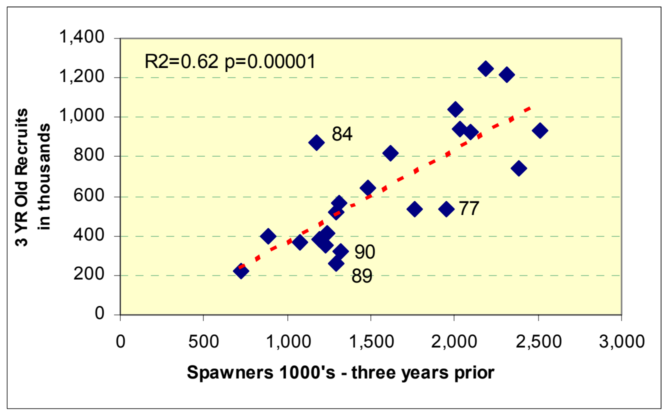

Figure 37. The striped bass 3-yr-old estimate versus the adult population three years earlier -1972 to 1993. Years designated were years when 3 yr old recruits were estimated.

The number of three year olds is significantly negatively related to the June-July export level three years earlier (Figure 38). Year 1993 was a negative outlier possibly because the spawning population was low in 1990 and years 1990-1992 were drought years – a double whammy for the 1990 yearclass. Year 1976 was likely a positive outlier because 1973-1975 had been wet years and the spawning population was high in 1973 – all good things for the 1973 yearclass.

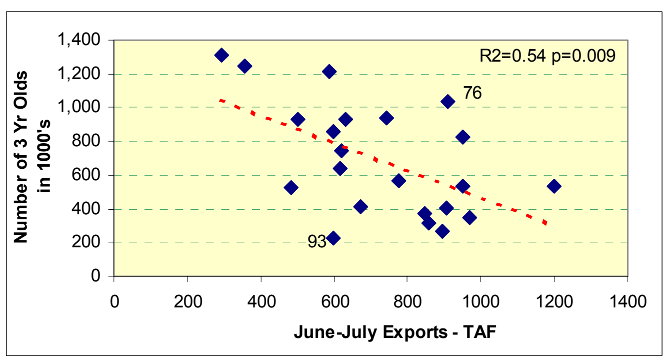

Figure 38. The number of 3 yr olds versus June-July export three years earlier -1972 to 1993.

Conclusions on Young Production and Recruitment into Adult Population

Figure 31 pretty much tells the story on young striped bass production.

1. The number of young produced each year is directly related to the number of spawners at least in the observed range of 500,000 to 2,500,000 spawners. There is no sign that young production declines at high spawner or young abundance, thus compensatory mortality of young does not seem to be occurring. Density-dependent reduction in young production would be a realistic possibility at high levels of young (competition or cannibalism) or adults (reduced fecundity or cannibalism), but this does appear to be the case at the recent historic levels of young and adults.
2. Young production is severely depressed in drier years (about a third of the production capability of a given sized spawning population for wet years). Flow and exports are factors in the lower production. Flow and export effects are highly confounded; however, the YOY index, the fall midwater trawl index, and the 3-yr-old index are significantly negatively related to export level in June-July as originally hypothesized by Turner and Chadwick (1972). Flow certainly is important, as few striped bass are lost to exports in very wet summer years with low export levels (i.e., 1967). However, regardless as to whether the entire year is wet or not (generally determined by winter-spring flows), most summers are not wet, and in the vast majority of these summers striped bass young production is negatively related to export levels. In a few of the wetter years like 1967 and 1983 striped bass young are simply concentrated too far downstream in the Bay to be vulnerable to exports. High exports can lead to poor survival through direct losses to entrainment or indirect losses from a reduction in food or Delta rearing area caused by exports. Both flow and exports are likely important based on the available evidence, but exports are the principle culprit in reducing young production and driving the adult population down because exports have a large effect on Delta outflow in addition to direct loss of young in all but the wettest years.
3. Recruitment into the adult population as measured by the number of 3-yr-olds produced is strongly related to the number of spawners three years earlier, which would indicate as with the young that density dependent mortality is not being exerted among the 1 to 3 years olds and the adults are also not controlling survival of these age groups through competition or cannibalism. Recruitment as measured in 3-yr-old production does flatten out in both the YOY and FMWT relationships (Figures 35 and 36); however, I believe this is simply because some years with high young production have poor survival between age 0 and age 3 because of harsh environmental conditions (droughts) that is not density dependent.
4. Overall, the population has declined in an accelerated fashion as predicted by the Striped Bass Working Group in 1982. A gradual reduction in recruitment per unit spawner has driven the population down. Added higher older adult mortality during the 1976-77 and 1987-1992 droughts further depressed the adult population and young production. The cause of the reduction in recruitment is exports and the added adult mortality. There is no doubt that exports reduce recruitment through direct and indirect effects on young in the first month or two

of life (prior to or during the summer). Lost production of young from exports is compounded by the further lost production of the next generation of young from fewer spawners. Exports impacts on young production are compounded like interest – a five percent loss in any year continues to affect the population in subsequent years because of fewer adults in the spawning population. With the higher mortality of adults during droughts, the three factors have driven the population down sharply over the past three decades.

5. There have been no signs in the population that compensatory mechanisms are acting to increase survival or reproduction at the low young and adult population levels. Compensatory mechanisms are most likely to occur when young or adults are very abundant and they reach the capacity of the estuary to support them (their density is too high per unit area and they compete with one another or directly depress their food supply). Compensatory mechanisms or density-dependent survival would likely occur through several processes:
    - Increased mortality of adults at high population levels or increased survival at low levels of the population.
    - Decreased fecundity of adults at high population levels or increased fecundity at low population levels.
    - Increased mortality of young and subadults at high adult levels brought on by competition or cannibalism.
    - Increased mortality of young at high young levels, or increased survival at low levels.

    No convincing evidence of any of these density-dependent phenomenon has ever been found in the striped bass population. A concerted effort to find such evidence was made in the last four years by members of the CALFED Science Program. A summary of their findings is presented later.

Effects on Delta Smelt

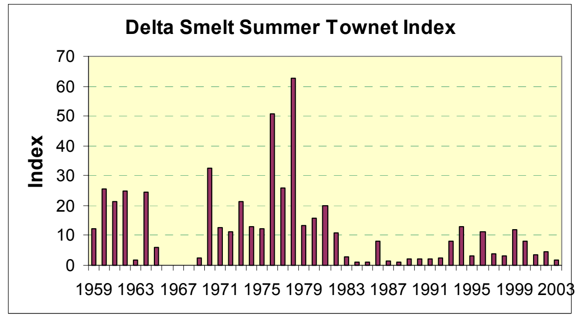

Figure 39. Delta smelt Summer Townet Survey abundance index.

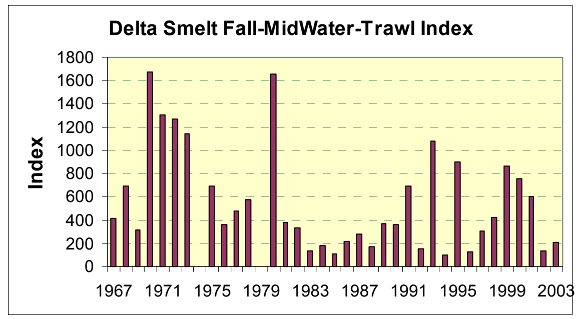

Figure 40. Delta smelt Fall Midwater Trawl Survey abundance index.

I conducted a similar analysis of the effects of exports on the delta smelt population. Delta smelt have replaced striped bass as the estuary's canary. Being an endangered species they are provided the protection of the Endangered Species Act. Because delta smelt generally only live one year and then spawn and die, indices of abundance in the summer and fall have been used to characterize the population and recruitment of young and pre-adults into the population. The population has declined from the levels of the 1960's and 1970's, and despite improving in the 1990's has again declined in 2002-2003 (Figures 39 and 40). The number salvaged at the south Delta pumping plant fish facilities has also generally declined, but has begun increasing in recent years (Figures 41 and 42). Salvage is a misnomer because most if not all delta smelt die in the salvage process. Furthermore, the fish facilities have a low efficiency of 'screening out' delta smelt because of the small size of the smelt. Therefore, salvage represents only the 'tip-of-the-iceberg' for delta smelt losses at the pumps.

Delta smelt salvage generally begins in mid May and continues through June (Figure 43), about 2 to 4 weeks before striped bass.

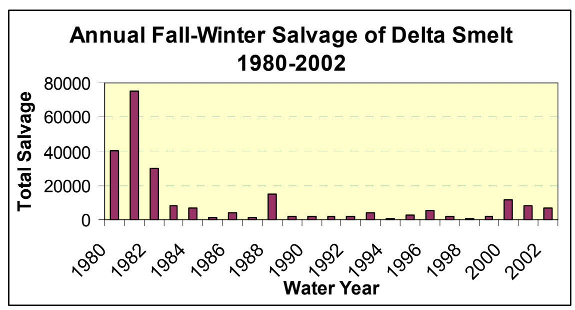

Figure 41. Total fall-winter (Oct-Mar) delta smelt salvage by water year (Oct-Sep).

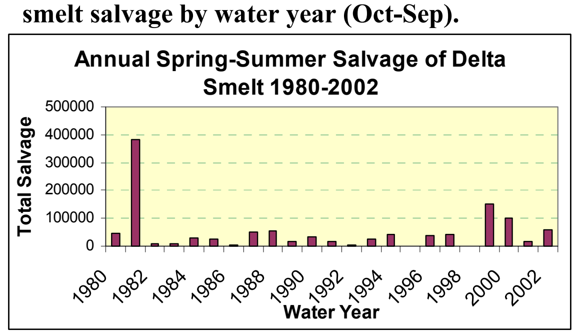

Figure 42. Total spring-summer (Apr-Sep) delta smelt salvage by water year.

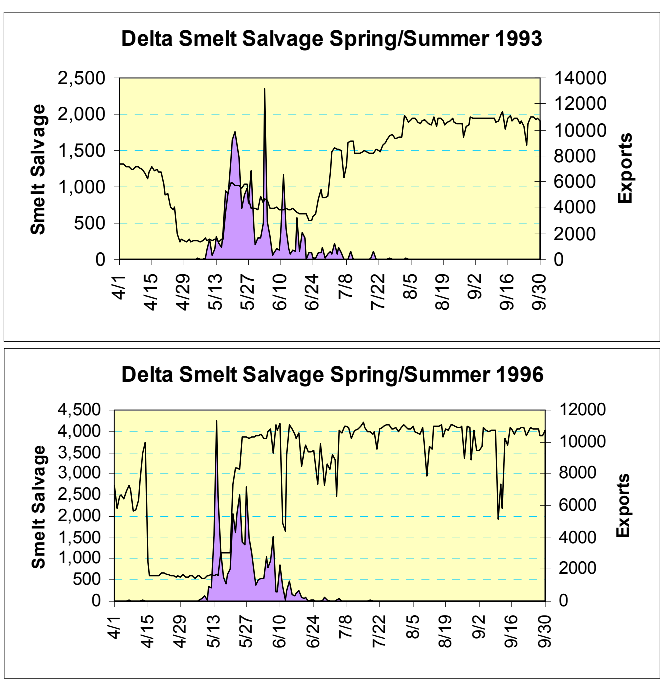

Figure 43. Delta smelt salvage patterns from 1993 and 1996.

To evaluate the effect of salvage losses on the delta smelt population, I related total annual salvage to the changes in the FMWT and STN indices and to residuals in the stock-recruitment relationships. The change in the STN Index from one summer to the next was significantly negatively related to the salvage between the two indices (r-square 0.33; P=0.003) (Figure 44). The relationship between the change in the FMWT Index and the previous year's salvage was not significant (P=0.06). However, some of the outliers (low salvage and large negative change) were flood years and two were drought years: 1992 and 1994. Leaving out the flood years the relationships were significant. The relationships for the flood years alone were also significantly negative.

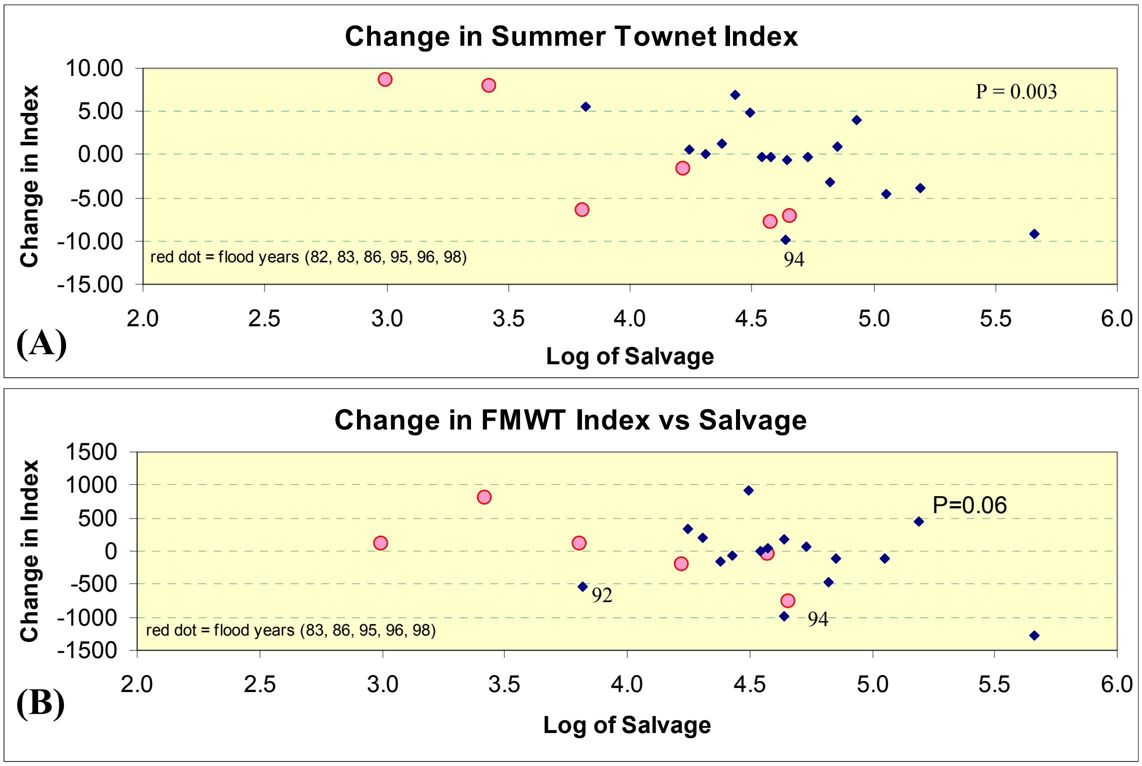

Figure 44. Change in STN Index (A) and FMWT Index (B) between one year and next year versus the logarithm of salvage for the year. Red dots indicate flood years.

I tested two stock recruitment relationships. First I tested if recruitment into the adult population were related to young production by regressing the summer young index against the subsequent pre-adult fall index. A significant positive relationship was apparent (Figure 45). The pattern of low indices in drought and flood years is also apparent. The significant positive relationship indicates the number of fall smelt is related to the number present in the summer.

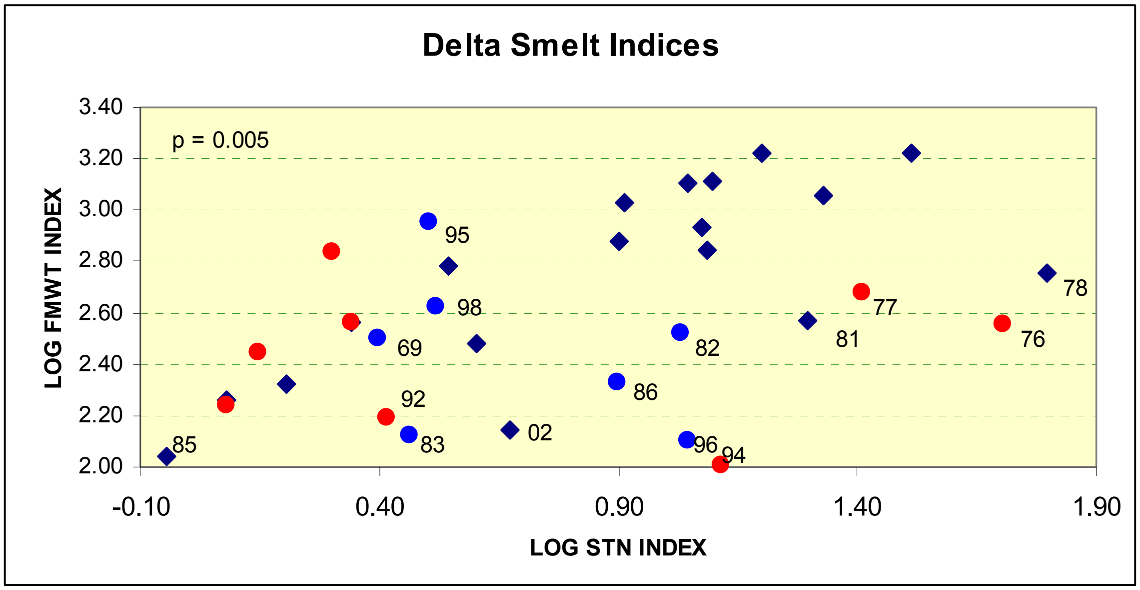

Figure 45. Log of delta smelt fall midwater trawl index versus log of summer townet index – 1969-2003. Drought and flood years tend to have lower indices for both surveys, and where the fall midwater trawl index is lower than expected those years tend to be drought or flood years.

To test to see if the summer and fall indices were related to exports I regressed the indices against June-July exports and June-September exports respectively, but without the flood and drought years. June-July exports have increased (see Figure 22) as the Summer Index has declined (see Figure 39). Summer exports have increased (Figure 46), while the Fall Index has declined (see Figure 40).

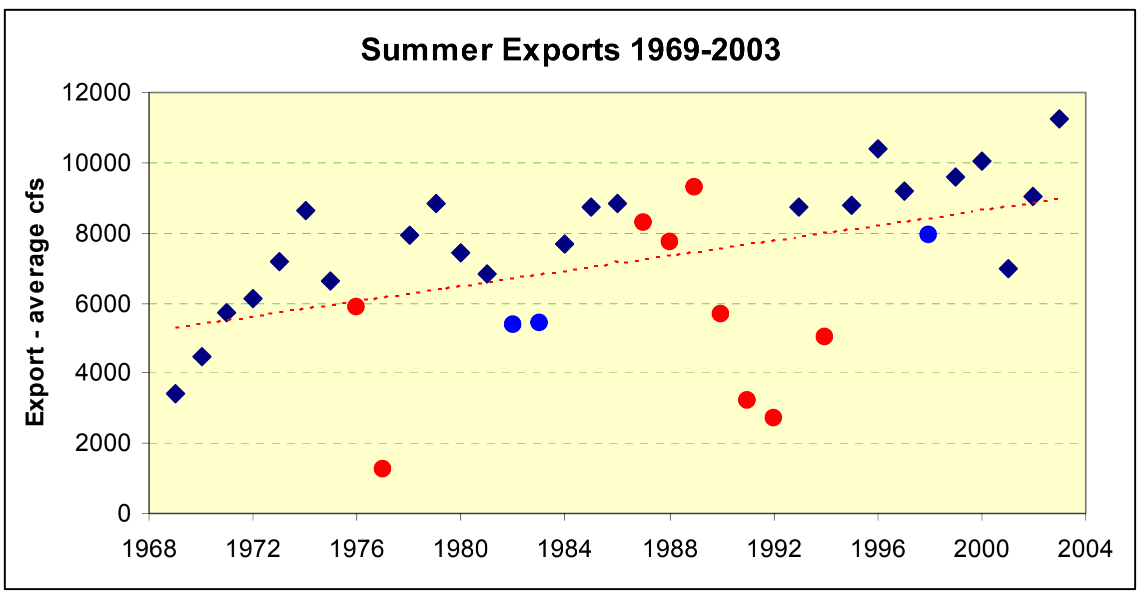

Figure 46. Summer (June-September) average daily exports (cfs) from 1969 to 2003. Blue dots are high summer outflow years and red dots are drought years. Red dotted line is trend or regression line, which is significantly positive.

The Summer Index has a significant negative relationship with June-July average export rate (Figure 47). The Fall Index has a significant negative relationship with the average June-September export rate (Figure 48). Both relationships are significant without the wet-summer and drought years included. The relationships indicate that production is cut by about half by high summer exports (> 8,000 cfs), except in wet summers when the delta smelt are downstream in the Bay. In drought years production is cut by low flows through the spring and summer in combination with high summer exports early in the drought periods (1976, 1987-1989; see figure 46).

The delta smelt summer index is also significantly related to the previous fall midwater trawl index (Figure 49). This indicates production of young varies positively with the number of spawners in the population. As for the striped bass population, export losses are compounded by the subsequent loss of production from a reduced spawning population.

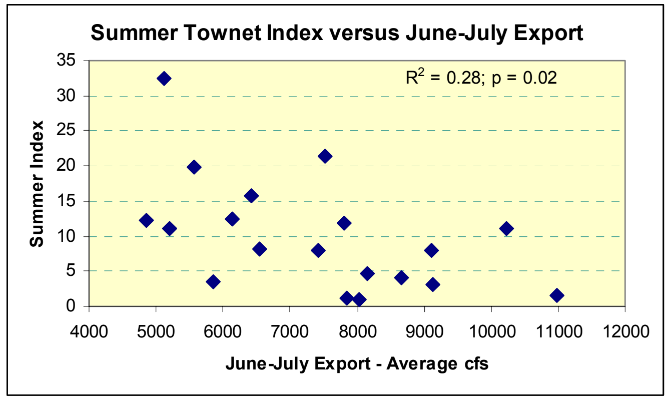

Figure 47. Delta smelt Summer Index versus average June-July export rate. Drought years and years with wet summers are not included.

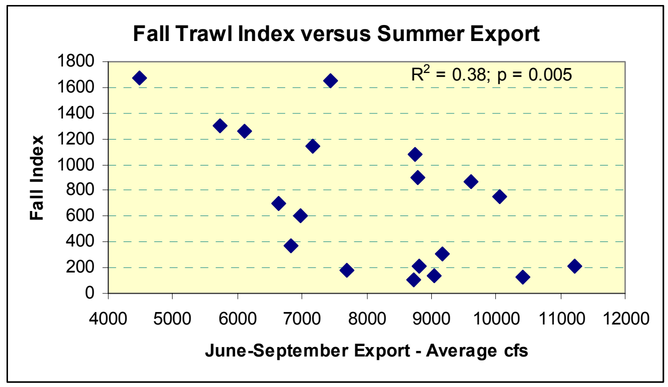

Figure 48. Delta smelt Fall Index versus average June-September export rate. Drought years and years with wet summers are not included.

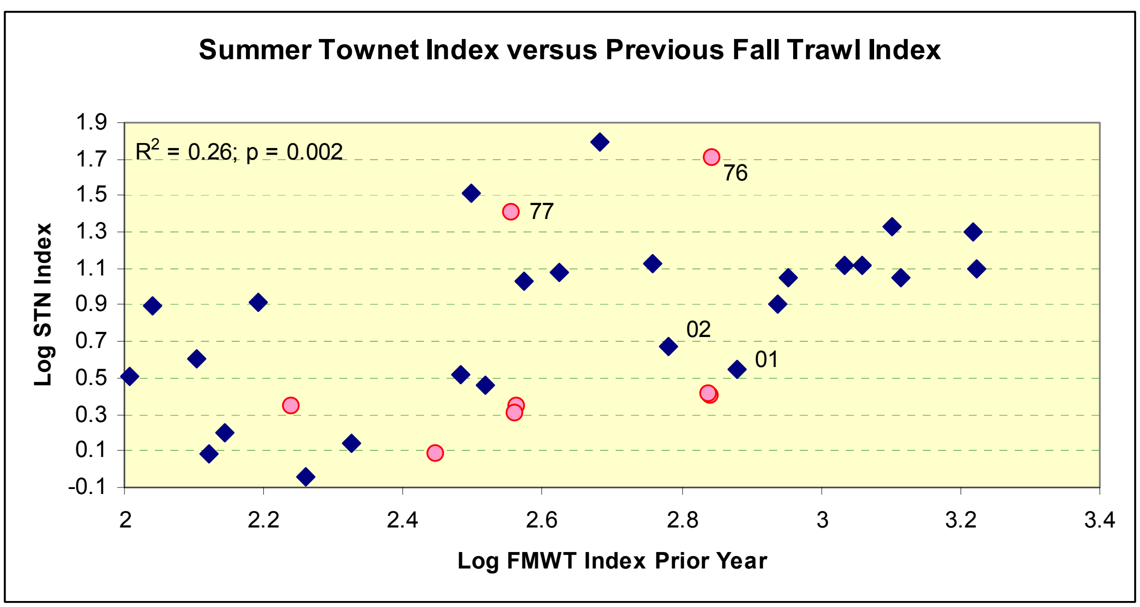

Figure 49. Log of delta smelt summer townet index versus log of fall midwater trawl index the prior year – 1969-2003. Drought years shown with red dots. Drought years 1987-1992 tended to have lower production of young per size of population the previous fall.

Effects on the San Joaquin Salmon Population

Like the striped bass and delta smelt, the San Joaquin River tributaries salmon population is at risk to CVP and SWP exports. I also conducted an analysis of the potential effect of exports on the San Joaquin salmon population using spawning escapement for the period 1958-2003. The analysis indicates that recruitment into the population is primarily controlled by San Joaquin Delta inflow and the size of the spawning population. Multiple regression analysis of the spawner – recruit relationship indicates that flow in the spring two years prior (spring of the year when the young of 3-yr-olds were migrating to the ocean) explains 46 percent of the variation in the population (Figure 50), while flow one year prior (representing the spring outmigration flow for young of two-year old salmon in the run) explained an additional 18 percent of the variation. The number of spawners two years prior explained six percent of the variation. Overall 70 percent of the variation in the population abundance was explained by these factors. Exports in spring and spawner abundance three years earlier were not significant.

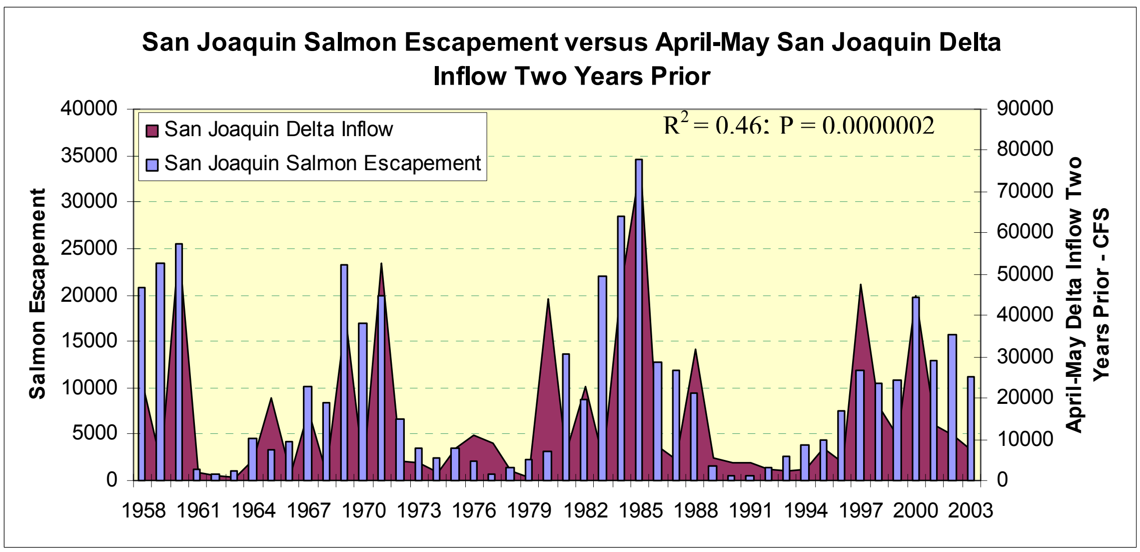

Figure 50. San Joaquin tributary spawner escapement from 1958-2003 and April-May Delta inflow two-years prior (the flow when three year old salmon would have been migrating a young through the Delta to the ocean).

Escapement two to three years after high runoff springs often reach 10,000-35,000 adult salmon, while two to three years after low runoff drought periods escapement was generally less than 5,000 adult salmon (Figure 50). The flow relationship is shown directly in Figure 51. The spawner-escapement relationship is shown in Figure 52.

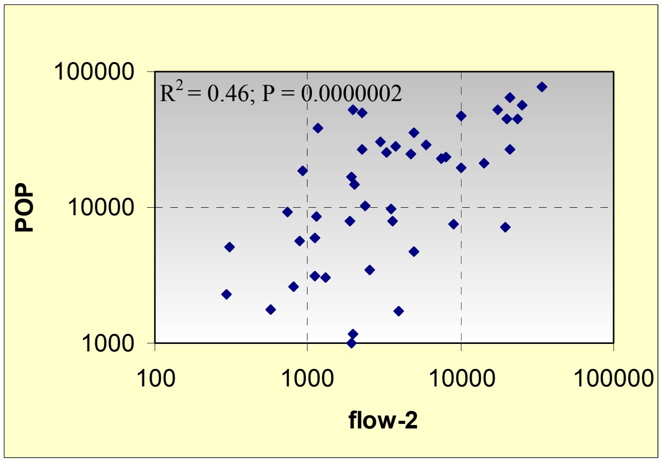

Figure 51. Log of salmon escapement versus log of flow in spring two years earlier.

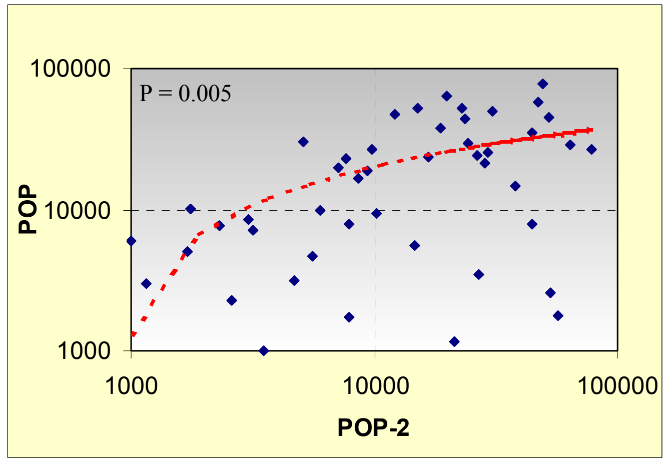

Figure 52. Log of salmon escapement versus log of escapement two years earlier.

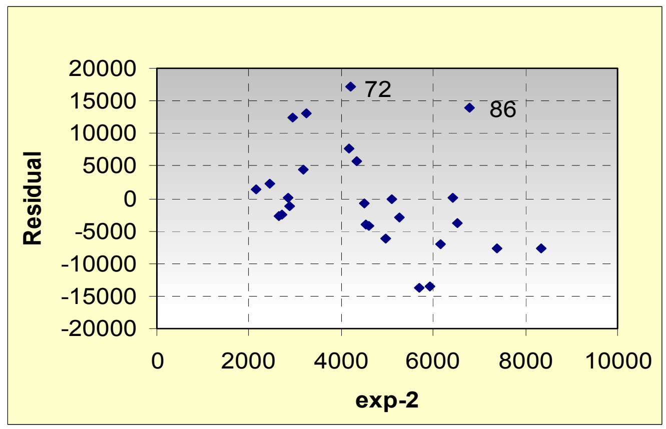

Figure 53. Residuals of regression of escapement, flow, and escapement two years earlier versus export level in April-May two years earlier for only low flow years. The relationship is marginally significant with 1972 and 1986, and highly significant without these years.

I then attempted to determine the cause of the poor escapement after low flow springs. Although exports were not significantly related to escapement in the multiple regression analysis, I plotted exports two-years earlier (during the period when outflows were significant) against the residuals of the multiple regression between escapement, flows, and prior escapement and found the relationship was not significant. I then left out the wet years when exports had less potential effect (Figure 53). Despite two apparent outliers, the relationship was significantly negative. Without the two outliers the relationship was highly significant. The higher than expected escapement of the outliers, 1972 and 1986, can be explained: both years followed several years of very high escapement. Furthermore, the high fall flows in 1986 may have contributed to the higher than expected escapement that year. Regardless, I took the negative relationship between the residual and exports to indicate that low smolt survival in drier years contributed to poor escapement two years later. Other factors that may contribute to poor smolt survival in these dry years include poor conditions in the rivers (e.g., low flows, higher temperatures, and higher predation).

CALFED Science Papers on Striped Bass

CALFED Independent Scientists published several papers on the striped bass and export issue in recent years. The authors included William Kimmerer, James Cowan Jr., and Kenneth Rose from the CALFED Science Program and Lee Miller from DFG.

Kimmerer et al. 2000

Kimmerer et al. 2000 conducted an analysis of the striped bass data and concluded that production of 3-yr-old striped bass was limited by the carrying capacity of the Delta based on a flattening out of the young to 3-yr-old relationship (see Figures 30 and 31). They fit the relationship to a standard Beverton-Holt function and determined that a limiting 3-yr-old production at higher young abundance levels indicated density dependent survival. I do not concur with these conclusions because the relationship appears more linear and I could explain the few outliers being caused by high density-independent mortality factors (i.e., drought). Furthermore, the spawner – recruit relationship (Figure 32) did not indicate any curvilinear structure, and there has been no evidence of density dependent mortality or fecundity in the population. Even if their conclusion is correct, the production of young since the mid 1980's has been below the level that would exhibit density dependent mortality between age 0 and age 3.

Rather than 'carrying capacity', production is limited by production capacity, which changes depending on the water year type (Figure 54). Production is limited in dry by poor density independent mortality factors such as export losses. Yes, the capacity of the estuary to produce striped bass is reduced in drier years, but not by density dependent factors.

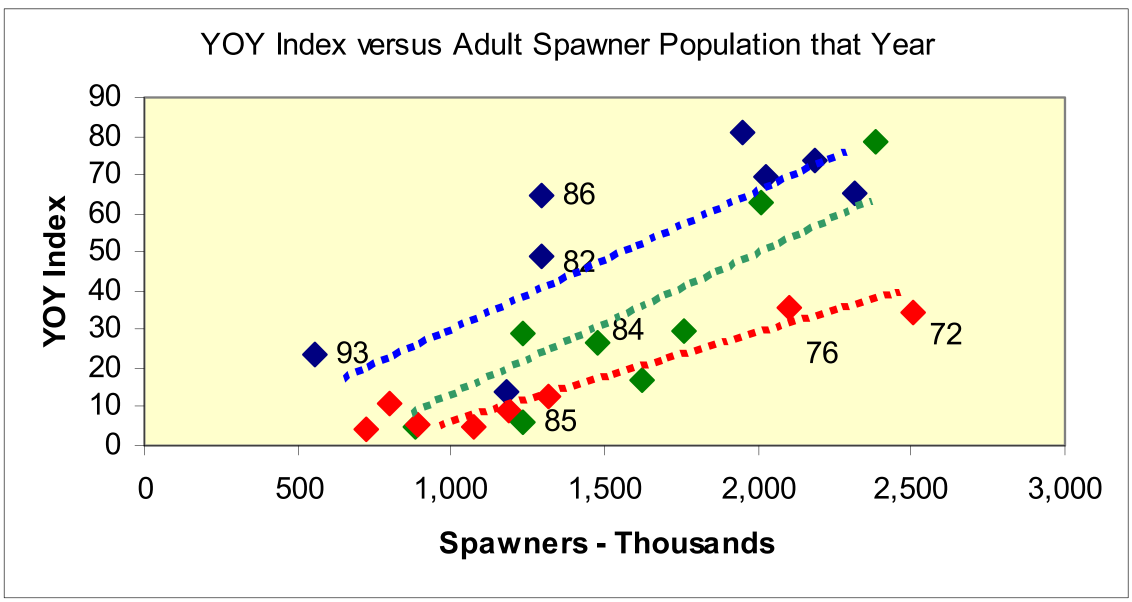

Figure 54. Version of Figure 31 showing spawner to first-summer recruit relationship for different water year types (blue = wet year; green = moderate year; and red = dry year).

Kimmerer et al. further add:

- *"Year-to-year variability in early survival is affected by flow conditions, so abundance in the summer YOY stage is largely a function of egg production (which has declined and flow or X_2, which has no trend."* I agree that the summer index is positively related to egg production (number of spawners) and flow, as is evident from Figure 54 above, but the flow affect is manifested at least in part by exports (Figures 18 and 19). Furthermore, X_2 is a very crude parameter for flow being an average for April-June that does not take into account July flows that are an important determinant of risk to the striped bass population.
- *"We suggest that a decline in carrying capacity of the system has indeed occurred and has acted over time to reduce the potential for production of strong striped bass year-classes".* Carrying capacity implies that striped bass densities are reaching a level that reduces survival, which is not the case. As stated above, the density independent production capacity is reducing striped bass yearclasses. I contend based on the analysis in this paper that production could again be high if exports can be controlled and reverse flows brought on by closure of the DCC at low Delta inflows are not allowed. The USBR experiment in 1985 made it clear that the system can be manipulated and estuary productivity can be restored in short order. Carrying capacity has not declined – what has changed is the density independent factors that control survival (e.g., exports have risen sharply).
- *"The decline in the striped bass population in the San Francisco Estuary appears to have resulted from a combination of two factors: the decline in carrying capacity resulting in lower recruitment and the decline in older adults due to higher mortality and episodic drips in abundance possibly due to climate."* While I generally agree with the decline in older adults as a factor in the decline, as stated above it is not a decline in carrying capacity, but density independent production capacity. I would further add that lower recruitment is being caused by the compounding effects of export effects on young production, and the qualification on the higher adult mortality occurring in droughts that is likely exacerbated by high exports early in droughts (76, 87-89) that would reduce the food supply for adult striped bass.
- *"In this population the YOY index appears to be less predictive of recruitment than has been reported for other striped bass populations."* I disagree because the relationship between the YOY summer index, the fall MWT index, the 3-yr-old estimate, and the total spawning population estimates are all positive, linear, and significant. The stock-recruitment relationship in Figure 54 appears to portray well the population dynamics of the population. In drier years with high export losses, production of striped bass is lower.
- *"The existence of density dependent and decreasing carrying capacity after the YOY index is set, evidence of higher adult mortality and possible climate effects, and the lack of time trend in early survival or its predictors suggest that management and research efforts should be broadened to consider the juvenile and adult segments of the life cycle."* Certainly causes of abnormally high adult mortality should be looked into whether it is from toxins or poor food supply (of which both would be affected by exports). However, the implication is that we should look away from effects on young and particularly exports, which is simply the wrong thing to do. The

impact of exports on young production has very serious ramifications because of not only the direct effect of reducing recruitment but also the compound affect of reducing subsequent egg production because of the lack of density dependent survival. Density dependent survival is always there to control the population when it reaches the limits of its resources or carrying capacity, but it usually is not a factor at low population levels. Generally, a population can sustain some additional mortality (e.g., harvest) when it is near its carrying capacity and its mortality rates are likely a little higher and fecundity is a little lower. The population responds to the added mortality by increasing survival and fecundity to make up for the extra or new resource capacity. However, at depressed levels, added mortality has the compounding effect of not only affecting the existing yearclass but future yearclasses. This was the conclusion of the Striped Bass Working Group in 1982 and the data presented in this paper indicate this is so.

Kimmerer et al. 2001

In a follow-up paper Kimmerer et al. (2001) carry their earlier conclusions a step further and directly address the subject of effects of exports:

- *"Recruitment at age 3 yr, previously shown to depend on freshwater flow during the first spring (Stevens 1977), had no relationship with flow in the more recent data."* Even with explained outliers, I found Stevens (1977) relationships with flow/export still significant (see Figure 38).
- *"Abundance of young in the summer townet survey and fall midwater trawl survey showed the influence of reduced potential egg production after 1976-1977."* I also found this to be the case, but the relationship probably existed prior to 1976 (see Figures 31 and 34).
- *"Results presented here and in a previous paper (Kimmerer et al. 2000) show that little of the substantial flow related variability in YOY propagates into variability in recruitment."* Analyses above indicate that the YOY index is significantly related to 3-yr-old recruitment estimate (Figure 35), and that the YOY index is significantly related to exports and 3-yr-old abundance is significantly related to exports, thus the export effect on young propagates into recruitment at age 3.
- *"This does not mean that losses to the export facilities are not important sources of mortality, but that variation in export losses does not contribute to variation in recruitment."* I found that export losses did contribute to variation in recruitment.
- *"Variability in total mortality, and possibly also in the success of the salvage operations, may have obscured any effects of exports on subsequent recruitment of striped bass."* I found exports were negatively related to recruitment (Figure 38). One reason is that I (and Turner and Chadwick 1972) used June and July exports, which is the time period when young bass would be affected, whereas Kimmerer et al. used April-June.
- *"Alternatively, the fish remaining in the tidal freshwater region of the estuary may not contribute significantly to recruitment in most years irrespective of the export pumping effects."* The authors imply that these fish will die from one source or another, which if true would certainly be due at least in part to exports. However, I found this not to be the case because of the strong negative relationship between the

Delta portion of the Summer Index of young striped bass and exports (see Figure 19), and the fact that the Summer Index is positively related to the Fall Index and the population estimates of 3-yr-olds.

- *"High mortality due to pumping losses may be partially offset by density-dependent effects occurring during and after the YOY stage (Kimmerer et a. 2000)."* I found no evidence that this was occurring at the existing low adult and young population levels. The reduction in young and adult recruitment is most likely caused by direct export losses in combination with poor survival of young and adults during droughts, all density independent factors.
- *"Individual based modeling studies show that exports alone are unable to explain the observed decline, despite apparent negative effects of removal of tens of millions of young striped bass."* The analyses I performed clearly indicate that exports losses could cause the decline because of the compounding effect of young losses at low adult population levels on not only recruitment of 3-yr-olds, but subsequent young production.
- *"We interpret these results to mean that the decline in striped bass was more likely related to events happening later in life, and further seaward, than previously thought."* My analyses confirm much of the early conclusions of DFG that export effects early in the striped bass life cycle indeed are the primary cause of the decline.

Kimmerer 2002

Kimmerer (2002) in further describing effects of exports from the Delta stated:

- *" Total annual export volume from the two major and one minor water export facilities increased up to the mid-1970s, after which annual export volume remained roughly steady, with a median of about 5.7 km3 or 29% of inflow since 1974.* " This statement is clearly inconsistent with the data (Figures 21 and 22), which indicate export levels have increased by 50% from about 4 million AF in 1974 to 6 million AF by 2001.
- *"The diversion of a substantial amount of water from the tidal freshwater reach appears to be a peculiar feature of the San Francisco Estuary. During low-flow periods as much as 70% of the freshwater entering the estuary is subsequently exported, and although the daily export flow is only about 2–3% of the volume of the Delta, its cumulative effect could be substantial. "* These are remarkable feats for such a large watershed. The 2-3% daily figure includes all the Delta volume, but the real effect where most of the delta smelt and striped bass occur is more like 5-10%, which compounded daily results in most of the freshwater pool in the Central Delta being exported in a time frame of days rather than weeks or months. Some scientists will say that tides are far more dominant; however, those who have spent a lot of time in the Delta and with data from the Delta know that blocks of water maintain their signatures and move with the net flows of the estuary, and they can move upstream to the export pumps. Furthermore, the further upstream they get the quicker they move to the pumps, especially once they reach the zone of "No Return". In the CBDA 2003 Report, scientists related their surprise at the high rate of entrainment of young salmon from the Sacramento River into Georgianna Slough when the DCC was closed; well it was because the pump demand had to pull water from somewhere.

- *"Despite concern about the effects of these diversion facilities, and the likelihood that a substantial fraction of some fish populations may be entrained there (Stevens et al. 1985), few studies have attempted to document population-level effects."* This statement is clearly in conflict with studies by DFG and others over the past three decades that indicate the striped bass population has declined from export losses. Figure 25 shows that DFG interpreted there were population effects of the SWP as early as 1977. Furthermore, DFG also had records of sport-caught striped bass catch-effort that clearly indicated population-level effects.
- *"Although striped bass are entrained in large numbers during larval and juvenile stages, the effect of this entrainment on recruitment to the adult population appears to be negligible (Kimmerer et al. 2001)."* The arguments presented in DFG reports, papers, and testimony summarized in this white paper clearly contradict this conclusion.
- *"Mark-recapture experiments with salmon smolts released in the Sacramento River revealed little effect of export pumping rates (Rice and Newman 1997)."* While the statement relative to the Sacramento River populations may be true, it is certainly not true for San Joaquin River salmon populations.
- *"In contrast to the salinity standard, which is based on clear relationships to population parameters, restrictions on export flow are based mainly on observations that large numbers of fish are entrained in export pumping facilities (Brown et al. 1996), and equivocal results of mark-recapture experiments using hatchery-reared juvenile salmon (Rice and Newman 1997; Brandes and McLain 2001)."* No population level relationships with the salinity standard have been determined for salmon, striped bass, delta smelt, or splittail, whereas the magnitude of export levels have been related to their populations in the Delta.
- *"There is little clear evidence of effects of export flows on abundance or survival of species resident in or migrating through the Delta."* Clear evidence for striped bass, delta smelt, and San Joaquin salmon is presented in this paper.
- *"I do not suggest that the lack of evidence of export effects should be construed as evidence of no effect. Much of the difficulty with determining effects of export pumping is the low abundance of the species of greatest concern, resulting in low signal-to-noise ratio in the analyses and poor constraints on statistical estimates of population parameters. Monitoring is already intense, particularly in the Delta, with expenditures of several million dollars annually. There is little prospect that increased monitoring will substantially improve the estimates of export effects. Experimental manipulations, with export pumping alternated between high and low levels, may be the only way that these effects can be teased out of the noisy data."* The effect of exports on the striped bass population are clearly seen in the available data, which is not to say that the relationships found significant should not be tested with further experimental manipulations. However, there have been nearly 30 years of manipulation followed by experiments such as VAMP that provide a reasonable clear view of factors controlling fish survival in the Delta. Additional monitoring would greatly help in verifying the patterns and conclusions that I (and many others prior to me) have been able to ascertain from the existing data.
- *"The current state of knowledge about flow effects does not provide adequate support to decision making."* The information summarized in this paper clearly supports

decision-making as it did in the past. DFG's arguments in the 1982 Two-Agency Agreement still apply to this day.

- *"Reductions in export flow are inadequately supported by evidence, and there is little understanding of population-level effects of entrainment in export pumping facilities. The effectiveness of export reductions using environmental water has not been put in a population-level context or compared with alternative actions in the watersheds."* Reductions in exports are clearly supported by the available information for striped bass, San Joaquin salmon, and delta smelt. As a minimum, further analyses, monitoring, and experimental manipulation of flows, exports, and DCC should be undertaken by the two water projects and the CBDA, IEP, and CVPIA programs. Until proven otherwise, control of exports should remain as the primary focus for restoring fish populations in the Delta.
- *"All of these problems are shortfalls of knowledge that can be addressed through a program of research coupled with experimental manipulation of some aspects of freshwater flow."* We have had three decades of manipulations where exports have doubled, then doubled again, and then doubled again. How much more than 70% of the Delta inflow needs to be exported before CBDA scientists like those that contributed to these three papers can acknowledge that there is an effect on the fish populations that depend on the Delta estuary.

Conclusions and Recommendations

The above review and analysis indicate that the place to start to further improve conditions in the Delta for fish populations and their supporting environment is with proposals presented by DFG in the past (i.e., 1982 Two-Agency Agreement) that were not implemented despite considerable supporting documentation. The following sections outline some of these recommendations.

Limit Reverse or Negative Net Flows in Lower San Joaquin

One common thread of advise over the past 30 plus years is to not allow negative or reverse flows in the lower San Joaquin River at any time except perhaps late summer and early fall. In 1971, D-1379 included the intention to not allow reverse flows prior to construction of a Delta transfer facility. One way to help ensure reverse flows do not occur is to limit exports and not to close the DCC when inflow is low (at least below 12,000 cfs). Most certainly the conditions in early April 1991 (Figure 55) under the monthly average criteria of D-1485 should never be allowed. Outflow should not have been allowed to fall that quickly, certainly not under maximum exports. These circumstances virtually allowed the entire Delta freshwater nursery to be exported over a period of several weeks. The 1995 WQCP standards would have provided some protection (35% export limit) in early April and the VAMP restrictions from mid April to mid May. Further restrictions were then necessary from mid May through July. Reverse or negative flows should not be allowed except possibly in August and September.

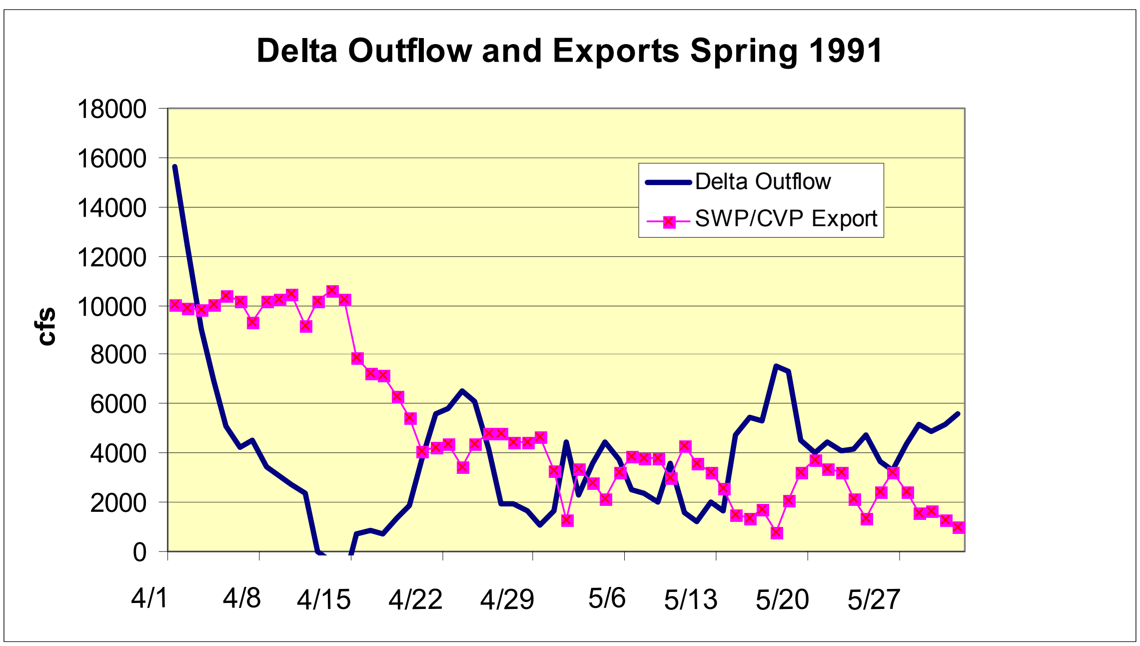

Figure 55. Daily Delta export and outflow in April and May of 1991 – a drought year. Striped bass and delta smelt generally spawn in April in the Delta in dry years, and thus were highly vulnerable to the zero outflow and 10,000 cfs export level in mid April. Under D-1485 the outflow standard for 4/1-4/15 (to protect striped bass spawning in the Delta) was a monthly average of 6700 cfs.

Limit Exports in Spring and Early Summer

Original water quality standards had protections in early spring and early summer that should be reinstated to protect striped bass and other estuarine organisms. Exports should be restricted to protect striped bass and delta smelt larvae early in spring and then juveniles late in spring or early summer. In dry years exports should be restricted earlier in spring (late March and early April), while in wet years this could be late May through July. Usually by late July most of the striped bass and delta smelt that have not been exported have reached the low salinity zone downstream of the influence of the pumps or have taken up residence in shallow habitats. High export rates after that point may have less impact. Increasing exports with the additional SWP four pumps to 8,500 cfs or 10,300 cfs should not be allowed unless there are high inflows and fish are not vulnerable. Allowing 8,500 cfs at less than high inflows with proposed south Delta barriers would further increase losses of striped bass and other Delta fishes. Exports over 8,000 cfs should be considered high and a significant risk to Delta fish populations even with new fish screening facilities. A combination of new fish facilities and a Through Delta Facility may provide sufficient protections to allow higher exports in wetter years.

Isolating the Old River Channel and TDF

Isolating the Old River Channel between its mouth on the lower San Joaquin River and CCF in combination with a Through Delta Facility should reduce the effects of exports.

Build New Fish Facilities in the South or Central Delta

Plans should proceed to build the newly designed intake and fish facilities at a northern entrance to Clifton Court Forebay and divert water from both the CVP and SWP plants from the Forebay. Another option would be construction of fish protection facilities at the mouth of an isolated Old River Channel.

Improve Trucking and Release Survival of Salvaged Fish

For two years the Striped Bass Stamp Committee and California Striped Bass Association have recommended immediate implementation of a new transport and release process. Based on UC Davis laboratory experiments trucking salvaged fish in brackish water to brackish water would greatly reduce mortality of salvaged young striped bass and other fishes. Antioch and Pittsburg locations offer significant potential improvement over the Sherman Island release sites. These improvements are required by present legislation and allowed under OCAP biological opinions.

Improve Delta Habitat

Improving Delta habitat will increase the productive capacity of the Delta, which will increase the intrinsic rate of natural increase in Delta fish populations if they again approach capacity. Improving habitat may also increase density-independent survival by simply providing more food and less rigorous conditions. The fact that striped bass and delta smelt young become less vulnerable to export in mid summer may be an indication that they are seeking shallow water habitats outside the flow to the pumping plants. Improving such habitat may further reduce export losses.

Striped Bass Stamp Program

The Striped Bass Stamp Program began in 1983 as a means of improving the striped bass population primarily through stocking programs. The program ceased stocking striped bass in 2001 when there a highly questionable increase in the striped bass population estimate above a limit allowed in the federal permit for the stocking program was apparent in the survey data. The program, which has raised approximately one million dollars per year from fishing license stamp fees, was suspended in 2002, although the advisory committee and DFG continue to fund projects with the remaining approximately two million dollars in the fund. Most of the money from the fund has been used to fund Bay-Delta DFG enforcement programs. For the past two years the advisory committee has recommended that DFG study possible further improvements in the salvage program, especially improvements in trucking and release survival, which are allowed (actually they are prescribed) in the OCAP Biological Opinions. The advisory committee and CSBA believe this is the only viable measure available to help reduce existing impacts on the striped bass population from the south Delta pumping plants.

Bay-Delta Stamp Program

The Striped Bass Stamp Program has been replaced by the new Bay-Delta Stamp required for fishing in the Bay-Delta and Central Valley rivers. Projects will be initiated beginning in 2005 to support Bay-Delta and river fisheries. This program should focus improvements in Bay-Delta habitat, and should not be used to (1) purchase water or improve fish facilities at project facilities, or fund DFG enforcement programs.

California Bay Delta Authority – Ecosystem Restoration Program

Like the stamp programs, the ERP funds should focus on habitat improvements in the Bay-Delta watershed. After several years these programs, which are the mainstays of the biological opinions mitigation for the water projects, as yet are under-funded and lack focus on protecting Bay-Delta threatened and endangered fish and their habitats that are to be protected by these biological opinions.

CBDA/CVPIA – Environmental Water Programs

These programs can provide an important insurance account for protecting Bay-Delta fishes throughout the year. However, there is a tendency to purchase water that was previously “unregulated flow”.

CBDA/CVPIA – Science Programs

Greater support for monitoring programs should be provided in the various science and mitigation programs. Egg and larvae surveys were cut in the past decade. Despite requiring PG&E to monitor entrainment at their Delta power plants for decades, no entrainment monitoring has been prescribed at either south Delta pumping plant. Millions if not billions of egg, larvae, and juvenile fish are pumped down the state and federal canals without any accounting. Crude salvage monitoring begun in the 1950’s continues to this day.

More large scale adaptive management experiments should be conducted like that in 1985 and the more recent VAMP experiment.

CALFED – Record of Decision

The ROD requires a thorough evaluation of a Through Delta Water Transfer Facility (TDF) in Stage 1 (first seven years) of the CALFED program. Nearly four years have gone by with little progress on this evaluation. A TDF would help greatly to reduce reverse flows in the lower San Joaquin River and the negative effects of closing the Delta Cross Channel under low Delta inflows. If the TDF cannot accomplish the ROD objectives, the ROD calls for evaluation and implementation of an Isolated Delta Transfer Facility (Peripheral Canal).

New Two-Agency Agreement

A new Two-Agency Agreement would serve to provide necessary protections to the Bay-Delta fish populations. The Two-Agency Agreement would control operation and development of the SWP, which is the feature that changes most in the Delta. Most importantly the Two-Agency Agreement should deal directly with SWP exports, especially the potential available from the four new pumps that expand capacity from 6,400 cfs to 10,300 cfs. Provisions in the 1982 Agreement should be reconsidered.

Four Pumps and Tracy Mitigation Agreements

A natural extension of the Two-Agency Agreement is a complete reevaluation of the Four Pumps and Tracy Mitigation Agreements between DFG and the water projects. These two mitigation programs have yet to prove cost-effective. Striped bass, delta smelt, and San Joaquin salmon continue declining despite millions of mitigation dollars being spent on a wide array of projects.

SWP and CVP Fish Protection Programs

Operations of both water projects should be reevaluated to provide better protection for fish. The DFG and SWRCB in 1982 felt the export level should be kept at no more than 4 million acre-ft until facilities are improved to protect the Bay-Delta ecosystem.

Monitoring Programs

Within a dynamic system like the Sacramento-San Joaquin Delta with so much variability from year to year, season to season, and day to day that can influence fish distribution and abundance and ecological processes there is no substitute for a comprehensive monitoring program that addresses these time scales. In this review I found the Egg and Larvae Survey, the Summer Townet Survey, Midwater Trawl Survey, and Beach Seine Survey most valuable in providing coverage in time and space scales for young fish of the targeted species. I also found the Zooplankton Survey excellent for depicting time and space scale difference for the major juvenile fish food species. Walters and Collie (1988) stated that in Canadian estuaries and rivers "*better understanding and predictive models are badly needed, but that these needs can be met more cheaply by improved monitoring programs in most management situations*". In their review they noted: *Various resource agencies have undertaken substantial oceanographic and limnological* *studies of particular areas (sometimes mislabeled "experiments") to investigate the effect of environmental factors on fish populations. These studies are producing fascinating insights into how fish respond to small-scale environmental variation. Such studies generally do not cover the full spatial distribution or life span of a species under study, but it is presumed that variability on those larger scales involves localized "critical events," the effects of which can be measured and will persist on the larger scales.* In the case of the Bay-Delta estuary, we have been looking at population responses on "large scales" via annual population indices from the surveys and season hydrology (e.g, X2), when in fact the small-scale events that have been the driving factors for the populations have become obscured. This review has attempted to bring out the small-scale features in the monitoring data that are related to how the fish and zooplankton may respond to a feature such as the TDF. A continuation of these monitoring programs will provide for historical comparisons on a small-scale and allow us to view new events at the same small scale.

Monitoring of the adult population has received less attention over the past decade by DFG from lack of funding and other resources. Data are only available through 1993, whereas other survey data are provided on DFG's website through 2003. Tagging and recovery efforts have been conducted every other year instead of obtaining yearly recruitment estimates as in the past. The number of tags applied and the numbers of adult striped bass recovered are insufficient to provide quality population estimates. The adult tagging and recovery program elements should be fully funded and staffed to provide accurate estimates of adult population abundance, mortality rates, and harvest rates. Elements of the adult population residing in the ocean, Bay, Delta, and Valley rivers should all be included in the population survey.

Controlled Experiments

While the various monitoring program surveys provided a comprehensive picture of the responses of key organisms to the varied hydrology and hydraulics offered by the Bay-Delta system over the past several decades there is no substitute for experiments that control key variables. Controlled experiments are necessary if we are to test the hypotheses that we have developed from detailed analysis and interpretations of monitoring data. With so many important variables acting at the same time in antagonistic and synergistic ways it remains difficult to separate out cause and effect and to determine effective solutions. Experiments that control variables will allow us to separate effects and get a clearer picture of cause and effect mechanisms.

Experiments should be devised that cover variability in all time and space scales as needed. For example the VAMP experiment is designed to view responses of San Joaquin salmon smolts to various yearly outflow patterns. Last fall's salmon smolt release experiments near the DCC were designed to determine the migration direction response of salmon smolts in relation to daily changes in DCC operations. In both of these examples the experiments require their own specific monitoring program to provide data to test the experimental hypotheses. We need more experiments that manipulate the large-scale hydrologic and hydraulic characteristics of the Delta where we can observe effects in the general monitoring program.

Bibliography

CALFED. 2001. Strategic Plan for the ERP. CALFED Bay Delta Program. Sacramento CA.

Cannon, T. C. 1982a. The importance of the Sacramento-San Joaquin Estuary as a nursery area of young chinook salmon, striped bass, and other fishes. Prepared for National Marine Fishery Service, Southwest Region, Terminal Island, CA.

Cannon, T. C. 1982b. Factors related to the number of striped bass in the Sacramento-San Joaquin Estuary. In San Francisco Bay: Use and Protection. Pages 201-213. Pacific Division of AAAS.

Davis, C. 1981. The SF Bay Ecosystem – A summary of our present knowledge of the physical, chemical, and biological systems operating in the Bay and man's interactions with those systems. SFSU Tiburon Center Rrp for USFWS Bay Institute

Hanson, C. 1987. Delta outflow and the fishery resources of SF Bay. Report to SWC.

Kelley. D.W. 1982. Report of the striped bass working group to SWRCB. SWRCB, Sacramento, CA.

Kimmerer, W.J. 2002. Physical, Biological, and Management Responses to Variable Freshwater Flow into the San Francisco Estuary Estuaries Vol. 25(6B): 1275–1290.

Kimmerer, W.J., J.H.Cowan, Jr., L.W. Miller, and K.A. Rose. 2000. Analysis of an estuarine striped bass (Morone saxatilis) population: influence of density-dependent mortality between metamorphosis and recruitment. CJFAS 57:478-486.

Kimmerer, W.J., J.H.Cowan, Jr., L.W. Miller, and K.A. Rose. 2001. Analysis of an estuarine striped bass population: effects of environmental conditions during early life. Estuaries. Vol. 24(4): 557-575.

Kjelson, MA, P.F. Raquel, and FW Fisher. 1980 Influences of freshwater inlfow on chinook salmon (Onchorhynchus tshawytscha) in the Sacramento-San Joaquin Estuary. California Department of Fish and Game Stockton CA.

Department of Water Resources and Department of Fish and Game (DWR/DFG). 1982. Final Environmental Impact Report and Proposed Agreement to Manage Fish & Wildlife Resources Sacramento – San Joaquin Estuary. State of California Resources Agency, Department of Water Resources and Department of Fish and Game. September 1982.

National Marine Fisheries Service (NMFS). 1981. Letter from Southwest Region (Gary Smith, Acting Regional Director) to the California Department of Water Resources (R. Kretsinger, Chief of Delta Branch). June 10, 1981.

Odenweller, D.B. and R.L. Brown. 1982. Delta Fish Protection Facilities Program Resport through June 30, 1982. Tech Rpt 6, IEP.

Orsi, J. J., and W.L. Mecum. 1986. Zooplankton distribution and abundance in the Sacramento-San Joaquin Delta in relation to certain environmental factors. Estuaries 9(4): 326-339.

Smith, S.E. and S. Kato. 1979. The fisheries of San Francisco Bay: past, present, and future. P. 445-468. in T.J. Conomos ed. San Francisco Bay; The Urbanized Estuary. Pac Div Amer Assoc. Adv. Sci. San Francisco California.

Stevens, DE, and LM Miller 1980. Effects of flow on abundance of young chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River system. DFG Stockton Bay Delta Fishery Project.

Stevens, D.E., D.W. Kohlhorst, L.W. Miller, and D.W. Kelley. 1985. The decline of striped bass in the Sacramento-San Joaquin Estuary, California. Trans. Amer. Fish. Soc. 114:12-30.

Turner, J.L. 1986. Effects of geographic distribution of larval striped bass in determining year class size of striped bass in the Sacramento – San Joaquin Estuary. Testimony of Jerry Turner for the US Bureau of Reclamation, Sacramento, CA.

Turner, J.L. 1986. The feeding environment of 6 and 7 mm larval striped bass in the Sacramento/San Joaquin Estuary in 1984 and 1985. Testimony of the California Department of Fish and Game, Stockton, CA.

Turner, J.L. and H.K. Chadwick. 1972. Distribution and abundance of young-of-the-year striped bass, Morone saxatilis, in relation to river flow in the Sacramento-San Joaquin Estuary. Trans. Amer. Fish. Society. 101:442-452.

Appendix Figures

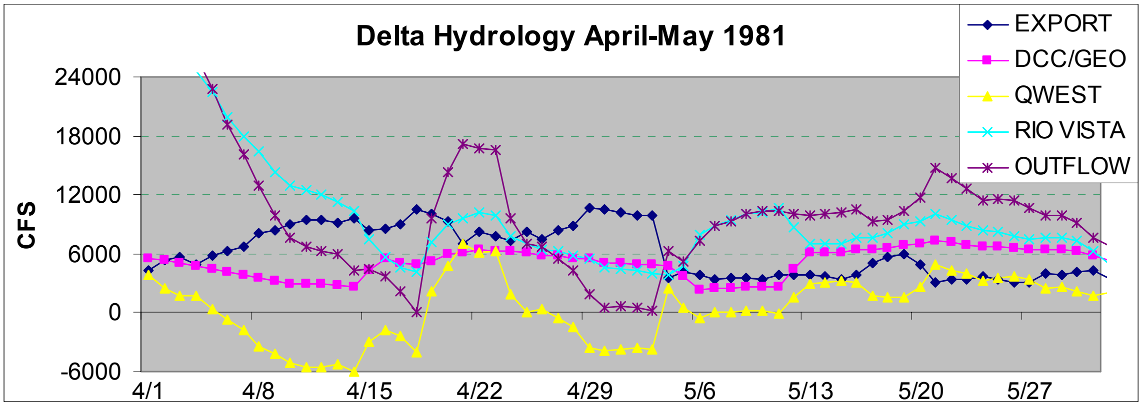

Figure A-1. Delta hydrology in spring of 1981. Outflow and inflow (Rio Vista) were very high from 1-15 April with the Delta Cross Channel (DCC) closed. Exports increased to near maximum with average EC and 6700 cfs outflow controlling. Lower San Joaquin River net flows fell until they were near –6,000 cfs during the second week of April. With the DCC closed export pumps were pulling water from the western Delta up the San Joaquin River. The opening of the DCC on April 16th immediately helped to reduce reverse flows. Only Rio Vista flows and Delta EC standards applied from April 15 to May 5, and because these were average condition standards for the period, outflow was again allowed to fall to zero under maximum exports late in the period. After May 6th Delta outflow and export limit standards applied, leading to more stable and realistic conditions. I hypothesize that the extreme conditions affected the striped bass spawn and led to the unexpected low striped bass production index for 1981. These conditions also contributed to the record spring salvage losses of delta smelt and poor delta smelt production in 1981. Closure of the DCC from April 1-15 and May 8-13, a D-1485 standard to protect striped bass larvae in the Sacramento River from crossing into the central Delta, exacerbated problems for the striped bass (and delta smelt) already in the Delta by causing reverse flows in the lower San Joaquin River channel.

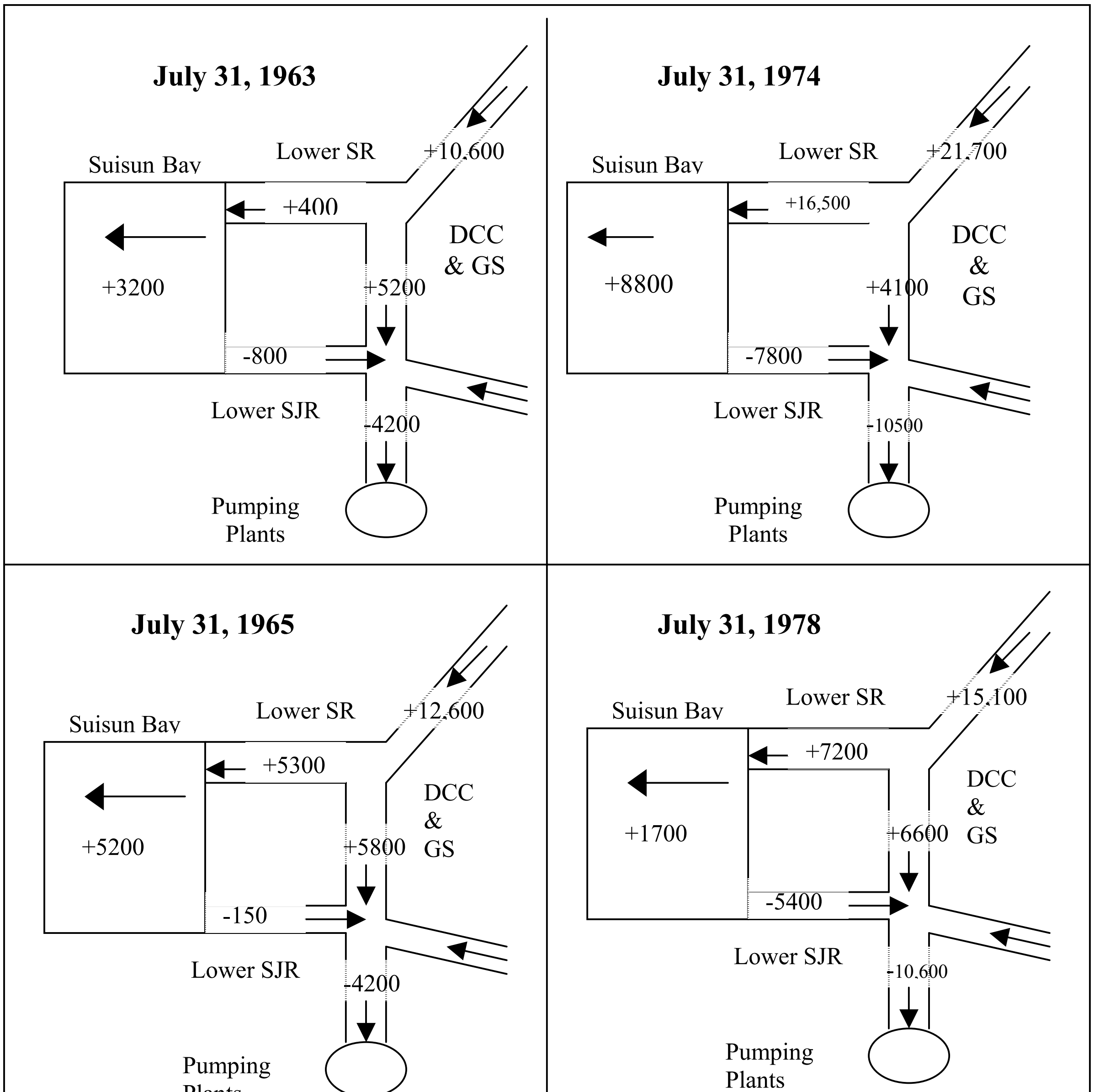

Figure A-2. Schematic of Delta hydrology before and after the SWP Banks pumping plant came on line. Note negative or reverse flow in the lower San Joaquin River (SJR) in 1973 and 1978. Also note higher lower Sacramento River (SR) channel flows as a portion of the export water had to pass down the Sacramento River channel and around lower Sherman Island because of the limited capacity of the cross Delta channels (the Delta Cross Channel (DCC) and Georgianna Slough (GS). Data are from DAYFLOW, which is available on the IEP website.