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17.1 INTRODUCTION

17.1.1 Background

Water supply in California has evolved into a system of large-scale water conveyance from the wetter northern part of the state southward to the drier central and southern portions of the state. At present, the conveyance occurs through the maze of channels in the Sacramento–San Joaquin River Delta (Delta). This system has several undesirable impacts:

- The conveyance path alters and in many locations reverses the natural direction of flow, thereby creating unnatural and in some cases sustainability-threatening flow regimes for aquatic organisms.
- The water is pumped from the south Delta by large state and federal facilities that discharge water into canals that then take the water further south to its users; the pumps often entrain and kill aquatic organisms and the fish-screening and salvage facilities stress the aquatic organisms saved from entrainment by the pumps, further threatening the viability of affected species.
- The quality of the freshwater is degraded (salinity is increased) by exposure to tidal action from Suisun Bay, lessening its value as urban and agricultural water supply.
- The quality of the water is also degraded by exposure to organic carbon in the rich peaty environment of the Delta, which can lead to the use of health-threatening disinfection byproducts for urban users.
- Large quantities of extra water (carriage water) must be released to San Francisco Bay as Delta outflow to keep the salinity interface downstream of the Delta.
- The present through-Delta conveyance system is particularly vulnerable to a major Delta levee breach incident from either an earthquake or flood, as demonstrated by the Delta Risk Management Strategy (DRMS) Phase 1 Risk Analysis Report (URS/JBA 2008h).

One approach to lessening these impacts is to decrease the reliance of water users on water that is exported from the Delta. This approach may have the benefit of lessening the state's overall vulnerability to a major Delta levee breach event. This section addresses reducing Delta water exports as a DRMS building block.

17.1.2 Purpose and Scope of this Building Block

The purpose of this building block is to explore (in a preliminary, conceptual way) the changes that would be involved in lessening Delta water exports. The analysis addresses three major spheres of change:

- Water users. Changes are implicit for water users in terms of demand shifts, alternate supplies, and the economics of such changes. A second and separate consideration concerns the changes in impacts of a major levee breach event on water users.

- Water operations. Stipulated reductions in annual exports do not need to be uniformly applied on a monthly basis. This analysis estimates how these monthly reductions might be distributed.
- Aquatic organisms. If less water is exported from the Delta, more water would be available for sustaining the aquatic ecosystem in the Delta and less damage would be done to fish, because pumps and fish screening/salvage operations would be less intensive. This analysis characterizes how these benefits could be facilitated and what positive results could be anticipated. As a separate consideration, this analysis characterizes the changes in the impacts of a major levee breach on aquatic organisms.

17.1.3 Objective and Approach

The objective of this building block is to provide an initial understanding of what it would mean if Delta water exports were decreased. The approach is to consider three alternative levels of decrease: 10 percent, 25 percent, and 40 percent. It is assumed these decreases would apply across the board, to all types of water years. However, within a given water year, decreases may be more in some months than in others. Figure 17-1 presents the flashcard summary of this building block and its effects, based on this preliminary analysis.

17.2 CONCEPTUAL DEVELOPMENT OF IMPROVEMENT

17.2.1 Water Use and Economic Effects

17.2.1.1 Overview

Decreasing water exports from the Delta would have substantial effects on the ways in which water is used in all areas and for all agencies that now rely on Delta exports for part of their supply. The major factors that must be considered to develop an understanding of these effects are itemized in Table 17-1.

17.2.1.2 Discussion

This building block investigates three alternatives for water export reductions: reductions of 10 percent, 25 percent, and 40 percent. Before these alternatives can be analyzed, they must be further defined. Percentage reductions could be variable by year type (averaging to 10 percent, 25 percent, or 40 percent over time) or they could be implemented as across-the-board reductions in all year types.

For purposes of discussion, we assume that the percent reduction options represent across-the-board, long-term fixed percentage reductions in Delta exports applicable to all water year types. However, we also assume that the reductions may be allocated more strongly to some months than others (for the benefit of aquatic organisms or to increase the reliability of water supplies). We call these the “long-term options” to distinguish them from the levee failure case studies. So, the analysis of a levee failure case would be layered onto each of the long-term options (the initial Phase 1 baseline and the new baselines corresponding to 10 percent reduction; 25 percent reduction; and 40 percent reduction). The Phase 1 Risk Analysis Report evaluated the effects of levee failure cases only on the baseline, or business-as-usual option (0 percent long-term reduction). We further assume that long-term reductions apply only to water exports from the California State Water Project (SWP) and the Central Valley Project (CVP) Delta pumps. Water diversions by Contra Costa Water District would be unaffected. Therefore, the long-term options will have no effect on Contra Costa Water District's levee failure costs (which the Phase 1 report showed to be a major source of economic costs resulting from an urban water shortage caused by Delta levee failure).

Costs of water supply reduction (whether long-term reductions or short-term, unanticipated shortages resulting from levee failure) increase nonlinearly, that is, more than proportionately, with the percent reduction of supply. This pattern of cost increase results because water agencies and water users employ the lowest-cost responses for small reductions in supply, but have to use increasingly costly responses for larger and larger reductions. Also, the long-term choices of water agencies and water users have a significant effect on the availability and cost-effectiveness of short-term responses in case of levee failure. These nonlinearities and interactions mean that the analysis provided in the Phase 1 report for the baseline case cannot be easily or directly transferred to an analysis of the long-term alternatives for decreased exports.

Therefore, the following discussion highlights the kinds of effects that the long-term options might have but does not attempt to quantify them. Quantification would require a much more careful re-analysis of both urban and agricultural users, using the tools developed for the Phase 1 report. We also stress that the following discussion involves some speculation on the relative magnitudes of different responses and costs. A quantitative analysis is needed to provide more supportable conclusions.

17.2.1.3 Effects on Urban Agencies and Water Users

Urban agencies would likely replace most or all of the long-term water supply reduction from other sources. These sources could be:

- Water purchases from agricultural agencies
- Conservation
- Other local water sources, such as recycling and desalination

To develop these new, long-term analyses, we would need to review the work done with the CALVIN model for the recent Public Policy Institute of California study on Delta export reductions, and then also use the California Department of Water Resources' LCPSIM model to develop a list of likely agency actions and their costs. These actions and costs would then need to be reviewed with the urban agencies for reasonableness. It is likely that these new long-term conditions would include combinations of all three of the replacement sources listed above. It is almost certain that the new long-term conditions would be more costly for the urban agencies (compared to the baseline case in the original analysis), with the increase in cost being more than proportional to the decrease in water supplies. That is, the increase in costs for the 40 percent case would be considerably more than four times the increase in cost for the 10 percent case because of the increasing marginal cost of water supply.

The effect on costs resulting from a levee failure under these conditions would then be re-analyzed using the tools and approach developed for the Phase 1 report. The costs of levee failure would depend on the additional, long-term replacement supply sources chosen. The discussion below concentrates on the economic costs of Delta levee failures alone. It does not address the balance of the costs for the new, long-term replacement sources. It also assumes that the amount of water that could be supplied given a Delta failure is unaffected by the long-term condition. That is, if a given Delta failure scenario resulted in deliveries of 100 thousand acre feet (TAF) in the initial Phase 1 analysis, the same amount (100 TAF) would also be available for the three long-term reduction options; those options would not be accompanied by new regulations that require increases in Delta outflow. This assumption is clearly very important, and a complete analysis would use water project operations modeling to evaluate how the long-term options would affect reservoir storage and Delta operations.

To the extent that the new water resources are purchases from agricultural agencies that are also Delta export contractors, our analysis would likely show a decrease in urban economic costs from levee failure, because a greater proportion of the water that could be exported through the Delta after levee failure would be going to urban agencies.[1] However, the length of time during which no exports are available would be unlikely to change, so this improvement may be minor.

However, this result stems from the business-as-usual assumptions in the initial analysis. Under this restriction, we did not allow for transfers between agricultural and urban agencies to occur as a result of the failure in Delta water supplies. Thus, our analysis did not reflect the decrease in water available for transfer that would occur under this situation. In contrast, if water supplies were purchased from south-of-Delta agricultural agencies that were not export contractors, the costs of Delta levee failure would likely be reduced.

If the reduction in water supplies were matched entirely by conservation, the change in economic costs to urban areas resulting from Delta levee failures is unclear. The percentage reduction in demand would be lessened, but the demand would have “hardened” (i.e., become more inelastic), resulting in greater costs per unit of water supply reduced. The balance between these two offsetting tendencies is likely to vary from agency to agency, according to the mix of end-user demands and the proportion of water supplies currently obtained through the Delta. Also, once the costs of implementing local conservation measures are taken into account, the net change in cost could be positive or negative.

If the additional water supplies were obtained from local sources, the economic cost of Delta levee failures would be reduced, because the urban agencies would be less dependent on Delta water supplies. The lower economic cost of Delta levee failures would be offset to an unknown extent by the cost of substituting locally developed water supply for Delta water supply. The net difference could be positive or negative depending on the costs of local water supply development. Also, local water supplies are likely to be obtained either through reclaimed water or desalination. Expansion of these uses would likely require increased electric generation. This result would be in opposition to other state aims regarding reductions in energy use per person and carbon emissions.

[1] For example, assume that currently urban agencies are receiving 20 percent of the exported water, and agriculture 80 percent, and that the emergency water allocation followed this ratio. Under a 40 percent cutback in total supplies, urban agencies would be receiving 12 percent of current contract totals, and agriculture 48 percent. If urban agencies made up for this loss by purchasing their lost water from agriculture, the urban agencies would still get 20 percent of current contracts (12 plus 8 purchased from agriculture), but agriculture would receive 40 percent (48 minus 8 sold to urban). This would translate to 20/(20+40) or one-third share of emergency water going to urban agencies, and two thirds going to agriculture instead of the 20/80 allocation of the original assumption.

An unexplored issue is the potential effect of the long-term reduction on local agencies' ability to store imported water in local surface or ground reservoirs. Local storage is an important mechanism to provide water during droughts and other shortages. If the long-term export reduction options reduced the expected amount of water in local storage (compared to the Phase 1 baseline) then costs to local agencies of levee failure would be greater. Detailed, quantitative analysis would be needed to evaluate this issue.

17.2.1.4 Effects on Agricultural Agencies and Water Users

Agricultural agencies would likely lose water supplies both from the long-term reduction in Delta exports and from any water they voluntarily sell to urban agencies as a result of the long-term reductions to those agencies. Their response to these long-term reductions in supply could include one or more of the following replacement sources:

- Reductions in agricultural production
- Conservation
- Increased use of groundwater

To develop these new, long-term analyses, we would need to review the work done with the CALVIN model for the recent Public Policy Institute of California study on Delta export reductions, and then also use CVPM or a similar model to develop a list of likely regional changes and their costs. These changes and costs would then need to be translated to likely actions by agricultural agencies and then reviewed by those agencies for reasonableness. It is reasonable to assume that these new baseline long-term conditions would include combinations of all three of the replacement sources listed above. It is certain that the new long-term conditions would be more costly (compared to the original baseline case) for the agricultural agencies, with the increase in cost being more than proportional to the decrease in water supplies due to the rising marginal costs of conservation and groundwater development. These conditions would lead to decreases in overall farm income, but likely an increase in farm income per unit of Delta water used, as low-return crops would be the most likely to decrease in acreage.

The effect on costs to agricultural agencies from a levee failure under these conditions would depend on the long-term replacement sources chosen. The discussion below concentrates on the economic costs of Delta levee failures alone. It does not address the balance of the costs for the new, long-term replacement supply sources (or reductions in baseline agricultural production) and the costs of Delta levee failure.

If the long-term reduction were met entirely by reducing agricultural production, the direction of the economic costs of Delta levee failure is unclear. There would be a smaller reduction in the amount of water delivered in a levee breach event, but each acre-foot of Delta water not delivered in the emergency would be more costly because only higher-return crops are being grown. For example, a smaller crop base concentrated on higher-value production could significantly increase the likelihood that Delta levee failures would destroy investments in tree and vine crops. The net of these two opposing effects could vary by district or over time, depending on the crop mix. On balance, the net effect of reduced long-term delivery would likely be to lower the cost of levee failure.

It is unlikely that the reductions in water supply would be met entirely by conservation, because it is likely that the additional costs associated with this option would reduce production of lower-value crops. In other words, the marginal cost of agricultural water conservation rises steeply, and crop reduction or groundwater pumping quickly becomes a cheaper response for crops with relatively low net return. However, to the extent that conservation was relied on, the direction of change in economic costs is unclear. The reduction in water supplies would be lessened, but each acre-foot supplied would be more valuable to the farmer. Once again, the net result of these two effects is hard to predict and may vary by district and over time. On balance, the net result of reduced long-term delivery would likely be to lower the cost of levee failure.

Finally, assuming the reductions in water supply could be met entirely by increased groundwater production, the reduction in water supply would be less, but the options open to agencies to respond to the event would also be decreased, perhaps significantly. In the initial analysis, increasing groundwater production in response to the event reduced agricultural costs. If long-term groundwater pumping had already been increased, less groundwater would be available in the event of levee failure and its cost would be higher. It should also be noted that virtually all groundwater basins in the Delta export areas are either in overdraft or avoid overdraft because of the availability of Delta export water, so this option is not sustainable over the long term. If groundwater replacement were the primary long-term response to reduced exports, the cost of levee failure could be higher than in the original Phase 1 analysis.

17.2.1.5 Summary

On balance, the costs imposed by levee failure on Delta export water users depend on how the local agencies and users adjust to the long-term reduction options. If the long-term reduction reduces the year-to-year reliance on Delta export supply, through conservation or development of other supplies, then the effect of levee failure would probably be lower because the change in water delivery from levee failure would be smaller (for example, dropping from, say, 4 million acre feet (MAF) delivery to 100 TAF is a smaller reduction that dropping from 5 MAF to 100 TAF).

However, local agencies could respond to the reduced long-term supply by reducing the amount of water in local surface and groundwater storage (their shortage insurance), either by using less imported water to refill local storage or by pumping more of it to replace the lost Delta export supply. If this effect dominates, the cost of levee failure could be greater under the long-term reduction options. The relationship between water supply options, agency actions, and alternative cost levels is extremely complex and needs to be modeled carefully with the assistance of the agencies involved.

17.2.2 Water Operations Effects

Because decreases in Delta water exports are primarily intended to benefit the Delta's aquatic ecosystem, we need to understand how water operations should be changed to most effectively achieve these benefits. This section examines both present Delta water operations and operations with reductions. Two example water years are used: 2000 is used as an example of a normal or wet year and 1994 is used as an example of a dry or critical year.

17.2.2.1 Present Delta Water Operations: No Decrease in Exports

The state and federal projects currently use the following strategic concepts in managing Delta exports:

- October and November. During these months, the summer irrigation demands are over and the south-of-Delta reservoirs are usually low. The upstream (north-of-Delta) reservoirs must ensure availability of their required flood control space for the winter. Thus the upstream reservoirs must be drawn down if they are high. If these drawdowns or other circumstances result in Delta inflows, the projects will pump them (consistent with Delta water quality standards and outflow requirements) to add to south-of-Delta storage (especially San Luis) and protect against a dry winter.
- December, January, February, and early March. During these winter months, rainfall usually results in periods of high Delta inflows. The projects will pump from these high flows opportunistically to the maximum extent possible (consistent with Delta water quality standards and outflow requirements) in an attempt to fill south-of-Delta storage (particularly San Luis).
- Late March and early April. During this period, snowmelt has begun and the upstream reservoirs can fill; they no longer have to maintain flood control space. Delta inflows may still be high, due to spring runoff that is not captured by upstream reservoirs. The projects will continue to pump from these high flows opportunistically to fill south-of-Delta storage if it is not already full.
- Late April and early May. During this period, Delta water exports by the state and federal projects are limited to 1,500 cubic feet per second (about 10 percent of capacity) to benefit fish.
- Late May and June. Spring Delta inflows may still be high and the projects will pump as much as possible to satisfy increasing current demand and to complete the filling of south-of-Delta reservoirs, if not already achieved.
- July, August, and September. Irrigation demands increase throughout this period and south-of-Delta storage must be supplemented with releases from upstream reservoirs. Thus, the projects will release and pump, consistent with their target for upstream storage at the end of the season, Delta outflow and water quality standards, south-of-Delta demand, and facility capacities.

Figure 17-2 shows examples of monthly pumping under the above strategies for two recent years:

- Water year 2000 was an above-normal year preceded by a wet year, with total exports of 6 MAF
- Water year 1994 was a critical year preceded by an above-normal year, with total exports of 4 MAF.

17.2.2.2 Altered Delta Water Operations: With Reduced Exports

The most important months for fish in the Delta to be impacted by exports are February through June, as described in more detail in the next section. Accordingly, the decreases in water exports were concentrated in those months, as shown in Table 17-2 and Figure 17-3. The following thoughts (from the viewpoint of water operations) were used to supplement the basic objective of protecting fish:

- October, November, and December. The sensitive fish species are less prevalent and water operators do not know whether the upcoming winter will be wet or dry. Thus, water exports were not decreased in these months.
- January. The sensitive fish species are beginning to become more impacted. In the case of a wet/normal year, no decrease was assigned to January. For a dry year, no decrease was assigned to January for a 10 percent reduction, but modest decreases were assigned for the 25 percent and 40 percent reductions. To implement these January reductions, water operators would need to recognize by mid January that a dry or critical year was developing. This recognition would require further attention when designing detailed operating rules to implement the reductions in exports.
- February. For a wet/normal year, no decrease was assigned to February for a 10 percent overall reduction. Large decreases were assigned for the 25 percent and 40 percent export reductions. For a dry or critical year a significant decrease was assigned for the 10 percent program and major reductions were included for the 25 percent and 40 percent reductions.
- March, April, May, and June. Dramatic reductions were included under both water year types and all export reduction options.
- July, August, and September. Export amounts were assumed to rise while not exceeding the cumulative total allowed for the water year.

These are obviously first estimates of water export reductions under a “reduce Delta exports” approach to addressing the impacts that export operations have on fish. It will be necessary to refine these alterations of export amounts based on further consideration of both fish impacts and water system operability.

17.2.3 Effects on Aquatic Species

The Delta supports a diverse community of resident and migratory fish and other aquatic resources. The Delta and Suisun Bay serve as the estuarine transition zone between freshwater habitats within the Sacramento and San Joaquin river watersheds and the marine environments of San Francisco Bay and coastal waters. A number of the fish species inhabiting the Delta have experienced declines in population abundance in recent years and are now listed for protection under the California and/or federal Endangered Species Acts. These protected species include winter-run chinook salmon, spring-run chinook salmon, Central Valley steelhead, Delta smelt, and green sturgeon. Many of the fish species that inhabit the Delta, such a striped bass, also support important recreational fisheries.

The Delta also serves as the water supply for tens of millions of Californians and hundreds of thousands of acres of agricultural land. The two major water diversions from the Delta are the federal CVP and the SWP. These two water export facilities are located in the southern region of the Delta. The SWP and CVP export facilities are equipped with louvered intake structures and fish salvage facilities designed to collect fish from the water being exported and subsequently return the fish to the Delta. Those fish that reside within the Delta year-round or use the Delta seasonally as a migratory corridor are vulnerable to entrainment in the water project diversions. The majority of fish subject to entrainment into the export facilities are juveniles, with the greatest seasonal period of entrainment and fish salvage occurring during the late winter and spring (February–June). Although the risk and vulnerability of various fish to entrainment at the

SWP and CVP export facilities are influenced by a variety of factors, such as their geographic distribution and seasonal period of occurrence within the Delta, the rate of water diversions at the export facilities is also a factor affecting the number of fish vulnerable to entrainment and salvage. Higher rates of freshwater exports, particularly during the late winter and spring months, are typically associated with higher numbers of fish being salvaged at the export facilities. Fish that are entrained or salvaged at the export facilities may experience increased levels of stress and mortality associated with increased vulnerability to predation mortality and the physical stresses associated with being salvaged, including handling and trucking salvaged fish to release points located within the Delta.

To assess the potential effects of reductions in SWP and CVP exports on the numbers of various fish species subject to entrainment and salvage, a simple model of fish salvage at the SWP and CVP export facilities was developed. The model assumes that the number of fish that would be entrained and subsequently salvaged at the export facilities varies directly in proportion to monthly export rates. Therefore, the number of a particular species of fish estimated to be salvaged can be calculated as the product of the monthly volume of water exported (acre-feet) and the corresponding monthly average density (number of each fish species per acre-foot) vulnerable to entrainment at the export facilities. For purposes of evaluating the potential changes in the magnitude of fish entrainment and salvage, average monthly densities were calculated for various fish species based on the actual reported salvage at the SWP and CVP export facilities over the period 1995 to 2005. The average monthly densities for each of the target fish species were assumed to be representative of the seasonal occurrence within the Delta and the relative vulnerability of each species to salvage at the export facilities. The corresponding volumes of water exported were calculated assuming a total export volume of the SWP and CVP facilities of 6 million acre-feet in above-normal or wet hydrologic years and 4 million acre-feet in dry or critically dry water years. The total volume of water exported at the two facilities was then allocated on a monthly basis. The monthly export volume allocation assumed that there would be a reduction in export volume during the spring months (April–May) in both wet and dry water years, generally reflecting the current seasonal patterns in export operations.

To provide increased levels of fishery protection and reduce the vulnerability of various fish to salvage at the export facilities, export rates have been reduced during the April–May seasonal period as part of the Vernalis Adaptive Management Program as well as to reduce the vulnerability of listed fish species, such as Delta smelt, to losses associated with export operations. In addition to the assumed baseline export operations under both wet and dry water years, additional reductions in SWP and CVP export operations were assumed, representing a 10 percent, 25 percent, and 40 percent reduction in combined SWP and CVP exports. A professional fishery biologist, familiar with SWP and CVP export operations and fish salvage, allocated the export reductions on a monthly basis under both wet and dry water year types, with the greatest reductions in export operations targeted for the February through June seasonal period. Reduction in exports during February–June was anticipated to yield the greatest biological benefit from reducing fish salvage when compared to baseline operations. The resulting monthly export operations under both wet and dry year conditions assumed for purposes of this assessment are shown in Table 17-2.

17.3 IMPACT ESTIMATES: NON-BREACH CONDITIONS

17.3.1 Urban Water Agencies

For south-of-Delta urban water agencies, the following may occur:

- For a 10 percent reduction, some combination of additional conservation, purchases from agricultural contractors, and additional development of local surface and groundwater sources, possibly including additional banking for dry years or possibly decreasing emergency reserves
- For a 25 percent reduction, more intensive implementation of the above plus additional reclamation of wastewater and desalination at substantially greater capital and operating costs may occur.
- For a 40 percent reduction, extremely intensive implementations of the above with heavy reliance on both wastewater reclamation and desalination for a substantial portion (perhaps 20 percent) of the water supply.

In all of these cases, urban agencies must absorb increased capital and operating costs that would increase nonlinearly (more rapidly) than the percentage reduction in Delta exports.

17.3.2 Agricultural Water Agencies

For south-of-Delta agricultural water agencies, the following may occur:

- For a 10 percent reduction, some combination of additional conservation, sales of water to urban agencies, switching to higher valued crops, additional development of groundwater (including additional overdraft), and drought year fallowing of land for annual crops
- For a 25 percent reduction, more intensive implementation of the above heavily weighted toward sales to urban agencies, higher-valued crops, and maximum development and overdraft of groundwater (It is unclear whether permanent fallowing of land and use of wet and normal year water to recharge groundwater to protect high-value permanent crops could be achieved.)
- For a 40 percent reduction, likely widespread fallowing of agriculture land combined with maximum development and overdraft of groundwater (A strict system for groundwater rights and groundwater basin management would necessarily evolve at some point.)

These changes imply increased capital and operating costs for agriculture and/or decreased value of farm properties. The financial impacts would be nonlinear. They would increase more rapidly than the percentage reduction in Delta exports.

17.3.3 State and Federal Project Operations

There should not be significant capital costs for SWP and CVP facilities, assuming that existing facilities are not increased in capacity and monthly pumping patterns allow these capacities to be adequate. If increased storage were needed (e.g., south of the Delta), this need would represent a major capital cost. Operating costs would decrease, primarily by avoiding energy use for pumping the portion of exports that is no longer allowed. Revenues would likely decrease as well.

17.3.4 Aquatic Ecosystem Impacts

Reducing the volume of freshwater exported from the Delta by the SWP and CVP would affect habitat conditions for fish and other aquatic species and reduce their vulnerability to increased mortality resulting directly from entrainment into the export facilities and fish salvage operations. Reducing exports would result in greater freshwater flows passing through the Delta and San Francisco Bay. Higher flows would result in the low-salinity region of the estuary being located further downstream within the area of Suisun Bay and would be expected to contribute to increased habitat area and habitat quality for estuarine species. Reduced export rates would also be expected to contribute to reductions in the effects of SWP and CVP export operations on hydrodynamic conditions, such as reversed flows within Old and Middle rivers and the lower San Joaquin River. Reversed flows and short hydraulic residence times in response to increased export rates within many of the Delta channels have been identified as factors adversely affecting habitat and the vulnerability of fish, such as Delta smelt, chinook salmon, and others to export related losses. Reduced exports are also expected to result in a reduction in the salvage and losses of a variety of fish species, several of which have been listed for protection under the California and/or federal Endangered Species Acts. A simple model was used to assess the potential reduction in fish salvage that may result from 10, 25, and 40 percent reductions in SWP and CVP exports at the most sensitive seasonal time periods for various fish. The biological benefits of reduced exports on the vulnerability of various fish species to entrainment and salvage varies depending on the seasonal time period when the change in exports occurs and the magnitude of the reduction in export rates (for purposes of this assessment it was assumed that fish entrainment and salvage varies in direct proportion to the magnitude of the exports). Results of the assessment are summarized in Table 17-3 and in Figure 17-4 for both wet and dry year types. In most cases, the reduction in salvage (by percent) is greater than the percentage decrease in exports.

17.4 RISK REDUCTION ESTIMATE

Reducing water exports would have no impact on the frequencies of levee failures from sunny-day, flood, or seismic events. Similarly, this building block would have no effect on the magnitude of in-Delta economic consequences from a levee breach event. Its effects would be concentrated in the statewide economic effects involving water exports and in effects on the aquatic ecosystem, as discussed below. All of these assessments of risk reduction are preliminary, variable, have varying degrees of uncertainty, and need to be revisited and refined if further consideration is to be devoted to this building block.

17.4.1 Urban Water Agencies

For urban water agencies, to the extent that a smaller percentage of their supply comes from Delta exports, one might expect them to be less impacted by the disruption of a major levee breach event. However, if their conservation efforts have increased the critical need for and value of the export water they receive, or if they respond by skimping on emergency supplies, their negative impacts from a levee breach event could actually increase. Such hardening of demand

and lack of flexibility to address contingencies is difficult to model; most agencies would say they would not let such things happen. But they would also have the normal difficulties in approving the capital budget required to provide for these contingencies.

17.4.2 Agricultural Water Users

For agricultural water users, a Delta levee breach event is likely to have much more dramatic impacts under a reduced Delta exports option, even though substantial acreage would have been fallowed. Groundwater basins are likely to be severely overdrawn in agricultural areas and unavailable as significant emergency supplies. More acres of high-value, permanent crops are likely to be lost, because farmers would take the risk of a drought or other water shortage in an attempt to increase their margins. Agricultural enterprises operate on very tight margins. Their ability to provide for emergencies is limited and that will be more obvious with less water exports.

17.4.3 Aquatic Ecosystem

For aquatic organisms, the only chance for reduced Delta exports to provide an improved outcome to a major levee breach event is to have a more viable aquatic ecosystem when the event occurs. Entrainment onto flooding islands and other adverse mechanisms are still likely to produce very high mortalities. Only the advantage of having a larger and stronger population at the beginning of the event may lead to a larger number of survivors. This advantage may give the species an ability to regenerate a sustainable population. In contrast, the species may have been so marginal that it would have been lost under business as usual.

17.5 FINDINGS AND CONCLUSIONS

17.5.1 Findings

The key findings of this exploratory analysis are the following:

- Responses and impacts to stipulated reductions in Delta water exports are complex and uncertain. Even preliminary characterizations require more detailed and intensive analyses than have been possible within the DRMS Phase 2 schedule and resources.
- Responses and impacts in the context of normal conditions (no levee breaches) are expected to be nonlinear; they would increase more dramatically, especially in capital and operating cost, as the size of the export reduction is increased. Exported water would transfer from agriculture to urban agencies, groundwater would be increasingly developed and overdrafted and agricultural land fallowing would occur. To the extent that fish are now adversely impacted by diversion of Delta waters and entrained in the south Delta pumps, they should be less impacted and the surviving species should be more viable.
- Risk reduction impacts are extremely uncertain and are likely to be variable.
  - For urban agencies, to the extent that a smaller percentage of their supply comes from Delta exports, one might expect them to be less impacted by the disruption of a major levee breach event. However, if their conservation efforts have increased the critical need for and value of the Delta export water they receive or if they respond by skimping on

emergency supplies, their negative impacts from a given levee breach event could actually increase.

- For agricultural water users, a Delta levee breach event is likely to have much more dramatic impacts, even though substantial acreage has been fallowed. Groundwater basins are likely to be severely overdrawn in agricultural areas and unavailable as significant emergency supplies. More acres of high value, permanent crops are likely to be lost.
- For aquatic organisms, the only chance for reduced Delta exports to provide an improved outcome to a major levee breach event is to have a more viable aquatic ecosystem when the event occurs. Entrainment onto flooding islands and other adverse mechanisms are still likely to produce very high mortalities. Only the advantage of having a larger and stronger population at the beginning of the event might lead to a larger number of survivors. This advantage may give the species an ability to regenerate a sustainable population. In contrast, the species may have been so marginal that it would have been lost under business as usual.

17.5.2 Conclusion and Recommendations

The choices, relationships, and interactions necessary to characterize the results of decreases in Delta exports are exceptionally complex. Assessment of risk reduction benefits (in the face of Delta levee breaches) requires another step to extend the analyses beyond “normal conditions,” which are already uncertain and have received limited study. More intensive analysis is required if a quantitative estimate of the results is desired.

If more analysis of this building block is performed, it is recommended that studies avoid focusing too much on the overall quantity of water exported from the Delta. Varying the amounts that exports are reduced in various water year types and further varying the way in which pumping is allowed or limited in various months may offer additional benefits to fish while limiting some of the costly impacts to water users.

Until more analyses are conducted, reviewed, and widely discussed, the DRMS consulting team cannot recommend adoption or rejection of this building block.

Tables

Table 17-1 Effects on Urban and Agricultural Agencies of a Permanent Reduction in Export Supplies

(Assuming change is phased in to allow agencies time to adjust)

1. Initial Costs – Up-front costs associated with potential alternative water resources:

Urban Water Agencies

- Capital costs of desalination or recycled water treatment plants
- Investment for conservation programs
- Up-front costs for purchases of water from other contractors

Agricultural Water Agencies

- Up-front costs associated with land retirement
- Investment in conservation programs
- Investment in additional groundwater wells and pumps

2. Annual Costs – Recurring costs associated with the reduction in export supplies

Urban Water Agencies

- Operating, maintenance, and replacement costs for desalination or recycled water treatment
- Operating, maintenance, and replacement costs for conservation programs
- Volumetric costs for purchases of water from other contractors

Agricultural Water Agencies

- Reduction in farm income either from cropping changes or acreage reductions
- Operating, maintenance, and replacement costs for conservation programs
- Operating, maintenance, and replacement costs for groundwater wells and pumps

3. Potential for Risk Reduction from Reduced Supplies

Urban and Agricultural Water Agencies

- Because normal supplies are reduced and it is assumed that acre-foot deliveries through the Delta would be the same for a given scenario, reductions in deliveries would be lessened under a levee failure scenario.

Urban Water Agencies

- To the extent that urban agencies purchased increased contractual rights from agricultural agencies to mitigate for this loss, they would get a greater share of water supplied under an emergency.

4. Potential for Risk Enhancement (Increased Vulnerability) from Reduced Supplies

Urban Water Agencies

- Increased conservation (demand hardening) means each acre-foot reduced would have increased economic costs associated with it.*
- Reduced likelihood of purchasing emergency transfer water from agriculture.
- Reduced water in south-of-Delta storage

Agricultural Water Agencies

- Fewer acres in lower-value crops means that high-value crops are more likely to be at risk.
- Increased non-emergency use of groundwater supplies means that less is available (or more expensive supplies must be developed) for emergency use.
- Reduced water in south-of-Delta storage.
- Sales of water rights to urban agencies would mean a smaller share of the water supplied under an emergency.

* For example, if all toilets are ultra-low flush, you can no longer save much water by reducing flushing, and need to reduce use in more costly ways.

Table 17-2 Summary of Combined Water Exports (acre-feet) at the SWP and CVP Facilities Assumed in the Fish Salvage Estimates

Normal or Wet Year (Water Year 2000 as an example; Above Normal Preceded by Wet)				
	Base	**10 percent**	**25 percent**	**40 percent**
October	567,985	567,985	567,985	567,985
November	558,268	558,268	558,268	558,268
December	388,826	388,826	388,826	388,826
January	594,079	594,079	594,079	594,079
February	661,581	661,581	300,000	200,000
March	549,520	450,000	200,000	150,000
April	312,768	200,000	150,000	100,000
May	182,992	200,000	150,000	100,000
June	442,029	250,000	200,000	100,000
July	625,516	563,755	508,615	216,281
August	656,400	563,756	508,615	316,282
September	640,042	563,756	508,616	416,282
Total	**6,180,007**	**5,562,006**	**4,635,005**	**3,708,004**
Dry or Critical Year (Water Year 1994 as an Example; Critical Preceded by Above Normal)				
	Base	**10 percent**	**25 percent**	**40 percent**
October	662,184	662,184	662,184	662,184
November	406,829	406,829	406,829	406,829
December	641,649	641,649	641,649	641,649
January	355,051	355,051	280,000	225,051
February	321,182	230,000	120,000	90,000
March	257,650	150,000	50,000	30,000
April	112,991	70,000	40,000	20,000
May	112,536	70,000	40,000	20,000
June	108,723	90,000	60,000	30,000
July	260,309	235,719	167,227	60,000
August	366,730	315,720	242,227	100,000
September	430,691	405,720	317,278	136,202
Total	**4,036,525**	**3,632,872**	**3,027,394**	**2,421,915**

Table 17-3 Summary of the Change in Fish Salvage in Response to Reductions in SWP and CVP Exports

Wet Year							
Fish Species	Annual Fish Salvage Estimate				Percentage Reduction From Base		
	Base	10% Export Reduction	25% Export Reduction	40% Export Reduction	10% Export Reduction	25% Export Reduction	40% Export Reduction
Delta smelt	57,894	52,231	39,077	25,782	**10**	**33**	**55**
Chinook salmon	81,556	73,867	51,107	36,466	**9**	**37**	**55**
Striped bass	1,634,682	1,263,284	1,084,402	651,576	**23**	**34**	**60**
Threadfin shad	5,053,072	4,651,226	4,262,023	3,353,563	**8**	**16**	**34**
Longfin smelt	10,877	10,694	8,022	5,367	**2**	**26**	**51**
Steelhead	6,461	6,078	3,694	3,001	**6**	**43**	**54**

Dry Year							
Fish Species	Annual Fish Salvage Estimate				Percentage Reduction From Base		
	Base	10% Export Reduction	25% Export Reduction	40% Export Reduction	10% Export Reduction	25% Export Reduction	40% Export Reduction
Delta smelt	28,160	19,557	12,093	6,728	**31**	**57**	**76**
Chinook salmon	40,580	28,224	16,759	10,574	**30**	**59**	**74**
Striped bass	715,120	633,953	494,997	325,894	**11**	**31**	**54**
Threadfin shad	3,451,896	3,272,938	2,888,646	2,327,531	**5**	**16**	**33**
Longfin smelt	6,019	3,783	2,181	1,115	**37**	**64**	**81**
Steelhead	3,299	2,516	1,510	1,145	**24**	**54**	**65**

Figures

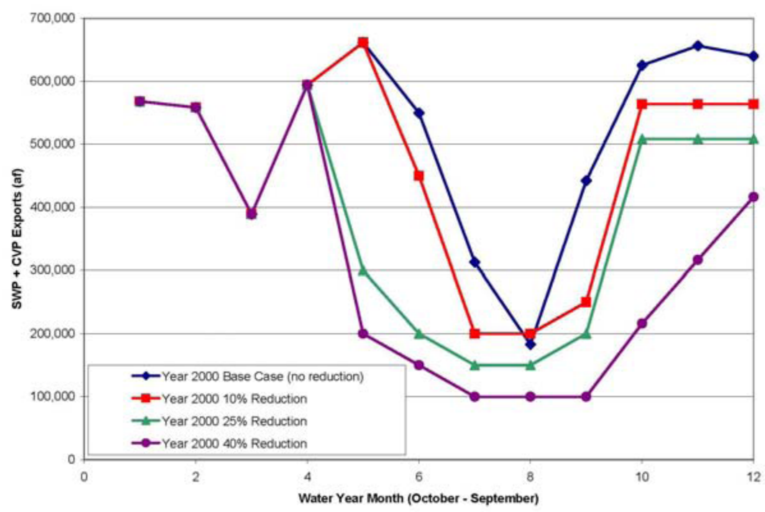
Reduce Exports: Purpose

- For normal conditions (no levee breaches)
  - Decrease adverse impacts on fish
- In a levee breach event
  - Reduce risk for urban water users
  - Reduce risk for agricultural water users
  - Reduce risk for fish

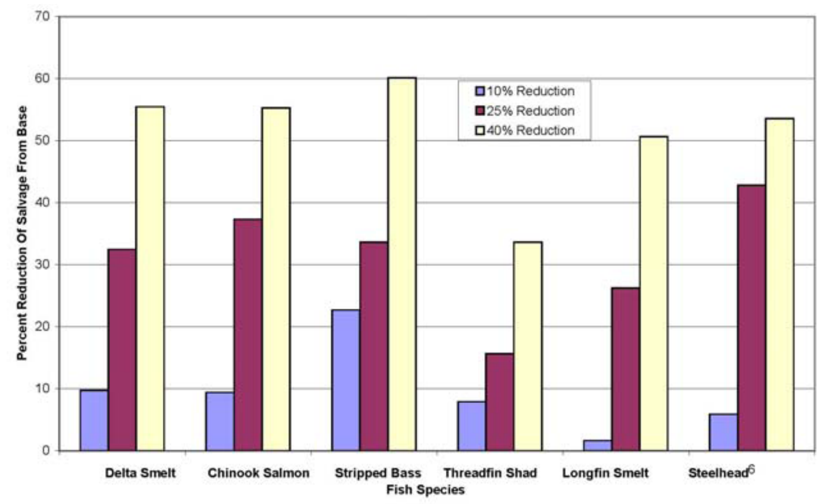
Reduce Exports: Options

- 10% reduction
- 25% reduction
- 40% reduction

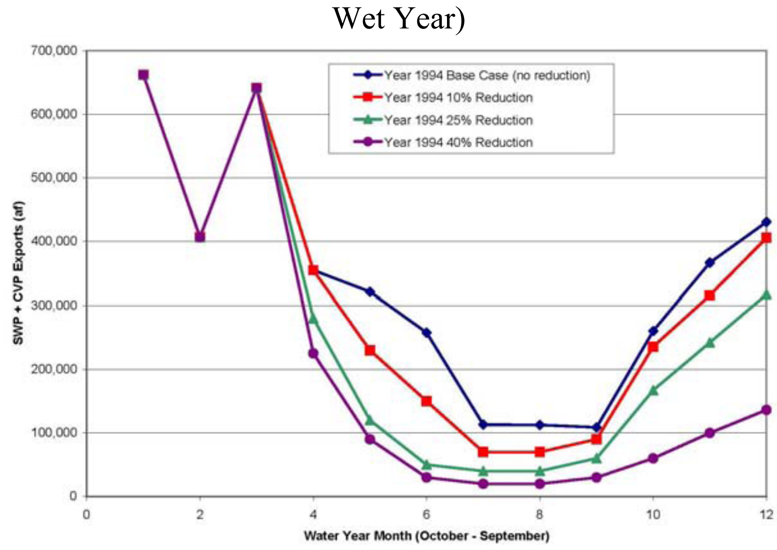
Apply to all types of water years but vary the monthly reductions within water years, based on benefits to fish.



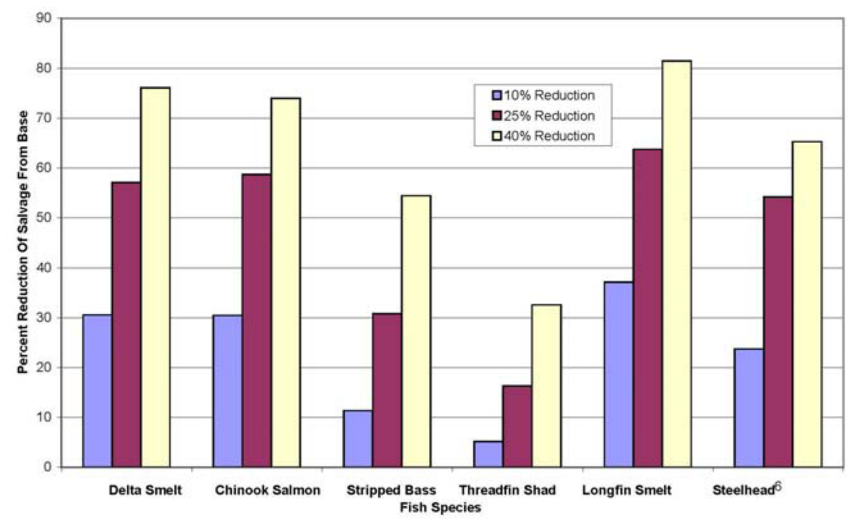
Monthly Water Exports with Reductions – Normal or Wet Years – Water Year 2000 as Example (Above-Normal Year Preceded by Wet Year)



Percent Reduction in Fish Salvage for Various Reductions in Delta Exports Wet or Normal Year – Water Year 2000 as an Example



Monthly Water Exports with Reductions – Dry or Critical Years – Water Year 1994 as Example (Critical Year Preceded by Above-Normal Year)



Percent Reduction in Fish Salvage for Various Reductions in Delta Exports Dry or Critical Year – Water Year 1994 as an Example

Results for Normal Conditions

Urban water users – Intensify conservation, purchase from Ag or develop alternate supplies, all at high cost.

Agricultural users – Intensify conservation, sell to Urban, fallow land, develop more groundwater, switch to higher value crops.

Fish – Less entrainment at pumps and less salvage at fish screens (so less handling stress and predation mortality). Also more Delta outflow, so improved habitat.

Risk Reduction for Levee Breaches

Urban water users – Uncertain, may reduce consequences if less dependent on Delta supply or may increase consequences if limited Delta supply has more value.

Agricultural water users – Uncertain, but likely to increase consequences because of higher value crops, more dependence on limited supply , and decreased ability to draw on contingent supplies.

Fish – Larger and stronger population is more likely to regenerate, avoiding extinction.

Issues/Concerns with Decreased Exports

- Need more detailed analysis of urban and agricultural responses and costs
- Need analysis of increase versus decrease in water user risk
- Need to assess other water year and monthly strategies for applying decreases.

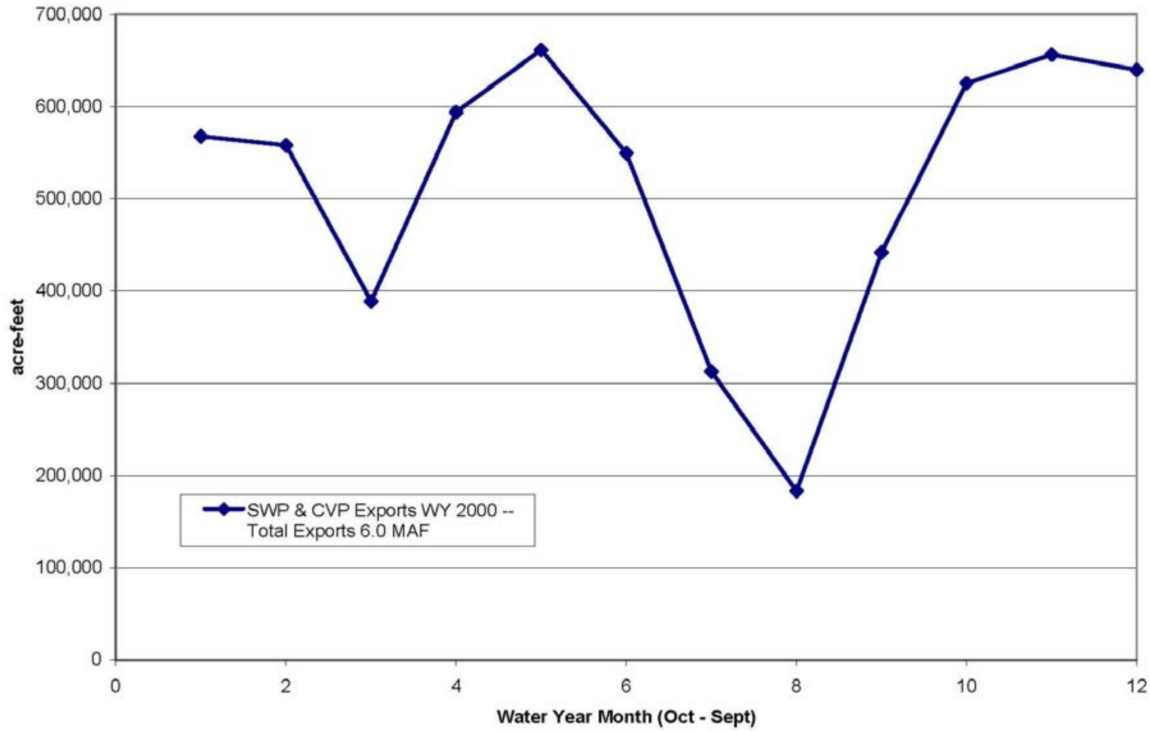


Figure 17-2a SWP and CVP Exports, WY 2000 – Above Normal Year Preceded by Wet Year

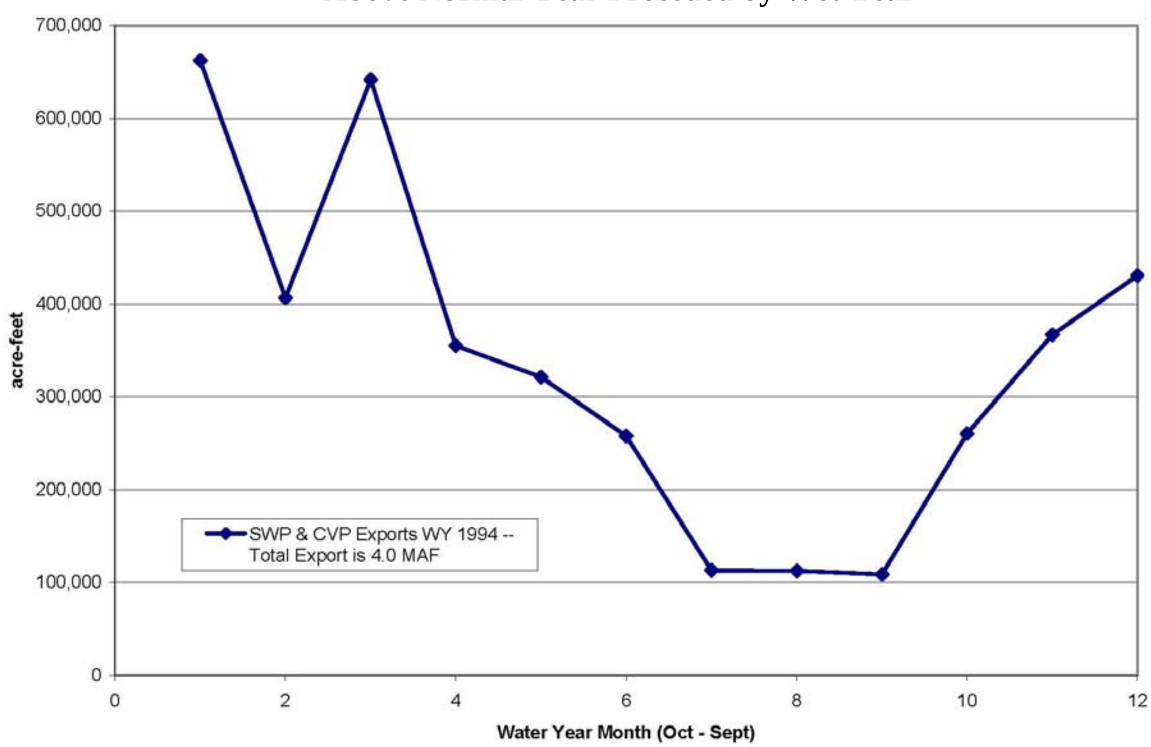


Figure 17-2b SWP and CVP Exports, WY 1994 – Critical Year Preceded by Above-Normal Year

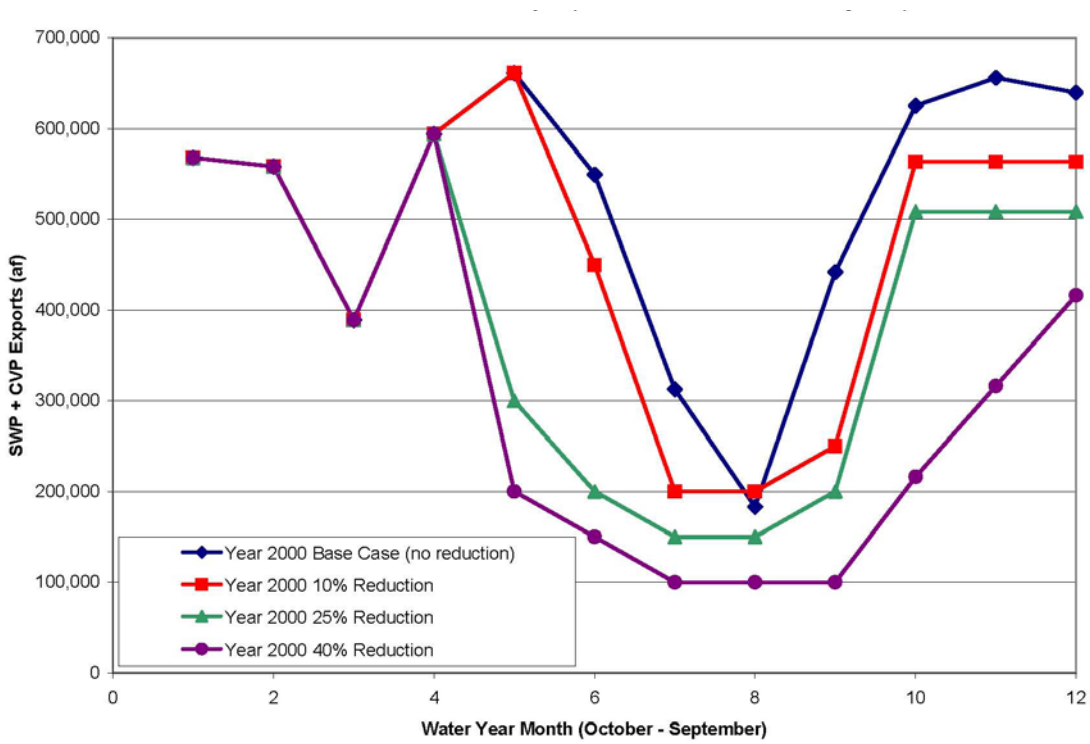


Figure 17-3a Monthly Water Exports with Reductions – Normal or Wet Years – Water Year 2000 as Example (Above Normal Year Preceded by Wet Year)

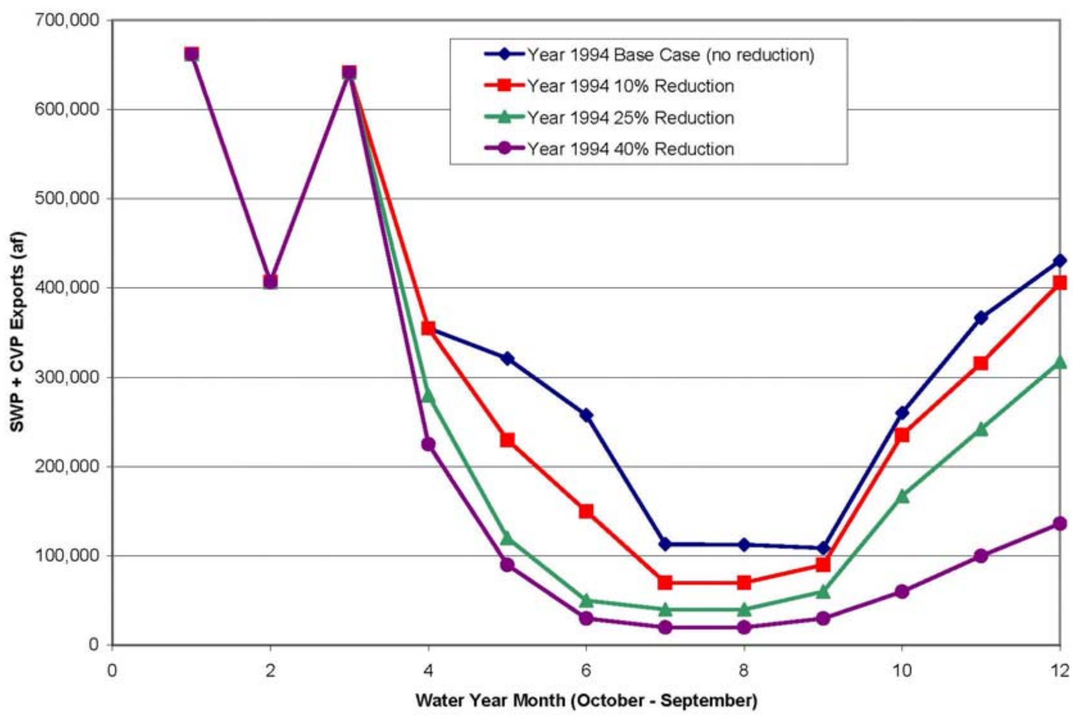


Figure 17-3b Monthly Water Exports with Reductions – Dry or Critical Years – Water Year 1994 as Example (Critical Year Preceded by Above-Normal Year)

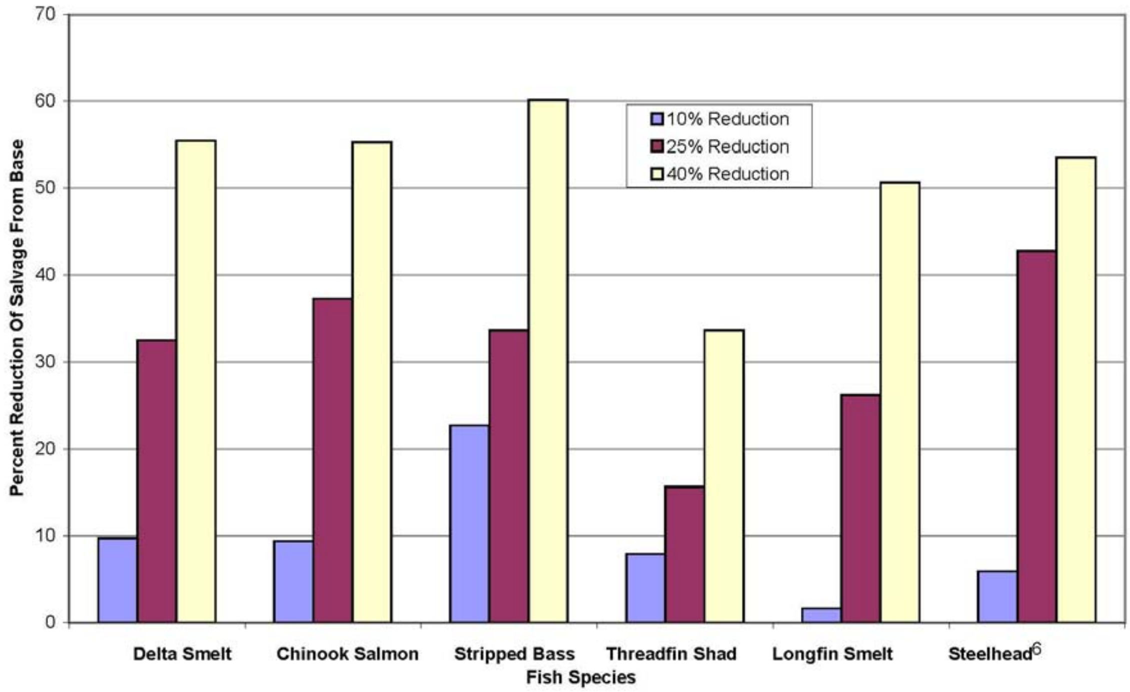


Figure 17-4a Percent Reduction in Fish Salvage for Various Reductions in Delta Exports Wet or Normal Year – Water Year 2000 as Example

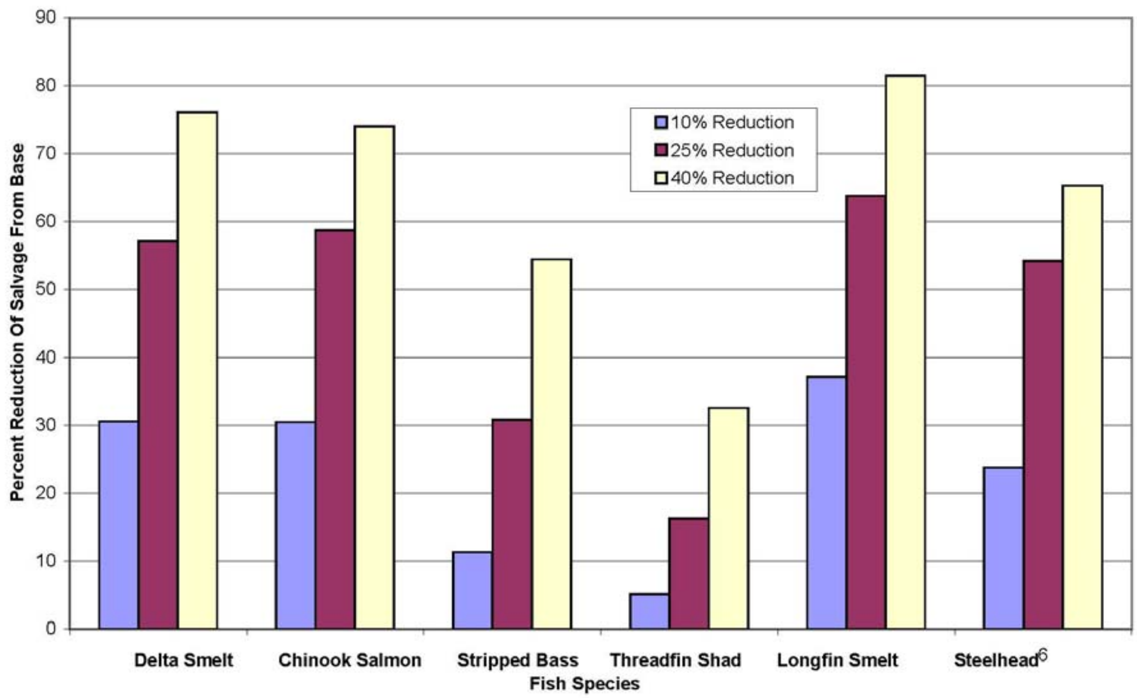


Figure 17-4b Percent Reduction in Fish Salvage for Various Reductions in Delta Exports Dry or Critical Year – Water Year 1994 as Example