

CALFED Water Management Strategy - Gaming 1981-1989

Biological Resource Concerns, Actions, and Rationales

Biological concern/ priority profile	Actions/tools	Rationale	Estimated water costs
<b>Yearling salmon emigrants (Oct - Jan)</b>  Profile (1981-89, Scenario 1A,B): A - 4, B - 7, C - 1, OK - 1 "A" priority typically following years of low spring-run chinook escapement or when upstream rearing conditions were likely to have been poor (low flow, high temperature). High densities of large smolts in the salvage following inflow spikes also led to an "A" priority rating.	Close DCC	Closure of the DCC effectively reduces movement of emigrating salmon into the central Delta. Survival of Sacramento River salmon in the central Delta is reduced relative to survival of smolts that remain in the mainstem Sacramento (USFWS1998). The mechanisms contributing to reduced survival in the central Delta are not well understood.	Costs are primarily in terms of water quality rather than quantity.
	Increase inflow	As Sacramento River flow increases, the proportion of total flow that enters Georgiana Slough declines in a non-linear way, with the greatest changes from 5,000 to 20,000 cfs of Freeport flow. If emigrating smolts are assumed to move in proportion to flow splits, then increasing Sacramento River inflow to the Delta reduces the proportion of emigrants that enter the central Delta via Georgiana Slough. Survival of Sacramento River salmon in the central Delta is reduced relative to survival of smolts that remain in the mainstem Sacramento (e.g., USFWS 1998). Increasing inflow can also generally improve central Delta hydrodynamic conditions and counteract inappropriate migratory cues generated by export	This action was not taken during gaming, however, Sacramento R. inflow to the Delta may increase in years when flow was added in the upper Sacramento River or Lower American River to improve salmon spawning habitat in the fall.

Biological concern/ priority profile	Actions/tools	Rationale	Estimated water costs
<b>Yearling salmon emigrants (Oct - Jan)</b> (continued)		operations.	
	Reduce export	Sacramento River yearling chinook occasionally are salvaged at the export facilities in high numbers relative to the number emigrating in the fall. Yearling life history of spring run chinook salmon represents a variable proportion of annual juvenile production for the different stream systems. Emigration as yearlings may be the predominant strategy in some streams in some years. In any case, yearlings may make a disproportionate contribution to recruitment because ocean survival of salmon is positively related to smolt size. Presence of yearlings in the fall salvage indicates that Sacramento River chinook have deviated from their normal migration path to the ocean. Entrainment may be exacerbated by artificial hydrodynamic conditions in the central Delta created by export operations. Yearling-sized chinook are relatively resilient to salvage procedures, but remain susceptible to high predation rates in Clifton Court Forebay. Salmon survival in the Delta relative to the lower Sacramento River is inversely related to exports. Reduced exports improves central Delta hydrodynamic conditions, reduces direct impacts at the export facilities, and increases the survival of emigrating salmon. Yearlings often emigrate in conjunction with the first storms of the season. High-volume export operations that attempt to capture these early season pulses of inflow can be particularly detrimental.	Costs are variable depending on current pumping rate and magnitude and duration of action

Biological concern/ priority profile	Actions/tools	Rationale	Estimated water costs
<p><b>Winter-run chinook smolt survival (Dec - Mar)</b></p> <p>Profile (1981-89, Scenario 1A,B): A - 6, B - 3, C - 1, OK - 1</p>	Close DCC	Rationale similar to that for salmon yearlings applies as well to juvenile winter-run chinook. Historically, the DCC was often closed during this time period for flood control purposes. In the 1990s the DCC has been closed beginning in February for winter run chinook salmon and since 1996 has been closed in November or December through January for yearling spring run chinook and other salmon.	
<p>"A" priority was associated with low winter-run escapements (except 1982), high densities of winter-run sized fish in the historical salvage record, and high export to inflow ratios.</p>	Increase inflow	See rationale for yearling salmon above.	
	Reduce exports	See rationale for yearling salmon above.	
<p><b>Steelhead smolt survival (Feb - May)</b></p> <p>Profile (1981-89, Scenario 1A,B): A - 1, B - 5, C - 1, OK - 2</p> <p>The single "A" priority corresponded to consistently high salvage, including peak salvage densities &gt; 100/TAF, which are rare for steelhead, during a time period when protections for other species were uncertain.</p>	Reduce exports	The large size of juvenile steelhead likely reduces their susceptibility to adverse indirect and direct impacts in the Delta, making protective actions exclusively for steelhead a relatively low priority. Although steelhead smolts are resilient to salvage procedures, they likely experience predation at some (unknown) rate in Clifton Court Forebay. Steelhead often benefit from protective actions taken for other salmonids and delta smelt.	
<p><b>Salmon fry survival (Feb - Mar)</b></p>	Reduce exports	Fall-run chinook fry move to the Delta in winter in most years. Fall-run chinook fry from the San	

Biological concern/ priority profile	Actions/tools	Rationale	Estimated water costs
<p>Profile (1981-89, Scenario 1A,B): A - 1, B - 4, C - 0, OK - 5</p> <p>High uncertainty about effective ways to protect salmon fry, and high overlap with protective actions for other species led to relatively low priority ratings for this concern. The single "A" priority occurred during a wet year with fry salvage densities in February exceeding 1,000/TAF, and no protective actions anticipated for other species during this time frame.</p>		Joaquin move to the Delta in large numbers particularly in wet years. Export curtailment for a discreet period after arrival of fry in the Delta will allow some salmon to move into the western Delta beyond the influence of the export pumps. Avoiding entrainment for a few days may enable fry to form habitat associations in the Delta and reduce their tendency to be entrained at the export facilities during the 1 to 3 months these fry spend rearing in the Delta before emigrating. Considerable uncertainty surrounds the potential effectiveness of this second mechanism. At minimum, delaying entrainment for several days will provide a small increase in the ability of fry to survive salvage procedures. Given the long period of exposure to entrainment risk of Delta-rearing fry, and lack of alternative protective actions, experimental implementation of this approach is warranted. Salmon fry present in the Delta during this time period often benefit from protective actions for other species.	
<p><b>San Joaquin smolt survival (Apr - Jun)</b></p> <p>Profile (1981-89, Scenario 1A,B): A - 9, B - 7, C - 4, OK - 0</p> <p>This concern consistently received the highest priority ranking. Smolt emigration from the San Joaquin corresponds with emigration timing of Sacramento salmon, and presence of young delta smelt in the Delta, thus increasing the</p>	Close Head of Old River Barrier	Closure of the Head of Old River barrier keeps San Joaquin smolts in the mainstem San Joaquin river, reducing or delaying the opportunity for direct entrainment at the export facilities. Further downstream movement in the mainstem San Joaquin may provide time for smolts to transition from flow to salinity cues to guide migration. During gaming, the Head of Old River Barrier was assumed to be closed during the VAMP period.	No water costs

Biological concern/ priority profile	Actions/tools	Rationale	Estimated water costs
value of protective actions during this period.			
Priority A was the appropriate export rate for the 31-day VAMP period. B and C priorities when salmon entrainment was high before and/or after the VAMP and lower exports were provided.	Increase San Joaquin River flow	Experimental salmon survival studies have shown a significant relationship between San Joaquin River flow at Stockton and smolt survival through the Delta	
	Reduce exports	Various combinations of flow and exports may be equally effective in protecting San Joaquin chinook salmon smolts. VAMP experiments use current knowledge to protect salmon for 31 days and obtain information that may improve the efficiency of protection. 45-75% of San Joaquin salmon smolts emigrate within a 30 day window each spring; 75-90% emigrate within a 60 day window. Providing one part of the VAMP condition (lower exports) for additional days when many salmon are emigrating reduces entrainment and provides improved conditions and higher survival for a greater fraction of the outmigrating population.	
<b>Delta smelt adult entrainment (Jan - Mar)</b> Profile (1981-89, Scenario 1A,B): A - 2, B - 3, C - 0, OK - 4	Reduce exports		
<b>Delta smelt juvenile entrainment (Apr - July)</b> Profile (1981-89, Scenario 1A,B): A - 4, B - 2, C - 0, OK - 4	X <sub>2</sub> placement		
	Reduce exports		

Biological concern/ priority profile	Actions/tools	Rationale	Estimated water costs
<b>X<sub>2</sub> estuarine ecosystem function (Feb - Jun)</b> Profile (1981-89, Scenario 1A,B): OK - 9	Increase inflow		No actions taken to improve X <sub>2</sub>
	Reduce exports		No actions taken to improve X <sub>2</sub>
<b>Striped bass juvenile entrainment (May - July)</b> Profile (1981-89, Scenario 1A,B): A - 0, B - 5, C - 6, OK - 0	X <sub>2</sub> placement		
Actions had lower priority relative to other species, few were undertaken. Some protection for striped bass provided at times by actions for other species, however, more often very high entrainment losses occurred during export pumping which was deferred to July-September.	Increase Sacramento River flow	Improve survival and transport of eggs and larvae to nursery habitat in the estuary.	
	Reduce exports	Particle tracking studies indicate that particles inserted at Freeport have up to a 35% chance of reaching the export pumps in 28 days, and export rates are the primary factor affecting export probability. Over 40% of inert particles injected at Freeport reach the export facilities after 30 days when Sacramento flows are low (12,700 cfs) and exports are high (8,900 cfs).	
<b>Splittail juvenile entrainment (May - Jul)</b> Profile (1981-89, Scenario 1A,B): A - 1, B - 5, C - 0, OK - 4	Close Head of Old River Barrier		
	Reduce exports		