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## SAIC IN-PROGRESS DRAFT

**Table X. Effectiveness Monitoring for Selected Conservation Measures and Example Applications for Adaptive Management Decision Making**

**Note to Reviewers:** this table illustrates the linkages among proposed conservation measures, supporting hypotheses, and monitoring metrics for three conservation measures. This table is for illustrative purposes only and the information presented and linkages inferred in this table will be further refined as development of the BDCP monitoring program progresses. Section A of the table presents elements of conservation measure implementation that could be monitored to provide information relevant to informing ongoing implementation of the conservation measure and increasing the understanding of the ecological effects of implementation over time (e.g., under what conditions does *Egeria* establish in restored marshes). Results of the monitoring identified in Section A would provide information for routine adaptive management decision making by the Implementing Entity. Section B identifies monitoring elements listed in Section A that would likely be those that would inform major adaptive management decisions regarding conservation measure implementation through the routine or non-routine decision making processes.

Conservation Measure Component	Hypotheses	SECTION A: Effectiveness Monitoring/Targeted Research for Learning		SECTION B: Major Monitoring Elements for Adaptive Management Decision Making (Subset of SECTION A)			
		Monitoring Element	Monitoring Metrics	Effectiveness Monitoring Element	Monitoring Metrics	Example Adaptive Management Decision Tree	
						Outcome Threshold	Decisions
<b>HRCM4: Restore at least 5,000 acres freshwater tidal marsh within the Cache Slough Complex ROA.</b>							
<b>Monitoring Approach:</b> <i>To come. This section will identify all anticipated monitoring requirements related to implementation of this conservation measure. This information will provide guidance to the Implementing Entity in its formulation of the monitoring program for this conservation measure.</i>							
<b>DELTA SMELT</b>							
Marsh plain, tidal channels, tidal flushing	1. Food and or food availability is a stressor inhibiting delta smelt 2. Restoring tidal marsh in Cache Slough will increase the abundance of delta smelt zooplankton food	HRTM1. Export of phytoplankton species that support production of zooplankton species that are delta smelt food from marsh plain into adjacent subtidal habitat during periods delta smelt are present	Metric #1: Phytoplankton species composition/relative abundance Metric #2: Phytoplankton (mg/L chlorophyll a)	HRTM13. Density of zooplankton that are delta smelt food	Metric #3: Zooplankton species composition/relative abundance Metric #4: Zooplankton (number/1,000 m <sup>3</sup> )	1. Density of zooplankton in restored subtidal habitat is similar to or greater than in existing Liberty Island subtidal habitats	1. Continue with marsh restoration 2. Adjust water operations if sufficient delta smelt benefits are demonstrated and there are no substantial adverse effects on other covered fish species
		HRTM2. Export of zooplankton species that are delta smelt food from marsh plain into adjacent subtidal habitat during periods delta smelt are present	Metric #3: Zooplankton species composition/relative abundance Metric #4: Zooplankton (number/1,000 m <sup>3</sup> )			2. Density of zooplankton in restored subtidal habitat is substantially less than in existing Liberty Island subtidal habitats	1. Modify marsh design to increase inputs of phytoplankton, zooplankton, and total organic carbon 2. Implement actions to reduce effects of stressors that may be suppressing zooplankton abundance (e.g., <i>Corbicula</i> ) 3. Discontinue restoration of tidal marsh in Cache Slough
		HRTM3. Export of organic carbon that supports delta smelt food production from marsh plain into adjacent subtidal habitat during periods delta smelt are present	Metric #5: Total organic carbon (mg/L)			HRTM11. Presence of delta smelt by life stage.	Metric #13: Number of delta smelt/10,000 m <sup>3</sup>

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		Monitoring Element	Monitoring Metrics	Effectiveness Monitoring Element	Monitoring Metrics	Example Adaptive Management Decision Tree			
						Outcome Threshold	Decisions		
Increase in subtidal habitat area	Increase in subtidal habitat area will increase the extent of delta smelt habitat area	HRTM4. Extent of new subtidal habitat area	Metric #6: acres			2. Abundance of delta smelt in restored subtidal habitat is trending towards abundances in existing Liberty Island subtidal habitats	1. Continue with marsh restoration 2. Adjust water operations if sufficient delta smelt benefits are demonstrated and there are no substantial adverse effects on other covered fish species		
		HRTM5. Turbidity	Metric #7: NTUs			3. Delta smelt habitat conditions in existing Liberty Island and Toe Drain habitats are improved and delta smelt abundance increases	1. Continue with marsh restoration 2. Adjust water operations if sufficient delta smelt benefits are demonstrated and there are no substantial adverse effects on other covered fish species		
		HRTM6. Salinity	Metric #8: EC			4. Abundance of delta smelt in restored subtidal habitat is substantially less than in existing Liberty Island subtidal habitats	1. Modify marsh designs to improve delta smelt habitat conditions 2. Discontinue restoration of tidal marsh in Cache Slough		
		HRTM7. Abundance of non-native delta smelt fish predators relative to similar habitat areas	Metric #9: Number of fish/10,000 m <sup>3</sup>			5. Delta smelt habitat conditions in existing Liberty Island and Toe Drain habitats decline	1. Modify marsh designs to eliminate adverse effects on existing habitats 2. Undertake actions to improve conditions in existing habitats 3. Discontinue restoration of tidal marsh in Cache Slough		
		HRTM8. <i>Corbicula</i> density	Metric #10: <i>Corbicula</i> /M <sup>2</sup>			HRTM12. Detection of delta smelt spawning	Metric #14: Detection of eggs, larvae, or spawning behavior in restored habitats	1. Delta smelt are spawning in restored habitats and are continuing to spawn in existing Cache Slough habitats	1. Continue with marsh restoration 2. Adjust water operations if sufficient delta smelt benefits are demonstrated and there are no substantial adverse effects on other covered fish species
		HRTM9. Water temperature	Metric #11: water temperatures August-October						

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		Monitoring Element	Monitoring Metrics	Effectiveness Monitoring Element	Monitoring Metrics	Example Adaptive Management Decision Tree	
						Outcome Threshold	Decisions
		HRTM10. Presence of non-native aquatic vegetation	Metric #12: Kg/1,000 m <sup>3</sup>				
		HRTM11. Presence of delta smelt by life stage.	Metric #9: Number of fish/10,000 m <sup>3</sup>				
		HRTM12. Detection of delta smelt spawning	Metric #13: Detection of eggs, larvae, or spawning behavior in restored habitats				
	Subtidal habitat area increases production of delta smelt food	HRTM13. Density of zooplankton that are delta smelt food	Metric #3: Zooplankton species composition/relative abundance  Metric #4: Zooplankton (number/1,000 m <sup>3</sup> )				
Establishment of cool water delta smelt refugia	Restored tidal marsh creates adjacent subtidal habitat areas that are cooler and provide seasonal refuge habitat areas to maintain individuals through warm periods	HRTM9. Water temperature	Metric#11: water temperatures August-October				
		HRTM11. Presence of delta smelt by life stage.	Metric #9: Number of fish/10,000 m <sup>3</sup>				
Food export to downstream habitat areas	Organic carbon produced in restored tidal marshes will be exported to downstream delta smelt habitats and will increase the abundance of delta smelt zooplankton food in those locations.	HRTM14. Presence of organic carbon produced from restored tidal marsh present at downstream sampling stations	Metric #5: Total organic carbon (mg/L)  Metric #14: Proportion of total organic carbon that originated from restored tidal marsh				
<b>SACRAMENTO RIVER CHINOOK SALMON RUNS</b>							
Marsh plain, tidal channels, tidal flushing	1. Food and or food availability is a stressor inhibiting growth and survival of juvenile Chinook salmon 2. Restoring tidal marsh in Cache Slough will increase the abundance of juvenile Chinook salmon food	HRTM15. Export of phytoplankton species that supports production of Chinook salmon fish and macroinvertebrate prey species from marsh plain into adjacent subtidal habitat during periods juvenile Chinook salmon are present.	Metric #1: Phytoplankton species composition/relative abundance  Metric #2: Phytoplankton (mg/L chlorophyll a	HRTM22. Density of fish that are juvenile Chinook salmon food	Metric #9: Number of fish/10,000 m <sup>3</sup>	1. Density of fish and macroinvertebrate Chinook salmon prey species in restored subtidal habitat is similar to or greater than in the Sacramento River	1. Continue with marsh restoration 2. Adjust water operations if sufficient Chinook salmon benefits are demonstrated and there are no substantial adverse effects on other covered fish species

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		Monitoring Element	Monitoring Metrics	Effectiveness Monitoring Element	Monitoring Metrics	Example Adaptive Management Decision Tree	
						Outcome Threshold	Decisions
		HRTM16. Export of zooplankton species that supports production of Chinook salmon fish and macroinvertebrate prey species from marsh plain into adjacent subtidal habitat during periods juvenile Chinook salmon are present.	Metric #3: Zooplankton species composition/relative abundance  Metric #4: Zooplankton (number/1,000 m <sup>3</sup> )	HRTM23. Density of macroinvertebrates that are juvenile Chinook salmon food	Metric #15: Macroinvertebrates (number/1,000 m <sup>3</sup> )	2. Density of of fish and macroinvertebrate Chinook salmon prey species in restored subtidal habitat is substantially less than in the Sacramento River	1. Modify marsh design to increase production of phytoplankton, zooplankton, total organic carbon, macroinvertebrates, and fish prey species  2. Implement actions to reduce effects of stressors that may be suppressing fish and macroinvertebrate prey species  3. Discontinue restoration of tidal marsh in Cache Slough
		HRTM17. Export of organic carbon that supports production of Chinook salmon fish and macroinvertebrate prey species from marsh plain into adjacent subtidal habitat during periods juvenile Chinook salmon are present.	Metric #5: Total organic carbon (mg/L)	HRTM21. Presence of juvenile Chinook salmon by run.	Metric #9: Number of fish/10,000 m <sup>3</sup>	1. Abundance of juvenile Chinook salmon in restored subtidal habitat is similar to or greater than in existing Sacramento River habitats	1. Continue with marsh restoration  2. Adjust water operations if sufficient Chinook salmon benefits are demonstrated and there are no substantial adverse effects on other covered fish species
		HRTM18. Production of Chinook salmon fish prey species in tidal marsh channels.	Metric #9: Number of fish/10,000 m <sup>3</sup>			2. Abundance of juvenile Chinook salmon in restored subtidal habitat is trending towards abundances in existing Sacramento River habitats	1. Continue with marsh restoration  2. Adjust water operations if sufficient Chinook salmon benefits are demonstrated and there are no substantial adverse effects on other covered fish species
		HRTM19. Production of Chinook salmon macroinvertebrate prey species in tidal marsh channels.	Metric #15: Macroinvertebrates (number/1,000 m <sup>3</sup> )			3. Abundance of juvenile Chinook salmon in restored subtidal habitat is substantially less than in existing Sacramento River habitats	1. Modify marsh designs to improve delta smelt habitat conditions  2. Discontinue restoration of tidal marsh in Cache Slough
Increase in subtidal habitat area	Increase in subtidal habitat area will increase the extent of juvenile Chinook salmon rearing habitat area	HRTM4. Extent of new subtidal habitat area	Metric #6: acres				

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						Outcome Threshold	Decisions
		HRTM20. Abundance of non-native Chinook salmon fish predators relative to similar habitat areas	Metric #9: Number of fish/10,000 m <sup>3</sup>				
		HRTM9. Water temperature	Metric #11: water temperatures August-October				
		HRTM10. Presence of non-native aquatic vegetation	Metric #12: Kg/1,000 m <sup>3</sup>				
		HRTM21. Presence of juvenile Chinook salmon by run.	Metric #9: Number of fish/10,000 m <sup>3</sup>				
	Subtidal habitat area increases production of juvenile Chinook salmon food	HRTM22. Density of fish that are juvenile Chinook salmon food	Metric #9: Number of fish/10,000 m <sup>3</sup>				
		HRTM23. Density of macroinvertebrates that are juvenile Chinook salmon food	Metric #15: Macroinvertebrates (number/1,000 m <sup>3</sup> )				
Food export to downstream habitat areas	Organic carbon produced in restored tidal marshes will be exported to downstream Chinook salmon habitats and will increase the abundance of Chinook salmon food in those locations.	HRTM14. Presence of organic carbon produced from restored tidal marsh present at downstream sampling stations	Metric #5: Total organic carbon (mg/L)  Metric #14: Proportion of total organic carbon that originated from restored tidal marsh				
<b>OSCM13: Remove non-native submerged and floating aquatic vegetation from Delta waterways.</b>							
<b>Monitoring Approach:</b> <i>To come. This section will identify all anticipated monitoring requirements related to implementation of this conservation measure. This information will provide guidance to the Implementing Entity in its formulation of the monitoring program for this conservation measure.</i>							
Not applicable.	Removal of SAV and FAV will increase turbidity	HRTM5. Turbidity	Metric #7: NTUs	OSNN1. Abundance of delta smelt by life stage relative to abundance in similar untreated channels.	Metric #9: Number of fish/10,000 m <sup>3</sup>	1. The abundance of delta smelt substantially increases in treated channels	1. Continue with implementation of FAV and SAV control measures  2. Adjust water operations if sufficient delta smelt benefits are demonstrated in conjunction with over all improvement of delta smelt status

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						Outcome Threshold	Decisions
	Increased turbidity will increase the abundance of delta smelt in treated channels	OSNN1. Abundance of delta smelt by life stage relative to abundance in similar untreated channels.	Metric #9: Number of fish/10,000 m <sup>3</sup>			2. The abundance of delta smelt in treated channels relative to densities in untreated channels does not change	1. Modify implementation to further increase turbidity and decrease fish predator habitat 2. Discontinue control measures if no benefits are demonstrated for juvenile salmonids
	Increased turbidity will increase the survival of rearing salmonids in treated channels	OSNN2. Abundance of juvenile salmonids by run relative to abundance in similar untreated channels.	Metric #9: Number of fish/10,000 m <sup>3</sup>			3. The abundance of delta smelt in treated channels decreases relative to densities in untreated channels	1. Identify cause for decrease relative abundance and discontinue control measures
	Increased turbidity will reduce non-native fish predation on delta smelt and juvenile salmonids in treated channels	OSNN3. Abundance of non-native predatory fish relative to abundance in similar untreated channels.	Metric #9: Number of fish/10,000 m <sup>3</sup>	OSNN2. Abundance of juvenile salmonids by run relative to abundance in similar untreated channels.	Metric #9: Number of fish/10,000 m <sup>3</sup>	1. The abundance of juvenile salmonids substantially increases in treated channels	1. Continue with implementation of FAV and SAV control measures 2. Adjust water operations if sufficient delta smelt benefits are demonstrated in conjunction with over all improvement of delta smelt status
						2. The abundance of juvenile salmonids in treated channels relative to densities in untreated channels does not change	1. Modify implementation to further increase turbidity and decrease fish predator habitat 2. Discontinue control measures if no benefits are demonstrated for delta smelt
						3. The abundance of juvenile salmonids in treated channels decreases relative to densities in untreated channels	1. Identify cause for decrease relative abundance and discontinue control measures
<b>WOCML2: Modify the Fremont Weir and Yolo Bypass and operate the Fremont Weir to provide for a higher frequency and duration of inundation of the Yolo Bypass</b>							
<b>Monitoring Approach:</b> <i>To come. This section will identify all anticipated monitoring requirements related to implementation of this conservation measure. This information will provide guidance to the Implementing Entity in its formulation of the monitoring program for this conservation measure.</i>							

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						Outcome Threshold	Decisions
Operation of the modified Fremont Weir to inundate floodplain habitat.	Increasing inundation of the Yolo Bypass will increase covered salmonid, splittail, sturgeon, and lamprey habitat area	WOFL1. Water depth	Metric #16: Extent and spatial distribution of depth classes by stage	WOFL9. Abundance of spawning splittail	Metric #9: Number of fish/10,000 m <sup>3</sup>	1. The abundance of spawning splittail is similar to or exceeds pre-BDCP Yolo Bypass inundation events	1. Continue with Femont Weir operations
				WOFL10. Abundance of larval and early juvenile splittail emigrating from the Yolo Bypass			
		WOFL2. Water velocity	Metric #17: Extent and spatial distribution of flow velocities by stage			1. The abundance of spawning splittail is substantially less than pre-BDCP Yolo Bypass inundation events	1. Modify Fremont Weir operations to increase splittail spawning and abundance
						2. The abundance of spawning splittail produced in the Yolo Bypass and emigrating from the Bypass is substantially less than pre-BDCP Yolo Bypass inundation events	
WOFL3. Extent of new inundated floodplain habitat area	Metric #18: Acres inundated by stage	WOFL11. Proportion of juvenile salmonids in the Sacramento River upstream of Fremont Weir that pass into the Yolo Bypass	Metric #21: Proportion of juvenile salmonids that pass into the Yolo Bypass relative to Sacramento River stage	1. The proportion of salmonids entering the Bypass is similar to or greater than the proportion of Sacramento River flow diverted into the Bypass	1. Continue with Femont Weir operations		
WOFL4. Inundation duration	Metric #19: Number of consecutive days floodplain is inundated						2. The proportion of salmonids entering the Bypass is substantially less than the proportion of Sacramento River flow diverted into the Bypass and salmonid survival and/or growth is substantially greater in the Bypass relative to the Sacramento River

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						Outcome Threshold	Decisions	
		WOFL5. Inundation frequency	Metric #20: Inter- and intra-annual frequency that the Fremont Weir is operated			3. The proportion of salmonids entering the Bypass is substantially less than the proportion of Sacramento River flow diverted into the Bypass and salmonid survival and/or growth is similar to or less than that of fish in the Sacramento River	1. Continue with Femont Weir operations if there are substantial benefits to other covered fish species  2. Reduce or discontinue Femont Weir operations if there are no substantial benefits to other covered fish species	
Increasing inundation of the Yolo Bypass will increase the production and availability of zooplankton, macroinvertebrate, and fish covered fish species food	WOFL6. Density of zooplankton	Metric #3: Zooplankton species composition/relative abundance  Metric #4: Zooplankton (number/1,000 m <sup>3</sup> )	WOFL12. Same year juvenile salmonid growth rates in Yolo Bypass and Sacramento River	Metric #22: Fulton Condition Factor (length/weight <sup>3</sup> )	1. Juvenile salmonids grow at substantially higher rate than in the Sacramento River	1. Continue with Femont Weir operations		
	WOFL7. Density of macroinvertebrates that are covered fish species food	Metric #15: Macroinvertebrates (number/1,000 m <sup>3</sup> )					2. Juvenile salmonids grow at about the same rate as in the Sacramento River	1. Continue with Femont Weir operations 2. Modify Fremont Weir operations to increase in-Bypass salmonid food production
	WOFL8. Density of fish that are covered fish species food	Metric #9: Number of fish/10,000 m <sup>3</sup>					3. Juvenile salmonids grow at a substantially lesser rate than in the Sacramento River	1. Continue with Femont Weir operations if there are substantial benefits to other covered fish species 2. Modify Fremont Weir operations to increase in-Bypass salmonid food production 3. Reduce or discontinue Femont Weir operations if there are no substantial benefits to other covered fish species

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						Outcome Threshold	Decisions		
	Increasing inundation of the Yolo Bypass will increase the production of Sacramento splittail	WOFL9. Abundance of spawning splittail	Metric #9: Number of fish/10,000 m <sup>3</sup>	WOFL13. Same year proportion of juvenile salmonids entering the Bypass that emigrate from the Bypass and proportion of juvenile salmonids that stay in the Sacramento River and arrive at Rio Vista	Metric #23: Percent survival	1. Juvenile salmonid survival is substantially greater than in the Sacramento River	1. Continue with Femont Weir operations 2. Modify Fremont Weir structure or place fish guidance structures in the Sacramento River such that a greater proportion of juvenile salmonids pass into the Bypass		
		WOFL10. Abundance of larval and early juvenile splittail emigrating from the Yolo Bypass	Metric #9: Number of fish/10,000 m <sup>3</sup>			2. Juvenile salmonid survival is about the same as in the Sacramento River	1. Continue with Femont Weir operations		
	Operation of the Fremont Weir will increase the proportion of juvenile salmonids that rear in the Yolo Bypass	WOFL11. Proportion of juvenile salmonids in the Sacramento River upstream of Fremont Weir that pass into the Yolo Bypass	Metric #21: Proportion of juvenile salmonids that pass into the Yolo Bypass relative to Sacramento River stage			3. Juvenile salmonid survival is substantially less than in the Sacramento River	1. Modify Fremont Weir operations to reduce number of salmonids entering the Bypass 2. Identify cause of low survival and implement actions as appropriate to increase survival (e.g., reduce stranding sites) 3. Reduce or discontinue Femont Weir operations if there are no substantial benefits to other covered fish species		
	Restored inundated floodplain habitat will increase the growth of juvenile salmonids that rear in the Bypass relative to those that rear in the Sacramento River	WOFL12. Same year juvenile salmonid growth rates in Yolo Bypass and Sacramento River	Metric #22: Fulton Condition Factor (length/weight <sup>3</sup> )			WOFL14: Passage of adult salmonids and sturgeon over the Fremont Weir	Metric #24: Proportion of adult salmonids and sturgeon in the Yolo Bypass that pass over the Fremont Weir	To come.	To come.
	Survival of juvenile salmonids that rear in the Bypass is greater than those that rear in the Sacramento River	WOFL13. Same year proportion of juvenile salmonids entering the Bypass that emigrate from the Bypass and proportion of juvenile salmonids that stay in the Sacramento River and arrive at Rio Vista	Metric #23: Percent survival						

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						Outcome Threshold	Decisions
Fish passage improvements	Improving passage of adult salmonids and sturgeon over the Lisbon Weir, up the Toe Drain and Tule Canal, and over the Fremont Weir will increase the number of adults that migrate to upstream spawning habitats	WOFL14: Passage of adult salmonids and sturgeon over the Fremont Weir	Metric #24: Proportion of adult salmonids and sturgeon in the Yolo Bypass that pass over the Fremont Weir				
	Improving the function of the Fremont Weir fish passage structure will decrease migration delays of adult salmonids and sturgeon	WOFL15: Time period required for adult salmonids and sturgeon to pass the Fremont Weir	Metric #25: Residence time of adult salmonids and sturgeon within 0.25 mile of the Fremont Weir				
Fish stranding improvements	Improving the drainage of water from the Yolo Bypass floodplain will reduce stranding loss of covered fish species	WOFL16: Fish stranding locations and incidences of fish stranding	Metric #26: Incidences of fish stranding				

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