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Monitoring and Adaptive Management Sections for Selected Conservation Measures

Water Operations Conservation Measures

WOCM2a: Modify the Fremont Weir and the Yolo Bypass to provide for a higher frequency and duration of inundation.

Performance Monitoring Metric #1: Flow rate passing Fremont Weir (cfs) and duration (days)

Justification: Flow rate and duration of flow over the Fremont Weir is the conservation measure action that creates inundated floodplain habitat within the Yolo Bypass.

Target: Mean flow over Fremont Weir of at least __ cfs for __ days over a 30-45 day period with no more than __ days without flows passing Fremont Weir.

Monitoring approach: A rating curve for water surface elevation and flow rates over the Fremont Weir would be developed and a remote sensor would be installed at the Fremont Weir that would continuously (e.g., hourly) monitor water surface elevations. Data from gage stations in upstream locations in the Sacramento River and its tributaries would be monitored to forecast flows expected at the Fremont Weir over the periods the weir is operated. Monitoring would be conducted over the term of the BDCP.

Adaptive management triggers and responses: If, after Fremont Weir operations have commenced, forecasts of Sacramento River flow to the Fremont Weir indicate that sufficient flow is not available to sustain inundation for a period of at least 30 days:

1. Continue operation of the Freemont Weir if conditions are such that benefits for splittail production and juvenile salmonid passage and growth exceed potential adverse effects on splittail and juvenile salmonids of reduced or discontinued flow into the bypass. Considerations for continuing Freemont Weir operations include contributions or forecasts of contributions of flow into the Yolo Bypass from the Westside tributaries.

2. Discontinue operation of the Fremont Weir if conditions are such that adverse effects on splittail and juvenile salmonids would likely exceed benefits of continuing to operate the Fremont Weir. Fremont Weir operations would be conducted to ramp down flows into the bypass such that the probability for fish stranding is minimized.

Performance Monitoring Metric #2: Inundation duration (days) and extent (acres)

Justification: The duration and extent of floodplain inundation are primary factors determining the success of splittail spawning, the extent of splittail spawning habitat, the extent of juvenile salmonid and splittail rearing habitat, and the extent food production and support to aquatic food web process (production and export of organic carbon, phytoplankton, zooplankton, and macroinvertebrates) (Sommer et al. 2001a,b, Harrell and Sommer 2003, Feyrer et al. 2006).

Target: Provide at least __ to __ acres of floodplain inundation for a period of at least 45 days.

Monitoring approach: A rating curve for determining the extent and duration of floodplain inundation based solely on flows entering the Yolo Bypass from the Sacramento River would be developed based flow rates and durations passing over the Fremont Weir and estimates of hydraulic residence time within the bypass.

Adaptive management trigger and response: Triggers and responses for this monitoring metric are the same as described for Performance Monitoring Metric #1.

Performance Monitoring Metric #3: Inundation frequency (years in which the Fremont Weir is operated)

Justification: The duration and extent of floodplain inundation are primary factors determining the success of splittail spawning, the extent of splittail spawning habitat, the extent of juvenile salmonid and splittail rearing habitat, and the extent food production and support to aquatic food web process (production and export of organic carbon, phytoplankton, zooplankton, and macroinvertebrates) (Sommer et al. 2001a,b, Harrell and Sommer 2003, Feyrer et al. 2006).

Target: The Yolo Bypass is inundated with flows passing over the Fremont Weir for a period of at least 45 days at least __ out of every __ years.

Monitoring approach: Assessment based on recorded frequency and duration of bypass inundation events.

Adaptive management trigger and response: The inability to achieve the target would constitute a changed circumstance and would be addressed as described in Section 3.6, *Adaptive Management*.

Performance Monitoring Metric #4: Residence of adult covered fish species within __ mile of the Fremont Weir of greater than __ hours

Justification: The number of adult covered fish species are present in the vicinity of the Fremont Weir and their duration are hypothesized to be indicators of the relative ability of adult fish to successfully pass the Fremont Weir into the Sacramento River with minimum of exposure to stranding and harvest risk.

Target: Residence of fewer adult covered fish species within __ mile of the Fremont Weir for greater than __ hours than observed from [year] to [year].

Monitoring approach: Initially, annual visual and/or remote surveys (e.g., hydroacoustics) would be conducted during periods the Fremont Weir is in operation to determine the numbers of adult covered fish species within the reach of the bypass extending ¼ mile downstream of the weir. This information would be evaluated to determine if adult fish are successfully able to pass the Fremont Weir without delays that could increase stranding and harvest risk. If survey data is not sufficient to evaluate the efficacy of fish passage, adult fish may be tagged (e.g., acoustic tag, radio tag, PIT tag, etc.) and monitored within the bypass to monitor the rate and success of upstream migration. Once the ability of adult fish to successfully pass the Fremont Weir is established, monitoring each year of Fremont Weir operation would be discontinued and a more limited monitoring effort to be determined by the Implementing Entity would be conducted every fifth year that the Fremont Weir is operated to confirm that passage success is being maintained.

Adaptive management triggers and responses: If passage of adult fish is impaired, the Implementing Entity would implement studies to identify the cause. If the cause is related to bathymetry/bypass topography, operation of the Fremont Weir, or design/operation of the new fish passage facility, the Implementing Entity would undertake appropriate actions to modify these factors to improve passage.

Performance Monitoring Metric #5: Incidences of covered fish species stranding

Justification: Incidences of fish stranding is an indicator of the likely extent of covered fish species mortality from desiccation, predation, and harvest.

Target: Fewer incidences of fish stranding than the mean number of incidences reported from [year] to [year].

Monitoring approach: Initially, annual visual and other surveys (e.g., beach seining) would be conducted immediately following periods the Fremont Weir is in operation and flows are receding from the bypass floodplain to document stranding locations and magnitude. Once documented, monitoring each year of Fremont Weir operation would be discontinued and a more limited monitoring effort to be determined by the Implementing Entity would be conducted every fifth year that the Fremont Weir is operated to document any changes in stranding location and magnitude that may result for changes in floodplain topography (e.g., formation of scour holes or sedimentation that create isolated pools).

Adaptive management triggers and responses: If the incidence of fish stranding exceeds the target, the Implementing Entity will undertake actions as appropriate to address site-specific causes of stranding at locations with the potential to strand the greatest numbers of fish. Likely anticipated actions could include altering floodplain topography to improve drainage or adjusting Fremont Weir operations to improve ramping flows.

Effectiveness Monitoring Metrics #1-3: Total organic carbon (mg/L), phytoplankton (mg/L chlorophyll a), and zooplankton (number/1,000 m^3)

Justification: Total organic carbon, phytoplankton, and invertebrate production within and export from the Yolo Bypass into Delta waterways are likely primary constituents of food production for covered fish species (Sommer et al 2001a, Schemel et al. 2004). Measurements of these constituents, therefore, are indicators of the contribution of this conservation measure towards improving food production potential within the Delta.

Target: Increase total organic carbon concentrations in Yolo Bypass outflows relative to concentrations in flows passing over the Fremont Weir by at least __ percent, chlorophyll a by at least __ percent, and invertebrate density by at least __ percent during periods the Fremont Weir is operated.

Monitoring approach: Take daily grab samples and measurements for total organic carbon, chlorophyll a, and zooplankton at the Fremont Weir during periods the weir is operated and at the outflow to Cache Slough over the term of bypass inundation. Assess measurements of total organic carbon, chlorophyll a, and zooplankton and performance monitoring results to establish relationships between season, extent, and duration of floodplain inundation and production and export of total organic carbon, chlorophyll a, and zooplankton. Once these relationships have been established, monitoring each year of Fremont Weir operation would be discontinued and a more limited monitoring effort to be determined by the Implementing Entity would be conducted every fifth year that the Fremont Weir is operated to document any changes in production of these constituents over the term of the BDCP.

Adaptive management triggers and responses: If production and export of total organic carbon, chlorophyll a, and zooplankton do not achieve the targets, the Implementing Entity will undertake investigations to determine causes for insufficient production and export of these constituents or determine if the targets were established incorrectly given the uncertainties surrounding the internal and external factors that govern the capacity of the bypass to produce these constituents. Potential actions, if appropriate, that could be undertaken to improve production and export of these constituents could include modifying

Fremont Weir operations to increase hydraulic residence time within the bypass and operating the weir during warmer periods.

Effectiveness Monitoring Metric #4: Production of Sacramento splittail (number of larval and early juvenile splittail/10,000 m^3)

Justification: Measurements of Sacramento splittail production in the Yolo Bypass during periods the Fremont Weir is operated will provide the Implementing Entity with information necessary to determine the effectiveness of a range of weir operations in supporting splittail production.

Target: Increase the density of larval and early juvenile splittail densities in Yolo Bypass outflows relative to densities in inflows by at least __ percent during periods the modified Fremont Weir is operated.

Monitoring approach: Take daily grab sample (500 um mesh net) measurements of fish eggs and larvae (icthyoplankton) in the inflow to the weir and outflow to Cache Slough. Samples would be processed to identify and enumerate the density of each larval and juvenile Sacramento splittail and other fish species. Assess measurements of larval and juvenile splittail densities and results of performance monitoring to establish relationships between season, extent, and duration of floodplain inundation and splittail production. Once these relationships have been established, monitoring each year of Fremont Weir operation would be discontinued and a more limited monitoring effort to be determined by the Implementing Entity would be conducted every fifth year that the Fremont Weir is operated to document any changes in production over the term of the BDCP.

Adaptive management triggers and responses: If the production of splittail does not achieve the target, the Implementing Entity will undertake investigations to determine causes for insufficient production or determine if the target was established incorrectly given the uncertainties surrounding the internal and external factors that govern the production of splittail. Potential actions, if appropriate, that could be undertaken to improve splittail production could include modifying Fremont Weir operations to improve conditions that support spawning and rearing habitat or improving other habitat elements such as vegetative structure.

Effectiveness Monitoring Metric #5: Percent survival of juvenile Chinook salmon and steelhead.

Justification: Survival rates for juvenile Chinook salmon and steelhead using the Yolo Bypass during periods the Fremont Weir is operated will provide the Implementing Entity with information necessary to determine the relative effectiveness of a range of weir operations in increasing juvenile salmonid survival rates. It has previously been demonstrated that survival of juvenile

Chinook salmon was somewhat greater in the Yolo Bypass compared to the mainstem Sacramento River, although not statistical significant (Sommer et al. 2001b).

Target: Increase the survival of juvenile Chinook salmon and steelhead migrating through the Yolo Bypass by __ percent relative to the survival of juvenile salmonids that migrate down mainstem of the Sacramento River between the Freemont Weir and Rio Vista.

Monitoring approach: Conduct comparative mark-recapture experiments under a range of Fremont Weir operations (e.g., using CWT, acoustic, radio, PIT tags) using juvenile Chinook salmon and steelhead released into the bypass and in the mainstem Sacramento River downstream of the weir. Monitoring the number of marked fish released from each of the upstream locations as they pass near Rio Vista will provide the data necessary to assess the difference in survival rates between the migration routes. Once a relationship between weir operations and juvenile salmonid survival rates have been established, monitoring each year of Fremont Weir operation would be discontinued and a more limited monitoring effort to be determined by the Implementing Entity would be conducted every fifth year that the Fremont Weir is operated to document any changes in survival over the term of the BDCP.

Adaptive management triggers and responses: If the survival of Chinook salmon and steelhead passing through the Yolo Bypass does not achieve the target, the Implementing Entity will undertake investigations to determine causes for insufficient survival rates or determine if the target was established incorrectly given the uncertainties surrounding the internal and external factors that govern the survival of juvenile salmonids. Potential actions, if appropriate, that could be undertaken to improve juvenile salmonid survival could include modifying Fremont Weir operations to improve rearing habitat conditions or reduce occurrences of stranding.

Effectiveness Monitoring Metric #6: Growth of juvenile Chinook salmon and steelhead (mm/day).

Justification: Determining growth rates of juvenile Chinook salmon and steelhead using the Yolo Bypass during periods the Fremont Weir is operated will provide the Implementing Entity with information necessary to determine the relative effectiveness of a range of weir operations for increasing juvenile salmonid growth rates. It has previously been demonstrated that growth of juvenile Chinook salmon was greater in the Yolo Bypass compared to the mainstem Sacramento River (Sommer et al. 2001b).

Target: Increase the growth rate of juvenile Chinook salmon and steelhead migrating through the Yolo Bypass by __ percent relative to the growth rates of juvenile salmonids that migrate down mainstem of the Sacramento River between the Freemont Weir and Rio Vista.

Monitoring approach: Conduct comparative mark-recapture experiments under a range of Fremont Weir operations (e.g., using CWT, acoustic, radio, PIT tags) using juvenile Chinook salmon and steelhead released into the bypass and in the mainstem Sacramento River downstream of the weir. Capturing and measuring the length of marked fish released from each of the upstream locations as they pass near Rio Vista will provide the data necessary to assess the difference in growth rates between the migration routes. Once a relationship between weir operations and juvenile salmonid growth rates have been established, monitoring each year of Fremont Weir operation would be discontinued and a more limited monitoring effort to be determined by the Implementing Entity would be conducted every fifth year that the Fremont Weir is operated to document any changes in growth rates over the term of the BDCP.

Adaptive management triggers and responses: If the growth of Chinook salmon and steelhead passing through the Yolo Bypass does not achieve the target, the Implementing Entity will undertake investigations to determine causes for insufficient growth rates or determine if the target was established incorrectly given the uncertainties surrounding the internal and external factors that govern the growth of juvenile salmonids. Potential actions, if appropriate, that could be undertaken to improve juvenile salmonid growth rates could include modifying Fremont Weir operations to increase the time that juvenile salmonids remain in the bypass.

Physical Habitat Restoration Conservation Measures

HRCM4: Restore a mosaic of __ to __ acres of freshwater tidal marsh, shallow subtidal aquatic, and transitional grassland habitat within the Yolo Bypass/Cache Slough Complex Restoration Opportunity Area.

Performance Monitoring Metrics #1-2: Vegetative structure (percent absolute cover) and composition (percent relative cover of native emergent vegetation)

Justification: Vegetative cover and composition are primary components of tidal marsh that support food production and habitat for covered species.

Target: Absolute vegetation cover within the restored tidal marsh of at least __ percent and __ percent comprised of at least __ percent and __ percent native emergent vegetation within 5 and 10 years following restoration, respectively.

Monitoring approach: Percent absolute vegetative cover will be determined in years 1, 2, 5, 8, and 10 following restoration through use of aerial photography or other appropriate method that would yield comparable results. Percent relative cover of native emergent vegetation will be determined in years 1, 2, 5, 8, and 10 following restoration using a statistically valid survey sampling design and methods to be determined by the Implementing Entity.

Adaptive management triggers and responses: If monitoring surveys indicate that vegetative cover and composition is not trending towards achieving targets, the Implementing Entity will conduct investigations to determine the likely cause(s). Based on investigation results, the Implementing Entity will implement appropriate actions to improve vegetative cover and composition. Potential actions could include controlling non-native emergent vegetation, planting native emergent vegetation, and modifying designs of future tidal marsh restoration projects to improve their likelihood for achieving targets.

Performance Monitoring Metric #3: Non-native predatory fish abundance (ratio of non-native predatory fish to native fish).

Justification: Restoration of tidal marsh would include creation of shallow subtidal habitats adjacent to restored marsh plains. This monitoring is necessary to determine if these subtidal areas develop as habitat for non-native predatory fish such that their abundance precludes effective use of the restored tidal marsh and adjacent habitats by covered fish species.

Target: The abundance of juvenile and adult non-native predatory fish in restored marsh channels and shallow subtidal habitats adjacent to restored marsh should not exceed a ratio of __:__ to with native fish species.

Monitoring approach: Conduct monthly fish sampling surveys within Delta channels adjacent to tidal marsh restoration sites for a least one year before restoration is implemented using survey methods consistent with the current Suisun Marsh fishery survey program and additional survey methods as needed (e.g., beach seine, otter trawl, tow net, ichthyoplankton net) to establish baseline conditions. Following restoration, initiate comparable surveys within marsh channels and in adjacent Delta waterways and continue surveys until a relationship is established between the abundance of non-native predatory fish and covered fish species and the extent and function of restored tidal marsh is established. Subsequently, surveys would be conducted at least every five years to document any changes that may occur in use of restored marshes and adjacent Delta waterways over the term of the BDCP.

Adaptive management triggers and responses: If the abundance of non-native predatory fish exceeds target levels, the Implementing Entity will undertake investigations to determine causes for their abundance or determine if the targets were established incorrectly given the uncertainties surrounding the internal and external factors that govern the distribution and use of habitats by non-native predatory fish. Potential actions to reduce the abundance of non-native predatory fish could include actions to remove them from restored habitats or, if supported by investigations, adjusting designs of restored tidal marshes to create habitat conditions that disfavor their use by non-native predatory fish (e.g., removal of non-native submerged aquatic vegetation).

Performance Monitoring Metric #4: Non-native submerged and floating aquatic vegetation.

Justification: Restoration of tidal marsh would include creation of shallow subtidal habitats adjacent to restored marsh plains. This monitoring is necessary to determine if non-native submerged and floating aquatic vegetation establish in densities such that they substantially increase the risk for predation of covered fish species and/or substantially decrease turbidity as a result of filtering particles from the water column.

Target: Non-native submerged and floating aquatic vegetation should occupy less than __ percent of the surface area of shallow subtidal habitats adjacent to restored marshes.

Monitoring approach: For the first __ years following completion of tidal marsh restoration projects, annually conduct aerial and/or field surveys (e.g., sonar for egeria) in October to map the extent of non-native submerged and floating aquatic vegetation in shallow subtidal habitats adjacent to restored tidal marsh habitats. Subsequently, if supported by survey results and effects of any treatments implemented to reduce the extent of non-native submerged and floating aquatic vegetation, future surveys would be conducted at least every five years to document any changes in the extent of non-native submerged and floating aquatic vegetation adjacent to restored tidal marshes over the term of the BDCP.

Adaptive management triggers and responses: If initial annual surveys indicate that the extent of non-native submerged and floating aquatic vegetation is trending towards exceeding target levels, the Implementing Entity will implement actions to control non-native submerged and floating aquatic vegetation. The Implementing Entity would also undertake investigations to determine causes for their abundance. If supported by results of these investigations, designs of subsequent restored tidal marshes would be adjusted as appropriate to create conditions that would further discourage the establishment of non-native submerged and floating aquatic vegetation.

Effectiveness Monitoring Metrics #1-3: Total organic carbon (mg/L), phytoplankton (mg/L chlorophyll a), and zooplankton (number/1,000 m^3)

Justification: Total organic carbon, phytoplankton, and zooplankton production within and export from restored tidal marshes into Delta waterways are primary constituents of food production for covered fish species (Sommer et al 2001a, Schemel et al. 2004). Measurements of these constituents, therefore, are indicators of the contribution of this conservation measure towards improving food production potential within the Delta.

Target: Increase mean annual total organic carbon concentrations entering Delta waterways adjacent to restored tidal marsh relative to concentrations in the channels before marsh is restored by at least __ percent and chlorophyll a concentrations and zooplankton densities within Delta waterways adjacent to restored tidal marsh by at least __ and __ percent, respectively within __ years of restoration

Monitoring approach: Take weekly grab samples and measurements for total organic carbon, chlorophyll a, and zooplankton in Delta waterways adjacent to tidal marsh restoration sites for a least one year before marsh is restored to establish baseline conditions in adjacent waterways. Following restoration, annually take weekly grab samples and measurements for total organic carbon within restored marshes and for chlorophyll a and zooplankton in Delta waterways adjacent to restored marshes. Assess measurements of total organic carbon, chlorophyll a, and zooplankton and performance monitoring results to establish relationships between restored tidal marsh extent and structure as restored marsh develops and production and export of total organic carbon, chlorophyll a, and zooplankton. Once these relationships have been established, annual monitoring of would be discontinued and a more limited monitoring effort to be determined by the Implementing Entity would be conducted every fifth year that the Fremont Weir is operated to document any changes in production of these constituents over the term of the BDCP.

Adaptive management triggers and responses: If production and export of total organic carbon, chlorophyll a, and zooplankton do not achieve the targets, the Implementing Entity will undertake investigations to determine causes for insufficient production and export of these constituents or determine if the targets were established incorrectly given the uncertainties surrounding the internal and external factors that govern the capacity of restored tidal marshes to produce these constituents. Potential actions, if appropriate, that could be undertaken could include modifying tidal marsh restoration designs to improve vegetative structure and composition and tidal exchange to improve production and export of these constituents.

Effectiveness Monitoring Metric #4: Abundance of covered fish species (number of covered fish species/10,000 m^3)

Justification: Change in abundance of covered fish using restored tidal marsh channels and adjacent Delta waterways will provide the Implementing Entity with information necessary to determine the effectiveness of restoring tidal marsh as a tool to improve habitat conditions (e.g., local food availability, hydrodynamics, water temperature) for covered fish species.

Target: Increase the abundance of each covered fish species inhabiting restored tidal marsh channels and adjacent Delta waterways by __% relative to their abundance in Delta waterways adjacent to restoration sites before restoration is implemented.

Monitoring approach: Conduct monthly fish sampling surveys within Delta channels adjacent to tidal marsh restoration sites for a least one year before restoration is implemented using survey methods consistent with the current Suisun Marsh fishery survey program and additional survey methods as needed (e.g., beach seine, otter trawl, tow net, ichthyoplankton net) to establish baseline conditions. Following restoration, initiate comparable surveys within marsh channels and in adjacent Delta waterways and continue surveys until a relationship is established between the abundance of each covered fish species and the extent and function of restored tidal marsh is established. Subsequently, surveys would be conducted at least every five years to document any changes that may occur in use of restored marshes and adjacent Delta waterways over the term of the BDCP. Monitoring results would be used to assess the effectiveness of restoring tidal marsh in achieving covered fish species biological goals and objectives relative to other conservation measures.

Adaptive management triggers and responses: If the abundance of covered fish species is not increased to target levels, the Implementing Entity will undertake investigations to determine causes for low abundance or determine if the targets were established incorrectly given the uncertainties surrounding the internal and external factors that govern the distribution and use of habitats by covered fish species. If low use of restored tidal marsh is attributable to insufficient food production or elevated predatory fish abundance, potential implementation of actions to improve these conditions would be same as described for Effectiveness Monitoring Metrics #1-3 and Performance Monitoring Metrics #3-4, respectively.

HRCM5: Restore a mosaic of __ to __ acres of freshwater tidal marsh, shallow subtidal aquatic, and transitional habitat within the Cosumnes/Mokelumne ROA.

Performance monitoring and effectiveness monitoring metrics, justifications, targets, monitoring approach, and adaptive management triggers and responses are the same as described for conservation measure HRCM4.

HRCM6: Restore a mosaic of __ to __ acres of freshwater tidal marsh and shallow subtidal aquatic habitat within the West Delta Restoration Opportunity Area.

Performance monitoring and effectiveness monitoring metrics, justifications, targets, monitoring approach, and adaptive management triggers and responses are the same as described for conservation measure HRCM4.

HRCM9: Restore a mosaic of __ to __ acres of freshwater tidal marsh, shallow subtidal aquatic and transitional grassland habitat within the South Delta Restoration Opportunity Area.

Performance monitoring and effectiveness monitoring metrics, justifications, targets, monitoring approach, and adaptive management triggers and responses are the same as described for conservation measure HRCM4.

HRCM10: Restore a mosaic of __ to __ acres of freshwater tidal marsh, shallow subtidal aquatic, and transitional grassland habitat within the East Delta Restoration Opportunity Area.

Performance monitoring and effectiveness monitoring metrics, justifications, targets, monitoring approach, and adaptive management triggers and responses are the same as described for conservation measure HRCM4.

HRCM11: Restore a mosaic of __ to __ acres of brackish tidal marsh, shallow subtidal aquatic, and transitional grassland habitat within the Suisun Marsh Restoration Opportunity Area.

Performance Monitoring Metrics #1-2: Vegetative structure (percent absolute cover) and composition (percent relative cover of native emergent vegetation)

The justification, monitoring approach, and adaptive management triggers and responses for these metrics are the same as described for conservation measure HRCM4.

Target: Absolute vegetation cover within the restored brackish tidal marsh of at least __ percent and __ percent comprised of at least __ percent and __ percent native emergent vegetation within 5 and 10 years following restoration, respectively.

Performance Monitoring Metric #3: Non-native predatory fish abundance (ratio of non-native predatory fish to native fish).

The justification, monitoring approach, and adaptive management triggers and responses for these metrics are the same as described for conservation measure HRCM4 , except that monitoring would take place within shallow subtidal habitats of Suisun Bay and Suisun Marsh sloughs adjacent to restored habitats.

Target: The abundance of juvenile and adult non-native predatory fish in restored marsh channels and shallow subtidal habitats adjacent to restored marsh should not exceed a ratio of __:__ to with native fish species.

Effectiveness Monitoring Metrics #1-3: Total organic carbon (mg/L), phytoplankton (mg/L Cholrophyll A), and zooplankton (number/1,000m^3)

The justification, monitoring approach, and adaptive management triggers and responses for these metrics are the same as described for conservation measure HRCM4 , except that monitoring would take place within shallow subtidal habitats of Suisun Bay and Suisun Marsh sloughs adjacent to restored habitats.

Target: Increase mean annual total organic carbon concentrations entering Suisun Marsh channels and Suisun Bay adjacent to restored brackish tidal marsh relative to concentrations in the channels and Bay before marsh is restored by at least __ percent and Chlorphyll A concentrations and zooplankton densities within Suisun Marsh channels and Suisun Bay adjacent to restored tidal marsh by at least __ and __ percent, respectively within __ years of restoration.

Effectiveness Monitoring Metric #4: Abundance of covered fish species (number of covered fish species/10,000^3)

The justification, monitoring approach, and adaptive management triggers and responses for this metric is the same as described for conservation measure HRCM4 , except that monitoring would take place within shallow subtidal habitats of Suisun Bay and Suisun Marsh sloughs adjacent to restored habitats.

Target: Increase the abundance of each covered fish species inhabiting restored brackish tidal marsh channels and adjacent Suisun Marsh/Bay waterways by __% relative to their abundance in Suisun Marsh/Bay waterways adjacent to restoration sites before restoration is implemented.

Other Stressors Conservation Measures

Conservation Measure OSCM1: Reduce the Load of Ammonia in Effluent Discharged from the Sacramento Regional County Sanitation District into the Sacramento River if Warranted Based on Research.

[Note: the research component of this conservation measure will be described in Section 3.5, Monitoring Plan.]

Performance Monitoring Metric #1: Ammonia concentrations of water at influent and effluent of a new treatment facility if such a facility is built.

Justification: This metric would be employed only if a new ammonia-reduction treatment facility is built. The metric would determine the effectiveness of such a new facility by measuring the change in ammonia/ammonium concentration before and after treatment.

Target: The 4-week moving average reduction in ammonia/ammonium concentration would exceed __% year-round. The 4-week period would account for small-scale temporal variation in concentrations but would not be too long to fail to detect changes in the efficiency of the technique. Further, this period would include an entire tidal cycle, which influences flow rates and, therefore, dilution in the Delta, such that short-duration exceedances would be allowed.

Adaptive management triggers and responses: If the treatment fails to reduce ammonia/ammonium concentrations to below __% on a 4-week moving average, the action would be re-evaluated and modified to meet this goal.

Monitoring approach: Year-round daily monitoring would be conducted at the input and output of the treatment facility. Standard water chemistry techniques would be employed to determine the concentration of ammonia/ammonium in water samples.

If sufficient evidence indicates that the treatment is effective in reducing ammonia concentrations by finding that the 5 year average, corrected for total sewage volume, is lower than the previous 5 years, monitoring can cease. This length of time accounts for interannual variation and represents a long enough period to determine effectiveness.

Conservation Measure OSCM7: Maintain Dissolved Oxygen Levels for Covered Fish Species in the Stockton Deep Water Ship Channel during Periods when Covered Fish Species are Present.

Performance Monitoring Metric #1: Dissolved oxygen levels at multiple locations throughout the Stockton Deep Water Ship Channel.

Justification: The Central Valley Regional Water Quality Control Board (CVRWQCB) has identified the SDWSC as impaired and has established an objective to maintain dissolved oxygen concentrations of at least 6.0 mg/l between September and November and 5.0 mg/L between December and August (CVRWQCB 2005). It is hypothesized that these concentrations are necessary to allow the migration and survival of fish in and near the ship channel, particularly fall-run Chinook salmon (Hallock et al. 1970) and steelhead (Jassby and Van Nieuwenhuyse 2005).

Target: Maintain dissolved oxygen concentrations of at least 6.0 mg/l between September and November and 5.0 mg/L between December and August (CVRWQCB 2005).

Adaptive management triggers and responses: If the performance target is not met, the BDCP Implementing Entity would work with the Port of Stockton, USACE, and CVRWQCB to develop more effective techniques to improve oxygen concentrations.

Monitoring approach: Monitoring is ongoing by the Port of Stockton, USACE, and CVRWQCB using data collected at DWR's Rough and Ready Island monitoring station. The Rough and Ready Island station measures dissolved oxygen concentrations every 15 minutes year round. Monitoring stations would be added such that dissolved oxygen concentrations are measured every mile throughout the SDWSC at 15 minutes intervals. The new monitoring stations would be modeled after DWR's Rough and Ready Island station for consistency in approach.

If dissolved oxygen concentrations do not exceed CVRWQCB objectives for more than 2 consecutive days in 2 critical dry years (for the San Joaquin Valley), expanded monitoring at multiple locations can cease. The period of 2 consecutive days is suggested because dissolved oxygen sags over this period are expected to have minimal impact on salmonid migration and spawning due to the amount of lingering by fish that occurs in the Delta (Williams 2006). Two critical dry years are suggested to be used because dissolved oxygen sags are most common in the lowest flow years. Monitoring would continue at Rough and Ready Island, where data are collected for multiple purposes outside the BDCP.

Effectiveness Monitoring Metric #2: Adult salmonid passage

Justification: It is hypothesized that migration and survival of fish, particularly adult fall-run Chinook salmon and steelhead, in and near the SDWSC are impaired by low dissolved oxygen concentrations in the late summer and early fall (Hallock et al. 1970, Alabaster 1989, Jassby and Van Nieuwenhuyse 2005).

Target: Average upstream migration rates of adult Chinook salmon and steelhead (measured in distance of river per unit time) would not be impaired in and near the SDWSC relative to other sections of the San Joaquin River.

Adaptive management triggers and responses: If upstream migration rates are reduced by an average of __% relative to other nearby reaches of the river, the dissolved oxygen enhancement technique would be re-evaluated and improved or replaced

Monitoring approach: Tag up to 25 adult fall-run Chinook salmon and 25 adult steelhead per month between September 1 and November 30 with external acoustic tags or other easily applied tags. Acoustic receivers would be set up in and near the SDWSC and in other reaches of the San Joaquin River to measure migration rates of fish. Dissolved oxygen levels and other physical parameters (e.g., temperature, flow rates, etc.) would be measured at monitoring stations identified in Metric #1 and elsewhere along the San Joaquin River to determine the relationship between migration rates and physical factors (a similar technique was employed in the 1960s by Hallock et al. 1970).

If sufficient evidence indicates that neither Chinook salmon nor steelhead upstream migration are impaired while using the dissolved oxygen enhancement technique, monitoring can cease.

Effectiveness Monitoring Metric #3: Dissolved oxygen levels after intertidal marsh habitat restoration in the San Joaquin River nearby and upstream of the Stockton Deep Water Ship Channel

Justification: Preliminary modeling efforts predict that intertidal marsh habitat restoration in the San Joaquin River nearby and upstream of the SDWSC (e.g., Middle Roberts Island) could increase the range of tidal flows at Rough and Ready Island by approximately 50% (A. Munevar, pers. comm.). Average daily flows in late summer and early fall (8/1/07-10/31/07) at Rough and Ready Island are positively correlated with dissolved oxygen concentrations (CDEC unpubl. data). This increase in flows associated with tidal marsh restoration would be expected to provide the exchange of water and material with high BOD that is needed to maintain sufficient dissolved oxygen levels in the SDWSC.

Target: According to the CVRWQCB's objectives, maintain dissolved oxygen concentrations of at least 6.0 mg/L between September and November and 5.0 mg/L between December and August (CVRWQCB 2005) independent of any other artificial oxygen inputs (e.g., diffusers).

Adaptive management triggers and responses: If dissolved oxygen levels drop below CVRWQCB's objectives for at least 7 consecutive days at any time within a year, the use of additional dissolved oxygen enhancement techniques (e.g., diffusers) would be considered. The period of 7 consecutive days is sufficient to delay the upstream migration of salmonids, which could impact their spawning success, particularly fall-run Chinook which spawn shortly after reaching spawning grounds (Williams 2006).

Monitoring approach: After intertidal marsh has been restored, dissolved oxygen concentrations would be measured throughout the SDWSC using monitoring stations identified in Metric #1.

If dissolved oxygen concentrations do not exceed CVRWQCB objectives for more than 2 consecutive days in 2 critical dry years (for the San Joaquin Valley), expanded monitoring at multiple locations can cease. The period of 2 consecutive days is suggested because dissolved oxygen sags over this period are expected to have minimal impact on salmonid migration and spawning due to the amount of lingering by fish that occurs in the Delta (Williams 2006). Two critical dry years are suggested to be used because dissolved oxygen sags are most common in the lowest flow years. Monitoring would continue at Rough and Ready Island, where data are collected for multiple purposes outside the BDCP.

Conservation Measure OSCM13: Remove Non-Native Submerged and Floating Aquatic Vegetation from Delta Waterways

Performance Monitoring Metric #1: Change in Biovolume of *Egeria densa* relative to Control Areas

Justification: The most direct way to determine whether treatment of Egeria is effective is to compare the change in biovolume of Egeria before and after treatment/removal to a nearby control location. Egeria biovolume is constantly changing with growth and senescence. Egeria growth is highly variable and dependent on many factors, including nutrient status, light intensity, day length, temperature, turbidity, salinity, and flow rate (Department of Boating and Waterways 2006). As a result, it is necessary to compare changes in Egeria biovolume in treatment locations to nearby control sites with similar levels of these variables. Because biovolume in control plots is expected to change during the period, it is necessary to compare changes and not absolute values of biovolume after treatment. ReMetrix, LLC is funded by the Department of Boating and Waterways to perform hydroacoustic analyses on Egeria to determine biovolume in the Delta previously, which has been deemed “the best evidence to date of site efficacy” by the Department of Boating and Waterways (2006).

Target: There are two performance targets to be met:

1. Reduce the biovolume of Egeria by __% on average after 90 days of treatment in treated areas relative to control areas. A reduction of __% is suggested based on current known efficacy of existing treatments (Department of Boating and Waterways 2008). The 90 day period is currently used by the Department of Boating and Waterways to measure efficacy.

2. No year-over-year increase in pre-treatment biovolume in a treatment site relative to nearby control site.

Adaptive management triggers and responses: There are two adaptive management targets that, if not met, would trigger a re-evaluation and different, more effective removal techniques would be developed:

1. If the biovolume of Egeria in cleared areas is not reduced relative to control areas on average after 90 days post-treatment.

2. If there are increases in year-over-year pre-treatment and post-treatment biovolume in a treatment site relative to a nearby control site in more than 50% of years over a 10 year period. A period of 10 years is meant to provide sufficient time to account for high interannual variation to determine whether the treatment technique is inadequate.

Monitoring approach: Field surveys would be conducted using hydroacoustic analysis, as has been previously conducted, in treatment locations to estimate the biovolume of plants.

If sufficient evidence indicates that treatment/removal is effective by meeting both performance targets above for 5 consecutive years, monitoring can cease. This period accounts for interannual variation and meeting this requirement would be difficult to achieve if the technique were not effective.

Performance Monitoring Metric #2: Change in Areal Coverage of Water Hyacinth relative to Control Areas

Justification: The most direct way to determine whether treatment and/or removal of water hyacinth are effective is to compare the change in areal cover of water hyacinth before and after treatment/removal to a nearby control location. Areal cover of water hyacinth is constantly changing with growth, senescence, and, because it floats, flow patterns. Susan Ustin's lab at UC Davis is currently funded by the Department of Boating and Waterways to employ hyperspectral imagery for estimating areal coverage of water hyacinth (Ustin et al 2008).

Target: There are two targets identified:

1. Reduce the areal cover of water hyacinth by __% on average after 90 days of treatment in treatment/removal areas relative to control areas. The 90 day period is currently used by the Department of Boating and Waterways to measure efficacy of Egeria removal and, given that the Department of Boating and Waterways primarily uses chemicals for treatment of both chemicals, this period is expected to be sufficient.
2. No year-over-year increase in pre-treatment areal cover in a treatment site relative to nearby control site.

Adaptive management triggers and responses: If the areal cover of water hyacinth in treatment/removal areas is not reduced relative to control areas on average after 90 days post-treatment, the action would be re-evaluated and different, more effective removal techniques would be developed. Further, if there are increases in year-over-year pre-treatment areal cover in a treatment/removal site relative to a nearby control site for 5 consecutive years, the action would be re-evaluated and different, more effective removal techniques would be developed.

Monitoring approach: Field surveys would be conducted using remote sensing areal cover estimates, such as that used by Susan Ustin's lab at UC Davis, in treatment locations to estimate the biovolume of plants.

If sufficient evidence indicates that treatment/removal is effective by meeting the two performance targets above for 5 consecutive years, monitoring can cease.

This period accounts for interannual variation and meeting this requirement would be difficult to achieve if the technique were not effective.

Effectiveness Monitoring Metric #3: Turbidity

Justification: Evidence suggests that *Egeria densa* reduces turbidity levels by reducing water motion, thereby allowing material to settle out (Grimaldo and Hymanson 1999). Turbidity levels in the Delta have declined over the past 30 years (Wright and Shoellhamer 2004), which may influence the foraging ability and/or predator avoidance of delta and longfin smelt. Delta and longfin smelt are thought to be attracted to high turbidity levels (Feyrer et al. 2007, U.S. Bureau of Reclamation 2008).

Target: Increase localized turbidity levels by __% from 1 week prior to treatment/removal to 90 days after treatment within the removal area relative to a nearby control location. The period of 90 days will allow sufficient time for the herbicide to take effect.

Adaptive management triggers and responses: If turbidity does not increase by __% relative to control locations despite a reduction in areal coverage of non-native aquatic vegetation of __%, the action would be re-evaluated and cessation of the conservation measure would be considered if there were no other benefits to removal.

Monitoring approach: The monitoring will coincide with removal of Egeria to allow an experimental monitoring approach. Turbidity levels would be measured using a turbidity meter 1 week prior to and 90 days after removal of Egeria in areas within and nearby treatment/removal locations (BACI approach).

If sufficient evidence indicates that Egeria removal effectively increases localized turbidity levels in removal locations by meeting the performance targets for 5 consecutive years, monitoring the effects of removal on turbidity levels can cease. This period accounts for interannual variation and meeting this requirement would be difficult to achieve if the technique were not effective.

Effectiveness Monitoring Metric #4: Local abundance of juvenile salmonids and Sacramento splittail

Justification: The presence of non-native aquatic vegetation is hypothesized to exclude the presence of rearing juvenile salmonids and splittail from shallow tidal marsh and channels (Brown 2003). If true, the treatment/removal of non-native vegetation in these areas would be expected increase the local abundance of these species.

Target: Increase localized abundance of covered fish species by __% from 1 week prior before to 90 days after treatment/removal relative to a nearby control location.

Adaptive management triggers and responses: If localized abundance of both juveniles splittail and Chinook salmon species does not increase after removal of Egeria in at least half of the sites relative to control locations, the action would be re-evaluated and cessation of the conservation measure would be considered.

Monitoring approach: Monitoring will coincide with removal of Egeria to allow an experimental monitoring approach. Abundance would be measured using electrofishing, pop nets, or other unbiased sampling technique for collecting fish in vegetation (in combination with Metric #5) 1 week prior to and 90 days after treatment/removal of non-native aquatic vegetation in areas both within and nearby treatment/removal locations (BACI approach).

If sufficient evidence indicates that local abundances of juvenile salmonids and splittail increase after Egeria removal by at least as much as the performance criteria for 5 consecutive years, monitoring can cease.

Effectiveness Monitoring Metric #5: Local abundance of non-native predatory fish

Justification: The presence of Egeria is hypothesized to provide habitat for non-native predatory fish, particularly largemouth bass (Brown and Michniuk 2007) that may have adverse effects on covered fish species. Thus, the removal of non-native aquatic vegetation should reduce there local abundance of these fish.

Target: Reduced localized abundance of large mouth bass (and other non-native predators, as necessary) by __% from 1 week prior before to 90 days after removal relative to a nearby control location. The value of __% is used because it is considered sufficient to allow survival of covered fish species to increase by __% according to predation studies of large mouth bass

Adaptive management triggers and responses: If localized abundance of large mouth bass does not decrease by __% relative to control locations despite a reduction in areal coverage of non-native aquatic vegetation of __%, the action would be re-evaluated and cessation of the conservation measure would be considered.

Monitoring approach: The monitoring will coincide with removal of Egeria to allow an experimental monitoring approach. Abundance would be measured using electrofishing, pop nets, or other unbiased sampling technique for collecting fish in vegetation (in combination with Metric #4) 1 week prior to and 90 days after removal of Egeria in areas both within and nearby removal locations (BACI approach).

If sufficient evidence indicates that local abundances of large mouth bass abundance decreases to __ by removing Egeria, monitoring can cease.

Conservation Measure OSCM16: Reduce Illegal Harvest of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and White Sturgeon in the Delta.

Effectiveness Monitoring Metric #1: Average number of citations issued per contact

Justification: The DBEEP program would add up to 17 wardens in 4 warden increments every 3 years (with the exception of the first year, during which 5 wardens would be added), as needed. The effectiveness of the program can be assessed by monitoring the average number of citations issued per contact with the public and comparing among each 4 warden addition. It is predicted that the average number of citations per contact could remain constant as more wardens are added or could at some level of staffing begin to decline, indicating that the increased number of wardens had reduced the amount of illegal fishing in the Delta.

Target: While maintaining a similar or higher number of contacts per warden, the average number of citations per warden contact in a given year will decline once the number of wardens patrolling the Delta is sufficient to reduce the rate of illegal harvest of Chinook salmon, Central Valley steelhead, green sturgeon, and white sturgeon in the Delta.

Adaptive management triggers and responses: The BDCP Implementing Entity would consider the number of wardens staffed in DBEEP as a sufficient number to reduce illegal harvest at such time as a 3-year average decline in citation rate per contact begins for all target species (Chinook salmon, Central Valley steelhead, green sturgeon, and white sturgeon) given that the number of contacts per warden is the same or higher than previous years.. At this time, the BDCP Implementing Entity would determine whether the number of wardens is optimal. At some point in the future, if the number of citations per contact begins to increase, the BDCP Implementing Entity could reconsider funding more wardens up to 17. If the number of citations becomes too low, the BDCP Implementing Entity could consider terminating funding for the number of positions that they see fit to regain efficient use of funds based on monitoring.

Monitoring approach: The DBEEP program would add up to 17 wardens in 4 warden increments every 3 years as needed. The total number of contacts with the public and the total number of citations issued per year would be monitored annually and compared among 3-year increments.

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Additional Pers. comms.

D. Fullerton (Biologist, MWD) email to R. Wilder, 11/17/2008 about abundance correlations with ammonia.

A. Munevar (Hydrologist, CH2M Hill) presentation to HOTT Team on 6/18/2008 on the effects of South Delta tidal marsh restoration on hydrodynamics.