Species	**longfin smelt**			
<u>Goals</u> (what needs to happen to recover species)	abundance	distribution	Diversity (genetic and life history)	stability
<u>Objective</u> (how will we know we've reached the goal)	**Grand Mean**: >=1 fish/tow (CPUE) Grand Mean of Fall Midwater over 4 months (first 10 to 20 years of the index didn't usually go below this -- Kimmerer *unpublished*) **or** "Longfin smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1984 period." (*see pp.56-66, 1996 USFWS Recovery Plan*)	*Wet year: detection of spawning (gravid or post-spawning adults) at ___ % of sampling stations from Napa River to the west, and east through western Delta* *Dry Year: detection of spawning (gravid or post-spawning adults) at __% of sampling stations throughout western and central Delta* *[plus, include a metric for specific locations where you want to detect these fish linked to location of restoration projects]* **or** "Longfin smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the	genetics (=1 panmictic population -- more = better) life history -- 1) spawning continues throughout time period when temperatures in the Delta are suitable **and** distribution of hatching times of spawners matches distribution of hatching times in population as a whole **and** x% of spawning population is anadromous (1-x% non-anadromous).	**Grand Mean**: >=1 fish/tow (CPUE) Grand Mean of Fall Midwater over 4 months in >90% of years **or** "Longfin smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1984 period." (see pp.56-66, 1996 USFWS Recovery Plan)
	Life stage:Egg			
Hypotheses	**Physical substrate/Flow** *Low flows during Dec-March limit availability of proper spawning substrate (possible X2 mechanism)*	**Physical substrate/Flow** *Low flows during Dec-March limit availability of proper spawning substrate in lower San Joaquin*	**Temperature** *Temperatures above LFS egg tolerance limit or will limit LFS spawning season*.	
Desired Change	1) Increase delta outflow (and decrease intra-annual flow variance) from Dec-March such that max amount of spawning area is produced for a given hydrology **Lower Detection Threshold:** 10km west movement of Dec-March X2 Upper Detection Threshold: ___ (if this is an X2 mechanism, it produces, linear log-log change until X2 ~__km) 2) Provide increased spawning throughout eastern region of potential spawning area such that sufficient spawning habitat exists even during low flow periods **Lower Detection Threshold**: Unknown (LFS spawning micro-habitat substrate/flow requirements are unknown)	Increase flows in lower SJR to confluence during Dec-Mar **Lower Detection Threshold:** ___ **Upper Detection Threshold**: ___	Maintain temperatures below embryogenesis threshold through May of each year. **Lower Detection Threshold:** weeks prior to May 31 that temperatures exceed ___(LFS temperature threshold unknown)	
Hypotheses	**Predation (diversity/abundance)** *Non-native egg predators (inland silverside) occupy likely LFS oviposition habitats (sandy beaches) and present a level of LFS egg predation that is substantially greater than historical*			
Desired Change	Reduce abundance of non-native egg predators in likely egg deposition habitats from Dec-March such that predation on LFS eggs is reduced **Lower Detection Threshold**: Removal of potential LFS egg-predators from potential egg deposition habitat to produce the desired change is not deemed possible using methodologies currently available			
Hypotheses	**Toxins/Water Chemistry** Elevated concentration of pyrethroid, organophosphate, estrogen mimicing compounds, ammonia (and their interactions) in the western Delta increase mortality for LFS eggs	**Toxins/Water Chemistry** Elevated concentration of pyrethroid, organophosphate, estrogen mimicing compounds, ammonia (and their interactions) in the lower San Joaquin increase mortality for LFS eggs		
Desired Change	Decrease concentrations of each compound in western Delta and eastern Suisun Bay to levels <detectable (or background) level during Dec-March **Lower Detection Threshold:** unknown (toxic concentrations and dose response varies by compound and presence of other toxins/stressors) **Upper Detection Threshold**: unknown (toxic concentrations and dose response varies by compound and presence of other toxins/stressors)	Decrease area of lower San Joaquin River and western Delta with concentrations of pyrethroid, organophosphate, EMC's, and ammonia >detectable (or background) level during Dec-Mar **Lower Detection Threshold:** unknown (toxic concentrations and dose response varies by compound and presence of other toxins/stressors) **Upper Detection Threshold**: unknown (toxic concentrations and dose response varies by compound and presence of other toxins/stressors)		
	Life stage: Larvae			
Hypothesized Stressor	**Temperature** *Temperatures >20oC limit survival of LFS larvae May-September in the Delta*	**Temperature** *Temperatures >20oC limit survival of LFS larvae May-September in the Delta*	**Temperature** *Temperatures >20oC limit survival of late-spawning, late-hatching LFS larvae May-September in the Delta*	**Entrainment** *Positive correlation between larval entrainment and spawning adult entrainment in same year exacerbates population fluctuations.*
Desired Change	Transport LFS out of Delta and into habitats that remain cool **Lower Detectability Threshold:** ___ (potential X2 Mechanism) **Upper Detectability Threshold**: ___ (if this is an X2 mechanism, it produces, linear log-log change until X2 ~__km)	Increase distribution of larval LFS so that less of the population is exposed to stressful/lethal temperatures **Lower Detectability Threshold:** Downstream distribution of larvae tracks position of X2 during winter/spring **Upper Detectability Threshold:** ___	Transport LFS out of Delta and into habitats that remain cool **Lower Detectability Threshold:** Downstream distribution of larvae tracks position of X2 during winter/spring **Upper Detectability Threshold**:	(see adult)

Hypothesized Stressor	**Toxins/Water Chemistry** *Elevated concentration of pyrethroid, organophosphate, estrogen mimicing compounds, ammonia (and their interactions) in the western Delta and Suisun increase mortality for LFS larvae*	**Toxins/Water Chemistry** *Elevated concentration of pyrethroid, organophosphate, estrogen mimicing compounds, ammonia (and their interactions) in the lower San Joaquin increase mortality for LFS larvae*		
Desired Change	Decrease concentrations of each compound in western Delta and eastern Suisun Bay to levels <detectable (or background) level during Dec-March **Lower Detection Threshold:** unknown (toxic concentrations and dose response varies by compound and presence of other toxins/stressors) **Upper Detection Threshold**: unknown (toxic concentrations and dose response varies by compound and presence of other toxins/stressors)	Decrease area of lower San Joaquin River and western Delta with concentrations of pyrethroid, organophosphate, EMC's, and ammonia >detectable (or background) level during Dec-Mar **Lower Detection Threshold:** unknown (toxic concentrations and dose response varies by compound and presence of other toxins/stressors) **Upper Detection Threshold**: unknown (toxic concentrations and dose response varies by compound and presence of other toxins/stressors)		
Hypothesized Stressor	**Predation (competitive advantage)** *LFS larval predators are much more effective today than they were historically because of water quality conditions (high temperature, stable salinity, low turbidity) that favor predators*	**Predation (competitive advantage)** *LFS larval predators are much more effective today than they were historically because of water quality conditions (high temperature, stable salinity, low turbidity) that favor predators*		
Desired Change	Change water quality (e.g. increase trubidity) and/or variability in water quality (e.g. seasonal shifts in salinity) such that predators are not at an advantage **Lower Detection Threshold**: (1) *turbidity* --- increase turbidity to at least ___ in west delta and Suisun Bay/Marsh from Jan-May (2) *Salinity* -- Duration, frequency, and magnitude of salinity variation required to suppress predators is unspecified at this time.	Change water quality (e.g. increase trubidity) and/or variability in water quality (e.g. seasonal shifts in salinity) such that predators are not at an advantage **Lower Detection Threshold**: (1) *turbidity* --- increase turbidity to at least ___ in west delta and Suisun Bay/Marsh from Jan-May (2) *Salinity* -- Duration, frequency, and magnitude of salinity variation required to suppress predators is unspecified at this time.		
Hypothesized Stressor	**Predation (diversity/abundance)** *Non-native predators (e.g., inland silverside) present predation pressure in certain habitats (sandy beaches in fresh or brackish water) that is much greater than historical*	**Predation (diversity/abundance)** *Non-native predators (e.g., inland silverside) present predation pressure in certain habitats (sandy beaches in brackish water) that is much greater than historical*		
Desired Change	Reduce abundance of non-native larval predators in shallow brackish habitats from Jan-May such that predation on LFS larvae is reduced **Lower Detection Threshold**: Removal of potential LFS egg-predators from these habitats in order to produce the desired change is not deemed possible using methodologies currently available	Reduce abundance of non-native larval predators in shallow brackish habitats from Jan-May such that predation on LFS larvae is reduced **Lower Detection Threshold**: Removal of potential LFS egg-predators from these habitats in order to produce the desired change is not deemed possible using methodologies currently available		
Hypothesized Stressor	**Entrainment** *Export-related entrainment and predation at export facilities limits larval survival*	**Entrainment** *Export-related entrainment and predation at export facilities limits survival of larvae spawned in the central and southern Delta*	**Entrainment** *Entrainment mortality is non-random with respect to hatching date and this limits period of successful spawning and subsequent life history variation*	
Desired Change	Reduce entrainment-related mortality of larval LFS. Larval/Juvenile entrainment at SWP/CVP facilities is sensitive to Delta outflow. **Lower Detection Threshold:** 50% reduction in entrainment/loss mortality of LFS juveniles (as an indicator of larval entrainment) compared with ___ [time-period] **Upper Detection Threshold**: Eliminate direct and indirect entrainment mortality	Reduce entrainment-related mortality of larval LFS. Larval/Juvenile entrainment at SWP/CVP facilities is sensitive to Delta outflow. **Lower Detection Threshold:** 50% reduction in entrainment/loss mortality of LFS juveniles (as an indicator of larval entrainment) compared with ___ [time-period] **Upper Detection Threshold**: Eliminate direct and indirect entrainment mortality	Entrainment related mortality distributed evenly (proportionately) over larval period. **Lower Detection Threshold:** ___ **Upper Detection Threshold:** ___	
Hypothesized Stressor	**Transport Flows** *Reduced winter and early-spring flows limits transport of LFS to productive habitats (in and around X2) and away from habitats (e.g. western Delta) with higher mortality. (See Kimmerer 2002b for description of gravitational flows as an X_2 mechanism)*	**Transport Flows** *Larval distribution is limited by reduced Delta outflows between Jan-May*	**Transport Flows** *Reduced late-winter and spring flows in the lower SJR limits transport of LFS hatched in the lower SJR and central Delta to productive habitats (in and around X2) and away from habitats (e.g. western Delta) with higher*	
Desired Change	Increase Delta outflows from Jan-May **Lower Detection Threshold**: 10km westward shift in Jan-May X_2 **Upper Detection Threshold**: LFS population responds logarythmically to linear decreases in X_2	Increase Delta outflows from Jan-May **Lower Detection Threshold**: 10km westward shift in Jan-May X_2 **Upper Detection Threshold**: LFS population responds logarythmically to linear decreases in X_2	Increase Delta outflows from lower SJR in Jan-May **Lower Detection Threshold**: ___ **Upper Detection Threshold**: ___	
Hypothesized Stressor	**Low salinity habitat** *reduced winter and early-spring flows limit availability of prefered habitat.*			
Desired Change	Increase Delta outflows from Jan-May **Lower Detection Threshold:** 10km westward shift in X2 **Upper Detection Thresold:** LFS Abundance increases log-wise with linear decreases in X2			
		Life Stage: Juvenile/Ocean -- Sub-Adult		

Hypothesized Stressor	**Food** *Limited supply of calanoid copepods,* *<u>Eurtytemora</u>, and mysid shrimp in within ___ km of X2 during April-Dec limits growth and survival of Age 0 LFS.*	**Transport Flows** *Juvenile distribution is limited by larval distribution due to reduced Delta outflows between Jan-May.*	**Transport Flows** *Juvenile distribution and thus, the marine/anadromous life history is limited by larval distribution due to reduced Delta outflows between Jan-May.*	
Desired Change	Increase food (calanoid copepod, mysid shrimp, Eurytemora) densities in rearing habitat (within __km of X_2) during April-Dec **Lower Detection Threshold**: ___ **Upper Detection Threshold:** Restore food abundance levels in rearing habitats (within ___ of X2) to > those observed during April--Dec in the 1967-1984 period	Increase Delta outflows from Jan-May **Lower Detection Threshold**: 10km westward shift in Jan-May X_2 **Upper Detection Threshold**: ___ (LFS population responds logarythmically to linear decreases in $X_{2)}$	Increase Delta outflows from lower SJR in Jan-May **Lower Detection Threshold**: (the prevalanece and benefit/cost of the anadromous life history have not been studied to date) **Upper Detection Threshold**: (the prevalanece and benefit/cost of the anadromous life history have not been studied to date)	
Hypothesized Stressor	**Temperature** *Temperatures >20oC limit survival of LFS juveniles May-September in the Delta and San Pablo Bay*	**Temperature** *Temperatures >20oC limit survival of LFS juveniles May-September in the Delta and San Pablo Bay*	**Temperature** *Temperatures >20oC limit survival of late-spawning, late-hatching LFS larvae May-September in the Delta and Suisun Bay*	
Desired Change	Transport LFS out of Delta and into habitats that remain cool **Lower Detectability Threshold:** ___ (potential X2 Mechanism) **Upper Detectability Threshold**: ___ (if this is an X2 mechanism, it produces, linear log-log change until X2 ~__km)	Create temperature refuges (<20oC) in San Pablo Bay and/or west Delta during months between May and September **Lower Detectability Threshold:** $100km^2$*weeks **Upper Detectability Threshold:** ___	Create temperature refuges (<20oC) in San Pablo Bay and/or west Delta during months between May and September **Lower Detectability Threshold:** $100km^2$*weeks **Upper Detectability Threshold:**	
Hypothesized Stressor	**Predation (competitive advantage)** *LFS juvenile predators are much more effective today than they were historically because of water quality conditions (high temperature, stable salinity, low turbidity) that favor predators*	**Predation (competitive advantage)** *LFS juvenile predators are much more effective today than they were historically because of water quality conditions (high temperature, stable salinity, low turbidity) that favor predators*		
Desired Change	Change water quality (e.g. increase trubidity) and/or variability in water quality (e.g. seasonal shifts in salinity) such that predators are not at an advantage **Lower Detection Threshold**: (1) *turbidity* --- increase turbidity to at least ___ in west delta, Suisun Bay/Marsh, and San Pablo Bay year-round (2) Salinity -- Duration, frequency, and magnitude of salinity variation required to suppress predators is unspecified at this time.	Change water quality (e.g. increase trubidity) and/or variability in water quality (e.g. seasonal shifts in salinity) in particular areas of the west Delta and Suisun Bay such that predators are not at an advantage in those areas (thus, allowing increased distribution of LFS) **Lower Detection Threshold**: (1) *turbidity* --- increase turbidity to at least ___ in west delta, Suisun Bay/Marsh, and San Pablo Bay year-round (2) Salinity -- Duration, frequency, and magnitude of salinity variation required to suppress predators is unspecified at this time.		
		Life Stage: Spawning Adult		
Hypothesized Stressor	**Food** *Limited supply of calanoid copepods,* *<u>Eurtytemora</u>, and mysid shrimp within ___ km of X2 during Dec-Mar limits survival and spawning success of Age1+ LFS.*	**Entrainment** *Export-related entrainment and predation at export facilities limits survival of spawning adults in the central and southern Delta*	**Entrainment** *Entrainment mortality is non-random with respect to spawning date and this limits period of successful spawning and subsequent life history variation*	**Entrainment** *Positive correlation between larval entrainment and spawning adult entrainment in same year exacerbates population fluctuations.*
Desired Change	Increase food (calanoid copepod, mysid shrimp, Eurytemora) densities in rearing habitat (within __km of X_2) during Dec-Mar **Lower Detection Threshold**: ___ **Upper Detection Threshold:** Restore food abundance levels in rearing habitats (within ___ of X2) to > those observed during Dec-Mar in the 1967-1984 period	Reduce entrainment-related mortality of spawning-class LFS (Dec-Mar). Spawner entrainment at SWP/CVP facilities is sensitive to export volume. **Lower Detection Threshold:** ___ reduction in entrainment/loss mortality of LFS Age1+ compared with ___ [time-period] **Upper Detection Threshold**: Eliminate direct and indirect entrainment mortality	Entrainment related mortality distributed evenly (proportionately) over spawning period (Dec-Mar). **Lower Detection Threshold:** ___ **Upper Detection Threshold:** ___	Reduce correlation between Age Class 1+ (spawning age; Dec-Mar) and larval/juvenile (Mar-Jun) entrainment so that both cohorts were not impacted in the same year **Lower Detection Threshold:** ___ **Upper Detection Threshold:** ___
Hypothesized Stressor	**Predation (competitive advantage)** *LFS predators are much more effective today during LFS spawning season than they were historically because of water quality conditions (high temperature, stable salinity, low turbidity) that favor predators*	**Predation (competitive advantage)** *LFS predators are much more effective today during the LFS spawning season than they were historically because of water quality conditions (high temperature, stable salinity, low turbidity) that favor predators. These conditions prevail in the Central and South Delta limiting spawning in those regions and narrowing the overall spawning range of LFS in this Estuary*		
Desired Change	Change water quality (e.g. increase trubidity) and/or variability in water quality (e.g. seasonal shifts in salinity) during Dec-Mar such that predators are not at an advantage **Lower Detection Threshold**: (1) *turbidity* --- increase turbidity to at least ___ in west delta, Suisun Bay/Marsh, and San Pablo Bay year-round (2) Salinity -- Duration, frequency, and magnitude of salinity variation required to suppress predators is unspecified at this time.	Change water quality (e.g. increase trubidity) and/or variability in water quality (e.g. seasonal shifts in salinity) in the Central and South Delta during December-March such that predators are not at an advantage **Lower Detection Threshold**: (1) *turbidity* --- increase turbidity to at least ___ in west delta, Suisun Bay/Marsh, and San Pablo Bay year-round (2) Salinity -- Duration, frequency, and magnitude of salinity variation required to suppress predators is unspecified at this time.		