DIVERSION EFFECTS ON FISHERIES
DELTA SMELT
MATRIX NARRATIVE
COMMENTS FROM AG/URBAN on 6/2/98 IN BOLD ITALICS

(GIVEN ALL OF THE CONCERNS AND ISSUES RAISED BY AG/URBAN SCIENTISTS COVERING THE ASSUMPTIONS AND CONCLUSIONS REACHED BY THE TEAM (FIRST 12-13 PAGES OF THIS DOCUMENT) WE BELIEVE IT WAS PREMATURE TO EVALUATE THE ALTERNATIVES AND PRIMARY ISSUES FROM CALFED UNTIL SUCH TIME AS THE CONCERNS, ISSUES, AND DIFFERENCES ARE RESOLVED. WE CAN AGREE TO DISAGREE. HOWEVER, WE BELIEVE THERE IS MUCH COMMON GROUND. WE ALSO DID NOT ADDRESS THE RECOVERY CRITERIA IN APPENDIX 1 SINCE MANY OF THE ISSUES, CONCERNS, AND ASSUMPTIONS ARE THE SAME. THIS DOCUMENT WILL SERVE AS A STARTING POINT FROM WHICH WE CAN JOINTLY DEVELOP A PAPER ON DIVERSION EFFECTS ON DELTA SMELT. WE LOOK FORWARD TO ACTIVELY PARTICIPATING WITH CALFED AND OTHER STAKEHOLDERS IN COMPLETING THIS IMPORTANT TASK).

The delta smelt team consists of Michael Thabault, U.S. Fish and Wildlife Service, Larry Brown, U.S. Bureau of Reclamation, Dale Sweetnam, Department of Fish and Game, and Chuck Hanson, State Water Contractors. Those who participated in the creation of the first draft of the matrices include Michael Thabault, Larry Brown, and Dale Sweetnam.

The scale of each matrix box ranges from +3 to -3 which expresses the relative impact of the effects identified that would affect delta smelt in relation to water diversions. Entries were based on a qualitative discussion of the degree to which operations or proposed operations impact the delta smelt population. The values in each box represent the combination of two estimates on the part of the Team: 1) the potential effect on the delta smelt population if exposure occurs, and 2) the probability that the population will be exposed. ***(THE KEY WORD HERE IS ESTIMATED BY THE TEAM. Population level data is really lacking.)*** Therefore, caution should be used in interpretation of the matrix values. For example, exposure to toxicants includes the likelihood that fish will be exposed in addition to a judgement on the possible effects to the individuals that experience the exposure.

The delta smelt matrices were divided into Awet years@ and Adry years@ because distribution is strongly tied to hydrologic conditions and the effects (positive or negative) of potential actions in the delta potentially would be dampened in Awet years@. The differences between the magnitude of the effects in wet and dry years is discussed in the narrative. ***(THIS PARAGRAPH ASSUMES THAT A SINGLE POPULATION OF DELTA SMELT OCCURS IN THE DELTA. EVIDENCE FOR A SINGLE POPULATION IS HIGHLY QUESTIONABLE. REAL TIME MONITORING DATA INDICATES THAT AT LEAST TWO OR MAYBE MORE POPULATIONS COULD EXIST IN THE DELTA. EARLY SALVAGE RECORDS COULD BE INTERPRETED TO SHOW A LOCALIZED POPULATION AND OTHER, MORE REMOTE POPULATIONS, SUCH AS UP THE SACRAMENTO RIVER, SUISUN MARSH, NAPA RIVER, CACHE SLOUGH COULD BE CONTRIBUTING TO THE OVERALL POPULATION, BUT NOT A POPULATION SEGMENT SUBJECT TO***

ENTRAINMENT. THIS SITUATION NEEDS TO BE INCLUDED IN ANY FINAL EVALUATION.)

Definitions

Entrainment: Entrainment is defined as the direct effects of entrainment of delta smelt at in-Delta diversion facilities. Effects include: 1) entrainment and loss through export; 2) predation in Clifton Court Forebay and any other predation related to screens; and 3) losses due to handling of fish at fish salvage facilities. ***(EFFECTS ARE NOT EVALUATED FOR IN DELTA DIVERSIONS OTHER THAN THE CVP AND SWP. NO EVALUATION OF LOSSES IN OTHER AREAS OR OTHER FACTORS INFLUENCING POPULATIONS).*** The entrainment score will represent an overall effect of the three factors. The matrix will include rows for the three factors but the three rows may not necessarily add up to the total effect score assigned to entrainment. The extra scores are meant to indicate the relative importance of the various factors included in entrainment.

Hydrodynamics: Hydrodynamics is defined to include the indirect effects of holding delta smelt in the interior delta longer than would occur under more natural flow conditions. ***(ASSUMES THAT LONGER RESIDENCE TIME IN THE DELTA RESULTS IN HIGHER POPULATION LEVEL MORTALITY RATES THAN WOULD OCCUR IN DOWNSTREAM REARING AREAS. NO DATA TO SUPPORT THIS ASSUMPTION).*** Losses presumably occur through longer exposure of delta smelt to undefined mortalities that occur in the central Delta. ***(ASSUMES THAT EXPORT PUMPING AND DIVERSIONS AHOLD@ DELTA SMELT IN THE DELTA AGAINST THEIR WILL. HANSON=S PUMPING LEVEL EXPERIMENT IN 1994 DEMONSTRATED THAT THIS WAS NOT THE CASE. DELTA SMELT MOVED DOWNSTREAM WHEN THEY WERE READY AND DID NOT CHANGE POSITION BASED ON INCREASED PUMPING LEVELS.)*** These sources of mortality likely included predation by species common in the Delta such as largemouth bass, and exposure to water quality conditions ***(ASSUMES INCREASED PUMPING LEVELS LOWERS WATER QUALITY IN THE DELTA. CONTRA COSTA WATER DISTRICT=S AND MWD=S OWN MODELING DEMONSTRATES THAT SOUTH DELTA DIVERSIONS ACTUALLY IMPROVES WATER QUALITY, NOT DEGRADES IT.)*** in the Delta. The effects of hydrodynamics were assessed by explicitly considering the following geographic locations identified in modeling runs: 1) cross Delta flow; 2) QWEST; 3) Old River @ Bacon Island; 4) Sacramento River at Rio Vista; 5) San Joaquin River at Antioch. Other points were considered as needed. ***(NEED MORE DEFINITION OF WHAT AND WHEN THESE OTHER POINTS WERE NEEDED AND HOW THEY WERE USED).***

Predation: Predation includes all predation other than that occurring in Clifton Court Forebay and in front of screens.
Handling: Handling losses are included in entrainment. Handling is associated with a very high level of mortality given the delicate nature of delta smelt.

Food supply: Recent studies of delta smelt feeding indicate that the availability of appropriate food types may be very important at certain points in the delta smelt life cycle and for overall survival. Food supply summarizes the best guess of the team as to the effects certain actions will have on availability of food to the population.

Shallow-water habitat: Assessments of shallow water habitat are based on possible effects on spawning habitat and food supply. ***(ASSUMES SHALLOW WATER HABITATS ARE ONLY IMPORTANT FOR SPAWNING AND FOOD PRODUCTION. OTHER HABITAT PARAMETERS, SUCH AS COVER MAY BE PROVIDED BY SHALLOW WATER HABITAT. HANSON=S WORK IN THE SPRING OF 1997 CLEARLY DEMONSTRATED THE ASSOCIATION OF DELTA SMELT IN THE LOWER SAN JOAQUIN WITH ROOTED EMERGENT AND ROOTED AQUATIC VEGETATION.)*** Nothing definitive is known about the need of delta smelt for shallow-water habitat. ***(IEP HAS NOT COMPLETED MUCH SAMPLING IN SHALLOW AREAS, NOR HAVE ANY COMPREHENSIVE STUDIES BEEN CONDUCTED ON THE IMPORTANCE OF THIS TYPE OF HABITAT TO DELTA SMELT. A NUMBER OF OTHER BIOLOGISTS WORKING IN THE DELTA BELIEVE THAT THIS TYPE OF HABITAT IS VITALLY IMPORTANT TO DELTA SMELT. THEIR BELIEF IS BASED ON THE LIFE HISTORY STRATEGY AND ECOLOGICAL REQUIREMENTS OF DELTA SMELT, NOT RESULTS OF SAMPLING PROGRAMS FOCUSED ON STRIPED BASS OR NOT INTENDED TO SAMPLE SHALLOW, VEGETATED AREAS.)***This type of habitat is known to be used for spawning but it is unclear if spawning habitat is limited under present conditions.

Water quality (toxicants): Nothing is really known about population level effects of toxics on the delta smelt population. The matrix assumes that exposure to San Joaquin River origin water is equivalent to greater exposure to contaminants. ***(HIGHLY QUESTIONABLE ASSUMPTION. MOST OF THE MEASURED CONTAMINANTS COMING FROM THE SAN JOAQUIN ARE COMING IN EARLY SPRING, GENERALLY BEFORE THE DELTA SMELT ARE UP IN THE SPAWNING AREAS TO ANY GREAT EXTENT. CHECK THE TIMING OF SAN JOAQUIN PULSES BY LOOKING AT THE USGS=S WEB SITE AND WORK COMPLETED BY KATHY QUIVELA. FOX=S LOOK AT CONTAMINANTS ALONG THE SACRAMENTO RIVER INDICATES HIGH LEVELS OF TOXICITY DOWNSTREAM OF THE CITY OF SACRAMENTO, MOST OF THE TIME. SACRAMENTO RIVER SHOULD BE INCLUDED IN THE ASSESSMENT.)***

Water quality (temperature): The Team believed that none of the alternatives would have a major effect on in-Delta water temperatures. This row was scored 0 through all matrices; therefore it was omitted from the matrices.

Salinity/X2 (originally called Water quality (salinity)): For Delta smelt the original AWater quality (salinity)@ row was changed to Salinity/X2. We believe this better defines the variable of interest for delta smelt.

Agricultural diversions: The Team assumed an aggressive program of screening and consolidation of in-Delta agricultural diversions. Screen design was assumed to have some benefit for various life stages of delta smelt

Sources of uncertainty

The Team identified many sources of uncertainty. The major areas are identified below. Additional text is provided in the narrative for each of the alternatives.

We do not know the absolute size of the delta smelt population. All effects are based on relative CPUE available from the various existing monitoring programs. ***(CPUE IS NOT A GOOD MEASURE OF DELTA SMELT POPULATION LEVELS, GIVEN THE EXPERIENCES OF THE PAST FEW YEARS. FIRST, HANSON PULLED HIS KODIAK TRAWLS RIGHT ALONG SIDE THE CHIPPS ISLAND TRAWL AND CDFG=S FALL MIDWATER TRAWL GEAR WITH UP TO THREE ORDERS OF MAGNITUDE DIFFERENCE IN CATCHES. DEPENDING ON WHICH INDEX IS USED (GENERALLY THE FALL MIDWATER TRAWL) IS USED, WE HAVE HAD VERY HIGH SUBSEQUENT YEAR INDICES FROM EXTREMELY LOW CURRENT YEAR INDICES. SO THE ABILITY OF DELTA SMELT TO RECOVER TO SOME VERY HIGH FMT INDEX VALUES HAS BEEN DEMONSTRATED EMPIRICALLY IN THE RECENT PAST. WE NEED TO KNOW WHICH INDICES WERE USED AND HOW. ALSO, MANY BIOLOGISTS QUESTION THE CALCULATION OF THE FALL MIDWATER TRAWL INDEX VALUE IN PARTICULAR BECAUSE OF STATISTICAL AND MATHEMATICAL IRREGULARITIES IN THE SAMPLING AND CALCULATION PROTOCOLS).***

Screening criteria for both large project screens and smaller agricultural screens are unknown. ***(THIS STATEMENT IS NOT COMPLETELY TRUE. THE CALFED SCREENING TEAM HAS DEVELOPED CRITERIA WHICH THEY BELIEVE WILL PROBABLY WORK, BASED ON SWIMMING PERFORMANCE AND BEHAVIOR OF ADULTS AND JUVENILES.)*** Benefits for delta smelt are assumed; however, recent behavioral studies suggest that it may be very difficult to design screens that actually benefit delta smelt to a significant degree (Swanson et al 1998). It was also assumed there was some benefit to all life stages, which may not be the case depending on final screen design.

The benefits of shallow-water habitat rehabilitation to delta smelt are unknown. Such habitat is used for spawning and may contribute to overall productivity of the system. It is not known if spawning habitat is a limiting factor for the population. Shallow-water habitat is not believed to be an important rearing habitat for delta smelt. ***(WE STRONGLY DISAGREE WITH THIS STATEMENT. SAMPLING GENERALLY OCCURS IN OPEN WATER AREAS. LITTLE IF ANY SAMPLING HAS OCCURRED IN VEGETATED AREAS. IN ADDITION, THE FUNDAMENTAL LIFE HISTORY STRATEGY OF DELTA SMELT WOULD CONTRADICT THIS STATEMENT. A FISH THAT HAS LOW FECUNDITY, A ONE YEAR LIFE CYCLE, SPAWNS ON VEGETATION AND WAS EVOLVED IN A SYSTEM OF HUGE, TIDALLY INFLUENCED TIDAL MARSHES, MUST HAVE A STRONG AFFINITY FOR VEGETATION AND SHALLOWER WATERS. NO OTHER OPEN WATER FISH SPECIES HAS A SIMILAR LIFE HISTORY STRATEGY. THIS STRATEGY SCREAMS STABLE ENVIRONMENT AND RELATIVELY LOW MORTALITY RATES.***

The effect of toxicants on delta smelt is unknown. The Team assumed that water from the San Joaquin River likely carried a higher load of contaminants that might be detrimental to delta smelt. The Team also assumed that concentrations of contaminants were unlikely to be high enough to cause acute toxicity in life stages other than eggs and larvae. The only effects on other life stages would be chronic. Assumed effects and interactions are defined in the text for each alternative to define questions to facilitate input from the Water Quality Technical Team. ***(THIS ASSESSMENT NEEDS TO BE REVISITED BY SOME TOXICS EXPERTS LIKE FOX AND CHRIS FOE. SAN JOAQUIN CONTAMINANTS TEND TO BE INSECTICIDES SUCH AS DIAZANON AND NOT HERBICIDES THAT WOULD EFFECT PHYTOPLANKTON. ALSO TIMING OF EVENTS IS AN ISSUE. THE RELATIVE IMPORTANCE OF SACRAMENTO RIVER WATER ON OVERALL TOXICITY SHOULD BE BROUGHT INTO THE EVALUATION.)***

We have little understanding of in-Delta predation dynamics on delta smelt.

As indicated at several points above, we have very limited understanding of limiting factors for the delta smelt population. Recent studies suggest that availability of specific food types at specific times may be very important. ***(CITATIONS?)***

Existing Conditions

Entrainment: ***(THE FOLLOWING ENTRAINMENT DISCUSSION ASSUMES THAT ALL DELTA SMELT CAPTURED AT THE SALVAGE FACILITIES ARE OF EQUAL VALUE TO THE POPULATION. WE DISAGREE. ALL ASSESSMENTS OF EFFECTS SHOULD BE REPORTED IN ADULT EQUIVALENTS, SINCE THE POTENTIAL SURVIVAL TO SPAWNING OF A 21 MM DELTA SMELT TAKEN AT THE FACILITY IN AUGUST IS CONSIDERABLY DIFFERENT THAT AN ADULT FISH TAKEN IN MARCH. A TWO WEEK OLD DELTA SMELT HAS A LOT LOWER PROBABILITY OF SURVIVING TO SPAWN THAT AN ADULT THAT IS ONE WEEK FROM SPAWNING. BUELL INDICATES THAT THIS WAS AGREED TO IN A RECENT MEETING.)*** Entrainment values are based on historical salvage of delta smelt at the water project diversions in the South Delta. The strongest negative effects occur in the late spring/early summer when young-of-the-year delta smelt become large enough to be counted as salvage at the facilities in May, June and July. Entrainment of larval and early juvenile delta smelt < 21 mm are not counted as take at these facilities, therefore salvage data does not represent larval losses to entrainment and the peak effect might be prior to the salvage peaks observed in May or June. Screening efficiencies and pre-screening losses (e.g., predation) for delta smelt are not known so actual losses of delta smelt cannot be calculated. We assume that significant predation occurs on delta smelt entrained into Clifton Court Forebay, however it may be comparable to other species of the same size and shape (and swimming ability).

Delta smelt usually do not survive the handling process, therefore the larger the potential for handling smelt, the larger the potential negative effect. Handling of delta smelt was also assumed to be proportional to entrainment effects. More delta smelt are entrained in dry years therefore the potential for handling mortality increases. Survival may also be influenced by water temperature, which would be higher in dry years.

Secondary effects of moving delta smelt out of optimal delta smelt rearing areas is covered under hydrodynamics.

The negative effects of entrainment are strongest in dry years when a larger proportion of the population is located in the delta for a longer period of time. ***(THIS STATEMENT ASSUMES THAT A SINGLE POPULATION OF DELTA SMELT OCCURS IN THE DELTA. EVIDENCE FOR A SINGLE POPULATION IS HIGHLY QUESTIONABLE. REAL TIME MONITORING DATA INDICATES THAT AT LEAST TWO OR MAYBE MORE POPULATIONS COULD EXIST IN THE DELTA. EARLY SALVAGE RECORDS COULD BE INTERPRETED TO SHOW A LOCALIZED POPULATION AND OTHER, MORE REMOTE POPULATIONS, SUCH AS UP THE SACRAMENTO RIVER, SUISUN MARSH, NAPA RIVER, CACHE SLOUGH COULD BE CONTRIBUTING TO THE OVERALL***

POPULATION, BUT NOT A POPULATION SEGMENT SUBJECT TO ENTRAINMENT. THIS SITUATION NEEDS TO BE INCLUDED IN ANY FINAL EVALUATION.) In wet years, the population is more widely dispersed and distributed from the Delta to Suisun Bay. A second period of entrainment occurs in the late winter and early spring when pre-spawning adults move to freshwater to spawn.

Hydrodynamics: The delta smelt team decided ***(BASED ON WHAT CRITERIA AND DATA?)*** that entrainment, hydrodynamics and predation were highly correlated. For example, under existing conditions, the amount and timing of moving water across the delta (or around it) had a direct effect on the amount of entrainment and predation that a delta smelt would encounter. ***(THIS IS AN ASSUMPTION THAT IS NOT SUPPORTED BY EMPIRICAL EVIDENCE. WE HAVE NO WAY OF KNOWING IF IN DELTA MORTALITY RATES INCREASE AS A FUNCTION OF RESIDENCE TIME WITHIN THE DELTA. ALSO, WHERE IS THE POPULATION LEVEL EFFECT OF AN INCREASED MORTALITY RATE IN THE DELTA IF THIS STATEMENT WAS TRUE. THIS STATEMENT IS SPECULATION ONLY. THIS STATEMENT ASSUMES THAT FISH ARE PULLED AROUND THE DELTA, NO MATTER WHAT AGE. WE KNOW THAT IS NOT TRUE BASED ON THE TEMPORAL PATTERN OF SALVAGE AND HANSON=S 1994 EXPERIMENT. THIS STATEMENT ALSO ASSUMES A SINGLE POPULATION OF DELTA SMELT, WHICH IS QUESTIONABLE.)***

The effects of project related hydrodynamics on delta smelt occur mainly in the spring and summer months when pre-spawning adults move upstream to spawn and young-of-the-year delta smelt are present in freshwater before migrating to brackish water in the summer. ***(THIS STATEMENT IS BASED ON THE ASSUMPTIONS THAT HYDRODYNAMICS, READ AS EXPORT LEVELS, EQUALS SALVAGE LEVELS AND THAT EXPORT LEVELS INFLUENCES SURVIVAL RATES AND HAS A POPULATION LEVEL EFFECT. HANSON=S 1994 RESULTS IS DIRECT EMPIRICAL EVIDENCE THAT THESE ASSUMPTIONS ARE NOT VALID.)*** The rest of the year, delta smelt are usually associated with the low salinity areas of the estuary west of the Delta, primarily Suisun and Grizzly bays. The negative effects of hydrodynamics in dry years are stronger and longer in duration than in wet years. ***(THIS STATEMENT ASSUMES A POPULATION LEVEL EFFECT BASED ON DIFFERENTIAL SALVAGE LEVELS OCCURRING DRY AND WET YEARS. EXAMINATION OF THE FMT ABUNDANCE INDICES WILL SHOW A DELTA SMELT REBOUND FROM A DRY YEAR, LOW INDEX VALUE, TO THE SUBSEQUENT YEAR. OBVIOUSLY, POPULATION EFFECTS MUST BE SMALL OR EXISTENT. NO DATA TO SUPPORT THIS CONTENTION OR CONCLUSION.)***

Cross-Delta Flow: There may actually be some Cross-Delta flow in wet years but little effect is expected because of general high outflow conditions in wet years. In dry years Cross-Delta flow will be [positive] larger and tend to move delta smelt spawned above the Delta Cross-Channel toward the central and southern Delta. ***(THIS STATEMENT IS PURE SPECULATION AND NOT SUPPORTED BY THE DATA. REAL TIME MONITORING DATA DOES NOT DETECT THIS MOVEMENT FROM ABOVE THE CROSS CHANNEL TO THE SOUTH DELTA. THERE IS NO DATA TO DETERMINE FROM WHICH AREA OF THE DELTA OR UPSTREAM THAT SALVAGED DELTA SMELT ORIGINATE. THE PARTICLE***

TRACKING MODEL SHOWS THAT THE NET WATER MOVEMENT TIME FROM ABOVE THE CROSS CHANNEL TO THE SOUTH DELTA IS ON THE ORDER OF MONTHS, THEREBY GIVING DELTA SMELT TIME TO GROW INTO VOLITIONAL MOVING JUVENILES OR ADULTS. ALSO, THE PERCENTAGE OF FLOW MOVING FROM ABOVE THE CROSS CHANNEL TO THE SOUTH IS HIGHLY VARIABLE. THE TEAM NEEDS TO DOCUMENT THE SOURCE OF THEIR DATA USED TO SUPPORT THE CONCLUSION.)

QWEST: QWEST is generally positive over the period of record so it was assumed that QWEST would be positive in wet years and there would be little effect on delta smelt. In dry years, QWEST is negative in most months and only slightly positive in the remaining months. The retention of delta smelt in the Delta was felt to be a significant negative effect on the population, particularly for larvae and juveniles in the spring months. ***(THIS IS AN ASSUMPTION THAT IS NOT SUPPORTED BY EMPIRICAL EVIDENCE. WE HAVE NO WAY OF KNOWING IF IN DELTA MORTALITY RATES INCREASE AS A FUNCTION OF RESIDENCE TIME WITHIN THE DELTA. ALSO, WHERE IS THE POPULATION LEVEL EFFECT OF AN INCREASED MORTALITY RATE IN THE DELTA IF THIS STATEMENT WAS TRUE. THIS STATEMENT IS SPECULATION ONLY. THIS STATEMENT ASSUMES THAT FISH ARE PULLED AROUND THE DELTA, NO MATTER WHAT AGE. WE KNOW THAT IS NOT TRUE BASED ON THE TEMPORAL PATTERN OF SALVAGE AND HANSON=S 1994 EXPERIMENT. THIS STATEMENT ALSO ASSUMES A SINGLE POPULATION OF DELTA SMELT, WHICH IS QUESTIONABLE.)***

Old River @ Bacon Island: Based on the 1975-1991 period of record analyzed, flow in Old River was negative during all months. Spawning in wet years is diffuse and significant spawning can occur in the central and southern Delta. A slight negative effect was assigned in the winter because adults could be induced to spawn farther south than they would otherwise and larvae and juveniles spawned in the area would be held in the area of the pumps longer. ***(THIS IS AN ASSUMPTION THAT IS NOT SUPPORTED BY EMPIRICAL EVIDENCE. WE HAVE NO WAY OF KNOWING IF IN DELTA MORTALITY RATES INCREASE AS A FUNCTION OF RESIDENCE TIME WITHIN THE DELTA. ALSO, WHERE IS THE POPULATION LEVEL EFFECT OF AN INCREASED MORTALITY RATE IN THE DELTA IF THIS STATEMENT WAS TRUE. THIS STATEMENT IS SPECULATION ONLY. THIS STATEMENT ASSUMES THAT FISH ARE PULLED AROUND THE DELTA, NO MATTER WHAT AGE. WE KNOW THAT IS NOT TRUE BASED ON THE TEMPORAL PATTERN OF SALVAGE AND HANSON=S 1994 EXPERIMENT. THIS STATEMENT ALSO ASSUMES A SINGLE POPULATION OF DELTA SMELT, WHICH IS QUESTIONABLE.)*** During dry years negative flow in the area is assumed to be high. This negative flow is assumed to retain larvae and juveniles in the southern Delta and this is presumed to have a negative impact on survival. ***(THE TEAM NEEDS TO PROVIDE THE DATA OR ANALYSES TO SUPPORT THIS CONCLUSION. WE DISAGREE WITH THIS CONCLUSION.)*** This effect is in addition to direct entrainment effects.

Sac River @Rio Vista: Sacramento River flow is strongly positive during wet years with no effect expected on delta smelt. Sacramento River flow will be lower in dry years but this is not felt to be a major effect on the delta smelt population. Most of the negative effects ***(SPECULATIVE CONCLUSION, SEE ABOVE)*** are already implicitly included in the QWEST effect indicated above. In dry years, delta smelt accumulate in the Sacramento River and will be subject to the QWEST effect. ***(THIS ACCUMULATION WAS NOTED BEFORE THE SWP CAME ON LINE IN 1967. THE DISTRIBUTION OF DELTA SMELT PROVIDED IN TURNER AND KELLY=S 1966 PUBLICATION ON DELTA ECOLOGICAL STUDIES DESCRIBES A LATE SEASON CONCENTRATION OF DELTA SMELT NEARLY EXACTLY MATCHING THE DISTRIBUTION FOUND IN 1994, A DRY YEAR. THIS STUDY WAS CONDUCTED BEFORE THE SWP CAME ON LINE. QWEST WAS NOT A PROBLEM BACK THEN, SO HOW DOES QWEST AFFECT THE DISTRIBUTION? THE TEAM NEEDS TO DOCUMENT ITS CONCLUSION.)*** The delta smelt remaining in the more upstream portion of the Sacramento River were also felt to be negatively affected, ***(BASED ON WHAT CRITERIA?)*** but not to the degree of the rest of the population.

San Joaquin River @ Antioch: San Joaquin River flows likely stay positive during all months during wet years with little effect expected on delta smelt. ***(THIS STATEMENT IS PROBABLY AN OVER SIMPLIFICATION OF THE SITUATION. WATER YEAR 1997 WAS CLASSIFIED AS WET EXCEPT THE SPRING CONDITIONS EXPERIENCED BY DELTA SMELT WERE SIMILAR TO A DRY YEAR. THE GENERAL USE OF FLOW CONDITIONS IS HIGHLY QUESTIONABLE AND NOT SUPPORTED BY THE DATA.)*** In dry years, flow in the San Joaquin River is dramatically reduced with reverse flows ***(THIS CONCLUSION IS OF LIMITED USE. THE FISH NEVER SEE MONTHLY AVERAGED CONDITIONS AND ALL OF OUR PREVIOUS COMMENTS REGARDING THE USE OF FLOW DIRECTION, IN THE ABSENCE OF EMPIRICAL DATA MAKES THIS CONCLUSION SUSPECT. THE TEAM NEEDS TO PROVIDE THEIR DATA AND ANALYSES TO SUPPORT THE CONCLUSIONS REGARDING DELTA SMELT DISTRIBUTION PATTERNS AND RATES OF MOVEMENT.)*** in some months. The negative values for this parameter indicate longer residence time in an area where survival was believed to be relatively poor. ***(SEE EARLIER COMMENTS ON RESIDENCE TIME IN THE DELTA, MORTALITY RATES, AND POPULATION LEVEL EFFECTS. THESE CONCLUSIONS ARE SPECULATIVE AT BEST AND MUST BE SUPPORTED BY THE TEAM.)*** Fish in this area might also be vulnerable to moving into areas subject to the other effects described above (e.g. Old River flows).

Predation: There were two main types of predation that were considered for delta smelt: larval predation by inland silversides, and predation at structures other than screens by striped bass, largemouth bass, etc. Predation effects are diminished in wet years when the smelt population was widespread with a larger proportion out of the Delta. The potential for inland silverside predation appears to be greatest in drier years when the majority of the population spawns above the Confluence. Predation on adults was considered to be relatively low with the effect increasing in months when larvae and juveniles are present.

Food Supply: Recent studies *(CITATIONS PLEASE?)*suggest that *Eurytemora affinis* is a preferred food item of delta smelt. Reductions in *Eurytemora* abundance through the introduction of exotic species such as clams (*Potamocorbula*) and copepods (*Psuedodiaptomus*, *Sinocalanus*, etc.) has led to the potential for food limitation for delta smelt.***(WE NEED TO SEE THE DATA***

USED TO SUPPORT THIS CONCLUSION. ALTHOUGH THE ABUNDANCE OF EURYTEMORA HAS DECREASED OVER THE PAST DECADES, WE HAVE NOT SEEN A RESULTING DECLINE IN DELTA SMELT ABUNDANCE BASED ON FOOD SUPPLY. WITH EURYTEMORA AT EXTREMELY LOW LEVELS, WE SAW ONE OF THE HIGHEST FALL MIDWATER TRAWL INDICES IN HISTORY (1995). THESE RESULTS APPEAR TO BE INCONSISTENT. ALSO, WHAT DO THE SUMMER TOWNET SURVEYS SHOW IN TERMS OF ABUNDANCE AND DISTRIBUTION OF DELTA SMELT IN RELATION TO EURYTEMORA ABUNDANCE. HERBOLD=S DISSERTATION ALSO DESCRIBES HOW NATIVE SPECIES WERE MUCH MORE ADAPTED TO DEALING WITH CHANGES IN PREFERRED FOOD ITEMS BECAUSE OF EXOTIC INTRODUCTIONS. THE ENTIRE ISSUE OF FOOD LIMITATION SHOULD BE ADEQUATELY DOCUMENTED BY THE TEAM.) Wet years provide higher levels of food production in the estuary and decrease the effects of the clam on the ecosystem

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The negative effect of exporting a proportion of the food production with withdrawal of water from the estuary was also considered. This effect was not considered important in wet years. *(WHY ISN=T IT CONSIDERED IMPORTANT IN WET YEARS? ISN=T PRODUCTIVITY DRIVEN TO A GREAT EXTENT BY WATER TEMPERATURES AND TURBIDITY LEVELS IN ADDITION TO PHOTOPERIOD? WATER TEMPERATURES ARE LOWER IN WET YEARS, GENERALLY, AND TURBIDITY IS HIGHER. WHY ISN=T WET YEARS A PROBLEM IF YOUNG DELTA SMELT ARE DISTRIBUTED INTO LESS PRODUCTIVE (SUISUN BAY) HABITATS?)* In dry years a negative effect was assigned. *(TWO QUESTIONS WITH RESPECT TO THIS CONCLUSION. FIRST, HOW WAS IT ESTABLISHED THAT FOOD WAS LIMITING DELTA SMELT PRODUCTION? SEE COMMENTS IMMEDIATELY ABOVE. SECOND, HOW WAS IT DETERMINED THAT FOOD PRODUCTION LEVELS WERE BEING SIGNIFICANTLY INFLUENCED BY WATER EXPORTS. DOESN=T KIMMERER=S WORK CONCLUDE THAT THE PRODUCTION LOST THROUGH EXPORTS IS INCONSEQUENTIAL? ALSO, ISN=T THE HIGHEST LEVEL OF PRIMARY PRODUCTION IN THE ESTUARY OCCURRING IN THE CENTRAL AND SOUTHERN DELTA? ISN=T THE LEVEL OF PRIMARY PRODUCTION IN THE CENTRAL AND SOUTHERN DELTA SEVERAL TIMES THE RATE OF PRODUCTION OCCURRING IN THE APREFERRED@ DOWNSTREAM AREAS OF SUISUN BAY? IT APPEARS AS IF THERE IS AN INCONSISTENT LOGIC GAP BETWEEN THE DATA AND THE CONCLUSION. THE TEAM SHOULD EXPLAIN IN MORE DETAIL HOW THEY REACHED THIS CONCLUSION.)* The negative effect appears earlier than direct effects of entrainment because the Team felt that earlier export of primary production, nutrients, and zooplankton might have *(MIGHT HAVE? THE TEAM NEEDS TO SUPPORT THIS CONCLUSION. WE NEED TO LOOK AT THE DATA.)* some effect on productivity later in the season, even though fish were not present.

Shallow/Nearshore Habitat: Shallow or nearshore habitat is important to delta smelt as spawning habitat. It is not believed to be as important to delta smelt as rearing habitat. *(SEE EARLIER COMMENTS REGARDING THE IMPORTANCE OF SHALLOW AND NEARSHORE HABITATS AS THEY RELATE TO THE BASIC LIFE HISTORY STRATEGY OF DELTA SMELT. WE DISAGREE STRONGLY WITH THE CONCLUSION.)* It was difficult to assign a value to this for two reasons. First, while it is clear that such habitat has declined it is unknown whether spawning habitat is a limiting factor on the population. Effects were assigned during the spawning season from December through May; however, uncertainty with the existence and magnitude of any effect is very high. Even thought the location and amount of available spawning habitat varies between wet and dry years the team did not feel that the magnitude of the effect varied enough to warrant a change in effect especially given the level of uncertainty involved. Second, the Team also believes that shallow-water habitat may have some value as a source of nutrients and production to the channels but there is no data to assess this hypothesis. ***(THIS STATEMENT IS SIMPLY NOT TRUE. SIMENSTAD=S WORK CLEARLY DEMONSTRATES THE INFLUENCE OF TIDALLY INFLUENCED WETLANDS IN TERMS OF INCREASED NUTRIENT TRANSFER FROM MARSHES INTO THE FOOD WEB. A MILLION OTHER FOLKS HAVE PROVEN THIS TO BE THE CASE ALSO. ALSO, THE TEAM DID NOT RECOGNIZE THE POTENTIAL OF REDUCED COMPETITION AND PREDATION ON DELTA SMELT AS A RESULT OF PROVIDING MORE DIVERSE AND COMPLEX HABITATS? JUD MONROE=S EVALUATION OF PREDATION AND THE PAPER ON HABITAT IMPROVEMENTS COMPLETED FOR CALFED SHOULD SERVE AS ADEQUATE REFERENCES.)***

Water Quality (Toxicants): There is no evidence of a population effect on delta smelt due to toxicants, ***(BASED ON WHAT DATA? THE TEAM NEEDS TO PROVIDE DATA AND ANALYSES TO SUPPORT THIS CONCLUSION. ALSO, THE SACRAMENTO RIVER SHOULD BE BROUGHT INTO THE DISCUSSION.)*** however, high levels of toxicants in runoff from agricultural pesticides (such as runoff from orchards in the San Joaquin River) potentially may have a deleterious effect on delta smelt or its food supply. Concentrations of some toxicants may be diluted by high outflow, although increased levels of toxicants may be applied with increased rainfall. Others only enter the aquatic ecosystem during rainstorms associated with high outflow (e.g. orchard dormant sprays and urban runoff).

Delta smelt are thought to be more vulnerable to toxicants at earlier life stages and when they are in the Delta portion of the estuary, therefore stronger and longer negative effects are thought to occur in dry years. Uncertainty regarding these relationships is very high. These values may change with input from the Water Quality Technical Team or similar group.

Water Quality (Temperature): Delta water temperatures are not controlled by water project operations. As water temperatures increase in the Delta, delta smelt are thought to move to cooler portions of the estuary, therefore the delta smelt team decided that there was Ano effect@ of temperature on delta smelt for either water year type.

Water Quality (Salinity/ X2 Position): The delta smelt team decided that the effects of salinity on delta smelt are best described by the relationship between delta smelt abundance and X2 position. ***(WE DISAGREE WITH THIS CONCLUSION FOR A VARIETY OF REASONS. THE PRIMARY REASONS ARE: 1) NO CAUSE AND EFFECT RELATIONSHIP HAS EVER BEEN EMPIRICALLY ESTABLISHED BETWEEN THE 2 PPT ISOHALINE POSITION IN THE SPRING AND ADULT POPULATION LEVELS, 2) THE FALL MIDWATER TRAWL INDEX HAS FUNDAMENTAL DESIGN AND CALCULATION PROBLEMS WHICH RENDER THE USE OF AN INDEX NUMBER, AS CURRENTLY***

CALCULATED, AS A CORRELATE HIGHLY QUESTIONABLE, AND 3) THE WEAKNESS OF THE EXISTING (FATALLY FLAWED?) RELATIONSHIP CLEARLY DEMONSTRATES THAT MANY OTHER FACTORS BESIDES X2 ARE INFLUENCING THE ABUNDANCE INDICES (ASSUMING THEY ARE VALID FOR THE MOMENT). WE NOTE THE CHANGE IN THE CORRELATIONS SINCE THE INTRODUCTIONS OF POTAMOCORBULA AND INLAND SILVERSIDES. DATA ANALYSES FOR THESE CONCERNS ARE CONTAINED IN THE CUWA SUBMISSION TO THE SWRCB=S 1994 WATER QUALITY STANDARDS HEARINGS. Although the relationship is somewhat weak, delta smelt are most abundant *(THIS STATEMENT IS ONLY PARTIALLY TRUE. I REFERENCE FOX=S AND BUELL=S WRITEUPS FOR THE CUWA SUBMISSION. BOTH ANALYSES INDICATE DELTA SMELT ABUNDANCE INDICES CAN BE EITHER HIGH, LOW, OR INTERMEDIATE WHEN X2 IS LOCATED IN SUISUN BAY DURING THE SPRING.)* when X2 is located in Suisun Bay in the spring. Maintenance of X2 position is mainly dependent on freshwater inflow to the estuary. In wet years, the salinity gradient has little effect on delta smelt except in the summer months when outflow declines and the gradient moves upstream into the delta. In dry years, the effects of salinity may be much longer and last from February through November. The months of February through April were given positive effects in order to reflect export limitations and X2 flow requirements under the 1994 Water Accord. *(THE ACCORD IS A TEMPORARY AGREEMENT TO BE USED UNTIL A SUITABLE SOLUTION IS REACHED. IT IS INAPPROPRIATE (LEGAL?) TO USE A TEMPORARY SITUATION TO EVALUATE THE LONG TERM ALTERNATIVES IN A NEPA DOCUMENT. A DIFFERENT CRITERION SHOULD BE USED BY THE TEAM AS APPROPRIATE.)*

Agricultural Diversions: There are over 1800 agricultural diversions in the delta, which at times in the summer may export a similar magnitude of water as the export facilities in the south delta. Additional agricultural diversions in Suisun Marsh have the ability to entrain delta smelt when the population is located farther downstream in Suisun Bay. Not only do these exports have the potential to entrain larval and juvenile fishes, plankton and nutrients are also diverted. There may be agricultural diversion effects on delta smelt year round in different areas of the estuary, however the majority of impact would be at high levels of diversion in the spring and summer.

The delta smelt team discussed including the barriers in the southern delta as an additional effect, however in the first draft of these matrices they were not considered. (MAYBE THIS SHOULD BE CONSIDERED IN HYDRODYNAMICS)
(WHAT DID THE TEAM CONCLUDE WITH RESPECT TO THIS FACTOR?)

No Action Conditions

Entrainment: Based on modeling runs the majority of the increased diversions resulting from the 2020 level of demand would occur in December-March and July-August. The largest increases in exports (resulting in higher levels of entrainment) occur in February and March in wet years, and December-March in dry years. During this period, pre-spawning adults might be entrained at higher rates. The July increase in wet years was given a greater effect because young-of-year delta smelt are more likely to be in the area at that time compared to August.

Hydrodynamics: Changes in hydrology based on the increased level of demand are similar to existing conditions with increases in negative effects observed throughout the winter and spring. The magnitude of the effect might be greater in wet years since additional water would be available to be exported in the spring. Negative effects were lessened in April of both year types for export constraints already in place. The reduction did not carry through May because protections are curtailed while large numbers of young smelt are still present. San Joaquin River at Antioch appeared slightly worse in December and January, which may have an effect on adult delta smelt staging to move into the Delta.

Predation: No change from existing conditions for wet years with no additional effect. In dry years there is the potential for increased effects in the winter when additional water is exported; however, no changes in scores were made.

Handling: No change from existing conditions for wet years with no additional effect. In dry years there is the potential for increased effects in the winter when additional water is exported; however, no changes in scores were made.

Food Supply: With increased exports in the winter, higher levels of primary production and zooplankton are also exported. The team decided that this additional effect would be observed in December and January.

Shallow/Nearshore Habitat: The increased level of demand in the No Action Alternative would not change the amount or effect of shallow/nearshore habitat.

Water Quality (Toxicants): No change from existing conditions.

Water Quality (Temperature): No change from existing conditions.

Salinity/ X2 Position: According to the modeling runs available, there is little discernible difference in X2 position between the existing and no action conditions. The numbers in the matrix reflect these numbers. (For the consideration of the group our original comments were: With increased exports in the winter and early spring, there might be additional effects on habitat conditions in the spring. In wet years, these effects may be observed in January and February if rainfall occurs later in the spring. In dry years the effect may be observed from December through March. Our original comments were based on extrapolations from total Delta outflow.)

Agricultural Diversions: Unless there is same change in demand, no change in existing conditions is anticipated.

Common Programs

Entrainment: The Common programs do not address this issue.

Hydrodynamics: The Common programs do not address this issue.

Predation: The Common programs do not address this issue.

Handling: The Common programs do not address this issue.

Food Supply: Restoration programs and increases in Shallow/nearshore habitat may lead to increases in primary production, which may be a benefit year round.

Shallow/Nearshore Habitat: Additional shallow/nearshore habitat may benefit delta smelt in terms of spawning habitat. Shallow water areas as nursery habitat do not appear to be that important to delta smelt. This benefit is uncertain because there is no evidence that shallow/nearshore habitat is a limiting factor on the population.

Water Quality (Toxicants): Source control of application of toxicants as well as period of application may benefit delta smelt in dry years. This benefit will depend on the exact nature of the programs initiated. The benefit also makes the assumption that effects are presently occurring even though there is no definitive evidence demonstrating such effects.

Water Quality (Temperature): Common programs may affect the temperature of water coming into the Delta but no in-Delta change is anticipated.

Salinity/ X2 Position: The Common programs do not address this issue.

Agricultural Diversions: There is a net benefit of screening for delta smelt, which may be observed throughout the entire year. The largest magnitude of a positive benefit of screening would be observed in months when delta smelt are in close proximity to agricultural diversions and demand is high. This assumes that screening criteria and diversion consolidation can be designed to minimize effects on all life stages of delta smelt. Benefits will have to be adjusted if only certain life stages are benefited. This benefit includes screening and consolidation in Suisun Marsh.

Alternative 1

Alternative 1 was assumed to be the result of the benefits of the common programs above the existing conditions added to the No Action Alternative (expressed as Alt 1 = (Common Programs - Existing Conditions) + NA). See the text for the No Action alternative for explanations of factors.

Entrainment:

Hydrodynamics:

Predation:

Handling:

Food Supply:

Shallow/Nearshore Habitat:

Water Quality (Toxicants):

Water Quality (Temperature):

Water Quality (Salinity/ X2 Position):

Agricultural Diversions:

Alternative 2

Entrainment: Increased exports from the southern Delta in December through March in all years were assigned a large negative effect because of the size of the increase (about 3,000 cfs). A similar large increase occurred in July and August.

Less effect was assigned to direct entrainment at the times of the year when delta smelt would be large enough for effective screening, if screens with the correct criteria can be designed. Additional negative effects were assigned to handling because screened fish will have to pass through a bypass system. Clifton Court Forebay predation effects are now defined as taking place in front of the screens rather than in the Forebay proper. The greater effect in dry years results from a larger proportion of the population experiencing the effects.

Hydrodynamics: In wet years, modeling results indicate improvements in Qwest; however, Cross-Delta flows and Flows at Old River @ Bacon Island get worse. These negative effects outweigh the improvement in Qwest. In dry years, the negative effects are magnified, especially for Cross-Delta flow and Old River at Bacon Island. Reductions in flow of the Sacramento River were also assigned a negative value. Qwest remained favorable, except for June, July and August, when slight negative effects were assigned. Conditions in the San Joaquin River at Antioch remained favorable all year. The large negative effect of Alternative 2 is linked not only to hydrodynamic changes but to interactions with the physical changes as well. The Team believes that with this alternative any net production of delta smelt to the east of the Anew@ canal would be completely lost. It also seemed possible that young-of-year produced to the west of the new canal could be at risk if tidal action periodically moves young-of year in and out of the areas influenced by the new canal. It seems likely that hydrodynamic effects of east-west (more or less) tides on the water moving north-south (more or less) in the canal will be complex and difficult or impossible to model with existing tools.

Predation: No change from Alternative 1.

Food Supply: No change from Alternative 1.

Shallow/Nearshore Habitat: The possible benefits of shallow/nearshore habitat were reduced because strong Cross-Delta flows would reduce the value of such habitat within the influence of the diverted water.

Water Quality (Toxicants): No change from Alternative 1.

Salinity/ X2 Position: No change from Alternative 1.

Agricultural Diversions: No change from Alternative 1.

Alternative 3

Entrainment: The isolated facility reduces entrainment effects substantially and a large positive benefit (compared to existing conditions) is assigned. Reduction in predation is assigned a similar benefit. There is still some pumping from the South Delta and some negative effect is still assigned to the fish that would go through the bypass facility.

Hydrodynamics: Alternative three improves Cross-Delta and Old River flows substantially resulting in substantial improvement for delta smelt. Positive benefits are assigned to increased San Joaquin River flows in this alternative because there is no longer any complicating interactions with Cross-Delta and Old River flows, which stay positive in all months.

In dry years positive benefit was assigned to Old River at Bacon Island because negative flows were reduced and in February-June were near zero.

Predation: Predation in the Delta declines because hydrodynamics are now favorable and fish are no longer held in the Delta for an extended period of time.

Food Supply: No major change from Alternative 1.

Shallow/Nearshore Habitat: No change from Alternative 1.

Water Quality (Toxicants): No change from Alternative 1.

Salinity/ X2 Position:

Modeling results indicate a decrease in X2 position of roughly 2 kilometers in July and 6 kilometers in August (also 4 kilometers in September). This was given a positive benefit though it seems inconceivable to the Team that this is not a mistake. Why would Alternative 3 be operated in this way?

Agricultural Diversions: No change from Alternative 1.

Primary Issues

1. Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?

No Action: Larvae and young juveniles are the most sensitive life stages. These life stages are present in the spring and early summer. The major effects occur in the central and south Delta where altered hydrodynamics and entrainment are important. As delta smelt become adults, they migrate downstream to brackish water areas in the fall and winter and are considered less vulnerable to diversion effects. Pre-spawning adults migrating back into freshwater to spawn in the late winter and early spring become vulnerable to entrainment effects once again.

Alternative 1: The same as No Action.

Alternative 2: Larvae and young juveniles are still the most sensitive stages and are still vulnerable at the same times. The major changes in hydrodynamics anticipated with Alternative 2 are believed to be a negative factor for all life stages of delta smelt, but especially these sensitive stages. These negative effects are expected to be most severe in the eastern Delta.

Alternative 3: Alternative 3 was given high benefit because of its positive effects on returning Delta hydrodynamics to a more Anatural@ condition, meaning the rivers and most channels maintain positive outflows at most times and places. Positive benefits for delta smelt may be high compared to other species because it is the only species to complete its entire life cycle in the estuary.

2. Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?

No, common program actions have very uncertain effects for delta smelt but it seems unlikely that the positive benefits will outweigh the entrainment and hydrodynamic effects.

3. To what extent can alternatives 1, 2, and 3 offset diversions effects as presently configured?

Alternative 1: Little effect.

Alternative 2: Makes things much worse.

Alternative 3: Makes things much better.

4. To what extent can diversion effects be offset by modifications to the alternatives or by operational changes?

(Not to be answered yet)

5. What is the risk and chances of success of species recovery for each alternative?

For the delta smelt team recovery is defined in AThe Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes@ (Appendix 1). Alternative 1 is not a major change and probably has little influence on probability of recovery. Alternative 2 seems likely to negatively affect probability of recovery. Alternative 3 seems likely to improve the probability of recovery. All of these assessments are subject to the uncertainties already identified above.

6. What increment of protection or improvement for delta smelt will be provided by other programs such as the CVPIA, biological opinions?

The protections set forth for delta smelt under the Biological Opinion (USFWS 1995a) on the operation of the State and Federal water project diversions are similar to conditions set forth in the 1994 Water Accord and therefore are considered part of the baseline conditions known as Aexisting conditions@ in the model runs provided.

7. What degree of benefit and impact will the common programs provide?

We estimated that improvement would occur with the common programs. Much of the benefit predicted is due to the creation of additional shallow water habitat of several different types. The effect on delta smelt is uncertain. Much of this uncertainty stems from the scarcity of evidence of the effects of increasing such habitat. Delta smelt use such habitat for spawning but it seems to be of no special importance as rearing habitat. There is no evidence that spawning habitat is a limiting factor for the delta smelt population. While the habitat will also be favorable for predators, the increased spawning habitat and possible increases in Delta primary productivity and food supply were believed to be possible benefits and were assigned benefits even though this is an area of high uncertainty. Screening Delta diversions and improved Delta water quality are also expected to be beneficial.

8). What are the direct and indirect effects on delta smelt populations resulting from each Alternative and what is the expected response of the populations to these effects?

The improvement in conditions for Alternatives 1 and 2 are purely a result of the benefits assigned to the common programs. Neither of these alternatives improves in-Delta hydrodynamics to a significant degree, and the team believes that Alternative 2 will result in hydrodynamic conditions that are significantly worse than any other alternative. Alternative 3 performs best for delta smelt because the hydrodynamic changes associated with this alternative appear likely to have positive effects on the delta smelt population in addition to the positive effects of the common programs.

A summary of our assessments suggest that Alternatives 1 and 2 will aid the delta smelt population somewhat, through improvements related to the common programs, and that

Alternative 3 represents a significant improvement. However, it is unclear if the population will actually benefit to the degree anticipated in this document. Recent studies suggest that the success of the delta smelt population might be linked to timing and abundance of particular food organisms. Further, the ecology of these food organisms may be linked more to the effects of introduced predators and competitors than to the issues addressed in the alternatives. If this is actually the case, then the anticipated beneficial effects of the alternatives for delta smelt might not actually be achieved.

9. What Sacramento River flow is required below a Hood diversion to protect delta smelt?

10. What survival rate can be expected for delta smelt passing through Sacramento River screen and pumps in Alternative 2?

11. Should there be a screen on the Sacramento River intake of Alternative 2?

Yes.

12. What are the logical stages for a preferred alternative?

13. What is the range of biological criteria that should be considered in the operations of the three alternatives?

References
(including Appendix 1)

Moyle, P.B., B. Herbold, D.E. Stevens, and L.W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society.121:67-77.

Swanson, C. P.S. Young and J.J. Cech. 1998. Swimming performance of delta smelt: maximum performance, and behavioral and kinematic limitations on swimming at submaximal velocities. Journal of Experimental Biology: 201, 333-345.

Sweetnam, D.S. and D.E. Stevens. 1993. Report to the Fish and Game Commission: a status review of the delta smelt, (*Hypomesus transpacificus*) in California. California Department of Fish and Game. Candidate Status Report 93-DS.

U.S. Fish and Wildlife Service. 1995a. Formal consultation and conference on effects of long-term operation of the Central Valley Project and the State Water Project on the threatened delta smelt, delta smelt critical habitat, and proposed threatened Sacramento splittail, March 6, 1995. U.S. Fish and Wildlife Service, Portland Oregon. 52pp.

U.S. Fish and Wildlife Service. 1995b. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife service, Portland, Oregon. 195pp.

Appendix 1

The following is the Recovery section of the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes for delta smelt (USFWS 1995b), pages 29-34 and 37-38:

RECOVERY

Recovery Objective

The objective of this part of the Delta Native Fishes Recovery Plan is to remove delta smelt from the Federal list of threatened species through restoration of its abundance and distribution. Recovery of delta smelt should not be at the expense of other native fishes. The basic strategy for recovery is to manage the estuary in such a way that it is a better habitat for native fish in general and delta smelt in particular. Improved habitat will allow delta smelt to be widely distributed throughout the Delta and Suisun Bay, recognizing that areas of abundance change with season. Recovery of delta smelt will consist of two phases, restoration and delisting. Separate restoration and delisting periods were identified because it is possible that restoration criteria can be met fairly quickly in the absence of consecutive extreme outflow years (I. e., extremely wet or dry years). However, without the population being tested by extreme outflows there is no assurance of long-term survival for the species. Thus, restoration is defined as a return of the population to pre-decline levels, but delisting is not recommended until the population has been tested by extreme outflows. Delta smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period. This period was chosen because it includes the earliest continuous data on delta smelt abundances and was a period in which populations stayed reasonably high in most years (see below for a more detailed justification). The species will be considered recovered and qualify for delisting when it goes through a five-year period that includes two sequential years of extreme outflows, one of which must be dry or critically dry. Delta smelt will be considered for delisting when the species meets recovery criteria under stressor conditions comparable to those that led to listing and mechanisms are in place that insure the species' continued existence.

Recovery Criteria

Restoration of delta smelt should be assessed when the species satisfies distributional and abundance criteria. Distributional criteria include: (1) catches of delta smelt in all zones 2 of 5 consecutive years, (2) in at least two zones in 1 of the remaining 3 years, and, (3) in at least one zone for the remaining 2 years. Abundance criteria are: delta smelt numbers or total catch must equal or exceed 239 for 2 out of 5 years and not fall below 84 for more than two years in a row. Distributional and abundance criteria can be met in different years. If abundance and distributional criteria are met for a five-year period the species will be considered restored. Delta smelt will meet the remaining recovery criteria and be considered for delisting when abundance and distributional criteria are met for a five-year period that includes two successive extreme outflow years, with one year dry or critical. Delisting is contingent on the placement of legal mechanisms and interagency agreements to manage the CVP, SWP, and other water users to meet these criteria. Both criteria depend on data collected by DFG during the FMWT, during September and October.

Justification for using FMWT numbers: The FMWT covers the entire range of delta smelt distribution and provides one of the two best measures of delta smelt abundance (Sweetnam and Stevens 1993). The summer tow-net survey samples juveniles of this annual species and provides another good measure of abundance. The FMWT provides a better measure of abundance because it samples pre-spawning adult delta smelt. An index based on pre-spawning adults, rather than on juveniles, which are vulnerable to high mortality, provides a better estimate of delta smelt stock and recruitment. The FMWT may not be as efficient at sampling delta smelt compared with the Kodiak trawl, which is pulled by two boats and tends to sample the upper water column, but it has been continuously done for almost 30 years (since 1967) and so has a solid base of historical data with known sampling error.

September and October numbers of adults were chosen, because these are the months that were sampled most consistently in all years. In addition, when delta smelt begin moving upstream to spawn in November and December, they occur less frequently in the FMWT. Weather conditions are also more stable in September and October. The more frequent storms of November and December produce conditions that result in more variability in fish-capture numbers. There is a high correlation between September and October numbers and total numbers ($r= 0.93$).

Number of delta smelt rather than abundance index was used for recovery criteria. The abundance index was initially developed for striped bass. Numbers were chosen because delta smelt occupy the upper water column. Multiplying delta smelt captured by volume of water in the portion of the estuary sampled probably doesn't give a good representation of the number of fish present. Using numbers for delta smelt simplifies the assumptions of the criteria and there is a close correspondence between numbers and the abundance index for delta smelt ($r=0.89$).

Justification for using 1967-1981 for the standard: Graphs from different surveys were used to establish pre-decline and post-decline periods for delta smelt (Moyle *et al.* 1992). The surveys included were: (1) FMWT, (2) summer tow-net, (3) Suisun Marsh fish survey, and, (4) the bay survey (Appendix A). Each of the surveys showed slightly different patterns of decline. The most noticeable trend is that delta smelt decline began earlier in the south and east Delta than in the rest of the estuary (Sweetnam and Stevens 1993). The pre-decline period identified by Moyle *et al.* (1992) is 1967 through and including 1981; the post-decline period is 1982-92. Using 1982 as the beginning of the decline period is justified because 1982 and 1983 were very wet years and declines in delta smelt abundance correspond to extremes in outflow: very wet and very dry years result in low numbers (Moyle *et al.* 1992). The mechanisms for this are that delta smelt larvae are washed downstream of favorable nursery grounds in wet years; dry years decrease spawning habitat and move adults and juveniles upstream into less productive deep river channels where they are more at risk to entrainment in water projects.

Other alternatives were proposed for the decline period. One possibility was to use 1981 as the beginning of the decline period because it was a dry year followed by the wet year 1982. The occurrence of a dry year followed by a wet year produces a double stress on delta smelt and this may have been the true beginning of the decline. An argument can also be made for using 1983 as the beginning of the decline: this is the year that delta smelt declined in the FMWT and so is consistent with other recovery criteria (which is based on the FMWT). There is a noticeable change in geographic distribution of delta smelt in 1982 and 1983, which corresponds to the periods used in the Biological Opinion and the decline in FMWT numbers, respectively. The decline in delta smelt numbers actually occurred over a multi-year period from 1981-1983; the midpoint of this period, 1982, was used as the beginning of the decline.

Justification for including distributional recovery criteria: Geographical distribution and numbers of fish were used to measure recovery because recovery of delta smelt should include a restoration of the species to portions of their former range. Before 1982, delta smelt were captured at an average of 19 FMWT stations; after 1981 they were captured at an average of 10 stations. From 1986-1992, the delta smelt population was concentrated in the lower Sacramento River between Collinsville and Rio Vista (Sweetnam and Stevens 1993). Historically, when delta smelt were more abundant, the population was spread from Suisun Bay and Montezuma Slough through the Delta. The shallow, productive waters of Suisun Bay and Suisun Marsh are important habitat for delta smelt. Large percentages of delta smelt catches are in Suisun Bay when outflows are sufficient to maintain the mixing zone and salinities of 2-3 parts per thousand in that area. When concentrated in deep river channels due to intrusion of high salinities in Suisun Bay, delta smelt are more vulnerable to entrainment in water
project facilities, predation and other risks.

FMWT stations chosen to measure recovery: Stations chosen for recovery criteria were sampled in every year (that the FMWT was conducted) and had a record of delta smelt catches. Occasionally, this was modified to include stations sampled in all years but one (stations 509, 511, 602). The total number of stations is 35 and there is a strong correlation between delta smelt at **these stations and** total numbers of delta smelt (r = 0.94).

Zone A (North Central Delta)
11 stations
802 804 806 808 810 812 814 903 904 906 908

Zone B1 (Sacramento River)
5 stations
701 703 705 707 709

Zone B2 (Montezuma Slough)
4 stations
602 604 606 608

Zone C (Suisun Bay)
15 stations
410 412 414 416 418 501 503 505 507 509 511 513 515 517 519

Distributional criteria: Distributional criteria were developed on the basis of number of stations in each zone where delta smelt were captured during the predecline period (Tables 2.2, 2.3, Figures 2.7 and 2.8). Each zone has the following criteria: (1) in Zone A, delta smelt must be captured in 2 of 11 sites; (2) in Zone B (includes B1 and B2), delta smelt must be captured in 5 of 9 sites; and (3) in Zone C, delta smelt must be captured in 6 of 15 sites. Criteria for all zones need to be met in all years. Criteria for recovery are as follows: (1) site criteria must be met in all zones 2 of 5 consecutive years, (2) in at least two zones in 1 of the remaining 3 years, and, (3) in at least one zone for the remaining 2 years. A failure in all zones in any year will result in the start of a new 5-year evaluation period for the distributional criteria. Failure to meet these criteria in consecutive years should be avoided because such conditions will place the species in danger of extinction. These distributional criteria will be met in concert with the abundance criteria.

Abundance criteria: Abundance of delta smelt constituting recovery is based on pre-decline delta smelt numbers from the FMWT (Table 2.3). Two numbers were identified that had to be met during the five-year recovery period: (1) a low number below which abundance can not fall for more than two years in a row and, (2) a high number to be reached or exceeded in two out of five years. A low number was chosen to protect delta smelt from the risk of extinction during prolonged droughts or extremes of outflow. The lowest two-year running average of abundance in the pre-decline years was used for the low number. A running average was used because of the great degree of variability in delta smelt abundance. The high number is the median of delta smelt abundance in pre-decline years, in other words, abundance of delta smelt half of the time in the pre-decline period. To meet recovery criteria, delta smelt abundance must meet or exceed 239 in two out of five years and the two-year running average must never fall below 84. If any of these conditions are not met, the five-year recovery period will start again.

Length of restoration and recovery period: Delta smelt generation time and frequency of occurrence of very dry and very wet years were used to determine appropriate length of the restoration period. Because delta smelt live only a year, a five-year recovery period would include five generations of delta smelt; five generations is comparable to the period used in recovery plans for other fishes. A five-year restoration period has a reasonable probability of including years with extreme outflow. The 40:30:30 (Footnote: Year-type categories adopted by the SWRCB in the 1991 Salinity Control Plan.) Sacramento River Indices (SRI) from 1906-1992 was used for this analysis. The goal was to identify a period that had a high probability of including two extreme outflow years, preferably back-to-back. This method was chosen because when two extreme years occur together, delta smelt are at risk of extinction. Because extremes in outflow led to the listing of the delta smelt, the period identified for recovery differs from restoration and includes a stressor period. Delta smelt will be considered for delisting when abundance and distributional criteria have been met over a five-year period that includes two sequential years of extreme outflows. However, delisting may not take place until there is reasonable assurance that long term solutions to delta problems are in place. One of the extreme years must be dry or critically dry (SRI $\leq$6.0); the other can be wet SRI $\geq$11.2). Other indices can be used to identify dry, critically dry, and wet years, if appropriate. Dry conditions are included because delta smelt losses increase in dry and critical years due to high proportions of outflow diverted, which results in habitat loss and increased entrainment in water projects. Analysis of the historical hydrograph indicated that there is about a 24 percent chance that two extreme years (one being dry or critical) will occur in a five-year period. There is a 48 percent chance (based on the historical hydrograph) that the period of time required to delist delta smelt could be 10 years. According to existing records, the longest amount of time required to delist delta smelt is 38 years.

Table 2.2 Number of sites with delta smelt from FMWT September and October numbers for 35 stations. Numbers in brackets refer to station numbers. The FMWT did not sample in 1974 and 1979. See Figure 2.8 for how minimum number of sites was determined.

Sites

Year	Zone C Suisun Bay (410-519)	Zone B Montezuma Slough Sacramento River (602-709)	Zone A North Central Delta (802-908)
		Pre-decline	
1967	6	8	2
1968	9	6	8
1969	11	7	0
1970	12	8	7
1971	13	8	8
1972	12	8	9
1973	9	9	4
1975	12	5	5
1976	1	5	2
1977	0	5	5
1978	11	6	0
1980	10	8	3
1981	8	6	0
Minimum number of sites	6 of 15	5 of 9	2 of 11
Number of years minimum number of sites occurred	11 out of 13	13 of 13	10 of 13
		Post-decline	
1982	6	6	1
1983	5	4	0
1984	9	3	0
1985	2	3	0
1986	10	5	1
1987	2	4	1
1988	3	3	0
1989	6	5	3
1990	4	6	0
1991	4	6	3
1992	0	5	1
1993	12	6	4
1994*	**1**	**5**	**1**
1995*	**14**	**7**	**1**
1996*	**8**	**4**	**2**
1997*	**3**	**4**	**1**
Number of years minimum number of sites occurred	7 out of 16	9 of 16	4 of 16

Table 2.3 Numbers used for delta smelt abundance criteria. Numbers are from the September and October FMWT for 35 stations. The FMWT did not sample 1974 and 1979.

Year	Number	Two-year running average
	Pre-decline	
1967	139	
1968	251	195
1969	128	190
1970	589	359
1971	352	471
1972	551	452
1973	305	428
1975	**239**	272
1976	22	131
1977	146	**84**
1978	108	127
1980	312	210
1981	78	195
	Post-decline	
1982	37	58
1983	17	27
1984	51	34
1985	29	40
1986	70	50
1987	72	71
1988	43	58
1989	76	60
1990	81	79
1991	171	126
1992	26	98
1993	400	213
1994*	**19**	**210**
1995*	**255**	**137**
1996*	**28**	**146**
1997*	**62**	**44****

*** - Criteria updated to 1997**
**** - Two-Year Running Average below 84 criteria**