State of California
The Resources Agency
Department of Water Resources

COLLECTION, HANDLING, TRANSPORT, RELEASE (CHTR) NEW TECHNOLOGIES PROPOSAL: PHASE 1 BASELINE CONDITIONS

MAY 2005

ARNOLD SCHWARZENEGGER
Governor
State of California

MIKE CHRISMAN
Secretary
The Resources Agency

LESTER A. SNOW
Director
Department of Water Resources

State of California
The Resources Agency
Department of Water Resources

DRAFT COLLECTION, HANDLING, TRANSPORT, RELEASE (CHTR) NEW TECHNOLOGIES PROPOSAL: PHASE 1 BASELINE CONDITIONS

MAY 2005

Prepared by:

Roger Churchwell, P.E. .... Senior Engineer WR
Roger Padilla .... Engineer WR
Dennis Dorratcague, P.E. .... MWH Americas
Charles Hanson, Ph D .... Hanson Environmental
Peter Barton, P.E. .... MWH Americas
Justin Taplin .... Hanson Environmental

CA Department of Water Resources
Division of Environmental Services
Fish Facilities Section
3251 S Street
Sacramento, CA, 95816

In coordination with:
Central Valley Fish Facilities Review Team,
California Department of Fish and Game,
CHTR Coordination Team

State of California
The Resources Agency
Department of Water Resources

CHTR RELEASE PROPOSAL

TABLE OF CONTENTS

1.0 PROJECT SUMMARY 1

1.1 Background 1
1.2 John E. Skinner Fish Protection Facility 1
1.3 Fish Protection Research 7
1.4 Collection, Handling, Transport, and Release (CHTR) Release Proposal 11
1.5 References 12

2.0 PROBLEM STATEMENT 14

2.1 CHTR Process and Survival of Fish Following Release 14
2.1.1 Hydraulics at Release 14
2.1.2 Debris 16
2.1.3 Method of Introducing Flushing Flow 18
2.1.4 Geometry of Release Pipe Connection 18
2.1.5 Characteristics of Flow in the Release Pipe 18
2.1.6 Predation at Release Pipe Exit 19
2.1.7 Water Quality 20
2.1.8 Suitability of release pipe location 20
2.2 Coordination and Integration with Other CHTR Investigations 20
2.2.1 United State Bureau of Reclamation (USBR) 21
2.2.2 California Department of Fish and Game (CDFG) 21
2.2.3 University of California at Davis (UCD) 22
2.2.4 Study Team 22
2.2.5 CHTR Coordinating Team (CHTRCT) 24
2.3 Alternative Technologies 24
2.4 Conceptual Model 26
2.5 Research Objectives 28
2.6 Alternative Technologies Decision Framework (ATDF) 28
2.7 Elements of the Investigation 28
2.8 Adaptive Management 28
2.9 IEP Management Team and CVFFRT Status Reports 29
2.10 References 29

3.0 ELEMENT 1 - SURVIVAL FOLLOWING RELEASE *(IN RESPONSE TO COMMENTS, ELEMENT 1 HAS BEEN DELETED FROM THE PROPOSAL. IT WILL BE SUBMITTED AT A LATER DATE UNDER SEPARATE COVER)* 31

4.0 ELEMENT 2 - PREDATION AS A FACTOR CONTRIBUTING TO MORTALITY AT RELEASE 32

4.1 Research Problem Statement and Objectives 32
4.2 Linkage to Conceptual Model and Decision Framework 33
4.3 Research Questions in Detail 34
4.4 Hypotheses to be Tested 35
4.5 Assumptions and Limitations 36
4.6 Experimental Design, Methods and Approach 37
4.6.1 Hypothetical Predation Risk Analysis 41
4.6.2 Bioacoustic Determination of Predatory Fish Abundance, Distribution, and Behavior 43
4.6.3 DIDSON Observations of Predator Fish Behavior Before, During, and After Release 46
4.6.4 Sampling to Determine Predator Species Composition and Density at Release Sites 47
4.6.5 Radio/Acoustic Tagging to Examine Predator Movement (site fidelity, attraction) at Release Sites 48
4.7 Coordination 49
4.8 Data Analysis 50

4.9 Data Synthesis 52
4.10 Documentation Reporting and Dissemination of Results 53
4.11 ESA Incidental Take 53
4.12 Investigators and Staff 53
4.13 Equipment Requirements 54
4.14 References 54

5.0 ELEMENT 3. - PHYSICAL FACTORS INFLUENCING MORTALITY DURING RELEASE 57

5.1 Research Problem Statement and Objectives 57
5.2 Linkage to Conceptual Model and Other Studies 58
5.3 Decision Framework 59
5.4 Research Questions in Detail 61
5.5 Hypotheses to be Tested 62
5.6 Assumptions and Limitations 62
5.7 Experimental Design, Methods and Approach 62
5.8 Coordination 64
5.9 Data Analysis 65
5.10 Data Synthesis 65
5.11 Documentation Reporting and Dissemination of Results 66
5.12 ESA Incidental Take 66
5.13 Investigators and Staff 66
5.14 Equipment Requirements 66
5.14.1 Skinner Test Facility 67
5.15 University of California at Davis 67
5.16 References 68

6.0 PROJECT SCHEDULE AND MILESTONES 69

7.0 BUDGETS 70

7.1 Table 7-1 Summary of Costs 70
7.2 Table 7-2 Element 2 Costs 70
7.3 Table 7-3 Element 3 Costs 70

8.0 PERSONNEL NEEDS 71

APPENDICES

APPENDIX 1	**Omitted**
APPENDIX 2	**Standard Operating Procedures for Element 2**
APPENDIX 3	**Standard Operating Procedures for Element 3**
APPENDIX 4	**Qualifications of Investigators**
APPENDIX 5	**Evaluation of Collection, Handling, Transport and Release Effects on Delta Smelt (Hypomesus transpacificus) Salvaged at Southern Delta Water Export Facilities: Program Proposal (Coulston et.al., 2004)**

PHOTOS

Photo 2-1	**Debris Accumulates on SWP Trash Boom**
Photo 2-2	**Debris Clogged Trash Rake**
Photo 2-3	**Fish Transport Truck Outlet is Clogged During Release**
Photo 2-4	**SWP Horseshoe Bend Release Pipe**
Photo 2-5	**DIDSON Camera Image**

FIGURES

Figure 1-1	**Skinner Fish Protection Facility Layout**
Figure 1-2	**CHTR Process**
Figure 1-3	**Project Area**
Figure 1-4	**Clifton Court Forebay**
Figure 1-5	**Release Sites**
Figure 1-6	**Study Coverage**
Figure 1-7	**CHTR Mortality Measurements**
Figure 2-1	**SWP Release Site at Horseshoe Bend**
Figure 2-2	**Organization Chart**
Figure 2-3	**Conceptual Model**
Figure 4-1	**Element 2 Decision Framework**
Figure 5-1	**Element 3 Conceptual Model**

TABLES

Table 5-1	**Element 3 Decision Framework**
Table 7-1	**Summary of Costs**
Table 7-2	**Element 2 Costs**
Table 7-3	**Element 3 Costs**
Table 8-1	**Element 2 Personnel Needs**
Table 8-2	**Element 3 Personnel Needs**

LIST OF ABBREVIATIONS

CBDA	**California Bay Delta Authority**
CCFTAT	**Clifton Court Forestry Technical Advisory Team**
CDFG	**California Department of Fish & Game**
CHTR	**Collection, Handling, Transport & Release**
CVFFRT	**Central Valley Fish Facilities Review Team**
CVP	**Central Valley Project**
CWT	**Coded Wire Tagging**
DIDSON	**Dual Frequency Identification Sonar**
DO	**Dissolved Oxygen**
DWR	**(California) Department of Water Resources**
EC	**Electrical Conductivity**
ESA	**Endangered Species Act**
HE	**Hanson Environmental**
IEP	**Interagency Ecological Program**
NMFS	**National Marine Fisheries Service (now NOAA Fisheries)**
NOAA	**National Oceanic & Atmospheric Administration**
SWP	**State Water Project**
TFCF	**Tracy Fish Collection Facility**
TTAT	**Tracy Technical Advisory Team**
UCD	**University of California at Davis**
USBR	**United States Bureau of Reclamation**
USFWS	**United States Fish & Wildlife Service**
VAMP	**Vernalis Adaptive Management Plan**

CHTR RELEASE PROPOSAL

1.0 PROJECT SUMMARY

1.1 Background

The State Water Project (SWP) John E. Skinner Fish Protection Facility and the Central Valley Project (CVP) Tracy Fish Collection Facility (TFCF) were designed to protect fish from entrainment in the water diverted at these projects in the Sacramento/San Joaquin Delta (Delta). Operation of these facilities involves the collection, handling, transport, and release (CHTR) of a diverse assemblage of fish species including delta smelt, Chinook salmon, steelhead, and other resident and migratory species. Delta smelt, winter-run and spring-run Chinook salmon have been listed for protection under both the California and Federal Endangered Species Acts (ESA). Central Valley steelhead have been listed for protection under the federal ESA. Operation of the SWP and CVP, therefore, is necessarily performed in compliance with terms and conditions of the National Oceanic and Atmospheric Administration (NOAA) Fisheries and US Fish and Wildlife Service (USFWS) biological opinions and incidental take permits regulating the numbers of protected fish that can lawfully be taken during routine operations of the water diversion facilities. Currently, salvage monitoring and the calculation of incidental take of delta smelt assumes 100% mortality, in part as a result of anticipated stress and injury resulting from the diversion process. Results of investigations conducted at the fish salvage facilities in the past have provided mixed results regarding survival of delta smelt salvaged from the facilities and returned to the estuary. Several investigations showed that survival of delta smelt and other fish species is low (Odenweller 1990, Raquel 1989, Foss 2002) while other investigations (Morinaka 1995) suggest that the survival of delta smelt following salvage and return may be relatively high. The survival of delta smelt, and the factors associated with capture, handling, transfer at the fish salvage facilities affecting survival of delta smelt and other species, are largely unknown. An assessment and evaluation of the survival of delta smelt and other species at each stage in the CHTR process and identification of the factors contributing to high or low survival would provide valuable information for use in identifying alternative or new technologies and/or operational procedures that would reduce stress and improve survival of delta smelt and other fish species.

1.2 John E. Skinner Fish Protection Facility

The John E. Skinner Fish Protection Facility was built in the 1960's and designed to prevent fish from being entrained in water flowing to the SWP pumps in the south Delta. The facility was designed to screen a maximum of 10,300 cfs and bypass fish to holding tanks from which they would be loaded into tank trucks for transport to release sites. Water is drawn to the Skinner facility through Clifton Court Forebay, which is used as forebay storage for the pumping plant. Water drawn from Clifton Court first travels by a channel to the Floating Trash Boom, which is designed to intercept floating debris and guide it to the Trash Conveyor on shore. See Figure 1-1.

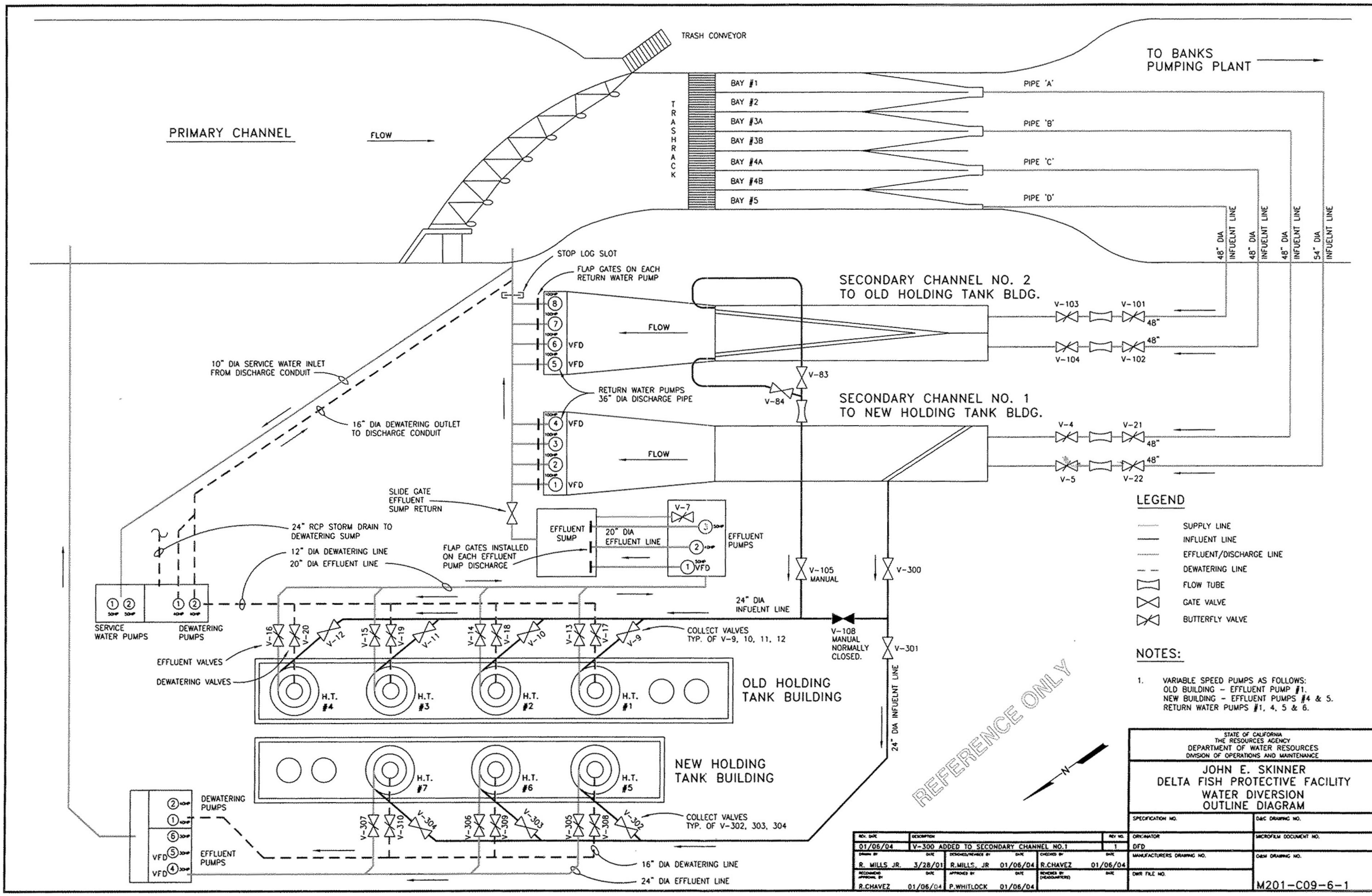


Figure 1-1 Skinner Fish Protection Facility Layout

Water and fish then flow through a trashrack equipped with a trash rake to a series of louvers arranged in a Vee pattern (three and one-half Vees). Fish are guided down the Vees to four Primary Bypass pipes, A, B, C, and D. The fish then travel to one of two secondary channels. Channel No. 1 is equipped with louvers and Channel No. 2 is equipped with perforated plate screens. Fish bypassed from Secondary Channel No. 1 travel through a pipe to the New Holding Tank Building. Two pipes carry fish bypassed from Secondary Channel No. 2 to the Old Holding Tank Building. The bypass flow and fish can be directed to either holding tank facility by means of a cross over valve (V-108), but only one holding tank building can be used at once if the cross over is activated. Return Water Pumps (one through eight on Figure 1-1) draw water through the secondary channels, and Effluent Pumps (one through six on Figure 1-1) draw water through the secondary bypasses and holding tanks.

Fish in the holding tank are held for four to 8 hours at Tracy and up to twenty-four hours at CVP depending on the time of year, presence of endangered species, and other factors, after which the tank is drained and fish are collected into a transfer bucket. The transfer bucket is lifted by a bridge crane in the holding tank building and placed above the tank truck hatch. The valve at the bottom of the transfer bucket is opened releasing fish and water into the truck. See Figure 1-2.

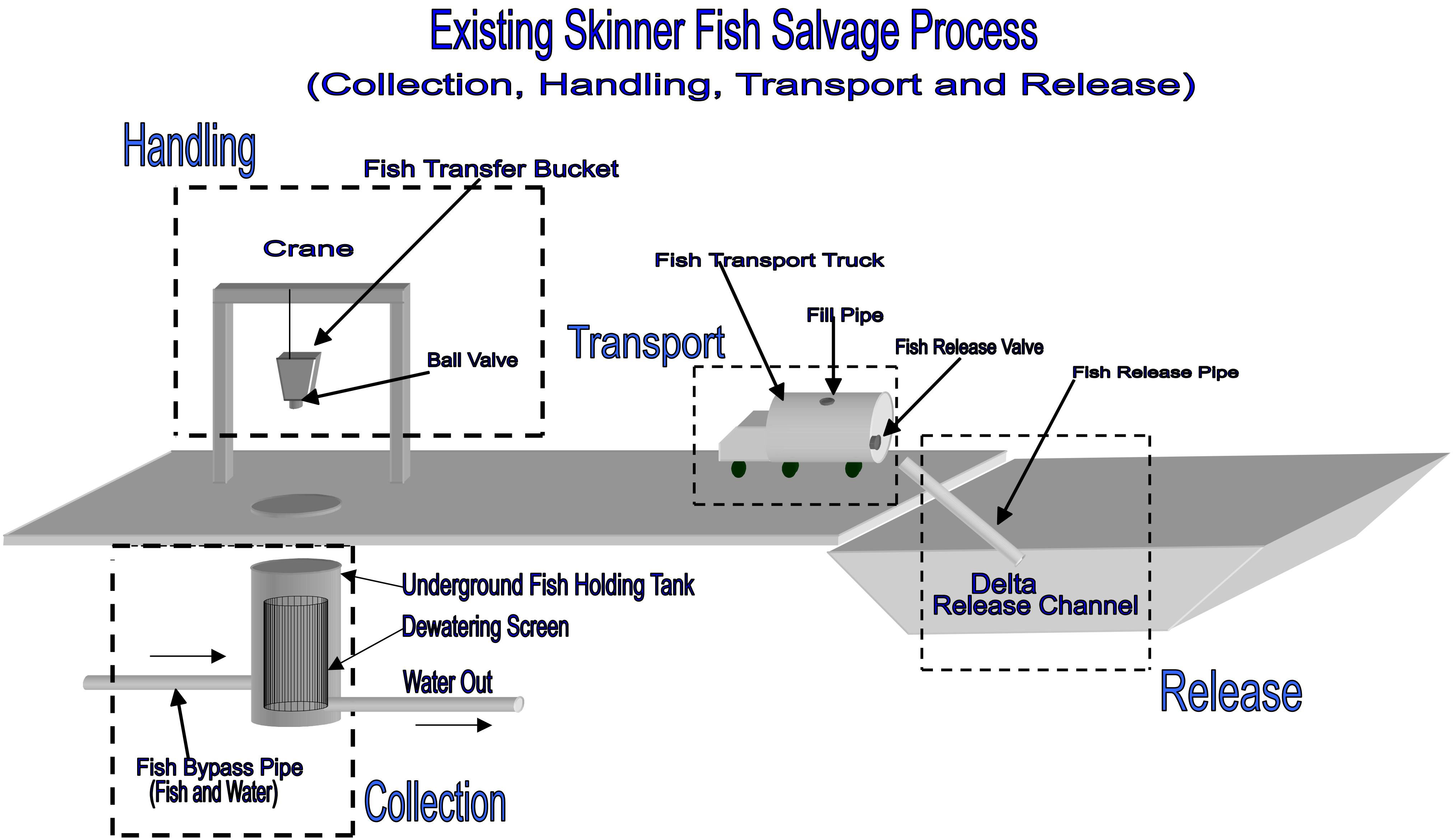


Figure 1-2 CHTR Process

The truck is then driven to one of two SWP release sites; one at Horseshoe Bend, and one Sherman Island. Either site is about 40 minutes away barring adverse traffic conditions. The truck release outlet is connected to the Release Pipe. Then the Fish Release Valve is opened and the fish and water in the truck drain through the Fish Release Pipe and into the receiving water.

Figure 1-3 shows the State and Federal salvage facilities and release sites. Figure 1-4 and 1-5 show more detail.

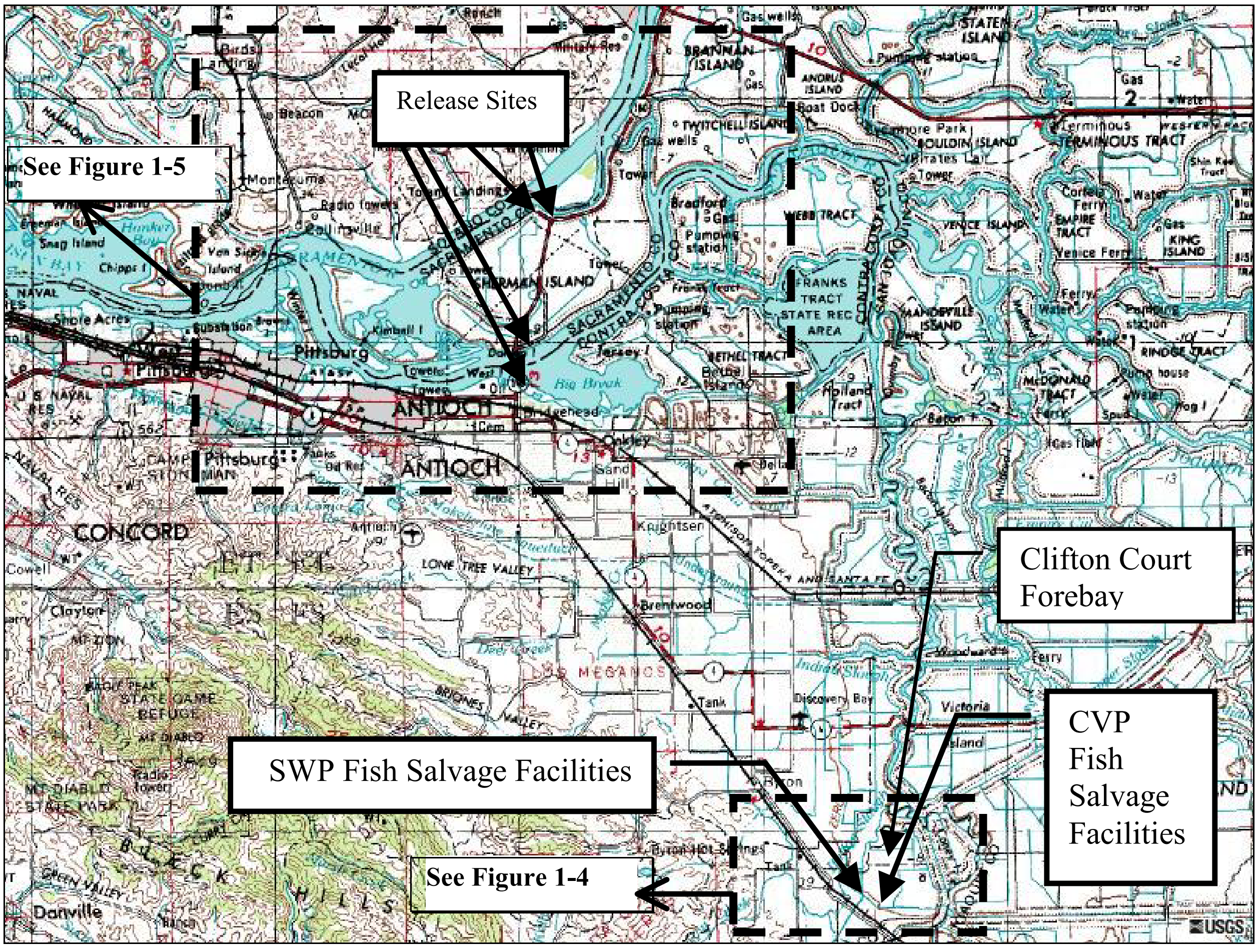


Figure 1-3 Project Area

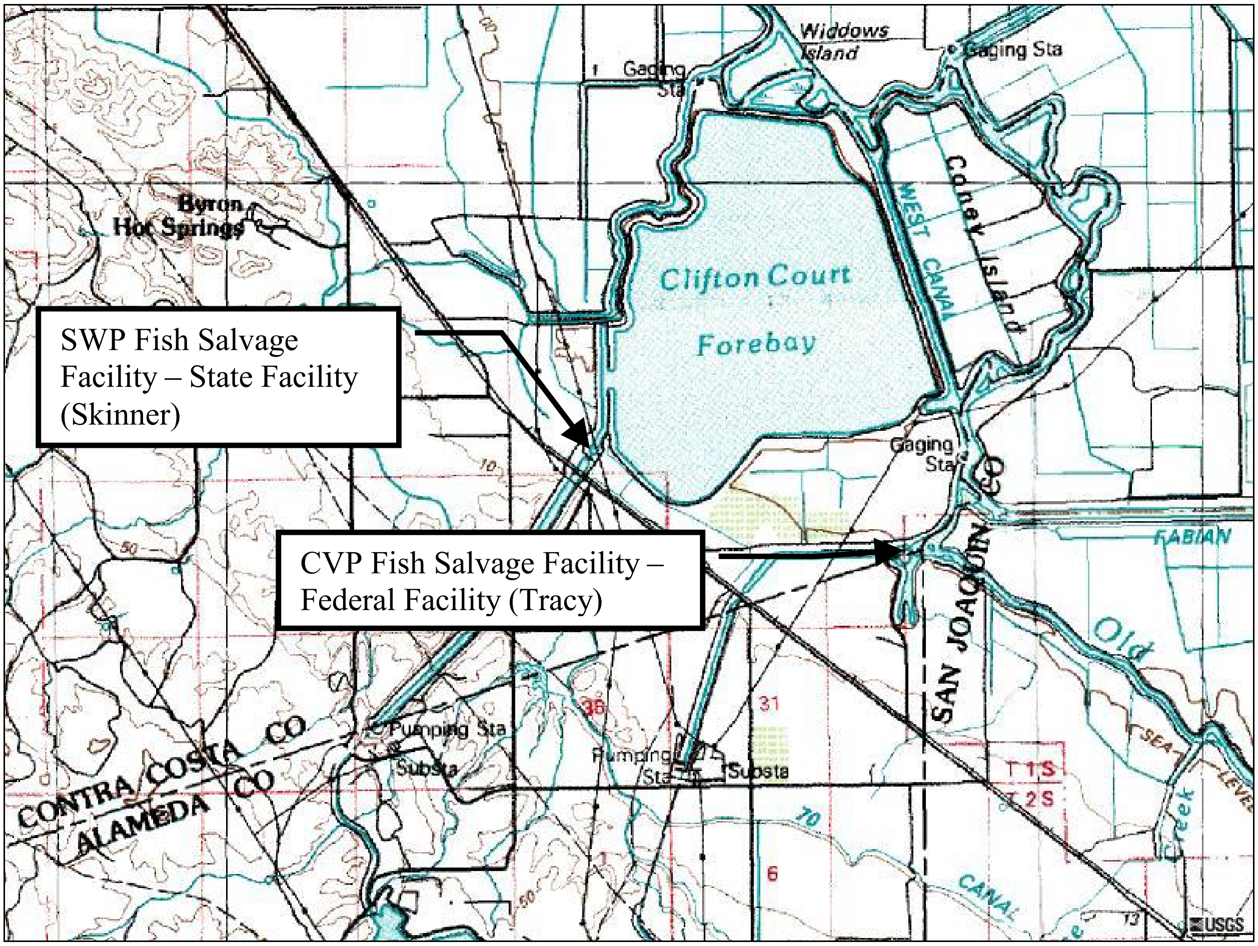


Figure 1-4 Clifton Court Forebay

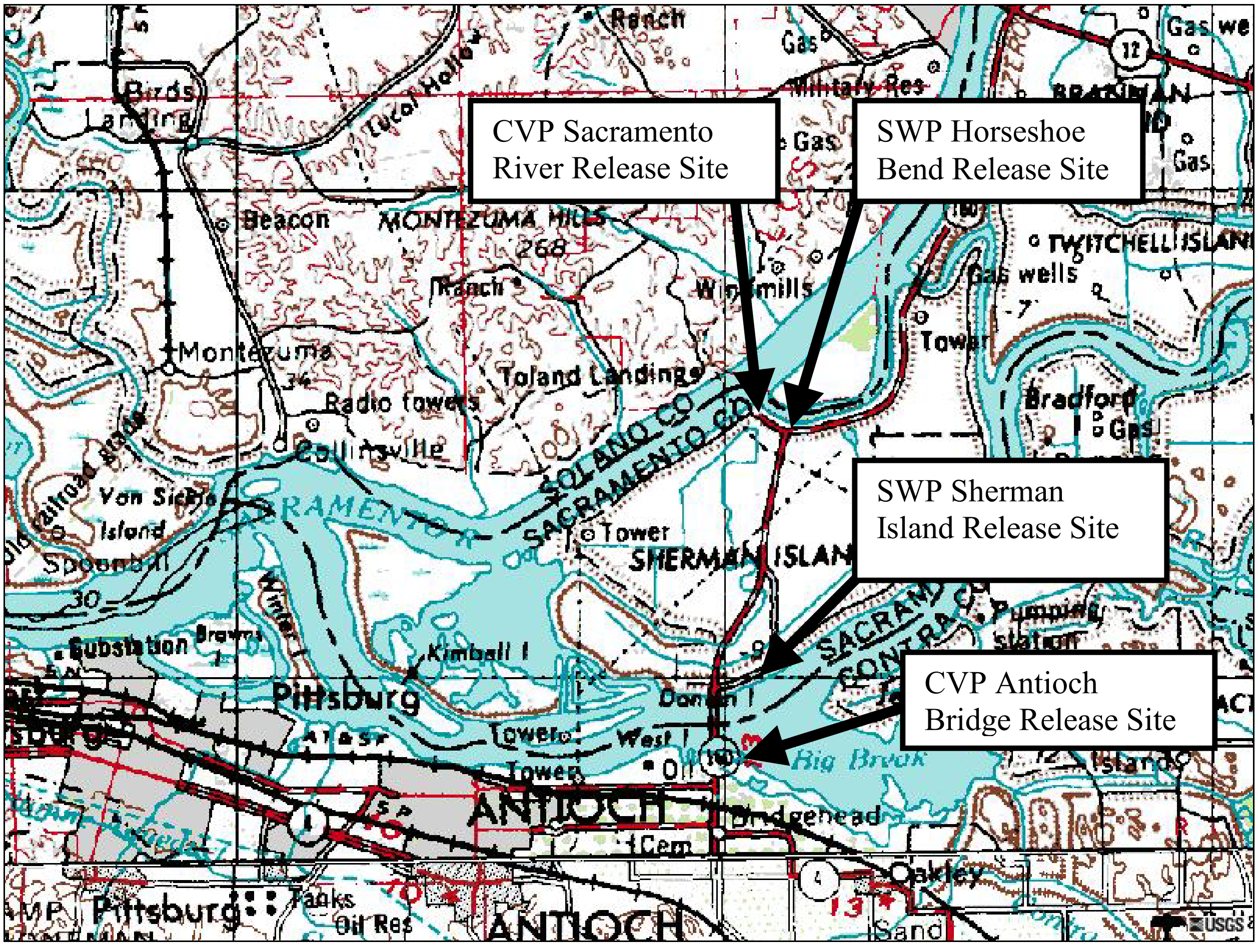


Figure 1-5 Release Sites

The salvage facilities over the years have faced a number of challenges related to operations and salvaging fish. Debris loads have increased over time with the introduction of invasive aquatic weeds. Egeria has become a major problem at the facilities in both maintaining diversions and salvaging fish. Increases in debris have had impacts on operations and additional impacts on fish throughout the salvage processes. The aging existing technologies and processes deployed at the fish facilities handle listed species that were not a concern when the facilities were originally built. The Sacramento-San Joaquin Delta is a diverse environment, with a large variety of fish, both native and introduced. Both migratory and resident species enter the facilities at different life stages in a tidal environment. This makes the fish salvage facilities at both the CVP and the SWP unique to and other fish salvage operations.

1.3 Fish Protection Research

A number of investigations have been conducted at both the SWP and CVP fish salvage facilities, in addition to investigations conducted at other water diversion sites, that provide insight into the mechanisms and factors affecting fish survival during the salvage process (Tracy Fish Collection Facility Studies, 1996; Tracy Fish Collection Facility Studies, 1997; Tracy Fish Collection Facility Studies, 2000; Black, 2001; Brown, 1996; Tracy Fish Collection Facility Studies, 2003). Studies are currently ongoing, or are being proposed, to further investigate various elements of fish salvage by the US Bureau of Reclamation (USBR), California Department of Fish and Game (CDFG), and the University of California, Davis (UCD). See Figure 1-6 Study Coverage. These studies address survival of fish in the overall process and possible improvements to existing salvage facilities and operations. However, significant questions remain as to the effects on fish during specific steps in the CHTR Process.

The CHTR program has been instituted in cooperation with the California Department of Fish and Game (CDFG) and the Department of Water Resources (DWR). The CHTR program is headed by Robert Fujimura, CDFG. A CHTR coordinating team has been formed. The CHTR Program is a collaboration of CDFG, DWR, UCD, NOAA Fisheries, and USBR researchers and technical experts. The purpose of the DWR portion of the CHTR program is to develop new technologies that address the fish salvage concerns and to address the operations and maintenance needs of the facilities. The DWR CHTR program is a two phased approach that investigates the existing conditions and measures the impacts. The second phase is to develop or recommend new technologies. The first phase started with a complete literature review and site visits to other salvage facilities in and outside California. The first phase will also include coordinating with ongoing studies being performed at TFCF by USBR and collaborating with the ongoing CHTR studies being conducted by CDFG and UCD.

One purpose of CHTR Program is to determine the effects of the existing facilities; another is to determine the feasibility and efficacy of alternative CHTR methods and pilot evaluate promising alternatives (Coulston et al 2004). Figure 1-7 shows the areas of the CHTR process that are being measured for mortality. Certain mortality measurements can be deduced by combining results of the studies. For example, transport mortality (Mt), and far field mortality (Mf).

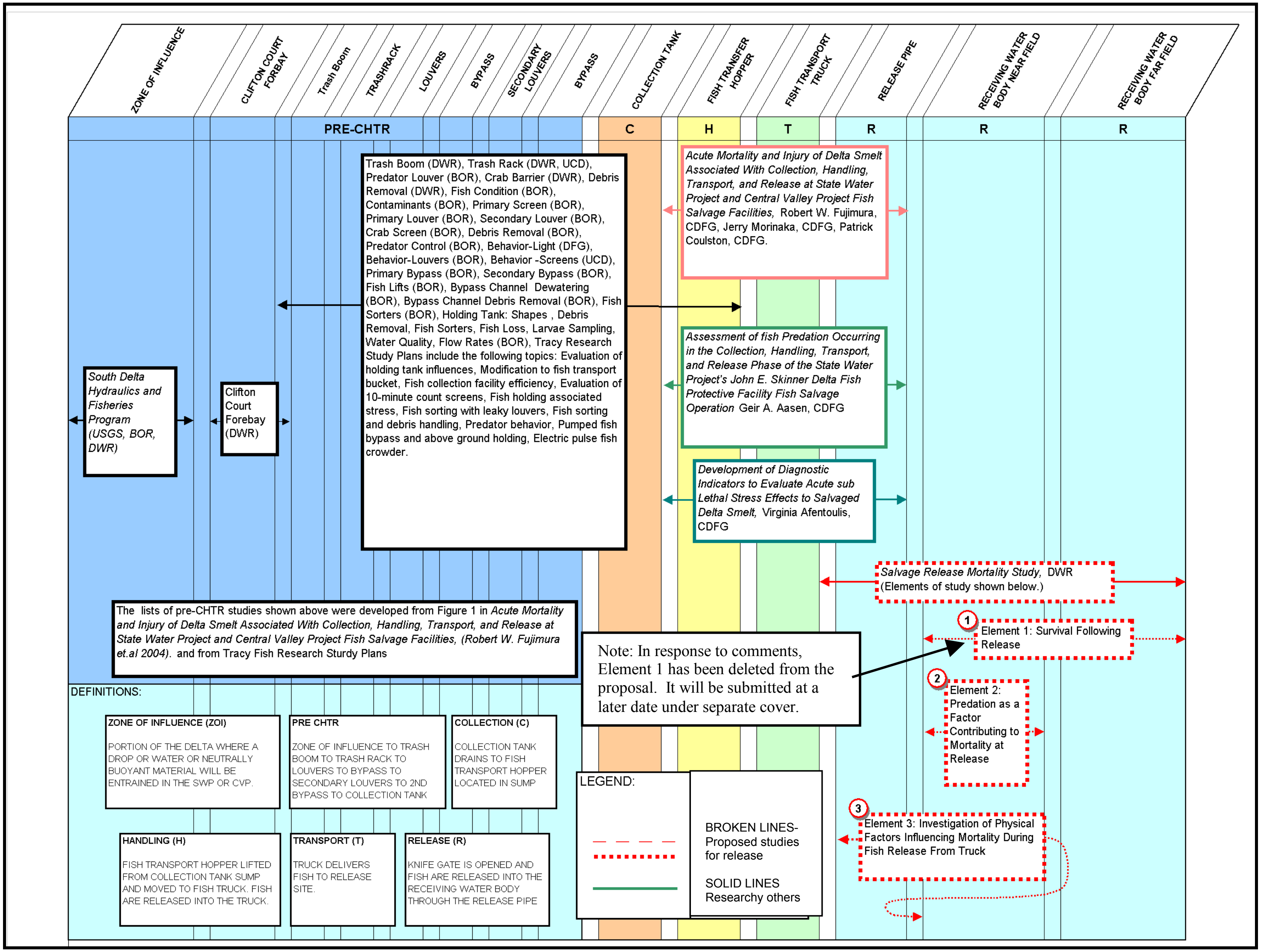
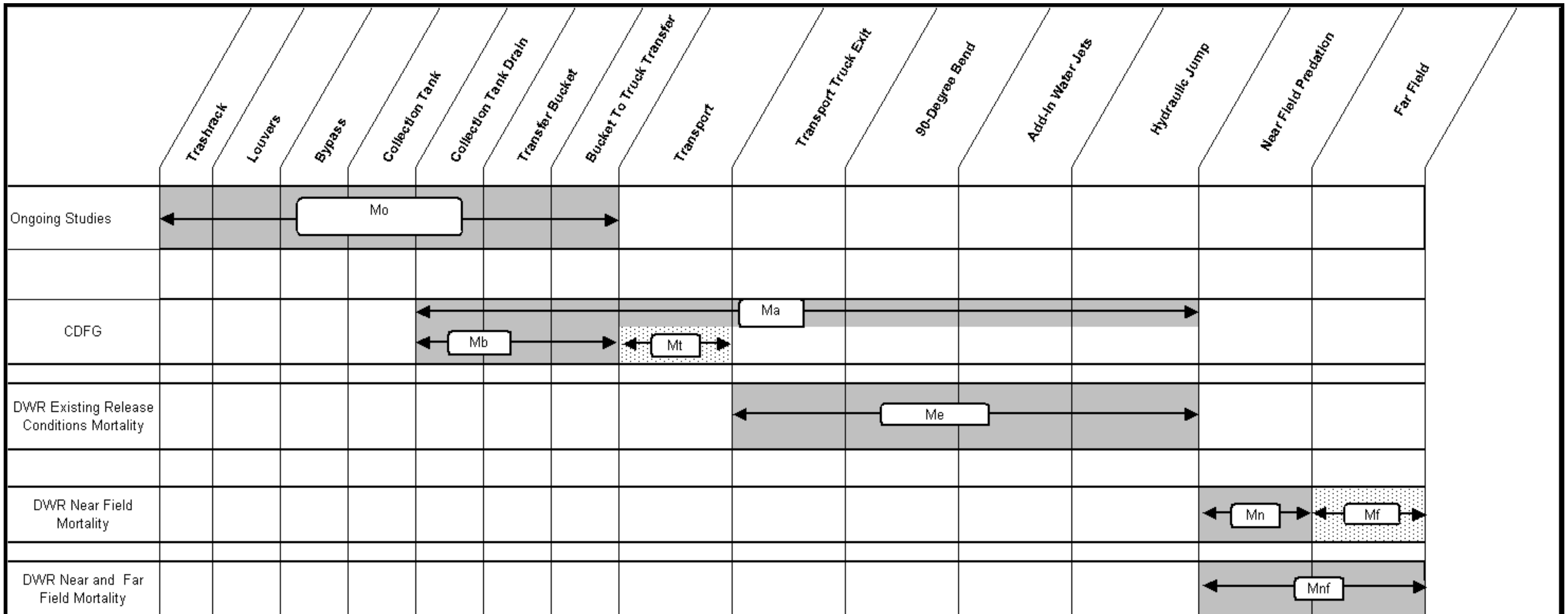


Figure 1-6 Study Coverage



Mortality	Symbol	Measured	Derived
Trashrack through bucket to truck transfer	Mo	Ongoing Fish and Debris Studies	
Collection tank drain through relase	Ma	Assessment of Fish Predation Occurring in the Collection, Handling, Trnsport, and Release Phase of the State Water Project's John E. Skinner Delta Fish Protective Facility Fish Salvage Operation	
Collection tank drain through transfer hopper	Mb	Assessment of Fish Predation Occurring in the Collection, Handling, Trnsport, and Release Phase of the State Water Project's John E. Skinner Delta Fish Protective Facility Fish Salvage Operation	
Fish transport truck exit through release	Me	CHTR Release Proposal - Element 3 - Physical Factors Influencing Mortality During Release	
Near field mortality	Mn	CHTR Release Proposal - Element 2 - Predation as a Factor Contributing to Mortality at Release	
Near and far field mortality	Mnf	CHTR Release Proposal - Element 1 - Survival Following Release	
Transport Truck Mortality	Mt		Mt = Ma - Mb - Me
Far field mortality	Mf		Mf = Mnf - Mn

Note: In response to comments, Element 1 has been deleted from the proposal. It will be submitted at a later date under separate cover.

Figure 1-7 CHTR Mortality Measurements

A program proposal and three specific proposals by CDFG have been approved and are underway. These are: *Evaluation of Collection, Handling, Transport and Release Effects on Delta Smelt (Hypomesus transpacificus) Salvaged at Southern Delta Water Export Facilities: Program Proposal* Pat Coulston et.al., *Acute Mortality and Injury of Delta Smelt Associated With Collection, Handling, Transport, and Release at State Water Project and Central Valley Project Fish Salvage Facilities,* Robert Fujimura et.al. *2004*, *Assessment of Fish Predation Occurring in the Collection Handling, Transport, and Release Phase of the State Water Projects John E. Skinner Delta Fish Protective Facility Fish Salvage Operation,* Geir A. Aasen, 2004, and *Development of Diagnostic Indicators to Evaluate Acute Sub Lethal Stress Effects to Salvaged Delta Smelt,* Virginia Afentoulis, 2004. DWR has been assigned the task of researching other elements of the CHTR process. Release has been identified as a critical element. The objective of this proposal is to research and analyze the causes of mortality to fish during and after the release process that are related to the physical effects of the existing components and other biological factors.

1.4 Collection, Handling, Transport, and Release (CHTR) Release Proposal

The California Department of Water Resources (DWR) proposes to conduct a focused investigation into the release aspect of the CHTR process at the John E. Skinner Fish Salvage Facility within a framework that will allow integration and coordination with the ongoing and proposed investigations. Results of this investigation will provide the necessary scientific and engineering foundation for design of improved fish handling facilities as part of the long-term fish protection solution to Delta water export operations. The investigation will provide three things:

1. A comprehensive evaluation of the effects of specific components of the release process on the survival of delta smelt and other species of concern including physical aspects of the release procedure, and the effects of predation in the near and far field.
2. Necessary scientific information for use in evaluating potential alternative technologies designed to reduce stress and improve survival throughout the CHTR process.
3. Criteria for the design of new facilities or large-scale improvements to the existing release facilities.

This proposal represents an integrated effort among water project operators, engineers with specific expertise in fish screening and handling technologies, and fishery biologists to address the existing fish salvage operations and to identify further investigations to specifically test the performance and biological benefits of modifications to CHTR facilities and operations that would benefit the existing SWP and CVP salvage facilities. The scope of this proposal focuses specifically on fish release from the salvage operation into the Bay-Delta estuary. The studies identified in this proposal complement and augment current and planned investigations of various facets of the CHTR process at both the SWP and CVP fish salvage and release sites. See Figure 1-6.

This proposal can be described as part of the "survival assessment" and "facility/process evaluation" phases of the overall *Program Proposal* (Coulston et.al., 2004) See Appendix 5. "Survival assessment" is proposed to determine the efficacy of making large incremental expenditures to improve fish survival at both the SWP and CVP facilities. Mortality studies accomplished by fish release and far field recapture (Element 1) will help determine the longer-term viability of fish released at the current release sites in this proposal. Predation studies near the release outlet pipe (Element 2 in this proposal) will help managers assess the viability of fish immediately following release. In Element 3 of this proposal, survival assessments will be made at a mock-up of the release facility to measure the effects of stressors on fish imposed by the physical structures and interacting hydraulic forces combined with debris that characterize the existing release method. From the results of these studies recommendations will be made on ideas for improving operations and improving or replacing systems in the CHTR process at the Skinner and Tracy fish facilities. For example, recommendations from near-field predation studies (Element 2) could provide insight into selection of the locations and configuration for new release sites.

"Facility/process evaluation" as described in (Coulston *et.al,*. 2004) will identify and then test technologies, facilities, and processes that can realize the potential for fish to substantially survive the CHTR process. In Coulston et al (2004) "at least the first portion of the facility/process evaluation phase will be initiated and conducted in parallel with the survival/assessment phase."

1.5 References

Black, 2001; *Shasta salmon salvage efforts: Coleman National Fish Hatchery on Battle Creek, 1895-1992*. Pages 177-268 in R.L. Brown, editor. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179, Vol. 1. State of California, The Resources Agency, Department of Fish and Game, Sacramento, CA.

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Volume 19 - Kubitschek, J. 2003. *Physical and Computational Model Studies to Improve Hydraulic Performance of the Primary Bypasses at Tracy. Tracy Fish Collection Facility Studies*, Volume 19. U.S. Bureau of Reclamation, Mid Pacific Region and Denver Technical Service Center. 27 pp + Appendices

2.0 PROBLEM STATEMENT

2.1 CHTR Process and Survival of Fish Following Release

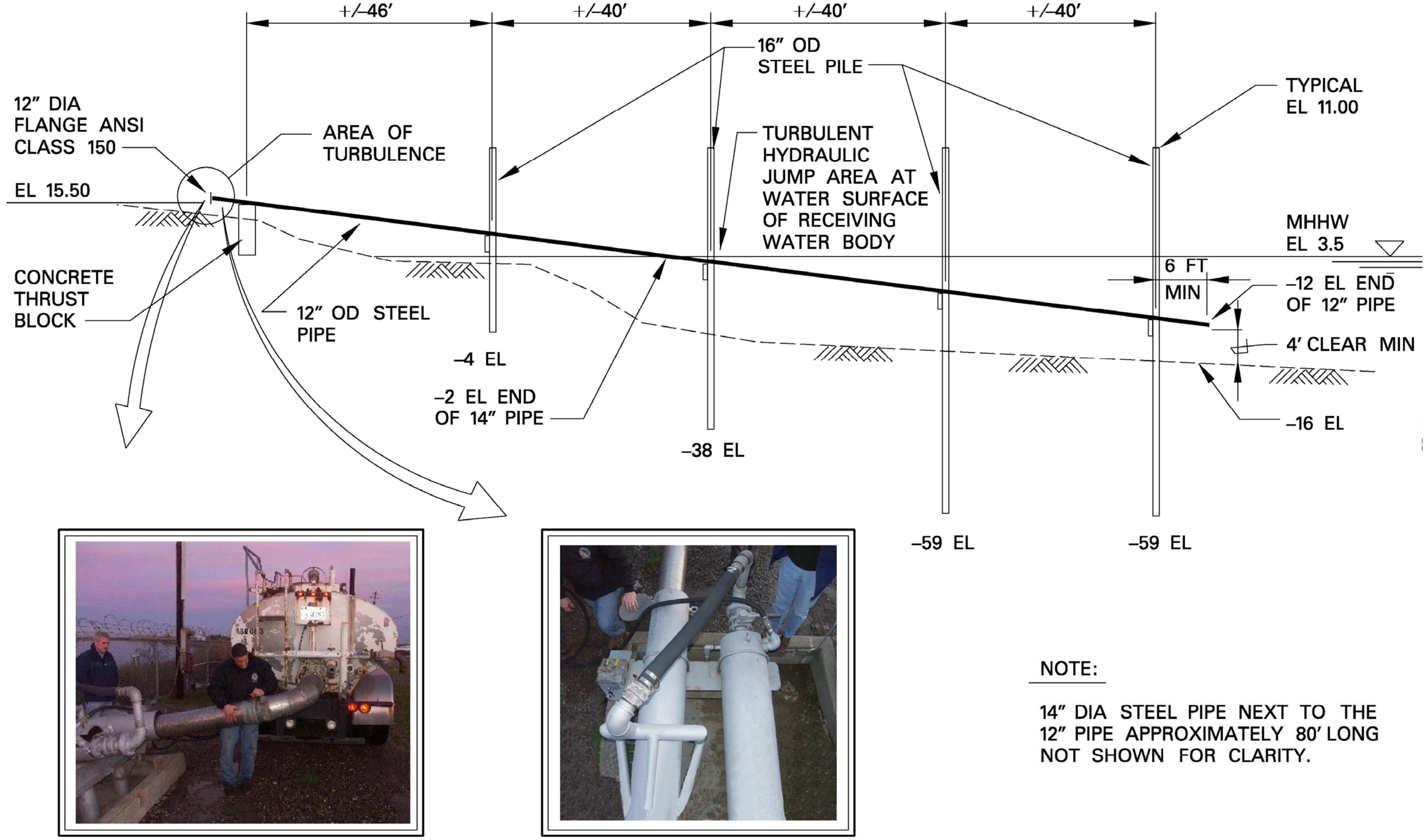
Many factors influence the survival of fish throughout the CHTR process. The factors include effects of operational decisions taken throughout the entire salvage process, limitations inherent in technologies used at the facilities, location of release outfalls, and the conditions salvaged fish encounter in the receiving water body, including predation, water quality, and suitability of the release site location for the life stage of the salvaged fish. Within the framework of the CHTR process, release begins when the knife gate attached to the outlet of the transport truck is opened, allowing fish to exit the fish transport truck holding tank. Observations of this process suggest several potential sources of stress, disorientation and mortality. These sources include:

- Hydraulics of the release
- Debris
- Method of introducing flushing flow
- Geometry of release pipe connection
- Characteristics of flow in release pipe
- Predation at release pipe exit
- Water quality
- Suitability of release pipe location

2.1.1 Hydraulics at Release

The descriptions below are based on the SWP release facility at Horseshoe Bend (see Figure 2-1). They can be considered typical to conditions at the CVP Sacramento River release site. Minor differences in velocities or Froude numbers (the ratio of inertial forces to gravity forces) may exist, but the similarities of the hydraulics at the sites are greater than their differences. As water exits the fish transport truck tank, the flow is controlled by the orifice of the exit pipe. At the start (at full tank) flow is approximately 6 cfs. When the water has drawn down to the level of the top of the exit pipe it is flowing at a rate of 0.7 cfs. With orifice control the water starts to exit the tank at approximately 20-fps and reduces to 10 fps as the tank empties. The vena-contracta (depth on the downstream side of the orifice) is approximately 0.5 ft deep as the flow exits the tank. At these velocities the flow will become superelevated (climbs pipe wall) in the 90-degree bend to the point that it will fall back on itself creating a spiraling of the flow as it continues down the pipe. As the water approaches the add-in water (flushing flow) pipes it is starting to approach normal depth.

Normal depth in the 12-in diameter pipe, (slope is approximately 20%), ranges from approximately 4.5 inches and a velocity of 21 fps at the maximum discharge of 6 cfs to about 1.5 inch and a velocity of 10 fps at 0.5 cfs. Four add-in water jets enter the flow line from above and below the pipe centerline at a velocity of approximately 10-fps creating turbulence as all four jets are focused at one location.



TRUCK IS PERPENDICULAR TO RELEASE PIPE AT SWP HORSESHOE BEND RELEASE SITE

FLUSHING FLOW IS ADDED TO RELEASE PIPE – TYPICAL OF SWP AND CVP RELEASE SITES

Figure 2-1 SWP Release Site at Horseshoe Bend

As the water continues down the pipe it approaches an hydraulic jump at Froude numbers ranging between 6 and 7 for both the high and low flows. Froude numbers at this level are indicative of a strong hydraulic jump with attendant rollers and turbulence. The rollers will likely present the fish with a debris laden, turbulent environment as they travel to the release pipe exit.

2.1.2 Debris

The presence of debris poses significant operational problems at the both the SWP and at the CVP. The CVP does not have a regulating forebay. It receives run of the river debris, which includes quantities of water hyacinth and peat; both of which clog the louvers. Debris presents CVP operators the same operating problems faced by the operators at the SWP.

At the SWP, the debris load has increased over the years, as Clifton Court Forebay has silted in. As the water became shallower, conditions have become favorable for the production of *Egeria* (pers comm Jim Odom). At peak periods a 6-foot deep mat of the pond weed can accumulate that is dense enough for a man to walk on.

Photo 2-1 Debris Accumulates on SWP Trash Boom

Egeria drifts along the trash boom where it encounters a conveyor system that lifts the weed up to loading facility. A large quantity of the *Egeria* rolls under the trash boom and clogs the trashracks in front of the louver bays. Egeria is neutrally buoyant and is distributed throughout the water column.

A trash rake is used to clean the *Egeria* off the trashrack. This process breaks some of the weed into smaller pieces, which pass through the trashrack into the louver bays. This can lead to clogged louvers and is the source of the debris in the CHTR process. When the trashrack is clean the smaller debris passes through the rack and enters the CHTR process.

Photo 2-2 Debris Clogged Trash Rake

The only exit from the primary louver bays for the debris is into the fish bypass. Some debris is removed from the bypass by the secondary screening system. Any debris that enters the holding tanks is transferred to the fish transport truck tanks. It was apparent from observations and information gathered from the operators, that large quantities of debris complicate the collection, handling, transport, and release process. One of the complications resulting from the presence of debris is the repeated dewatering and stranding of fish throughout the CHTR process. Stranding occurs in the collection tank, in the transfer buckets and in the fish transport truck tank. Release is complicated by the presence of debris. An example of dewatering is shown in the photo below.

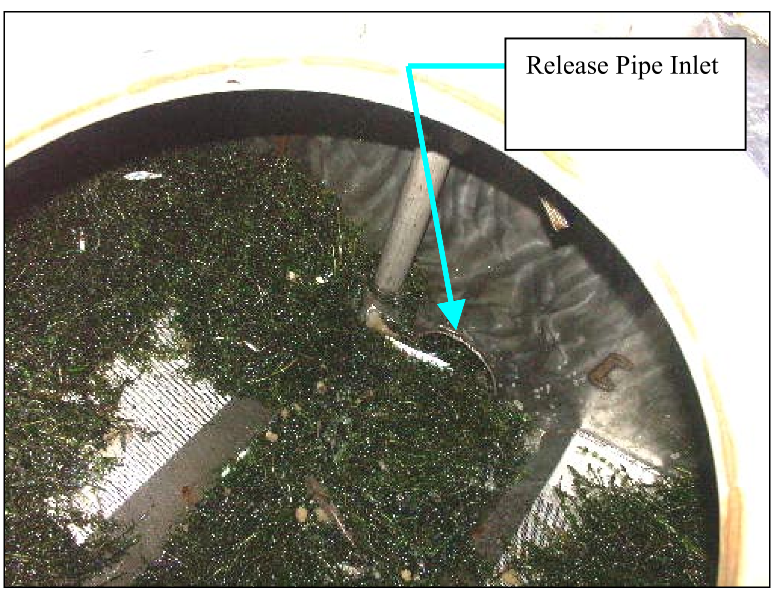


Photo 2-3 Fish Transport Truck Outlet is Clogged During Release

After opening the knife gate to release fish from the fish transport truck holding tank, debris can clog the outlet. The debris then acts like a sieve, separating fish from the flow, and stranding them in the tank.

2.1.3 Method of Introducing Flushing Flow

The release pipes sit unused most of the time. When a fish transport truck arrives the pipe is dry. One of the first things done when a fish transport truck arrives at a release site is to turn on the pump that sends flushing flow (or add-in water) down the release pipe. This water establishes flow in the pipe in advance of the knife gate opening. The flushing flow prevents fish from sliding down a dry pipe. Flushing flow is introduced during the release process at two points: directly into the fish transport truck tank, and into the release pipe. A hose is used to flush debris and fish out of the truck. The flow from the hose can cause stress and mortality in the fish.

The presence of water jets could cause stress, disorientation, and mortality as the fish are exposed to shear forces and turbulence at the point of water jet entry into the pipe. An evaluation of injury mechanisms during exposure to a high velocity jet at Pacific Northwest National Laboratory shows injuries increasing with water jet velocity. Fish used included rainbow trout and steelhead (*Oncorhynchus mykiss*), fall-run Chinook salmon (O. tshawytscha), and American shad (*Alosa sapidissima*) in their tests. Fish tested ranged in size from 81 mm to 157 mm. It was reported that injuries were rare below 9 meters per second (29.5 fps) except for American shad. Smaller fish experienced more disorientation but less major injuries than larger fish. (Guensch et al 2002).

2.1.4 Geometry of Release Pipe Connection

Due to site constraints, a fish transport truck cannot back up straight to the SWP release site at Horseshoe Bend. There is not enough room between the riverbank and road. The truck must park perpendicular to the release pipe.

The 90-degree bend in the Fish Release Pipe could increase stress, turbulence, and disorientation as fish, debris and water interact through the bend. A high velocity jet of water exits the tank and travels on the bottom of the pipe to the bend. The flow becomes so superelevated in the bend (that is to say that the water climbs up the side of the pipe rather than remaining at the bottom of the pipe) that it can fall back on itself. The bend could decrease the amount of debris that can exit the tank without having to introduce flush water into the fish transport truck tank.

2.1.5 Characteristics of Flow in the Release Pipe

Another possible source of stress, disorientation and mortality in the release process centers on the flow regime in the release pipe. The two flow regimes in the release pipe are open channel (free surface), and full pipe (water is in contact with the entire pipe wall). The release pipe extends into the receiving water body to a depth of between 12 and 30 feet depending on the site and the tide stage. At the SWP release site at Horseshoe Bend, the truck sits approximately 20 feet above the water surface of the receiving body, approximately 80 feet of pipe extends out of the water and approximately 80 feet of pipe extends into the water. The slope of the release pipe is approximately 20 percent.

Photo 2-4 SWP Horseshoe Bend Release Pipe

Initially, fish experience open channel flow conditions enroute from the fish transport truck outlet to the receiving body water surface. Flow in the pipe will be supercritical and a hydraulic jump will occur. The jump will most likely occur near the water surface level of the delta. The jump will result in a concentration of turbulence and a backrolling of the flow. It is also likely that there will be a concentration of debris in the backroller since not all of the debris will immediately be washed out of the lower end of the pipe. The result of these interactions could increase disorientation, stress, and mortality.

2.1.6 Predation at Release Pipe Exit

Observations of the release pipe outlet using the Dual Frequency Identification Sonar (DIDSON) camera (see Photo 2-5) have shown predators concentrating in the immediate vicinity of the release pipe exit. It is not known if the concentration of predators is greater at the release sites than occurs normally in the river. It is not known if predation causes a statistically significant level of mortality for the released fish. It is not known if predators learn to congregate at the release site when the flushing pump is turned on.

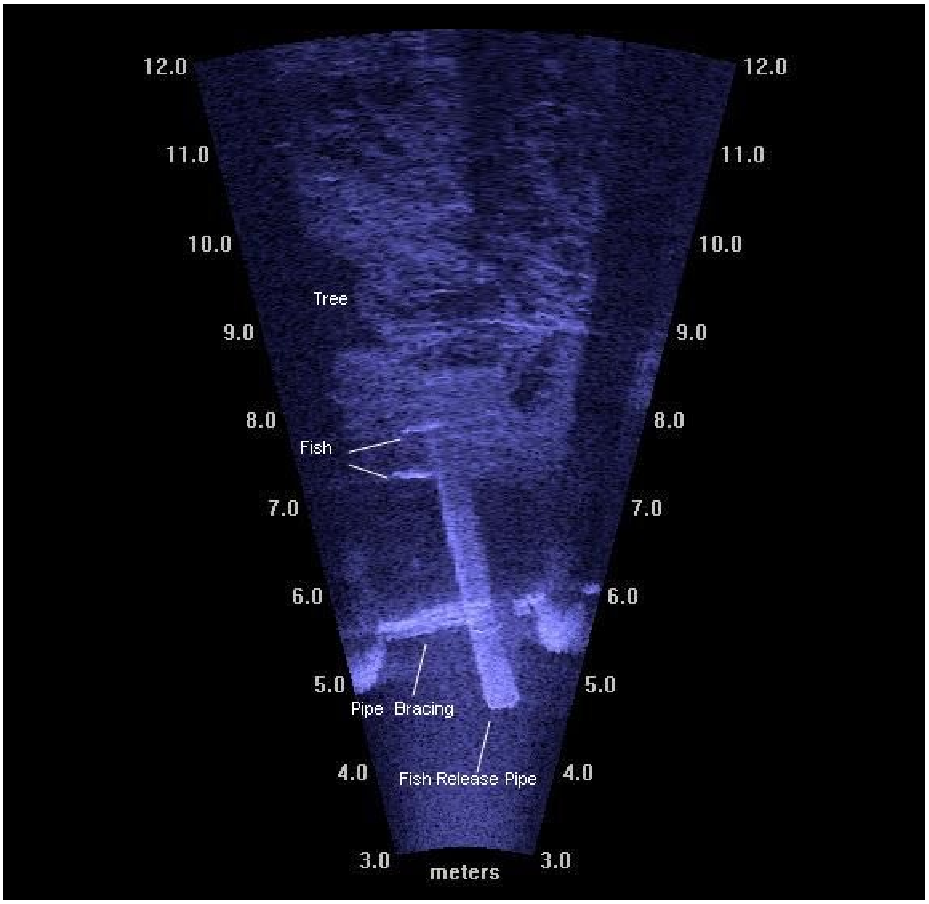


Photo 2-5 DIDSON Camera Image

2.1.7 Water Quality

Water quality in the fish transport truck tank could be different than that of the receiving water. This could lead to stress and affect the survival of released fish. Water quality has been monitored and reported throughout the fish salvage process (Tracy Fish Collection Facility Studies, 2000, 2002, 2003) as well as within natural habitats locally (Baracco, 1980) to the release sites.

2.1.8 Suitability of release pipe location

The CVP and SWP release sites have differences. They differ by the depth of the outlet and the velocity of the receiving water body. Channel morphology is different at the two sites. Other differences include facility layout and the engineering specifications of the equipment. The release locations may impact fish survival by returning them to less favorable habitat, or less desirable migration routes. Comparing survival rates of fish released at both sites will determine if there are significant differences between the two sites.

2.2 Coordination and Integration with Other CHTR Investigations

Many issues facing the development of new technologies are specific to the Skinner Fish Facility, Tracy Fish Collection Facility and the Sacramento-San Joaquin Delta, but technologies have been developed in other areas that may support the development of new technologies that can be deployed to improve the survival of delta smelt and other species of concern. To be successful this proposal recommends working closely with other agencies to develop new technology teams and collect information on past and future experiences and studies. The multidisciplinary nature of this study element requires the varied and in-depth expertise obtained through the collaboration of several agencies and from fish experts from other regions of the country.

Close coordination will be maintained with other CHTR work through the CHTR Coordinating Team. The major objective of the CHTR Coordinating Team is to act as the functional Project Work Team for the CHTR studies and provide technical advisory support to the CHTR program staff. Team members will review program products, monitor study program activities, assess the quality of the program data, and recommend program modifications. The specific objectives are to ensure that the results are of scientific quality and high relevance to the management's directives, develop timely programmatic review points, foster dissemination of interim results to scientists and managers, and encourage adaptive management of the study's implementation (Fujimura et al 2004). Through these meetings work can be coordinated to insure no gaps or unnecessary overlapping of work is occurring. (See Figure 1-6 Study Coverage)

Studies of the CHTR processes have also been conducted within the framework of the Interagency Ecological Program (IEP) and as part of Central Valley Fish Facilities Review Team (CVFFRT). CVFFRT and IEP play an important oversight role for CHTR programs at the request of the California Bay Delta Authority (CBDA) managers. These biological and engineering investigations provide added insight into issues associated with bypass pipeline design and operations, hydraulic performance of fish salvage facilities (Swanson *et al.* 1998), predation (Pickard *et al.* 1982), fish behavior, and other issues directly relevant to the CHTR investigations. Information from these past and ongoing investigations will be integrated into the synthesis of available literature and analyses performed as part of this investigation.

2.2.1 United State Bureau of Reclamation (USBR)

The United States Bureau of Reclamation (USBR) has performed work in the past at Tracy Fish Collection Facility (TFCF) related to CHTR (Tracy Fish Collection Facility Studies, 1995; Tracy Fish Collection Facility Studies, 1997) and collaboration and discussions with USBR are being conducted to gather information for the development of new CHTR technologies. The past and future work at TFCF will help us better understand how the facility operates and provide insight into CHTR improvements. Close coordination will be maintained with these researchers and their studies. Work will also be performed in coordination with the Tracy Technical Advisory Team (TTAT).

Specific elements of this proposal require collaboration with the USBR. Element 1 – Survival Following Release envisions the use of the USBR CVP Sacramento River release facility. Element 3 will require collaboration with SWP personnel, the UC Davis Delta Smelt Culture Facility, and managers of the CHTR Test Fish Building and Collection Pool.

2.2.2 California Department of Fish and Game (CDFG)

CDFG has proposed a program of studies on the effects of CHTR on delta smelt in the south Delta, primarily at the Skinner and Tracy Fish Protection Facilities. The overall program is described in *Evaluation of Collection, Handling, Transport and Release Effects on Delta Smelt (Hypomesus transpacificus) Salvaged at Southern Delta Water Export Facilities: Program Proposal* Pat Coulston et.al., 2004. The specific proposed studies include:

- Acute Mortality and Injury of Delta Smelt Associated with Collection, Handling, Transport, and Release at State Water Project and Central Valley Project fish Salvage Facilities, Robert Fujimura et.al. 2004.
- Assessment of Fish Predation Occurring in the Collection Handling, Transport, and Release Phase of the State Water Projects John E. Skinner Delta Fish Protective Facility Fish Salvage Operation, Geir A. Aasen, 2004.
- Development of Diagnostic Indicators to Evaluate Acute Sub Lethal Stress Effects to Salvaged Delta Smelt, Virginia Afentoulis, 2004

Close coordination will be maintained with these researchers and their studies.

2.2.3 University of California at Davis (UCD)

Researchers at UCD are conducting a number of studies that would support the investigations into CHTR at Delta fish protection facilities. These include debris and debris removal studies and fish swimming ability studies. Close coordination will be maintained with these researchers and their studies.

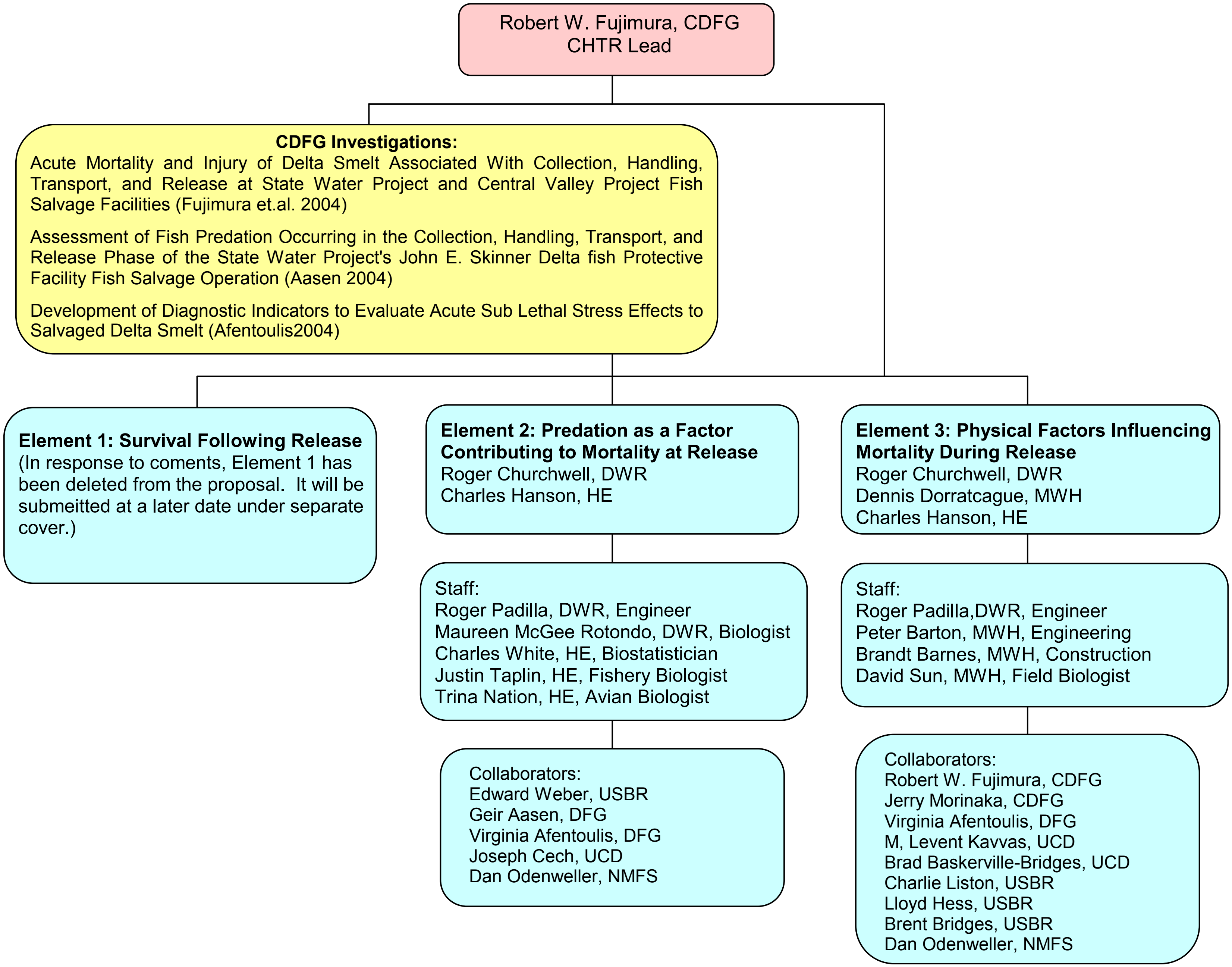
2.2.4 Study Team

This CHTR program will be a cooperative effort between several agencies, researchers, and multidisciplinary committees. The DWR study team and partners supporting this program are listed below.

- Roger Churchwell, P.E., Section Chief, Engineer, DWR Fish Facilities
- Dennis Dorratcague, P.E., MWH, Consultant Lead and Bioengineer
- Charles Hanson, Ph.D., Hanson Environmental, Lead Biological Scientist
- Support Team, Engineers and scientists from DWR
- Support Team, Engineers and scientists from MWH, Hanson Environmental, Natural Resource Scientists, North State Resources
- California Department of Fish and Game, Bob Fujimura
- United States Bureau of Reclamation, Ron Silva, Charlie Liston
- University of California at Davis, Lev Kavvas, Ph.D., Joe Cech, Ph.D.
- Central Valley Fish Facilities Review Team (CVFFRT Multi Agency)
- Clifton Court Forebay Technical Advisory Team (CCFTAT Multi Agency)
- CHTR Coordinating Team (CHTRCT Multi Agency)

An organization chart is included below, Figure 2-2.

Figure 2-2 Organization Chart



2.2.5 CHTR Coordinating Team (CHTRCT)

Coordination with the investigations proposed by CDFG, as well as additional investigations being conducted by USBR and UCD, represents a key element in the successful development of a comprehensive investigation of the CHTR process. Coordination among investigators will be facilitated by the formation of a CHTR Coordinating Team. The CHTR Coordinating Team will include participation by the principal investigators involved in designing and conducting biological and engineering studies of the fish salvage facilities. Coordination among these investigators will serve to reduce redundancy among various studies, identify opportunities for synergistic and additive benefit to the integration of both biological and engineering investigations, encourage peer review to develop the most rigorous scientific investigations possible, support the development of alternative hypotheses, testing methods and analytical approaches, and the interpretation of resulting information. Other reasons for close collaboration include: efficient development and standardization of experimental procedures, sharing of operational facilities and processes, increase in effective training of program staff, reduced costs, effective use of limited funding resources, expansion of the available expertise and labor pool for each study project.

Information is presented in Section 1 of this proposal identifying opportunities for complementary investigations to augment specific studies being proposed as part of the CHTR program with proposed activities and investigations being conducted by other scientists working on delta smelt salvage issues.

Close coordination among investigators performing experimental tests to evaluate various aspects of CHTR operations and the DWR/UCD Delta Smelt Culture Facility is required. Testing the survival of delta smelt at various stages in the CHTR process can be accomplished using wild delta smelt entering the fish facilities during routine water project operations or through the experimental introduction of cultured delta smelt at various specific locations within the salvage facilities. Testing using wild delta smelt is difficult because of uncertainties regarding the health and condition of the fish at the time they enter the salvage facilities, the limited ability to obtain suitable controls, variability in the number and seasonal distribution of smelt occurring at the facility, and uncontrolled variability in pretest conditions. Given these concerns, the use of cultured delta smelt is expected to provide the most reliable information for experimentally evaluating various aspects of the CHTR process and for developing comparative control and treatment test groups that can be used in more rigorous statistical hypothesis testing. The number of cultured delta smelt available for testing, however, is limited and close coordination among investigators will be required to optimize the allocation and use of cultured delta smelt available for these investigations.

2.3 Alternative Technologies

The Pacific Northwest offers many examples of salvage and release technologies. The following discussion draws on site visits and interviews with resource managers which took place in 2003 and 2004. It should be noted that important differences exist between the Pacific Northwest environment and the Bay-Delta. A key element of flexibility evident in the Northwest is the topography. Many fish handling processes are accomplished using the power of gravity. For the most part, tides do not complicate the fish handling process in the manner they do in the Delta, where the tide reverses flow directions throughout the day. The Delta environment is further complicated by the magnitude of fish species encountered there.

Separation of debris from fish is considered an essential step in the salvage process. Debris is removed before transport on the Columbia River. (Steve Rainey, NOAA pers com). At McNary Dam (considered the most advanced handling and transport facility on the Columbia) during the peak debris season, thirty 50-gallon drums of debris are removed by hand from various separators, holding tanks and raceways per day (Dave Hurson, Walla Walla District COE pers com). This leaves nothing but fish and water to be transferred from holding areas to the transport vehicles (trucks and barges).

Water is added and subtracted from the flow line many times during the salvage process. Water is removed through floor mounted profile wire and perforated plate panels and added through diffusers.

Sample subsets of fish are directed through Passive Integrated Transponder (PIT) tag operated gates to an onsite laboratory. No "hot" (unanaesthetized) fish are touched by humans throughout the process. Handling hot fish is considered too stressful.

Depending on the number of the fish, either a truck or a barge is used to transport the fish downriver; a journey of approximately 180 miles. The trucks used are 3500 gallon, aerated, and refrigerated tankers. A water to water transfer is begun by opening a flap gate at the bottom of a holding raceway. Fish are crowded towards the outlet. Fish and water exit the raceway into at 10-inch pipe. A series of dewatering panels reduce the flow before the fish and water enter the fish transport truck tank. Screened drains bleed off excess water from the truck during the loading procedure.

In the past, release from the trucks was accomplished by dropping a 6-inch hose into the receiving body just below Bonneville Dam. This practice was halted after it was reported that the water was "boiling" with predators (northern pike minnows). The transport trucks now drive to Portland where they board a barge. The barge then allows the trucks to release fish from varied locations on the Columbia River.

The Portland District COE has developed criteria for siting fixed fish release outfalls. (Rock Peters, Portland District COE pers com) The four criteria are:

1) Velocity of receiving body of water (determined by swimming capabilities of the local predators)

2) Separation from other structures. Outlet is kept 30 feet from any structure laterally. This keeps eddies from forming at the outlet that could provide rest areas for predators.

3) Depth of the outlet (10 meters)

4) Conditions downstream of the outfall. The conditions need to favor the juveniles for 20 to 30 minutes downstream of the outfall to allow the fish time to recover. The velocities have to be high enough in this reach to discourage predation.

The Puget Sound Energy's Baker River Project consists of Upper and Lower Baker Dams on the Baker River in the Cascade Mountains of northwest Washington. Adult sockeye, Chinook, coho, and steelhead are trapped at a barrier dam below Lower Baker Dam and hauled by truck or trailer above Upper Baker Dam or to a series of spawning beaches. Downstream migrants are trapped in a floating surface collector and held in a floating trap at the dam. The fish are then crowded into a hopper. The hopper is lifted by crane and the fish are transferred to tank on a trailer or truck.

The truck or trailer is then driven about 15 minutes to the Lower Baker River near its confluence with the Skagit River where the fish are released. The hopper affects the water-to-water transfer of fish to the transfer tank. This is accomplished by first filling the transport tank with water, then lowering the hopper on to a rubber seal before opening the hopper hatch. Excess water is drained from the transport tank as the water from the hopper enters the tank.

Downstream migrants are collected at Cowlitz Falls Dam on the Cowlitz River and transported around three downstream dams to the lower Cowlitz River. They are released to stress release ponds where they are held for prescribed period of time and then allowed to leave the pond voluntarily to the river. After a prescribed holding period of time, remaining fish are crowded out of the stress ponds. Parallel release ponds allow a range of holding periods and fish release strategies. The benefit of the release ponds has been studied in terms of survival of fish to adult stage. These facilities are currently being used as a model for design of other projects in the northwest.

2.4 Conceptual Model

A conceptual model, based on the existing conditions, of salvage release mortality is shown below (Figure 2-3 Conceptual Model). For clarity, the release process was segregated into four focal points: (1) the release from the truck, (2) the release pipe, (3) the receiving body near field, and (4) receiving body far field. These are considered discrete components in which it may be possible to isolate factors that contribute to fish stress and mortality. Each focal point has its own equipment, structure, and environment that creates potential stressors that act on the fish. Each focal point has experimental variables associated with it that can be manipulated in an attempt to reduce the effects of the stressors and increase fish survival.

FOCAL POINT	RELEASE FROM TRUCK	RELEASE PIPE	RECEIVING WATER NEAR FIELD (WITHIN 150 FEET OF RELEASE PIPE)	RECEIVING WATER FAR FIELD
EQUIPMENT / STRUCTURE / ENVIRONMENT	TRUCK DESIGN, OUTLET DESIGN, FLUSHING METHOD, DEBRIS LOAD, RAKE HANDLE, WATER TEMPERATURE, DISSOLVED OXYGEN,SALINITY	PUMPED ADD-IN WATER, VELOCITY IN PIPE, MIXED FLOW REGIME (OPEN CHANNEL AND PIPE FULL), DEBRIS LOAD, PIPE DESIGN, WATER SURFACE DIFFERENTIAL	DEPTH OF RECEIVING WATER, VELOCITY OF RECEIVING WATER, EDDIES CAUSED BY NEARBY STRUCTURES, COVER FOR RELEASED FISH, WATER TEMPERATURE, SALINITY, LIGHT, TURBIDITY, FREQUENCY OF RELEASE, LOCATION, PREDATOR DENSITY, PREDATOR ATTRACTION TO STRUCTURE, PREDATOR ATTRACTION (LEARNED BEHAVIOR) TO RELEASE SITE, TIDAL PATTERN, SEASONALITY, PREDATOR COMPOSITION, PREDATOR FEEDING	DEPTH OF RECEIVING WATER, VELOCITY OF RECEIVING WATER, EDDIES CAUSED BY NEARBY STRUCTURES, COVER FOR RELEASED FISH, WATER TEMPERATURE, SALINITY, PREDATOR DENSITY, LOCATION, LOCAL HYDRODYNAMICS, CHANNEL MORPHOLOGY, PREY SPECIES BEHAVIOR, DISSOLVED OXYGEN, FOOD AVAILABILITY
POTENTIAL STRESSORS IN PROCESS	OUTLET SIZE, FLUSHING METHOD, TURBULENCE, COLLISIONS WITH DEBRIS, COLLISIONS WITH OUTLET, COLLISIONS WITH RAKE HANDLE, DEBRIS CLOGGING OF OUTLET, DEWATERING OF FISH BY DEBRIS, CROWDING	DEBRIS LOAD, BENDS IN PIPE, SHEAR STRESS FROM ADD-IN WATER, TURBULENCE FROM ADD-IN WATER, IMPACT OF FISH WITH RECEIVING WATER BODY, COLLISIONS OF FISH WITH DEBRIS, COLLISIONS OF FISH WITH PIPE WALLS	IMMEDIATE PREDATOR-PREY INTERACTIONS, PREDATION LOSS, SEPARATION FROM OPTIMUM REARING OR SPAWNING HABITAT, DIFFERENCE IN OXYGEN AND OTHER DISSOLVED GASES, PREDATOR AVOIDANCE, DIFFERENCE IN WATER TEMPERATURE, DIFFERENCE IN SALINITY, DISTANCE FROM SUITABLE LIFE STAGE HABITAT	PREDATOR AVOIDANCE, PROLONGED ADVERSE PREDATOR-PREY INTERACTIONS, SUBOPTIMUM REARING OR SPAWNING HABITAT, INCREASED, PHYSIOLOGICAL COSTS TO MOVE TO OPTIMUM HABITAT,DIFFERENCE IN WATER TEMPERATURE, DIFFERENCE IN SALINITY, DISTANCE FROM SUITABLE LIFE STAGE HABITAT
IMPACTS OF STRESSORS ON FISH	ABRASION, SCALE LOSS SHEAR STRESS, DISORIENTATION, IMMEDIATE/DELAYED MORTALITY, ACUTE/CHRONIC STRESS, SUSCEPTIBILITY TO DISEASE	ABRASION, SCALE LOSS, SHEAR STRESS, DISORIENTATION, IMMEDIATE/DELAYED, MORTALITY, ACUTE/CHRONIC STRESS,	PREDATION, ACUTE/CHRONIC STRESS, SUSCEPTIBILITY TO DISEASE, IMMEDIATE/DELAYED MORTALITY	ACUTE/CHRONIC STRESS, SUSCEPTIBILITY TO DISEASE, IMMEDIATE/DELAYED MORTALITY, PREDATION
EXPERIMENTAL VARIABLES	OUTLET SIZE, FLUSHING METHOD, DEBRIS COMPOSITION, DEBRIS QUANTITY AND QUALITY, RELEASE SITE /FACILITY, RELEASE PROCEDURE	OUTLET SIZE, ADD-IN WATER INTRODUCTION, QUANTITY OF DEBRIS, NEW RELEASE TECHNOLOGIES, RELEASE PIPE DIAMETER	LOCATION OF RELEASE, RECEIVING WATER CONDITIONS AND NEARBY HABITATS, TIME OF DAY, PREDATOR DENSITY OR BEHAVIOR, ACCLIMATION TO RECEIVING BODY WATER QUALITY	LOCATION OF TEST FISH RELEASE, TIME OF RELEASE, LOCATION OF TEST FISH RETRIEVAL, EXPOSURE TIME TO SUBOPTIMAL CONDITIONS, PREDATION RATE, SHORT TERM SURVIVAL RATES

Figure 2-3 Conceptual Model

2.5 Research Objectives

Interrelated problems permeate the salvage and CHTR process. Exposure to salvage, collection, handling, and transport may cause cumulative stress to the salvaged fish before release. This proposal focuses on release and seeks to answer the following questions:

- Is predation a major factor in salvaged fish survival?
- Are the two release sites on the northern shore of Sherman Island equally effective?
- Of the differences between the sites, which factors influence fish survival?
- What level of mortality do fish of concern experience during or after release using the existing release facility?
- Is there a threshold level of debris that can be released without increasing the levels of stress, disorientation and mortality experienced by fish of concern using the existing release facility?
- What are the characteristics of a good release site for the salvaged fish?

2.6 Alternative Technologies Decision Framework (ATDF)

The experiments proposed fit into the overall structure of the CHTR program. As outlined in the *Program Proposal* (Coulston, 2004), determinate factors for the survival and condition of salvaged delta smelt will be identified and conceptual evaluation criteria will be developed and used to rank promising alternatives.

2.7 Elements of the Investigation

This proposal focuses on survivability of salvaged fish following release from the fish transport truck. The elements of the investigation are:

- Survival following release
- Predation as a factor contributing to mortality at release
- Physical factors influencing mortality during release

Descriptions of these elements are found in the Sections 3 through 5.

2.8 Adaptive Management

Given the interdisciplinary nature of the proposed investigations and the ability to refine and redirect the experimental design of the proposed investigations, the project will be managed within the context of an adaptive management framework. The experimental design for the proposed investigations presented in the proposal provide guidance for the investigations, however as new information becomes available through these studies individual aspects of the studies may be revised or refined to take advantage of the new information. As information is developed through each aspect of these investigations, analyses will be conducted and used to help refine the tests, data collection methods, and analytical tools used to test the various hypotheses outlined in the investigation. Results of ongoing data collection efforts and analyses will be discussed with the CHTR technical workgroup, CVFFRT, and among colleagues. Based upon results of the ongoing tests, the identification of refinements or alternative methods and experimental techniques, and other new information the team will periodically reassess the investigation and refine or modify the investigation as appropriate within the framework of adaptive management.

2.9 IEP Management Team and CVFFRT Status Reports

As noted above, the CHTR team of investigators will analyze and assess the data being collected as part of this investigation on an ongoing basis throughout the period of the studies. On an annual basis the CHTR team will prepare and present a formal annual status review and summary of preliminary findings. The CHTR team will present results of the annual status review to the IEP Management Team and CVFFRT in August each year.

2.10 References

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Volume 5 - Hiebert, S., E. Holroyd 111, and R. Wydoski. 1997. *Field-testing and evaluation of a video image counting system for fish eggs in the Sacramento River, California, during May 1994. Tracy Fish Collection Facility Studies*, Volume 5. U. S. Bureau of Reclamation, Mid Pacific Region and Denver Technical Service Center. 19 pp.

3.0 ELEMENT 1 - SURVIVAL FOLLOWING RELEASE *(IN RESPONSE TO COMMENTS, ELEMENT 1 HAS BEEN DELETED FROM THE PROPOSAL. IT WILL BE SUBMITTED AT A LATER DATE UNDER SEPARATE COVER)*

4.0 ELEMENT 2 - PREDATION AS A FACTOR CONTRIBUTING TO MORTALITY AT RELEASE

4.1 Research Problem Statement and Objectives

Fish released into the Delta estuary, following salvage from the SVP and CVP export facilities, may experience increased mortality as a result of predation by both fish and birds. Studies have been conducted that document predation mortality as part of the salvage operations at both the SWP and CVP facilities (Delta Fish Facilities Technical Coordinating Committee 1980; Kano 1987; CDFG 1984; 1985; Fausch 2000; Willis et al. 1994) and at locations within the Delta receiving waters (Pickard et al. 1982). Quantification of actual losses resulting from predation mortality by both fish and birds within the receiving waters following release has not been done. During the salvage process, fish may experience elevated levels of stress, abrasion, and physical injury that may reduce their ability to avoid predation within the near-field waters surrounding a release site. In addition, fish released from the salvage operation are concentrated within a relatively small area immediately following release and may be disoriented by hydraulic turbulence as water and fish are released at a relatively high velocity through the release pipe. The concentration of potential prey, and the occurrence of dead or injured fish at the release point, may further result in the attraction and concentration of predators within the receiving waters at the point of release. Currently there are five release sites (four sites are currently operational and used for routine release of salvaged fish; one release site on the Sacramento River near Rio Vista is not currently operational) for the return of salvaged fish within the Delta. Active release sites include the SWP release sites in Horseshoe Bend, and a release site on Sherman Island on the lower San Joaquin River the CVP release sites are at the confluence between Horseshoe Bend and the Sacramento River, and a release site on the lower San Joaquin River at the Antioch Bridge. Relatively large numbers of fish are released at one or more of these sites on a frequent basis. The frequency of releases vary based on a number of factors including the seasonal densities and patterns of fish collected in salvage operations, debris loading, maximum fish loading times as specified in Biological Opinions, and diversion operations. The frequency of releases per site also varies, but generally does not exceed twice per day per site.

Anecdotal observations by recreational anglers have indicated that predatory fish are concentrated near these points of release. Field observations have also documented the attraction of predatory birds to the areas when releases of salvaged fish are being made. Preliminary observations using the DIDSON camera system at the SWP Horseshoe Bend release site provides further evidence of the occurrence of predatory fish at the release site. The potential magnitude of predation mortality as a factor contributing to overall survival of fish salvaged at the SWP and CVP facilities and released into the Delta estuary, however, is unknown.

The primary objective of Element 2 is to develop quantitative and qualitative information for use in assessing the potential magnitude of predation mortality within the near-field receiving waters at the release sites. Element 2 will also provide information on the geographic distribution and behavioral patterns of predatory fish at release sites in addition to comparative investigations of predator behavior and distribution during daytime and nighttime releases of salvaged fish. The field studies included in Element 2 are intended to provide the necessary scientific and technical information for assessing the importance of predation as a factor affecting survival of salvaged fish and, in the event that predation mortality is identified as a significant factor, the studies in Element 2 will provide a foundation of information useful in identifying and evaluating potential alternative their new technologies designed to reduce or avoid predation mortality of released fish.

4.2 Linkage to Conceptual Model and Decision Framework

The conceptual model of salvage release mortality (Figure 2-3) identifies several potential linkages between the survival of salvaged fish and predation mortality within the near-field receiving waters. Factors such as predator density, predator attraction to physical structures associated with release sites, predator attraction through learned behavior to release sites, increased vulnerability of prey to predation mortality following salvage as a result of disorientation by turbulence within the receiving waters, and reduced predator avoidance as a consequence of stress and injury resulting from salvage collection, handling, transport, and release are all identified as factors potentially affecting the overall survival of fish released into the Delta estuary following salvage. The conceptual model identifies both physical parameters, such as water depth, water velocity, physical habitat structures, water quality, and light levels associated with either turbidity or time of day, as factors affecting vulnerability of salvaged fish to predation. Biological factors are also included in the conceptual model such as the species and density of predators within the area, attraction of predators to an area of increased availability and vulnerability of potential prey, and learned behavior by predators (e.g., in response to arrival of a salvage truck, operation of the pumps providing water at the site of release, or other behavioral cues) that may also influence predator abundance and distribution within the near-field receiving waters. For purposes of the conceptual model and decision framework it has been assumed that a hypothetical predation loss of 10% or more of the salvaged fish would be considered to significant. The 10% criteria loss criterion was based on professional judgment regarding a level of predation mortality that would be detectable and sufficiently high to warrant further analysis and consideration. The criteria and the general approach designed to examine the potential role of predation mortality at the release site as a factor affecting salvage will be submitted to the IEP Estuarine Ecosystem Team (EET) for peer review and comment as part of development of these investigations. The decision framework for evaluating results of the predation investigations is shown in Figure 4-1. The proposed experimental design for Element 2 has been developed to address, in part, a number of these potential factors.

Is Predation Mortality a Biologically Significant Factor Affecting Overall Survival of Salvaged Fish

No

No further investigation

Yes

Identify and evaluate new technologies and alternative release strategies

- **Nighttime releases**
- **Reduced stress and injury**
- **Reduced turbulence and disorientation**
- **Release site characteristics**
- **Altered release frequencies**
- **Reduce attraction cues (random pump operations)**
- **Multiple, random release sites**

Figure 4-1 Element 2 Decision Framework

4.3 Research Questions in Detail

A number of questions exist regarding the potential magnitude and severity of predation mortality as a factor influencing overall survival of fish salvaged at the SWP and CVP and returned to the Delta estuary. These research questions include:

- What are the species of predatory fish and birds inhabiting the Delta estuary, on a seasonal basis, within the near-field receiving waters at each of the designated release sites?
- What is the density (concentration) and geographic distribution of predatory fish within the near-field receiving waters at each release site and do the abundance and distribution of predators change before, during, and after the release of salvaged fish?
- How does predation on salvaged fish vary between light and dark (day and night) conditions, effects of turbidity, high and low water velocities, with and without cover and structures that attract predatory fish?
- Are predatory fish behaviorally attracted to the near-field receiving waters at one or more of the designated release sites, and is there evidence of learned behavior contributing to the attraction of predators?
- Does the frequency of salvaged fish release at a release site change the distribution and density of predatory fish (e.g., multiple releases at a site within a day, one release every other day, one release per week, one release per month, etc.)?
- Do the distribution, abundance, and behavior of predatory fish and birds vary in response to release of salvaged fish during the daytime when compared to releases at night?

- Do differences in predatory species, density, or distribution vary among release sites in response to environmental factors such as differences in water depth and/or tidal current velocities?
- Can the attraction of predators to the near-field receiving waters at a release site be disrupted by alternative release strategies and/or behavioral avoidance stimulus to disrupt predator aggregation or feeding behavior?

4.4 Hypotheses to be Tested

The hypotheses to be tested regarding potential predation mortality on salvaged fish at the release sites include:

Hypothesis 1: Predation mortality within the near-field receiving waters is not a biologically significant contribution to overall mortality (fish consumed by predators) associated with release of salvaged fish.

For purposes of hypothesis testing a biologically significant level of predation mortality within the near-field receiving waters has been assumed to be 10% or more of the numbers of fish released from the salvage operation. The 10% predation mortality level is considered to be a general guideline for identifying a biologically significant level of predation mortality associated with the release of salvaged fish. The 10% value was selected based on professional judgment to represent a level of mortality to fish following release that potentially could be detected in filed studies and would be of sufficient magnitude to be identified as a significant factor affecting performance of the CHTR process to warrant higher priority when considering new release technologies. The actual results of the hypothetical predation mortality calculations will be presented in the technical report for Element 2 to assist scientists and managers to independently assess the potential significance of predation mortality as a significant factor affecting the overall survival of fish following release.

Hypothesis 2: The density (abundance) of predatory fish and birds is not significantly different within the near-field receiving waters at existing release sites when compared to a control location.

Hypothesis 3: The geographic distribution of potential predatory fish within the near-field receiving waters does not change significantly before, during, and after release of salvaged fish.

Hypothesis 4: Predatory fish do not exhibit behavioral attraction, learned behavior, or site fidelity within the near-field receiving waters at a release site.

Hypothesis 5: There is no significant difference in the density or geographic distribution of potential predatory fish and birds among the four existing salvage release sites.

Hypothesis 6: There is no significant difference in the density or distribution of potential predatory fish or birds within the near-field receiving waters in response to potential behavioral cues, such as operation of the water supply pump or timing of releases, resulting in behavioral attraction of predators to a release site.

Hypothesis 7: The density, distribution, and species composition of potential predators within the near-field receiving waters does not vary among seasons, or in response to variation in environmental conditions associated with factors such as water temperature, salinity, turbidity, and hydrologic conditions (including both seasonal changes in Delta hydrology and differences in water velocities at a release site within a day in response to tidal conditions).

Hypothesis 8: The density and distribution of predatory fish and birds does not change significantly in response to the species composition or numbers of fish released from the salvage operations.

Hypothesis 9. There is no significant difference in predation in response to the numbers or species of salvaged fish released at a site.

Hypothesis 10. No movement of predatory fish occurs into the near-field areas associated with release sites.

4.5 Assumptions and Limitations

Fundamental assumptions and limitations of the near-field receiving water predation study include, but are not limited to, the following:

- The near-field receiving waters are defined as an area extending 150 feet (radius) from each release site for predatory fish and 0.25 miles for predatory birds.
- Preliminary field pilot observations at the release sites using the DIDSON camera suggest that predatory fish aggregate near the release pipe.
- Preliminary observations at the release sites suggest that predatory birds are dispersed over a larger area as fish disperse from the release pipe.
- Field data collection efforts as part of this investigation do not change or alter the density or distribution of predatory fish or birds within the near-field receiving waters;
- The investigation of predation mortality within the receiving waters will require use of a variety of field data collection methods and analyses to address the range of hypotheses and environmental and biological factors affecting predation within the receiving waters;
- Given the difficulties of field data collection and observations it will not be possible to quantitatively evaluate differential vulnerability of different species or life stages of prey to predation mortality within the receiving waters (e.g., the studies will not differentiate between predation on juvenile threadfin shad and delta smelt);
- A wide variety of environmental and biological variables influence predator dynamics within the receiving waters, however by necessity, the proposed experimental field investigations have been simplified to focus on specific parameters and biological responses and therefore would not provide a comprehensive investigation of a wide range of factors affecting predation or the interaction among many of these factors on the vulnerability of fish released from salvage operations to predation mortality within the receiving waters; and
- For purposes of this investigation, a control location has been selected which is assumed to be representative of the habitat conditions and structural components of a

release site. The control location is a water intake structure, including multiple pipes, stationary fish screens, and surrounding pilings located approximately 0.5 miles upstream of the existing SWP release site within Horseshoe Bend. Other potential (additional) control sites will be investigated in the vicinity of each of the four currently operating release sites (control sites such as water intakes will be selected for inclusion if they are located in the same general vicinity as a release location and have similar structural characteristics). The experimental study assumes that predator response and distribution at the control site is representative of conditions occurring at the SWP Horseshoe Bend release site and can be used on a comparative basis to evaluate the results of field studies and observations at other release sites. Based on the similarities in water depths and velocities the proposed control location and the SWP Horseshoe Bend release site habitat and environmental conditions appear to be similar. Water depths and velocities, at the control site, however, differ from environmental conditions occurring at the CVP Sacramento River release site and Antioch Bridge release site. As a result, comparisons between the release site and control location may be limited to data collected at the SWP Horseshoe Bend release location.

4.6 Experimental Design, Methods and Approach

The experimental design, methods, and approach for evaluating predator dynamics and the potential significance of predation mortality on overall survival of salvaged fish within the near-field receiving waters at the existing release sites include five separate, but interrelated, field studies and data analyses. The five approaches developed for assessing potential predator dynamics within the receiving waters include:

- Hypothetical predation risk analysis;
- Bioacoustic determination of predator abundance, distribution, and behavioral attraction;
- DIDSON observations of near-field predator behavior before, during, and after release;
- Sampling to determine predator species composition and density at release sites; and
- Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites in response to release patterns and alternative release strategies.

As part of developing the CHTR proposed experimental design and the identification of methods and protocols, scientific and technical literature regarding the collection, handling, transport, and release of fish was conducted. The literature review included information from previous investigations conducted at the SWP and CVP salvage facilities as well as results of investigations conducted on similar projects located in the Pacific Northwest and elsewhere. In addition to the literature review, the CHTR team consulted with a variety of experts regarding the experimental design, methods and protocols for conducting the tests, techniques for data analysis, and results of these investigations. In addition, datasets from fishery and operations monitoring preformed at the SWP and CVP fish salvage facilities were also obtained and preliminary analyses of these datasets were used in forming the basis for the proposed CHTR investigations. Information developed through this literature review and consultation process has been used in the development of the proposed Phase I CHTR investigations. Although results and citations to the literature reviewed have not been included in this proposal, a separate report has been prepared in draft form presenting results of the literature review and consultations. Information from the literature review, which will be ongoing throughout the period of these investigations, will be included in the technical documentation report for these investigations.

Based on results of the literature review, preliminary analyses of fishery and operations data for the salvage facilities, discussions with knowledgeable experts and facility operators, a range of hypotheses (Section 4.4) were identified to be tested as part of these investigations. Information from the literature review and other sources was also used to identify a range of experimental methods and approaches that could be used to test the hypotheses. The matrix presented below summarizes the linkages between the hypotheses to be tested and the proposed experimental design and methods for each of the investigations.

Number (see Section 4.4)	Hypothesis to Test	Experimental Design/Methods
1	Predation mortality within the near-field receiving waters is not a biologically significant contribution to overall mortality (fish consumed by predators) associated with release of salvaged fish.	Hypothetical predation risk analysis Bioacoustic determination of predator abundance, distribution, and behavioral attraction Sampling to determine predator species composition and density at release sites
2	The density (abundance) of predatory fish and birds is not significantly different within the near-field receiving waters at existing release sites when compared to a control location.	DIDSON observations of near-field predator behavior before, during, and after release Sampling to determine predator species composition and density at release sites
3	The geographic distribution of potential predatory fish within the near-field receiving waters does not change significantly before, during, and after release of salvaged fish.	Bioacoustic determination of predator abundance, distribution, and behavioral attraction DIDSON observations of near-field predator behavior before, during, and after release Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites

4	Predatory fish do not exhibit behavioral attraction, learned behavior, or site fidelity within the near-field receiving waters at a release site.	DIDSON observations of near-field predator behavior before, during, and after release Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites
5	There is no significant difference in the density or geographic distribution of potential predatory fish and birds among the four existing salvage release sites.	Bioacoustic determination of predator abundance, distribution, and behavioral attraction DIDSON observations of near-field predator behavior before, during, and after release Sampling to determine predator species composition and density at release sites Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites
6	There is no significant difference in the density or distribution of potential predatory fish or birds within the near-field receiving waters in response to potential behavioral cues, such as operation of the water supply pump or timing of releases, resulting in behavioral attraction of predators to a release site.	Bioacoustic determination of predator abundance, distribution, and behavioral attraction DIDSON observations of near-field predator behavior before, during, and after release Sampling to determine predator species composition and density at release sites Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites

7	The density, distribution, and species composition of potential predators within the near-field receiving waters does not vary among seasons, or in response to variation in environmental conditions associated with factors such as water temperature, salinity, turbidity, and hydrologic conditions (including both seasonal changes in Delta hydrology and differences in water velocities at a release site within a day in response to tidal conditions).	Bioacoustic determination of predator abundance, distribution, and behavioral attraction DIDSON observations of near-field predator behavior before, during, and after release Sampling to determine predator species composition and density at release sites Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites
8	The density and distribution of predatory fish and birds does not change significantly in response to the species composition or numbers of fish released from the salvage operations.	Bioacoustic determination of predator abundance, distribution, and behavioral attraction DIDSON observations of near-field predator behavior before, during, and after release Sampling to determine predator species composition and density at release sites Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites
9	There is no significant difference in predation in response to the numbers or species of salvaged fish released at a site.	Hypothetical predation risk analysis DIDSON observations of near-field predator behavior before, during, and after release Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites

10	No movement of predatory fish occurs into the near-field areas associated with release sites.	Bioacoustic determination of predator abundance, distribution, and behavioral attraction DIDSON observations of near-field predator behavior before, during, and after release Sampling to determine predator species composition and density at release sites Radio/acoustic tagging to examine predator movement (e.g., site fidelity, behavioral attraction, etc.) at release sites

Each of these complementary study efforts is briefly described below.

4.6.1 Hypothetical Predation Risk Analysis

An extensive body of information is available on the development and application of bioenergetics models used to assess predation by both fish and birds on juvenile fish and other aquatic organisms. A variety of model formats have been used including individual based models, relational spreadsheet models, bioenergetic simulation models, statistical models (regressions models, etc.) and others (Whipple et al. 2000; Penczak et al. 2002; Huse and Giske 1998; Tolonen 1998; Breck 1998; Chipps and Bennett 2002; Eggleton et al. 2004; Sarvala et al. 2002; Mohn and Bowen 1996; Winship et al. 2002; Phillips et al. 1999; and many others). These modeling approaches have been used, for example to assess the significance of predation mortality on juvenile Chinook salmon from fish within the Columbia and Snake River reservoirs (Shively et al. 1991). Models have also been used to assess the significance of predation by birds (e.g., Caspian terns) on salmon and steelhead within the Columbia River estuary (NOAA Fisheries 2002) and by cormorants and pelicans on fish inhabiting rivers (Derby and Lovvorn 1997). Bishop and Green (2001) examined predation mortality on Pacific herring eggs by birds using a bioenergetics-based model. Information is also available on the integration of environmental factors such as seasonal water temperatures into predation models as well as basic bioenergetic relationships between predation rates and environmental conditions (Trudel et al. 2000;Ault et al. 1999; Mehner 2000; Rand and Stewart 1998; Krohn et al. 1997; Taylor and Collie 2003; Paakkonen and Marjomaki 2000; Petersen and Kitchell 2001). Based on a review of the application of these and other models we have concluded that the potential magnitude of predation mortality on salvaged fish released into the Delta estuary can be addressed using a bioenergetically based hypothetical risk analysis.

Although a variety of modeling approaches are available, we have proposed that a simple spreadsheet mechanistic bioenergetic-based modeling approach be used in the initial development of the predation risk assessment. As the model is being developed, consideration will be given to adapting alternative model formats to refine the assessment and address the key issues. Information would be compiled from fishery studies conducted within the Delta estuary by CDFG and others regarding the species composition, size distribution, and relative density of predatory fish species for use in the predation analysis. Field observations of the species composition and abundance of predatory birds at the release sites would also be compiled as part of the predation analysis. Information on the species composition and numbers of fish released at individual sites from both SWP and CVP salvage operations is available from salvage records maintained in a central database by CDFG (Steve Foss, pers. com.). Information from the salvaged database can be used to characterize the numbers of fish released at each location and the frequency of releases under normal routine salvage operations. Information is also available from the scientific literature on the number of prey consumed by different species and sizes of predatory fish and birds in addition to the changes in prey consumption and gastric evacuation rates of prey as a function of environmental variables such as water temperature. Information from these various sources would be compiled; the relationships and assumptions documented, and a series of hypothetical predation risk analysis will be performed.

The predation risk analysis would assume a range of predator densities occurring over the geographic area encompassed by the near-field receiving waters at a release site in order to generate a population abundance estimate of predatory fish within the area adjacent to a release location. A similar analysis would be performed using field observations of the abundance and species composition of predatory birds occurring at each release location. Based on the estimated population abundance within the near-field receiving waters, in combination with data on prey consumption from the scientific literature, an estimate can be derived of the total number of prey potentially consumed by fish and bird predator populations inhabiting the near-field receiving waters. The analyses would be refined using site-specific information on seasonal water temperature conditions and gastric evacuation rates to assess potential predation mortality within and among days characterized by individual or multiple salvage releases. The analyses will also be refined by using site-specific information on avian predator densities at each of the release sites developed through monitoring performed as described in Section 4.6.4.

The hypothetical estimate of predation mortality within the near-field receiving waters would be compared to information on the seasonal patterns in the numbers of fish salvaged and returned to release locations within the central Delta. Descriptive statistics would then be generated, by season, for the expected percentage and 95% confidence intervals on the proportion of salvaged fish expected to be consumed by predators. For purposes of these hypothetical analyses a preliminary threshold for a biologically significant level of predation mortality (e.g., 10% consumption of fish released as part of the salvage operation) would be assumed to represent a biologically significant level of predation mortality.

The analyses could be further refined to include information on local water velocities and dispersal of fish following the release from salvage operations. This could then be factored into the predation vulnerability analysis to estimate the effects of a large number of fish being released at a site over short period of time (predator swamping). Results of these analyses will provide a general background and foundation for assessing the probable biological impact of near-field predation and its effect on the overall survival of fish released from the salvage operation. The analyses can be further refined to include assumptions regarding differential predation rates on fish released in a healthy condition and actively able too avoid predation, fish released in a stressed condition with a reduced predator avoidance capability, and the effects of predation on fish released which were dead following salvage as additional parameters within the hypothetical predation vulnerability model.

Results of the predation calculations are not intended to represent a field-based experimental quantification of predation mortality at a release site, but rather are designed to provide an analytical framework for assessing the potential magnitude of predation mortality within the receiving waters and the relative contribution of various factors influencing the magnitude of predation. The predation calculations can also be used to examine the sensitivity of various parameters such as fish size, number, and species of predators as factors affecting predation risk for salvaged fish. A key element in developing the predation model would be documentation of the sources of information used to construct various assumptions and biological relationships within the model in addition to interactive review of the model construct and assumptions with other scientists involved in Delta fishery investigations. The model will provide a flexible framework for incorporating a range of parameters and relationships that can be tested as part of the development of the predation assessment tool.

4.6.2 Bioacoustic Determination of Predatory Fish Abundance, Distribution, and Behavior

Bioacoustic surveys would be developed and conducted within the receiving waters to identify the geographic distribution and relative abundance of predatory-sized fish for comparative analyses during periods before, during, and after the release of salvaged fish. During the initial stage of identifying specific instruments and methods to be used in conducting the bioacoustic surveys manufactures (e.g., BioSonics and HTI) and other knowledgeable experts (e.g., Mike Horn USBR) will be contacted to discuss the application of specific alternative equipment and deployment methods. Equipment will include consideration of the application of both fixed position and mobile survey methods. CHTR staff will be trained in the deployment, maintenance, servicing, and operations of the survey equipment. Manufactures and other knowledgeable experts will be included as part of the project team, as needed to assist in developing and implementing the bioacoustic surveys, as well as data analysis and interpretation. Bioacoustic survey data will be subject to quality control review throughout the investigation. The receiving waters in the vicinity of each of the four operating release locations will be surveyed using (1) boat mounted survey equipment to assess predator distribution and movement within the region surrounding a release location (the survey area will extend approximately 0.25 mile (radius) around the release site), and (2) fixed location survey equipment to monitor predator abundance and movement within the near-field zone (extending 150 foot radius) around one or more release site(s). Using the two complementary acoustic survey designs provide opportunities to assess general predator distribution within the receiving waters while also providing high resolution information on predator occurrence in the shallower areas and around the structures associated with release sites. As part of the initial phase of establishing the acoustic monitoring program, field tests will be performed to determine the most effective transect spacing and alignment for both the moving and stationary (rotating) transducers. Tests will also be performed to calibrate the equipment for various target sizes and to assess potential interference caused by entrained air bubbles and debris during a salvage release. Results of the initial testing will be used to refine the experimental design and determine any special needs for equipment mounting or operations. During the initial pilot testing phase surveys and inspections will also be made to identify potential control sites within the area. One control site located at a water intake structure in Horseshoe Bend has already been identified, however other potentially suitable sites may be identified along both the lower Sacramento and lower San Joaquin rivers for comparison to adjacent release sites.

A boat mounted bioacoustic (hydroacoustic) transducer(s) will be used to survey along a series of pre-established transect lines representing a grid of transects both parallel and perpendicular to the channel alignment within an area approximately 0.25 miles from the release site. The bioacoustic surveys would be performed within each of the designated transect grids in a systematic way to identify the location and estimate the abundance (density) of predatory-sized fish. Surveys would be conducted at each of the four release locations, in addition to the control site within Horseshoe Bend (and other control sites identified near release locations), before, during, and after salvage fish releases. The location of the survey vessel along each transect line will be mapped using GPS to allow for analysis of the geographic distribution of predatory fish, which would be plotted using a GIS system, to show the locations of predators with respect to location of each release.

Fixed position acoustic transducers, equipped with remote rotator units to allow coverage over the entire near-field area, and would also be temporarily mounted at each release and control site to assess predator distribution and changes in abundance in the area immediately surrounding a release site. One or two transducers would be operated at each site depending on site-specific characteristics and coverage of the near-field area. The area surveyed with the fixed transducers would extend approximately 150 feet from the release and would include the near-shore shallow-water areas adjacent to each release location. The fixed position transducers will provide useful information on movement and behavioral patterns within the near-field zone for fish in response to the release of salvaged fish.

The acoustic surveys would be performed to evaluate salvage releases during both day and nighttime conditions at each release site to allow comparison of potential differences in predator distribution and behavioral response. Surveys would also be conducted to assess changes in predator distribution and abundance at each release site separately, during strong ebb, slack tide, and strong flood tide conditions to assess the potential effects of tidal current velocities on the distribution of predators within the near-field receiving waters. Surveys would also be conducted at one or more control locations (e.g., screened water diversions, etc.) to compare predator abundance and distribution patterns with those observed at the release sites.

The bioacoustic surveys would be performed on approximately a quarterly basis to coincide with the seasonal periods of peak abundance for various potential prey species. Preliminary scheduling of the surveys would include surveys conducted during May, August, November, and February to encompass a range of seasonal environmental conditions that may affect species composition and abundance of predators within the central Delta. The level of effort among surveys may vary to concentrate effort during those seasonal periods when the greatest numbers of sensitive fish species are present in the salvage operations. Surveys within specific time periods, such as the spring (May) survey, are intended to represent a seasonal period when juvenile fall-run chinook salmon and delta smelt are present in the salvage operations. Results of these surveys will be used to examine changes in the geographic distribution and abundance of predatory fish among the four release sites. The data would also be used to compare the response to three different frequencies of salvage releases, which would include (1) multiple releases at one site within a day; (2) one release at a site every other day; and (3) one release at a site once per week. Coordination regarding changes in the frequency of releases at one or more of the release locations will occur with state and federal resource agencies prior to finalizing the experimental design to assure compliance with Biological Opinions and other operating requirements. Changes in predator abundance and distribution in response to the frequency of salvage releases can then be assessed by alternating release frequencies at various sites and subsequently assessing changes in predator population dynamics.

Bioacoustic survey results provide an index of predatory fish abundance and distribution within the receiving waters. The acoustic monitoring detects a fish's air bladder and can infer fish size based on the signal strength. Acoustic surveys alone, however, can not identify the species of fish within an area. Acoustic surveys therefore are used as one of several survey methods during this investigation to augment results obtained from other sampling methods included in this investigation. Information on predatory fish species compositions, for example, will be developed from the physical fish sampling in the near-field zone described in Section 4.6.4. Additional information on the relative abundance, behavior, and potentially species composition of fish in the near-field zone will also be obtained from the DIDSON observations (Section 4.6.3). As a result of the strengths and weaknesses of various sampling methods available for assessing predation at a release site, the experimental design includes multiple complementary survey approaches.

Results of these surveys will provide useful information on the changes in predator abundance and distribution within the near-field receiving waters, comparisons among release sites, comparisons between day and nighttime releases, and the ability to assess potential changes in response to the frequency of releases at a site. The survey design would also provide the ability to examine changes in predator abundance and distribution seasonally in response to changes in both environmental conditions and potential changes in the species composition of both predators and prey inhabiting the Delta on a seasonal basis. Comparative information on changes in predator abundance and distribution between ebb, flood, and slack tidal stages will provide further information on evaluating potential alternative release strategies designed to reduce the potential risk and vulnerability of salvaged fish to predation mortality.

Analysis of Variance (ANOVA) will be used to determine if statistically significant differences exist in the number of predators in the vicinity of the CVP and SWP release sites, including statistical analyses of differences among release sites, and between release sites and their respective reference or control locations. ANOVA will also be used to determine if significant differences exist in the number of predators present within the near-field area at each site and their respective control locations diurnally (day and night); during various tide stages (ebb, flood, slack); if there are changes in predator density with relation to the timing of the release (before, during, and after release); seasonally (spring, summer, fall, and winter), and/or distance from the release point. The interaction terms of site and time of release, diurnal, and distance from the release point will also tested. A series of Ryan-Einot-Gabriel (REGWQ) multiple range tests will be used to determine if significant difference occur between the predator densities by release site, diurnally, timing of the release, tidal stage, and distance from the release point. Additionally, the least-squares estimates of the marginal means for the main effects will be calculated. The least-square estimates of the means are made with all covariates at their mean value. A biostatistician will participate throughout the investigation to provide assistance in designing the data collection program and the resulting statistical analyses of the data. Additional statisticians with expertise in analyzing and interpreting results of acoustic surveys, including researchers from the University of Washington and other academic institutions, private industry, and others will be consulted, as needed, throughout the design and analysis of results of the acoustic surveys.

4.6.3 DIDSON Observations of Predator Fish Behavior Before, During, and After Release

The DIDSON camera system provides a valuable observational tool that can be used to assess changes in predator behavior at a release site before, during, and after the release of salvaged fish. As part of these tests, permanent facilities would be installed (e.g., brackets to pilings and/or anchors for positioning boats and the DIDSON camera, etc.) at the SWP Horse Shoe Bend release site that would allow the DIDSON camera to be positioned at a fixed stationery (with capability to be rotated remotely) location for the purpose of determining predator behavior in the immediate area associated with the discharge from the release pipe. The field of view the DIDSON camera would be fixed at one location throughout the observational period to determine changes in predator behavior before, during, and after releases conducted both during the daytime and at night. With a fixed field a view predator abundance numbers would be measured within the field of view. Observations of the DIDSON camera would also be used to assess potential changes in predator behavior, in the potential behavioral attraction to the release pipe discharge location during ebb, flood, and slack tidal conditions representing a range of water velocities at both the SWP and CVP release sites. Similar observations would be conducted at the CVP release site at the confluence between Horseshoe Bend and the Sacramento River to compare predator behavior at these two locations characterized by differences in water depths and tidal velocities. At the CVP site the DIDSON camera would be boat mounted. A similar set of observations using the DIDSON camera would be made at the control location sited approximately 0.5 miles upstream of the SWP release site within Horseshoe Bend (using an anchoring system to position the DIDSON camera). As discussed above, other potential control sites within the lower Sacramento and lower San Joaquin rivers will be examined for potential inclusion into the investigation.

During each set of DIDSON observations, a grid would be established within the field of view of the DIDSON camera designated by individual X - Y coordinates. A series of three 10-minute observation periods would be recorded prior to a release, three 10-minute observation periods during a release (with the actual release coinciding with the start of the second 10-minute observation period), and three 10-minute observation periods after the release has been completed. The number of predatory-sized fish observed entering and exiting the DIDSON field of view grid during each of the 10-minute periods would then be quantified in addition to quantification, to the extent possible, of the length of potential predator fish observed. Additional observations from the DIDSON records on the frequency of occurrence of predator strike behavior during each of the observation periods would also be recorded. Pilot tests will be performed using the DIDSON camera to assess predator behavior in response to live and dead prey released from the pipe. The observational tests for the releases would be replicated under each treatment and control condition a minimum of three times during each survey period. Survey periods would be approximately quarterly to provide information on changes in predator behavior and frequency of occurrence at the point of release in response to various seasonal conditions.

Results of the DIDSON observations will be documented both electronically as part of computer files containing the DIDSON observations and images, in addition to quantified in accordance with pre-established criteria for determining the occurrence of potential predatory-sized fish under each of the observational scenarios. The data derived from the observations would be entered into a Microsoft Access database, and subsequently used for statistical comparisons to identify potential differences in predator behavior and occurrence within the area immediately adjacent to the release pipe discharge under each of the test conditions.

Analysis of Variance (ANOVA) will be used to determine if statistically significant differences exist in the number of predators in the vicinity of the CVP release site, the SWP release site, and the control site. The ANOVA will also be used to determine if significant differences exist in the number of predators present diurnally (day and night); during various tide stages (ebb, flood, slack); if there are changes in predator density with relation to the timing of the release (before, during, and after release); or seasonally (spring, summer, fall, and winter) the interaction terms of site and time of release and site and tide and will also tested. Regardless of whether a significant difference existed between stations, an *a priori* comparison will be made between predator densities at the test sites (SWP and CVP) and survival rates at the reference location. A series of Ryan-Einot-Gabriel (REGWQ) multiple range tests will be used to determine if significant difference occur between the predator densities by release site, diurnally, by timing of the release, and by tidal stage and flow. Additionally, the least-squares estimates of the marginal means for the main effects will be calculated. The least-square estimates of the means are made with all covariates at their mean value. A biostatistician will participate in the design of the data collection program and the analyses of resulting information.

4.6.4 Sampling to Determine Predator Species Composition and Density at Release Sites

Information on the species composition, length frequency, and density-of predatory fish captured within the near-field receiving waters at selected release sites and control locations would be collected using conventional fishery sampling techniques (electrofishing and beach seine, etc). Fishery sampling would be limited to periods after the completion of each quarterly field survey to reduce and avoid the influence and bias to the local predator populations as a result of disruption caused by fishery sampling. In the event that there is evidence that the sampling is affecting the species or habitat within the area the sampling will be modified or discontinued. The primary location for collecting predatory fish will be the SWP Horseshoe Bend release site, where bottom topography is flat, water depths are relatively shallow (15 feet and less), and tidal water velocities are relatively low compared to the CVP release site. The environmental conditions and configuration of the SWP Horseshoe Bend release site would permit capture and quantification of predatory fish inhabiting the area immediately adjacent to the release pipe. To the extent that fishery sampling can be conducted successfully other release sites will also be surveyed.

Following completion of a quarterly field sampling event a commercial-sized beach seine, with two-inch nylon mesh netting, extending approximately 20 feet deep and up to 1,000 feet in length, would be deployed by boat from a location upstream of the existing SWP release pipe. The beach seine would then be set in a way that would completely enclose the area of Horseshoe Bend surrounding the existing release site. The net would be held in place by a series of pilings and/or buoys and anchors used to entrap all of the potential predatory-sized fish inhabiting the area immediately adjacent to the release pipe. The area within the beach seine would then be electrofished using a boat-mounted electroshocker to recover captured fish. Similar sampling will also occur at the upstream “control” location within Horseshoe Bend for comparison to results from the SWP release site. As a result of differences in physical habitat conditions among release sites, results of surveys at sites within Horseshoe Bend may not be representative of predatory fish populations at other release sites. To the extent that other sites can be surveyed, comparative information will be developed to assess similarities and differences in the predatory fish populations among release sites. As a result of the disturbance to the predator population within the near-filed area surrounding a release site and the potential to bias results of other predation surveys (e.g., bioacoustic and radio tagging surveys) beach seining and electrofishing collections will be conducted as the last activity during the quarterly predation surveys.

Fish captured would be identified to species, and length and weight would be measured. Each predatory fish (greater than 150 mm in length) would then be tagged using a Floy or other suitable tag to determine potential recapture in subsequent sampling events, and released at the site. Based on the number of each predatory fish collected and the area sampled using the beach seine, an estimate of the density (number to 1000 square meters) of predatory fish within the area would be derived. Results of tagging would provide information on fidelity of predators to the release location in the event that a tagged fish is subsequently recaptured near a release location. The expected probability of recapturing tagged predators is anticipated to be low.

The predator surveys would be repeated at the SWP release site approximately quarterly to assess changes in predator community on a seasonal basis. The predator surveys would be conducted following a period of routine salvage releases at the site. Results of the predator surveys would also be evaluated, in combination with corresponding results of both the DIDSON camera observations and bioacoustic surveys, to provide further complementary information on calibrating results of various field methods and in determining the relative size and species composition of the predator population inhabiting the near-field receiving waters.

The species composition, abundance (density), and location within the receiving waters of predatory birds will be monitored before, during, and after releases of salvaged fish. Observation locations will be established adjacent to each of the four operating release sites and control locations for avian surveys. A map will be used to mark the location of avian predation activity. Binoculars and/or a spotting scope will be used, if necessary, for species identification. The near-field receiving waters will be video taped over a series of releases during each season to document changes in abundance and distribution of avian predators in response to salvaged fish releases. No birds will be collected or sacrificed to determine actual predation success at the release or control sites.

4.6.5 Radio/Acoustic Tagging to Examine Predator Movement (site fidelity, attraction) at Release Sites

Predatory fish, including striped bass and Sacramento pikeminnow, would be captured in the area adjacent to the existing release sites, and would be tagged using individually identifiable radio or acoustic tags. Predatory fish would be captured at each of the four operating release and control sites using hook and line for tagging. After tagging and recovery, the fish would be released near the release site where they were captured. The tagged fish would subsequently be monitored, using fixed and/or portable detection equipment. The location of each predator would be determined based on triangulation. Movements of predators would be tracked and monitored on a daily basis, specifically before, during, and after releases, or other appropriate frequency based on fish movement and tag battery life, to determine their behavior patterns within the area during both day- and nighttime conditions.

Results of the tag monitoring would be used to assess site fidelity of predators, with predatory fish remaining in the immediate near-field or adjacent receiving waters associated with a release location over an extended period of time. Additionally the data will be used to examine behavioral attraction of predators that may move from far-field locations (e.g., 0.25 or more miles away from a release location) into the area immediately adjacent to the release in response to behavioral cues or the release of salvaged fish (behavioral attraction in response to a release). The location of predatory fish would be monitored to allow comparison of behavior and distribution before, during, and after releases, to allow comparative information to be developed on predator behavior and attraction to a release site during day- and nighttime surveys, and to compare predator behavior between release locations.

The radio tagging investigation will be designed with the assistance of individuals with expertise in conducting biotelemetry investigations to assess predatory fish movement and behavior. A biostatistician will also participate throughout the investigation to assist in the experimental design and subsequent statistical analysis of resulting information.

4.7 Coordination

Coordination among investigators involved in the predation studies will require frequent communications between operators at both the SWP and CVP fish salvage facilities and scientists involved in conducting the predation studies. Coordination would include scheduling the time and location for salvage releases during periods when experimental observations are being made, in addition to coordination of data transfer regarding species composition and numbers of individual fish returned to each specific release location. Performance of the predation studies should not interfere with routine fish salvage operations other than modifications to the schedule and locations where releases are made.

Additional coordination will occur through communications with fishery scientists from IEP, CALFED, CDFG, USFWS, DWR, USBR, academia, and private consultants. Collaboration with investigators conducting stomach digestion investigations (Geir Aasen), Charles Simenstad (University of Washington), and others will strengthen the investigation. Consultation with CDFG research staff knowledgeable about biotelemetry and potential involvement in the investigation as well as others from the University of Washington and other institutions and the private sector will occur throughout the investigation. Similarly, consultation with USBR research staff knowledgeable about bioacoustic surveys and potential involvement in the investigation as well as others from the University of Washington and other institutions and the private sector will occur throughout the investigation. Collaboration with USBR staff regarding the design, location (potentially mobile), and operations of an additional salvage release site/facility will also benefit from information gained through this investigation regarding potential differences in predation risk for salvaged fish at different locations.

Coordination among investigators will facilitate the compilation and analysis of information on predator population density, seasonal changes in species composition of predators within areas associated with salvage releases. Communication among investigators will also facilitate the review and analysis of information from the scientific literature and other investigations regarding predation rates, gastric evacuation rates, the influence of fish species, size, water temperature, and prey availability and swamping effect on predation rates, and the integration of other relevant scientific information within the analytical framework established by the near-field predation vulnerability and risk model. Coordination among investigators will be facilitated by participation in IEP workgroup meetings, presentation of information at the IEP and American Fisheries Society conferences, and frequent communications between the project team and both DWR and USBR staff involved in actual salvage operations of the two facilities.

Coordination will also occur with investigators participating in the salmon survival investigations described in Element 1 (Section 3). Observations of predatory fish and birds using the techniques described in Section 4.6.4 will be made simultaneously with the release of marked salmon as part of this test. Coordination of sampling between Elements 1 and 2 will provide additional information useful in identifying and evaluating factors affecting survival of fish following release. As part of Element 2 information will also be collected on water velocities, tidal conditions, and water quality coincidentally with the experimental releases of marked salmon.

4.8 Data Analysis

A biostatistician will participate throughout the design, implementation and data collection, analysis, and interpretation phases of this investigation. As a result of the specialized survey techniques to be used, consultation with knowledgeable experts in the analysis and interpretation of specific types of data (e.g., radio tag behavioral analysis, bioacoustic survey analysis, etc.) to complement the statistical input from the project statistician. The results of the data analysis will also benefit from peer review and discussions with the IEP Estuarine Ecosystem project Work Team and others.

Data analysis for the predation risk model includes primarily the compilation and synthesis of information available from past and ongoing fishery investigations being conducted within the Delta estuary, in addition to synthesis of information from the scientific literature, both published and unpublished reference material, identifying various functional relationships that affect predator dynamics within the receiving waters. Data analysis will involve providing specific documentation on the source of information used in developing the predation risk analysis, in addition to the formulation of specific functional relationships that would be included within the model framework. A series of sensitivity analyses would also be performed using the model to explore the importance of various specific assumptions and relationships within the model as they affect estimated rates of predation mortality for salvage fish. Results of the analyses would be documented in a technical report as described in Section 4.10.

Results of the bioacoustic surveys of predator abundance, distribution, and behavior would involve the analysis of bioacoustic survey results within the context of the transect grid established within the near-field receiving waters used to conduct systematic surveys of fish populations inhabiting the near-field area adjacent to each release location. Information collected from the bioacoustic surveys would include the geographic location, as determined by GPS, where each potential predator target was detected during each of the surveys. Data from the bioacoustic surveys would be processed and analyzed to determine the time, location, and if possible the length, of individual predator-sized fish detected within the receiving waters. Results of the surveys would be entered into a Microsoft Access database, and correlated with the time and characteristics of salvaged fish releases. Using these data, characteristics of the predator distribution before, during, and after a salvage release can be determined and mapped on NOAA nautical charts for each area. Changes in the distribution of predator fish detected through the mapping can then be related to changes in potential behavior triggered by individual releases at each location in response to conditions such as day and night, ebb and flood tidal stage, and other environmental parameters. Information from the mapping will also provide the ability to look at predator accumulations immediately downstream of the release pipe coincident with a release and will provide useful information on predator densities for incorporation into the predator risk model. All data developed from the bioacoustic surveys will be documented in a searchable database, subject to quality control checks, and will be made available as part of the technical documentation provided for this element of the predation investigations.

Data collected using the DIDSON camera system will include a series of observational data points documenting the time, location on an X-Y grid, and size of fish entering the field of view of the DIDSON camera during each observation period. The observations would include the presence of fish within the field of view and the number of fish passing through the area immediately adjacent to the release pipe before, during, and after a release. Observations made using the DIDSON camera will be limited since it will not be possible to determine whether or not each individual fish observed during an observation period is unique, or whether the same fish repeatedly entered the field of view. The information developed from the DIDSON observations will be documented both electronically and in a searchable database. Data will be analyzed to determine an index of potential predator-sized fish abundance within the near-field area immediately adjacent to the release pipe during each test period. Indices of predator-sized fish abundance can then be compared among different treatment and control conditions as part of the experimental design. Information will also be documented as part of the database on patterns of predator behavior indicating a strike response to a potential prey during each of the observational periods, which would then also be compiled as part of the analyses to generate a predation strike index for each treatment and control condition being tested. Indices of predator abundance and potential predator strikes are then analyzed statistically to compare comparable indices before, during, and after salvage releases. Statistical tests will also be performed to compare indices between day and nighttime conditions, between ebb, slack, and flood tidal conditions, and among release locations. Analyses will also be performed to compare indices between the SWP Horseshoe Bend release site and the identified control site.

Data collected during the physical sampling to determine predator species composition and densities will include, for each sampling event, the area enclosed by the beach seine and the corresponding number, size, and species of all fish collected. Information will be entered into a searchable database and used to calculate estimates of predator density (number of predators per hundred square meters) within the near-field receiving waters. Information on the species and size of predatory fish will also be used to refine the assumptions and data incorporated, for each specific release location, into the predation model. Data analysis will primarily involve descriptive statistics comparing the density and species composition of predatory fish in the near-field receiving waters as a function of various environmental parameters, the frequency of salvaged fish releases at the site, seasonal conditions, and environmental parameters such as water velocities, temperature and salinity. Results of the physical sampling will be correlated with results of the bioacoustic surveys to provide an independent estimate of the density of predatory fish inhabiting the receiving waters. Individual predatory fish will be tagged and included in the database, which will be further analyzed in the event of subsequent recaptures of tagged fish. Recaptures of tagged predators will provide information on whether or not predators are recaptured within the near-field receiving waters at a release site, suggesting attraction and site fidelity to a release site, or are widely dispersed within the Delta estuary. Data from the physical sampling will be entered into a documented database and included as part of the technical documentation report prepared for this predation studies.

Results of radio/acoustic tagging of predatory fish will include the species, size, tag code, location of capture, location of release, and subsequent results of tag monitoring. Tags will be monitored after release to determine the location of tagged fish relative to the location and operations of individual salvage releases. Information on movement patterns of predatory fish, including potential behavioral attraction and accumulation at the point of release, will be developed through tag tracking and will be mapped, using GIS, on NOAA nautical charts showing the location of predatory fish over time, traces of movement patterns relative to the location of individual release sites, and corresponding information on the frequency and characteristics of salvaged fish releases. Results of the tagging will also be used to evaluate predator movements within the near-field receiving waters between day and nighttime conditions and in response to ebb, flood, and slack tidal conditions. Since multiple species of predatory fish will be tagged and monitored, information on the differential behavior of different species of predators will also be documented and mapped as part of data analysis of this phase of the investigation. Results of the data analysis will be presented graphically showing traces of movement patterns as determined by the location where tags are detected at various time intervals in addition to tabular summaries documenting the physical and environmental conditions occurring within the near-field receiving waters that may affect predator behavior.

4.9 Data Synthesis

The predation risk analysis will be presented within the analytical framework provided by the predation dynamics model, which will serve as the basis for integrating and synthesizing information from field studies, site-specific data collection activities, observations from other investigators, and the synthesis of scientific information available within the literature. The model construct will provide tabular and graphic representation of biological and physical relationships developed from the available data regarding predation risk within the near-field receiving waters in addition to graphical displays of various relationships included in the model development. By its nature, the predation model provides a method and framework for compiling and synthesizing information derived from these investigations.

Information developed from bioacoustic surveys, DIDSON data collection, physical sampling within the receiving waters, and radio/acoustic tagging will be used to provide additional input to the predation model in addition to providing independent and complementary study results addressing various aspects of potential predation risk within the near-field receiving waters at each of the release sites. Data from these analyses will be synthesized in the form of GIS maps and graphic presentations, to show relationships between predator abundance and distribution and various physical and biological factors affecting habitat conditions within the receiving waters, including the release of salvaged fish. Since all of the databases developed in the predation study will be integrated and linked, opportunities exist for synthesizing data and statistical relationships and integrating both physical and biological data to examine predator dynamics, as a function of a variety of factors within the receiving waters, and the relationship to release of salvaged fish. The synthesis of information will provide the necessary technical and scientific foundation for assessing and evaluating potential risk of significant predation mortality occurring within the receiving waters, and help provide the framework for identifying and evaluating alternative release strategies and new technologies that may reduce the significance of predation mortality on overall survival of salvaged fish released into the Delta estuary.

4.10 Documentation Reporting and Dissemination of Results

A technical report would be prepared in draft form and distributed for review by participants in the CHTR workgroup, and by other interested scientists. The draft technical report, and accompanying documented database, would also be provided to a group of independent scientific peer reviewers (three individual scientists) with knowledge and expertise in conducting and evaluating results of predation investigations. Results of the review and comment on the draft technical report would subsequently be used to revise the technical documentation report and, if needed, perform further analysis of results of the predation investigations. The revised report would be prepared as a final technical documentation report for Element 2 of the investigations and would be made available both in hardcopy and electronically for dissemination to interested parties. A summary of the technical documentation report would also be prepared for publication in the IEP newsletter, presentation to the IEP annual conference or other scientific conferences (CALFED, American Fisheries Society, etc.), and based upon results of the independent peer review a manuscript may also be submitted for publication in a peer reviewed scientific journal.

4.11 ESA Incidental Take

Fishery sampling associated with the predation study will result in the incidental collection of fish listed for protection under the California and federal ESA. Take of delta smelt is estimated to be approximately 200 fish per year assuming that sampling is limited to area immediately adjacent to the release site (approximately 5000 square feet – 50 by 100 feet) using the beach seine and electrofishers. The estimates conservatively assume the collection of 5 delta smelt per collection and 40 collections per year. Incidental take of juvenile steelhead is estimated to be 10 fish per year (typically released unharmed). Incidental take of juvenile spring run chinook salmon (typically release unharmed) is estimated to be 20 fish per year. Incidental take of juvenile winter run chinook salmon (typically release unharmed) is estimated to be 20 fish per year. All fishery sampling would include avoidance and minimization measures implemented as part of standard fishery sampling procedures.

4.12 Investigators and Staff

In addition to the staff shown on Figure 2-2 staff support for Element 2 will include, but not be limited to:

- Roger Padilla
- Trina Nation
- Tim DeVoe
- Dennis Hood
- Lynn Meyer

- Jeff Richey
- Support staff for radio tagging/tracking, bioacoustic surveys, and fishery sampling

4.13 Equipment Requirements

Equipment requirements would include bioacoustic monitoring equipment and operators (contracted with USBR, BioSonics, HTI or other vendor). Radio tags would be purchased to be compatible with tag detection equipment owned and operated by DWR and/or contracted to CDFG or other qualified research investigator. Boats, fishery sampling equipment, electrofishing equipment, water quality meters, and other equipment required for fishery sampling are available and will be provided by Hanson Environmental and DWR. The beach seine used to encompass the release site will be purchased from Research Nets, Memphis Net, or other vendor. The DIDSON camera is available from DWR. Pilings, moorings, work platforms, and other equipment required to mount and operate the DIDSON at each site will be purchased, rented, or fabricated.

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5.0 ELEMENT 3. - PHYSICAL FACTORS INFLUENCING MORTALITY DURING RELEASE

5.1 Research Problem Statement and Objectives

Routine salvage operations may be causing stress, injury, and disorientation in the salvaged fish. (Raquel 1989). This leaves the salvaged fish more vulnerable to predators following release. A number of Delta fish species may be experiencing mortality during release. It is reported that delta smelt suffered high levels of mortality during brood stock capture efforts if small waves were present on the day of capture. Apparently, the vibration/concussion transmitted through the boat hull to the buckets holding the captured fish was enough to kill them. Delta smelt survive capture quite well when the waters are calm (Brent Bridges, pers com). UCD researchers (Young et.al.) showed that water temperature and season are determining factors in survival of captured delta smelt. Protocols for handling juvenile delta smelt have improved survival during the performance of tests using delta smelt. However, it is possible that conditions experienced during the release process contribute significantly to stress, disorientation, injury, and mortality of salvaged delta smelt.

An inspection of the release truck tank was made, and observations of fish releases were made at the SWP Horseshoe Bend site and at the CVP Sacramento River site. Pipe characteristics such as slope and diameter were obtained. From these data, hydraulic calculations of flow out of the tank and through the release pipe were made. These calculations and observations show:

- The flow varies from about 6 cfs when the tank is full to about 0.7 cfs when the water is six inches deep in the tank.
- The depths of flow in the lower reaches of the pipe for fully developed flow vary from about 4 ½ inches to about 1 ½ inches for 6 cfs and 0.7 cfs, respectively.
- The release pipe is flowing partially full with a free surface for all flows. However, the bend in the release pipe at the SWP Horseshoe Bend site could cause enough turbulence to create a hydraulic jump and fill the pipe upstream of the bend.
- The Froude numbers for these flows are between 6 and 7 indicating that a relatively strong hydraulic jump could exist in the pipe near the level of the receiving water.
- The 90-degree bend at the CVP release site and the flushing water jets in the pipe cause considerable turbulence in the flow and could change the above depths.

The flow out of the tank and down a release pipe is similar to culvert flow. Ven Te Chow makes the following statement about such flow (Chow, 1959), “The characteristics of the flow are very complicated because the flow is controlled by many variables, including the inlet geometry, slope, size, roughness, approach and tailwater conditions, etc. Hence, an adequate determination of the flow through a culvert should be made by laboratory or field investigations”. The flow in the release pipe is even more complicated than a culvert because of the 90-degree bend and the change in release pipe diameter (an effective air vent) where the tank pipe fits inside the fixed release pipe. See Figure 2-1.

The debris that is also released during the process is considered to have an impact on fish. Debris loading during release may block the tank outlet (Photo 2-3) and cause additional fish stress and mortality in turbulent areas such as at bends, the flushing water jet entry into the pipe, and at the hydraulic jump. It is important to know what amount of debris has loaded into the release system. The amount of Delta debris loading has increased over the years at the diversion facilities to a level greater than what was originally seen. At the present time there is not a system in place to remove the debris that has passed through the trash racks. Observations at the ongoing Trash Rack Debris Study at The University of California Davis has indicated that cleaning debris at the trash racks may send more debris to the CHTR part of the facility. This is due to a cleaning method that breaks debris into smaller pieces and sends it downstream to the holding tanks and into the CHTR process. In addition, when the debris racks are clean smaller debris can pass through the racks. Understanding what amount of debris should be removed in the CHTR process will help determine the type of cleaning needed and at what location in the salvage system debris cleaning needs to occur.

The objective of Element 3 is to determine if the existing release process and facilities can safely pass fish to the receiving water body. The results of these experiments will:

1. Provide data to make informed decisions regarding recommendations for new technologies; These technologies can be in the form of new facilities, modifications to existing facilities, and alterations to operating procedures for releasing fish,
2. Be used to develop criteria for the amount of debris to be removed throughout the fish salvage facilities and in the CHTR process; Debris, coupled with the release hydraulic conditions, could be detrimental to fish survival.
3. Provide information for the identification of physical criteria for release site selection, design, and operations.

5.2 Linkage to Conceptual Model and Other Studies

Element 3 investigates two focal points of the conceptual model: (1) release from the truck and (2) travel through the release pipe. See Figure 2-3. Based on observation, the physical features identified to possibly cause stress in the fish release process are:

1. The truck tank outlet. Water immerges from the tank as free surface flow in a high velocity jet.
2. The 90-degree bend in the release pipe. This only exists in the SWP Horseshoe Bend Release Site, where it is required due to limited space to park the truck and connect to the pipe.
3. The introduction of four high-velocity jets discharging into the center of the release pipe at four equally spaced points around the circumference of the pipe. These water jets were implemented to provide flow to flush fish down the pipe as the tank empties but may also be causing damage to fish.
4. The hydraulic jump in the pipe where the release flow meets the receiving water backed up in the pipe.

The presence of debris in the flow could add to fish stress and mortality at the above four points in the release process.

The experiments outlined below will examine the effects of some of the stressors shown in Figure 5-1.

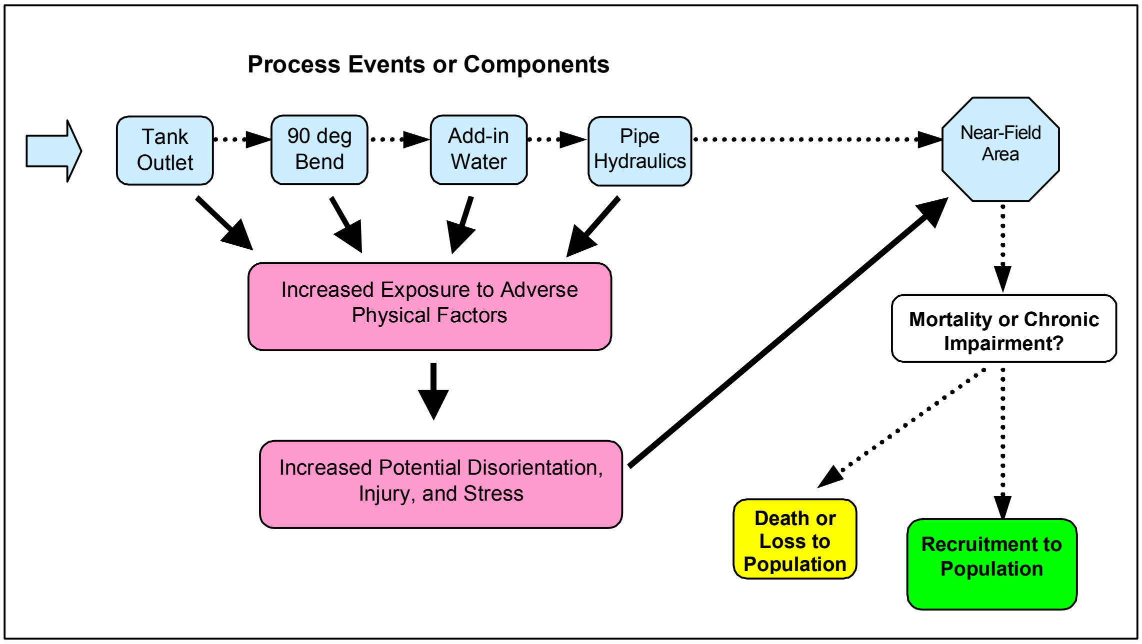


Figure 5-1 Element 3 Conceptual Model

As shown on Figure 1-6 elements of this study overlap with portions of the CDFG CHTR studies. This investigation differs from the *Acute Mortality and Injury of Delta Smelt Associated with Collection, Handling, Transport, and Release at State Water Project and Central Valley Project Fish Salvage Facilities* (Fujimura et.al, February 2004). Element 3 will use measured quantities of debris and will not include collection, handling, and transport as stressors. The CDFG CHTR experiments sample debris as it arrives in the holding tanks, and includes collection, handling, transport, and release as stressors.

Element 3 physically overlaps with a portion of the study area covered by *Development of Diagnostic Indicators to Evaluate Acute Sub Lethal Stress Effects to Salvaged Delta Smelt*, Virginia Afentoulis, CDFG, (February 2004), but asks separate questions. It will examine the primary indicators of stress, determine whether the near-term viability of salvaged smelt has been impaired by measuring swimming performance, and assess the impacts of CHTR by measuring successful reproduction. Element 3 will quantify the mortality within the release process. The possible factors include impacts from debris, physical factors of the system and the hydraulics in the release system.

5.3 Decision Framework

Table 5-1 lays out the decision framework guiding the Element 3 experiments. The experiments will be carried out in a laboratory setting that will simulate the physical and hydraulic characteristics of the Horseshoe Bend release site. There are two sites that could be used for the

Element 3 experiments: UCD and the Skinner facility. If UCD is selected, facilities producing the same hydraulics as the SWP Horseshoe Bend release site will be constructed including a replica of the transport truck tank. If the Skinner site is selected, modifications to the existing test facilities will be made to better simulate the hydraulic conditions of the Horseshoe Bend release site, and the SWP fish transport truck will be used for the experiments. All experimental trials shown on Table 5-1 will be performed at the chosen test facility.

First, the hydraulic characteristics of the truck tank and the release pipe will be measured during the release process. Then the ability of the system to pass debris will be tested using measured amounts of debris collected from the Skinner fish facility. Next, experimental runs will be made to document the effect that the existing facility has on fish injury and mortality for cultured juvenile chinook, cultured juvenile delta smelt and threadfin shad. Based on the injury and mortality results, recommendations will be made for new technologies to improve the release system. In keeping with the adaptive approach outlined for the CHTR program (Coulston et al, 2004) and based on these recommendations, one or more of the new technologies might be pilot tested.

It will also be necessary to quantify the amount of debris that will pass freely through the release system. This information will indicate the allowable volume of debris that would affect fish during release. Observation of the release process (see Photo 2-3) indicates that fish are prevented from moving freely through the exit of the release truck due to clogging by debris.

After the evaluation is completed, recommendations will be provided on how to proceed. Recommendations will fall into three categories. The first category is that the release system is operating in an acceptable range and nothing needs to be done. The second category is to make modifications to the existing release system or deploy an existing technology to address the improvements necessary and monitor the results of those improvements. The third category is to provide an experimental technology to be tested.

The next set of experiments (Tests 2A and 2B on Table 5-1) will be a pilot study and will be conducted on a facility modified according to these recommendations. This step is the "facility/process evaluation" phase outlined for the CHTR program (Coulston et al, 2004). If indicated by recommendations of the first phase of the study, the mock-up of the existing facilities will be modified. The modifications would include possible improvements to those features, which have been observed to be a possible source of mortality and injury.

	Test Name	Test Type	Trial Runs & Fish Requirements, Each Specie			Remarks
			Clear Water	**Debris**	**Totals**	
1A	Existing System Hydraulics and Debris	Hydraulic and Debris Test		Several		Observe and measure release hydraulics. Determine outlet clogging threshold debris amounts for future tests
1B	Existing System Juvenile Chinook, Cultured Juvenile Delta Smelt, Threadfin Shad	Fish Test	1 trial 2 replicates, 35 fish each.	4 trials 2 replicates, 35 fish each.	5 trials 350	<u>Esisting System Test:</u> Existing outlet, 90-degree bend, in-pipe nozzle flushing flows, hydraulic jump visual assesment.
2A	Modified System Hydraulics and Debris	Hydraulic and Debris Test		Several		Observe and measure release hydraulics. Determine outlet clogging threshold debris amounts for future tests.
2B	Modified System Cultured Juvenile Delta Smelt	Fish Test	1 trial 2 replicates, 35 fish each.	4 trials 2 replicates, 35 fish each.	5 trials 350	<u>Modified System Test:</u> Transition cone at outlet, 24-in diam pipe, no 90-degree bend, diffusion system introducing flushing water into tank

Table 5-1 Element 3 Decision Framework

Notes:

1. *An equal number of fish are required for control purposes*
2. *In Test 2B other types of fish or life stages could be substituted based on results of initial tests and fish availability.*
3. *Tests with adult delta smelt will be with fewer fish (approximately 200) depending on their availability.*

5.4 Research Questions in Detail

- Is there an acceptable level of debris that the release facility can accommodate without increasing mortality in salvaged fish? Debris load amounts for fish tests will be set at the level determined in the debris hydraulic test by the amount of debris that can be discharged and cause a hydraulic disturbance.
- Do the existing release facilities and procedures produce mortality in released fish?
- If the release facilities do produce mortalities, is the survival rate of the released fish improved if selected changes or new technologies are applied?

5.5 Hypotheses to be Tested

Hypothesis 1: There is no threshold level of debris that causes significantly more problems to salvaged fish at release.

If this hypothesis were refuted, then the approximate point where debris starts to cause problems with fish can be established. This knowledge can be used to determine how much debris should be removed from the system before the salvaged fish enter the transport process.

Hypothesis 2: The existing release facility does not cause mortality of fish at release.

5.6 Assumptions and Limitations

This experimental approach is to provide an indication of the injury or mortality to different fish covering a range of hardiness. These include juvenile delta smelt, juvenile chinook salmon, and threadfin shad. Performing numerous experiments to achieve statistical significance is not beneficial, in this phase. The focus in Element 3 is to identify the conditions affecting fish injury and mortality. There is some uncertainty as to the degree of impact on fish imposed by conditions in the release system, including those impacts associated with the hydraulics. Sufficient physical measurements and fish trials are provided to indicate whether impacts to fish are occurring and if additional replicates are needed to determine the significance of the results. The use of a clear plexiglass pipe will allow the conditions in the pipe to be observed while measurements of the hydraulic conditions are taken. If improvements are called for, then they will be tested. The approach of recommending and testing new technologies is in keeping with the approved CHTR program (Coulston et al, 2004).

This experiment does not account for the effects of accumulated stress responses induced from other parts of the salvage and transport process, which the fish go through prior to release. Fish encountering the release facilities could have higher stress levels at the start of the release process than the test fish. Therefore, the experimental measurement of mortality during release will not provide a true indicator of the effects of the release process on the salvaged fish. The experiments will quantify the impacts imposed on fish as they move through the release process. The mortality of cultured delta smelt exposed to cumulative stress in the CHTR process will be measured in other experiments being conducted by CDFG.

The experiments will use debris collected from the trash rack at the SWP. It is assumed that this debris will behave in a similar manner as the debris, which regularly passes through the system to the transport truck.

5.7 Experimental Design, Methods and Approach

The aim of this element is to analyze the release at all four sites. The hydraulics of the release conditions will be observed at all four sites. Hydraulic calculations will be made taking into consideration the variability of the individual structures. Although the sites are similar, there are some differences, including pipe length, pipe diameter, pipe slope, pump size, and other factors. Due to time and budget limitations it is not practical to physically test the conditions at each site. Tests will be accomplished on a replica of the SWP release site at Horseshoe Bend. The effects of the release on fish will be ascertained on the replica. Lessons learned can then be applied to the other three sites.

This study element will measure injury and mortality associated with the release aspect of CHTR by releasing test fish through a mock-up of the SWP release site into a receiving tank representing the receiving water body and measuring injury and mortality over a 48-hour period. A SWP transport truck will be used or a replica of the transport truck tank will be built and a mock-up of the SWP release pipe at Horseshoe Bend will be installed. The release pipe will be a 12-inch diameter approximately 80-foot long plexiglass pipe installed at a 20 percent slope. Refer to Sections 1 and 2 for a detailed description of the existing facilities. Depending on the site chosen a special steel supporting tower will be constructed to hold the transport tank at the same relative elevation above the receiving water body as exists at the SWP Horseshoe Bend site or a ramp will be constructed to accommodate the SWP transport truck. Pipe supporting structures will be constructed for the mock-up of the release pipe.

Plexiglass see-through piping will be used to allow observation of debris, fish, hydraulics and water interactions throughout the process. Monitoring equipment will be installed to measure the flow conditions in the pipe.

The first step in the investigation will be to observe the hydraulics of flow leaving the tank and in the release pipe. These would include measurements of depths and velocities in the pipe, flow currents in the tank, observations of turbulence in the pipe using dye, and measurements of the rate of tank evacuation. The next step will be to establish the level of debris that the existing release facility can pass without clogging. See Table 5-1. These experiments will be done without fish. Following the establishment of the threshold at which debris clogs the tank outlet, the live fish experiments will begin.

Hydraulic Observations and Calculations

At the beginning of work in this element all release sites will be visited. The physical dimensions of the release tanks and pipes will be measured, and the characteristics of the pumps and gates will be recorded. Based on these data, hydraulic computations will be made at each site to estimate the amount of flow out of the trucks. The velocity and depths of flow in the pipes will be measured. The strength of hydraulic jumps and the interaction of flow with the flushing flows will also be estimated.

Hydraulic and Debris Experiments

Experiments will be undertaken to document the hydraulics in the fish transport truck tank and in the release pipe. Measurements will include: depths and velocities in the pipe, flows out of the tank, currents in the tank, observations of turbulence in the pipe using dye, and measurements of the rate of tank evacuation.

The major objective of the debris-only experiments is to determine the threshold volume of debris that blocks the tank outlet. Initial tests will be conducted without fish. Debris will be gathered at the Skinner fish facility in a manner to simulate the types of debris that are present. Debris will be measured as volumes of wet debris placed in containers without compaction or time to dry and settle. Different measured volumes of debris will be placed in the release tank and the release valve opened. The actual amounts of debris used in subsequent tests will be chosen after analyzing observations from this experiment. Debris and water interactions will be observed and videotaped.

Fish Experiments

A series of live fish experiments will be conducted with cultured juvenile chinook, cultured juvenile delta smelt, and threadfin shad. Cultured juvenile delta smelt will be the primary test fish because they are specially designated in the CHTR program and are the prevalent life stage found at both Skinner and Tracy fish facilities. No cultured delta smelt will be released to the delta. Fish will be euthanized as described below to insure this. The numbers of fish and replicates are shown in Table 5-1. Cultured chinook salmon will be tested first in smaller amounts to verify the protocols and gauge the affects of the release system on a more hardy fish. Shad will also be tested to observe the effects on a known sensitive specie. Marked fish may be used if more than one trial group of fish share a holding tank for the 48-hr survival observation.

The live fish experiments will proceed in the following manner. After transport from the culture facility, fish will be held for 48 hours (96 hours for shad) to acclimate before being used for testing. Each set of live fish tests will involve 5 trial runs; one with no debris, and four with varying levels of debris using the existing system mockup. For each trial run, a control group of fish will be used to ensure that mortality measurements reflect the effects of the release procedure and not the effects of fish handling before and after the fish pass through the release facility mock-up.

Injury rates will be observed and recorded throughout the experiment. Five fish will be chosen at random from each treatment group and control group at the start of a replicate run. These fish will be euthanized and examined for injury. Following the experiment, 5 more fish will be chosen at random from each treatment group and control group from the 48-hr mortality test tanks. These fish will also be euthanized and examined for injury. Following the 48-hour mortality test, all the fish will be euthanized and examined for injury.

Mortality will be measured directly after release and throughout a 48-hr holding period. If water clarity is sufficiently clear, qualitative estimates of disorientation will be observed by taking video of the fish transiting and exiting the release pipe. The video will then be analyzed to determine the attitude of the fish in the flow and fish behavior upon entering the receiving water body.

The first set of live fish experiments will commence with the determined debris load. Debris data estimates compiled at the SWP facility will be obtained. These quantities will be compared with those in the experiment. From this an estimate of the likelihood of debris-caused mortality can be made for the present operations.

Video will be taken of fish and debris as they exit the tank. If the water is clear enough the action of the fish as the tank is drained can be observed. This will also answer the question of whether the fish leave the tank before or after the debris clogs the outlet and how many fish are stranded in the transport tank.

5.8 Coordination

Depending on the site chosen for performing the experiment, close coordination will be maintained with the UCD personnel or CDFG personnel in order to set up the experimental apparatus.

Coordination for conducting the physical factors survival studies would involve collaboration with culture facility personnel at Skinner to obtain cultured delta smelt for use in these investigations and the identification of isolated raceway facilities for holding these fish. Further coordination would be required in the transport and logistics of delivering fish to the experiment site at UCD if that site is selected. Collaboration will be maintained with UCD or CDFG biological personnel who will assist in maintaining the holding facilities. Coordination for obtaining debris and transporting it to the experiment site will be done with operations personnel at the Skinner Fish Facility. Coordination with CDFG experimenters at Skinner will be required since CDFG will be conducting experiments with delta smelt at the same time.

Researchers for this release study will collaborate with the two CDF CHTR studies:

- *Acute Mortality and Injury of Delta Smelt Associated with Collection, Handling, Transport, and Release at State Water Project and Central Valley Project Fish Salvage Facilities*, Jerry Morinaka.
- *Development of Diagnostic Indicators to Evaluate Acute Sub Lethal Stress Effects to Salvaged Delta Smelt*, Virginia Afentoulis.

Meetings will be held with the PI's for these studies to work out areas of collaboration. At a minimum cooperation will include an exchange of data and, perhaps, personnel especially if the release experiments are to be performed at Skinner. The monthly CHTR meetings will provide a forum for exchange of data and information useful to workers in all three experiments.

If the experimental site at Skinner is selected, collaboration with CDFG experimenters will be necessary and will take place. CDFG personnel will be performing acute mortality studies at about the same time. This affords opportunities for sharing facilities and personnel to perform the experiments. Greater efficiencies will be realized in running the experiments since knowledge of successful experimental protocols can be exchanged.

Collaboration with USBR personnel at the Tracy fish facility must be maintained. Different types of debris are often present at the two facilities. If this is true during the experiments, then debris will also be collected from Tracy and used in the experiments. The Tracy personnel have extensive knowledge of delta smelt handling. Their advice will be sought in setting up experimental protocols.

Collaborators will include: from UCD, Levent Kavvas, Ph.D., Brad Baskerville-Bridges, Ph.D.; from CDFG, Bob Fujimura, Virginia Afentoulis, Jerry Morinaka; from USBR, Lloyd Hess, Brent Bridges; and Dan Odenweller.

5.9 Data Analysis

A rigorous statistically robust experiment was not considered to be necessary for this investigation. Only minor analysis of data will be performed since the amount of fish survival data will not be numerous enough to statistically evaluate.

5.10 Data Synthesis

Additional data would be included as part of the analysis including water temperature within the hatchery during pre-release holding, length and condition of fish within each group prior to release, and water quality conditions of the water used in the experiment including that used in the 48-hour holding tanks. Water quality data will be collected at the Horseshoe Bend release site for comparison to the quality of water used in the experiments. Water quality parameters measured will include temperature, pH, dissolved oxygen, and conductivity. Times to drain the water from the transport tank will be measured and compared to the times recorded in initial tests to document that release pipe velocities are in the proper range. Data synthesis would include the use of conventional descriptive statistics. Data from this analysis will be presented in graphical and tabular format in the documentation report.

5.11 Documentation Reporting and Dissemination of Results

A technical report would be prepared in draft form and distributed for review by participants in the Collection, Handling, Transport, and Release (CHTR) workgroup, Interagency Ecological Program (IEP), and by other interested scientists. Results of the review and comment on the draft technical report would subsequently be used to revise the technical documentation report. The revised report would be prepared as a final technical documentation report for Element 3 of the investigations and would be made available both in hardcopy and electronically for dissemination to interested parties. A summary of the technical documentation report would also be prepared for publication in the IEP newsletter, presentation to the IEP annual conference or other scientific conferences (CALFED, American Fisheries Society, etc.). Based upon results of the independent peer review a manuscript may also be submitted for publication in a peer reviewed scientific journal.

5.12 ESA Incidental Take

Cultured juvenile and Adult Delta Smelt will be used. About 900 of these fish will be euthanized. Unlisted cultured juvenile chinook salmon and threadfin shad are considered for the other two fish species. No incidental take will result in this Element.

5.13 Investigators and Staff

Dennis Dorratcague, Principal Investigator, MWH

Roger Churchwell, Principal Investigator, DWR

Chuck Hanson Principal Investigator, HE

Peter Barton, MWH

Brandt Barnes, MWH

Clint Smith, MWH

Roger Padilla, DWR

Scientific Aides, DWR

David Sun, Fishery Biologist, MWH

5.14 Equipment Requirements

The equipment requirements for Element 3 depend on the location where the experiment will be performed. Two sites are under consideration: 1) the new facility at Skinner where the CDFG

CHTR experiments will be performed, 2) UCD at the outdoor flume facility. The equipment required for each of these is described below.

5.14.1 Skinner Test Facility

To support the CHTR experiments now being performed, facilities have been constructed in the southeast corner of the Skinner Fish Facility northwest of Tracy. These facilities include a metal building with concrete floor, an earthen ramp to accommodate fish transport trucks, and a receiving water tank, about 30 feet long, 15 feet wide, and 5 feet deep. A 22-foot long, 11-inch diameter release pipe has been installed to carry water down a 20% slope from the tank truck on the ramp to the receiving water tank. An extensive water supply system has been installed consisting of a supply pipeline and pump for bringing water from behind the fish louvers, a water treatment system with a sand filter and chiller, a supply pipe to the truck ramp, and a system to drain the receiving water tank. A head tank is located outside the building to distribute treated water to the fish holding tanks inside the building.

If this site is selected as the location for the Element 3 experiments, the following modifications would be necessary.

- Increase the height and move the ramp to the east and bury the receiving water tank. This would allow for a longer release pipe to more nearly match the release hydraulics at the SWP Horseshoe Bend Release Site.
- Replace the existing release pipe with a 60 to 80-foot long pipe of 12-inch diameter made of clear plexiglass.
- Add a pump to the water supply line at the truck ramp to simulate the flushing water supply pump and piping at the Horseshoe Bend site.
- Add a new drain and sump, with a pump, to drain the buried receiving water tank.
- Add 10 new holding tanks and their plumbing in the building to accommodate Element 3 test and control fish.
- Flow monitoring equipment

5.15 University of California at Davis

If the UCD site is selected the outdoor flume and the area around it would be used. The UCD facilities that would be employed are the outdoor flume (about 100 feet long, 5 feet wide, 8 feet deep) and the fish holding tanks (that has a water temperature control system). The outdoor flume would be used as receiving water for the release flow. The following equipment will be required.

- A new tank to duplicate the dimensions and size of the SWP tank on the most commonly used fish transport truck. Brackets would be placed on the tank to enable it to be rotated on its stand for testing a right angle bend or larger outlet.
- A support tower would be built to maintain the tank at the proper elevation above the receiving water to duplicate the proper elevation above the receiving water that exists

at the SWP Horseshoe Bend site. Stairs and platform would be built for access to the tank for loading debris and fish.

- A clear plexiglass release pipe, 80-feet long 12-inch diameter at a 20% slope.

5.16 References

Chow, Ven Te, 1959, *Open Channel Hydraulics*, McGraw-Hill Book Company, pg 493

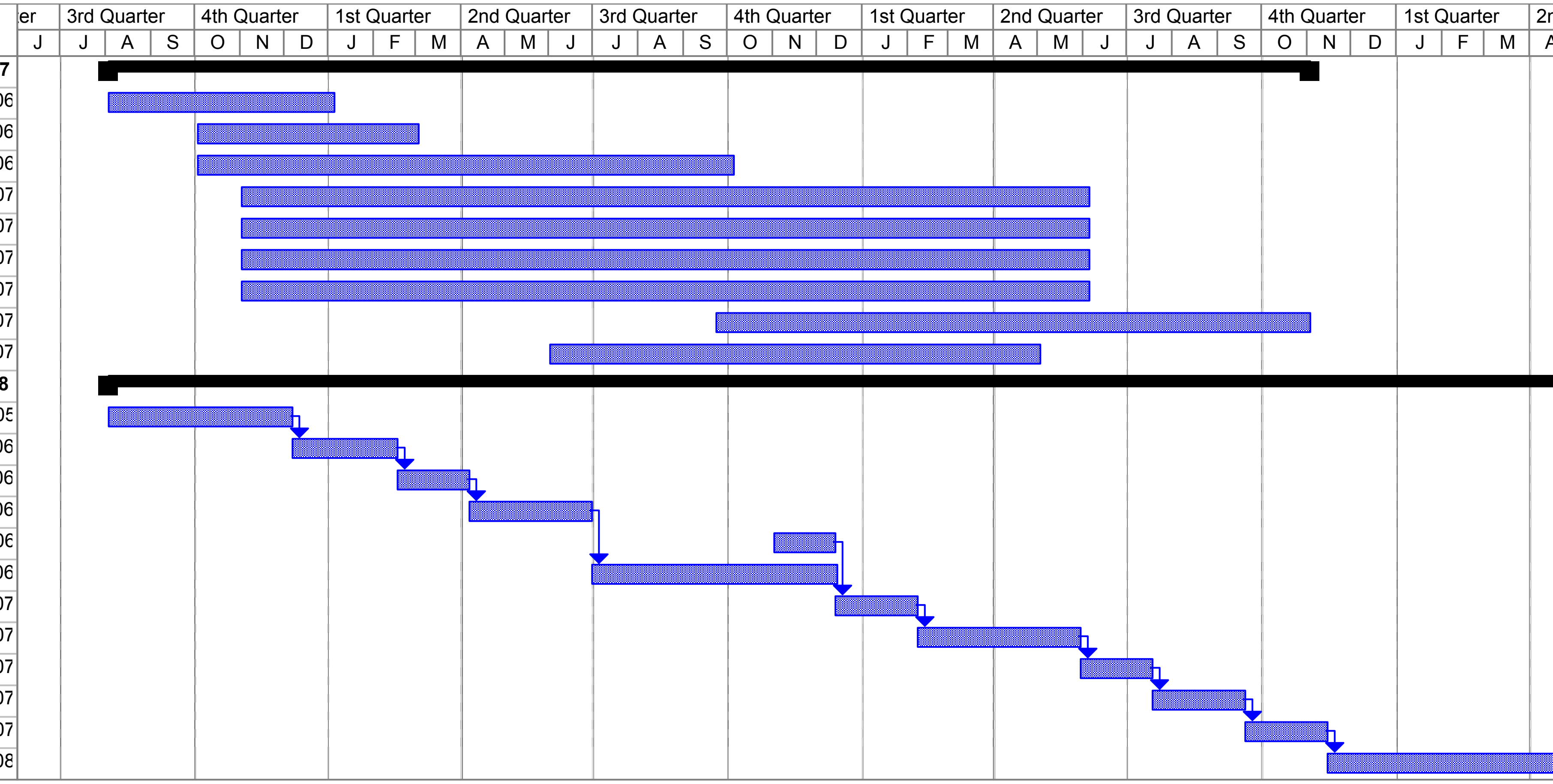
Coulston, Pat, Robert Fujimura, Geir Aasen, Virginia Afentoulis, January 2004, *Evaluation of Collection, Handling, Transport and Release Effects on Delta Smelt (Hypomesus transpacificus) Salvaged at the Southern Delta Water Export Facilities: Program Proposal.*

Raquel, Paul F. 1989. *Effects of Handling and Trucking on Chinook Salmon, Striped Bass, American Shad, Steelhead Trout, Threadfin Shad, and White Catfish Salvaged at the John E. Skinner Delta Trout Protective Facility.* Department of Fish and Game, Technical Report 19, Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary.

Young, Paciencia, Melody L. Danley, Nicole J. Hutt, Stephanie N. Chun, Christina Swanson, Joseph Cech 1999. *Wind and rough weather decrease captured delta smelt survival.* IEP Newsletter. Interagency Ecological Program for the Sacramento-San Joaquin Estuary. Volume 12, Number 3. Summer 1999. Pgs 35-37.

6.0 PROJECT SCHEDULE AND MILESTONES

ID	Task Name	Duration	Start	Finish
1	**Element 2**	**588 days**	**Tue 8/2/05**	**Thu 11/1/07**
2	Hyp Pred - Data Mining	111 days	Tue 8/2/05	Tue 1/3/06
3	Hyp Pred - Assemble Database	108 days	Mon 10/3/05	Wed 3/1/06
4	Hyp Pred - Field Effort	262 days	Mon 10/3/05	Tue 10/3/06
5	Bio Acoust - Field Effort	415 days	Tue 11/1/05	Mon 6/4/07
6	DIDSON Obs - Field Effort	415 days	Tue 11/1/05	Mon 6/4/07
7	Pred Samp - Field Effort	415 days	Tue 11/1/05	Mon 6/4/07
8	Pred Move - Field Effort	415 days	Tue 11/1/05	Mon 6/4/07
9	Analysis	290 days	Fri 9/22/06	Thu 11/1/07
10	Report	239 days	Thu 6/1/06	Tue 5/1/07
11	**Element 3 - Phase 1**	**716 days**	**Tue 8/2/05**	**Tue 4/29/08**
12	Design and Construction and Preparation	90 days	Tue 8/2/05	Mon 12/5/05
13	Existing System Hydraulic Test	52 days	Tue 12/6/05	Wed 2/15/06
14	Existing System Chinook Test	35 days	Thu 2/16/06	Wed 4/5/06
15	Existing System Shad and Delta Smelt Test	60 days	Thu 4/6/06	Wed 6/28/06
16	Test Adult Delta Smelt	30 days	Wed 11/1/06	Tue 12/12/06
17	Analyze Data	120 days	Thu 6/29/06	Wed 12/13/06
18	Decide on New Technologies to be Tested	40 days	Wed 12/13/06	Tue 2/6/07
19	Construct Modified Sys If Decided	80 days	Wed 2/7/07	Tue 5/29/07
20	Test Chinook, Mod Sys If Decided	35 days	Wed 5/30/07	Tue 7/17/07
21	Test Delta Smelt, Shad, Mod Sys If Decided	45 days	Wed 7/18/07	Tue 9/18/07
22	Analyze Data, Mod Sys if Decided	40 days	Wed 9/19/07	Tue 11/13/07
23	Report	120 days	Wed 11/14/07	Tue 4/29/08



7.0 BUDGETS

7.1 Table 7-1 Summary of Costs

Fiscal Year Basis				
Elements 2 and 3				
Budget Category	**2005 - 2006**	**2006 - 2007**	**2007-2008**	**Total**
Element 2	$ 616,808	$ 512,976	$ 151,736	$ 1,281,520
Element 3	$ 593,818	$ 396,499	$ 141,297	$ 1,131,614
Total	$ 1,210,626	$ 909,475	$ 293,033	**$ 2,413,134**

7.2 Table 7-2 Element 2 Costs

Fiscal Year Basis				
Element 2				
Budget Category	**2005 - 2006**	**2006 - 2007**	**2007-2008**	**Total**
Personnel	$ 415,208	$ 488,976	$ 150,736	$ 1,054,920
Equipment Costs	$ 150,000	$ 15,000		$ 165,000
Rental Costs	$ 3,000	$ 6,000		$ 9,000
Direct Costs	$ 1,000	$ 3,000	$ 1,000	$ 5,000
DWR Internal Contracts	$ 47,600			$ 47,600
Total	$ 616,808	$ 512,976	$ 151,736	$ 1,281,520

7.3 Table 7-3 Element 3 Costs

Fiscal Year Basis				
Element 3				
Budget Category	**2005 - 2006**	**2006 - 2007**	**2007-2008**	**Total**
Personnel	$ 388,504	$ 313,499	$ 136,297	$ 838,300
Equipment Costs	$ 173,512			$ 173,512
Equip Rental Costs		$ 40,000		$ 40,000
Direct Costs	$ 22,000	$ 43,000	$ 5,000	$ 70,000
DWR Internal Contracts	$ 9,802			$ 9,802
Total	$ 593,818	$ 396,499	$ 141,297	$ 1,131,614

8.0 PERSONNEL NEEDS

Table 8-1 Element 2 Personnel Needs

ELEMENT 2	FY: 2005-2006															
CLASSIFICATION	MONTH												TOTAL DAYS	HOURS	RATE	COST
	J	A	S	O	N	D	J	F	M	A	M	J				
PRINCIPAL INVESTIGATOR		6	5	5	10	5	5	5	5	5	6	5	62	496	$130	$64,480
BIO 1		22	22	22	22	22	22	22	22	22	22	22	242	1936	$75	$145,200
BIO 2													0	0	$68	$0
STATISTICIAN		2	2	2	5	2	2	2	2	2	2	2	25	200	$85	$17,000
FIELD TECH 1					20			20			20		60	480	$50	$24,000
FIELD TECH 2					20	4	4	20	4	4	20	4	80	640	$55	$35,200
DWR Senior Engineer PI	3	3	3	3	5	5	5	5	10	10	10		62	496	$63	$31,248
DWR Engineer	5	5	5	5	20	20	20	10	10	10	10	10	130	1040	$63	$65,520
DWR Biologist		5	5	5	5	5	5	5	5	5	5	5	55	440	$63	$27,720
ADMIN		1	1	1	1	1	1	1	1	1	1	1	11	88	$55	$4,840
Total	8	44	43	43	108	64	64	90	59	59	96	49	727	5816		$415,208

ELEMENT 2	FY: 2006-2007															
CLASSIFICATION	MONTH												TOTAL DAYS	HOURS	RATE	COST
	J	A	S	O	N	D	J	F	M	A	M	J				
PRINCIPAL INVESTIGATOR	5	6	5	5	6	5	5	10	10	5	5	5	72	576	$140	$80,640
BIO 1	22	22	22	22	22	22	22	22	22	22	22	22	264	2112	$78	$164,736
BIO 2													0	0	$70	$0
STATISTICIAN	2	2	10	10	10	10	10	5	5	5	5	5	79	632	$90	$56,880
FIELD TECH 1		10			20								30	240	$52	$12,480
FIELD TECH 2	10	12			20								42	336	$58	$19,488
DWR Senior Engineer PI		2	1	1	1	2	1	2	1	2	1	2	16	128	$63	$8,064
DWR Engineer		15	10	10	10	10	10	10	10	10	10	10	115	920	$63	$57,960
DWR Biologist		15	15	15	15	15	15	15	15	15	15	15	165	1320	$63	$83,160
ADMIN	1	1	1	1	1	1	1	1	1	1	1	1	12	96	$58	$5,568
Total	40	85	64	64	105	65	64	65	64	60	59	60	795	6360		$488,976

ELEMENT 2	FY: 2007-2008															
CLASSIFICATION	MONTH												TOTAL DAYS	HOURS	RATE	COST
	J	A	S	O	N	D	J	F	M	A	M	J				
PRINCIPAL INVESTIGATOR	6	6	6	2	2	2	2	2	2	2			32	256	$145	$37,120
BIO 1	22	22	22										66	528	$80	$42,240
BIO 2	3	3	3										9	72	$73	$5,256
STATISTICIAN	2	2	2	1	2	2							11	88	$93	$8,184
FIELD TECH 1													0	0	$54	$0
FIELD TECH 2													0	0	$60	$0
DWR Senior Engineer PI		1		1	1	1	1	1	1	1			8	64	$63	$4,032
DWR Engineer		5	5	5	5	5	5	5	5	5			45	360	$63	$22,680
DWR Biologist		5	5	5	5	5	5	5	5	5			45	360	$63	$22,680
ADMIN	2	2	2	1	1	2	2	2	2	2			18	142.4	$60	$8,544
Total	35	46	45	15	16	17	15	15	15	15	0	0	234	1870		$150,736

Table 8-2 Element 3 Personnel Needs

ELEMENT 3	FY: 2005-2006											
CLASSIFICATION	MONTH											TOTAL DAYS
	J	A	S	O	N	D	J	F	M	A	M	J	
PRINCIPAL INVESTIGATOR	3	3	3	3	4	4	4	4	4	4	4	5	45
ENGINEER	8	8	7	7	9	9	9	8	8	8	6	7	94
CAD	0	0	0	0	0	0	0	0	0	4	5	5	14
LAB SUPERVISOR	5	5	21	9	9	10	12	5	5	4	4	3	92
LAB TECH 1	3	3	18	8	9	10	5	4	4	3	3	3	72
LAB TECH 2	0	0	9	9	8	9	6	3	2	3	3	3	54.5
DWR Senior Engineer PI	3	5	10	10	10	10	10	10	10	10	10	10	108
DWR Engineer	5	5	5	5	5	5	5	5	5	5	5	5	60
DWR Biologist	5	5	5	7	7	7	7	7	7	7	7	7	78
ADMIN	1	1	1	1	1	1	1	1	1	2	2	2	14
Total	33	35	78	58	62	65	59	47	46	50	49	50	631

ELEMENT 3	FY: 2006-2007												
CLASSIFICATION	MONTH												TOTAL DAYS
	J	A	S	O	N	D	J	F	M	A	M	J	
PRINCIPAL INVESTIGATOR	3	3	3	3	3	3	3	3	3	3	3	3	36
ENGINEER	12	12	8	8	7	7	7	7	8	7	8	8	99
CAD	0	0	0	0	0	0	0	0	0	4	5	5	14
LAB SUPERVISOR	4	4				14	7	7	1	2	2	2	43
LAB TECH 1	3	3				14	7	8	4	3	3	3	48
LAB TECH 2	0	0				4	7	6	2	3	3	3	28
DWR Senior Engineer PI	4	4	4	5	4	4	4	4	4	4	4	4	49
DWR Engineer	5	5	5	5	10	10	10	10	10	10	10	10	100
DWR Biologist	5	5	5	5	5	5	5	5	5	5	4	4	58
ADMIN	1	1	1	1	1	1	1	1	1	1	2	2	13
Total	37	37	26	27	30	62	51	51	38	42	44	44	488

ELEMENT 3	FY: 2007-2008												
CLASSIFICATION	MONTH												TOTAL DAYS
	J	A	S	O	N	D	J	F	M	A	M	J	
PRINCIPAL INVESTIGATOR	3	3	4	4	5	5	5						29
ENGINEER	9	9	9	9	9	12	12						69
CAD		2	2			3	3						10
LAB SUPERVISOR													0
LAB TECH 1													0
LAB TECH 2													0
DWR Senior Engineer PI	2	2			3	3	3						13
DWR Engineer	2	2	2	2	2								10
DWR Biologist	2	2	2	2	2								10
ADMIN	1	2	2	2	3	3	4						17
Total	19	22	21	19	24	26	27	0	0	0	0	0	158

APPENDIX 1: ELEMENT 1 - STANDARD OPERATING PROCEDURES

(In response to comments, Element 1 Standard Operating Procedures has been deleted from the proposal. It will be submitted at a later date under separate cover)

APPENDIX 2: ELEMENT 2 - STANDARD OPERATING PROCEDURES

Hypothetical Predation Risk Analysis

1. Review and summarize information from fishery studies conducted within the Delta estuary by CDFG and others regarding the species composition, size distribution, and relative density of predatory fish species for use in the predation analysis.
2. Compile information from field observations of the species composition and abundance of predatory birds at the release sites
3. Compile information on the species composition and numbers of fish released at individual sites from both SWP and CVP salvage operations from salvage records maintained in a central database by CDFG. Information from the salvage database will be used to characterize the numbers of fish released at each location and the frequency of releases under normal routine salvage operations.
4. Compile and summarize information available from the scientific literature on the number of prey consumed by different species and sizes of predatory fish and birds in addition to the changes in prey consumption and gastric evacuation rates of prey as a function of environmental variables such as water temperature. Coordinate with other investigators (e.g., Geir Aasen, Don Portz, Charles Simenstad, etc.) regarding the synthesis of available information.
5. Document the sources of information and the relationships and assumptions included in the hypothetical predation risk analysis
6. The predation risk analysis will assume a range of predator densities occurring over the geographic area encompassed by the receiving waters at a release site (assumed to have a near-field radius of 150 feet for fish and a radius of 0.25 miles from each release site for avian predators) in order to generate a population abundance estimate of predatory fish and birds within the area adjacent to a release location. A similar analysis will be performed using field observations of the abundance and species composition of predatory birds occurring at each release location.
7. Based on the estimated population abundance within the near-field receiving waters, in combination with data on prey consumption from the scientific literature, an estimate will be derived of the total number of prey potentially consumed by fish and bird predator populations inhabiting the near-field receiving waters.
8. Refine the analyses using site-specific information on seasonal water temperature conditions and gastric evacuation rates to assess potential predation mortality within and among days characterized by individual or multiple salvage releases.
9. Compare the hypothetical estimates of predation mortality within the near-field receiving waters to information on the seasonal patterns in the numbers of fish salvaged and returned to release locations within the central Delta. Descriptive statistics will be generated, by season, for the expected percentage and 95% confidence intervals on the proportion of salvaged prey expected to be consumed by predators.

10. Assume for purposes of the hypothetical analyses a preliminary threshold for a biologically significant level of predation mortality of 10% consumption of fish released as part of the salvage operation to represent a biologically significant level of predation mortality. As noted in Element 2, the 10% predation mortality threshold is considered to be a general guideline for assessing and interpreting results of the hypothetical predation risk analysis. Results of the predation risk analyses and all underlying assumptions will be documented as part of the technical report to allow an independent assessment of the potential biological significance of predation as a factor affecting survival of fish following release.

11. Further refine the analyses to include information on local water velocities and dispersal of fish following release from salvage operations. These refinements would then be factored into the predation vulnerability analysis to estimate the effects of a large number of fish being released at a site over short period of time (predator swamping).

12. Further refine the analyses to include assumptions regarding differential predation rates on fish released in a healthy condition and actively able too avoid predation, fish released in a stressed condition with a reduced predator avoidance capability, and the effects of predation on fish released which were dead following salvage as additional parameters within the hypothetical predation vulnerability model.

13. Information from site-specific field studies will be used to further refine the data inputs, assumptions used in the predation model to reflect, to the extent possible, actual field data collected on a site-specific basis from existing release locations within the Delta.

14. Document all sources of information used to construct various assumptions and biological relationships within the model in addition to iterative review of the model construct and assumptions with other scientists involved in Delta fishery investigations.

15. Compile and synthesize information available from past and ongoing fishery investigations conducted within the Delta estuary, in addition to information from the scientific literature, both published and unpublished reference material, identifying various functional relationships that affect predator dynamics within the receiving waters.

16. Data analysis will primarily involve providing specific documentation on the source of information used in developing the predation risk analysis, in addition to the formulation of specific functional relationships included within the model framework.

17. Conduct a series of sensitivity analyses using the model to explore the importance of various specific assumptions and relationships that affect estimated rates of predation mortality for salvaged fish.

18. The model construct provides tabular and graphic representation of biological and physical relationships developed from the available data regarding predation risk within the near-field receiving waters in addition to graphical displays of various relationships included in the model development. .

19. Results of the analyses will be documented in a technical report.

Bioacoustic Determination of Predator Abundance, Distribution, and Behavior

20. Develop and conduct bioacoustic surveys within the receiving waters to identify the geographic distribution and relative abundance of predatory-sized fish for comparative analyses during periods before, during, and after the release of salvaged fish. The receiving waters are defined as an area approximately 0.25 miles (radius) surrounding the release location.

21. The receiving waters in the vicinity of each of the four currently operating release locations will be surveyed using a boat mounted bioacoustic (hydroacoustic) transducer(s) to survey along a series of pre-established transect lines representing a grid of transects both parallel and perpendicular to the channel alignment. Transects will be spaced at approximately 50-foot intervals.

22. Fixed position acoustic transducers will also be placed at the release sites to survey fish in the area immediately adjacent to the release pipe (within approximately 150 of the pipe discharge)

23. Acoustic survey equipment (e.g., split beam) will be determined with the assistance of knowledgeable experts. Additional equipment for monitoring water quality (temperature, dissolved oxygen, electrical conductivity) and water velocity profiles (acoustic Doppler) will be available for use during these surveys.

24. Perform bioacoustic surveys within each of the designated transect grids in a systematic way to identify the location and estimate the abundance (density) of predatory-sized fish.

25. Mobile bioacoustic surveys will be conducted at each of the four release locations, in addition to the control site within Horseshoe Bend (and additional control locations if suitable), before, during, and after salvage fish releases. In addition, fixed location (mounted) bioacoustic surveys will be performed at one or more of the release and control sites depending on site-specific conditions and opportunities to locate and mount survey equipment. Site-specific conditions (e.g., requirements to drive pilings for equipment mounting) may preclude the use of fixed location bioacoustic surveys at some release and/or control locations.

26. The location of the survey vessel along each transect line will be mapped using GPS to allow for analysis of the geographic distribution of predatory fish, which would be plotted using a GIS system, to show the locations of predators with respect to location of each release.

27. The surveys will be performed to evaluate salvage releases during both day and nighttime conditions at each release site to allow comparison of potential differences in predator distribution and behavioral response.

28. Surveys will be conducted to assess changes in predator distribution and abundance at each release site separately, during strong ebb, slack tide, and strong flood tide conditions

to assess the potential effects of tidal current velocities on the distribution of predators within the receiving waters.

29. Bioacoustic surveys will be performed on approximately a quarterly basis to coincide with the seasonal periods of peak abundance for various potential prey species. Priority and additional field sampling effort will be focused on surveys during the late fall, winter, and spring periods to coincide with the occurrence of protected fish in the salvage operations. Preliminary scheduling of the surveys will include surveys conducted during May, August, November, and February to encompass a range of seasonal environmental conditions that may affect species composition and abundance of predators within the central Delta.

30. Surveys within specific time periods, such as the spring (May) survey, are intended to represent a seasonal period when juvenile fall-run chinook salmon and delta smelt are abundant in the salvage operations.

31. Results of bioacoustic surveys will be used to examine changes in the geographic distribution and abundance of predatory fish among the four release sites. The data will be used compare the response to three different frequencies of salvage releases, which would include (1) multiple releases at one site within a day; (2) one release at a site every other day; and (3) one release at a site once per week. Changes in predator abundance and distribution in response to the frequency of salvage releases will be assessed by alternating release frequencies at various sites and subsequently assessing changes in predator population dynamics. Amendments to the Biological Opinions and agreements will be required from the resource agencies prior to modifying the release schedule.

32. Analysis of Variance (ANOVA) will be used to determine if statistically significant differences exist in the number of predators in the vicinity of the CVP release sites, the SWP release sites, and the combined release site near Antioch and the respective control locations. ANOVA will also be used to determine if significant differences exist in the number of predators present diurnally (day and night); during various tide stages (ebb, flood, slack); if there are changes in predator density with relation to the timing of the release (before, during, and after release); seasonally (spring, summer, fall, and winter), and/or distance from the release point.

33. The interaction terms of site and time of release, diurnal, and distance from the release point will also be tested. A series of REGWQ multiple range tests will be used to determine if significant differences occur between the predator densities by release site, diurnally, timing of the release, tidal stage, and distance from the release point. Additionally, the least-squares estimates of the marginal means for the main effects will be calculated. The least-square estimates of the means are made with all covariates at their mean value.

34. Analyze results of bioacoustic surveys to determine the geographic location, as determined by GPS, where each potential predator target was detected during each of the surveys. Data from the bioacoustic surveys will be processed and analyzed to determine

the time, location, and if possible the length, of individual predator-sized fish detected within the receiving waters.

35. Results of the surveys will be entered into a documented Microsoft Access database, and correlated with the time and characteristics of salvaged fish releases.

36. Analyze survey data to assess characteristics of the predator distribution before, during, and after a salvage release.

37. Map the distribution of predators on NOAA nautical charts for each area and survey time. Changes in the distribution of predator fish detected through the mapping will then be related to changes in potential behavior triggered by individual releases at each location in response to conditions such as day and night, ebb and flood tidal stage, and other environmental parameters.

38. Information from the mapping will also be analyzed to look at predator accumulations immediately downstream of the release pipe coincident with a release and will provide useful information on predator densities for incorporation into the predator risk model.

39. All data developed from the bioacoustic surveys will be documented in a searchable database, subject to quality control checks, and will be made available as part of the technical documentation provided for this element of the predation investigations.

DIDSON Observations of Predator Behavior Before, During, and After Release

40. Design and construct temporary facilities at the SWP Horseshoe Bend release site (e.g., brackets attached to pilings) that will allow the DIDSON camera to be positioned at a fixed stationery location for the purpose of determining predator behavior in the immediate area associated with the discharge from the release pipe. The DIDSON mounting system will allow the camera to be rotated, vertically and horizontally, remotely for the purpose of observing fish throughout the near-field water column. At the other locations an underwater target will be established to focus the DIDSON on and the range and view of the target will set the camera.

41. Underwater permanent boat anchor points will be established at each location

42. During the 10 minute observation periods before, during, and after a release, the field of view the DIDSON camera will be fixed at one location throughout the observational period to determine changes in predator behavior before, during, and after releases conducted both during the daytime and at night.

43. Analyze observations of the DIDSON camera to assess potential changes in predator behavior, in the potential behavioral attraction to the release pipe discharge location during ebb, flood, and slack tidal conditions representing a range of water velocities at both the SWP and CVP release sites.

44. Analyze DIDSON observations at the four currently operating release sites to compare predator behavior at these locations characterized by differences in water depths and tidal velocities. A similar set of observations using the DIDSON camera will be made at the control location sited approximately 0.5 miles upstream of the SWP release site within Horseshoe Bend and at other control locations identified on the lower Sacramento River and lower San Joaquin River.

45. For each set of DIDSON observations, a grid will be established over the field of view of the DIDSON camera designated by individual X - Y coordinates.

46. A series of three 10-minute observation periods will be recorded prior to a release, three 10-minute observation periods during a release (with the actual release coinciding with the start of the second 10-minute observation period), and three 10-minute observation periods after the release has been completed.

47. The number of predatory-sized fish observed entering and exiting the DIDSON field of view grid during each of the 10-minute periods will be quantified in addition to quantification, to the extent possible, of the length of potential predator fish observed.

48. Analyze observations from the DIDSON records on the frequency of occurrence of predator strike behavior during each of the observation periods.

49. DIDSON observations for the releases would be replicated under each treatment and control condition a minimum of three times during each survey period.

50. Survey periods will be scheduled approximately quarterly to provide information on changes in predator behavior and frequency of occurrence at the point of release in response to various seasonal conditions.

51. Document results of the DIDSON observations both electronically as part of computer files containing the DIDSON observations and images, in addition to quantified in accordance with pre-established criteria for determining the occurrence of potential predatory-sized fish under each of the observational scenarios.

52. Enter results of the DIDSON observations into a documented Microsoft Access database.

53. Analysis of Variance (ANOVA) will be used to determine if statistically significant differences exist in the number of predators in the vicinity of the CVP release sites, the SWP release sites, and the control site(s).

54. ANOVA will be used to determine if significant differences exist in the number of predators present diurnally (day and night); during various tide stages (ebb, flood, slack); if there are changes in predator density with relation to the timing of the release (before, during, and after release); or seasonally (spring, summer, fall, and winter). The interaction terms of site and time of release and site and tide and will also tested.

55. An *a priori* comparison will be made between predator densities at the test sites (SWP and CVP) and at the reference location. A series of REGWQ multiple range tests will be used to determine if significant difference occur between the predator densities by release site, diurnally, by timing of the release, and by tidal stage. Additionally, the least-squares estimates of the marginal means for the main effects will be calculated. The least-square estimates of the means are made with all covariates at their mean value.

56. Data collected using the DIDSON camera system will include a series of observational views of the DIDSON camera during each observation period.

57. DIDSON observations will include the presence of fish within the field of view and the number of fish passing through the area immediately adjacent to the release pipe before, during, and after a release.

58. Information developed from the DIDSON observations will be documented both electronically and in a searchable database.

59. Data will be analyzed to determine an index of potential predator-sized fish abundance within the near-field area immediately adjacent to the release pipe during each test period.

60. Indices of predator-sized fish abundance will be compared among different treatment and control conditions as part of the experimental design.

61. Documentation as part of the database information on patterns of predator behavior indicating a strike response to a potential prey during each of the observational periods, will be compiled as part of the analyses to generate a predation strike index for each treatment and control condition being tested.

62. Indices of predator abundance and potential predator strikes will be analyzed statistically to compare indices before, during, and after salvage releases.

63. Statistical tests will be performed to compare indices between day and nighttime conditions, between ebb, slack, and flood tidal conditions, and among release locations. Analyses will also be performed to compare indices between the SWP Horseshoe Bend release site and the identified control site.

<u>Sampling to Determine Predator Species Composition and Density at Release Sites</u>

64. Apply for NOAA Fisheries, USFWS, and CDFG scientific collection permit and an incidental take authorization.

65. Sampling predatory fish will occur at the SWP Horseshoe Bend release site, where bottom topography is flat, water depths are relatively shallow (15 feet and less), and tidal water velocities are relatively low compared to the CVP release sites and the joint release site at the Antioch Bridge. The environmental conditions and configuration of the SWP Horseshoe Bend release site will permit capture and quantification of predatory fish inhabiting the area immediately adjacent to the release pipe.

66. Remove debris and potential obstacles to sampling predatory fish at the site. Prior to removing material from the site, conduct a visual inspection using the DIDSON camera to determine if the structure(s) or debris to be removed provides cover or attracts predatory fish to the area and to map the locations of material removed from the area. Debris removal should be minimized to the extent possible to retain the current characteristics of the release site.

67. Purchase a commercial-sized beach seine, with two-inch nylon mesh netting, extending approximately 20 feet deep and up to 1,000 feet in length,

68. Practice deploying the net from a boat at a location upstream of the existing SWP release pipe.

69. Set the beach seine during sampling in a way that will completely enclose the area of Horseshoe Bend surrounding the existing release site.

70. Hold the net in place using pilings and/or buoys and anchors to entrap all of the potential predatory-sized fish inhabiting the area immediately adjacent to the release pipe.

71. Use a boat-mounted electroshocker to recover captured fish from the beach seine. Available data on salinity (electrical conductivity) in the area will be reviewed to identify potential seasonal periods when water quality conditions in the area would adversely affect the performance of the electroshocker. Water quality measurements will be made at the site immediately prior and during sampling to document electrical conductivity, water temperature, and dissolved oxygen concentrations.

72. Conduct multiple passes using the electroshocking boat until the fish population within the net has been depleted (no additional catch).

73. Fish captured will be identified to species, fork length (mm) and weight (g or by water displacement) measured.

74. Each fish will be tagged using an individually numbered Floy or other suitable tag (labeled with contact information and a unique numeric code) inserted into the back musculature behind the dorsal fin to determine potential recapture in subsequent sampling events, and released at the site. Predatory fish collected during the sampling may also be tagged using the radio or acoustic tags to monitor fish behavior and movement within the receiving waters.

75. Based on the number of each predatory fish collected and the area sampled using the beach seine, calculate an estimate of the density of predatory fish (number of fish per 100 square meters) within the area surveyed.

76. Repeat predator surveys at the SWP release site, after completing the quarterly fishery monitoring and evaluations, to assess changes in predator community on a seasonal basis.

77. Schedule predator surveys to be conducted following a period of routine salvage releases at the site.

78. Evaluate results of the predator surveys, in combination with corresponding results of both the DIDSON camera observations and bioacoustic surveys, to provide further complementary information on calibrating results of various field methods and in

determining the relative size and species composition of the predator population inhabiting the near-field receiving waters.

79. Data collected during the physical sampling to determine predator species composition and densities will include, for each sampling event, the area enclosed by the beach seine and the corresponding number, size, and species of all fish collected.

80. Information will be entered into a searchable documented database and used to calculate estimates of predator density (number of predators per hundred square meters) within the near-field receiving waters.

81. Information on the species and size of predatory fish will be used to refine the assumptions and data incorporated, for each specific release location, into the predation model.

82. Data analysis will primarily involve descriptive statistics comparing the density and species composition of predatory fish in the near-field receiving waters as a function of various environmental parameters, the frequency of salvaged fish releases at the site, seasonal conditions, and environmental parameters such as water velocities, temperature and salinity.

83. Results of the physical sampling will be correlated with results of the bioacoustic surveys to provide an independent estimate of the density of predatory fish inhabiting the receiving waters.

84. Individual predatory fish will be tagged and included in the database, which will be further analyzed in the event of subsequent recaptures of tagged fish. Recaptures of tagged predators will provide information on whether or not predators are recaptured within the near-field receiving waters at a release site, suggesting attraction and site fidelity to a release site, or are widely dispersed within the Delta estuary.

85. Data from the physical sampling will be entered into a documented database and included as part of the technical documentation report prepared for this predation studies.

<u>Radio/Acoustic Tagging to Examine Predator Movement (site fidelity, attraction) at Release Sites</u>

87. Contact vendors and evaluate the suitability of radio tags and acoustic tags for conducting tracking studies at release sites based on information on water depths and electrical conductivities in the area (developed from existing water quality monitoring information). Consideration will be given to the potential application of 2-D and 3-D telemetry tracking equipment, as well as the availability of existing tracking equipment with DWR or other agencies, when determining the equipment to be used in this study.

88. Purchase required tracking equipment, if necessary, and individually identifiable tags

89. Capture predatory fish, including striped bass and Sacramento pikeminnow (using hook and line, as part of the physical sampling at the release site described above, or other suitable method), from the area adjacent to the existing release sites

90. Surgically tag individual predatory fish

91. Hold tagged fish in ambient water bath at the site until recovered from handling and tagging stress

92. Release tagged predators near the release site where they were captured.

93. Monitor the location of individually tagged fish using fixed and/or portable detection equipment.

94. Determine the location of each predator based on triangulation.

95. Track movements of predators on a daily basis, or other appropriate frequency based on fish movement and tag battery life, to determine their behavior patterns within the area during both day- and nighttime conditions.

96. Monitor the location of predatory fish to allow comparison of behavior and distribution before, during, and after releases, to allow comparative information to be developed on predator behavior and attraction to a release site during day- and nighttime surveys, and to compare predator behavior between release locations.

97. Results of radio/acoustic tagging of predatory fish will include the species, size, tag code, location of capture, location of release, and subsequent results of tag monitoring. Tags will be monitored after release to determine the location of tagged fish relative to the location and operations of individual salvage releases.

98. Information on movement patterns of predatory fish, including potential behavioral attraction and accumulation at the point of release, will be developed through tag tracking and will be mapped, using GIS, on NOAA nautical charts showing the location of predatory fish over time, traces of movement patterns relative to the location of individual release sites, and corresponding information on the frequency and characteristics of salvaged fish releases.

99. Results of the tagging will be used to evaluate predator movements within the receiving waters between day and nighttime conditions and in response to ebb, flood, and slack tidal conditions.

100. Since multiple species of predatory fish will be tagged and monitored, information on the differential behavior of different species of predators will be documented and mapped.

101. Results of the data analysis will be presented graphically showing traces of movement patterns as determined by the location where tags are detected at various time intervals in addition to tabular summaries documenting the physical and environmental conditions occurring within the receiving waters that may affect predator behavior.

Documentation Reporting and Dissemination of Results

102. A technical report will be prepared in draft form and distributed for review by participants in the CHTR workgroup, Interagency Ecological Program (IEP), and by other interested scientists. A one-month comment period will be provided for review of the draft report.

103. The draft technical report, and accompanying documented database, would also be provided to a group of independent scientific peer reviewers (three individual scientists)

with knowledge and expertise in conducting and evaluating results of similar scientific investigations. Peer reviewers will have one month to review and comment on the draft report.

104. Results of the review and comment on the draft technical report will be used to revise the technical documentation report and, if needed, perform further analysis of results.

105. The revised report will be prepared as a final technical documentation report and made available in both hardcopy and electronically for dissemination to interested parties.

106. A summary of the technical documentation report will be prepared for publication in the IEP newsletter, presentation to the IEP annual conference or other scientific conferences (CALFED, American Fisheries Society, etc.)

107. Based upon results of the independent peer review a manuscript may also be submitted for publication in a peer reviewed scientific journal.

APPENDIX 3: ELEMENT 3 – STANDARD OPERATING PROCEDURES

Apparatus Design and Construction

1. Schedule and conduct site visits and meetings with operators at the Skinner and Tracy fish facilities to compile data on the main fish transport truck tanks used for transport of fish. Manufacturer's data and drawings will be gathered, if available, and drawings of the tank will be made, if necessary.

2. If the University of California at Davis (UCD) site is selected, a tank and trestle supports for the tank would be designed. This includes the foundation design and geotechnical investigations. The pipe slope and size will be the same as the pipe at the Horseshoe Bend site. A fabricator will be hired to construct a replica of the transport tank. It will be constructed out of coated mild steel, or other material, and fitted with baffles and the other fixtures to simulate the main truck at Skinner. Mounting brackets on the outside of the tank will be attached so that the tank can be easily rotated 90 degrees and remounted. Fish holding tanks and water treatment facilities are already available at the UCD lab.

3. If the Skinner experiment site is selected the tank truck at Skinner will be used. However, the existing outdoor laboratory release facility would be modified as follows. The truck ramp would be raised and extended to the northeast. The existing receiving water tank would be buried about 3 feet. A longer (60 to 80 feet) clear plexiglass release pipe would be installed on new supports. A sump would also be built to pump the drain water from the receiving water tank up into the drain system. A pump would be added to the water supply pipe at the ramp to simulate the release pipe flushing flow volume and pressure. The objective is to simulate the conditions at the Horseshoe Bend release site as closely as possible. About 10 fish holding tanks would be purchased and plumbed into the water system in the new building. Water filter and chiller are already installed at the experiment facility. This water would feed the holding tanks. Coordination would be closely maintained with the researchers at Skinner throughout the design and construction process.

4. Schedule and conduct site visits to the four release sites: SWP sites at Horseshoe Bend and Sherman Island and CVP sites on the Sacramento River and at Antioch. Meet with operators at the Skinner and Tracy Fish Facilities to compile data on the release sites. Drawings of the facilities at the site will be obtained. Measurements of the pipes and other facilities and pump nameplate data will be gathered at the four sites. These data will be used to compute hydraulic conditions for comparison to the data collected in the experiments.

Debris Collection and Transport

5. Collect wet debris recently removed from the trashracks at Skinner. The debris must be wet. Add water, if necessary, prior to transport. The debris sample will be removed from the debris pile so that it is representative of the debris encountered at Skinner at that time of year.

6. Transport the debris to the test site maintaining its water content.

7. Several trips will be required during the course of the experiments. Each batch of debris transported will be photographed and the debris characterized. This will identify any change in debris composition over the duration of the experiments.

8. Hold the debris at the site in containers. Keep the debris wet to prevent deterioration.

Experimental Fish (Experiments 1B)

9. 700 cultured chinook salmon, 350 for treatment group, and 350 for the control group, will be purchased and delivered to the experiment site to arrive at least 72 hours in advance of the cultured salmon trials to allow for acclimation. The fish will be placed in the UCD or Skinner holding facilities.

10. 700 threadfin shad (exact numbers to be determined based on availability), 350 for treatment group, and 350 for the control group, will be collected at SWP or CVP and delivered to the test holding facilities at least 96 hours in advance of the shad trials to allow for acclimation. The fish will be placed in the UCD or Skinner experimental holding facilities.

11. 700 cultured juvenile delta smelt, 350 for treatment group, and 350 for the control group, will be obtained and delivered to the UCD facilities or Skinner experimental building at least 72 hours in advance of the cultured delta smelt trials to allow for acclimation. The fish will be placed in the holding facilities. Approximately 200 adult delta smelt will be obtained depending on availability for additional tests, if scheduling and time allows.

12. The temperature and water quality in the fish holding facility will be adjusted to match that of the receiving water in the test flume.

Hydraulics

13. With the data from Task 4 above hydraulic calculations would be made to estimate the hydraulics of all four release sites.

14. A test will be performed with clean water (no debris) to test the equipment. During the runs visual observations, photos, and video will be taken of the following: 1) inside of the tank, 2) the tank outlet from inside the tank, 3) flow in the pipe through the plexiglass near the pipe outlet, through the 90-degree bend, at the add-in water introduction, at the water level of the receiving water, and 4) the outlet of the pipe.

15. The tank will be filled with water and the depth in the tank measured so that a depth-volume curve can be developed. During experiments the water level will be measured as the tank drains. With these data and the depth-volume curve the flow rate out of the tank can be calculated.

16. The depth of flow in the pipe will be measured at two or three points in the pipe.

1A Existing System Debris Tests

17. The purpose of the tests is to determine the threshold amount of debris that will clog the tank outlet and to document the physical movement of debris and water during the release with photos and videos.

18. Runs will be made with varying amounts of debris in the sequence below to identify the threshold amount of debris that causes the outlet to clog.
   a) A maximum amount of debris, sure to clog the outlet will be tested.
   b) Half the amount of debris will be tested
   c) If the debris in *b)* clogs the outlet, then half debris in *b)* will be used next. If not, then the average of the amounts of debris in the previous two runs will be tested.
   d) The procedure in *c)* will be used until the threshold amount of debris is determined.

19. During the tests, in addition to the photos and videos described above, flow depths will be measured in the pipe using standard point gauges and the time to drain the tanks to various depths will be recorded. From test data the flow versus time will be calculated.

20. The procedure for performing the debris trial runs is as follows:
   a) Fill the receiving water tank.
   b) Fill the transport tank to a level achieved in normal operations at the Skinner facility.
   c) Add debris to the transport tank spreading the debris on the surface to simulate how the debris disperses during the trip to the release site.
   d) Turn on the flushing flow pump and set the valve to direct the flushing flow to the four-pipe input to the release pipe.
   e) Open the release valve at the outlet of the transport tank.
   f) Record the event on video and still camera
   g) Record the water level in the tank and time from valve opening at 6 intervals while the tank drains.
   h) If the outlet is clogged with debris, force the debris out the outlet similar to the procedures used at the release site. This procedure is to wash out the debris with a high-pressure hose similar to the one used at the release site and to assist this process by pushing debris through the outlet with a broom handle.
   i) Remove debris from the receiving water flume.
   j) Repeat steps *b)* through *i)* with different debris loads as described above to determine the threshold debris load, which clogs the outlet.

1B Existing System Fish Test

21. For each fish species tests will be performed in five trials with two replicates each. This begins with cultured spring chinook salmon, followed by cultured juvenile delta smelt then by shad. Each trial will be performed with the same amount of debris. The amounts of debris to be used in each trial will be set from the debris study at the maximum amount of debris that will pass without clogging.

22. The procedure for performing the trial runs with fish is as follows:
   a) Fill the receiving water tank.
   b) Fill the transport tank to a level normally achieved in normal operations at the Skinner facility.
   c) Measure temperature in the fish holding tanks, transport tank, and receiving water flume. The fish holding tank water temperature will be regulated to be about the same as the temperature in the receiving water flume.

d) To estimate injuries associated with pretrial handling, remove 5 fish at random from each control and treatment group. Examine for injuries to those fish as outlined in Measures of Effects section below.

e) Transfer experimental fish to the transport tank in buckets containing seven fish each. See Fish Handling section below. Five trips with buckets required.

f) Transfer control fish to the control holding tank in buckets containing seven fish each. Five trips with buckets required.

g) Add debris to the transport tank spreading the debris on the surface. The debris is measured as a volume wet and uncompacted.

h) Turn on the flushing flow pump and set the valve to direct the flushing flow to the four-pipe input to the release pipe.

i) Open the release valve at the outlet to the transport tank.

j) Record the event on video and still camera

k) Record the water level in the tank and time from valve opening at 6 intervals while the tank drains.

l) If the outlet is clogged with debris, force the debris out the outlet similar to the procedures used at the release site. This procedure is to wash out the debris with a high-pressure hose similar to the one used at the release site and to assist this process by pushing debris through the outlet with a broom handle.

m) Transfer fish from the receiving water tank to a new 48-hour holding tank. Five trips with seven fish per bucket required.

n) Transfer fish from the control holding tank (step *f)* above) to a new 48-hour holding tank. Five trips with seven fish per bucket required.

o) Remove debris from the receiving water tank.

p) Repeat steps *b)* through *o)* again with the same amount of debris to complete one trial.

q) Following transfer from the receiving water tank to the 48-hour holding tank, remove 5 fish at random from each treatment group and control group, and examine them for injuries as outlined in Measures of Effects section below.

23. At the end of 48 hours of holding count remaining live fish for each trial.

24. Determine if significant differences exist between mortalities of the runs in each trial.

25. Plot mortality versus debris amount.

26. Repeat steps 22 through 25 for the five trials (one clear water and four with different loads of debris).

27. Repeat steps 22 through 26 with cultured delta smelt.

28. Repeat steps 22 through 26 with threadfin shad.

2A Modified System Debris Test

29. Based on the modification to the equipment or operation, debris tests will be run if appropriate.

2B Modified System Fish Test

30. Based on the modification to the equipment or operation, fish tests will be run if appropriate. The species and numbers will be decided based on the tests required and fish availability.

Fish Handling Protocols

1. Moving fish from holding tanks to fish transport truck tank or control holding tank:
   a. Fill 5-gallon buckets with 3 gallons of aerated water. Use white buckets for cultured chinook and shad and black buckets for cultured delta smelt. Use slightly saline (5.2 to 6.0 ppt) water for trials using delta smelt
   b. Carefully net fish from tanks chosen at random. Use medium-sized aquarium dip nets fitted with plastic bowls to minimize scale loss associated with use of a net.
   c. Place fish in 5 gallon bucket by submerging net in bucket.
   d. Without agitation carry buckets of fish to the fish transport truck tank and submerge the bucket to release the fish.
   e. Use same procedure for control fish walking the same distance as the test fish transport.
2. Moving fish from receiving water flume to 48-hr mortality test tanks:
   a. Carefully and slowly crowd treatment fish to far end of receiving water body test flume.
   b. Fill 5-gallon buckets with 3 gallons of aerated water. Use white buckets for cultured chinook and shad and black buckets for cultured delta smelt. Use slightly saline (5.2 to 6.0 ppt) water for trials using delta smelt
   c. Carefully net fish from tank. Use medium-sized aquarium dip nets fitted with plastic bowls to minimize scale loss associated with use of a net.
   d. Without agitation carry buckets of fish to the 48-hr mortality test tank and submerge the bucket to release the fish.
   e. Use same procedure for control fish walking the same distance as the test fish transport.

Measures of Effect

1. Record numbers of dead and live fish for the treatment and control groups immediately after release into 48-hr mortality test tank.
2. To estimate injury in treatment and control trial subsets (five fish each) that were removed at random:
   a. Immediately euthanize.

b. Examine fish with lighted three-power glass.

c. Report scale loss as the proportional area with scales missing in each of three zones on each side of a fish. The three zones are the upper body posterior to the operculum and dorsal fin; the lower body from the midline to the ventral surface anterior of the vertical line extending from the distal end of the dorsal fin; and the remaining area of the body posterior of the vertical line extending from the distal end of the dorsal fins. The proportional areas with scale loss for the six zones will be averaged to yield an overall estimate of percentage of scale loss. Other injuries, such as bruising, abrasion, and hemorrhaging of the head, eyes, body, and fins, will be recorded.

3. Forty-eight hours after the trials, the 48-hour mortality test tanks are to be drained and all living fish will be anesthetized and characterized as to their health. There will be four designations: healthy, minor abrasions and injuries (e.g. loss of scales), difficulty maintaining position in the water column and major injuries, or dead.

4. Survival, frequency of injuries, and health will be compared for each trial.

APPENDIX 4 QUALIFICATIONS OF INVESTIGATORS

The co-principal investigators for the physical factors during release investigation would be Dennis Dorratcague Roger Churchwell and Dr. Charles H. Hanson.

Mr. Dorratcague has been extensively involved in bioengineering projects addressing issues of fish passage, protection, and salvage within the Pacific Northwest and California. He is instrumental in performing both field and laboratory investigations regarding the hydraulics of fish passage. He served on a Corps of Engineers expert panel to investigate the affects on fish of passage over spillways at the Corps of Engineers' dams on the Columbia and Snake Rivers.

Mr. Churchwell is the DWR Fish Facilities Section Chief, and has been involved in bioengineering projects and studies for the last 3 years. Bioengineering studies have included adult sturgeon passage study conducted at UCD, Trash rack debris removal and fish passage study conducted at UCD and the Board Weir fish passage study conducted in the Yolo Bypass. His past experience has been involved in evaluating hydraulic and hydrology projects and studies. Which included storm water management new technologies studies conducted in the hydraulics lab at UCLA and field tested in the Los Angeles area.

Dr. Hanson has been actively involved in conducting water quality, fishery and fish protection projects within the Bay-Delta estuary for over 25 years, including experimental studies conducted at the Reclamation District 108 Wilkins Slough positive barrier fish screen site, Reclamation District 1004 Princeton positive peer fish screen site, Georgina Slough acoustic barrier investigation, and as part of VAMP and the evaluation of the effects of water quality conditions and exposure of Delta fish.

APPENDIX 5

Evaluation of Collection, Handling, Transport and Release Effects on Delta Smelt (*Hypomesus transpacificus*) Salvaged at Southern Delta Water Export Facilities: Program Proposal

Prepared by Pat Coulston, Robert Fujimura, Geir Aasen, and Virginia Afentoulis

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CO-lead INVESTIGATORS

Robert Fujimura, CDFG, 209-948-7097, bfujimur@delta.dfg.ca.gov

Roger Churchwell, DWR, 916-227-7546, rchurchw@water.ca.gov

Charles Liston, USBR, 502-255-9168, crlist@aol.com

Joseph Cech, UC Davis, 530-752-3103, *jjcech@ucdavis.edu*

Program Summary

We propose a suite of investigations to assess the viability of delta smelt, *Hypomesus transpacificus,* exposed to the collection, handling, transport, and release (CHTR) components of fish salvage operations associated with State Water Project (SWP) and Central Valley Project (CVP) south Delta water exports. The proposed program spans 4 years with a strong emphasis on early reporting of interim results to facilitate urgent decision making regarding potentially costly new CVP and SWP south Delta fish screening facilities. The proposed investigations will measure survival and injury rates, predation losses, and stress levels of delta smelt exposed to existing CHTR facilities and processes. In addition, the feasibility and efficacy of alternative CHTR methods will be investigated and pilot evaluation of promising alternatives will be conducted.

Three aspects of CHTR-related delta smelt impacts at existing facilities will be investigated. First, we will measure current CHTR-related acute mortality and injury rates and assess how variation in observed rates is influenced by certain biological, environmental and operational factors. The primary proposed method of measuring current mortality and injury rates is injection of known numbers of cultured delta smelt at selected points within the fish salvage process. Repeated trials (with appropriate controls) will be conducted with adult delta smelt during the period December through March and with juvenile smelt during the period April through July, which have historically been the periods of highest entrainment for each life stage.

We believe that experimental trials with cultured smelt provide the most reliable means of obtaining a sufficient number of observations to estimate acute mortality and injury rates (and the influence of environmental factors on those rates) with reasonable precision. Because low survival rates have been reported in earlier studies, we will also study the responses of wild smelt to the stresses of CHTR components. Comparisons of response rates of wild entrained smelt and cultured smelt will provide insights on the role of pre-CHTR stress or fish condition on post-CHTR survival and injury rates.

In the event that early results from the acute mortality and injury investigation suggest consistently high mortality rates for either life stage during CHTR exposure experiments, we propose to conduct complimentary experiments to assess the general potential for improved survival. Specifically, we propose to expose healthy (cultured) smelt to small scale, mock CHTR events and processes devised to

avoid known or suspected sources of acute stress associated with current CHTR processes. This experimental “kid gloves” CHTR-like treatment (in combination with what is known from other handling studies and experiences) is intended to establish an approximate upper limit on achievable survival rates for juvenile and adult smelt subjected to CHTR-type handling. These contingency investigations of survival potential are not intended to substitute for the fourth element of this program, the identification and comprehensive engineering/biological assessment of alternative CHTR facilities and processes.

A second investigation will attempt to measure the extent to which fish predators contribute to total acute mortality rates associated with existing CHTR facilities and processes. Again, during the December through March and April through July periods the pre- and post-CHTR stomach contents of entrained predatory fishes will be examined to determine the extent to which they feed on smelt or similar fish species during the CHTR process.

The assessment of current and future fish salvage process impacts on delta smelt would be facilitated by the ability to use stress indicators to measure sub-lethal responses. Also, stress indicators have the potential to provide a measure of sub-lethal CHTR effects that could affect post-release survival or essential life functions. We, therefore, propose a third investigation to determine if diagnostic parameters can be used to predict short and long term CHTR impacts on smelt survival or condition. A complete evaluation of current information on fish condition indicators will be conducted. Based on this review, a suite of diagnostic indicators will be selected for testing. Cultured and wild delta smelt will be exposed to the CHTR process and the response of selected diagnostic parameters measured. The sub-lethal effects of CHTR will be measured initially only for adult delta smelt using three types of experiments. The first type will compare primary indicators of stress (blood cortisol, glucose, and lactate) between control and CHTR-exposed smelt. The second type will compare a secondary indicator of stress (swimming performance) between CHTR-exposed and control fish. A third type of experiment is proposed to assess the degree to which CHTR-exposed smelt suffer a higher level impairment such as reduced reproductive ability (% egg viability). Collectively, these experiments will provide an assessment of the degree to which CHTR-exposed smelt experience sub-lethal effects that are likely to impair near- and long-term survival or condition.

In the fourth and final element of the proposed program, alternative facilities and operations that have the potential to improve the survival and condition of salvaged delta smelt will be identified through a thorough literature review, and promising new concepts evaluated for efficacy and feasibility. Determinant factors for the survival and condition of salvaged delta smelt will be identified. Conceptual evaluation criteria will be developed and used to rank promising alternatives. New CHTR system components scheduled for installation at the Tracy Fish Collection Facility (TFCF) or other facilities will also be evaluated for efficacy. Data gaps preventing the evaluation of new technologies will be identified, and recommendations for addressing these information needs will be developed. Promising concepts or methods will be identified for further engineering and biological evaluation. Data obtained from prototype trials will be compared against results from the current CHTR operations and facilities.

GENERAL (PROGRAM-LEVEL) PROBLEM STATEMENT

The proposed program of CHTR investigations is designed to address a specific management information need and to logically integrate with the current state of scientific knowledge regarding handling effects on delta smelt. The management and scientific contexts are addressed separately in the following sub-sections.

Management Context

The CALFED Bay-Delta Program is implementing the largest comprehensive water management and ecosystem restoration program in the world (CALFED 2000a). An important objective of the program is reducing the fisheries impacts associated with exporting water from the Delta through the two major water conveyance systems; the CVP operated by the U.S. Bureau of Reclamation (USBR) and the SWP operated by the California Department of Water Resources (DWR). Each of these distribution systems operates a large diversion facility in the southern portion of the tidal Delta, the CVP Tracy Pumping Plant and the SWP Harvey Banks Pumping Plant (Figure 1). The CALFED Record of Decision (ROD) (CALFED 2000a and 2000b) identifies reducing the direct loss of fish at these diversions through construction and operation of new, improved fish screening facilities as a high priority restoration action.

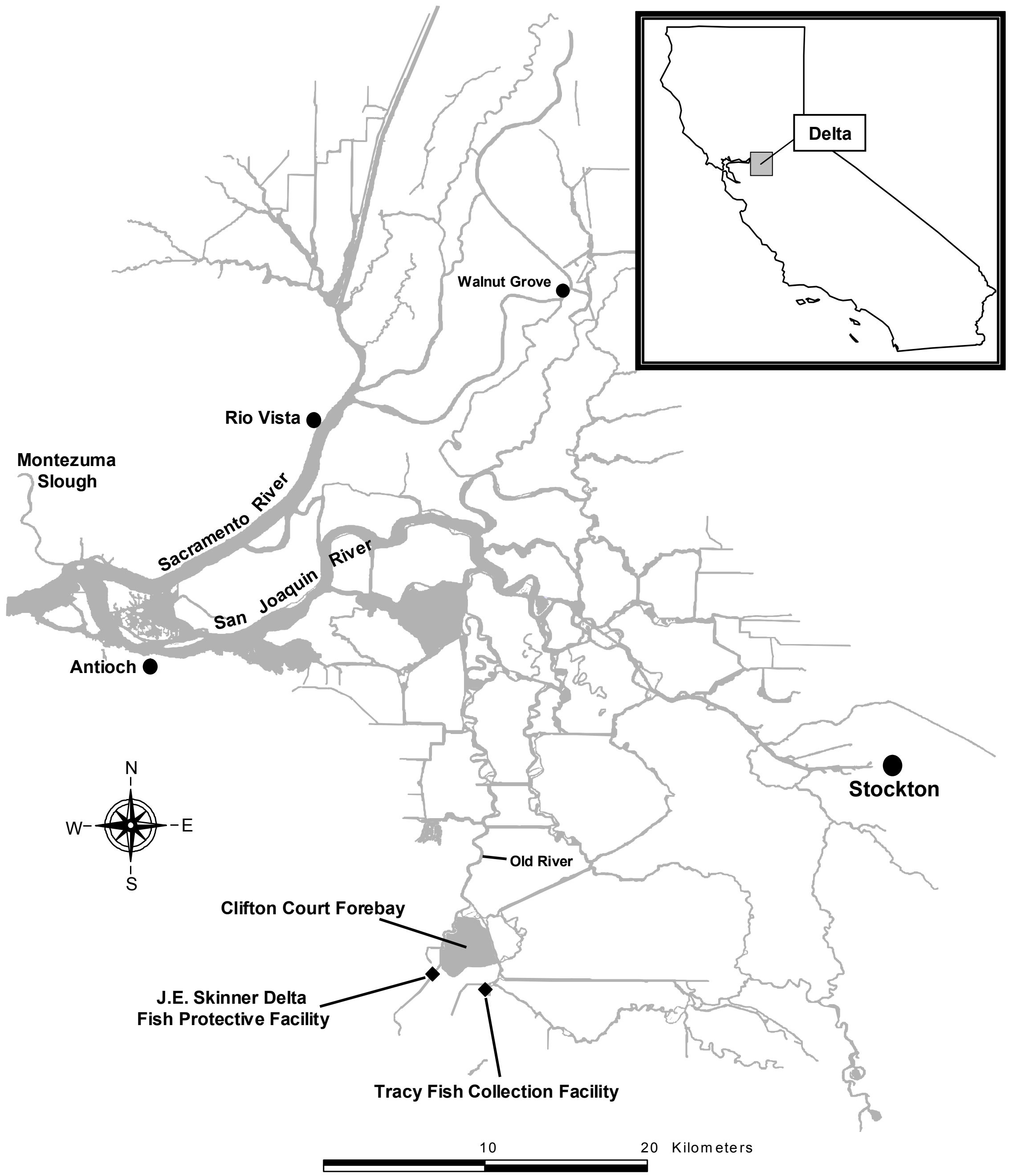

Figure 1. Map of the Delta showing the location of the John E. Skinner Delta Fish Protective Facility.

The improvement or replacement of screening facilities is potentially very costly. The initial phase of state-of-the-art, positive-barrier screens on the periphery of the SWP's Clifton Court Forebay (CCF) are expected to cost from 400 to 500 million dollars, including the cost of test facilities required to assess the performance of new facility designs (Glickman 2002, CCFTAT Subcommittee 2002). Designing the new facilities to efficiently screen delta smelt, a species listed as threatened under both the state and federal Endangered Species acts, contributes substantially to the overall cost of new screens. Because of the small size of smelt (60-120 mm adult length) and their generally weak swimming abilities (Moyle 2002), effectively screening this species requires relatively low water approach velocities (NMFS Southwest Region 1997; DFG 2000) and, therefore, screens with larger surface areas at any given diversion rate. Larger screens increase facility size, bypass complexity, and costs for construction and maintenance.

Exported Delta water and entrained fish are drawn from a wide area of the estuary towards the export facilities. In contrast with a diversion on a river with unidirectional flow past the diversion, screened fish at the CVP and SWP cannot simply bypass the diversion point. Effectively preventing the direct loss (entrainment) of fish at the SWP and CVP delta export facilities requires <u>both</u> fish screens and facilities to collect, handle, transport, and release fish beyond the influence of export pumping. Delta smelt are known to be very sensitive to handling so there is a substantial management concern that incremental expenditures intended to make new screens efficient for screening smelt could be wasted if smelt survive subsequent phases of the fish salvage process at low rates. This concern led the CALFED Management Team in 2002 to request the Interagency Ecological Program (IEP) to investigate the viability of delta smelt exposed to the CHTR phase of salvage. This suite of proposals was prepared in response to that request.

Figure 2 illustrates the approach the CHTR program will use to facilitate decision-making regarding the cost-effectiveness of incremental expenditures to design and build new southern Delta fish screens that efficiently screen smelt. Figure 2 also identifies the role that individual program elements play in the decision making process. The proposed approach is designed to:

1. Determine survival rates for delta smelt exposed to CHTR processes at existing CVP/SWP salvage facilities;

2. Assess the general potential for improving the survival of smelt exposed to CHTR processes;

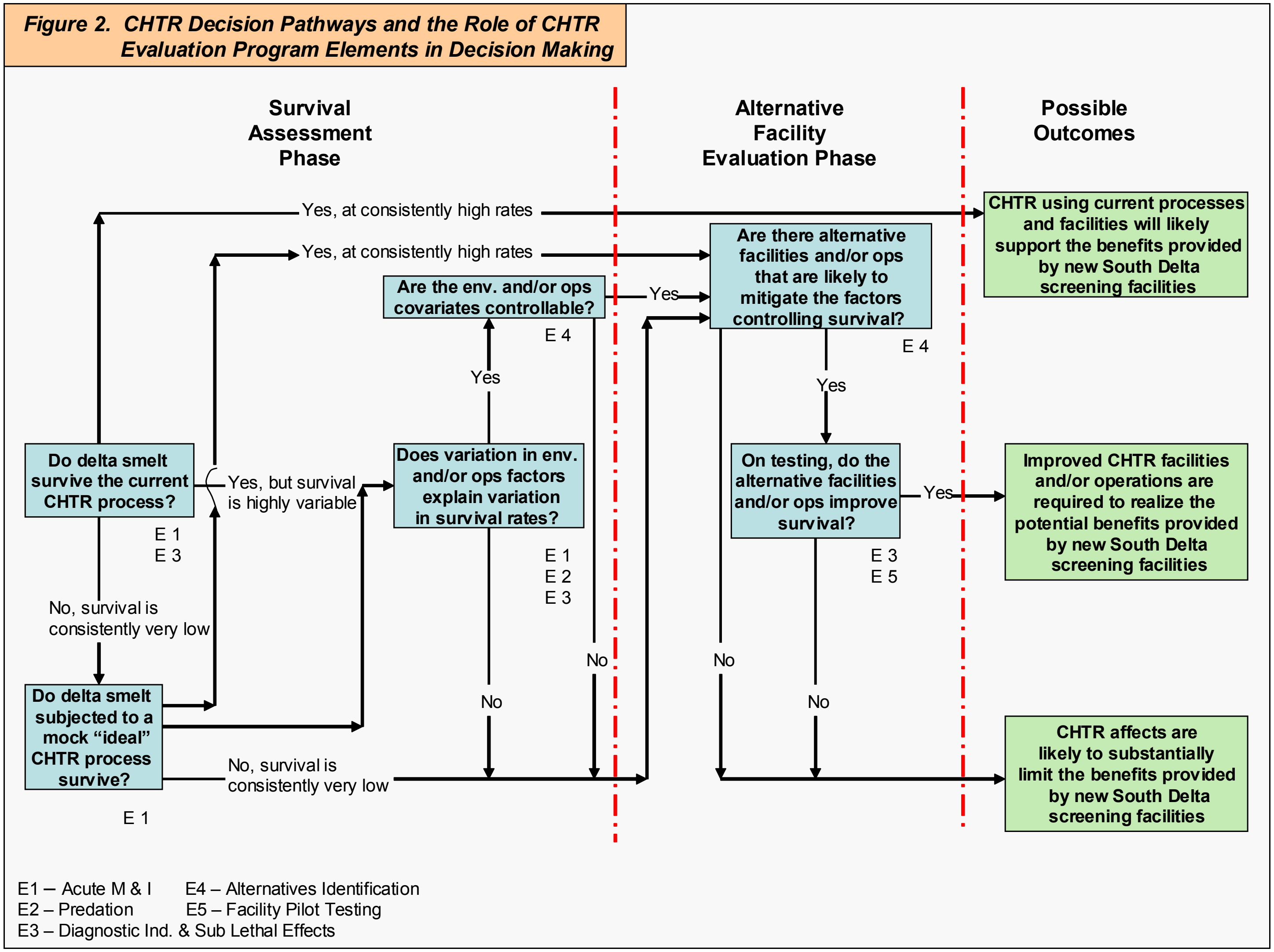
Figure 2. CHTR Decision Pathways and the Role of CHTR Evaluation Program Elements in Decision Making
Survival Assessment Phase
Alternative Facility Evaluation Phase
Possible Outcomes
Yes, at consistently high rates
Yes, at consistently high rates
CHTR using current processes and facilities will likely support the benefits provided by new South Delta screening facilities
Are there alternative facilities and/or ops that are likely to mitigate the factors controlling survival?
Are the env. and/or ops covariates controllable?
Yes
E 4
E 4
Yes
Yes
Do delta smelt survive the current CHTR process?
Yes, but survival is highly variable
Does variation in env. and/or ops factors explain variation in survival rates?
On testing, do the alternative facilities and/or ops improve survival?
Yes
Improved CHTR facilities and/or operations are required to realize the potential benefits provided by new South Delta screening facilities
E 1
E 3
E 1
E 2
E 3
E 3
E 5
No, survival is consistently very low
No
No
Do delta smelt subjected to a mock “ideal” CHTR process survive?
No
No
No, survival is consistently very low
CHTR affects are likely to substantially limit the benefits provided by new South Delta screening facilities
E 1
E1 – Acute M & I
E2 – Predation
E3 – Diagnostic Ind. & Sub Lethal Effects
E4 – Alternatives Identification
E5 – Facility Pilot Testing

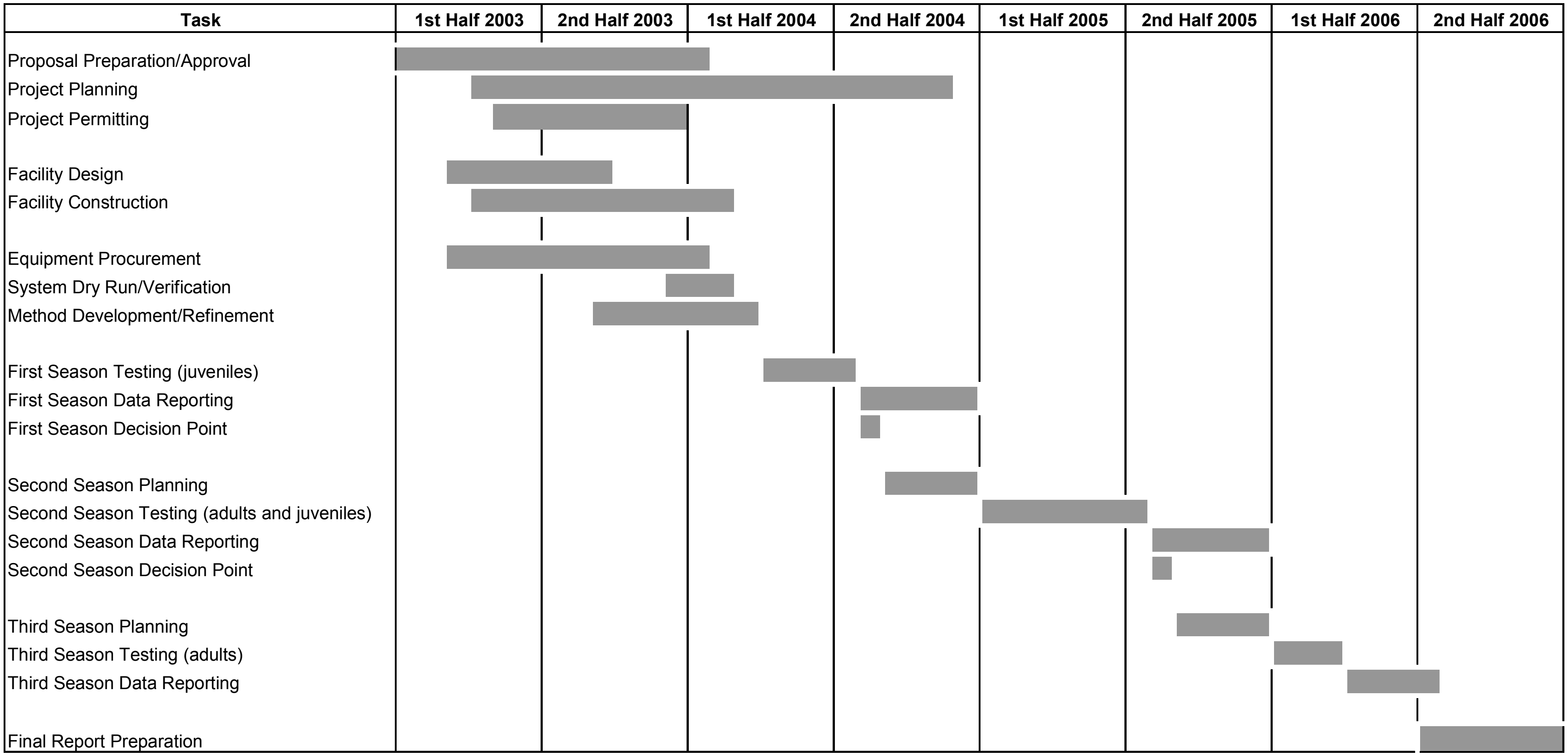

Figure 3. Example of the proposed schedule of one CHTR element's activities: Acute Mortality and Injury Evaluation

3. Identify conditions that influence survival during CHTR; and

4. Identify and pilot test alternative processes and facilities that have a significant potential to improve survival.

The first three components of the proposed approach compose a “survival assessment” phase, and the fourth a “facility/process evaluation” phase. If the results of the first phase indicate that smelt have very limited potential for CHTR survival, it will suggest making large incremental expenditures to enhance smelt screening efficiency at the SWP and CVP, and may not be a cost-effective way to reduce direct losses. If the first phase indicates that smelt have the potential for substantial CHTR survival the “facility/process evaluation” phase will identify and then test technologies, facilities, and processes that can realize that potential. Because the current schedule for designing and building new SWP/CVP screening facilities will not permit a purely serial approach to conducting the two phases of the proposed program; at least the first portion of “facility/process” evaluation phase will be initiated and conducted in parallel with the “survival/assessment” phase. This first portion consists of a comprehensive review of fish handling and fish facility literature, and existing facilities, to identify promising candidate technologies for pilot testing.

The aggressive design and implementation schedule for new SWP/CVP screening facilities also creates a need for rapid and continuous dissemination of program results, which is reflected in the program schedule (Figure 3).

<u>Scientific Context</u>

Available scientific information does not provide a clear understanding of the capacity of delta smelt to survive the unavoidable handling associated with fish screening at southern Delta water export facilities or the factors affecting survival.

It is generally recognized that delta smelt at all life stages are sensitive to handling (Moyle 2002), suggesting they may inevitably suffer high rates of mortality during the post-screening (CHTR) phases of fish salvage. If it was clearly established that meaningful rates of delta smelt survival could not be achieved during the CHTR phases of salvage, large incremental expenditures to make new screens efficient for smelt would probably not be judged cost effective.

Alternatively, if available scientific information clearly demonstrated that delta smelt consistently and predictably survived salvage or salvage-like handling conditions at high rates, a decision about new screens could be made on that basis and the investigations proposed here would be unnecessary. In fact, the current state of knowledge regarding the ability of delta smelt to survive salvage-related handling stresses is clearly insufficient to support informed decision making regarding the efficacy of incremental expenditures to make new CVP/SWP fish screens efficient for delta smelt.

Studies of delta smelt survival during handling have yielded widely varying results. Early observations during field collections, experimental aquaculture efforts and general investigations of salvaged fish at the SWP Skinner Fish Facility have demonstrated that delta smelt are sensitive to handling and can experience low survival rates during salvage operations. Odenweller (1990) investigated the survival of salvaged delta smelt held at the Skinner Striped Bass Grow-out Facility and observed that no juvenile smelt survived (N=3590) during the summer of 1989. Swanson et al (1996) reported that early attempts to obtain live delta smelt from field collections resulted in mortality rates exceeding 90%. Raquel (1989) conducted a general fish handling and trucking investigation during 1984 and 1985, and Foss (2002a) observed from the unpublished data that handled and trucked juvenile delta smelt (20 to 50 mm long) survived at rates of 11% and 17%, respectively. Raquel's control fish (screened smelt that did not undergo handling, trucking, and release processes) survived at a rate of 31%. Small-scale directed studies at the Skinner Fish Facility examined the survival of juvenile delta smelt exposed to CHTR processes in 1999 and 2000 and observed low and varying levels of survival ranging from 48% in 1999 to 0% in 2000 after 48-h (Foss 2002b; Afentoulis 2002). However, the fact that low survival rates were also experienced by the control groups during these studies (22% in 1999 and 4% in 2000) suggests possible deficiencies in the experimental protocol.

In contrast, other delta smelt handling studies have shown that high survival can be achieved. Morinaka (1995) conducted a pilot study at the Skinner Fish Facility exposing wild adult delta smelt to CHTR processes during the winter of 1995. Survival in five trucking experiments averaged 90% for smelt held for at least 48 hours post-treatment. The survival of delta smelt in one handling experiment was 97%. When delta smelt were segregated from other fish after the experiments, survival of control groups ranged from 93 to 100% (Morinaka 1995). Investigations at the CVP's TFCF involving secondary screen and fish pump evaluations reported high survival rates of both cultured delta smelt and entrained wild delta smelt. Helfrich et al (2001) reported an initial survival of 99% for wild entrained delta smelt in helical fish pump evaluations at the TFCF during 1998 and 1999. Similarly, the survival of cultured delta smelt ranged from 94 to 100% after passage through the helical fish pump and held for up to 96 hours (Helfrich et al 2003). Finally, the UC Davis Fish Treadmill and Delta Smelt Aquaculture programs have achieved consistently high smelt holding and handling survival rates associated with their swimming performance, fish screen behavior, and experimental rearing experiments (Young et al 1999; Bradd Baskerville-Bridges, personnel communication, 2002). Improved handling procedures and the use of dark-colored rearing tanks have enabled consistently successful handling and holding of experimental fish. Again, the information presently available clearly indicates that delta smelt are sensitive to handling, but sometimes survive fish facility and other fish handling situations quite well.

Our proposed program will for the first time comprehensively examine delta smelt mortality and injury rates, and non-lethal stress effects associated with the CHTR phases of south delta fish salvage operations. In addition to measuring mortality and injury rates of juvenile and adult delta smelt during high entrainment periods, the proposed study is designed to assess how variations in environmental and operational conditions, including the presence of predators, affect CHTR-related survival and injury rates and the pre-CHTR viability of entrained wild smelt.

The proposed CHTR investigations are one component of a larger effort to provide more robust scientific information to reduce the uncertainty around estuary management and restoration actions designed to improve the status of delta smelt.

The CHTR phases of the CVP and SWP fish salvage represent the terminal few steps of a complex linear process intended to minimize direct losses. This process begins with primary screens (louvers) and finishes with the release of salvaged fish into Delta waters remote from the export facilities (Figure 4). In addition to CHTR-related information, an informed decision to develop and build new south delta screens will also require an assessment of how well juvenile and adult smelt will survive the screen bypass and holding tank components of the salvage process. These components are currently being addressed through complementary research programs, in particular the USBR Tracy Fish Collection Facility Improvement Program and the Tracy Fish Test Facility (TFTF) programs (Charles Liston, personal communication). The results of the CHTR investigations will allow some inferences about pre-CHTR viability.

Delta smelt loss rates within CCF have not been measured, but loss rates are known to be high for juvenile salmon (Gingras 1997). However, this current area of uncertainty and potential source of substantial direct loss for smelt is largely irrelevant to the pending decision about building new CVP/SWP screens in the south Delta, because new screen proposals would place the screens hydrologically in front of the Forebay.

Another area of substantial uncertainty regarding direct loss of smelt at the CVP and SWP is that of long-term, post-release survival. Although the proposed CHTR program will attempt to measure the health of released smelt and identify facility and process improvements to increase fish health, we are not proposing to examine the long-term viability of smelt after release to Delta waters. This is a very difficult area of research, which has yet to be attempted for any species, so the long-term post-release survival of salvaged fish will likely still be an area of substantial scientific uncertainty at the point a decision is made regarding building new CVP/SWP screens in the southern Delta. It is our understanding, however, that the CALFED Science Program will be encouraging work in this area during the next few years through its research grant program.

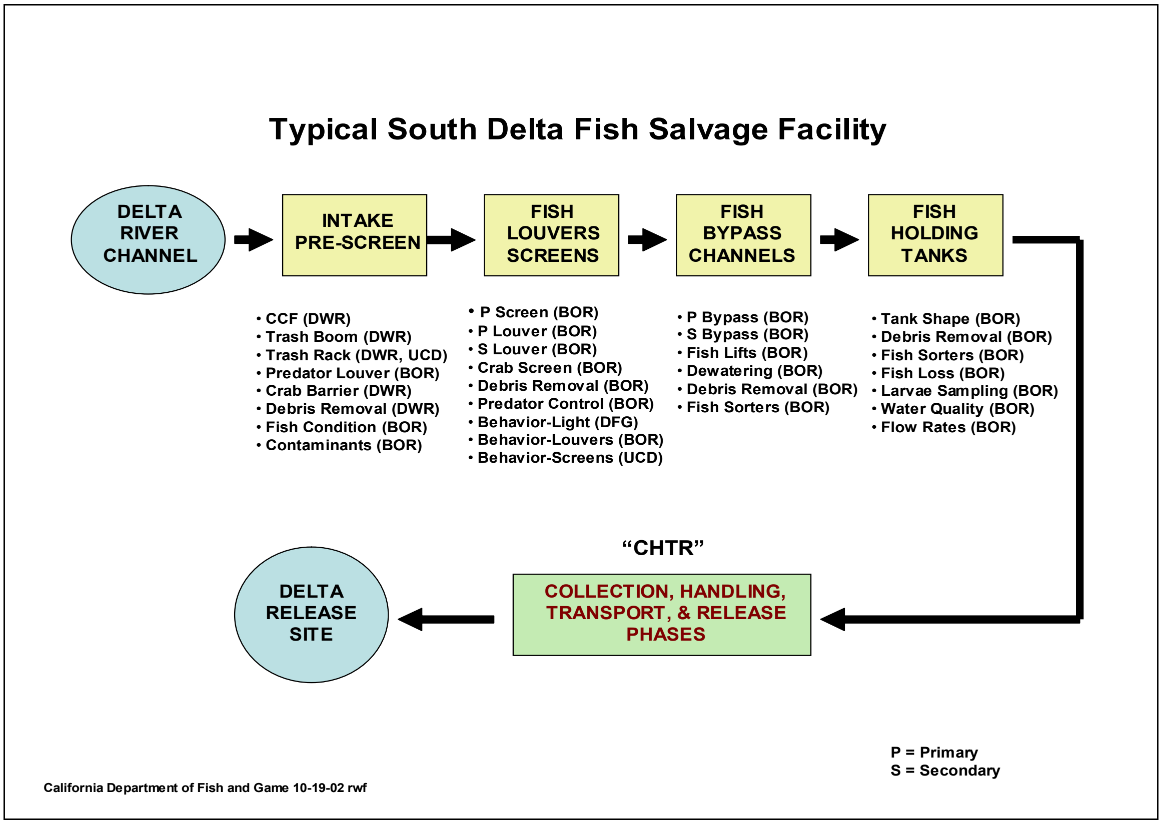

Figure 4. Component model of a typical large South Delta fish salvage facility in relationship to the collection, handling, transport, and release phases. Current or proposed research projects and their proponents are listed below each component unit.

The complete screening and salvage process represents only a portion of the exposure that delta fishes have to water export effects. Other, so called “indirect”, export effects potentially include transport to unfavorable habitats by export induced artificial flow patterns and changes in Delta productivity related to changes in water residence time in channels. At this time very little is known regarding the type and magnitude of indirect CVP and SWP impacts on delta smelt.

Direct and indirect effects of water exports are two types of stressors among many other potential stressors in the delta that may influence delta smelt abundance. Presently, we have a very limited understanding about the factors controlling smelt abundance. However, two general observations suggest that direct export losses could be important. First, there is strong evidence that direct losses can impact a substantial proportion of the delta smelt population.
Unpublished analysis (Wimm Kimmerer, personal communication) based on export volumes and the distribution of juvenile smelt suggest that in some years as many as 75% of the juveniles present during the spring may be entrained by the CVP and SWP. Second, at recent low levels of smelt abundance there has been little evidence of density-dependence in the population, suggesting that high levels of direct loss probably do suppress the size of the population. The IEP is planning a comprehensive investigation in 2005 to improve our measurement of juvenile smelt entrainment loss, the factors influencing that loss, and the effects water operations have on juvenile smelt distribution.

9.0 **guiding questions & hypotheses**

10.0

11.0 THE FOLLOWING IS A GENERAL TREATMENT OF THE RESEARCH QUESTIONS ADDRESSED BY THE PROPOSED CHTR PROGRAM. THE SPECIFIC QUESTIONS AND HYPOTHESIS TO BE ADDRESSED BY EACH OF THE FOUR PROGRAM ELEMENTS CAN BE FOUND WITHIN THE INDIVIDUAL ELEMENT PROPOSALS.

GENERAL

The broad question guiding the proposed CHTR investigation program is:

Is it likely that juvenile and adult delta smelt will survive the CHTR phases of fish salvage at proposed new SWP and CVP screening facilities?

We presume that new state-of-the-art CHTR facilities and processes proposed in the ROD can achieve delta smelt survival levels at least equal to those of the 30 – 40 year-old facilities now operating at the SWP and CVP.

By carefully documenting adult and juvenile delta smelt survival at the existing SWP salvage facilities the proposed **Acute Mortality & Injury** element of this program will essentially establish the lower end of the range in CHTR survival rates achievable with the proposed new facilities. The **Acute Mortality & Injury** element is intended to clearly answer for the first time the question:

What are the rates of juvenile and adult delta smelt survival during the CHTR phase of salvage at the SWP and CVP during typical periods of entrainment for each life stage?

Because we expect survival rates to vary with certain environmental and operational conditions, the **Acute Mortality & Injury** element will specifically examine survival differences between night and day and between the two major sub-phases of CHTR, collection/handling and transport/release. We also hope to relate variations in survival with variations in certain uncontrolled operational and environmental variables (e.g. debris loads and temperature). To the extent we can make inferences about the influences of key uncontrolled variables, we can design follow-up investigations and/or guide the development and testing of pilot facilities during the final element of the program.

We plan to sample during the day and night because certain operational, environmental, and biological factors that may influence the survival or injury of delta smelt vary by diel period. Pumping rates (water flow), fish salvage rates, wind-caused mixing of Clifton Court Forebay, water temperature, and debris loads frequently vary by day/night periods. Higher fish salvage rates occur at night at both the Central Valley Project and the State Water Project (SWP) fish salvage facilities. The species composition and densities of the fish salvage commonly differ between day and night. The SWP exports water generally during the night when electricity rates are lower. Light or its absence influences fish behavior and their interactions with fish screens and other facility features. The UCD Fish Treadmill Program has observed increased screen contact rates and higher injury rates of delta smelt tested at night (Swanson et al. 2002). It is presumed that sight predators would feed at higher rates during daylight periods.

Insights into the causes of CHTR related mortality could influence future operational scenarios. Daytime pumping rates at the SWP can be currently modified based on operational need or possibly on environmental protection objectives. Proposed alternatives for filling the Clifton Court Forebay may provide greater pumping schedule flexibility. Light levels in fish salvage components can be modified through covers or artificial lighting.

A second component of the **Acute Mortality & Injury** element will attempt to answer the question:

How great is the potential for improving juvenile and delta smelt survival during CHTR?

If preliminary results from our efforts to measure survival rates for existing facilities and processes indicate that rates are low, this will argue against a decision to move forward with planning for new, delta smelt-centric screening facilities or even the comprehensive development and testing of alternative CHTR technologies unless there is reasonable evidence that substantial improvements in delta smelt survival are achievable. To facilitate these decisions, the **Acute Mortality & Injury** element has a contingency for experiments designed to measure survival rates of juvenile and adult smelt exposed to a mock optimal CHTR process. The mock process will include all the basic components of CHTR, but will be designed to avoid, to the extent possible, known and assumed stressors.

The **Predation** element of the program focuses on a particular potential source of acute mortality in the salvage process that has not been well addressed for the CHTR phase of salvage by past investigations, loss to predatory fish coincidentally salvaged with delta smelt. Specifically, this element is intended to answer the question:

To what extent do fish predators feed during the CHTR phases of the salvage process, and to what extent does predation contribute to the overall acute mortality and injury rates?

The degree to which predation does occur during the CHTR phase of salvage is an important consideration in the design of new facilities. Losses due to fish predation within the CHTR process have not been studied despite observations of significant pre-screen predation losses (Gingras 1997) and the fact that current predator control measures are employed in the secondary louver and bypass systems in both CVP and SWP facilities. Predator and prey fish are crowded together to facilitate truck transport and predation has been observed by the facility operators. Previous CHTR studies using wild fish did not take into account predation losses. Estimates of CHTR predation are necessary to accurately measure the total mortality of delta smelt and to assess the overall impact of the existing Delta fish salvage facilities.

The extent of predation within the CHTR process will be used to determine the need for costly predator management strategies such as fish size grading, predator segregation, or control facilities. The majority of the concepts to reduce predation in the CHTR have focused on reducing the number of predators entering the CHTR process or segregating predators from prey fish. Most of these concepts require additional equipment or special fish holding or transport facilities. Estimates of predation rates could help determine the cost/benefit of these control measures. For example, considerable cost saving could be achieved if CHTR predation rates are relatively low on listed species and control measures are not needed within this process.

The **Diagnostic Indicators** element of the program is intended to answer two general questions.

1) What practical measures of sub-lethal stress are available, or can be developed, to assess the near- and long-term viability of CHTR-exposed smelt?

2) Do delta smelt exposed to existing CVP/SWP CHTR facilities and processes experience sub-lethal levels of stress that are likely to impair their near- and long-term viability?

The inclusion of this element in the proposed program recognizes the fact that smelt may survive CHTR exposure without visible injury, yet may be sufficiently stressed by the experience to impair their post-release viability in the delta environment. In addition to providing an indirect measure of post-exposure viability, the **Diagnostic Indicators** element will provide tools for assessing and comparing the effectiveness of alternative CHTR technologies.

The fourth element of this program is designed to first answer the question:

What new or alternative fish handling technologies, facilities, and processes are available to improve the survival of salvaged delta smelt?

Once promising alternatives have been identified this element will focus on the general question:

How effective and feasible are alternative CHTR technologies, facilities, and processes in improving the viability of delta smelt?

This question will be addressed by designing, building, then testing prototypes of promising alternatives

ASSUMPTIONS AND LIMITATIONS

In general, the three most important limitations of the proposed program are:

1) The proposed program does not, and is not intended to at this time, directly measure the long-term viability of CHTR exposed delta smelt. The question of long-term, post-release viability has not been addressed for any Delta species. This is a difficult area of research important to decisions about future water export facilities and operations. We encourage work in this area to begin as soon as possible, perhaps beginning with juvenile salmon. Juvenile salmon lend themselves to this research, because of our relatively robust understanding of their life history and use of the Delta, access to test animals, and ability to tag and recover them in concert with ongoing research and monitoring programs.

2) As stated earlier, we assume that the rates of mortality and injury during our proposed investigations represent at least the minimum that could be achieved by modern screening systems installed on the periphery of CCF as proposed in the ROD. It should be recognized, however, that because the location of the new screens will reduce pre-screen losses and they are of a positive barrier design, dramatic increases will likely occur in the number of fish, especially smaller fish < 20 mm FL, that must be handled during the CHTR phase of salvage. The design of new facilities must account for this increase in salvage or problems associated with fish density within the new systems could negatively impact salvaged fish survival.

   High density release and recapture studies during the pilot evaluations of new CHTR technologies can address this issue on a component or small scale level for delta smelt. Larger scale evaluations involving new fish salvage facility systems with multiple Delta species will be effectively addressed by the construction and operation of the proposed TFTF. Investigations involving large numbers of small, post-larval fish present new research challenges (e.g. noninvasive experimental handling and species identification methods) which requires research techniques that have not been developed or tested on Delta fish species and therefore, better candidates for future work.

3) To a large extent our proposed approach utilizes cultured delta smelt rather than wild, entrained smelt. This approach assumes that cultured smelt will respond similarly to wild smelt to the stresses of CHTR. We will compare our results from cultured smelt against the responses of wild smelt to the extent they occur during our studies. However, wild smelt sample sizes may be too small and erratic to provide robust results and these fish may be affected by pre-CHTR stresses or in poor condition. Information on the stress indicator levels of wild and cultured smelt and the relative survival rates of pre-CHTR exposed wild smelt should provide insights into this issue. The use of surrogate species (e.g., longfin smelt or threadfin shad) should be considered if the availability of wild delta smelt is problematic and the responses of wild fish must be evaluated.

SUMMARY OF METHODS

The following are brief descriptions of the proposed methods for each of the four program elements. More detailed descriptions of the study methodologies and analyses can be found in the individual element proposals.

Acute Mortality & Injury

The primary method of measuring the delta smelt mortality and injury associated with CHTR is the release and recovery of marked cultured delta smelt. Each experimental trial will begin with an introduction of a known number of marked fish into the CHTR process. The use of cultured fish will ensure that each trial will have an adequate number of fish of consistent general health and condition. Cultured delta smelt will be obtained, marked, and acclimated to water from Clifton Court Forebay prior to each trial at the UCD Delta Smelt Culture Facility at the Skinner Fish Facility. Test fish will be introduced at one of two points in the CHTR process and exposed to a series of routine operational conditions. After exposure to the CHTR processes, the test fish will be recovered using low stress techniques, the number of dead or injured fish noted, and the surviving fish held in experimental fish tanks for up to 48 hours. The number of dead fish will be recorded every 24 hours during the post-experiment holding period. Injury rates will be obtained by performing fish injury assessments on sub-samples of test fish prior to the start and at the end of each trial, and subsequently during the post experiment holding period.

The acute mortality and injury rates for CHTR exposed delta smelt will be compared against rates obtained for marked cultured delta smelt that have undergone similar experimental handling procedures but not exposed to the CHTR process (control group). Repeated trials of these experimental releases, with appropriate controls, will be made with seasonally appropriate life stages. In addition, entrained wild delta smelt will be collected, monitored, and their pre-TR and post-CHTR survival and injury rates compared with that of cultured test fish. We will compare the survival and injury rates of adult delta smelt exposed in the winter against the rates of juvenile delta smelt tested in the spring. We will examine whether diel period or partial exposure of CHTR affect delta smelt survival or injury rates. Various environmental and operational factors will be measured during cultured smelt releases and wild fish collection periods to evaluate how these factors influence survival and injury rates.

PREDATION

This study will determine predation rates during the CHTR phase of salvage by comparing stomachs contents of sampled predatory fish immediately before and after CHTR. The study will be implemented during the summer of 2003 and the winter and spring of 2004. After the usual 8 or 12-hour pre-CHTR holding tank phase, a sub-sample of predators will be removed with hand nets after the water is drained from the holding tank into the loading bucket. Sampled predators will be euthanized and stomachs removed by incisions in the esophagus and upper intestine and preserved by deep freezing (-30 °C) (stomach sample 1). The remaining fish will then undergo the entire CHTR phase. After being moved by the loading bucket into the transport truck and transported for 45 minutes, the fish will be released into an above ground swimming pool with a rotary screen and water drained so fish can be scooped out with dip nets. All fish will be identified to species and measured to the nearest millimeter [fork length (FL) or standard length (SL), depending on species]. Dead fish will be recorded. Potential predators will be euthanized and stomachs removed by incisions in the esophagus and upper intestine and preserved by deep freezing (-30 °C) (stomach sample 2).

In order to improve our ability to gauge when predation occurred during the salvage process, seasonally occurring predators (including striped bass) will be held in captivity and fed weekly delta smelt and other seasonally available prey fish. The artificially fed striped bass will be euthanized and stomachs dissected after 1, 2, and 4 hours to simulate the CHTR and holding tank time periods, respectively. Stomach samples will be dissected at the Central Valley Bay-Delta Branch (CVBDB) laboratory following Bowen's methods (1996). A lengthwise incision made to the stomach, and contents identified to nearest taxa.

In addition to the stomach content and individual predator information described above, the following variables will be recorded for each run of the CHTR process from which predators are sampled and analyzed for their effects on predation-related losses: season, diel period, predator fish size and species composition, predator species, prey fish species abundance and composition, and percent composition of prey fish by wet weight. These data will be used collectively to determine predator selectivity indices, diet overlap indices, and hybrid numerical-volumetric diet indices. Water quality parameters including temperature, dissolved oxygen, conductivity, and transparency will also be analyzed for effect on predation.

DIAGNOSTIC INDICATORS

This biological indicator approach involves measurement of a suite of selected stress responses at several levels of biological organization to assess sub-lethal stress effects on fish, to give early warning of stress, and to obtain insights into causal relationships between stressors and effects manifested at higher levels of biological organization (Adams 1990). Therefore, this program element will attempt to select and test, using efficacy and feasibility as selection criteria, an applicable suite of indicators that is integrative and practical for tests on delta smelt at the fish protective facilities.

This program element will begin by using primary biological indicators of fish stress at the physiological level (e.g. elevated levels of plasma cortisol, blood glucose and lactate) of organization, but also attempt to use latent or secondary effects as stress indicators. Since this work is proposed as a set of pilot experiments to test the efficacy of the stress test methodology, research into alternative stress impact methodologies will be concurrent with the preliminary field and laboratory CHTR stress assessment work, allowing for the incorporation of more effective tests as the study progresses.

As a latent or secondary indicator of stress, we are proposing to observe the swimming performance and biochemical response of fish already exposed to CHTR by exposing them to a secondary stress, a swim challenge. We propose an additional methodology to observe latent effects of CHTR through reproductive indices, since environmental stressors may cause reproductive impairment, which can lead to the gradual reduction or elimination of fish populations (Donaldson 1990). We plan to submit separate sub proposals to describe the specific methods and justifications for the swimming performance and reproductive effect tests later this year for technical review. The use of complex indicators such as reproduction will require technical review of the proposed protocols and extending the study period beyond the 4-year period initially proposed for the CHTR program.

Initially, this element will focus on adult delta smelt. Repeated trials will be conducted where cultured smelt are released into the holding tanks at the beginning of the CHTR phase of salvage, then run through the entire process to the point of a simulated release into a pool. Appropriate controls will be conducted by carefully transferring smelt from the aquaculture facility directly to the fish collection pool. For physiological observations, four fish will be sampled per time period for blood at resting, 0, 0.5, 2, 24 and 48 hours post experiment for a total of 24 fish sampled per experiment. Blood samples from two of the four fish sampled for each time period will be pooled and analyzed for glucose and lactate; blood plasma from the other two fish will be pooled and analyzed for the presence of plasma cortisol (this method adapted from Young et al. 2001). Fish held for 48 hours or more may be examined post experiment to ascertain acute effects. Swimming performance tests will provide indications of the latent effects of CHTR on juvenile and adult smelt.

The implementation of these later proposal phases may be affected by a number of potential reasons. First, time line for completion may extend beyond the time when decisions will be made regarding the design or efficacy of new screening facilities. Second, the cost of the proposed studies may exceed available funding. Lately, information gathered on sub lethal effects may not prove to be useful in fish facility decision making as information on acute lethal effects.

Alternative Facilities and Operations

The description of this study element and its implementation is being addressed in separate and tiered series of study proposals authored by DWR's Roger Churchwell. In general, element objectives will be met in two phases covering a 3-year period. The first phase of research, Phase A, is intended to identify alternative CHTR facilities and operations that have significant potential to improve delta smelt survival. Phase A activities will include literature reviews on existing and new CHTR technologies, gathering and reviewing unpublished design and performance information on selected existing facilities, and delta smelt and site-specific performance criteria to objectively evaluate alternative facilities and operations. The purpose of Phase B is to pilot test promising alternative CHTR facilities and methods identified in Phase A using study designs also to be developed in this phase.

Information gathered during Phase A will consist of data from the Skinner Fish Facility, the TFCF, other fish facilities, and new data from the other CHTR Program elements. Phase A is mainly descriptive and exploratory and will focus on alternative fish collection options for fish holding tanks and fish transfer buckets, transport methods, and alternative transport and release technologies and operations. Element investigators will collaborate with local and out-of-area experts to obtain information on new concepts used in facilities in and outside of California. The engineering, biological, and economic performance criteria developed in Phase A will be used to make a reconnaissance-level screening regarding the feasibility of identified alternative facilities and operations.

Phase B of this element will begin after the one year duration of Phase A. Phase B will consist primarily of pilot testing promising new concepts (and associated operations) identified in Phase A. Phase B work will include field evaluation of new fish handling prototypes and operations such as holding tanks, dewatering, debris management, and fish transport and fish release technologies. Phase B will only occur if 1) delta smelt demonstrate significant potential for CHTR survival in the Acute Mortality & Injury element, and 2) promising alternative facility and operations alternatives are identified in Phase A of this element.

COORDINATION & OVERSIGHT

The Delta Smelt CHTR Evaluation Program will be a cooperative effort between USBR, DWR, California Department of Fish and Game (DFG), and U.C. Davis (UCD) biologists and engineers. The program will be conducted under the auspices of the IEP, specifically within the purview of the IEP's Central Valley Fish Facility Review Team (CVFFRT). The CVFFRT, along with the IEP Management Team and Coordinators, will track program progress, provide program support, and ensure timely completion of products. The program will be implemented in close coordination with the study activities of the Tracy Fish Facility Improvement Program (TFFIP) and TFTF researchers through direct participation in the proposed CHTR Program Technical Advisory Committee (TAC) or Project Work Team (PWT) sharing resources and products and attending joint project meetings. Several workshops and CHTR-focused meetings have already been conducted.

With assistance from the IEP Management Team, CVFFRT, and CBDA Science Program, we hope to form a CHTR Program TAC or PWT that contains local and out-of-area delta smelt and fish facility experts not directly involved in program implementation. The TAC will be formed during the first 3 months of program implementation and will be employed throughout the program duration to review program products, assess the quality of program data, and recommend program modifications.

The leader for the overall program is Robert Fujimura (DFG), and DFG will directly manage implementation of three program elements, acute mortality and injury, stress indicators, and fish predation. Jerry Morinaka, Virginia Afentoulis, and Geir Aasen, respectively, will lead these projects. Roger Churchwell (DWR) will lead both phases of the remaining element, which will identify and examine the feasibility and efficacy of alternative CHTR methodologies or new technologies.

DFG and DWR personnel will focus on developing the specific testing protocols, construction and operation of the experimental testing facilities, and conducting the experimental trials for study elements based at the Skinner Fish Facility. USBR Denver and Tracy personnel under the leadership of Dr. Charles Liston, Brent Bridges, Dr. Johnson Wang, and Mark Bowen will provide technical support for proposed work at the USBR TFCF and technical advice on testing and operational procedures.

USBR Denver and Tracy staff will provide training for DFG, DWR, and cooperating UCD staff on general test methodology consistent with methods currently in use by USBR investigators at the TFCF. DFG personnel (Fish Facilities Research and Operations Monitoring Unit, Stockton) are currently gaining experience through cooperative participation in current USBR TFCF studies. Project element lead persons are collaborating with USBR research counterparts such as Mark Bowen and Cathy Karp. Initial training objectives will include test fish rearing and handling, fish injection and marking techniques, test fish recovery methods, and health/injury assessment protocols. USBR Tracy and the Delta Mendota Water Authority personnel will provide logistical support such as access to TFCF fish salvage equipment and test fish rearing/holding facilities for pilot testing at this location.

DWR Delta Field Division staff (Jerry Raasch and Jim Odom) will collaborate on the site planning and development for the expansion of the UCD Delta Smelt Aquaculture Program facility and the construction and installation of testing facilities for CHTR studies at the DWR Skinner Fish Facility. Similarly, the Delta Field Division will be providing access, logistical, technical, and some personnel support to conduct tests at the Skinner Fish Facility. DWR Ecological Services Office staff members (Roger Churchwell and Roger Padilla) are leading on-site planning for expansion of the UCD Aquaculture Facility and writing a new contract to fund this expansion effort. DWR Department of Engineering (DOE) staff (Don Kurosaka) is in charge of the budget support the CHTR Program. T.C. Liu and Tim Talbert (DOE) have worked on the design and construction of on-site holding/testing facilities at the Skinner Fish Facility. DWR is currently construction testing facilities for these studies.

UCD Delta Smelt Aquaculture Program staff (primarily, Dr. Bradd Baskerville-Bridges) will provide the test fish, additional training on fish handling and rearing techniques, and assist in the design of test holding facilities at the Skinner Fish Facility. USBR and DFG will assist the field collection of brood stock delta smelt necessary for the production of cultured delta smelt. Since the various elements of the CHTR Program will use the same facility equipment (fish facility holding tank, fish tanker truck) and experimental facilities (test fish recovery tank, post experiment holding tanks) to conduct related CHTR experiments, CHTR investigators will closely coordinate, and in some cases, integrate their activities.

ENDANGERED SPECIES TAKE

This study element will take fish species of special concern, but current CVP/SWP and/or IEP take authorizations may already cover the take of federally listed species by this program. The 2004 IEP take allocation should cover the take of listed species beyond the take associated with routine salvage operations which would be normally covered by the current CVP/SWP BO (Chuck Armor, personal communication, 2002); however, IEP Management will consult the regulatory agencies. The Diagnostic Indicator element will require field collection of wild adult delta smelt.

Based on mean monthly salvage estimates, rough annual estimates of the number per listed species or race likely to be taken by this program are provided detail in the individual *element work plans. More precise estimates can be obtained after 1) mining past fish salvage data, 2) developing a tentative test schedule, 3) developing work plans for the Alternative Facilities and Operations Phase B and 4) verifying with the regulatory agencies on the exact method of calculating the incidental take for this study. Not included in these estimates are cultured delta smelt obtained solely for use in these experiments. Take information will be submitted to the DFG Salvage Monitoring Program, IEP incidental take reporting database, and to the appropriate regulatory agencies.*

RESOURCES AND CAPABILITIES

As mentioned previously, these elements will be conducted primarily at the state and federal fish facilities with special attention at the Skinner Fish Facility. The two facilities are the only existing fish salvage facilities in the Delta with a known history of entraining delta smelt. They are located at the site of proposed new fish salvage facilities and are the current staging areas for prototype technologies for inclusion in the proposed fish facilities. Studies that require post-experiment fish holding and office facilities at the Skinner Fish Facility will be accommodated by the construction of a 60 x 40 foot fish rearing building which will contain 28 circular fish tanks supplied with filtered, UV-treated, and cooled CCF water. Studies requiring on-site facilities at the TFCF will use the USBR Tracy Aquaculture Facility and other support facilities at this location. This study has access to and use of the both DWR and USBR facilities, facility personnel, and equipment. Additional laboratory facilities will be provided at the DFG CVBDB Stockton office or through the UC Davis campus. DWR projects will obtain additional biological and engineering expertise through a contracted consultant firm. Field collection support (e.g., boats and operators) will be provided through the CVBDB or Tracy USBR staff. Any equipment needed for these studies, not already in possession of the DFG Fish Facilities Research and Operations Monitoring Unit, DWR DES Fish Facility Unit, USBR Denver/Tracy Research teams, and other program collaborators, will be purchased prior to study implementation.

PRINCIPAL INVESTIGATOR/COLLABORATOR QUALIFICATIONS

ROBERT W. FUJIMURA
California Department of Fish and Game
4001 N. Wilson Way
Stockton, CA 95205
(209) 948-7097 bfujimur@delta.dfg.ca.gov

EDUCATION

1977	BS and BA	Fisheries and Biology	Humboldt State University
1980		Limnology Program	Uppsala University, Sweden
1986	MS	Fisheries	Humboldt State University

PROFESSIONAL EXPERIENCE

Robert Fujimura is the Project Leader of the Fish Facilities Research and Operations Monitoring Units with the California Department of Fish and Game with 15 years of experience investigating fish management and water quality problems associated with the San Joaquin-Sacramento Estuary and its river basin.

1987-1983:	*Water Quality Chemist*, Coachella Valley Water District, Coachella
1989-1987:	*Fishery Biologist*, CDFG, Stockton
1996-1989:	*Environmental Specialist III*, CDFG, Elk Grove
1999-1996:	*Associate Fishery Biologist*, CDFG, Stockton
1999-Present:	*Senior Biologist Supervisor*, CDFG, Stockton

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CHARLES R. LISTON, Ph.D.
US Bureau of Reclamation
MP-400, Resources Management Division
168 Ralston Road, Bedford, KY 40006
502/255-9168 Crlist@aol.com

EDUCATION

1965BS Degree Composite Natural Sciences, College of the Ozarks, Clarksville, Arkansas
1967 MS Degree Zoology, University of Arkansas, Fayetteville, Arkansas
1972 Ph.D. Degree Biology/Aquatic Sciences, University of Louisville, Louisville, Kentucky

PROFESSIONAL EXPERIENCE

1965-1971 *Graduate Student Assistant* (Univ. Arkansas.), *National Science Foundation Trainee* (Univ. Louisville), *Summer NSF Instructor* (Univ. Louisville); research on tailwaters below large dams and stream ecology, teaching in NSF “Science of Inland Waters” summer institutes (4 summers)

1971-1989 *Research Associate, Assistant Professor, Tenured Associate Professor,* Department of Fisheries and Wildlife, Michigan State University; directed fisheries and limnological research on hydropower effects on Lake Michigan, limnology and fisheries of the St. Marys River between Lakes Superior and Huron, and Great Lakes coastal wetlands; major professor to 25 graduate students; taught upper level courses in “ichthyology”, “fish and wildlife of North America”, and seminars in ichthyology and limnology

1989-Present *Research Aquatic Scientist, GS-14*, US Bureau of Reclamation; direct and coordinate applied fisheries research and technology development for numerous water projects throughout the Western US; most recently, focused on the Central Valley in California (Mid-Pacific Region) with emphasis on Red Bluff Research pumping Plant (Sacramento River) and the Tracy Fish Salvage Facilities (south Delta)

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JOSEPH J. CECH, JR.
Department of Wildlife, Fish, and Conservation Biology
University of California, 1 Shields Ave., Davis, CA 95616
(530) 752-3103 jjcech@ucdavis.edu

EDUCATION

1966 Bachelor of Science, Zoology, University of Wisconsin, Madison
1970 Master of Arts, Zoology, University of Texas, Austin
1973 Doctor of Philosophy, Zoology, University of Texas, Austin

PROFESSIONAL EXPERIENCE

1965-1966 *Resident Zoologist;* Sea Search I, assisted in investigations of shallow reef ecology aboard the R/V Dante Deo, Caribbean Sea and S. Pacific Ocean.

1965-1973 *Research Assistant, Teaching Assistant, and Research Associate;* Univ. Texas Marine Science Institute, assisted with research and teaching concerning estuarine fishes.

1973-1975 *Research Associate*, The Research Institute of the Gulf of Maine, (and *Lecturer*, University of Maine at Portland-Gorham); conducted research/instruction on marine fishes.

1975-Present

Assistant, Associate, and Full Professor of Fisheries Biology; University of California, Davis, conduct research/instruction/outreach service concerning fishes.

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ROGER CHURCHWELL, P.E.
Section Chief, Fish Facilities
Department of Water Resources
Division of Environmental Services
3251 S Street
Sacramento, CA 95816-7017
(916) 227-7546 rchurchw@water.ca.gov

EDUCATION

1988 BS Degree Civil Engineering, University of Arizona, Tucson Arizona

PROFESSIONAL EXPERIENCE

1988-2001 California Department of Transportation

District Hydraulics Engineer (Stockton CA), Responsible for a nine county area. Hydraulic and hydrology analysis supported with numerical modeling. Design of hydraulic structures. Supported Caltrans Legal as expert witness and provided court testimony in the area of hydraulics and hydrology.

Senior Transportation Engineer (Sacramento CA), directed and coordinated the research and development of storm water treatment devices for Caltrans Storm Water Program. Worked in collaboration with University of California Los Angeles (UCLA) and tested technologies in the flume at UCLA.

2001-Present Department of Water Resources

Senior Engineer, Section Chief, Fish Facilities (Sacramento CA), direct and coordinate research and development of fish facilities with a staff of 2 engineers and 3 biologists. Majority of projects are in the Sacramento-San Joaquin Delta. In addition, working in collaboration with University of California at Davis (UCD), researching fish behavior and flows (UCD hydraulics lab) related to fish facilities. Directing 2 field research studies evaluating flows and fish behavior. Chairing the Clifton Court Technical Advisor Team and co-chair of the Central Valley Fish Facilities Review Team.

DATA ANALYSIS & INTERPRETATION

The data analyses and interpretation procedures are described in detailed in the individual study element proposal. The individual work plans and detailed test protocols will be reviewed by the appropriate technical review teams prior to implementation. The principal investigators will consult with local experts and statisticians on the statistical methods used to interpret the study results. Special effort will be made to consult a DFG statistician on regular basis and seek other qualified statisticians if funding is available. We also intend to include in the TAC or PWT one or more individuals with proven expertise in statistics and data analysis.

DISSEMINATION OF RESULTS

The results of the proposed investigation are intended to facilitate urgent decision making about the efficacy and design of new fish screening facilities at the CVP and SWP intakes. Consequently, we expect great interest in the preliminary results of the investigation. Preliminary results will be disseminated through written and verbal quarterly reports to the TAC, IEP oversight groups, and the CALFED Management Team. In addition, we proposed to disseminate results through:

- An IEP Technical Report or other technical publication submitted at the end of the study; December 31, 2006.
- Regular oral presentations of results at venues such as the IEP Asilomar conference, CALFED workshops and science conference, and AFS regional meetings.
- Highlights or annual summaries in the IEP Newsletter and oral presentations to CALFED and IEP management and technical teams.
- One or more peer reviewed publications will be submitted, probably to regional journals such as the California Department of Fish and Game quarterly or the CALFED on-line journal.

PROGRAM ADAPTIVE MANAGEMENT

Assuming IEP project approval in early February 2004, we propose to report preliminary results for the first season of juvenile delta smelt investigations in June (Stress Indicators) and August (Acute Mortality and Predation) 2004 to the CVFFRT and the IEP Management teams. Since we anticipate that the winter of 2005 will provide be our first full season of adult smelt investigations, we will provide a reporting of preliminary results for this life stage during the period of June - August 2005. The preliminary reporting of results will provide the Project Investigators, the two IEP teams, and others the opportunity to evaluate the program and make recommendations for modifying or terminating specific program components. Similarly tiered annual reports will be provided for program evaluation of any program elements continuing after 2005 (if approved).

BUDGET

Current rough estimate of program cost is *$4,980,000* for a 3.5 year program. This estimate includes approximately $3,100,000 for planned biological and engineering evaluations, $1,410,000 for test fish from the UCD Delta Smelt Aquaculture Program, and $462,000 for a fish holding/testing facility at the Skinner Fish Facility. Not included are costs for 1) USBR support for UCD graduate student, Don Portz, 2) Phase B of the Alternative Facility and Operations element, and 3) in-kind services provided by the TFCF or SFF operations staff.

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