State of California
The Resources Agency
Department of Water Resources

SUMMARY OF THE COLLECTION, HANDLING, TRANSPORT, AND RELEASE (CHTR) PROCESS AND DATA AVAILABLE ON STATE WATER PROJECT (SWP) AND CENTRAL VALLEY PROJECT (CVP) FISH SALVAGE

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CHTR TECHNICAL DOCUMENTATION REPORT

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1.0 OVERVIEW

1.1 Background

The State Water Project (SWP) John E. Skinner Fish Protection Facility and the Central Valley Project (CVP) Tracy Fish Collection Facility were designed to protect fish from entrainment in the water diverted at these projects. The Skinner facility is designed to screen a maximum of 10,300 cfs, and to bypass fish to holding tanks from which they are 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 that is drawn from the Clifton Court first travels by channel to a floating trash boom, which is designed to intercept floating debris and guide it to a trash conveyor on shore. Water and fish then flow through a trashrack, equipped with a trash rake, to a series of louvers arranged in a vee pattern. Fish are guided down the vees to bypass pipes. The fish then travel down one of two secondary channels equipped with either louvers or perforated plate screens. The bypassed fish and flow is then directed to holding tank facilities. Figure 2-1 shows the location of the facility, and Figure 2-2 shows a schematic of the facility.

Operation of these facilities involves the collection, handling, transport, and release of a diverse assemblage of fish species including delta smelt, Chinook salmon, steelhead, and other resident and migratory species. Delta smelt, and 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 be lawfully taken during routine operations of the water diversion facilities.

Currently, salvage monitoring and the calculation of incidental take of delta smelt assumes 100% mortality for smelt counted in the facilities' collection tanks. This is 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 collection, handling, transport, and release 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 could reduce stress and improve survival of delta smelt and other fish species.

Problems surrounding the salvage process are complicated and interrelated. Many groups are involved in studying them. In order to divide the work among the various constituencies the salvage process has been compartmentalized. For the purposes of this report the collection, handling, transport, release (CHTR) process begins when fish are collected from the concrete collection tanks and ends at their release back in the delta waters. Between those points, the fish are handled for counting and for transport to the release sites.

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). 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 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 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 the Tracy Fish Collection Facility by USBR and collaborating with the ongoing CHTR studies being conducted by CDFG and UCD.

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.

1.2 Scope

The scope and purpose of this report is to provide a scientific foundation for further investigations that will be conducted as part of this project. Section 1 of this report presents the background issues surrounding the fish salvage operations at the SWP and the CVP facilities. Section 2 provides an overall description of the fish protection facilities at the SWP and the CVP. It then describes in detail the capture, handling, transport, and release (CHTR) process at both facilities. These descriptions are based on site visits and interviews with SWP and CVP personnel. Additionally, SWP standard operating procedures, operations manuals, and project drawings were used as sources of information relied on to form a basis for understanding the salvage process. Section 3 describes the results of a literature search undertaken to assemble a reference library of reports regarding various aspects of the CHTR process. A searchable database is described. Summaries of key biological and water quality data are presented.

2.0 FISH PROTECTION FACILITIES

2.1 SWP

2.1.1 Salvage Facility Overview

The SWP facility was designed for a flow of up to 10,300 cfs plus a tidal flow of 700 cfs. Figure 2-1 shows the location of the facility, and Figure 2-2 shows a schematic of the facility.

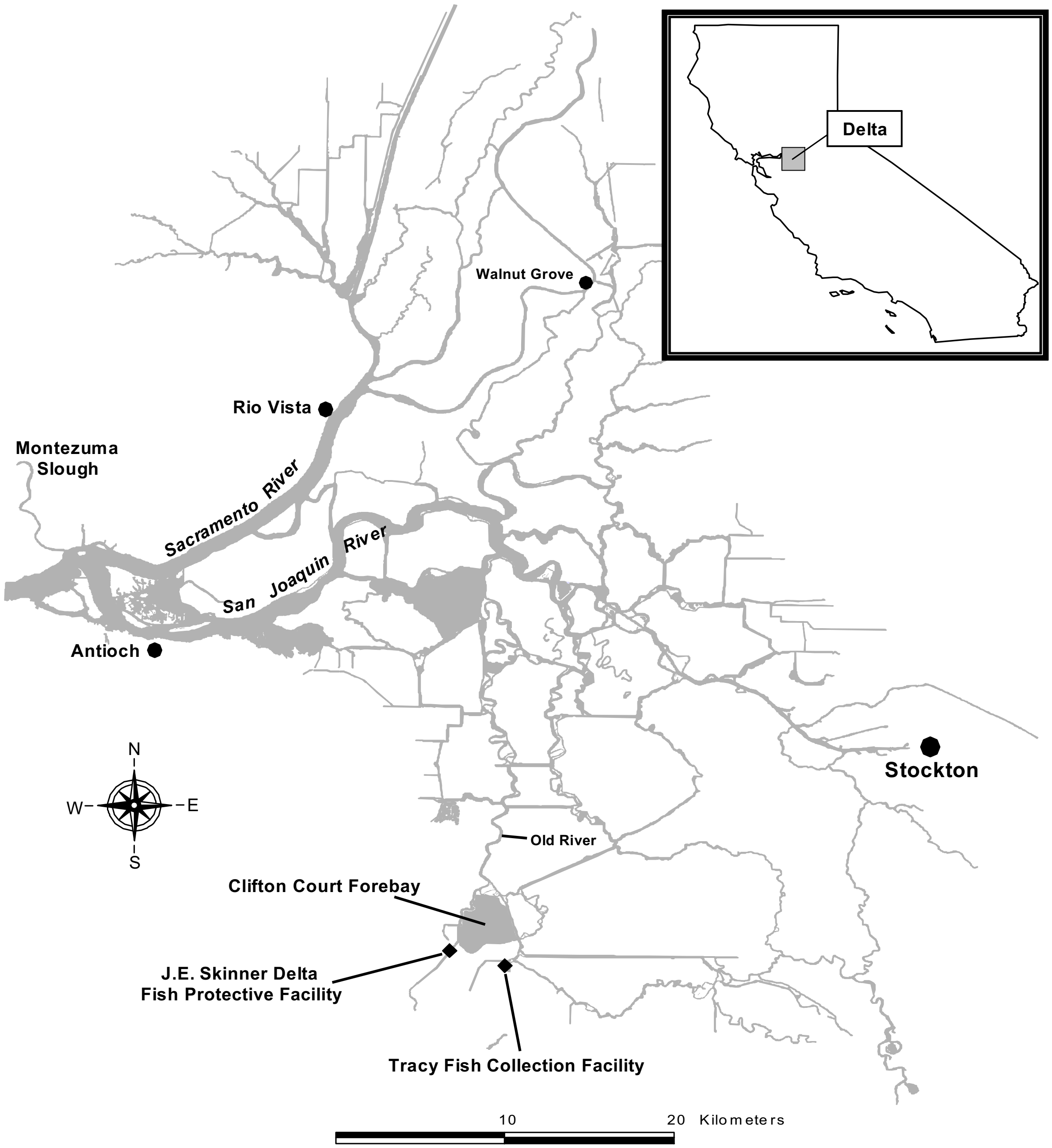


Figure 1. Map of the Delta showing the location of the John E. Skinner Delta Fish Protective Facility.

Figure 2-1 Project Location

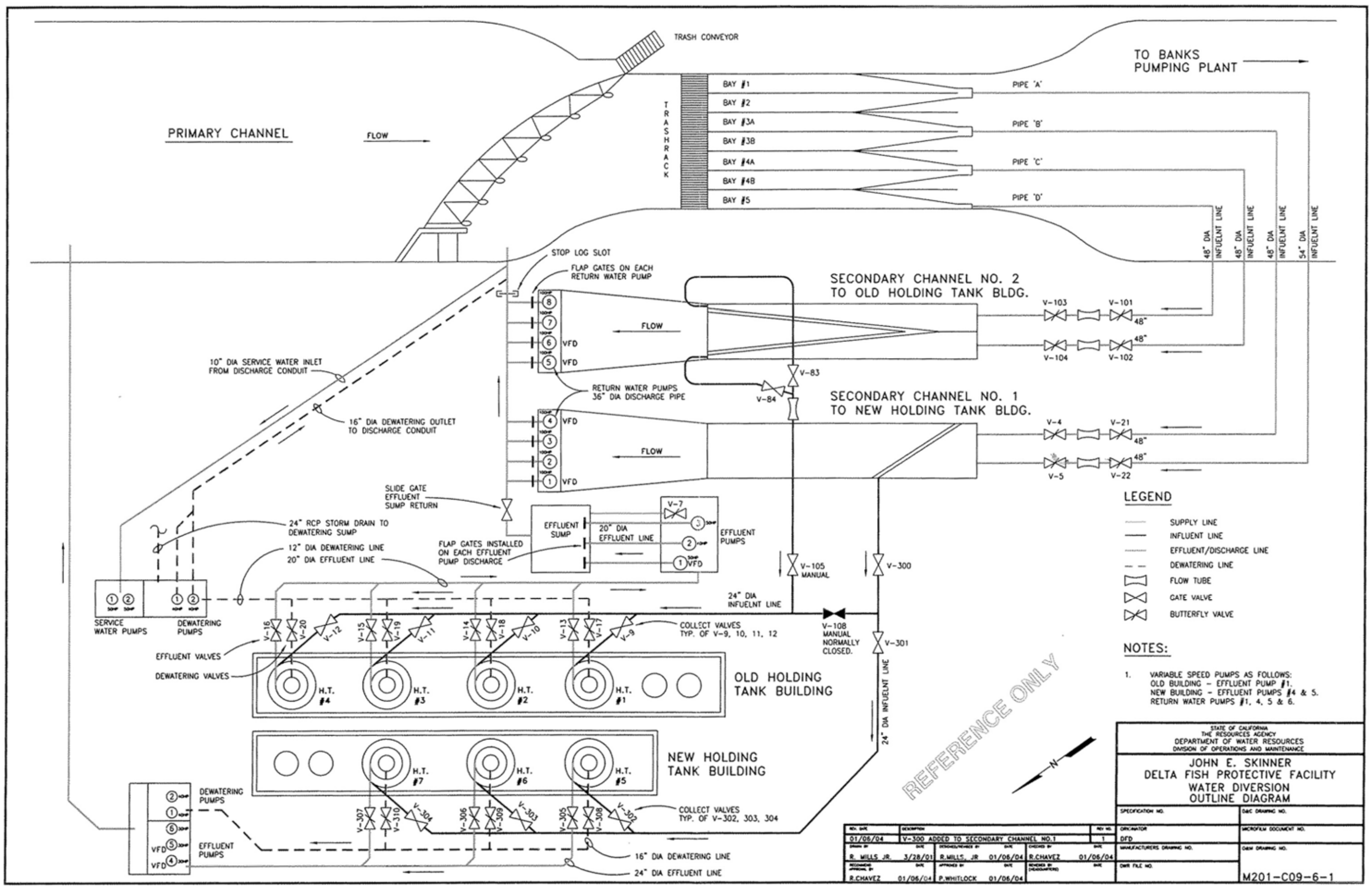


Figure 2-2 Skinner Fish Protection Facility Layout

The main features of the fish salvage facilities include:

Clifton Court Forebay – Flow from the Delta flows through gates into the Clifton Court Forebay. It is operated to minimize water level fluctuations at the intake by opening the gates at high tide and closing them at low tide.

Floating Trash Boom – A floating trash boom is set at a 37-degree angle to flow across the California Aqueduct Channel. The boom is a 390-foot long floating steel truss. The floating boom is designed to deflect trash for an 11-foot range of forebay elevations. The trash and debris is deflected to a trash conveyor located on the left bank at the downstream end of the boom. The trash boom is constructed of 9 pontoons connected to form the structure. The pontoon assemblies are covered by steel access walkways. See Figure 2-3.

1	Floating Debris Barrier
2	Trash Conveyor

Figure 2-3 SWP Trash Boom and Conveyor

Trash Conveyor - A trash conveyor lifts debris that has been funneled down the channel along the trash boom face. The conveyor lifts the debris and drops it into a dump truck for transport to disposal. The trash conveyor is approximately 75 feet long by 10.5 feet wide. It is inclined at an angle of approximately 20 degrees. See Figure 2-3

Inlet Bays – Downstream of the floating trash boom the inlet channel is divided into 7 bays. The bays are designed to allow for flow control needed to optimize the hydraulic conditions for fish encountering the louvers further downstream. Each bay is equipped with a trash rack and two control gates. See Figure 2-4.

1	Inlet Bays
2	Floating Trashrack

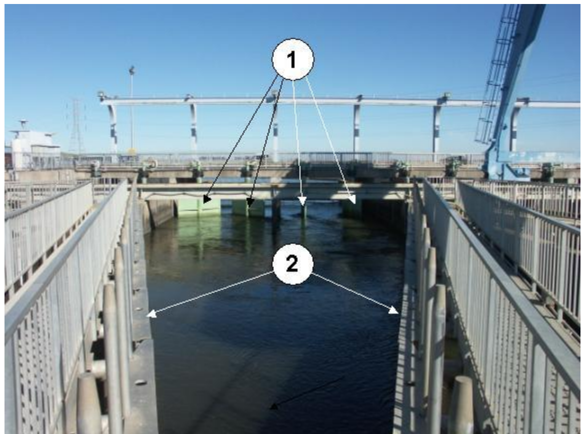
Figure 2-4 Inlet Bays

Trashracks – The trashracks are constructed with 2-inch wide vertical openings on the upstream side of each bay. The trashrack bars are 35 feet in length and inclined on a 1:2 slope. Debris that has passed under the floating trash boom is collected on the trashracks. The racks exclude fish wider than 2 inches. Smaller fish have been found to take up residence behind the screens and grow too large to pass back through the bars. The trashracks are cleaned by two mechanical rakes designed for a maximum load of 1 ton. The 8-foot wide rake rides along a monorail hoist to clean all the racks the width of the channel. See Figure 2-5.

1	Trashrack upstream of screen bays.

Figure 2-5 Trashrack

Flow Control Gates – There are 14 flow control gates, 2 gates for each 20-foot wide bay. Each rectangular gate has a wing-type configuration. The gates are approximately 25.75 feet tall and 10 feet wide and pivot on a vertical axis. The gates are designed to operate against a normal differential head of 0.5 feet and maximum differential head of 1.5 feet. See Figure 2-6.



1	Flow Control Gates (looking upstream)
2	Louver Panels

Figure 2-6 Flow Control Gates

<u>Louvers</u> – The louvers are designed to divert fish into the bypass system while passing flow to the pump station. The channel downstream of the flow control gates is divided into 5 bays containing the louvers. The louver assemblies are comprised of two panels, stacked and bolted together. Each panel is approximately 13.75 feet high. The louvers are arranged in a "Vee" shape and are composed of one-inch-clear vertical slots oriented perpendicular to the direction of flow. The louvers turn the water 90-degrees to flow between the slots. This creates turbulence along the face of the louvers. Theoretically, the fish seek to avoid the turbulence and are thus guided to the bypass at the apex of the "Vee". The louvers are seated on vertical pipe guides. Cleaning is accomplished by lifting a louver panel with the gantry crane and washing it with high-pressure washer hoses mounted to the gantry crane structure. See Figure 2-7.

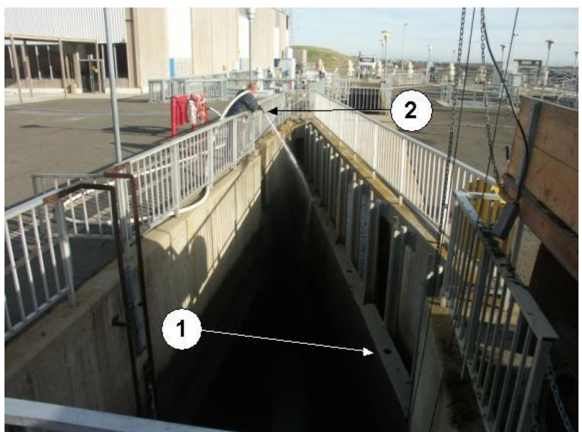
1	Fish Bypass Entrance
2	Louvers (looking downstream)
3	Flow Control Vane Actuators
4	High-pressure nozzle for louver cleaning.
5	Louver is in raised position for cleaning.

Figure 2-7 Louvers

Bypass – Four bypass pipes lead from the louver "Vee" apexes (one 54-inch diameter and three 48-inch diameter) direct the flow to the secondary screening system. The bypass pipes lead to two valve chambers. The chambers contain a butterfly shutoff valve, a velocity meter, and a butterfly regulating valve for each bypass pipe. From there the water flows through a transition structure before encountering one of the secondary screening systems.

The effectiveness of the bypass depends on maintaining the ratio between the main channel flow velocity and the bypass channel flow velocity, between 1.2 and 1.6. This prevents fish from fighting entrainment to the bypass system.

Secondary Screen System – There are two open flow channels. The older (No.1) is similar to the primary screening system; it is comprised of a row of louvers spanning the channel diagonally. The newer screening system is constructed of perforated plate. At the apex of both screening systems is the influent pipe system leading to the concrete holding tanks. The secondary screens are cleaned by hand. With two secondary screen systems, salvage efforts can be maintained in one while cleaning the other. See Figure 2-8.

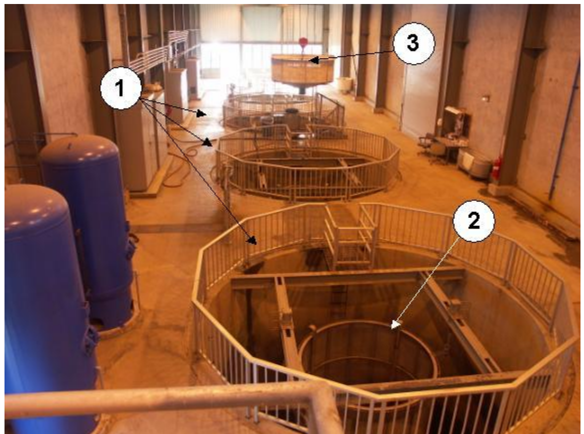


1	Secondary Louver
2	High-pressure hose for

Figure 2-8 Secondary Louvers

Valve Gallery – The valve gallery, located downstream of the secondary screen bays, contains the service water pumps, dewatering pumps, access to the holding tank's piping and valves, the holding tank effluent pumps, the screen water pumps, and the traveling screen slots. The traveling screen is not in operation.

Fish Holding Tanks – There are seven cylindrical concrete holding tanks; four in the old building and three in the new building. One tank in each building is used for the 10 minute counts, (see Section 2.1.2.2 while the others are used to collect fish for transport. The tanks are 20 feet in diameter and 19.5 feet deep. The fish holding tank bottom slopes to the center for drainage. There is a bucket well and a bucket sump in the center of the tank bottom. The bucket well is 7.67 feet in diameter and 4 feet deep and slopes to the center. The bucket sump is 3 feet in diameter and 3 feet deep. A fish collection bucket is placed in the bucket well when the tank is drained and fish are to be collected for removal from the holding tank. A 2-foot diameter influent pipe is located approximately 2 feet off the floor of the fish holding tank. An aeration pipe is located about 10 feet from the tank bottom. The outlet effluent pipe is located in the bucket well wall, while the outlet dewatering pipe is located at the bottom of the bucket sump wall. A cylindrical screen surrounds the bucket well and extends to the top of the collection tank. This screen keeps fish to the outer edge of the holding tank. See Figure 2-9.



1	Three holding tanks.
2	Cylindrical Screen
3	Fish Transfer Bucket

Figure 2-9 Fish Holding Tanks

Effluent Piping System – Fish and water enter the holding tank through the influent pipe. Flow circulates around the holding tank and exits through the effluent pipe located behind the cylindrical screen in the bucket sump wall. The effluent pipes drain to a common effluent sump. The circulation is driven by 3 effluent pumps, which return water to the primary channel.

Dewatering Pipeline System – The dewatering system is independent of the effluent watering system. An individual tank cannot be drained through the effluent water system while the other holding tanks are in service with their influent and effluent pipes open. The dewatering system consists of a 16-inch pipe from each holding tank, manifolded together, leading back to a common wet well where it is pumped to the discharge conduit and back to the primary channel.

Aeration Pipeline System – Aerated water can be delivered to the holding tanks through a 6-inch diameter piping system.

2.1.2 CHTR Facilities

For the purpose of the ongoing investigations of the fish salvage efforts the CHTR process is defined as beginning when the cylindrical screen surrounding the bucket sump is lifted to pass fish from the fish holding tank into the fish transport bucket. Handling occurs when the fish transport bucket is lifted and moved to the transport truck, and the fish are released into the fish transport truck tank. Handling also occurs when a counting bucket is used to move the fish to counting station for enumeration, measurement, species identification, tag search, or other research efforts. Transport occurs when the hatches on the fish transport trucks are closed and the fish are delivered to the release site. The release begins when the knife gate attached to the outlet of the fish transport truck is opened, allowing fish to exit the fish transport truck holding tank and enter the release pipe leading to the receiving water body.

2.1.2.1 Collection

Collection of the fish from the holding tank is accomplished in the following manner:

1. Shut off influent (collect pipe)
2. Shut off effluent pipe (fill pipe) (Holding tanks have a common effluent pipe wet well. An individual holding tank cannot be drained through the effluent water system while other holding tanks have their influent and effluent pipes open.)
3. Open 16-in drain pipe.
4. Water drains through circular screen to the level of the 10.5-inch tall dead panel in the bottom of the circular screen.
5. Water drains from the sump on the downstream side of the circular screen.
6. At this stage the sump can be backwatered to cushion the fish's plunge into the bucket. It is backwatered by opening the effluent pipe (fill pipe).
7. Lower the sample bucket or the transfer bucket into the sump.
8. Lift screen (approx 6 inches)
9. Fish drain into sample bucket or transfer bucket.
10. Fish and debris stranded on the tank floor are flushed into the sample hopper or transfer bucket by opening the influent pipe, which creates a swirl of water and washes the stranded fish from the bottom of the tank. A high-pressure hose is used to move stragglers.
11. Lift the bucket with the hoist and trolley and move it to the counting station or the transport truck.

Potential problems observed include:

1. Ladders and pipes extend into the flow lines in the holding tanks. These catch debris and could have an impact on fish.
2. At times the debris concentration dictates the schedule for fish transport.
3. The tanks act as debris concentrators.
4. Fish are stranded on the bottom of the tank after the circular screen is lifted.
5. If the sump is backfilled before the bucket is lowered into position, the fish are cushioned in their fall into the bucket. However, any drainage out of the bucket occurs through a narrow band of screen along the top of the bucket. Fish could be impinged on the screen by the force of the draining water.

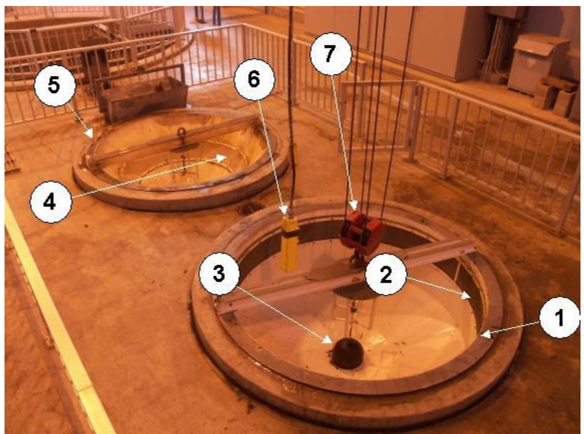
2.1.2.2 Handling

Operators are required to count and classify the fish entering the facility every 2 hours (or after a change in the export flow). The sample time varies from 10 minutes to 1 minute depending on the quantity of fish arriving in the holding tanks. These counts are used to estimate the total fish collected in the other holding tanks in order to determine when the fish should be transported. The count is also used to quantify the endangered species take.

Fish Transfer Buckets – There are two types of fish transfer buckets. One is used to load fish from the holding tanks to the fish transport truck tanks. The other is used to load fish from the holding tanks to the counting station.

The bucket used to load fish to the truck has a capacity of approximately 500 gallons. It is approximately 4 feet tall and 8 feet across. The bucket has a conical shape with lever operated 12-inch ball valve seated in an 8-inch outlet pipe at the bottom of the bucket.

The bucket used to load fish to the counting station is similar in design to the other bucket but has a capacity of approximately 50 gallons. See Figure 2-10.



1	Transport Truck Transfer Bucket (in storage)
2	Overflow screen section
3	Ball Valve on Bucket
4	Overflow screen section
5	Sample Transfer Bucket
6	Pendant Controller for
7	Lifting Block for Hoist

Figure 2-10 Fish Transfer Buckets

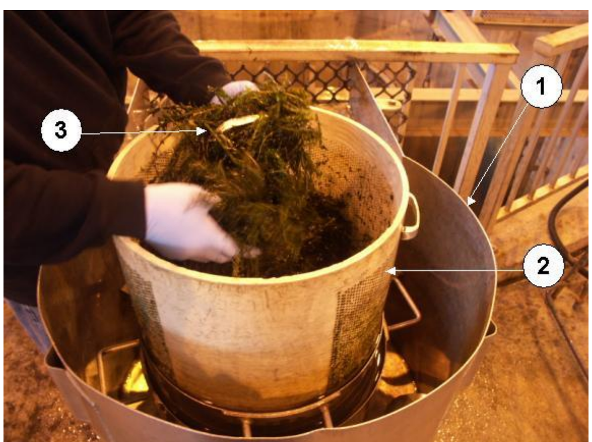
Fish Transfer to Counting Station - The process of transferring the fish from the holding tanks to the sample station is as follows:

1. Following collection, the sample bucket is lowered onto the tire gasket that sits on a circular screen.
2. The lever is pulled which raises the ball valve and drains the fish into the center of a circular screen.
3. The water passes through the screen and is captured in the outer housing.
4. Water drains from outer housing into the tank.

Fish are hand picked from the screened compartment and processed. The following data are collected and recorded: time of count inflow, total minutes pumping since last count, length of count, holding tank water temperature, species, and size class. The operators can use this information to enter charts based on size and temperature that will indicate the number of fish that can be safely transported. See Figure 2-11 and 2-12.

1	Fish Sampling Transfer Bucket
2	Overflow Screen
3	Rubber tire gasket at counting station.
4	Debris and fish are flushed with a hose.
5	Operator lifts ball valve to empty sample bucket
6	Screened water outfall into the adjacent holding tank.

Figure 2-11 Fish Sample Counts



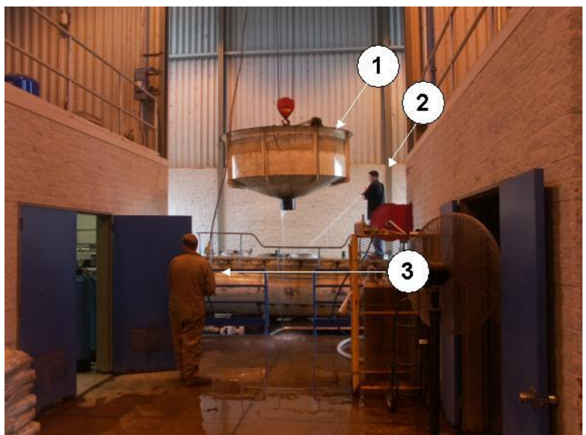
1	Counting station outer bucket.
2	Counting station screen.
3	Fish recovered from debris.

Figure 2-12 Fish Count Station

Fish Transfer to Fish Transport Truck Tank:

The process of transferring the fish from the holding tanks to the fish transport truck tank is as follows:

1. Salt is added to the fish transport truck tank.
2. The truck is partially filled with water from a high-pressure hose. See Figure 2-13.
3. Bucket is positioned over the hatch.
4. The lever is pushed, raising the ball that seals the transfer bucket.
5. This provides a clear space of approx 5 inches for fish and debris to pass.
6. If debris is heavy a pitchfork and a high-pressure hose are used to force the debris through the outlet.



1	Transport Truck Transfer
2	Operator fills truck tank.
3	Operator controls bucket with pendant controller.

Figure 2-13 Transport Truck Bucket

1	Fish Sampling Transfer Bucket
2	Transport Truck Hatch
3	Operator steps on lever to open ball valve and pushes debris through the opening to empty bucket.
4	Second operator (behind) sprays debris and fish to empty the bucket.

Figure 2-14 Fish are Transferred to Truck

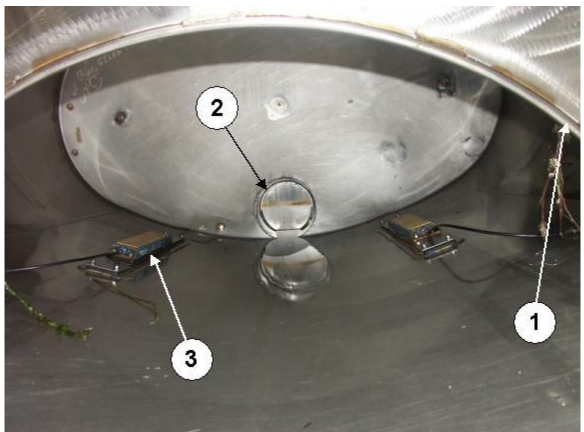
Potential problems observed include:

1. Bolts holding the screen to the bucket were loose and protruded into the flow line.
2. Debris hangs up on the surficial irregularities in the bucket. The debris is washed off with a high-pressure hose. The high pressure could damage fish.
3. The transition from the bucket to the screen was not smooth. Caulk had been placed to fill in gaps. The caulk was failing. This could impact the fish.
4. Density of fish in bucket could raise stress levels through contact or suffocation.
5. It seemed difficult to separate the fish from the debris. Fish could be hiding in the debris that is tossed back into the tank.
6. When using the smaller truck or when the density of fish or debris in the holding tanks is high, the operators used the practice of "double dipping" the transfer bucket. This entails going through the normal procedure of collecting the fish into the buckets from the holding tank as described above. Then, rather then emptying the bucket into the truck, as is the normal procedure, the bucket containing fish and debris is lowered into the next holding tank to collect the fish it holds. That is, the load from the second holding tank is added to the load from the first tank already present in the bucket. The reason this is done is to allow large loads to be transported to the release site in one trip by effectively doubling the concentration of fish and debris in the bucket without doubling the volume of water. This added density of fish and debris may lead to acute loss of DO in water resulting in suffocation. It may also lead to increased stress and injury from acute crowding and contact with debris.
7. When the practice of "double dipping" is used, the bucket is emptied into a totally empty truck. This is done to save space in the truck for the fish laden water. The

lack of water in the truck may add to fish injury through impact with the truck floor and added contact with higher concentrations of debris and fish.

2.1.2.3 Transport

Three trucks are used at the SWP facility. The largest truck is most commonly used for fish transport. This truck has an oval metal tank that is baffled with three communicating compartments. The compartments reduce sloshing in the tanks. Fish are loaded through the middle hatch (2-foot diameter). Oxygen diffuser stones are attached to the bottom of the tank. The oxygen lines are attached with clips to the truck bottom. The outlet for the truck is approximately 9.5 inches in diameter. It is controlled by a hydraulically operated slide gate. The truck capacity is 2,800 gallons. See Figure 2-15.



1	Inerior Baffle
2	Tank Outlet
3	Oxygen Diffuser Stone

Figure 2-15 Typical Transport Truck Interior

The medium sized truck is similar to the truck described above but is smaller. This truck has perforated plate panels running the length of the truck on both sides. The panels cover the oxygen diffusers. The operators do not like this because debris lodges in the perforated plate. The tank capacity is 2,500 gallons.

The small truck has a steel rectangular tank that is covered with an insulating material. There are no baffles in this truck. The truck capacity is 1,200 gallons.

The fish are transported to one of two release sites located approximately 45 minutes from the SWP facilities.

Potential problems observed include:

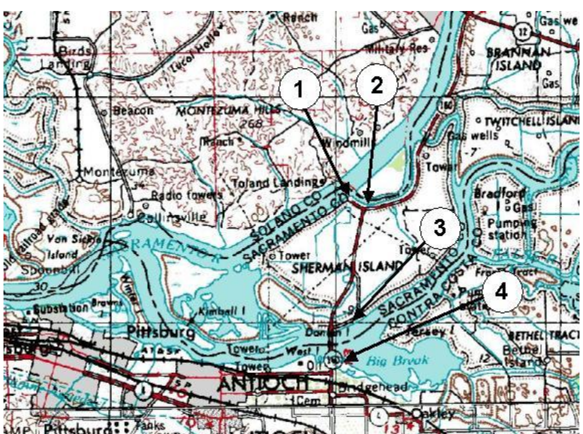
1. Trucks cannot handle the debris load. The exits and baffles clog with the debris.
2. Trucks do not have oxygen or temperature sensors.

3. Interior of tank is not fish friendly. Bolts and clips protrude and could impact the fish.
4. Transition from tank to exit pipe is abrupt. This could damage fish.
5. Tanks lost water in a steady stream on way to release site.
6. Buckets dump fish into the partially filled tank. It is not a water-to-water transfer.
7. In the summer the fish could heat up in the uninsulated tank trucks, especially if caught in a traffic jam.
8. Trucks filled from a high-pressure hose could hold water that is supersaturated with nitrogen gas.
9. Transport process could cause disorientation.
10. Water quality deteriorates with the length of the trip.

2.1.2.4 Release

There are currently four release sites that are used. Two are SWP sites, one is a CVP site, and the final site is shared. See Figure 2-16 for locations of the release sites.

Horseshoe Bend Release Site (SWP) – This site consists of two pipes supported by pilings extending from the bank into a side channel of the Sacramento River. The release pipe is 12 inches in diameter. The other pipe is used as a pump inlet and is 14 inches in diameter. The release pipe extends approximately 170 feet off shore. The outlet is approximately 13 feet deep. There is electricity at the site to run a pump. The pump is used to establish flow in the release pipe in advance of the fish release. The add-in water is delivered through four 2-inch pipes entering the release pipe at angles of approximately 30 degrees. Because of limited space between the road and the riverbank, the fish transport truck parks at a 90-degree angle to the release pipe. The site is enclosed by cyclone fence topped with barbed wire. See Figure 2-17. Both Horseshoe Bend sites are considered remote and dangerous to use at night.



1	Horseshoe Bend, CVP site.
2	Horseshoe Bend, SWP site.
3	SWP Sherman Island release site
4	Shared Antioch Site

Figure 2-16 Release Sites

1	Fish Transport Truck
2	Horseshoe Bend, CVP site release pipe.

Figure 2-17 SWP Horseshoe Bend Release Site

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.

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 rate of 0.5 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 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.

Normal depth in the 14-in diam pipe, at a 20% slope, ranges from approximately 4.5 inches and a velocity of 21 fps at a discharge of 4 cfs to about 1.5 inch and a velocity of 10 fps at 0.5 cfs. See Figure 2-18. 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 spot.

As the water continues down the pipe it approaches the hydraulic jump located at the water surface of the receiving water body within the release pipe. Froude numbers of the jump range around 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.

Figure 2-19 shows a picture of the CVP Horseshoe Bend pipe.

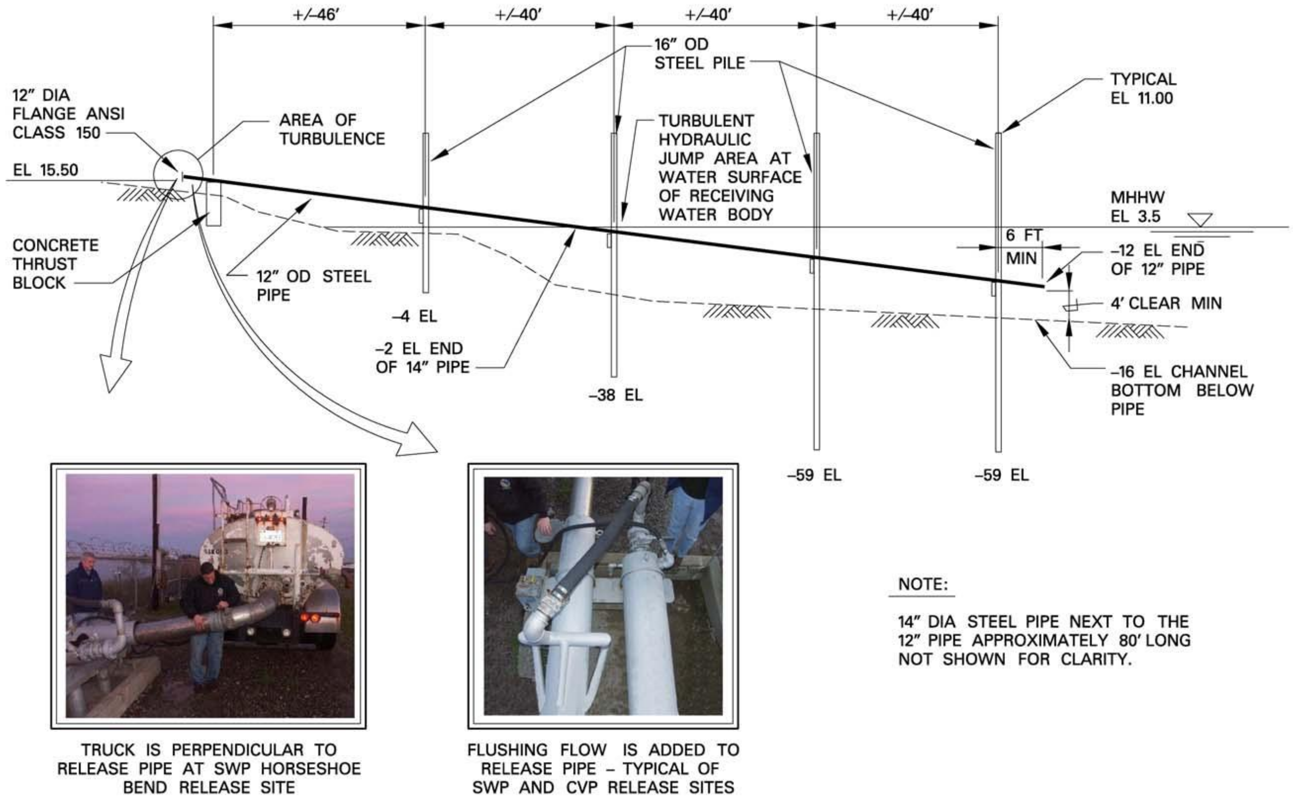


Figure 2-18 Release Site Schematic

1	Fish Transport Truck
2	Addin water pipes
3	Release pipes

Figure 2-19 CVP Horseshoe Bend Release Site

Antioch Bridge Site – The second SWP release site is located on the south bank of the San Joaquin near the Antioch Bridge. This site is shared with the CVP project. It is sited in a park behind a USFWS maintenance facility fenced compound. This site is similar in detail to the Horseshoe Bend site. However, there is adequate space that allows a truck to back up to the release pipe. The elevation difference between the bank and the river water surface is less than at the Horseshoe Bend site. The San Joaquin River is much wider at the Antioch Bridge site than water at the Horseshoe Bend site. Consequently, the release pipe is longer and has a shallower slope. See Figure 2-20.

1	Release Pipe
2	Addin water piping
3	Pump intake pipe.
4	Fish release pipe.
5	Antioch Bridge.

Figure 2-20 Antioch Bridge Release Site

Potential problems observed include:

1. <u>Debris</u> - The presence of debris poses significant operational problems 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 pondweed that is dense enough to walk on can accumulate on the trash boom. Much of the *Egeria* drifts along the trash boom where it encounters a conveyor system that lifts the weed up to a loading facility. A large quantity of the *Egeria* rolls under the trash boom and clogs the trashracks in front of the louver bays.

   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. It is reported that the debris buildup led to the collapse of one of the intake bay's divider walls in the winter of 2003-2004. Apparently half an intake bay became clogged with debris and was closed. Debris then clogged the trashrack in front of the other half. This caused the water level to draw down in the open half, as the pumps continued to draw water into the canal. The differential head on either side of the central wall caused it to collapse. The only exit from the louver bay for the Egeria is into the fish bypass. In the bypass system the *Egeria* encounters the secondary screens or secondary louvers enroute to the holding tanks.

   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 fish release is complicated by the presence of debris. 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 water, and stranding them in the tank.

   Debris is present throughout the year. However, the major amounts of debris occur in the summer time and, especially, during fall when *Egeria* dies and floats free of the bottom. It is then drawn toward the intake at Skinner. The amount of *Egeria* experienced at Tracy is considerably less indicating that most of the *Egeria* at Skinner is from Clifton Court. However, the Tracy intake receives considerably more water hyacinth. See Section 3.3.4 in this report for more on debris at the fish salvage facilities.

2. <u>Method of introducing flushing flow</u> - 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 to the fish in the truck. Additional flow is added to the release pipe downstream of fish transport truck outlet. This water establishes flow about 10 to 15 feet downstream of the truck. The flow enters through four jets at about 45 degrees to the pipe and equally spaced around the pipe.

   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 mps except for American shad. Smaller fish experienced more disorientation but less major injuries than larger fish.

3. Geometry of release pipe connection - A fish transport truck cannot back up to the SWP release site at Horseshoe Bend. 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 could become so superelevated in the bend that it can fall back on itself. The bend could decrease the amount of debris that can exit the tank without introducing flush water into the fish transport truck tank.

4. Characteristics of flow in release pipe – Another possible source of stress, disorientation and mortality in the release process centers on the flow regime in the release pipe. The release pipe extends into the receiving body to a depth of between 12 and 30 feet depending on the site and the tide stage. The truck sits approximately 20 feet above the water surface of the receiving body. The slope of the pipe is approximately 20 percent. Initially, fish experience open channel flow conditions en route from the fish transport truck outlet to the receiving body water surface. Flow in the pipe will probably be supercritical and a hydraulic jump would occur. The jump will most likely occur near the water surface level of the delta. The jump would result in a concentration of turbulence. It is also likely that there could be a concentration of debris in the back roller since not all of the debris will immediately be washed out of the lower end of the pipe. The result of these interactions could be increased disorientation, stress, and mortality.

5. Predation at release pipe exit – Observations of the release pipe outlet using the Dual Frequency Identification Sonar (DIDSON) camera 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 and if predators learn to congregate at the release site when the flushing pump is turned on.

6. 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 (Craft et al 2003, 2002, and 2000) as well as within natural habitats locally (Baracco, 1980) to the release sites. However, water quality monitoring within the transport truck and specifically in the near-field at the release sites would add an important dimension to the understanding of water quality changes throughout the CHTR process.

7. 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 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 Central Valley Project (CVP)

2.2.1 Salvage Facility Overview

The CVP facility was designed for a flow of up to 4,600 cfs. The water does not flow smoothly to the facility; it takes a sharp turn just before entering the conveyance channel. There is no forebay to absorb tidal fluctuations. This introduces operational difficulties to the salvage process. The water surface varies but the pumped flow remains constant. This results in velocity fluctuations. The main features of the fish salvage facility include:

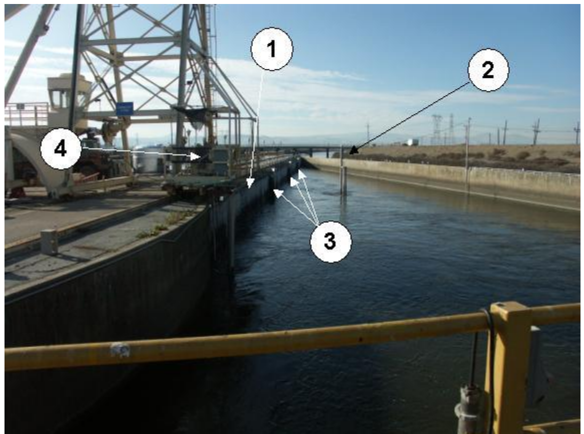
Trashrack – Just before the trashrack, a large articulated rake attached to an articulated boom is positioned at a point that allows it intercept some debris before it impinges on the trashrack. The debris is dragged to a mechanized conveyor for disposal. The rake has a reach of approximately 25 ft. The trashrack is cleaned by a crane-mounted rake that dumps debris into a dump truck. See Figure 2-21.

1	Dump truck for debris removal
2	Trash Rake
3	Trash Rack
4	Trash rake on articulated boom.
5	Trash conveyor ramp.

Figure 2-21 Trashrack

Flow Meter – A meter is installed across the primary channel. Approx 20 % of the time the meter does not work properly because of the presence of bubbles in the water column induced by debris on the trashracks. Additionally, the flow is not evenly distributed across the channel. It is fast at the louvers and slow against the opposite wall. So the averaging calculation used by the meter gives misleading velocity estimates for the channel. This tends to skew the bypass/main channel velocity ratio calculations.

Louvers – The louvers are designed to divert fish into the bypass system. The louvers are arranged in a straight line that is skewed to the flow line at an angle of 15 degrees. The louver arrays are approximately 310 feet long. Four fish bypass entry points are located at equally spaced intervals. The louvers are composed of one-inch clear vertical slots oriented perpendicular to the direction of flow. The louvers turn the water 90 degrees to flow between the slots. This creates turbulence along the face of the louvers. Theoretically, the fish seek to avoid the turbulence and are entrained in the bypass at the fish bypass entry points. The louvers are most effective when the primary channel velocity is between 1.5 fps and 3.5 fps. The bypass is most effective when the flow velocity into the bypass channel is greater than the velocity in the primary channel. When the water surface level varies, optimum conditions are not met.

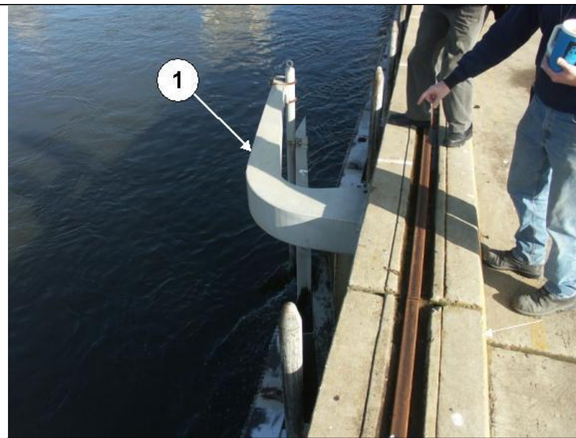


1	Primary Louvers
2	Old flow measurement platform
3	Fish bypass entrances.
4	Crane mounted louver cleaner

Figure 2-22 Primary Louvers

The louvers are seated on vertical pipe guides. Cleaning is accomplished by lifting a louver panel with the rail-mounted crane and washing it with high-pressure washer nozzles mounted to the gantry crane. When the louvers are lifted, fish and debris flow down the main channel to the pump station. The louvers are cleaned two times a day. It takes approximately 1.5 hours to clean all of the louvers, so a louver panel is lifted for about 3 hours per day. Although raising one louver represents a small percentage of the total louver length, it is suspected that fish pass through the opening in a disproportionate ratio to the percent open space. See Figure 2-22.

Bypass – Flow into the bypass system is drawn by 4 large pumps and 2 smaller pumps. For operational control, the flow of each large pump is estimated at 30 cfs while the flow from a small pump is 17 cfs. The flow however, varies with fluctuating water surface. Four bypass pipes lead from the louvers to a single secondary louver bay. These pipes are 36 inches in diameter. The entrances to these pipes extend from the bottom to the top of the channel and are designed to intercept any fish that are nosing down the louvers in the main channel. The effectiveness of the bypass depends on maintaining the ratio of the main channel flow velocity to the bypass channel flow velocity between 1.2 and 1.6. This prevents fish from fighting entrainment in the bypass system. Each bypass pipe is equipped with a flow meter. See Figure 2-23.



1	Fish Bypass Entrance (looking upstream)

Figure 2-23 Fish Bypass Entrance

Secondary Screen System – The four bypass pipes join in a concrete transition structure and lead to a secondary louver bay. If these louvers are clogged and require cleaning, fish salvage operations are halted as the bypass system is dewatered. The louvers are cleaned by hand. The channel downstream of the secondary louvers is equipped with a flow meter. See Figure 2-24.

1	Secondary Louvers, partially dewatered, looking downstream.
2	Trash accumulation.
3	Secondary Louvers, partially dewatered, looking upstream.
4	Operator removing trash.

Figure 2-24 Secondary Louvers

Fish Holding Tanks – There are three cylindrical concrete holding tanks. They are similar in design and operation to the tanks at the SWP. A white epoxy coating has been applied to the floor of the fish holding tanks. This reduces friction making it easier for fish to slide into the transfer buckets. It also makes the fish more visible in the tank.

Effluent Piping System – Fish and water enter the holding tank through the influent pipe. Flow circulates around the holding tank and exits through the effluent pipe located behind the cylindrical screen in the bucket sump wall. The effluent pipes drain to a common effluent sump. This circulation is driven by effluent pumps which return water to the primary channel. There are no variable speed pumps in this system. Each effluent pipe is metered.

Dewatering Pipeline System – The dewatering system is independent of the effluent watering system. An individual tank cannot be drained through the effluent water system while the other holding tanks are in service with their influent and effluent pipes open. The dewatering system consists of a pipe from each holding tank connected to a manifold which leads back to a common wet well where the water is pumped to the discharge conduit and back to the primary channel.

2.2.2 CHTR Facilities

2.2.2.1 Collection

The collection process is similar to the process used at SWP. There are some differences. The cylindrical screen at the center of the holding tank has been modified by extending the dead panel at the bottom of the cylinder. This increases the volume of water held in the tank when the sump is dewatered. This was done to promote flushing action when the cylindrical screen is raised. The volume held back in the holding tank is 3 times the volume of the transfer bucket. Any water above the capacity of the transfer bucket must drain through a band of screen material near the top of the bucket. The greater the flow through this screen, the greater the risk of fish impingement during the process.

2.2.2.2 Handling

Fish are handled in a similar manner as the fish at the SWP. There are some differences. The screen used at the counting station has been modified to promote drainage. The mesh of the counting station screen is larger than the mesh on the fish holding tank cylindrical screen.

2.2.2.3 Transport

The CVP facilities use 3 identical 2,000-gallon fish transport trucks. The fish transport truck tanks are similar in design to those used at the SWP facility though somewhat more refined. The trucks have three compartments to reduce sloshing. The trucks are equipped with oxygen diffuser stones and oxygen tanks. In addition the trucks are equipped with an alarm system that signals to the driver if the oxygen is turned on or has run out. The trucks are not completely fish friendly in that bolts, clips, and aeration stones protrude above the interior surface of the tank. The trucks provide a stiff ride for the fish which may add to the cumulative stress burden. The truck tanks are not insulated and heat up in the summer. Water used to fill the fish transport tank comes from pressurized tanks. Consequently, nitrogen supersaturation is concern. Additionally, the water lines are exposed to sunlight. This leads to heated water used to fill the fish transport trucks.

2.2.2.4 Release

Horseshoe Bend Release Site – This site consists of 4 pipes supported by pilings extending from the bank into the Sacramento River. (See Figure 2-18) Two of the pipes are release pipes and two of the pipes are pump intake pipes. There is electricity at the site to run a pump. The outlet is approximately 30 feet deep, and there is room at this site for a truck to back straight up to the pipe. The site is enclosed by cyclone fence topped with barbed wire. Both Horseshoe Bend sites are considered remote and dangerous to use at night.

The hydraulics of the release at this site are similar to the other Horseshoe Bend site used by the SWP. The outlet to the release pipe is considerably deeper.

Antioch Bridge Site – This site is located just east of the highway 160 bridge on the south side of the river. The release pipe is at a shallower slope and extends further from shore in shallower water than at the other release sites. There is a larger area for the release trucks to maneuver allowing them to back up directly to the release pipe. See Figure 2-20.

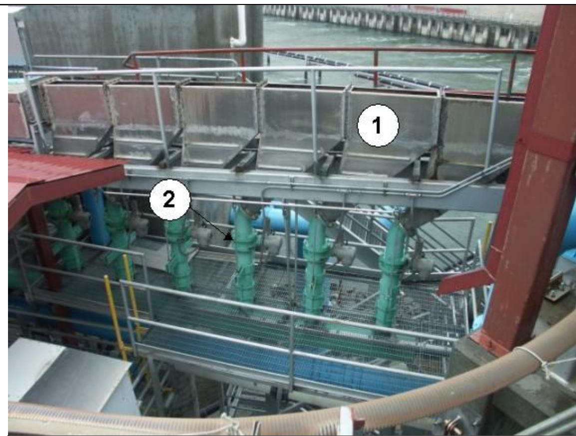
2.3 Other Facilities and Methods

2.3.1 Columbia River

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 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 personal communication). At McNary Dam (considered the most advanced handling and transport facility on the Columbia) during the peak debris season, up to 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 personal communication). This leaves only fish and water to be transferred from holding areas to the transport vehicles (trucks and barges).

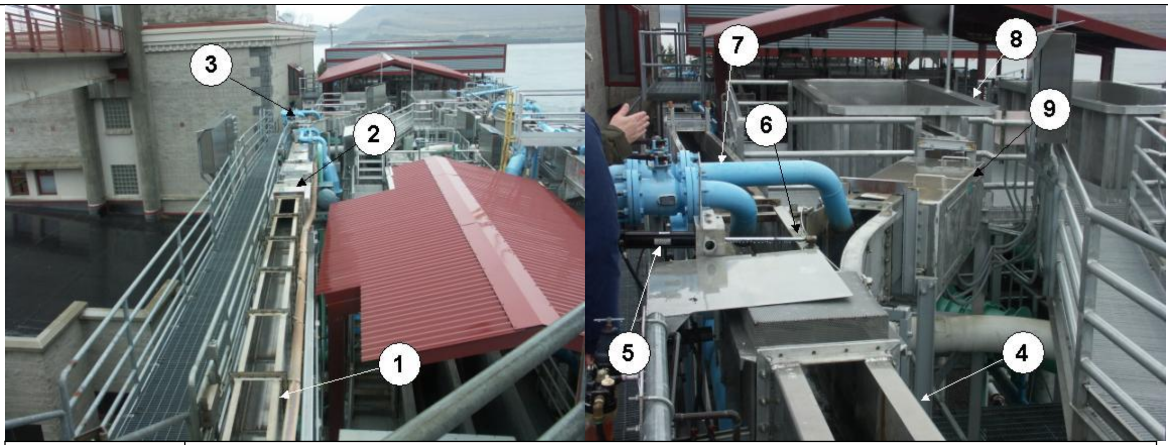
Water is added and subtracted from the flow line many times during the salvage process. Water is removed through floor mounted profile wire screens and perforated plate panels and added through diffusers. See Figure 2-25.



1	Side view of rectangular flume with profile wire screen bottom.
2	Valves to regulate dewatering.

Figure 2-25 Flume Dewatering

Sample subsets of fish are directed through Passive Integrated Transponder (PIT) tag operated gates to an onsite laboratory. See Figures 2-26 and 2-27. No “hot” (unanesthetized) fish are touched by humans throughout the process. Handling hot fish is considered too stressful.



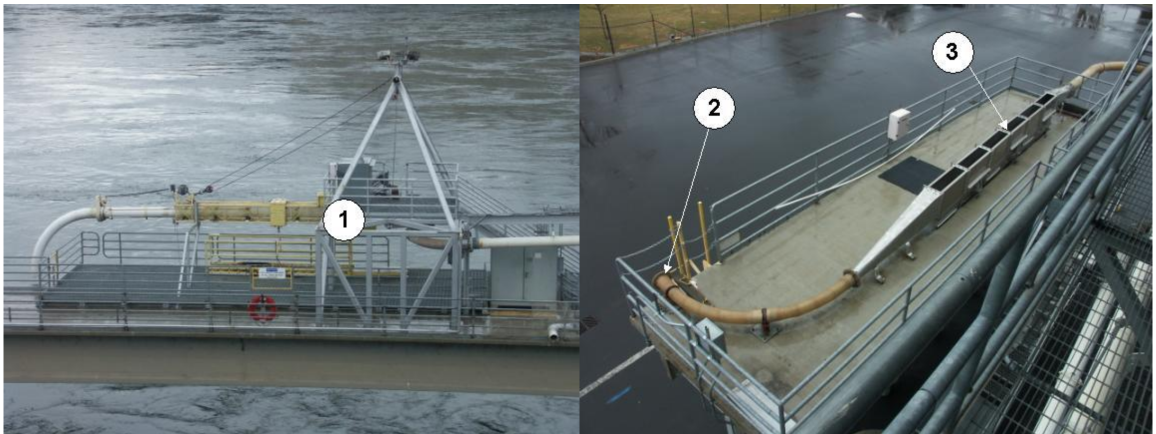
1	Rectangular flume with profile wire bottom.
2	PIT Tag Detector
3	Automatic air actuated side gate.
4	Rectangular flume with profile wire bottom.
5	Side gate operator
6	Side gate
7	Add-in water pipes
8	Sample dewatering screen box
9	PIT Tag Detector

Figure 2-26 PIT Tag Detection and Automated Side Gate

1	Fish enter lab in this flume.
2	Fish are sorted into troughs
3	PIT Tag reader

Figure 2-27 Fish Lab

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.



1	Barge Loading Facility
2	Pipe for truck loading
3	Dewatering screens.

Figure 2-28 Barge and Tank Loading Facilities

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 enables 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 personal communication) The four criteria are:

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

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

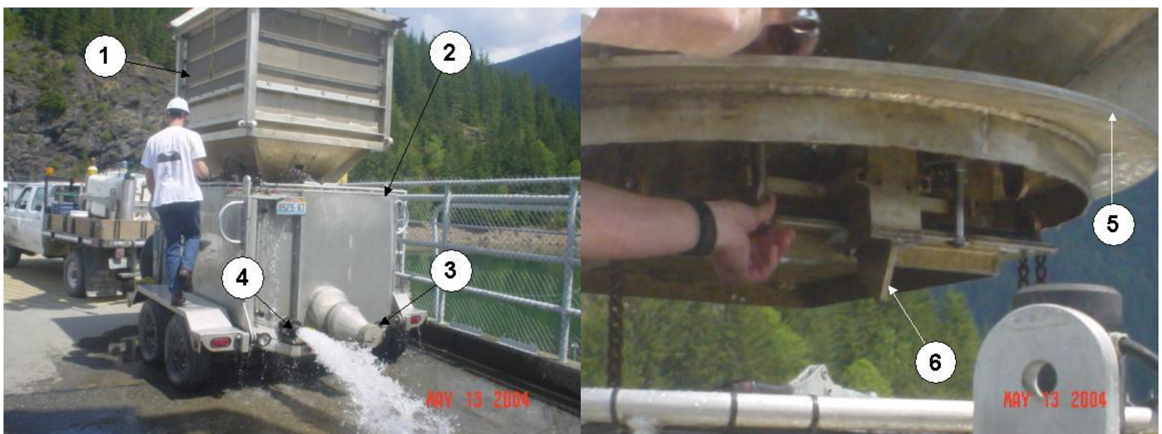
3) Depth of the outlet (10 meters)

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.

2.3.2 Baker River Project

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 adults 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 near Upper Baker Reservoir. 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 a tank on a trailer or truck. The truck or trailer is then driven about 15 minutes to Baker River near its confluence with the Skagit River where the fish are released. The hopper affects a 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. The weight of the hopper is sufficient to prevent leakage at the seal. Excess water is drained from the transport tank as the water from the hopper enters the tank. See Figure 2-29.

For juvenile fish release the tank trailer is backed up to the river across a gravel bar. A flexible release hose is attached and the release gate is opened. Starting in 2008, fish will be released to acclimation ponds near the river. After a period of about 24 hours the fish will be released to the river through a fixed release pipe. It is planned to test different holding durations and release times will be tested. It is believed that fish released at night might have a better chance of avoiding predators in the vicinity of the release site.



1	Fish hopper for water to water transfer
2	Fish Transport Trailer
3	Fish hopper exit.
4	Screened water outlet.
5	Underside of hopper
6	Trapdoor release mechanism

Figure 2-29 Water-to-Water Fish Transfer

2.3.3 Cowlitz Falls Project

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 relief ponds where they are held for prescribed period of time and then allowed to leave the pond voluntarily to the river. After a prescribed interval, remaining fish are crowded out of the stress relief 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.

3.0 INFORMATION SOURCES

Fish salvage at the State Water Project (SWP) and Central Valley Project (CVP) fish facilities has been the subject of extensive physical and biological monitoring and data collection. This section summarizes and catalogues the data sources available for CHTR based research and analysis. A library containing CHTR related literature and information has been assembled and catalogued into a searchable database. This section also presents and summarizes the available biological, operational, and water quality data available related to the SWP and CVP fish salvage facilities. The objectives of this section are to present a catalogue of these data sources and briefly describe possible analyses of the data. In depth data analysis are presented, as examples of possible analyses using the available data to demonstrate the capabilities of the databases for further research and study. Sources of biological, operational, and water quality data are also presented, especially when available on the internet. This section provides a comprehensive overview of the various sources of literature and data relating to SWP and CVP fish salvage operations. Access to this extensive knowledge base will be a useful tool for future research, identifying and testing new technologies, monitoring operations, and planning.

3.1 CHTR Literature Database and Available References

An extensive range of literature exists regarding all aspects of the SWP and CVP fish salvage process. The available literature, however, takes multiple forms and includes published journal articles, published and unpublished technical reports, summary reports of various aspects of operations undertaken during the salvage process (e.g. release), memos, data reports, correspondence, and data archives in both hard copy and electronic format. Information is also available on various aspects of fish salvage facility engineering and design, operational procedures, and biological testing. These sources of information provide a critical resource for research regarding fish salvage operations. One problem in utilizing this resource of data and information is the fragmented and de-centralized nature of the literature. No central reference list or library exists cataloging these information sources or making these reference sources available to investigators. The limitation this imposes on research is that researchers may not be aware that data and past studies exist that may aid ongoing and future investigations. As part of this investigation, a compilation of these references has been centralized into a single reference library with an electronic searchable catalog system. Many of the references have been scanned and are now available as electronic PDF files, which can be viewed on most computers. An electronic copy of the literature database is available upon request from California DWR, Environmental Division.

The main source of published and unpublished references regarding fish salvage is from libraries and collections held by individuals and agency personal. The collection of references presented in the CHTR electronic bibliography was assembled by establishing contact with individuals who have extensive involvement with fish salvage operation studies and research, and by conducting informal interviews to establish availability of reference materials. To date, the majority of references have come from the libraries of Dan Odenweller (CDFG and NMFS, retired) and Steve Foss (CDFG, Stockton). A series of visits were made to search the libraries of these individuals for key references regarding the fish salvage process and related topics. The references identified as relevant were then copied and the citations entered into a Microsoft Access database. These references were scanned to create electronic copies as part of the reference library. The result of this effort is an extensive searchable database on SWP and CVP fish salvage operations and related topics, as well as a library of these references in both hard copy and electronic format.

Currently, the "CHTR Literature Database" of fish salvage related studies and references (Version 1.0) has approximately nine hundred entries. The database lists references in the format of formal citations with authors, date, title, publication, and source listed. In addition, reference to keywords, salvage process stage (e.g. collection, handling, transport, or release), user comments on the articles (updatable in the CHTR Literature Database), and the format of the article (e.g. hardcopy and electronic) are included. These additional pieces of information (an example of the database is shown in Appendix 4) add functionality to the database beyond that of a catalog. It is envisioned that the database will serve as a useful tool to investigators by providing summaries of articles, links to similar work, and references to related studies, allowing the various aspects of fish salvage operations to be viewed holistically.

Compilation of the literature database is still under development and changes to the format and functions may occur over time as more efficient ways are developed for managing the references and using the database as a research tool. The database is composed to allow the following functions:

Searchable fields: Author, Year, Title, Source / Publisher, Keyword, Process Stage.

User editable fields: Comments.

Database / Library management fields: Hard copy, Electronic copy.

The database searchable fields allow users to search broadly through the database for a range of references as well as allowing users to perform refined searches specific to a few references dealing with a specific topic (e.g. searching under the "release" stage of the fish salvage process for "predation" studies conducted by "Department of Fish and Game"). The user editable fields allow users to add comments that are attached to specific references once these have been reviewed (e.g. to summarize data contained within the reference, or to cross reference with other studies). The database/library management fields support internal administrative functions to provide summaries of the status of the reference in question (e.g. is it available in hard copy or electronic copy).

The database has additional functions, accessible from the main database menu, to enable reference listings to be edited or added to the database through use of the "Edit Reference" and "Add Reference" functions. This brings up all entry fields and allows these fields to be edited or added to, expanding the information and summaries attached to the database references. Another function of the database is the "Run Print Report" capability, allowing the entire database to be printed in a readable and printer compatible format (Appendix 4).

3.2 Summary of Biological Data

Fish salvage data are collected both at the SWP and the CVP facilities in a variety of formats each day. Typically, a sub-sample of salvaged fish is taken from the fish collection that comprises a 10 or 20-minute diversion of flow and fish collected into an empty holding tank. The fish from these sub-samples are then processed and results of the sub-samples are used to calculate holding tank densities, salvage, and loss. Sub-samples are taken typically every two hours. From the collection and holding tank fish density estimates, the allowable holding time in the salvage facility collection tanks can be determined. This information is used to establish the transport and release schedule at the SWP. The CVP has regularly scheduled release times in the morning and evening each day. Sample counts are recorded at the facilities and salvage data is cataloged into a database from the datasheets each day. An example of the salvage datasheets is shown in Appendix 5. The recorded sample count data at the SWP and CVP facilities includes the following parameters:

- Species type and length (SWP and CVP),
- Operational parameters and species counts including (SWP and CVP):
    - Sample time
    - Total minutes pumping
    - Length of count (minutes)
    - Water temperature (F)
    - Channels or bays open
    - Primary depth (FT)
    - Primary flow (CFS)
    - Primary bypasses open
    - Secondary depth (FT)
    - Secondary flow (CFS)
    - Holding tank flow (CFS)
    - Species counts
- Numbers of individuals of each species collected (SWP and CVP),
- Numbers of individuals of listed species (SWP and CVP),
- Daily totals for each species are determined by adding each count within a 24 hour period (SWP and CVP),
- Salmon DNA collection is recorded with use of a Tissue Collection Form for use by CDFG (CVP only), and
- During times of mitten crab occurrence, 10-minute mitten crab and fish count on the traveling screen is recorded (CVP only).

The main biological data used in calculating salvage and loss are comprised of the species length, the species numbers with operational summaries, and the listed species salvage and loss estimates. These data are recorded and sent each day to CDFG for entry into an electronic database. From this CDFG managed fish salvage database, summaries and reports are generated (Appendix 5) giving bi-weekly salvage and loss estimates for listed species. The bi-weekly reports alert federal and state water managers that monthly incidental take limits for listed species are being approached or exceeded, and to inform decisions regarding potential changes to diversion operations. In addition, daily salvage data and loss estimates are used in preparing an annual summary report of fish salvage operations. Results of the annual salvage summary report are published in the IEP newsletter. At this time, the fish salvage database is hosted by CDFG, Stockton, and no public access is available. However, the datasets contained within the database are available online to the public (discussed below). The Microsoft Access database hosted by CDFG, Stockton, has fish salvage data from 1993 to present. Data is also available in older files (dBase files) from 1957 for the CVP and from 1968 for the SWP. The database offers quick access to a broad range of analyses. For example, calculations can be conducted that enable analyses of fish densities within the collection tank and within the transfer buckets.

Fish salvage data are also available in a raw format online at the Central Valley Bay-Delta Branch (CVBDB) website (http://www.delta.dfg.ca.gov/Data/Salvage/) where it can be downloaded from an FTP site. Before using the online data sets however, they must be downloaded into a spreadsheet before analysis can be performed.

The following sections outline the data available regarding fish salvage. For this report, only the available online datasets from the CVBDB website have been used in the analysis to demonstrate the range and scope of these datasets. The online data available at the CVBDB website are presented as five separate datasets. Also available are keys to species codes. Facilities are coded "1" for SWP and "2" for CVP. SWP has a further building demarcation of "O" for the older original fish holding tank building with four holding tanks, and "N" indicating of the newer fish holding tank building with three fish holding tanks. The five online datasets available include:

- Hourly and daily summaries of the number of each species and their lengths salvaged. The dataset also identifies if the adipose fin has been clipped for salmon and steelhead;
- Daily/hourly summaries of salmon species counts, salvage, and loss as well as length and a record of whether the adipose fin has been clipped;
- Daily/hourly species total counts;
- Daily summary of species salvaged per acre feet pumped;
- Daily/hourly summaries of facility operations for: number of bays open, primary flow (CFS), primary depth (FT), holding tank flow (CFS), minutes pumped until sub-sample taken (typically 120 mins), water temperature, and length of sub-sample taken (typically 10-20 mins).

3.2.1 Biological data presenation

The following sub-sections outline the various formats presented for the biological data relating to fish salvage operations. The purpose of these analyses is to provide examples of available data summaries and demonstrate the potential analyses generated from the available biological data. For the purposes of this report, fish salvage data from the year 2002 have been chosen for example. The data explored in this section represents the data that is entered onto the datasheets at the SWP and the CVP salvage facilities and entered into the database hosted and managed by CDFG, Stockton. These data are then made available online at the CVBDB website in its raw format.

The data sheets used to record the raw data at the salvage facilities are shown in Appendix 5 along with the species codes. In addition to species catch numbers at the fish salvage facilities, salvage and loss are also calculated. Loss represents an estimate of mortality resulting from entrainment at the export facilities based on estimates of pre-screen losses (predation), louver efficiency, and handling and trucking mortality. Appendix 6 presents a summary table of internet resources used for this report, the databases available, web locations, and parameters of the database as a quick reference guide and resource for fish salvage research.

3.2.1.1 Species Composition

Figures 3-1 and 3-2 show the species salvage composition for the SWP and CVP, respectively. The species composition charts represent the 4,652,899 fish salvaged at the SWP and the 6,134,982 fish salvaged at the CVP during 2002. For both facilities the most abundant species was threadfin shad. Chinook salmon, steelhead and delta smelt have been included in the species composition as listed species to demonstrate their contribution to total annual fish salvage. Tables 3-1 and 3-2 show the species composition of fish salvaged from the SWP and CVP for 2002 as well as the total number of each species salvaged and the percentage composition of each salvaged species. Both the SWP and CVP salvaged an identical number of species in 2002 with threadfin shad dominating the species composition at both facilities. Both facilities salvaged a similar range of species in 2002. However, species composition did show some differences in species salvaged between the two facilities. Threadfin shad, striped bass, American shad, and yellowfin goby made up the top four species at both facilities. Figure 3-3 (Foss 2003) demonstrates the annual proportion and trend since 1981 of threadfin shad as part of the total fish salvage at both the CVP and SWP facilities.

Tables 3-1 and 3-2 show the total numbers of Chinook salmon salvaged in 2002 at the SWP and CVP to be 6,348 and 15,573, fish respectively. It is possible to further expand on the salmon data using the 2002 salmon dataset available on the CVBDB website to estimate salvage for different salmon species. Tables 3-3 and 3-4 show the total number of Chinook salmon salvaged at the SWP and CVP separated into race (fall, late-fall, winter, and spring run) as well as defined by marked or unmarked (adipose fin clipped or unclipped). Salmon species identifications are based on the fish length and date collected using criteria developed by Frank Fisher and Sheila Green. These criteria are continuing to be revised and evaluated.

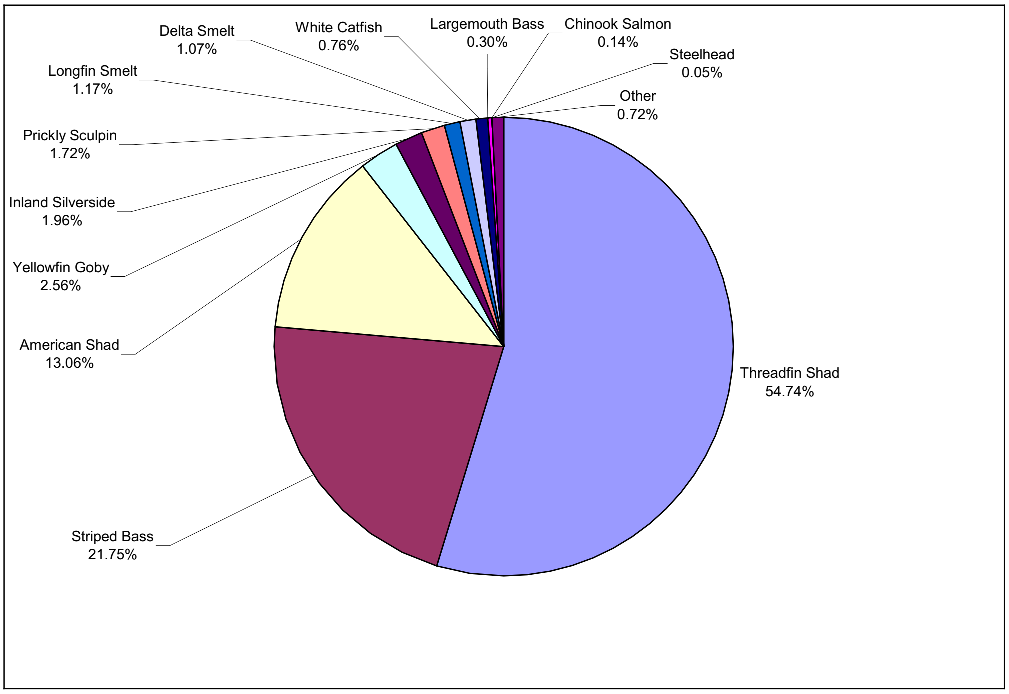


Figure 3-1. Relative species contribution to 2002 annual salvage at SWP.

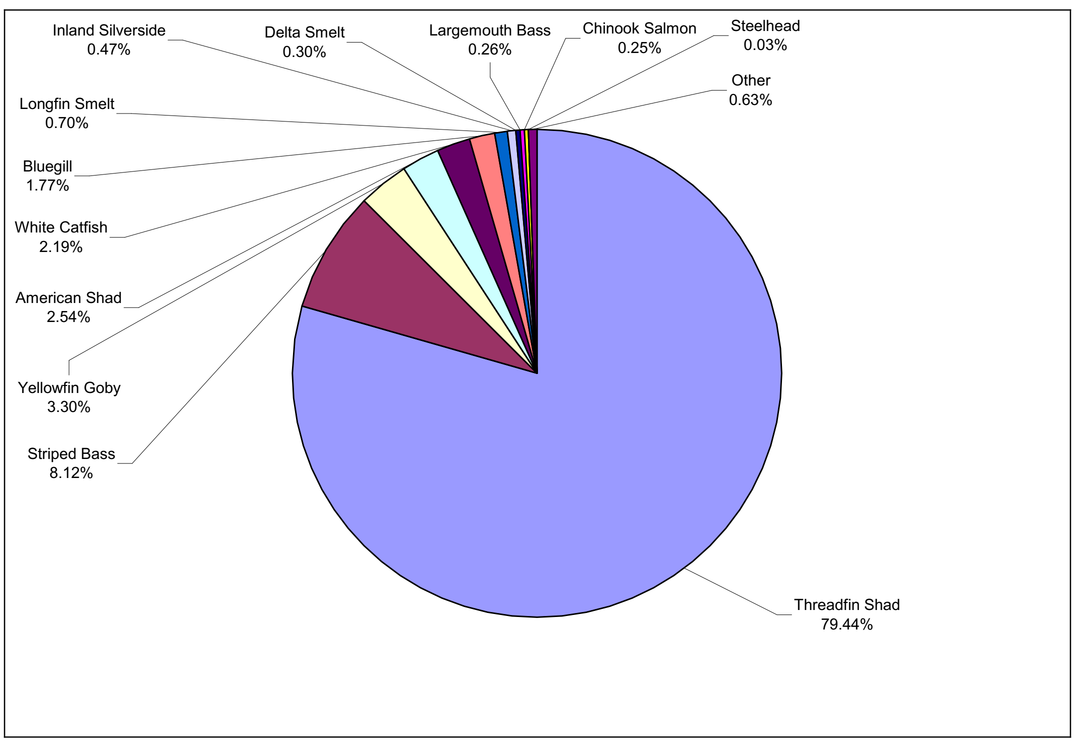


Figure 3-2. Relative species contribution to 2002 annual salvage at CVP.

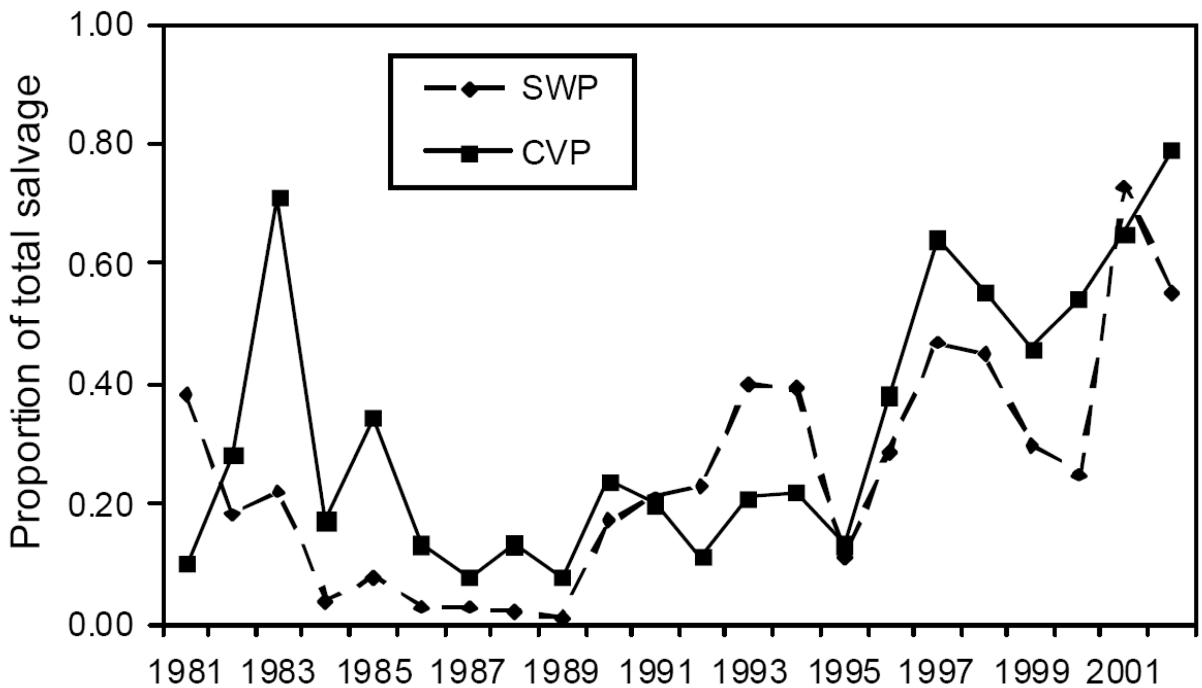


Figure 3-3. Relative proportion of Threadfin shad at SWP and CVP (Foss 2003).

Table 3-1. SWP 2002 species salvage composition.

Species	Salvage Total	Percent of Total
Threadfin Shad	2546901	54.74%
Striped Bass	1012198	21.75%
American Shad	607725	13.06%
Yellowfin Goby	119012	2.56%
Inland Silverside	91091	1.96%
Prickly Sculpin	80225	1.72%
Longfin Smelt	54582	1.17%
Delta Smelt	49823	1.07%
White Catfish	35413	0.76%
Largemouth Bass	13944	0.30%
Chinook Salmon	6348	0.14%
Steelhead	2181	0.05%
Bigscale Logperch	7712	0.17%
Channel Catfish	6461	0.14%
Splittail	5768	0.12%
Bluegill	5374	0.12%
Shimofuri Goby	2550	0.05%
Lampreys (all spp.)	1619	0.03%
80	1271	0.03%
Riffle Sculpin	786	0.02%
Staghorn Sculpin	678	0.01%
Black Crappie	330	0.01%
Golden Shiner	195	0.00%
Mosquitofish	185	0.00%
Wakasagi	105	0.00%
Chameleon Goby	58	0.00%
Redear Sunfish	51	0.00%
Threespine Stickleback	49	0.00%
Starry Flounder	48	0.00%
Black Bullhead	42	0.00%
Warmouth	36	0.00%
White Sturgeon	30	0.00%
Rainwater Killifish	20	0.00%
Brown Bulhead	15	0.00%
Green Sturgeon	12	0.00%
Pumpkinseed	12	0.00%
Smallmouth Bass	10	0.00%
Goldfish	9	0.00%
Carp	6	0.00%
Sacramento Blackfish	6	0.00%
Tule Perch	6	0.00%
Yellow Bullhead	6	0.00%
Pacific Brook Lamprey	6	0.00%

Table 3-2. CVP 2002 species salvage composition.

Species	Salvage Total	Percent of Total
Threadfin Shad	4877015	79.44%
Striped Bass	498546	8.12%
Yellowfin Goby	202464	3.30%
American Shad	155845	2.54%
White Catfish	134559	2.19%
Bluegill	108857	1.77%
Longfin Smelt	43188	0.70%
Inland Silverside	28962	0.47%
Delta Smelt	18396	0.30%
Largemouth Bass	16017	0.26%
Chinook Salmon	15573	0.25%
Steelhead	1656	0.03%
Channel Catfish	10697	0.17%
Golden Shiner	6939	0.11%
Prickly Sculpin	6819	0.11%
Splittail	3269	0.05%
Shimofuri Goby	2124	0.03%
Lampreys (all spp.)	1416	0.02%
80	1383	0.02%
Redear Sunfish	1117	0.02%
Warmouth	1008	0.02%
Black Crappie	939	0.02%
Bigscale Logperch	912	0.01%
Brown Bullhead	366	0.01%
Mosquitofish	300	0.00%
Tule Perch	204	0.00%
Wakasagi	192	0.00%
Carp	147	0.00%
Threespine Stickleback	132	0.00%
Striped Mullet	108	0.00%
Staghorn Sculpin	84	0.00%
Fathead Minnow	84	0.00%
Starry Flounder	72	0.00%
Red Shiner	36	0.00%
Black Bullhead	26	0.00%
Sacramento Blackfish	24	0.00%
Chameleon Goby	24	0.00%
Sacramento Squawfish	12	0.00%
Goldfish	12	0.00%
Riffle Sculpin	12	0.00%
White Crappie	12	0.00%
Sacramento Sucker	12	0.00%
Blue Catfish	12	0.00%

3.2.1.2 Seasonal Distribution

Figures 3-4 and 3-5 show the daily salvage for delta smelt at the SWP and CVP during 2002. Total estimates for salvaged delta smelt (greater than 20 mm) in 2002 are 49,823 fish at the SWP and 18,396 fish at CVP. The seasonal distribution of delta smelt salvage showed that salvage occurs mainly during January and February, when adults are salvaged, and May and June, when young-of-the-year are salvaged. The young-of-the-year salvage numbers for delta smelt represent the majority of the total annual salvage, especially at the CVP. Figures 3-4 and 3-5 show that the seasonal distribution in delta smelt salvage is similar between the SWP and the CVP facilities, but the difference in salvage numbers must be noted, with the SWP having peak delta smelt daily salvage numbers more then an order of magnitude larger then the CVP facility on some days.

Similar analyses are possible with the data on salmon salvage. Figures 3-6 and 3-7 show examples of the daily salvage for Chinook salmon at the SWP and CVP. In addition to the potential for daily and monthly salvage summaries, as with the delta smelt data, Chinook salmon are also examined for determination of hatchery (adipose fin clip) or wild/unmarked origin. This is achieved through inspection of fish to see if the adipose fin has been clipped off, indicating a fish of potentially hatchery origin. Figures 3-8 and 3-9 show the percent composition of the various salmon runs to the total salmon salvage for the SWP and CVP. Tables 3-3 and 3-4 present summaries of the salmon salvage data, expanded from the count data to account for sub-sampling effort, for comparison between the SWP and CVP for Chinook salmon by race and with reference to whether the salmon are marked or unmarked from the 2002 datasets. The Chinook salmon race compositions presented in Figures 3-8 and 3-9 demonstrate the limitations of using length class guidelines for salmon race determination, as wide margins of error in race identification based on the length-at-date classifications rather then genetic determination of salmon race based on DNA analysis. Also, the data on salmon run composition salvaged varies widely year to year within the long-term datasets.

Table 3-3. Unmarked Chinook salmon salvage by race, 2002.

Race	SWP	CVP	Total
Fall	1384	3626	5010
Late-fall	14	12	26
Winter	606	794	1400
Spring	1267	6910	8177
Total	3271	11342	14613

Table 3-4. Marked Chinook salmon salvage by race, 2002

Race	SWP	CVP	Total
Fall	615	821	1436
Late-fall	230	229	459
Winter	1584	1057	2641
Spring	642	2112	2754
Total	3071	4219	7290

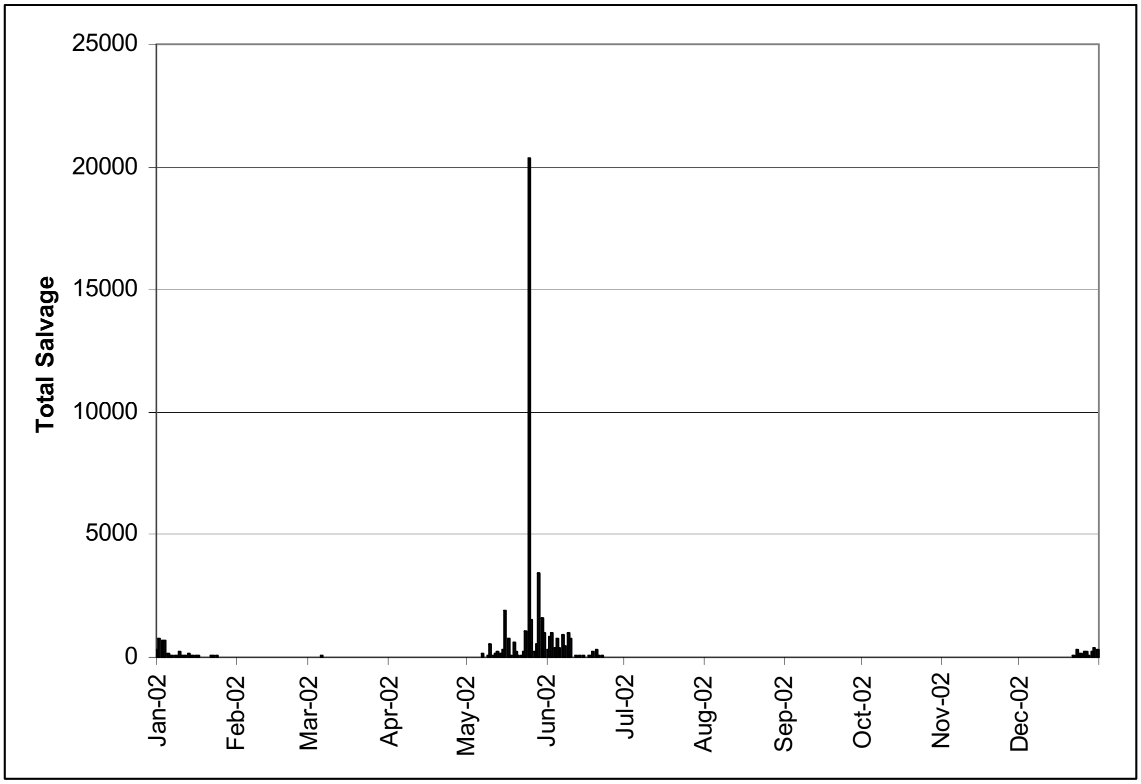


Figure 3-4. Seasonal distribution of delta smelt at SWP, 2002.

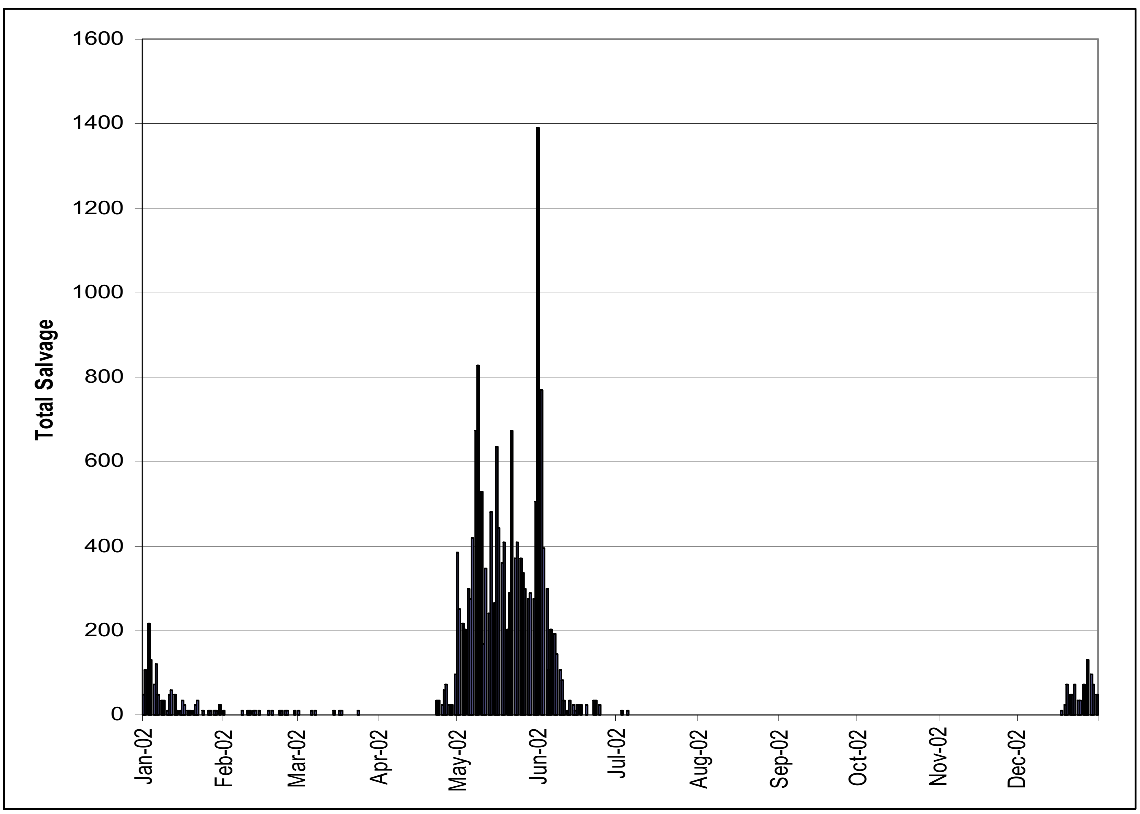


Figure 3-5. Seasonal distribution of delta smelt at CVP, 2002.

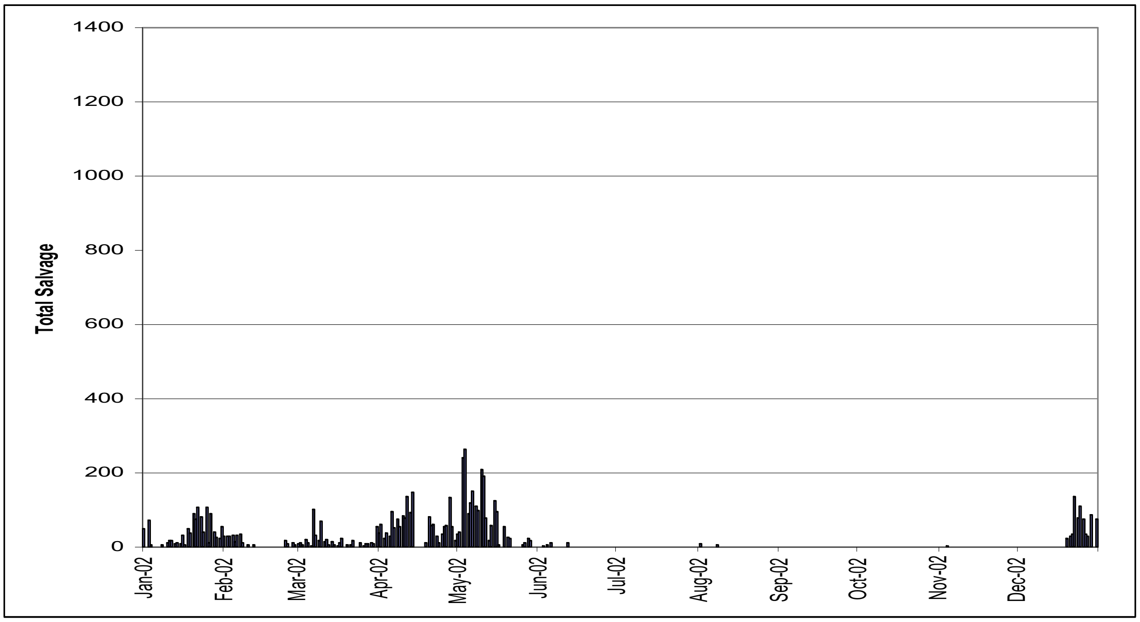


Figure 3-6. Seasonal distribution of Chinook salmon at SWP, 2002

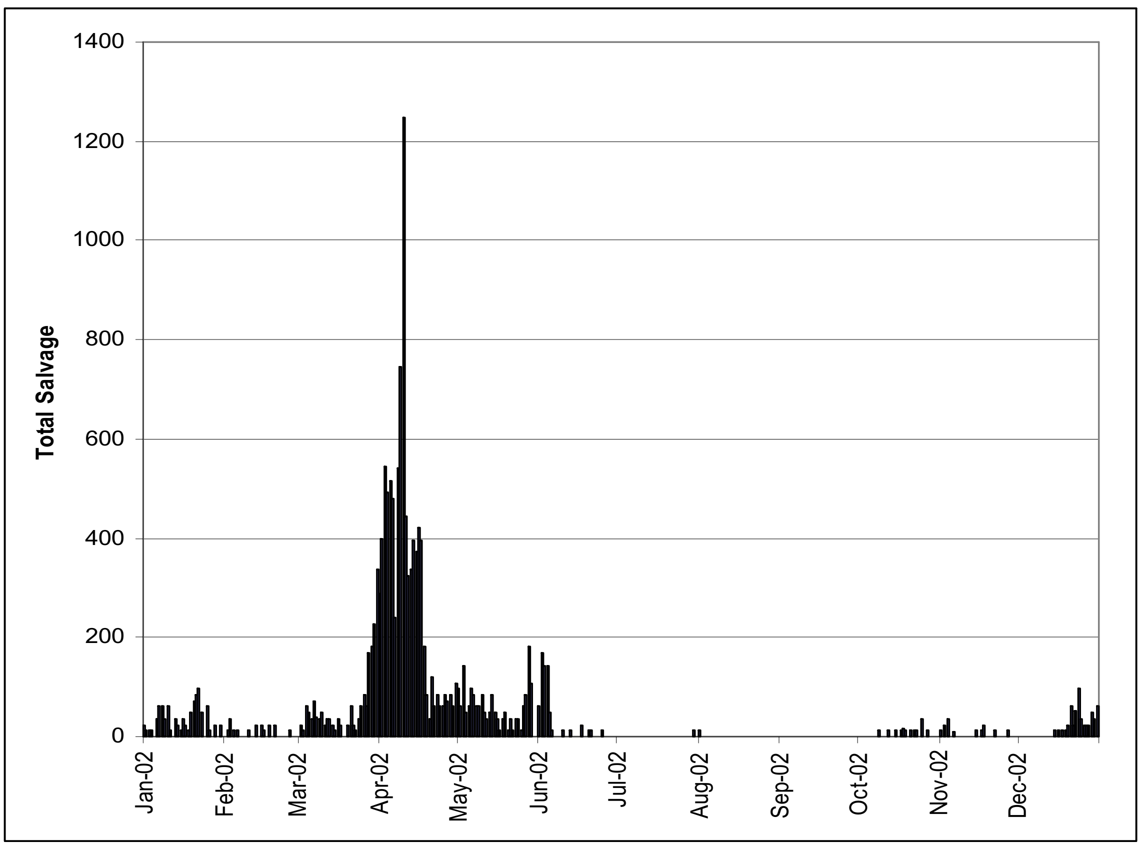


Figure 3-7. Seasonal distribution of Chinook salmon at CVP, 2002.

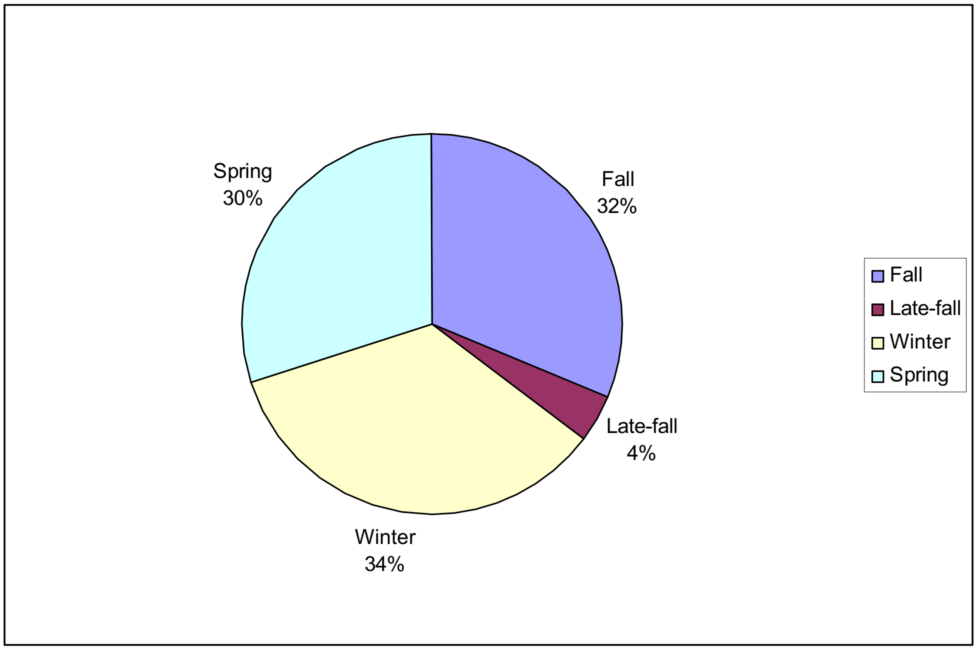


Figure 3-8. Percent salvage Chinook salmon runs at SWP, 2002.

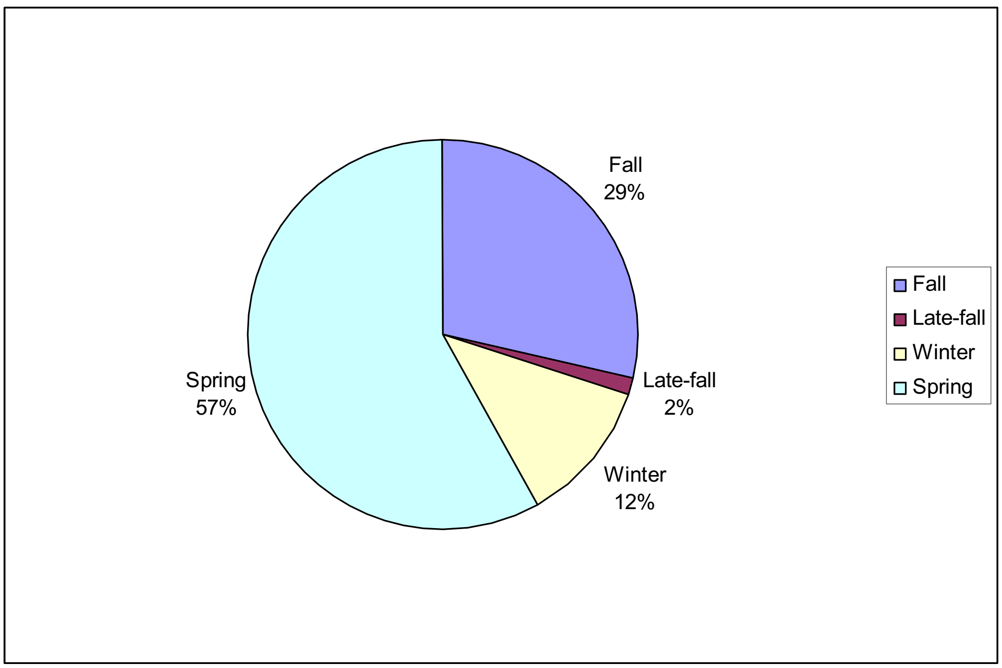


Figure 3-9. Percent salvage Chinook salmon runs at CVP, 2002.

3.2.1.3 Size Distribution

Size distribution (length) data is presented for clipped and unclipped juvenile Chinook salmon salvaged at the SWP and CVP is shown in Figures 3-10 and 3-11. Delta smelt size distributions are presented in Figures 3-12 and 3-13. These data, like the seasonal distribution data discussed above, show that delta smelt adults were salvaged at both facilities primarily in January and February, and delta smelt young-of-the-year were salvaged primarily in May and June. Tables 3-5 and 3-6 summarize the 2002 monthly size distribution of delta smelt at the SWP and CVP facilities. Results of these analyses show that in 2002 the largest number of delta smelt were salvaged in May as small young-of-the-year juveniles. Larger subadult and adult sized delta smelt primarily occur in the salvage during the winter.

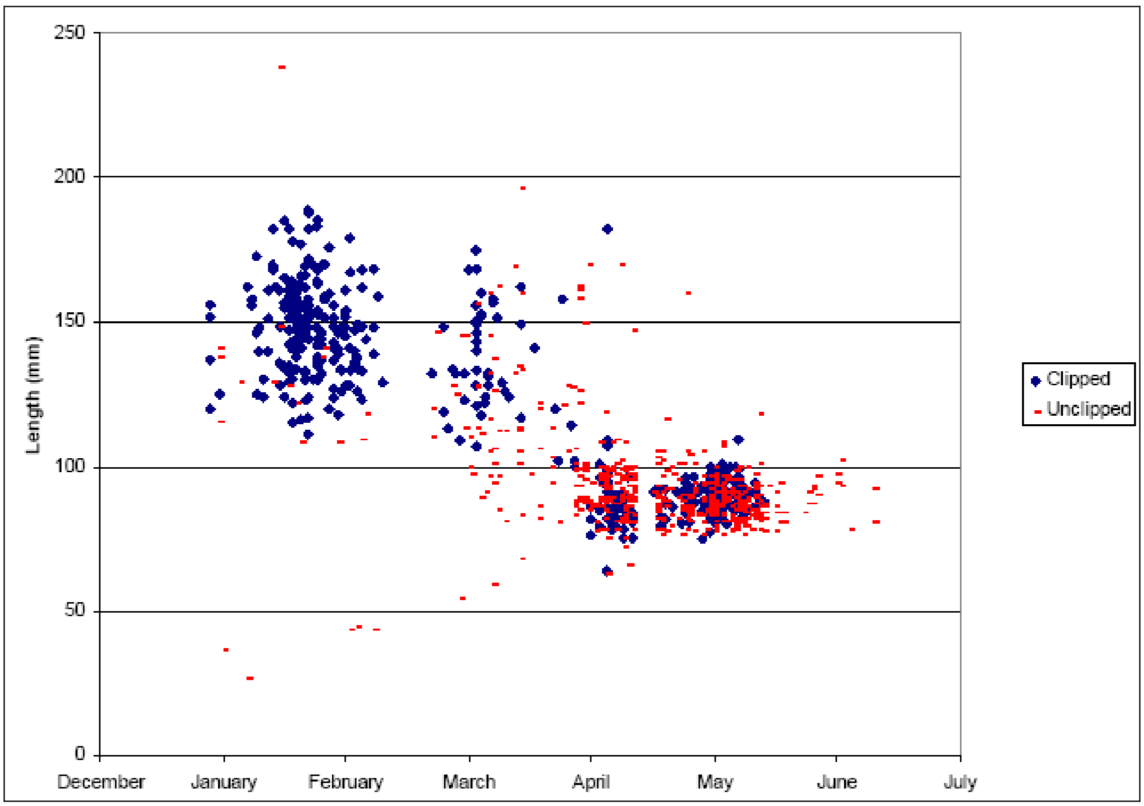


Figure 3-10. Size distribution for marked and unmarked Chinook salmon at SWP 2002.

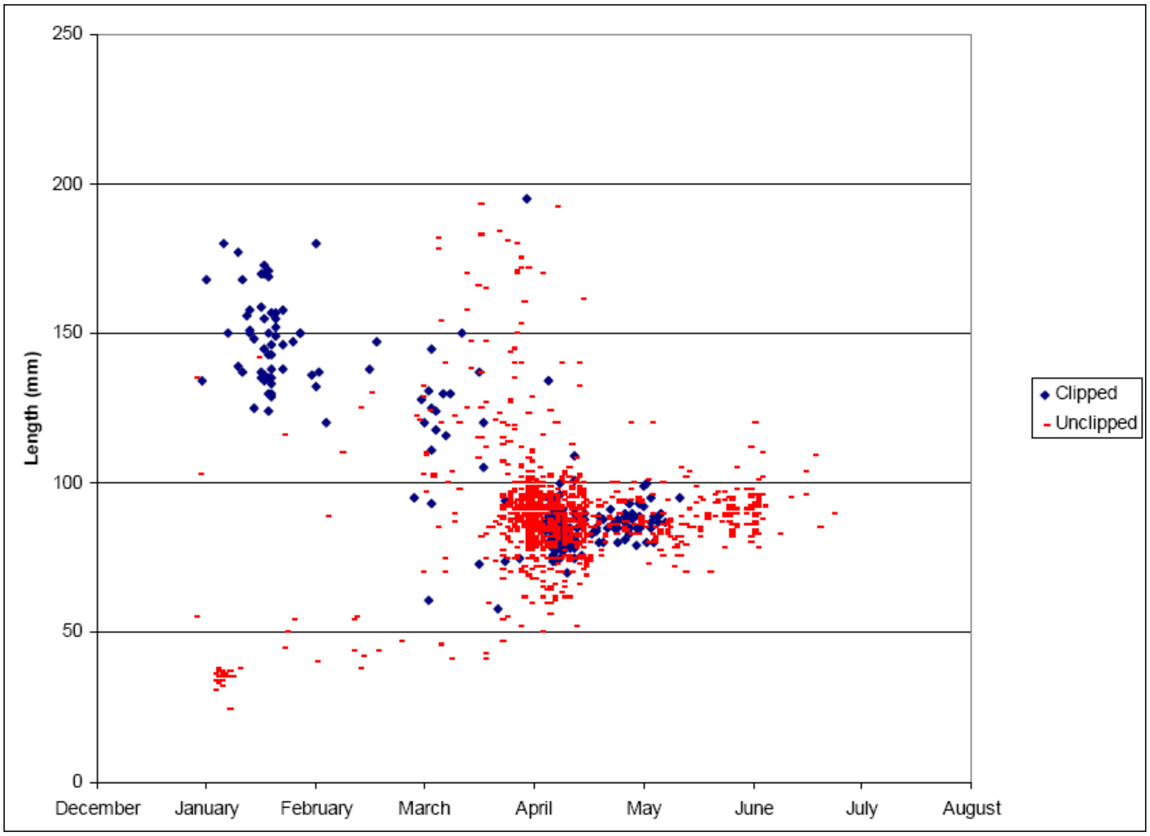


Figure 3-11. Size distribution for marked and unmarked Chinook salmon at CVP 2002.

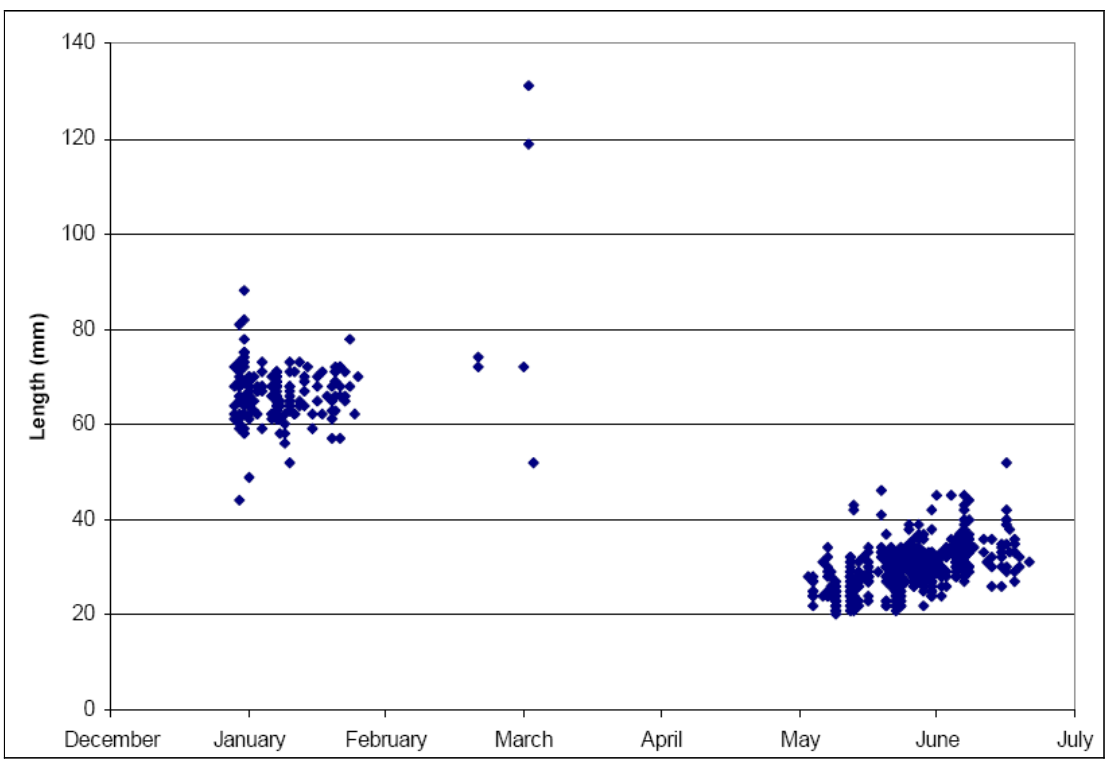


Figure 3-12. Size distributions for delta smelt at SWP 2002.

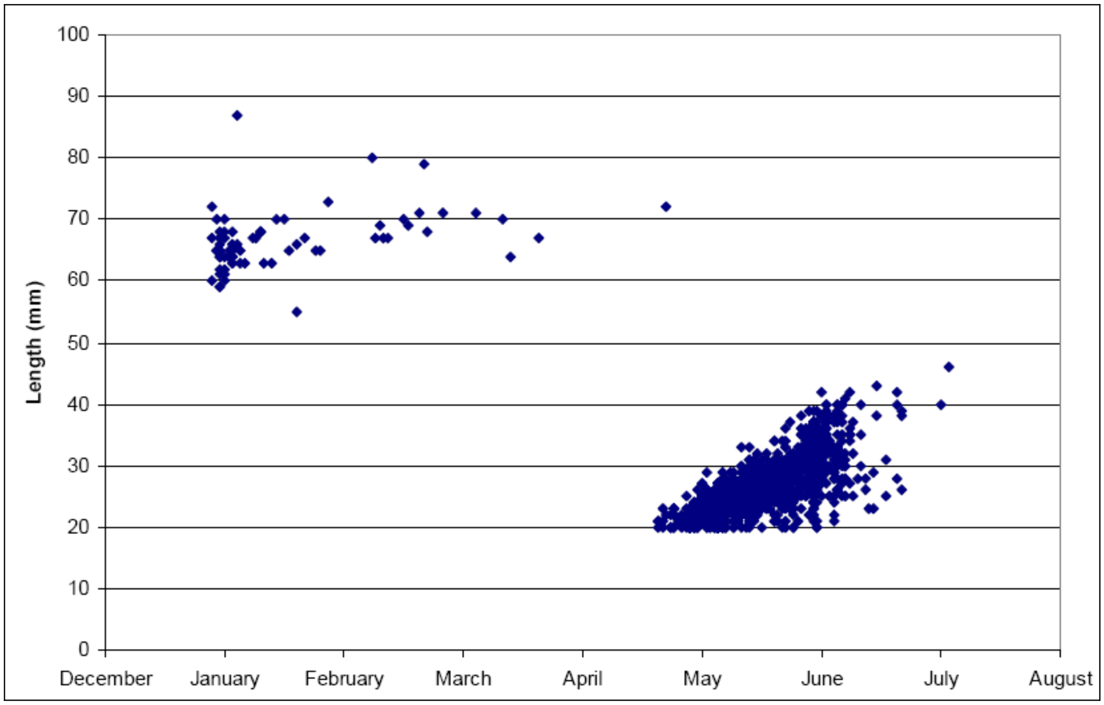


Figure 3-13. Size distributions for delta smelt at CVP 2002.

Table 3-5. Delta smelt lengths by month (mm) for SWP, 2002.

Month	Min	Mean	Max	Total Count	Total Salvage
January	44	66.4	88	379	3983
February	72	73	74	17	112
March	52	93.5	131	23	141
April	0	0	0	0	0
May	20	28.7	46	2822	35637
June	24	32.2	52	890	7942

Table 3-6. Delta smelt lengths by month (mm) for CVP, 2002.

Month	Min	Mean	Max	Total Count	Total Salvage
January	55	65.5	87	104	1248
February	67	70.7	80	14	168
March	64	68	71	7	84
April	20	23.1	72	31	372
May	20	25.6	39	974	11724
June	20	31.1	43	332	3984

3.2.1.4 Salvage Densities

Figure 3-14 shows the salvage densities (fish per 10,000 m^3 exported) for fish at the SWP and CVP facilities during 2002 (Foss 2003). In the case of delta smelt and Chinook salmon, native listed species, the salvage densities are presented in Figures 3-15 and 3-16 based on the numbers of individuals of each species salvaged per month during 2002.

As an example of potential analyses from the data available at the CVBDB website, the fish count on May 21st at 04:00 hrs, 2002 at the CVP was chosen to explore the possibilities for analysis using the datasets available online. Figure 3-17 shows the daily salvage summary for the CVP facility. The operation data for the period shows a 10-minute count was taken from a two-hour period of collection with a holding tank flow rate of 3.2 CFS and a water temperature of 65 F (Table 3-7). Figure 3-18 shows the species composition from the 10-minute count and the salvage estimates for that count. The salvage estimate was calculated by using an expansion factor of 12. This expansion factor represents a 10 minute sub-sample taken from a 120 minute collection period ($^1/_{12}$). The sub-sample species counts are then multiplied by 12 to expand the 10-minute counts up to a 120-minute collection period to estimate the total number of fish in the collection tanks. Of the collected species within this sub-sample, only Chinook salmon and delta smelt were native species. Figure 3-19 presents the length frequencies for the delta smelt collected in the 10-minute count. Figure 3-19 shows that the delta smelt collected were all within the 20-30 mm size class with the majority being 26-30 mm in length.

The data available online at the CVBDB website also summarizes Chinook salmon salvage. The salmon salvage data for the two salmon collected within this particular sub-sample were classified as fall-run Chinook salmon, 89 and 90 mm in length. The adipose fin of both salmon was intact, indicating that they had not been tagged as part of hatchery or experimental investigations (Table 3-8).

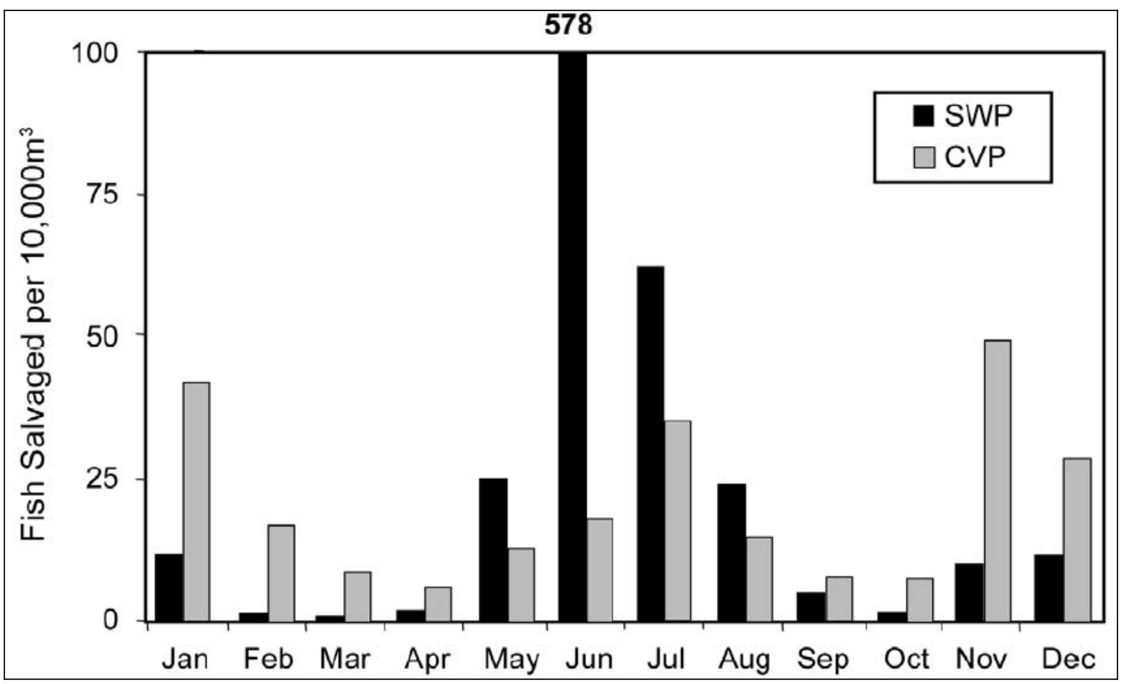


Figure 3-14. Fish salvage density in 2002 at SWP and CVP (Foss 2003).

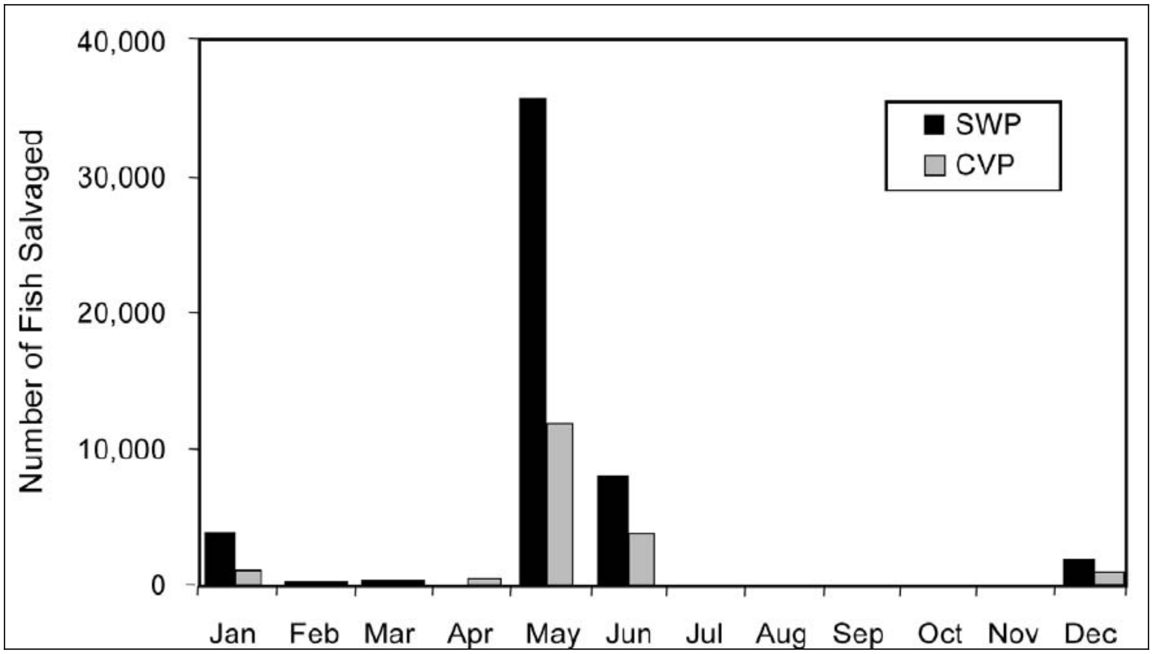


Figure 3-15. Monthly delta smelt salvage at SWP and CVP, 2002 (Foss 2003).

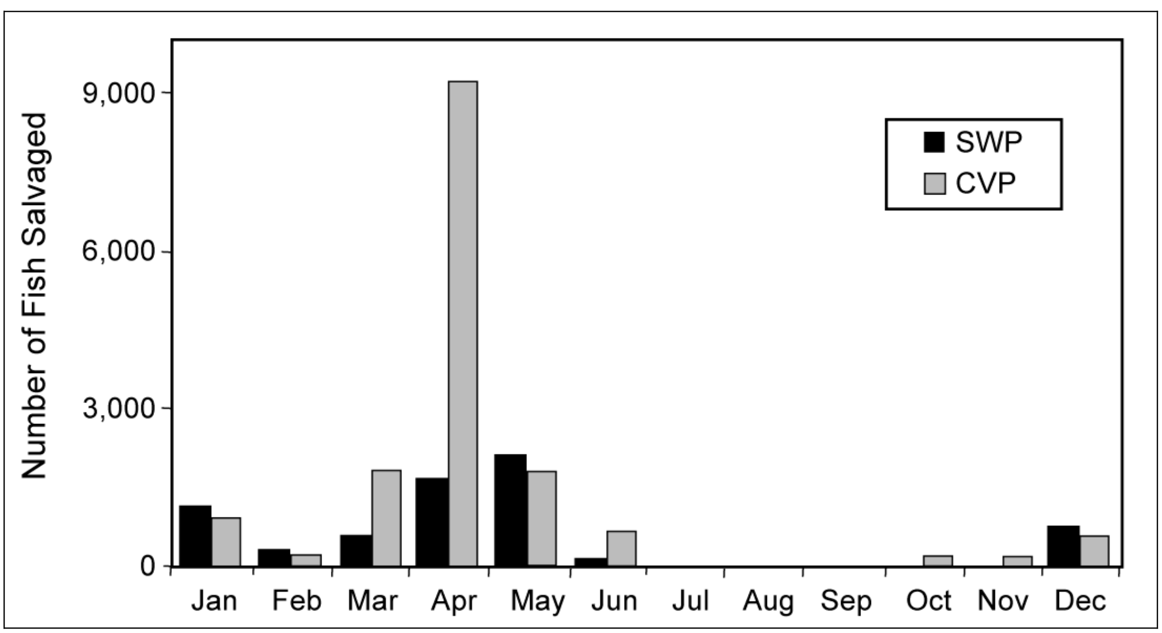


Figure 3-16. Monthly Salmon salvage at SWP and CVP, 2002 (Foss 2003).

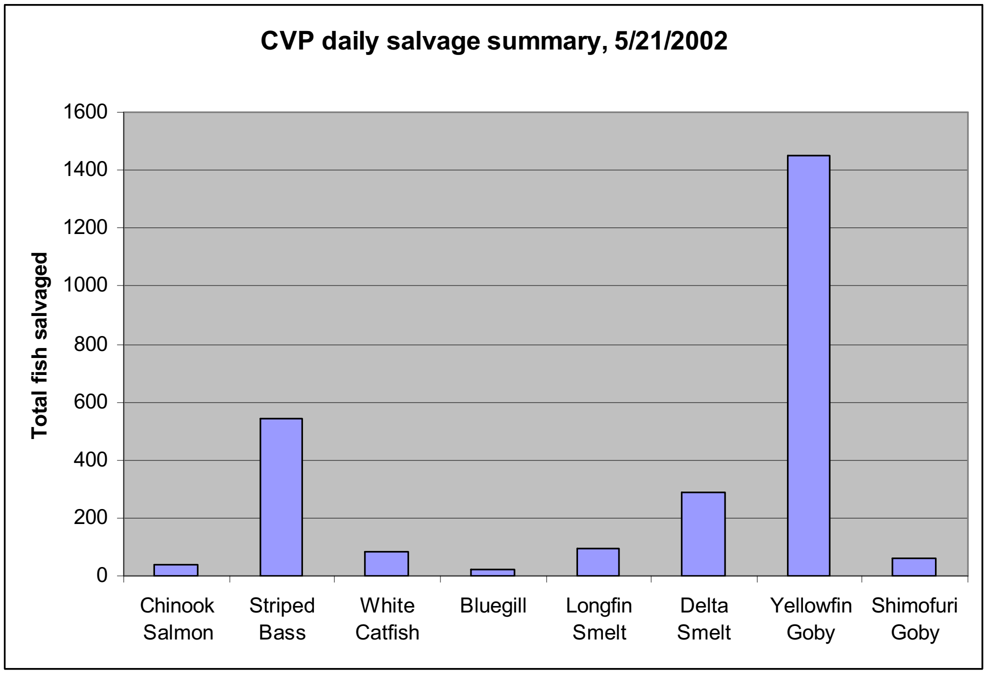


Figure 3-17. Daily salvage at the CVP on May 21st, 2002.

Table 3-7. Operation summary data for 10 minute count at CVP

DATE	TIME	FACILITY	MIN PUMP	CNT LGT	TEMP F
5/21/2002	04:00	CVP	120	10	65
OPENBAY	**PDEPTH**	**PFLOW**	**O_HOLDFLO**	**ACREFEET**	**SECONDARYF**
1234	19.9	836	3.2	1644	32

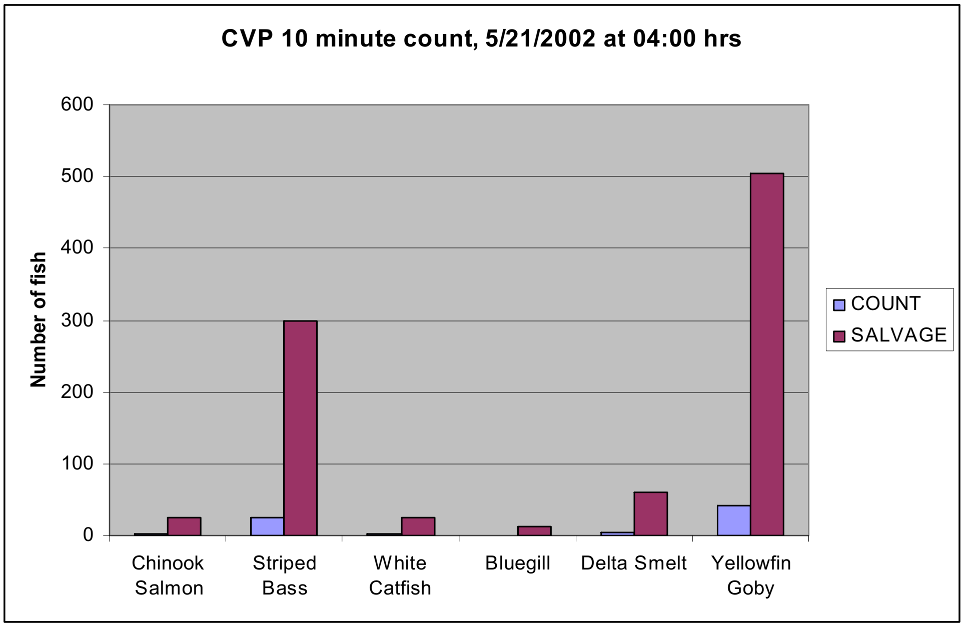


Figure 3-18. Species numbers at CVP for 10 minute count and expanded to total salvage at 04:00 hrs on 5/21/02.

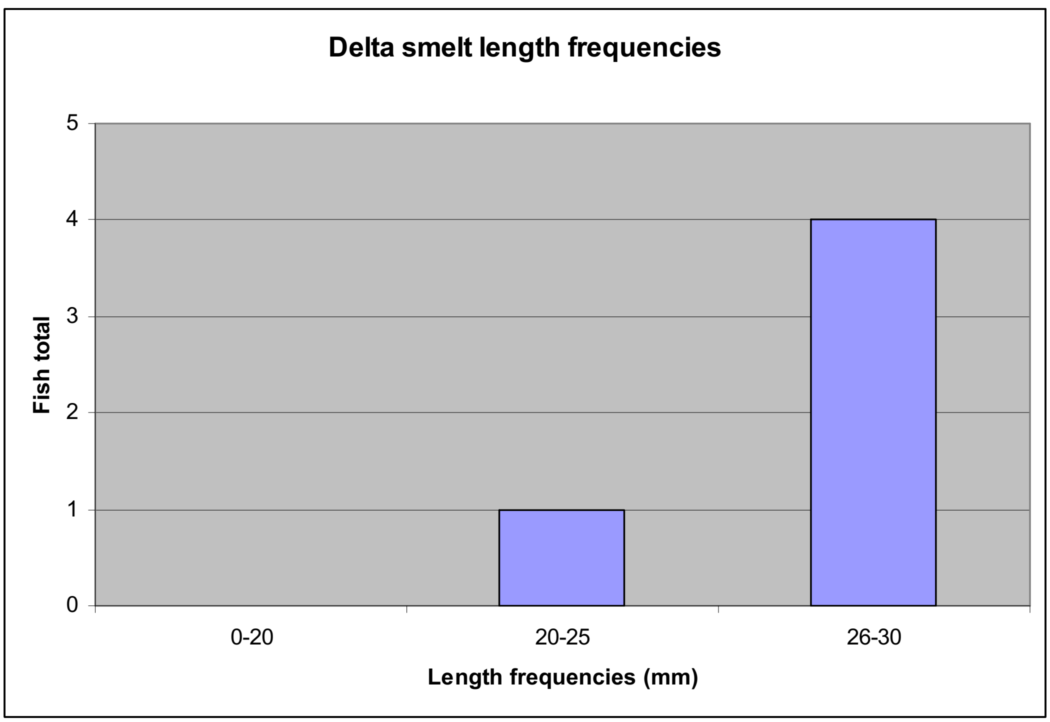


Figure 3-19. Length class frequencies for delta smelt caught in 10 minute count at CVP, 04:00 hrs 5/21/02.

Table 3-8. Salmon data summary from CVP 10 minute count.

FACILITY	DATE	TIME	SPECIES	LGT	ADCLIP	RACE
CVP	5/21/2002	0400	Chinook Salmon	90	N	F
CVP	5/21/2002	0400	Chinook Salmon	89	N	F

3.2.1.5 Fish Densities within the Transport Truck

Data on releases of fish that have been salvaged can be used in conjunction with collection data to calculate potential fish densities within the transport truck. However, in order to do these calculations, additional information from the SWP or CVP salvage data sheets are needed. SWP use internal "in house" calculations on holding tank densities based on sub-samples to determine when a release is needed. CVP simply schedule two releases a day, one in the morning and one in the evening. From the facility datasheets, it would be possible to calculate fish density in the holding tanks, transfer bucket, and transport trucks at the time of a release. Also, at the SWP, it would be necessary to know which transport truck was used, as trucks of varying capacity are available for transport and release. However, currently a 2500-gallon transport truck is primarily used for transport at SWP and a 2000-gallon transport truck is used at the CVP. Information on the specific trucks used for transport is not available from the online datasets available at CVBDB and hence calculations of fish densities within the transport trucks cannot be made without additional information.

Although formal fish density calculations within the transport trucks are not part of the fish facility data collection criteria, biomass calculations are conducted at the SWP salvage facility to calculate loading of fish into transport trucks. Biomass calculations are conducted with the use of "Baits" tables, which are used to estimate biomass per truckload through use of species data, average length data, and season. This allows operators to estimate the biomass of fish within the transport trucks. The assumptions and procedures for calculating biomass within the trucks have been developed from procedures and criteria for transporting fish from hatcheries. Some limited data are available regarding fish densities during transport, but there is no continuous data source. Data on fish densities within the transport truck was recorded as part of DIDSON camera trials in June 2003, which serve as an example for fish transport density data. Tables 3-9 and 3-10 show release and transport fish density data, as well as water quality data, including:

- The collection period;
- The truck used and the transport capacity;
- The time of release;
- The release site;
- The number of fish released;
- Dissolved oxygen at the start and end of transportation; and
- Reference to salt levels if added prior to transport.

These data reflect typical fish densities in June and August 2003. In June, the maximum density was 25,974 fish in a SWP transport truck (number 6), having a capacity of 2500 gallons. The calculated fish density in this example was approximately 9.3 fish per gallon. In August, the maximum density reached 51,269 fish transported in a 2800-gallon truck, resulting in a fish density of 18.3 fish per gallon. The fish releases for the recorded period took place at Horseshoe Bend on the Sacramento River and Curtis Landing on Sherman Island releasing into the San Joaquin River.

Table 3-9. Fish densities and water quality within transport trucks, June 2003.

Collection Period						Fish Released			Dissolved Oxygen			
Start Date	Time	Stop Date	Time	Truck Number	Release Site	Date	Time	Number	Begin	End	Salt	Driver
06/16/03	0700	06/16/03	1500	6	2	06/16/03	1600	186	8.8	8.2	7.3	CR
06/15/03	2300	06/16/03	0700	6	2	06/16/03	0800	3102	8.7	8.2	7.4	RR
06/15/03	1500	06/15/03	2300	6	1	06/15/03	2400	1236	8.8	8.3	7.3	BG
06/15/03		06/15/03			2	06/15/03						
06/15/03	2300	06/15/03	0700	6	1	06/15/03	0800	9696	8.6	8.2	7.5	CR
06/14/03	1500	06/14/03	2300	6	2	06/14/03	2400	879	8.7	8.3	7.4	GM
06/14/03	0700	06/14/03	1500	6	1	06/14/03	1600	627	8.8	8.2	7.8	BK
06/13/03	2300	06/14/03	0700	6	2	06/14/03	0800	21552	8.5	8.0	7.9	BG
06/13/03	1500	06/13/03	2300	6	1	06/13/03	2400	10410	9.1	8.6	7.9	GM
06/13/03	0701	06/13/03	1500	6	2	06/13/03	1600	4230	8.7	8.3	7.6	BG
06/12/03	2301	06/13/03	0700	6	1	06/13/03	0800	25974	8.9	8.4	7.7	BK
06/12/03	1500	06/12/03	2300	6	2	06/12/03	2400	15216	8.6	8.1	7.7	GM
06/12/03	0600	06/12/03	1500	6	1	06/12/03	1600	11277	8.1	7.7	7.4	RS
06/11/03	2301	06/12/03	0600	6	2	06/12/03	0800	16119	8.4	8.0	7.1	BG
06/11/03	1600	06/11/03	2300	6	1	06/12/03	0010	2687	8.8	8.5	7.8	GM
06/11/03	0900	06/11/03	1500	5	2	0611/03	1600	525	8.9	8.6	7.7	RS
06/10/03	2400	06/11/03	0800	5	1	06/11/03	0900	2016	8.6	7.9	7.2	RS
06/10/03	1500	06/10/03	2400	5	2	06/11/03	0100	1503	8.4	7.8	7.3	CR
06/10/03	0800	06/10/03	1500	5	1	06/10/03	1600	474	8.6	7.9	7.2	KV
06/09/03	2300	06/10/03	0700	6	2	06/10/03	0800	2022	8.9	8.0	7.4	KV
06/09/03	1600	06/09/03	2300	6	1	06/09/03	2400	765	8.8	8.3	8.0	RR
06/09/03	0700	06/09/03	1500	6	2	06/09/03	1600	1557	8.4	8.2	7.8	MF
06/08/03	2300	06/09/03	0700	6	1	06/09/03	0800	1542	9.3	9.0	8.6	MF
06/08/03	1500	06/08/03	2300	6	2	06/08/03	2400	894	9.6	9 .4	8.2	CR
06/08/03	0700	06/08/03	1500	6	1	06/08/03	1600	318	8.8	7.9	6.9	KV
06/07/03	2300	06/08/03	0700	6	2	06/08/03	0800	3462	9.1	8.6	7.2	MF
06/07/03	1500	06/07/03	2300	6	1	06/07/03	2400	1020	9.5	9.1	8	BK
06/07/03	0700	06/07/03	1500	6	2	06/07/03	1600	342	9.8	9.6	8.2	RR
06/06/03	2300	06/07/03	0700	6	1	06/07/03	0800	2586	9.7	9.3	8.1	RR
06/06/03	1500	06/06/03	2300	6	2	06/06/03	2400	903	9.6	9.4	8.2	BG
06/06/03	0700	06/06/03	1500	6	1	06/06/03	1600	429	9.4	9.1	7.9	RR
06/06/03	2300	06/06/03	0700	6	2	06/06/03	0800	3456	9.5	9.3	8.1	RR
06/05/03	1500	06/05/03	2300	6	1	06/05/03	2400	859	9.6	9.2	7.4	BK
06/05/03	0700	06/05/03	1500	6	2	06/05/03	1600	705	9.5	9.1	8.0	RS

Table 3-10. Fish densities and water quality within transport trucks, August 2003.

Collection Period						Fish Released			Dissolved Oxygen			
Start Date	Time	Stop Date	Time	Truck Number	Release Site	Date	Time	Number	Begin	End	Salt	Driver
08/18/03	0900	08/19/03	0800	6	2	08/19/03	0900	24876	6.7	6.4	2.9	GR
08/17/03	0900	08/18/03	0900	6	1	08/18/03	1000	47661	6.2	6.1	2.8	BK
08/16/03	0900	08/17/03	0900	6	2	08/17/03	1000	15475	7.9	7.5	3.8	BG
08/15/03	0800	08/16/03	0900	6	1	08/16/03	1000	24984	8.1	7.7	3.9	GM
08/14/03	0800	08/15/03	0800	2	2	08/15/03	0900	15981	7.7	7.2	4.1	GM
08/13/09	0900	08/14/03	0800	2	1	08/14/03	0900	21222	7.4	6.8	4.1	GR
08/12/03	0900	08/13/03	0900	5	2	08/13/03	1000	8364	8.6	8.1	3.8	GR
08/10/03	0900	08/12/03	0900	5	1	08/12/03	1000	11562	8.7	8.1	3.9	CR
08/09/03	0900	08/10/03	0900	6	2	08/10/03	1000	71229	8.6	8.0	3.9	RR
08/08/03	1000	08/09/03	0900	6	1	08/09/03	1000	36936	8.5	8.0	3.8	BK
08/07/03	1000	08/08/03	1000	6	2	08/08/03	1100	65121	7.7	7.4	3.5	BG
08/06/03	1000	08/07/03	1000	6	1	08/07/03	1100	47496	7.9	7.3	3.3	RS
08/05/03	1000	08/06/03	1000	6	2	08/06/03	1100	26361	8.0	7.2	3.0	RE
08/04/03	1500	08/05/03	1000	6	1	08/05/03	1100	34443	7.7	6.9	3.4	MF
08/04/03	1000	08/04/03	1500	6	2	08/04/03	1600	51269	7.7	6.8	3.7	MF
08/03/03	1100	08/04/03	1000	6	1	08/04/03	1100	37971	9.6	9.2	4.2	GR
08/02/03	0800	08/03/03	1100	6	2	08/03/03	1200	32586	9.1	8.0	4.9	MF

NOTES: For the Release Sites, and for the Truck Number

Release Sites:			Truck Capacity (Gallons)	
State Water Project			600	0
Curtis Landing	1	(San Joaquin River-on Sherman Island)	1000	1
Horseshoe Bend	2	(Horseshoe Bend, Sacramento River)	1200	2
Brannan Island	3	(Three Mile Slough, connecting Sacramento River and San Joaquin River)	1500	3
Central Valley Project			2000	4
CDFG Delta Base	4	(San Joaquin River, CDFG Delta Base in Antioch)	2500	5
Emmaton	5	(Sacramento River-on Sherman Island)	2800	6
			Other	7

3.3 Summary of Fish Salvage Operational Data

In addition to the biological data available from the fish salvage operations, there is a wide range of operational data available regarding the fish salvage facilities. This section describes and summarizes the data available regarding operational parameters of the fish salvage facilities, such as export pumping rates, holding tank flows, and water temperature during fish collection. Also described in this section are operational data from the fish salvage facilities that effect fish salvage as well as mortality and pre-screen losses. These data sets include gate operation summaries and intake flows into Clifton Court Forebay, pumping rates for the SWP Banks pumping station relating to flows through fish facilities, debris data at the fish facilities and debris trends through the years, and bathymetry data for Clifton Court Forebay. Similar operational data are recorded at the CVP fish salvage facility.

3.3.1 Operational summary for biological sampling

During fish salvage sub-sampling of holding tanks, operational data are recorded for the fish facilities. The operational data are recorded onto data sheets during sub-sample fish counts (Appendix 5) and is entered into a database along with all of the fish salvage biological data (described in Section 3.2 above). The operational, and biological, data are available to the public for download at the Department of Fish and Game website for the Central Valley Bay-Delta Branch fish salvage monitoring website at http://www.delta.dfg.ca.gov/Data/Salvage/.

The operational data describe and summarize the following parameters for the sub-sample fish counts at both the SWP and CVP salvage facilities:

- Date and time;
- The length of time in minutes water has been pumped into the holding tanks;
- The count length in minutes for the sub-sample;
- The water temperature (*f);
- The number of bays open (applicable to SWP only);
- The water depth (ft) at the primary louvers
- The water flow (acre- feet) at the primary louvers
- The water flow (CFS) in the holding tanks;
- Total pumping (acre-feet).

An example of the operational data can be seen in Table 3-7. The date and time allows hourly operational data to be correlated with the biological salvage data. In this way it is possible to summarize operational data, such as, water temperature or pumping rates, fish species and count numbers recorded for each sub-sample recorded.

3.3.2 Clifton Court Forebay (CCF) intake flows and radial gate operations

Summary data exist on the IEP website (described as a resource for data in Section 3.6 below) for Clifton Court Forebay (CCF) intake gate operations. These data are available hourly from the DWR sample station CHWST000. The intake data for CCF summarize the gate opening height for each of the five tidal radial intake gates as well as the water surface elevation inside and outside of Clifton Court Forebay in relation to mean sea level (Table 3-11).

Table 3-11. Clifton Court Forebay gate operation summary.

		Gate Opening (ft)						
Date	**Time**	**G1**	**G2**	**G3**	**G4**	**G5**	**Outside Elevation (ft)**	**Inside Elevation (ft)**
1-Mar-05	100	8.97	8.99	9	8.99	9	0.96	0.07
1-Mar-05	200	11.97	12	11.99	12	11.99	0.44	0.09
1-Mar-05	300	9	9.01	9.02	9.01	9	0.25	0.03
1-Mar-05	400	10.76	11.03	10.94	11.05	11.2	0.27	-0.08
1-Mar-05	500	11.97	12	11.99	12	11.99	0.46	0.02
1-Mar-05	600	11.97	12	11.99	12	11.99	0.75	0.23

It is possible to use these data to estimate flow through each radial intake gate, and therefore intake into Clifton Court Forebay during gate openings on an hourly basis. As an example of intake flow calculations for the period of gate opening shown in Table 3-11, Table 3-12 shows maximum potential flow through the gates hourly and the total intake to Clifton Court Forebay (cfs) hourly for the same duration.

Table 3-12. Maximum potential flow through CCF intake gates.

		Maximum flow through each gate (cfs)					
Date	**Time**	**1**	**2**	**3**	**4**	**5**	**Total**
1-Mar-05	100	1825	1582	1515	1501	1455	7878
1-Mar-05	200	1529	1344	1287	1271	1226	6658
1-Mar-05	300	913	809	776	763	734	3995
1-Mar-05	400	1375	1236	1174	1171	1145	6100
1-Mar-05	500	1714	1501	1436	1421	1371	7442
1-Mar-05	600	1863	1627	1556	1541	1488	8075

The intake maximum flow estimates shown in Table 3-12 are calculated using the open height of each 20-foot wide intake gate, the cross sectional area of the channel, as well as the elevation difference of surface water inside and outside the forebay. Intake velocities can effect fish entrainment into Clifton Court Forebay, as well as potential predator and larger fish movement into and out of Clifton Court Forebay when the radial gates are open. DWR online data sets from the IEP website, (Section 3.6) state that the intake velocity calculations were based on Ed Hill's calculation and the intake estimates were estimated as follows:

Bulletin 200 states: When q = 16,000 cfs then v = 3ft/sec

therefore, a = q/v = 16000 / 3 = 5333 sqft

velocity in intake channel = v = q / a = qtotal / 5333sqft

qtotal = g1 +g2 +g3 +g4 +g5, cfs

3.3.3 Pumping Volume

Summaries of hydrologic monitoring are available for a wide array of stations maintained by various agencies within the South Delta region. These data sets and the availability and source of the data are discussed in Section 3.6 below. Available among these datasets are 24-hour daily mean pumping rates for the Banks Pumping Station, maintained by the Department of Water Resources. Figure 3-20 shows an example summary for daily pumping rates from December 2004 through to March 2005 for the State and Federal fish salvage facilities.

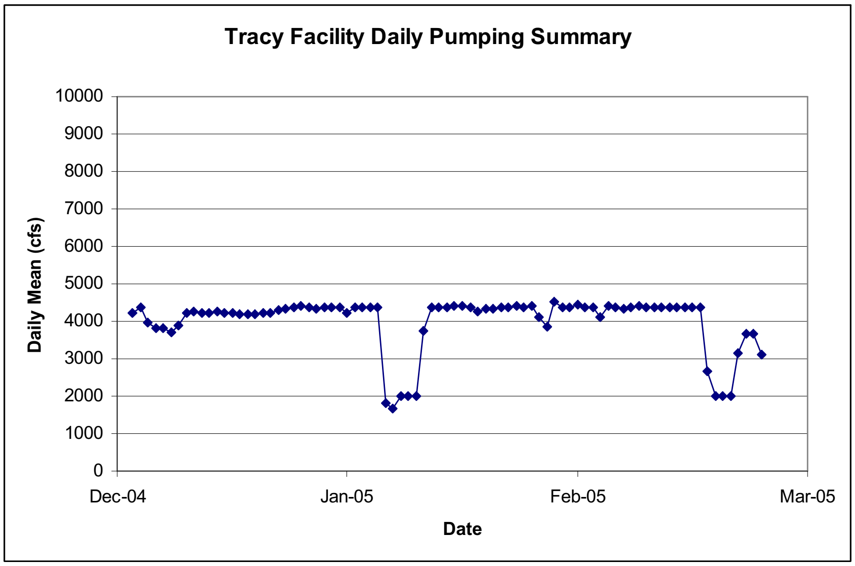


Figure 3-20. Daily pumping (cfs) from December to March, 2005, for the State and Federal fish salvage facilities.

Pumping rates dictate the water flow through the fish salvage facilities, and can affect factors such as debris loading on the trash racks and the fish salvage system.

3.3.4 Debris

Debris collection and concentration at all stages of the fish salvage process has become an increasing concern over the years. Debris build up and the management of debris has become a crucial issue at both the SWP and CVP for fish mortality and hydraulic operations. Debris interferes both with water supply reliability and with fish salvage operations. The current system of fish salvage concentrates debris and fish into the holding tanks and, subsequently, the transport trucks.

The most common and serious type of debris affecting the fish salvage operations are aquatic weeds including water hyacinth mats, *Egaria densa*, peat, and duckweed. Hyacinth mats have been reported to cover six square miles at peak times at the CVP. Although there is some evidence that the Boating and Waterways herbicidespraying program in the delta has been effective at localized water hyacinth control, the *Egaria densa* problem has worsened at the salvage facilities. Debris removal from the fish salvage facilities has become increasingly labor intensive over the years and an increasing challenge to maintain operational performance of the facilities. The increasing debris load on the facilities has necessitated new trash rack cleaning technologies to be installed as well as other systems focused on debris removal, such as a debris collection conveyor belt at the SWP. Peak debris loads in recent years have exceeded the capabilities of the existing facilities. Debris build up on the trash rack interferes with water supply reliability as a result of head loss through the system.

Similar debris problems are encountered at the CVP where hyacinth is the main aquatic weed impacting fish salvage operations and water supply reliability. In addition to aquatic weeds, the CVP facility has experienced heavy debris loading from large islands of peat entering the salvage facility. Large peat sections break off banks further upstream and are carried with the current to the salvage facility causing severe disruption. In addition to peat and hyacinth debris loading, the CVP facility has experienced heavy loading on the trash rack of the invasive species, Chinese mitten crab. This species has historically overwhelmed the CVP facility due to the very high numbers of mitten crabs. These crabs can foul the trash rack as well as all other parts of the CHTR process due to a behavioral tendency to cling together, forming walls and mats of crabs throughout the fish salvage process. These crabs can form mats similar to the hyacinth within the collection buckets, allowing water to drain out of the bucket, but retaining the fish and interrupting the handling process. At the peak of this problem, a traveling screen was installed at the CVP facility to filter the mitten crabs out of the secondary louvers before the collection tanks. Mitten crab numbers were recorded by taking ten-minute counts on individuals from the traveling screen. The data sheet for the mitten crab debris loading can be seen in Appendix 5, but these data are not available as an online resource at this time.

Fish collection is impacted severely by debris loading. In addition, the deep tank gravity fish bypass collection system concentrates fish and debris into the collection bucket. Heavy debris loading in the transport truck and collection bucket causes fish to be dewatered as debris acts as a sieve, allowing water to leave the collection bucket and transport truck, while retaining salvaged fish within the debris mats.

At the SWP facility, debris removal from the trash rack is recorded in cubic yards daily by the Department of Water Resources. Figure 3-21 summarizes the debris loads for the SWP facility from February 1999 to April 2005. There is a gap in the available debris loading records from April 2001 to August 2002. The debris data from the SWP shows a trend of increasing debris loads between 1999 to 2004. The peak debris loads occur in fall through January.

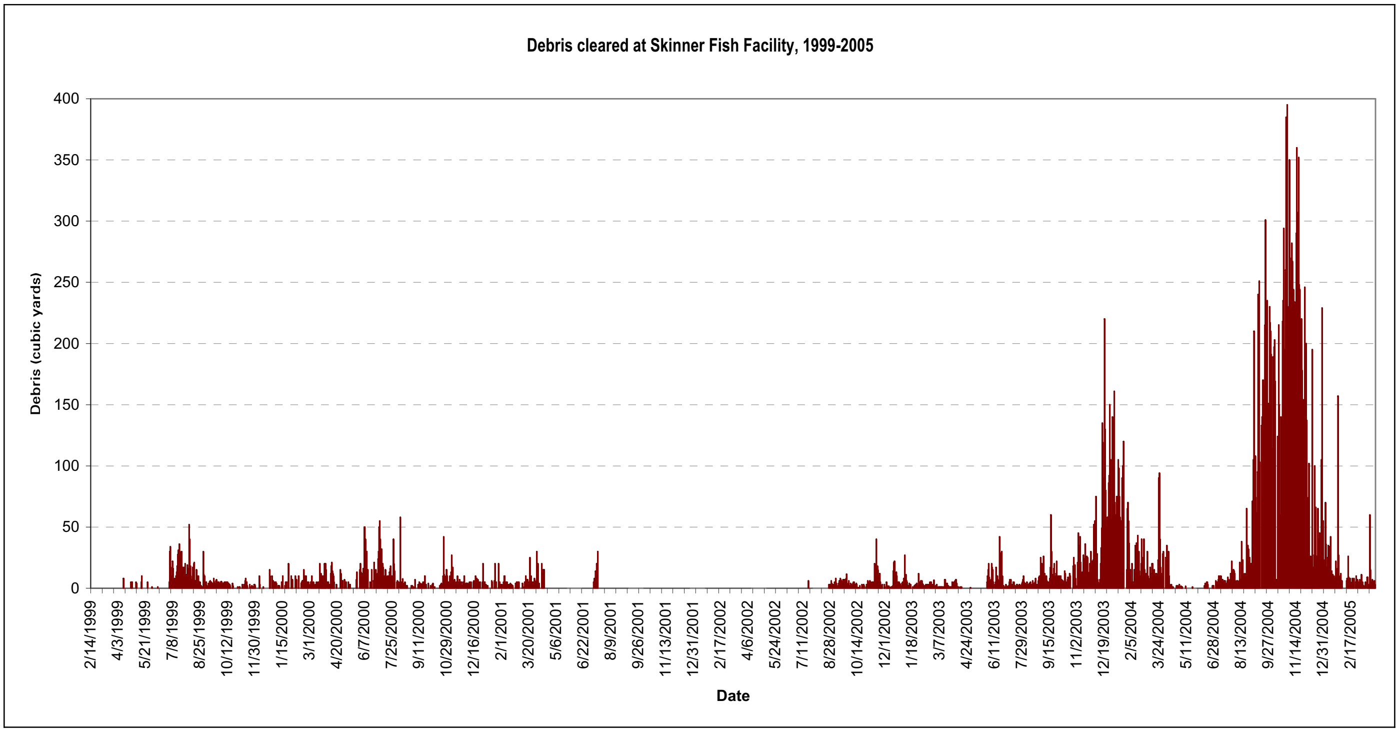


Figure 3-21. Daily debris loads (cubic yards) at SWP.

3.3.5 Clifton Court Forebay bathymetry data

Bathymetry surveys have been conducted detailing water depth across Clifton Court Forebay (CCF). The Department of Water Resources completed a bathymetry map of CCF in December 2004 using the GIS software ArcView. Figure 3-22 shows the water depth and bathymetry of CCF as measured in the recent bathymetry surveys. Current bathymetry data can be compared to historical records of water depth and bathymetry in CCF to better understand changes in water depth and sediment deposition patterns across CCF over time. Current accurate bathymetry data can also be used for management considerations for CCF such as potential dredging operations to increase water storage volume within the forebay and associated water supply and reliability.

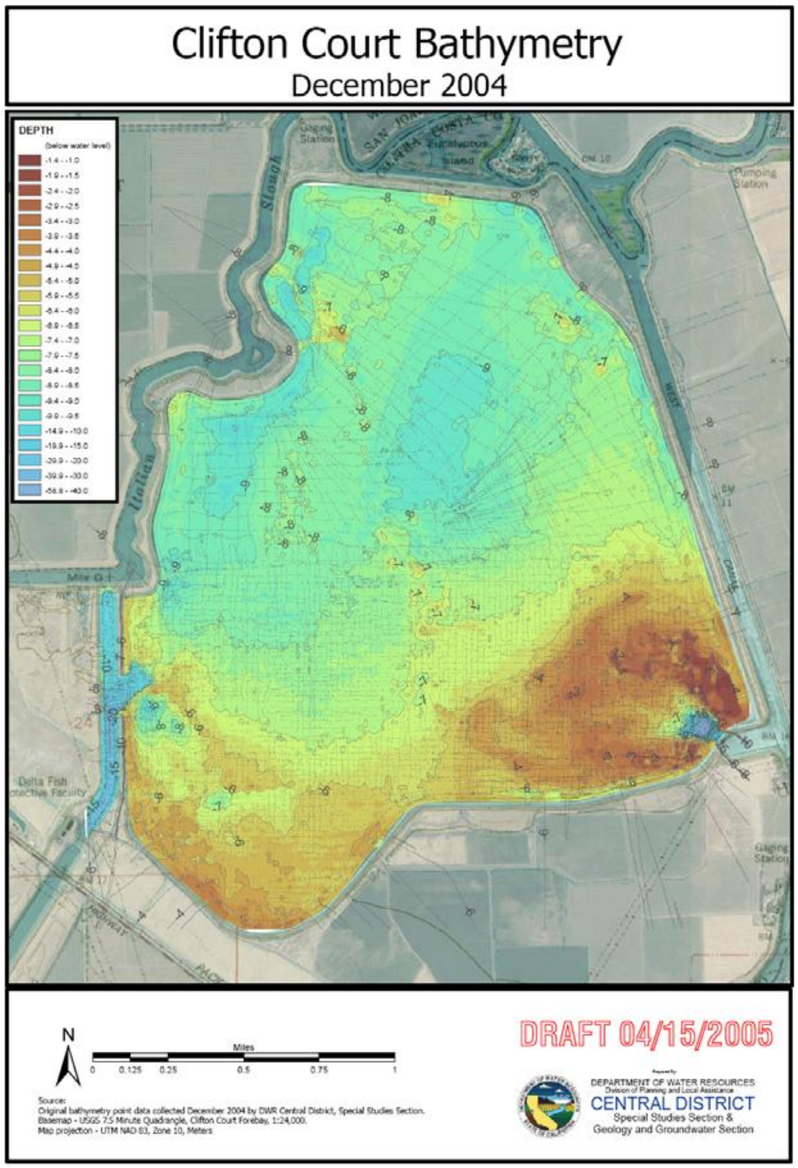


Figure 3-22. Clifton Court Forebay bathymetry map.

3.4 Predation and Pre Screen Losses

Losses of fish entrained into Clifton Court Forebay during passage from the radial gates to the salvage facility, termed pre-screening losses, include predation by fish and birds. Predation by adult and sub-adult striped bass may account for much of the pre-screen loss (Gingras 1997; Gingras and McGee 1997). Kano (1990) and Brown *et al.* (1995) described pre-screen loss as synonymous with predation by striped bass (cited in Gingras 1997). Gingras (1997) summarizes the results of mark / recapture experiments conducted by the Department of Fish and Game, as part of the Interagency Ecological Program. These studies, conducted between 1976 and 1993 were designed to estimate pre-screen loss to juvenile fish entrained into Clifton Court Forebay. The average pre-screen loss of the three earliest studies was integrated into the 4-Pumps Agreement as mitigation for direct fish losses due to operation of the State Water Project (Gingras 1997). The following sections describe both the previous research into pre-screen loss at the SWP facility, as well as ongoing studies and research into pre-screen loss to quantify loss estimates for juvenile steelhead entering Clifton Court Forebay.

The survival of juvenile fish, and the factors associated with predation mortality within Clifton Court Forebay affecting survival of protected species, needs to be further researched and understood. A pilot scale investigation of striped bass movement patterns and potential predation mortality for juvenile steelhead was conducted in 2005 and is planned to be expanded in 2006 to provide information on the magnitude and seasonal patterns of predation mortality, locations where juvenile fish are most vulnerable to predation, and to help identify potential actions that could reduce pre-screening losses. Factors such as water velocity through the forebay, radial gate operations, export rates, water temperature, water depth, and other factors may affect predation rates and pre-screening losses within the forebay.

3.4.1 Previous predation research in Clifton Court Forebay

Kano (1990) published data on the abundance of predatory fish in Clifton Court Forebay. This study, conducted between March 1983 and February 1984, provided important information on the composition and abundance of predatory fish within the forebay and an understanding of pre-screen losses to juvenile fish moving through the forebay. White catfish and striped bass were found to be the most numerous predators. Kano (1990) suggested that the possibility of predation accounting for the loss of fish crossing the forebay was very strong due to the numbers of predatory fish observed in the study. Kano (1990) discussed the impact on fish losses from striped bass due to the effectiveness of this species as a predator, especially in an impoundment situation due to their mobility and schooling feeding behavior.

Fluctuation in the abundance of the striped bass population inhabiting the forebay suggests that these species move into and out of the forebay through the radial gates affecting seasonal patterns in abundance within the forebay (Kano 1990). Levels of angler harvest and salvage of large fish by the Skinner facility were not high enough during the study by Kano (1990) to account for removal of significant numbers of striped bass. Emigration through the radial gates was hypothesized as a likely explanation for decreases in striped bass abundance. Before the study conducted by Kano (1990), it was assumed that the high velocities passing through the radial gates prevented fish from exiting the forebay. Kano (1990) observed velocities of less then 2.0 ft/sec for short periods when the radial gates were open and suggested that flow through the gates may not act as a barrier to movement by larger fish at these times. Although Kano (1990) did not actually monitor fish swimming out through the gates, anglers reported capturing tagged striped bass from the study (Kano 1990) outside the forebay. Recent results of radio and acoustic tagging of adult striped bass have confirmed these earlier speculations. The implication that striped bass are not isolated from the rest of the Delta population complicates the task of controlling this species through traditional management techniques.

A number of studies were conducted between 1976 and 1993 to estimate predation losses of fish moving across Clifton Court Forebay. Studies evaluating predation losses to juvenile Chinook salmon moving across Clifton Court Forebay revealed pre- screen losses of 97% and 88% (Schaffter 1978 and Hall 1980; cited in Kano 1985). Kano (1985) conducted further studies to estimate pre-screen losses of juvenile Chinook salmon and juvenile striped bass to predation in the forebay. Two groups of juvenile fall run Chinook were marked with different colored pigments in early April (Kano 1985). Approximately 17,587 salmon were marked with red pigment, and approximately 8,215 salmon were marked with green pigment (Kano 1985). The group of salmon marked with red pigment was released on the 25th of April inside the forebay near the radial gate intake at 18:30 hours, when water flow through the gates was approximately 6,000 cubic feet per second (cfs). The group marked with green was released near the floating trash boom about 100 m upstream from the Skinner facility primary louvers. Two separate releases were made at this location (Kano 1985). The first occurred at 19:30 hours when the export pumping rate was 2,260 cfs, and the second release was at 22:00 hours at a pumping rate of 6,400 cfs. The group released at the radial gates numbered 13,493 salmon with a mean fork length (FL) of 78.7mm. Release numbers for the two trash boom releases were 2,900 and 2,953 fish with a mean size of 74.7 mm FL (Kano 1985).

Marked fish were recovered by monitoring salvage at the Skinner facility starting immediately after the radial gate release and ending on May 5th 08:00 hours. All Chinook salmon salvaged were examined under ultra-violet light to determine if they were marked with the green or red pigment (Kano 1985). Recoveries were made by examining the entire catch of the facility from 18:30 hours on the day of the release to 24:00 hours on the following day (Kano 1985). Subsequent recoveries were made by taking 20-minute sub-samples at least once every two hours. The numbers of marked salmon observed during the sub-sampling recoveries were expanded to estimate actual numbers of recaptured (salvaged) marked salmon (Kano 1985).

From this experiment, a total of 3,910 salmon were recovered from the trash boom release of 5,853 fish, and 3,310 salmon were recovered from the radial gate release of 13,493 fish (Kano 1985). Marked salmon from the trash boom group were present in the salvage facility collections immediately after release, with the majority of recoveries occurring by midnight of that day (Kano 1985). The first recovery of a radial gate group salmon was made approximately two hours after that release, with peak returns occurring two days after release, and by May 1st 95% of total recoveries were made (Kano 1985).

Kano (1985) calculated the survival estimates for the trash boom release group of salmon with the following formula:

$$\text{Survival trash boom release group} = \frac{\text{No. trash boom salmon recovered}}{\text{Screen efficiency X No. salmon released}}$$

With an average screen efficiency (percentage of fish diverted from water export diversions for salvage) of 74%, survival of young-of-the-year salmon from the trash boom to the holding tanks was 90.2%. Survival of the radial gate release group was calculated with the following formula:

$$\text{Radial gate group survival} = \frac{\text{No. radial gate salmon recovered}}{\text{Trash boom survival X Screen efficiency X No. salmon released}}$$

It was estimated that the survival of salmon from the radial gate to the trash boom was 36.7% (Kano 1985)

The evaluations conducted by Kano in 1984 (Kano 1985) were consistent with results of previous experiments conducted to determine pre-screen losses within Clifton Court Forebay for juvenile fish to predation. Within the study presented by Kano (1985) juvenile Chinook salmon suffered losses of 63% between the radial gates and the Skinner facility trash boom. These pre-screen losses were much lower than in previous studies (97% and 88% by Schaffter 1978 and Hall 1980; cited in Kano 1985). Although Kano (1985) used salmon that were smaller than the fish used in the earlier studies, Kano (1985) conducted the study in the spring, whereas the earlier studies were conducted in the fall. Kano (1985) suggested this seasonal difference was a major contributor to the difference in pre-screen losses.

The population studies of predators inhabiting Clifton Court Forebay (Kano 1990) found that sub-adult and adult striped bass are present in large numbers in the forebay. Population size tends to fluctuate throughout the year with the lowest abundance occurring in early summer and highest abundance occurring in late fall (Kano 1990). Kano (1985) also describes a similar study using release and re-capture of juvenile striped bass in which losses of 94% were recorded. This study was conducted in July, when predator population numbers were increasing and losses for this study are more consistent with earlier findings.

A series of mark/recapture experiments have been conducted by the California Department of Fish and Game within Clifton Court Forebay between 1976 and 1993 in order to determine pre-screen losses for to juvenile Chinook salmon and striped bass (Gingras 1997). See Table 3-13. Of the ten studies conducted, eight evaluated losses to hatchery reared juvenile Chinook salmon, and two evaluated losses to hatchery reared juvenile striped bass. Pre-screen loss was calculated as a function of the proportion of marked fish released at the radial gates and at the trash boom that were recaptured during salvage operations at the Skinner facility (Gingras 1997). Proportions of recovered fish were adjusted for handling mortality, louver efficiency, and any sub-sampling at the facility. These studies showed the range of pre-screen juvenile Chinook salmon losses to be 63-99%.

In summarizing the mark / recapture studies conducted in Clifton Court Forebay, Gingras (1997) suggests there may be common biases throughout the studies due to similar methodologies used. Therefore, Gingras (1997) states that although the magnitude of pre-screen loss is open to debate, the results may still identify underlying mechanisms that influence pre-screen loss and from these it may be possible to suggest alternative operational criteria to reduce such loss. Tillman (1993, cited in Gingras 1997) suggests evaluating how pre-screen loss varies with experimental fish size, water export, water temperature, and predator sized striped bass abundance in Clifton Court Forebay to better understand pre-screen loss in Clifton Court Forebay.

Gingras and McGee (1997) conducted telemetry studies of striped bass observing emigration from Clifton Court Forebay through the radial gates. This emigration holds implications for predator enumeration and control within the forebay due to invalidating absolute abundance estimates of predator sized striped bass from previous mark / recapture studies.

Table 3-13. Summary of pre-screen loss estimates within Clifton Court Forebay based on mark-recapture tests using juvenile Chinook salmon and striped bass.

Year/Month	Species	Pre-Screen Loss (%)	Fork Length (mm)
1976/OCT	Salmon	97	114
1978/OCT	Salmon	88	87
1984/APR	Salmon	63	79
1984/JUL	Striped Bass	94	52
1985/APR	Salmon	75	44
1986/AUG	Striped Bass	70	55
1992/MAY	Salmon	99	77
1992/DEC	Salmon	78	121
1993/APR	Salmon	95	66
1993/NOV	Salmon	99	117

Source: Gingras, M. 1997. Mark/recapture experiments at Clifton Court Forebay to estimate prescreening loss to juvenile fishes: 1976-1993.

3.4.2 Current predation research in Clifton Court Forebay

Fish losses within Clifton Court Forebay have been shown to account for most of the direct losses associated with the entrainment of juvenile Chinook salmon and striped bass at the State Water Project's Delta water export facility. Fish losses within CCF have been largely attributed to predation by fish (particularly by striped bass) and birds (Gingras 1997) as described above. To date, no loss studies have been conducted for other fish species entrained into CCF. To better understand the potential loss rate of steelhead, the National Marine Fisheries Service (NMFS) OCAP Biological Opinion (2004) requires:

1) Investigation of predation on juvenile steelhead within Clifton Court Forebay, and

2) Identification of potential management actions to reduce predation on juvenile steelhead.

The CCF steelhead predation investigation is a precondition to increasing SWP water export rates to 8,500 cfs. In response to this Biological Opinion requirement, California Department of Water Resources has proposed a series of detailed studies in 2006 to evaluate steelhead predation mortality within the SWP CCF (Churchwell et al. 2003). Mark-recapture studies using hatchery steelhead are the primary method proposed to estimate losses within CCF. Telemetry studies are proposed to document the distribution and movement patterns of steelhead and predator sized striped bass.

Pilot investigations using hatchery steelhead were conducted during the spring 2005 to develop successful mark-recapture experiments for the 2006 study. The relatively larger size of out migrating steelhead (200-300 mm) and its stronger swimming capacity raises questions on whether entrained steelhead behave or experience losses similar to smaller juvenile Chinook salmon. Pilot studies using ultrasonically tagged steelhead were conducted in 2005 to evaluate key assumptions necessary for conducting mark-recapture investigations such as the recovery, residency, and emigration rates of marked steelhead. Pilot studies using ultrasonically tagged adult striped bass help identify potential locations within CCF where the risk of predation is increased, movement of predatory fish, and contribute to the identification of potential management actions that would reduce the risk of predation on juvenile steelhead. Results of the CCF steelhead predation pilot study were produced in late summer, 2005.

3.5 Water Quality

Water quality measurements are recorded for a variety of parameters at various locations within the fish salvage process at both the SWP and CVP fish salvage facilities. Water quality measurements are taken at the fish salvage facilities for water entering the facilities and within the holding tanks. Water quality is measured at a wide range of locations throughout the south Delta (Figure 3-23), including the SWP and CVP facility release locations and is available online in a variety of formats. Water quality measurements are also taken periodically within the fish salvage transport trucks, which allows comparison of water quality within the truck to water quality within the holding tanks, as well as comparing water quality at the start and end of the transportation process. These water quality measurements and sources of the data are discussed within this section as well as potential analysis and use of the data.

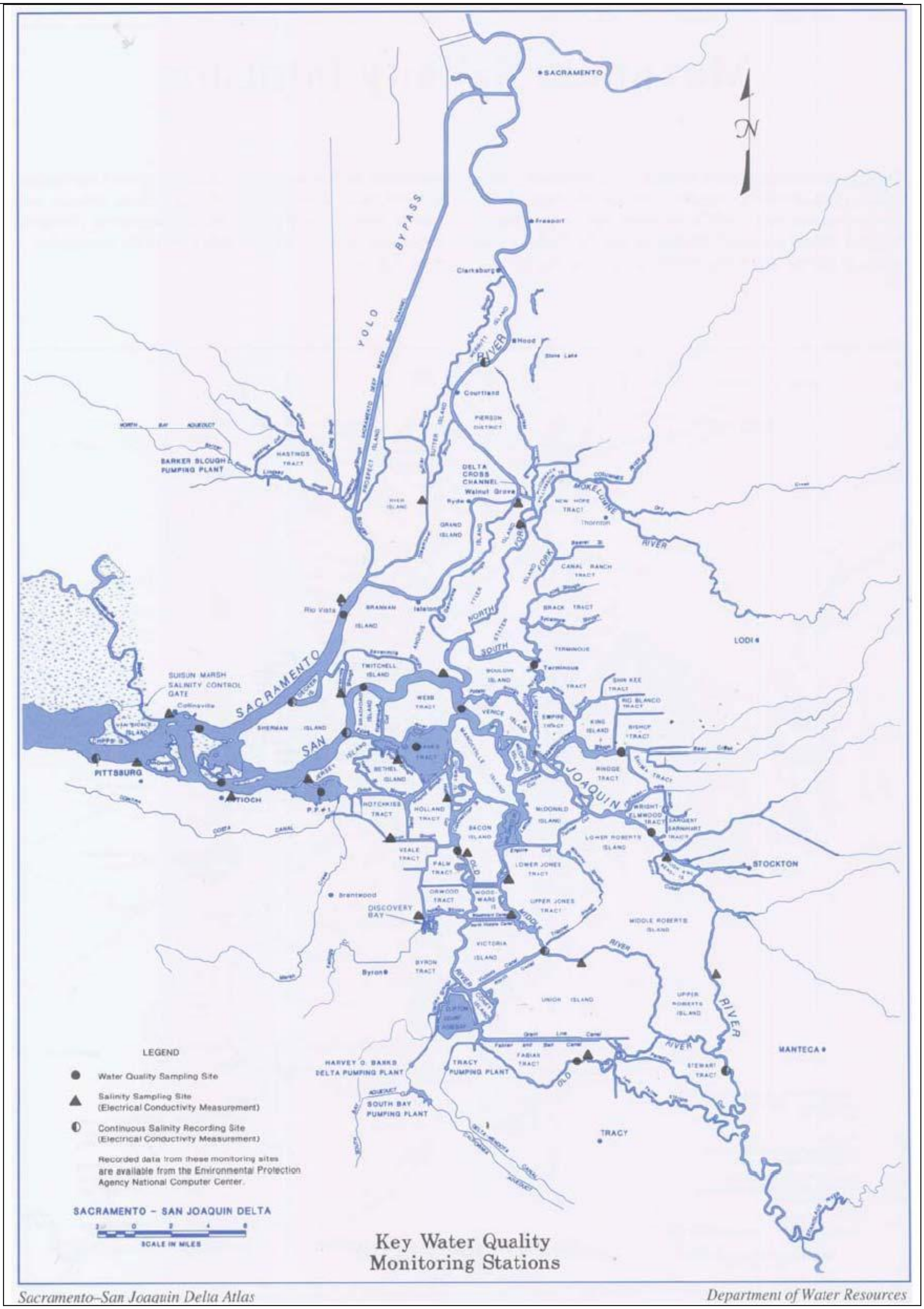


Figure 3-23. Water quality sample station locations around fish salvage operations and release sites (DWR 1993).

3.5.1 Water quality information at the salvage facilities

Water quality data from the Tracy Fish Collection Facility are available online in a variety of formats. Datasets are available for 30 minute and hourly interval multiprobe water quality monitoring as well as daily, weekly, and monthly summaries of water quality data. The multiprobe water quality monitoring data include temperature (C), pH, electrical conductivity (EC), dissolved oxygen (mg/l), turbidity (NTU), and dissolved oxygen as percent of saturation. The multiprobe data can be displayed with background operational data for comparison when summarizing water quality data on an hourly or daily interval. Comparative data are available for air temperature, precipitation, temporary barriers, pumping rates, Vernalis streamflow, and fish salvage. The data may be plotted graphically or be displayed in tabular format. These data are available online at:

www.usbr.gov/pmts/tech_services/tracy_research/index.htm

As an example Figures 3-24 thru 3-28 summarize the daily multiprobe water quality data from the Tracy Fish Collection Facility for temperature, pH, electrical conductivity, turbidity, and dissolved oxygen during January to December 2002. These water quality data have been displayed along with results of daily CVP fish salvage data. These data have been summarized in tabular format also (Table 3-14) from the online datasets. The tabular summary displays minimum, median, and maximum values for the multiprobe water quality data. Tabular data can also be summarized hourly, weekly, and monthly.

Similar water quality measurements for electrical conductivity, dissolved oxygen, and turbidity are not recorded at the SWP fish salvage facility. Water temperature which is recorded during the operational summary of sub-sample fish counts in the holding tanks (Table 3-7), is available online at:

ftp://ftp.delta.dfg.ca.gov/salvage/

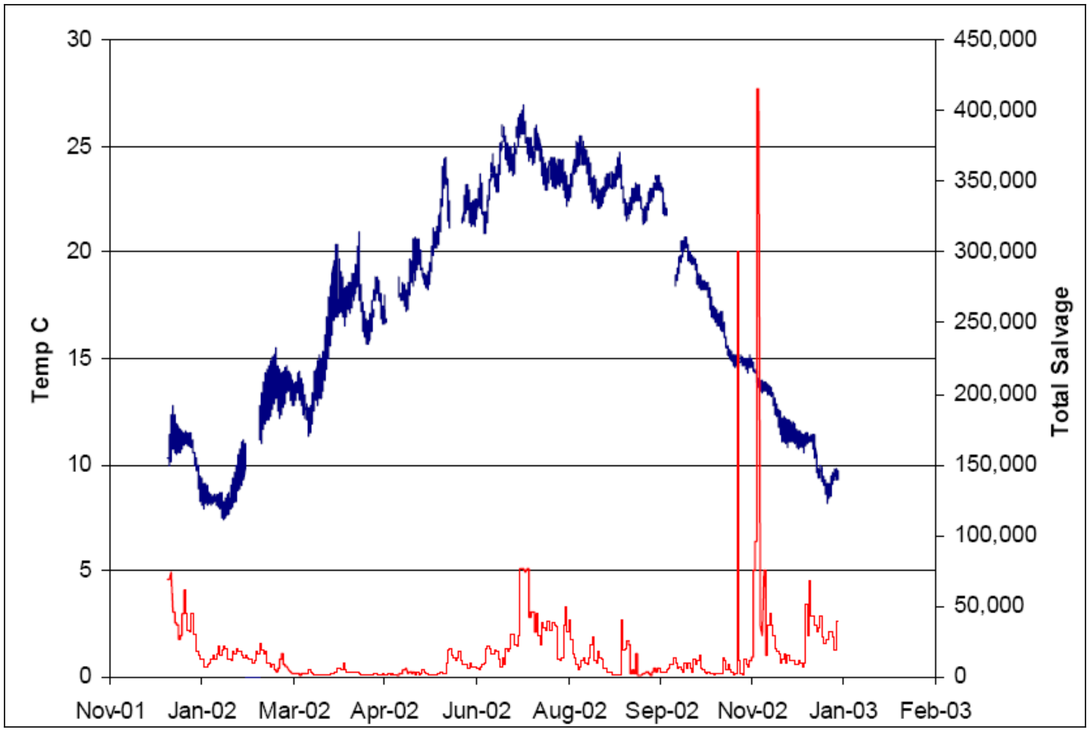


Figure 3-24. Water temperature and daily fish salvage at Tracy Fish Collection Facility, 2002.

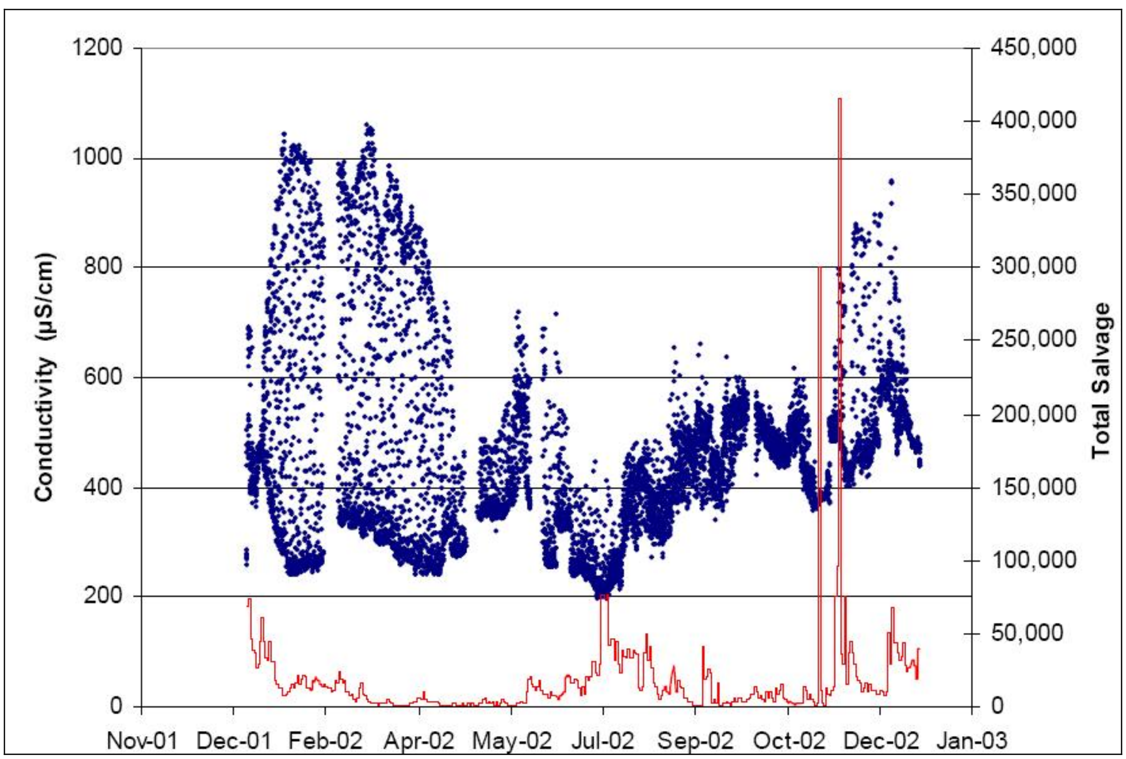


Figure 3-25. Conductivity and daily fish salvage at Tracy Fish Collection Facility, 2002.

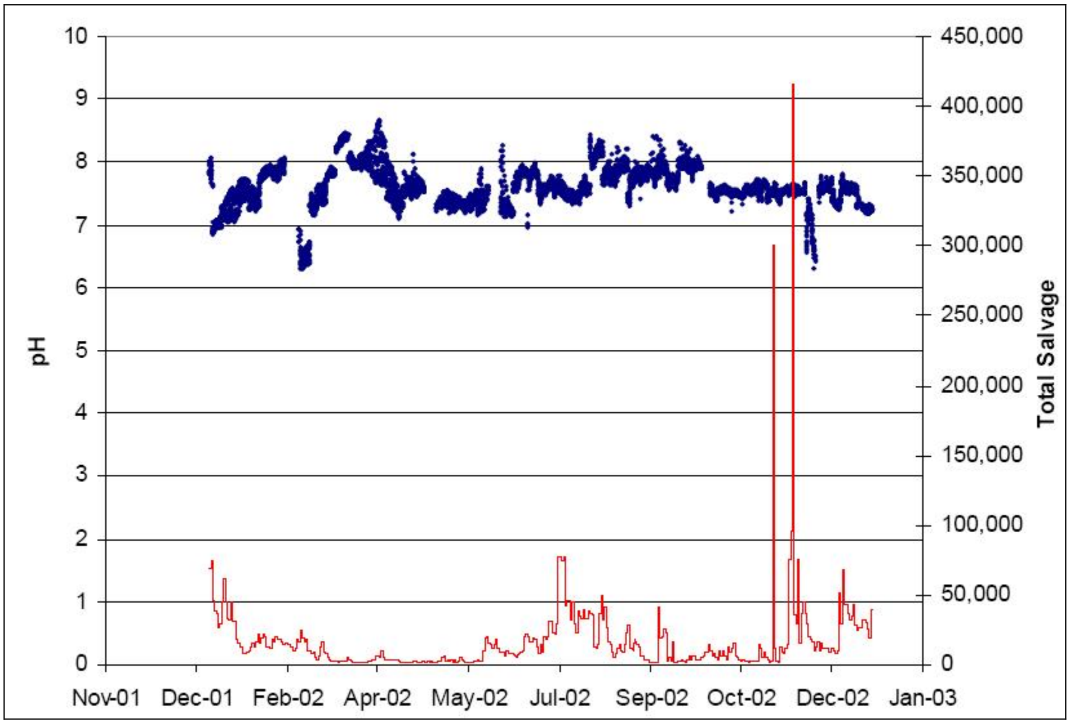


Figure 3-26. pH and daily fish salvage at Tracy Fish Collection Facility, 2002.

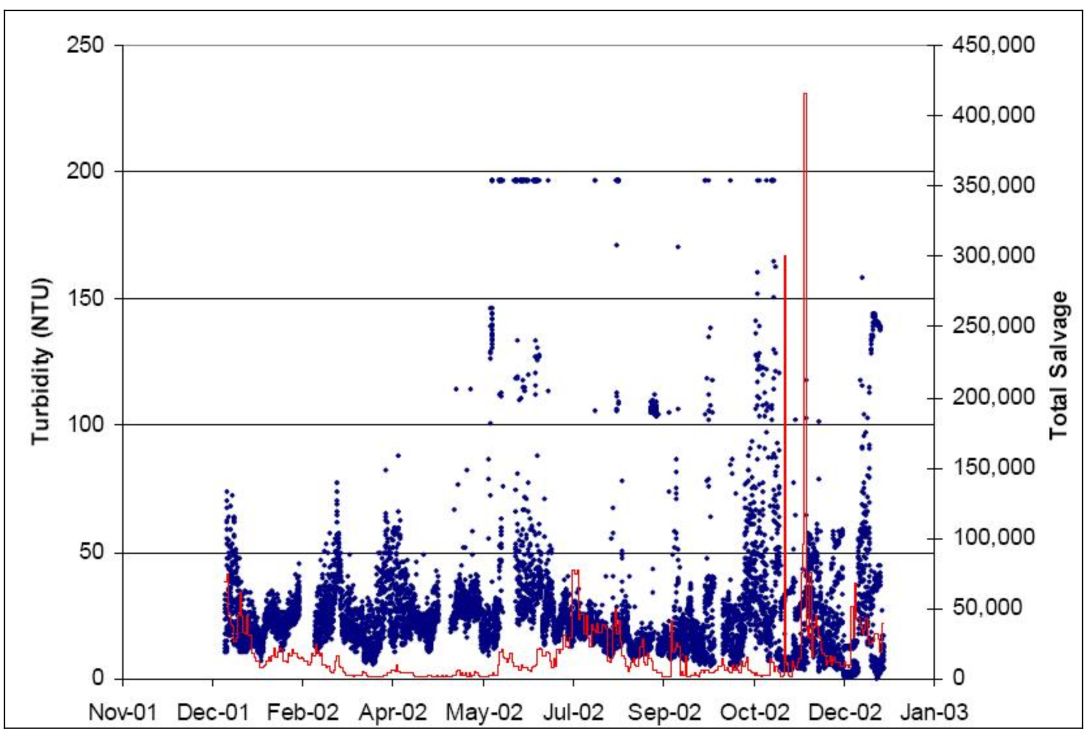


Figure 3-27. Turbidity and daily fish salvage at Tracy Fish Collection Facility, 2002.

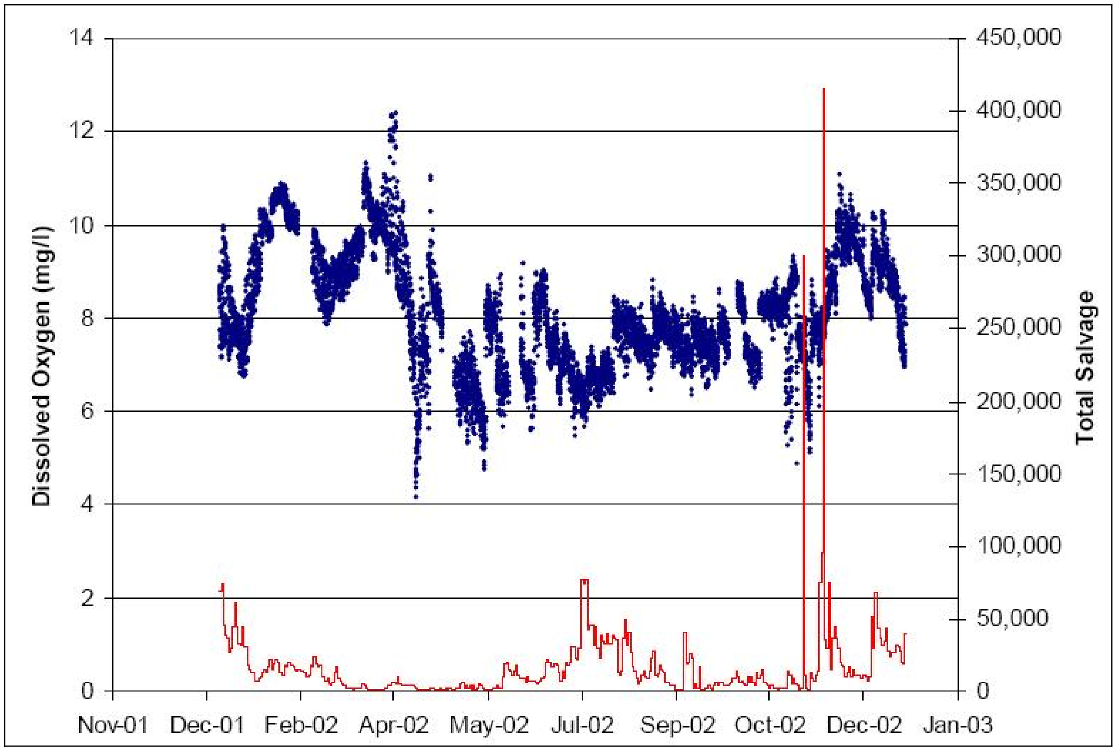


Figure 3-28. Dissolved oxygen and daily fish salvage at Tracy Fish Collection Facility, 2002.

Table 3-14. Summary of Tracy Fish Collection Facility water quality data.

Date	Minimum Temperature, °C	Median Temperature, °C	Maximum Temperature, °C	Minimum pH, su	Median pH, su	Maximum pH, su
5/1/2002						
5/2/2002						
5/3/2002						
5/4/2002						
5/5/2002						
5/6/2002	17.9	18.7	18.8	7.23	7.26	7.33
5/7/2002	17.5	18	18.4	7.24	7.31	7.41
5/8/2002	17.7	18	18.6	7.27	7.36	7.47
5/9/2002	17.5	18	18.6	7.26	7.38	7.46
5/10/2002	17.2	17.5	18.3	7.32	7.4	7.58
5/11/2002	17.3	18.1	18.8	7.29	7.42	7.57
5/12/2002	17.9	18.8	20	7.27	7.39	7.59
5/13/2002	18.6	18.8	19.6	7.18	7.34	7.48
5/14/2002	18.4	18.9	20.7	7.16	7.34	7.51
5/15/2002	18.6	19.4	20.9	7.22	7.36	7.5
5/16/2002	19.2	19.8	20.7	7.21	7.33	7.47
5/17/2002	19.4	19.8	20.6	7.21	7.33	7.43
5/18/2002	19.2	19.5	20.1	7.28	7.37	7.46
5/19/2002	18.5	19.2	19.3	7.25	7.34	7.44
5/20/2002	18.4	18.7	19	7.23	7.32	7.41
5/21/2002	18.3	18.5	18.9	7.19	7.3	7.41
5/22/2002	18.2	18.6	19.2	7.2	7.3	7.39
5/23/2002	18.4	18.8	19.7	7.23	7.35	7.46
5/24/2002	19.1	19.8	20.4	7.25	7.36	7.58
5/25/2002	19.9	20.4	21.3	7.17	7.33	7.45
5/26/2002	20.2	20.6	21.1	7.28	7.35	7.46
5/27/2002	20.1	20.6	21.2	7.3	7.4	7.6
5/28/2002	20.4	21.3	22	7.16	7.39	7.57
5/29/2002	21	21.9	22.7	7.14	7.31	7.86
5/30/2002	22.2	23.1	24.1	7.21	7.42	7.91
5/31/2002	23	23.6	24.5	7.2	7.43	

Table 3-14. Summary of Tracy Fish Collection Facility water quality data (Continued).

Date	Minimum Conductivity, µS/cm	Median Conductivity, µS/cm	Maximum Conductivity, µS/cm	Minimum Turbidity, NTU	Median Turbidity, NTU	Maximum Turbidity, NTU
5/1/2002						
5/2/2002						
5/3/2002						
5/4/2002						
5/5/2002						
5/6/2002	343	352	448	18.4	20.9	39.5
5/7/2002	339	350	482	17.2	23.3	196
5/8/2002	348	362	487	18.3	25.3	43.7
5/9/2002	352	373	494	23.3	28.6	196
5/10/2002	347	362	492	25.4	30	43.3
5/11/2002	350	361	480	23.3	31.9	41.3
5/12/2002	350	362	474	20.7	31	46.5
5/13/2002	340	367	467	17.6	29.8	54.9
5/14/2002	343	355	480	15.8	26.4	136
5/15/2002	347	354	489	20	28.1	36
5/16/2002	318	350	488	21.2	28.4	196
5/17/2002	348	352	505	23.2	29.2	51.4
5/18/2002	347	352	502	22.1	29.3	66.8
5/19/2002	344	353	525	23	30.3	44.4
5/20/2002	346	360	540	23	29.5	41.6
5/21/2002	351	361	543	22.5	26.8	37.9
5/22/2002	317	396	553	12.2	24.8	32.2
5/23/2002	367	406	557	10.5	16.1	32.3
5/24/2002	368	390	516	10.3	14.3	29.3
5/25/2002	366	429	613	10.6	14.7	30.3
5/26/2002	371	504	607	9.2	16.5	148
5/27/2002	382	551	729	13.6	20.4	148
5/28/2002	402	553	740	14.5	130	196
5/29/2002	420	547	685	10.7	29.9	196
5/30/2002	426	548	680	10.6	18.1	33.7
5/31/2002	422	543	676	14.1	21.4	33.1

Table 3-14. Summary of Tracy Fish Collection Facility water quality data (Continued).

Date	Minimum Dissolved Oxygen, mg/L	Median Dissolved Oxygen, mg/L	Maximum Dissolved Oxygen, mg/L	Minimum Percent DO Saturation	Median Percent DO Saturation	Maximum Percent DO Saturation	Sum of all fish salvaged, number/day
5/1/2002							2,688
5/2/2002							1,836
5/3/2002							2,004
5/4/2002							1,428
5/5/2002							1,716
5/6/2002	6.51	6.81	7.16	69.7	73.1	76.3	1,721
5/7/2002	5.84	6.59	7.11	62	69.8	75.3	1,980
5/8/2002	5.73	6.6	7.11	60.4	69.8	75.9	2,160
5/9/2002	5.59	6.6	7.23	58.9	69.9	77.1	4,596
5/10/2002	5.81	6.75	7.64	60.5	70.7	80.8	6,168
5/11/2002	5.92	6.83	7.5	62.1	72.4	80	2,604
5/12/2002	5.64	6.56	7.4	60.7	70.8	81.5	4,152
5/13/2002	5.04	6.46	7.79	54.2	69.6	85.2	2,772
5/14/2002	5.63	6.9	7.7	60.1	74.3	84	3,549
5/15/2002	5.54	6.69	7.46	59.8	72.3	82	1,533
5/16/2002	5.44	6.46	7.17	59.5	70.6	79.1	4,162
5/17/2002	5.28	6.3	6.89	57.8	69.3	76.4	1,608
5/18/2002	5.74	6.36	6.91	62.7	69.3	75.6	2,856
5/19/2002	5.22	6.09	6.65	56.6	65.9	72.2	5,064
5/20/2002	4.94	5.84	6.37	53.2	62.6	68.4	3,348
5/21/2002	4.92	5.59	6.28	52.8	59.9	67.3	2,580
5/22/2002	4.77	5.85	8.3	51.1	62.4	89.8	1,308
5/23/2002	7.15	8.06	8.66	76.8	87	94.1	900
5/24/2002	7.45	8.18	8.71	80.8	89.4	94.8	1,128
5/25/2002	7.07	7.82	8.48	78.1	87.5	93.5	1,152
5/26/2002	7.42	8	8.37	82.4	89	94	1,428
5/27/2002	7.65	7.98	8.71	85.2	88.9	98	2,256
5/28/2002	6.3	7.58	8.34	70.6	85.4	95.4	3,036
5/29/2002	5.63	6.74	9.02	63.7	76	105	3,876
5/30/2002	5.82	6.99	9.02	67.3	81.4	107	3,156
5/31/2002	5.55	6.89	7.78	65.3	81.5	91.6	3,156

3.5.2 Water quality information at release locations

Water quality data are available for electrical conductivity in the vicinity of the SWP and CVP facilities and at release locations (Figure 3-26) online at:

http://www.usbr.gov/mp/cvo/

Tables 3-15 to 3-17 provide examples of data available from this web source. These data allow comparison of conductivity between salvage facilities and release locations on a daily basis, but hourly data are not available. Data sets are available for the years 2000 to 2004. Some locations include other parameters such as dissolved oxygen, temperature, and pH, but these are not recorded for all water quality monitoring sites summarized at this website.

The data available online for release locations can, for example, be compared with the daily electrical conductivity measurements recorded at the Tracy Fish Collection Facility. Analyses of these data provide information on the changes in water quality from the salvage facility to release locations. If the water quality for May 7, 2002 is used for example comparison, Table 3-14, salvage data shows daily fish salvage at the Tracy Fish Collection Facility on that day to be 1,980 fish. Electrical conductivity on this day was recorded at the fish facility as ranging from 339 to 482 µS/cm with a median recorded value of 350 µS/cm. The median value from the salvage facility can be compared to the mean electrical conductivities recorded at or near release sites. On the same day, the mean electrical conductivity at Antioch (surface) on the San Joaquin River was 338 µS/cm, at Antioch (bottom) on the San Joaquin River EC was 341 µS/cm, and at Jersey Point on the San Joaquin River EC was 235 µS/cm (Figure 3-23). Exploring these data demonstrate that on this day, May 7, 2004, fish collected at the Tracy Fish Collection Facility, were released into a largely similar environment in terms of electrical conductivity. However, the addition of salt in the transport trucks would increase the conductivity substantially for transported fish.

Table 3-18 summarizes water quality data available for Clifton Court Forebay from periodic sampling (source:http://wdl.water.ca.gov/wq/gst/water_quality_report1_gst.asp). These data represent periodic sampling and water quality analysis rather then continuous monitoring, such as the type of monitoring conducted at the CVP facility, and summarizes a different range of water quality parameters involving toxins as well as conductivity and turbidity for water entering the forebay. Further water quality data are available for various sampling stations at a wide range of locations throughout the Bay-Delta system (Figure 3-29). These data are available at www.iep.water.ca.gov/dss/ and are discussed more completely in Section 3.6 below. The data available through the IEP time series Delta modeling website, give flow and water quality data for stations at Clifton Court Forebay, the water export pumping facilities, the SWP release location at Horseshoe Bend, and various other points around the Delta (Figure 3-29).

Table 3-15. Example water quality at Antioch (surface), May2002.

May 2002 **Antioch (surface) on the San Joaquin River** Run Date: June 5, 2002

Water Quality Report

Electrical Conductivity, UMHOS

Day	High	Low	Mean
1	746	237	427
2	560	239	407
3	517	185	383
4	463	232	353
5	424	238	343
6	433	249	337
7	476	246	338
8	479	256	335
9	522	248	348
10	633	261	364
11	609	251	362
12	710	254	405
13	787	271	445
14	1040	263	485
15	1157	265	539
16	1221	279	551
17	994	278	540
18	1031	287	563
19	774	269	503
20	699	281	507
21	688	263	433
22	552	263	379
23	511	265	361
24	494	270	365
25	541	262	372
26	627	259	376
27	697	250	376
28	665	251	364
29	590	250	362
30	521	253	357
31	461	264	381

Comments:

0 reading indicates that the station was out of service

Table 3-16. Example water quality at Antioch (bottom), May 2002.

May 2002 **Antioch (bottom) on the San Joaquin River** Run Date: June 5, 2002

Water Quality Report

Electrical Conductivity, UMHOS

Day	High	Low	Mean
1	843	234	431
2	672	240	411
3	542	234	391
4	468	232	346
5	434	236	343
6	453	243	342
7	485	244	341
8	476	255	336
9	527	245	351
10	655	261	376
11	706	252	384
12	773	260	419
13	859	266	464
14	1146	262	507
15	1269	271	561
16	1448	275	597
17	1106	272	560
18	1111	281	580
19	808	268	517
20	737	279	530
21	693	264	449
22	574	263	385
23	559	272	371
24	500	272	368
25	557	264	375
26	651	261	387
27	754	252	391
28	724	253	382
29	689	248	369
30	614	252	368
31	478	263	385

Comments:

0 reading indicates that the station was out of service

Table 3-17. Example water quality at Jersey Point, May 2002.

May 2002 **Jersey Point (surface) on the San Joaquin River** Run Date: June 5, 2002

Water Quality Report

Electrical Conductivity, UMHOS

Day	High	Low	Mean	14 Day Accum Mean	14 Day Avg Mean
1	252	220	226	3,066	219
2	243	222	227	3,063	219
3	234	223	229	3,062	219
4	239	225	230	3,064	219
5	240	227	232	3,081	220
6	237	228	233	3,104	222
7	240	231	235	3,130	224
8	242	231	235	3,150	225
9	243	234	237	3,174	227
10	251	233	239	3,199	229
11	249	235	240	3,224	230
12	258	236	241	3,248	232
13	267	237	243	3,269	234
14	276	236	245	3,291	235
15	292	238	248	3,313	237
16	310	239	252	3,338	238
17	280	235	249	3,358	240
18	298	239	251	3,379	241
19	257	239	246	3,393	242
20	254	240	246	3,406	243
21	253	236	243	3,415	244
22	254	238	243	3,423	245
23	260	237	243	3,429	245
24	262	236	244	3,434	245
25	262	236	244	3,438	246
26	264	227	242	3,439	246
27	265	233	240	3,436	245
28	262	232	239	3,430	245
29	254	227	236	3,418	244
30	255	229	235	3,401	243
31	263	228	236	3,388	242

Comments:

0 reading indicates that the station was out of service

Table 3-18. Example water quality at Clifton Court, December 18, 2002.

Station Name: CLIFTON
Collection Date: 12/18/02 7:40:00 AM
Station Number: KA000000
Sample Code: DZ1202B0260

Depth: 1 Meters Matrix:Water, Natural
Purpose: Normal Sample
Sample Parent: 0
Description: D 21221

Analyte	**Result**	**Rpt Limit**	**Units**	**Method**
Dissolved Boron	0.1	0.1	mg/L	EPA 200.7 (D)
Dissolved Bromide	0.34	0.01	mg/L	EPA 300.0 28d Hold
Dissolved Calcium	19	1	mg/L	EPA 200.7 (D)
Dissolved Chloride	110	5	mg/L	EPA 300.0 28d Hold
Conductance (EC)	543	1	µS/cm	Std Method 2510-B
Hardness	109	1	mg/L as CaCO3	Std Method 2340 B
Dissolved Magnesium	15	1	mg/L	EPA 200.7 (D)
Dissolved Nitrate	4.4	0.1	mg/L	EPA 300.0 48 hr (N03, OP)
Total Organic Carbon	3.9	0.1	mg/L as C	EPA 415.1 (T) Ox
Dissolved Organic Carbon	3.6	0.1	mg/L as C	EPA 415.1 (D) Ox
Total Organic Carbon	5.8	0.5	mg/L as C	EPA 415.1 (T) Cmbst
Dissolved Potassium	4	0.5	mg/L	EPA 200.7 (D)
Dissolved Sodium	67	1	mg/L	EPA 200.7 (D)
Total Dissolved Solids	331	1	mg/L	Std Method 2540 C
Dissolved Sulfate	36	1	mg/L	EPA 300.0 28d Hold
Turbidity	43	2	N.T.U.	EPA 180.1

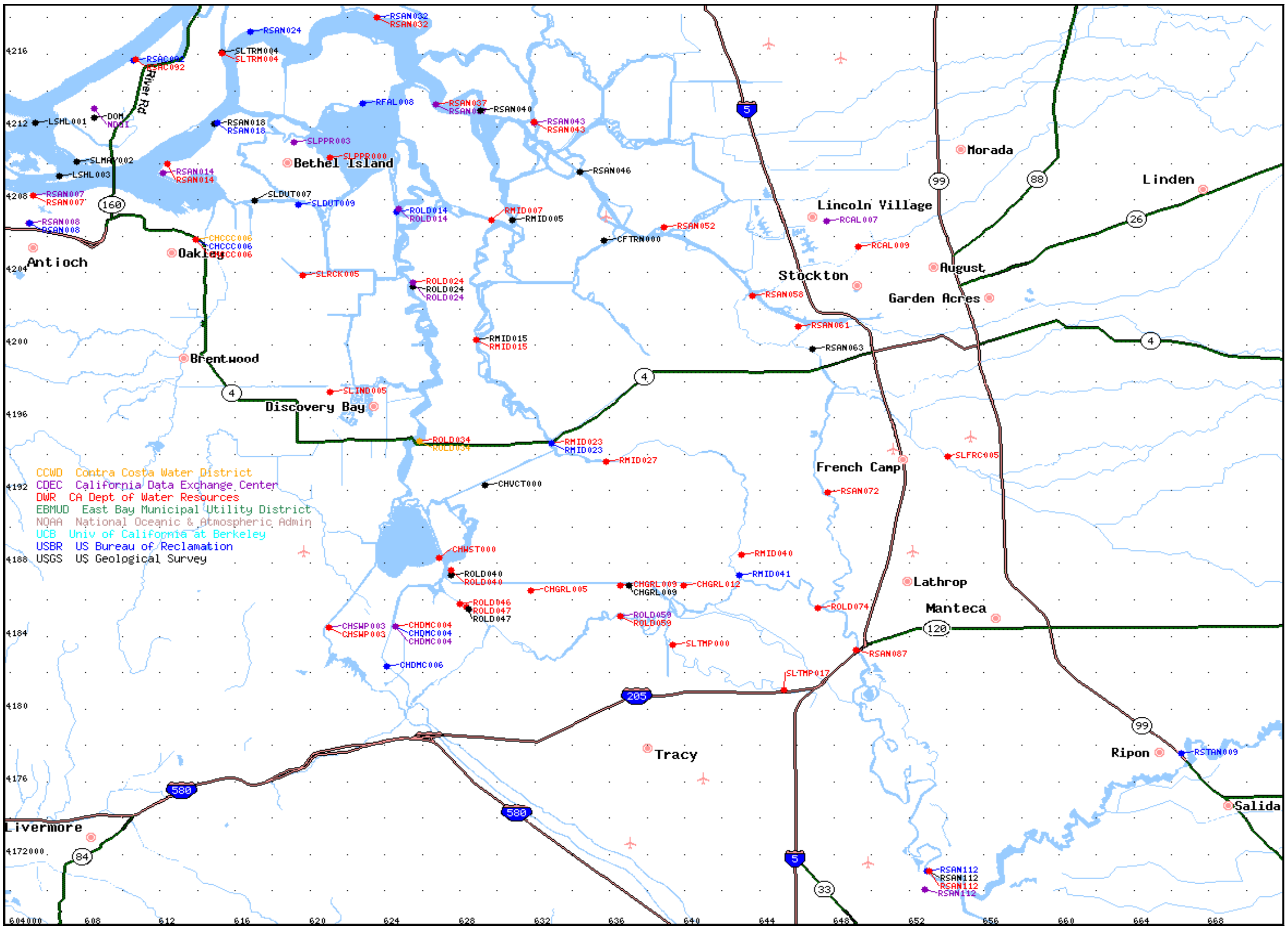


Figure 3-29. South Delta Region hydrodynamic and water quality monitoring stations with web based data sets.

3.5.3 Water quality information in transport trucks

Periodic measurements have been made of water quality within the fish transport trucks. Tables 3-9 and 3-10 show results from periodic water quality sampling within a fish transport truck. These data summarize the collection period for the fish prior to transport in the truck that is currently being used for transport (allowing truck volume capacity to be tracked), at the release site visited as well as release date and time with estimated number of fish released, the dissolved oxygen at the start and end of the transport process, and the volume of salt (in 50lb bags) added to the truck prior to fish transport.

Information on the salvage collection period allows the transport and release data to be correlated to salvage data for that date and time, in addition to detailed information on the numbers, species compositions, and length frequency distributions for fish salvaged and released. In addition, these data can then be used to analyze the effect of water quality changes on species transported at estimated fish densities (Section 3.5.1). Information on the release sites for specific groups of salvaged fish allows further analysis of potential water quality changes experienced by the fish as they move from collection, to holding, to transport, to release as water quality data are potentially collected and available for all of these stages of the salvage process. Access to these data sources will allow investigators to evaluate possible adverse affects or mortality on various fish species as they move through the CHTR process and highlight possible areas where there is a large fluctuation in conditions between CHTR stages that may potentially cause stress or shock to salvaged and released fish.

3.6 Hydrological Data for the Delta

Hydrological and additional water quality data are available at the IEP Delta Modeling website at www.iep.water.ca.gov/dss/. This resource allows investigators to run in-depth queries on various aspects of hydrodynamics and water quality sampled at stations throughout the Delta. Figure 3-29 shows the sample stations with available data for the South Delta region, including data from Clifton Court Forebay, export pumping rate, water stage elevation, and water quality including temperature and electric conductivity within Old River near the CVP facility and at the Horseshoe Bend release site.

Figure 3-20 and Tables 3-11 and 3-12 give examples of the hydrodynamic data available at stations CHSWP003 and CHSWT000 on the IEP South Delta modeling map (Figure 3-29). Tables 3-15 to 3-17 show examples of water quality data obtained from this web resource. Tables 3-15 to 3-17 summarize electrical conductivity at release locations at Antioch Bridge and Horseshoe Bend. These and other water quality parameter data, such as temperature and dissolved oxygen, are available from varying sampling stations maintained by different agencies at the IEP website listed above.

4.0 REFERENCES

Baracco. 1980. Aquatic Resources of Suisun Marsh With an Analysis of the Fishery Effects of a Proposed Water Quality Maintenance Plan. Bay-Delta Fishery Project, Anadromous Fisheries Branch Administrative Report No. 80-13.

Brown, R. S, Greene, P. Coulston, and S. Barrow. 1995. An evaluation of the effectiveness of fish salvage operations at the intake to the California Aqueduct, 1979-1993. In San Francisco Bay: The Ecosystem, J.T. Hollibaugh, editor, San Francisco: American Association for the Advancement of Science.

CA Department of Water Resources. Churchwell, R., C. Wilkinson, R. Padilla, D. Dorratcague, H. Hanson, P. Barton, J. Taplin. 2003. Collection, Handling, Transport, Release (CHTR) New Technologies Proposal: Phase 1 Baseline Conditions. CA Department of Water Resources, Division of Environmental Services, Fish Facilities Section. Unpublished, 2003.

Craft, D., L. Mao, and B. Moore. 2000. Chemistry and Water Quality at the Tracy Fish Collection Facility, California. Tracy Fish Collection Facility Studies, Vol. 9, U.S. Bureau of Reclamation, Mid Pacific Region and Denver Technical Service Center, 28 pp and appendices.

Craft, D., R. Houseweight, L. Mao, and J. Fields. 2002. Semi-Continuous Water Quality Measurements at the Tracy Fish Collection Facility, Tracy, California, April 2000 to March 2001. U S B R Mid-Pacific Region and the Technical Service Center, Tracy Fish Collection Facility Studies California Volume 17.

Craft, D., R. Housewright, and J. Fields. 2003. Semi-Continuous Water Quality Measurements at the Tracy Fish Collection Facility, Tracy, California, April 2001 to March 2002. Tracy Fish Collection Facility Studies, Vol. 22, U.S. Bureau of Reclamation, Mid Pacific Region and Denver Technical Service Center (in review).

Department of Water Resources (DWR). 1993. *Sacramento San Joaquin Delta Atlas*. (http://rubicon.water.ca.gov/delta_atlas.fdr/datp.html)

Foss, Steve. 2002a. Unpublished report. *Preliminary summary results of the survival of delta smelt in the 1985 Skinner fish handling and trucking investigations.* July 2002. 1 p.

Foss, Steve. 2002b. Unpublished report. *Preliminary summary results of the survival of delta smelt in the 1999 Skinner fish handling and trucking investigations.* July 2002. 1 p.

Foss, S. 2003. Fish Salvage at the State Water Project and Central Valley Project Fish Facilities. IEP Newsletter. Volume 16, No. 2, Spring, 2003.

Gingras, M. 1997. Mark / recapture experiments at Clifton Court Forebay to estimate pre-screening loss to juvenile fish: 1976-1993. Interagency Ecological Program Technical Report 55.

Gingras, M. and M. McGee. 1997. A telemetry study of striped bass emigration from Clifton Court Forebay: Implications for predator enumeration and control. Interagency Ecological Program, Technical report 54.

Hall, F.A. 1980. Evaluation of downstream migrant Chinook salmon, Oncorhyncus tshawytscha, losses in Clifton Court Forebay, Contra Costa County, California. DFG Administrative Report 80-4.

Hurson, David. 2003. Personal Communication

Kano, R. 1985. 1985 Clifton Court Forebay evaluations of predation losses to juvenile Chinook salmon. DFG memorandum report. Stockton, CA.

Kano, R. 1986. 1986 Clifton Court Forebay losses to juvenile striped bass. DFG memorandum report. Stockton, CA.

Kano, R. 1990. Occurrence and abundance of predator fish in Clifton Court Forebay, California. Interagency Ecological Program, Technical report 24.

Morinaka, Jerry. 1995. Unpublished report. *Handling and trucking experiments. Delta smelt handling and trucking pilot study conducted during the winter of 1995 at the Skinner Fish Facility*. DFG Fish Facilities Research Unit. Stockton, CA. 2 p.

National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries). 2004. Endangered Species Act Section 7 Consultation. Biological opinion on the long-term Central Valley Project and State Water Project operations criteria and plan. National Marine Fisheries Service, Southwest Region. October 2004.

Odenweller, Dan. 1990. *Delta fish facility study*. Chapter 8 in P.H. Herrgesell, (compiler), 1989 Annual Report, Interagency Ecological Study Program for Sacramento-San Joaquin Estuary.

Peters, Rock. 2003. Personal Communication

Rainey, Steven. 2003. Personal Communication

Raquel, P. 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 Fish Protective Facility.* Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. Technical Report 19.

Schaffter, R.G. 1978. An evaluation of juvenile King salmon (Oncorhyncus tshawytscha) loss in Clifton Court Forebay. DFG Anadromous Fisheries Administrative Report 78-21.

Tillman, T. 1993. April 1993 estimates of pre-screen mortality of juvenile Chinook salmon at Clifton Court Forebay; State Water Project, Byron California. DFG Memorandum Report. Stockton, CA.

APPENDIX 1

Contact Reports

DATE:	12/18/03	
CONTACT:	Brent Bridges	
ORGANIZATION:	USBR Tracy Facility	
ADDRESS:	Bbridges@MP.USBR.Gov	
TELEPHONE	Office:	209 833 0340
	Cell:	209 601 5821
	Fax:	
INTERVIEWERS	DED CH PTB JT	
ADDITIONAL REFERENCES OR CONTACTS:	Kieth Caldwell 209 836 6276- designed outfall	
	Joe Pinina 209 836 6212 – Head of Maintenance at Tracy	
	Mark Bowen – Delta Smelt study of losses through the louvers at Tracy.	
SUMMARY:	Detailed look at operations at Tracy. See Trip Report.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	1/13/04	
CONTACT:	Kozmo Ken Bates P.E.	
ORGANIZATION:	Fish Passage Habitat Planning and Design	
ADDRESS:	5211 Blvd Ext SE	
	Olympia, WA 98501	
TELEPHONE	Office:	360 352 7089
	Cell:	360 701 8909
	Fax:	253 541 6949
INTERVIEWERS	PTB	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	Acclimation before release is very important for fish survival.	
	Ken describes a volitional release scheme.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	12/17/03	
CONTACT:	Jim Odom	
ORGANIZATION:	Skinner Facility	
ADDRESS:	jodom@water.ca.gov	
TELEPHONE	Office:	209 833 2048
	Cell:	209 815 0044
	Fax:	
INTERVIEWERS	DED, CH, PTB, JT	
ADDITIONAL REFERENCES OR CONTACTS:	See Roger Churchwell for SOP manual.	
SUMMARY:	Gave overview of Skinner facility operations. (see trip report)	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	1/26/04	
CONTACT:	Dave Hurson	
ORGANIZATION:	Walla Walla District COE biologist.	
ADDRESS:		
TELEPHONE	Office:	509 527 7125
	Cell:	
	Fax:	
INTERVIEWERS	PTB	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	McNary dam is the most modern for fish handling.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	1/20/04	
CONTACT:	Blaine Ebberts	
ORGANIZATION:	Portland District COE	
ADDRESS:		
TELEPHONE	Office:	503 808 4763
	Cell:	
	Fax:	
INTERVIEWERS	PTB	
ADDITIONAL REFERENCES OR CONTACTS:	NMFS Criteria	
	Dave Hurson Walla Walla District COE for transport	
	Poe for release (USGS in Cook WA)	
	North American Journal of Fisheries Management, 23441449, 2003 Effects of High Flow Jet Entry on Juvenile Pacific Salmon	
SUMMARY:	Look at NMFS guidlelines.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	1/13/04	
CONTACT:	Steve Rainey	
ORGANIZATION:	NOAA Fisheries	
ADDRESS:		
TELEPHONE	Office:	503 808 4763
	Cell:	
	Fax:	
INTERVIEWERS	PTB	
ADDITIONAL REFERENCES OR CONTACTS:	Charley Liston	
SUMMARY:	Steve talks about fish lifts and the basics of a fish separation system	
	Steve just got back from vacation and doesn't have any room on his calendar. He is amenable to more phone calls.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	1/13/04	
CONTACT:	Rock Peters	
ORGANIZATION:	Portland District COE	
ADDRESS:		
TELEPHONE	Office:	503 808 4777
	Cell:	
	Fax:	
INTERVIEWERS	PTB	
ADDITIONAL REFERENCES OR CONTACTS:	NMFS Criteria	
	Dave Herson Walla Walla District COE for transport	
	Scott Abernathy – jet criteria Study done by PNNL. Dennis Doppel 509-376-3631	
	Carl Schreck at OSU for physiology (salinity and temperature gradient stress. 541 737 1961	
	Shrively and Poe for transport densities.	
SUMMARY:	Rock mainly talked about siting outfalls.	
	He stressed the use of NMFS guidelines.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	2/5/04	
CONTACT:	Doug Bruland	
ORGANIZATION:	Puget Sound Energy	
ADDRESS:		
TELEPHONE	Office:	360 853 8341
	Cell:	
	Fax:	425 462 3118
INTERVIEWERS	PTB	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	Left message	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	February 5, 2004	
CONTACT:	Dennis Dauble	
ORGANIZATION:	Pacific Northwest National Laboratory	
ADDRESS:	dd.dauble@pnl.gov	
TELEPHONE	Office:	509 376 3631
	Cell:	
	Fax:	
INTERVIEWERS	PTB	
ADDITIONAL REFERENCES OR CONTACTS:	DOE Web site	
SUMMARY:	Dennis will send a packet of reports to start.	
	His work includes effects of pressure on fish, effects of jets	
	on fish, both outside-in jet shear effects and launching a fish in the jet (inside-out)	
	They drop fish into water jets	
	.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	2-19-2004	
CONTACT:	Bob Fujimura	
ORGANIZATION:	Department of Fish and Game, Stockton	
ADDRESS:	4001 North Wilson Way	
	Stockton	
	CA 95205	
TELEPHONE	Office:	209 948 7097
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	Telephone contact made. Main reason for call is to establish contact and discuss possible key persons to meet with and key sources of literature. B. Fujimura indicates that best person to see at this point is Dan Odenweller, indicating Dan Odenweller to have extensive literature and experience of fish salvage research. B. Fujimura also indicates that he can be of help sourcing key literature references once literature database is established and attempts are being made to locate key papers.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	2/24/04	
CONTACT:	Dan Odenweller	
ORGANIZATION:	National Oceanic and Atmosphere Administration	
ADDRESS:	Visit to home address	
TELEPHONE	Office:	916 930 3615
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	Telephone contact made from referral by Bob Fujimura and Chuck Hanson. Permission granted for visit to home address for interview and collection of reference material.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	3/9/04	
CONTACT:	Dan Odenweller	
ORGANIZATION:	National Oceanic and Atmosphere Administration	
ADDRESS:	Visit to home address	
TELEPHONE	Office:	916 930 3615
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	Visit to Dan Odenweller home address. Home visit due to extensive personal reference library held at home. Discussion of literature sources, key references, and current and past research in fish salvage operations. Discussions also touch on use of DIDSON camera for field monitoring, capabilities, and limitations. Many references borrowed for duplication and entry into CHTR Literature Reference Database. Permission granted for ongoing series of visits to collect reference material for CHTR Literature Reference Database.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	4/15/2004	
CONTACT:	Steve Foss	
ORGANIZATION:	Department of Fish and Game	
ADDRESS:	4001 North Wilson Way	
	Stockton	
	CA 95205	
TELEPHONE	Office:	209 948 7094
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	Telephone contact made with Steve Foss. Initial contact established to discuss database of biological data from CVP and SWP facilities managed by S.Foss. Discussion explored the nature of the data collected, how analyzed, distribution of reports regarding data summaries, and availability of the biological data for my own analysis. Also the set up and management of the biological database was explored and discussed.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	4/27/04	
CONTACT:	Dan Odenweller	
ORGANIZATION:	National Oceanic and Atmosphere Administration	
ADDRESS:	Visit to home address	
TELEPHONE	Office:	916 930 3615
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	References borrowed on previous visit returned. Large number of new references collected.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	4/29/2004	
CONTACT:	Steve Foss	
ORGANIZATION:	Department of Fish and Game	
ADDRESS:	4001 North Wilson Way	
	Stockton	
	CA 95205	
TELEPHONE	Office:	209 948 7094
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	Visit to Department of Fish and Game, Stockton. Visit with Steve Foss, fish salvage database manager. Visit to further explore database capabilities, the nature of the biological data, how analyzed, and how data is entered and managed. Discussion included possibilities for hosting the database online to make available for researchers to query data and do indepth analysis. Fish salvage data availability discussed and limitations of data that is currently available online explored. Comparative analysis across many parameters harder to achieve using current dataset online. Also discussed availability of literature references, usefulness of references held at DFG office, Stockton, access and use of library as well as personal references held by S. Foss and possible access to those. Many very useful references regarding biological aspects of fish salvage held by S. Foss. References taken for the CHTR Literature Database.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	5/11/04	
CONTACT:	Dan Odenweller	
ORGANIZATION:	National Oceanic and Atmosphere Administration	
ADDRESS:	Visit to home address	
TELEPHONE	Office:	916 930 3615
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	References borrowed on previous visit returned. Large number of new references collected.	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	5/27/2004	
CONTACT:	Steve Foss	
ORGANIZATION:	Department of Fish and Game	
ADDRESS:	4001 North Wilson Way	
	Stockton	
	CA 95205	
TELEPHONE	Office:	209 948 7094
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	References borrowed on previous visit returned to Steve Foss personal library. Further discussion of relevant references and possible sources. Further search of DFG Foss personal library. More references borrowed for duplication and entry into CHTR Literature Reference Database. Possible future conferences discussed that may yield insight into current research in areas related to fish salvage (Calfed Conference, October 2004).	
DISTRIBUTION	MWH, Hanson Environmental	

DATE:	6/15/04	
CONTACT:	Dan Odenweller	
ORGANIZATION:	National Oceanic and Atmosphere Administration	
ADDRESS:	Visit to home address	
TELEPHONE	Office:	916 930 3615
	Cell:	
	Fax:	
INTERVIEWERS	Justin Taplin	
ADDITIONAL REFERENCES OR CONTACTS:		
SUMMARY:	References borrowed on previous visit returned. No further references borrowed at this time. Main body of useful references have been duplicated and entered into CHTR Literature Reference Database. Discussion regarding future contact and possibilities for future visits regarding fish salvage research.	
DISTRIBUTION	MWH, Hanson Environmental	

APPENDIX 2

Interview Memos

M E M O R A N D U M

MWH Americas, Inc.
2353 130th Avenue N.E., Suite 200
Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
From: Peter Barton
Subject: Interview with Brent Bridges
Date: 1/20/04
Reference: 1520659.031804

Per call to Brent Bridges (5-21-04):

Each bypass tube leading from the louvers has a flow meter. The channel behind the secondary louvers has a meter. These meters are used to establish the bypass ratio between the main channel flow and the flow in fish bypass. The bypass ratio is critical. If it falls below one, no fish are salvaged. A bypass ratio of 1.2 to 1.6 is required. Velocities of 3. to 3.5 fps are established while chinook salmon are present. A ration of 1.6 is almost never attained.

Flow is established by 4 large pumps and 2 small ones. None of these are variable speed. As the water surface varies the flow through the secondary channel varies. Operators ignore the flow meters and assign flows of 30 cfs for the large pumps and 17 cfs for the smaller ones.

Flow to the is metered on each effluent pipe. The meters are not accurate. (by an order of magnitude) Fow to the fish holding tank is between 2 and 14 cfs. A mech meter is installed downstream of the effluent manifold. It sometimes sticks.

A meter is installed across the primary channel. Approx 20 % of the time the meter doesn't work because of the presence of bubbles in the water column induced by debris on the trashracks. The flow is not evenly distributed across the channel. It is fast at the louvers and slow against the opposite wall. So the averageing give misleading velocity estimates for the channel and can skew the bypass ratio.

The primary louvers are cleaned twice a day. This opens a hole in the louver bank. It takes a 1.5 hours to clean the bank. So a hole exists for 3 hours a day. Fish go out the hole disprortionatley to the percent of open space. (5% opening = 100% of fish excaping to the pumps.)

The primary louvers are skewed at a 15 degree angle. The louver bank is 310 feet long.

cc:

M E M O R A N D U M

MWH
MONTGOMERY WATSON HARZA

MWH Americas, Inc.
2353 130th Avenue N.E., Suite 200
Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
Date: 1/26/04
From: Peter Barton
Reference: 1520659.031804
Subject: Interview with Dave Hurson

In accordance with Task 2 described in the scope of work the CADWR CHTR New Technologies Phase I Project, Peter Barton (MWH), interviewed Dave Hurson on January 26, 2004 by phone. Dave Hurson is a biologist at the Walla Walla District COE.

Release

Description release:

- Trucks drive onto barges in Portland and are towed from shore to get away from predators. The trucks discharge through a 6-inch hose into the river.
- Dave is trying to arrange to use the Bonneville juvenile outfalls. This would cut down the transportation time. This alternative would be safer for the operators than driving on to the barge.
- Fish that are barged down the river are released from the barge.
- There are no predation studies for the barge releases.
- Fish that are barged down the river are released from the barge.
- Dave prefers barging to trucking. A certain amount of fish must be present make barging cost effective. Barging is a 4 day round trip at a cost of $18,000 per trip just for the tow boat. The semi-truck costs $550 dollars a week plus 10 cents a mile plus labor for two days.

Transport

Fish Transport Trucks:

- 3500 gallon refridgerated trucks.
- Dave knows of no modern studies for densities. They use the following criteria:
  - ½ lb fish per gallon in the transport truck.
  - Flow rate for holding is determined by 5 lbs fish per gpm.

Collection and Holding

Collection Tank:

- Fish are held in raceways.
- No lifting is required. It is a gravity system.
- McNary Dam has the most modern facility.

cc:

M E M O R A N D U M

MWH
MONTGOMERY WATSON HARZA

MWH Americas, Inc.
2353 130th Avenue N.E., Suite 200
Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
From: Peter Barton
Subject: Interview with Doug Bruland
Date: 5/14/04
Reference: 1520659.031804

In accordance with Task 2 described in the scope of work the CADWR CHTR New Technologies Phase I Project, Peter Barton (MWH), interviewed Doug Bruland on May 13, 2004 at Upper Baker Dam in Whatcom County Washington. Doug Bruland is the Chief Biologist at Puget Sound Energy's Baker River Project. This 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.

Collection and Handling

The fish are collected in raceways specially fitted to floats and crowded into a hopper, which is about six feet wide and eight feet high. The hopper is lifted by crane to the deck of the dam for transfer of fish to the tanker trailer or truck. Figure 1 shows the hopper being lifted from the trap shown in the lower right. A closer view of the hopper is shown on Figure 2.

Depending on the number of fish, a trailer or a tank truck is used to transport the fish. The procedure for transferring fish is as follows:

- The hatch to the tank is opened and the tank is filled with water. The hopper is then placed over the hatch, which is fitted with a soft rubber seal.
- Two retaining screws are released. The retaining latch is pulled releasing the trap door. The water in the hopper drains into the tank, and the displaced water passes through a screen in the truck and out drain valve. See Figure 3. The drain is left open until the water in the tank is about ¾ full, then it is closed. Note the sight glass to the left of the release valve in Figure 4.
- Baffles inside the tank are on hinges. The baffles are drawn to the side prior to filling the tank. After it is filled the baffles are swung to the middle of the tank and pinned in place to for the baffle.
- The hopper is removed and the trap door is swung back into place and closed tight with the latch and retaining bolts. See Figure 5.
- The hopper is then lifted by the crane and placed back into its receiving slot in the trap. See Figure 6
- The hatch on the tank is closed and sealed shut.

The transport trailer is fitted with a aeration/re-circulation pump. See Figure 6.

Transport and Release

The trailer is towed about 10 miles to the confluence of the Baker and Skagit Rivers. The truck backs the trailer down a boat ramp into the water so that the release pipe is partially submerged. No extension pipe is required. The release gate is then opened, and the fish are released directly into the river. The gate is located inside the trailer and is operated after the hatch in the top of the tank is opened. The advantage of the trailer is that it can be backed into the water. A tanker truck's wheels would be in the water and loose traction.

cc:

Figure 1 Hopper and Fish Trap

Figure 2 Fish Hopper

Figure 3 Fish Release into Transport Tank

Figure 4 Drain Valve and Release Pipe

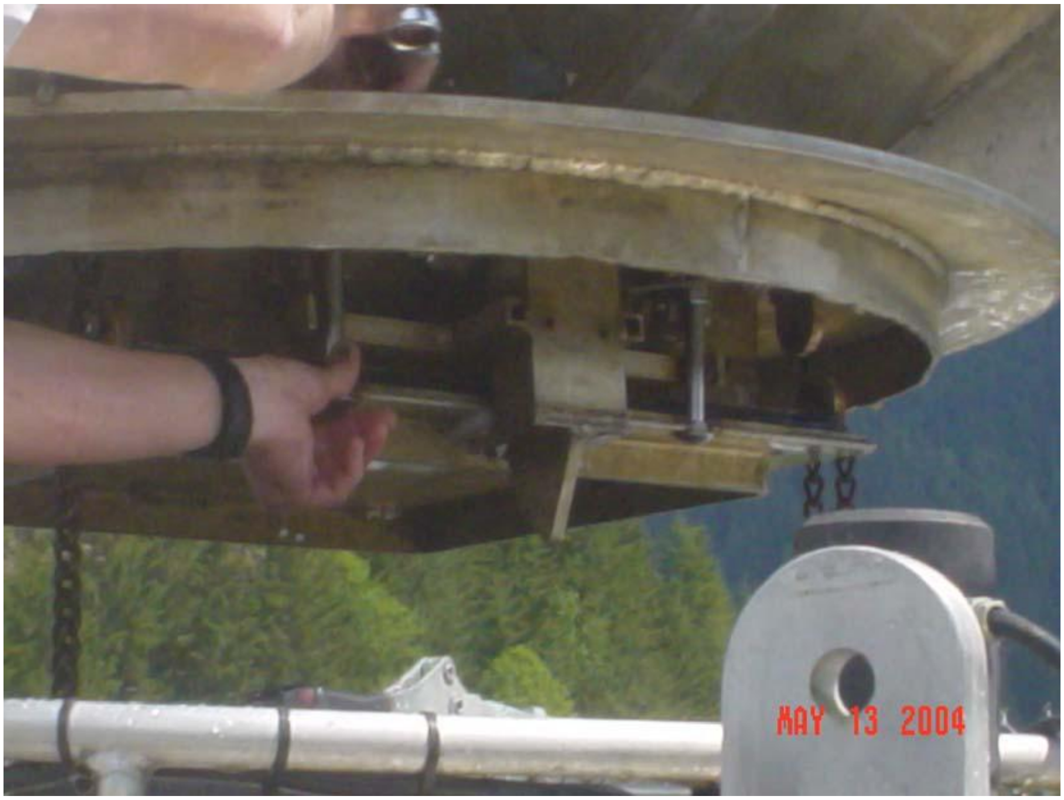


Figure 5 Release Latch and Retaining Bolts

Figure 6 Transport Trailer

M E M O R A N D U M

MWH
MONTGOMERY WATSON HARZA

MWH Americas, Inc.
2353 130th Avenue N.E., Suite 200
Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
Date: 1/15/04
From: Peter Barton
Reference: 1520659.031804
Subject: Interview with Ken Bates

In accordance with Task 2 described in the scope of work the CADWR CHTR New Technologies Phase I Project, Peter Barton (MWH), interviewed Ken Bates on January 13, 2004 at the MWH office in Seattle. Ken Bates was formerly the head of fisheries engineering at the WDFW, and is now running his own consultancy.

Release

Description of a volitional release suitable for low velocity receiving bodies:

- After the stresses of collection and transfer, the existing system immediately releases the fish into the river. An acclimation period is reccommended. This will allow the fish a chance to regain their wits before facing their predators. Ken envisions an acclimation facility with and exit that allow fish to leave volitionally. It is recognized that if the fish don't leave after a certain period of time, it will be necessary to encourgage the stragglers.

  One way to avoid stresses associated with introducing pumped flow water to the release pipe would be to pressurize the the water to force it down the release pipe.

  The release pipe is envisioned as a suitably long 24-inch diameter pipe with 1-inch diameter holes along its length. This would enable the fish to leave the cover of the pipe when they were comfortable. They could re-enter the pipe if they chose. Habitat could be provided beside the pipe to provide more cover.

- Time releases with tides. Release on outgoing tide.

Transport

Fish Transport Trucks:

- Use of salt in transport trucks is common practice. Talk with hatcheries for insights on loading densities.

Collection and Holding

Collection Tank:

- Excluding debris before its arrival in the collection tank is important.
- The oval tank experiments with side-mounted debris removal screens are interesting. (Charley Liston in Denver)

Fish Transport Bucket:

- Investigate a sphincter valve. (a twisted hypolon chute)

cc:

M E M O R A N D U M

MWH Americas, Inc.
2353 130th Avenue N.E., Suite 200
Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
Date: 1/15/04
From: Peter Barton
Reference: 1520659.031804
Subject: Interview with Rock Peters

In accordance with Task 2 described in the scope of work the CADWR CHTR New Technologies Phase I Project, Peter Barton (MWH), interviewed Rock Peters on January 13, 2004 by phone. Rock Peters is a biologist at the Portland District COE.

Release

Siting

- The Portland District COE has a lot of experience with siting juvenile outfalls. The velocity of the receiving body of water is determined by abilities of the predators. In the Columbia, the target predator is the squaw fish. It has been determined that these fish have difficulty feeding if the velocity of receiving body of water is 3.6 to 4 fps. The four criteria are:
  - Velocity of receiving body of water
  - Outlet is kept 30 feet from any structure laterally. This keeps eddies from forming at the outlet that could be comfortable for predators.
  - Depth of the outlet (10 meters)
  - 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. So the velocities have to be high enough in this reach to discourage predation.

Effects of pumped water entrance to release pipe

- Jet criteria were developed at PNNL. Work was done by Scott Abernathy. Contact Dennis Doppel at 509 376 3631 to get this report.

Transport Density

- Shively and Poe have done a study on transport densities.

Transport

- Fish and debris need to be separated before the holding tanks.
- Sharp variations in the temperature or salinity gradient induce stress in the fish.
- Contact Dave Herson in the Walla Walla District COE for information on transport. Rock suggests trying to get him on the review team.
- Contact Carl Scheck at OSU (541737 1961) for the effects of adding salt to the transport trucks.
-

Collection and Holding

General

- Look at NMFS criteria for fish bypasses.

cc:

M E M O R A N D U M

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MONTGOMERY WATSON HARZA

MWH Americas, Inc.
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Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
Date: 1/15/04
From: Peter Barton
Reference: 1520659.031804
Subject: Interview with Steve Rainey

In accordance with Task 2 described in the scope of work the CADWR CHTR New Technologies Phase I Project, Peter Barton (MWH), interviewed Steve Rainey, a biologist at NOAA Fisheries, on January 13, 2004 by phone. Steve is just back from vacation and does not have time on his calander. He doesn't mind taking a few phone calls though.

Release

Transport
Collection and Holding
Segregating Juveniles

- The basic method for collecting juveniles is:
  - Dewater
  - Debris separation
  - Adult separation
  - An exit for juveniles into a transport flume/pond/truck.

Lifting Fish

- The main difference between the Columbia River system and the California projects is that it easy to harness gravity in the NW. There two basic methods used to lift fish: a large volute fish friendly pump (wembco), and Archimidies screw type pumps. The downside of each of these is that they both require crowding.

Handling Fish

- Don't squeeze the fish.

cc:

APPENDIX 3

Trip Reports

MEMORANDUM

MWH
MONTGOMERY WATSON HARZA

MWH Americas, Inc.
2353 130th Avenue N.E., Suite 200
Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
Date: 12/22/03
From: Peter Barton
Reference: 1520659.031804
Subject: CHTR trip rpt to Skinner

Peter Barton (MWH), Dennis Dorratcague(MWH), Chuck Hanson (HE), Justin Taplin (HE) visited the Skinner site on 12/16/03 and 12/17/03 in accordance with Task 1 of our scope for the CHTR New Technologies Project. The following report is organized around 3 general areas of investigation: (1)release, (2)transport, and (3)collection, holding and transfer.

Release

Fish Release Sites:

- Horse Shoe Bend Site is xx miles from the facility. (45 minute drive in mild traffic through many small towns and business districts) It consists of a fenced site with 2 pipes (one 14" and one 12") leading into Horseshoe Bend. Tlhe 14 inch pipe is a pump intake and the other is the fish release pipe. Pumped water is piped into the release pipe though four smaller (2-in) pipes which intersect the release pipe at approximately 30 degrees in order to establish and maintain flow through the pipe. The pump flow is not known. The site is designed so a truck pulls in at a right angle to the release pipes and parks on an incline to facilitate flow out the back of the truck. The pump is turned on. A 90 degree elbow is attached to the truck outlet. The hydraulically operated knife valve is opened and the tanker truck begins to empty. If debris is present, the operators climb on the truck and spray water into the tank to blow debris through the outlet and off the screens that cover the O2 diffusers. A shovel is also used to clear blockage at the outlet. Three otters showed up at the site shortly after our arrival and dove at the pipe outlet. It is also common to see people fishing at this location.

Transport

Fish Transport Trucks:

- Three trucks:
    - Largest truck is commonly used. The oval metal tank is baffled with three communicating compartments. The compartments reduce sloshing in the tanks. Fish were loaded into the middle hatch (2' diam). Oxygen diffuser stones are attached to the bottom of the truck. The oxygen lines are attached with clips to the truck bottom. The outlet for the truck is approximately 9.5 inches in diameter. It is controlled by a hydraulically operated slide gate. The truck capacity is 2800 gallons.
    - Medium truck is similar to the above but is smaller. (2500 gallons) This truck has perferated plate panels running the length of the truck on both sides. The panels cover the oxygen diffusers. The operators don't like

this because debris lodges in the perf plate. The truck capacity is xxx.x gallons.

- The small truck is rectangular and is has an insulating covering. There are no baffles in this truck. The truck capacity is 1200 gallons.

Observations:

1. Trucks can not handle the debris load. The exits and baffles clog with the debris.
2. Trucks do not have O2 or temperature sensors.
3. Interior of tank is not fish friendly. Bolts and clips protrude and could impact the fish.
4. Transition from tank to exit pipe is abrupt. This could damage fish.
5. Tanks lost water in a steady stream on way to release site.
6. Buckets dump fish into the partially filled tank. It is not a water to water transfer.
7. In the summer the fish could heat up in the uninsulated tank trucks, especially if caught in a traffic jam.
8. Trucks filled from a high pressure hose could hold water that is supersaturated with nitrogen gas.
9. 50 lbs (100 lbs in summer) of salt are added to transport truck tank to reduce stress on fish. This equalizes the molarity of the salt in fish blood and the salt in the tank, reducing shock associated with osmosis.
10. Are vents open to allow release of CO2?
11. Generally the largest capacity truck is used. The two smaller trucks are used in combination when the larger truck is unavailable (due to maintenance procedures).

Collection and Holding

Collection Tank:

- 7 tanks in all, 4 in the old building, 3 in the new building.
  - 20-ft diam
  - 19'-10" deep to sloping bottom and sump.
  - 12" thick walls
  - 30-in influent pipe
  - 24-in effluent
  - 16-in drain
  - 4-in aerated water
  - Circulation in the tanks is limited to 10 cfs. If bypass flow is larger, another tank must be used.
- Circular Screen:
  - 17'-9" tall and 9' diameter.
  - 10.5-in dead panel below screen.
  - Screen sits on a rubber ring.
  - Hydraulic jack lifts screens approx. 6 inches.

Observations:

1. Ladders and pipes extend into the water. These catch debris and could have an impact on fish.

2. The enormous quantity of debris dictated the schedule for delivering fish to the release site.
3. The tanks act as debris concentrators.
4. Some shad are probably killed before getting to the tanks. They are probably killed while encountering debris on the louvers.
5. Fish are stranded on the bottom of the tank after the circular screen is lifted.
6. If sump is backfilled before the bucket is lowered, the fish are cushioned in their fall into the bucket. However any drainage out of the bucket occurs through a narrow band of screen. Fish could be impinged on the screen by the draining water.

Fish Transport Bucket:

- ❑ 4'-15/16" tall by 7'-11 3/8" diameter
- ❑ Bucket has sloped bottom for drainage.
- ❑ Lever-operated 12" ball valve seats in 8" pipe at bottom of bucket.
- ❑ 500 gallon capacity.

Observations:

1. There were many dead shad in the buckets.
2. Loose protruding bolts holding the screen to the bucket could impact fish.
3. Debris hangs up on the surficial irregularities. The debris is washed off with a high pressure hose. The high pressure could damage fish.
4. Density of fish in bucket could raise stress levels.
5. Density could crush fish.
6. Density could suffacate fish.

Fish Sample Bucket:

- ❑ Similar in design to transport bucket but smaller 50 gal capacity.

Observations:

1. There were many dead shad in the buckets.
2. The transition from the bucket to the screen was not smooth. Caulk had been placed to fill in gaps. The caulk was failing. This could impact the fish.
3. It seemed difficult to separate the fish from the debris. Fish could be hiding in the debris that is tossed back into the tank.
4. Sample counts with species identification are made every 2 hours or when a change in flow through the project occurs.

Fish Transfer from Tank

1. Shut off influent (collect pipe)
2. Open effluent pipe (fill pipe) and 16-in drain pipe.
3. Water drains through circular screen to the level of the dead panel in the holding tank.
4. Water drains from the sump on the downstream side of the circular screen.
5. At this stage the sump can be backwatered to cushion the fish's plunge into the bucket. It is backwatered by opening the effluent pipe (fill pipe).
6. Lower the sample bucket or the transfer bucket into the sump.
7. Lift screen (approx 6 inches)
8. Fish drain into sample bucket or transfer bucket.
9. Fish and debris stranded on the tank floor are flushed into the sample hopper or transfer bucket by opening the collect pipe which creates a swirl of water and washes the stranded fish from the bottom of the tank.
10. Lift bucket and move it to the counting station or the transport truck.

Observations:

1. When using the smaller truck or when the density of fish or debris in holding tanks is high, the operators used the practice of "double dipping" the transfer bucket. This entailed going through the normal procedure of collection into the bucket from the holding tank as described here. Then, rather then emptying the bucket into the truck, as is the normal procedure, the bucket with fish and debris already in it is lowered into the next holding tank, the contents of which are collected in the typical way. That is, the load from the second holding tank is added to the load from the first tank already present in the bucket. The reason this is done is to allow large loads to be transported to the release site in one trip by effectively doubling the concentration of fish and debris in the bucket without doubling the volume of water. This added density of fish and debris may lead to acute loss of DO in water resulting in suffocation. It may also lead to increased stress and injury from acute crowding and contact with debris.

Fish Transfer to Truck:
1. The truck is partially filled with water from a high pressure hose.
2. Bucket is positioned over the hatch.
3. The lever is pushed, raising the ball that seals the transfer bucket.
4. This provides a clear space of approx 5 inches for fish and debris to pass.
5. If debris is heavy a pitch fork and a high pressure hose are used to force the debris through the outlet.

Observations:

1. When the practice of "double dipping" is used (as described above) the bucket is emptied into a totally empty truck. That is, no water is present in the truck before the bucket is emptied into the truck. This is done to save space in the truck by emptying the contents of all holding tanks into the truck, only one trip to the release site is required. The lack of water in the truck when transferring from the bucket to the transport truck when "double dipping" may add to fish injury through high impact transfer onto truck floor with added contact to higher concentration of debris and other individuals.

Fish Transfer to Counting Station:
1. Transfer bucket is lowered onto the tire gasket that sits on a circular screen.
2. The lever is pulled which raises the ball valve and drains the fish into the center of a circular screen.
3. The water passes through the screen and is captured in the outer housing.
4. Water drains from outer housing into the tank.
5. Fish are hand picked from the screened compartment and processed.
6. Processed fish are dropped back into holding tank from floor level. This could injure or stress sensitive species.

Skinner Information Request:
- ❑ Drawings

- Department of Water Resources, Water Diversion Outline Diagram, M201-C09-6-1. (Seen on wall at Skinner facility on wall behind a desk in the southeast corner)
- Holding Tank, Screen and Metal Work, L-1011-2, Sheet 99, 6120-320 (Stick 6-B)
- Holding Tanks, Fish Transport Bucket, L-1011-3, Sheet 100, 6120-32 (Stick 6-B)
- Holding Tank, Fish Counting Bucket, EN-66-06 - L23-419 (Stick 6-B)
- Holding Tank, Fish Transport Bucket, EN-66-06 – L23-419 (Stick 6-B)
- Holding Tank, Counting Barrel, EN-66-06 – L23-418 (Stick 6-B)
- Holding Tank, Counting Barrel, L-1U11-5, Sheet 102, 6/20-322,
- Holding Tanks, Concrete and Reinforcement Details, L1U11-1, Sheet 98, EN-66-06 – L-1U11-1 (Stick 6-C)

- Request SOP's for facility. Check with Roger Churchwell.

Tracy Information Request:

- Design of Outfall used by Tracy facility
  - Designed by Kieth Caldwell, 209-836-6212, first contact is Head of Maintence, Joe Pinina, 209-836-6212
- Check with Mark Bowen for his work on Delta Smelt stranding through louvers at Tracy.
- Request SOP's from Ron Silva, Bob Edwards, and Joe Pinino. Get both the 1950's SOP and the current SOP.
- Request Pictures/Drawings for the plumbing of the facility.
- Detailed plumbing of the holding tanks and effluent pumps
- Detailed plumbing of bypass pumps.

cc:

FWP Fish Salvage Facility, Tracy: Trip Report.

Justin Taplin (HE), Chuck Hanson (HE), Peter Barton (MWH), Dennis Dorratcague(MWH), visited the FWP fish salvage site on 12/18/03 and 12/19/03 in accordance with Task 1 of our scope for the CHTR New Technologies Project. The following report is organized around 3 general areas of investigation: (1)release, (2)transport, and (3)collection, holding and transfer.

Interview with Brent Bridges, site biologist (main contact for CHTR process).

Contact details:
Bbridges@mp.usbr.gov
209 833 0340
209 601 5821 (general site office)

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1. Release

Fish Release Sites:

a. **Horse Shoe Bend** site is approx. 30 miles from the Central Valley Project (CVP) salvage facility (45-60 min drive) and is located approx. 1 mile from State Water Project (SWP) release site. It consists of a fenced site with release pipe leading into the Sacramento River. Pumped water is piped into a release pipe though smaller pipes which intersect the release pipe at approximately 60 degrees in order to establish and maintain flow through the pipe. The design of the release site allows the transport truck to be backed up directly to the release pipes. This allows the transport truck tank to be connected to the release pipes with a straight piece of collapsible tubing as opposed to the 90-degree elbow used at the SWP release site. The release truck sits on an incline to facilitate truck drainage during the fish release process. The operator turns on the pump and opens the knife gate valve at the back of the transport truck. Fish and debris are drained from the transport truck tank. If debris clogs the transport truck tank outlet, a high pressure hose directed through the hatch on the transport truck is used to help clear the debris. When the debris load is extreme, pitchforks and shovels may be used to aid clearing debris from truck.

Observations/comments from operators:

i. Fish release is designed to be accomplished by a single person.
ii. An automatic security gate protects equipment from vandals. The Horseshoe Bend site is not used at night for fear of operator safety.
iii. The Antioch Bridge site is used at night as located within secure compound.
iv. Horseshoe Bend release site is stationed at DWR water quality monitoring station.
v. Many seagulls were present and took flight when release began, circling and diving at approximate point of release pump exit in river.
vi. Fishing boat stationed close by in river, apparently a common sight.

b. **Antioch Bridge** site is approx. 25 miles from facility (30-45 minute drive). The design of the Antioch Bridge site is similar to Horse Shoe Bend release site. Release pipes are longer then pipes at Horseshoe Bend site due to shallower banks requiring longer pipes to reach required depth in Sacramento River. The pump is programmed to turn on and off periodically throughout the day in an effort to desensitize predator response to the sonic cue. There is a pier slightly down river of the release site with fisherman visiting regularly.

Observations/comments from operators:

i. Could create a reservoir of clean water in the last compartment of the tank for internal flushing.
ii. Is it possible to add release sites?
iii. Is it possible for State and Federal plants to adapt equipment to use each others release sites and increase number of release areas through sharing?
iv. Rio Vista site is out of commission, reducing release site options.
v. New fish transfer truck design could include a way to hook the release site pump to the tank. Baffled water could then be introduced into the tank to aid flushing without the blast effect associated the hose.

Keith Caldwell (tel: 209 836 6276) engineer who designed pumps at release site. Joe Pelino (tel: 209 836 6212) area engineer manager.

2. Transport

One truck size is used to transport fish from the CVP fish salvage operation to the release sites. The truck has a 2500 gallon tank. The central hatch on the tank roof is used for filling the truck from the transfer bucket. The tank is divided into three sections by baffles with semicircular openings at their base. This allows flow through the tank between compartments, and reduces sloshing during truck movement. There are oxygen diffusers installed into the tank, with hose lines clipped to the tank walls. The tank is emptied via a rear knife valve. There are three hatch openings on the tank ceiling, two of which are sliding doors at the front and rear ends of the truck. These do not fit well in their guides, allowing water and fish to slosh onto road during transport to a release site. Powdered salt is used in truck to avoid salt loss from fish blood through gills when fish stressed. 1 bag added most of the time. 2 bags added for delta smelt. Bag = 50 lb. Truck = 2500 gallon. Helps fish maintain osmolarity and improves fish health for transport / stress. Two scheduled trips are made each day at set times (morning and night) to release sites. These trips run on schedule regardless if 1,000 or 50,000 fish in holding tanks. This differs from Skinner facility where densities in holding tanks are calculated and used for decision as to when trip is needed to release site.

Observations / comments from operators / biologist:

i. May be useful to install flow or light inside transport truck to allow fish to orient within the truck to avoid fish damage by contact through random swimming patterns. Allow fish to school.
ii. Need watertight doors on truck tank. Sloshing can cause fish to be lost during transport out of hatch.
iii. To transport delta smelt, need to fill tank to brim to reduce sloshing during motion. These fish are especially sensitive to sloshing.
iv. Insulation needed in truck to maintain temperature in summer traffic. Water temperature increases rapidly and fish all die.
v. Would like to improve shocks on truck/tank (air cushions?). Lots of shock / vibration in tank during transport adding to stress of fish.
vi. Cannot use agitators to clear carbon dioxide from water as little fish get trapped in mechanism.
vii. Use bait tables for density. e.g. 40,000 shad in 2500 gallon truck.
viii. Fish transport truck tanks are filled with water from a pressurized tank. This could induce nitrogen poisoning in the fish.
ix. In the summer the water piping is exposed to the sun. This has the effect of filling the fish transport tanks with heated water.
x. The trucks are equipped with sensors that inform the truck driver the state of the O2 system. These systems had been disabled on the day of our visit. All four O2 bottles were empty on one truck.
xi. A depth gauge in the truck, visible to the crew loading the tank, would prevent accidentally loading the fish into an empty fish transport truck tank.

3. Collection, Holding, and Transfer

Collection Tank:

3 tanks in all, 1 outfitted with fish pump, 1 used for sampling, 1 used for collection. CVP facility collects fish direct from Old River, whereas SWP collects fish from Clifton Court Forebay.

- Tanks are epoxy coated to reduce abrasion to fish when fish slide into the transfer or sample buckets. Epoxy is white. This enhances the visibility of the fish.
- 20-ft diam
- 19'-10" deep to sloping bottom and sump.
- 12" thick walls
- 30-in influent pipe
- 24-in effluent
- 16-in drain
- 4-in aerated water
- Holding tanks have small baffle to create velocity refuge. Only works when flow is 2 f/s or less.

Circular Screen:

- 17'-9" tall and 9' diameter.
- 30-in dead panel below screen.
- Screen sits on a rubber ring.
- Hydraulic jack lifts screens approx. 6 inches.

Observations/comments from operators:

i. In theory, dead panel should hold back exactly one bucket amount of water, which flows into bucket when screen lifted. An additional dead panel was added. Consequently, 3 times the design volume of the bucket is held back when the fish tank sump is drained. This causes fish mortality when fish are impinged on the screen that drains the fish transfer and fish sample buckets

ii. Ladders and pipes extend into the water. These catch debris and could have an impact on fish.

iii. Some fish are probably killed before getting to the tanks. They are probably killed while encountering debris on the louvers.

iv. Biologist prefers to lower bucket and back fill from effluent to reduce impact of holding tank draining/flushing process and to allow debris to settle to bottom allowing fish to reside in upper layer. But means fish are simply de-watered as debris acts as sieve for bucket when bucket opening clogs.

v. D.O. and Flow meters installed in holding tanks, but only 2 months ago, so no useable data set is available.

vi. Attach a small rotating screen to slowly move debris out of holding tank into e.g. a hopper? Could attach to holding tank ladder.

vii. A larger research component is involved in fish salvage at CVP than at the SWP. Aqua culture lab, budget for testing new technologies, on site biology team, etc. e.g. in process of testing effects of swirl (washing the holding tank out during fish collection) on fish for scale loss, abrasion, etc. 12, 24 and 72 hour tests.

viii. Large slugs of fish enter the holding tanks. When this happens, the counting station is overwhelmed. When an operator notices this during a 10-minute count, he will flush the slug of fish and start over, sampling for 1 minute only. It was reported to us that during the previous evening a 1-minute count resulted in the capture of 4011 fish. These fish took 1.5 hours to count. Brent Bridges is experimenting with counting fish without handling them. He has painted stripes on the bottom of the one of the tanks, outlining 1/8th of the tank. A digital picture can be taken. The picture can be studied and an estimate made of the total number of fish in the tank. For this procedure to provide an accurate count, the fish must be evenly distributed around the tank. This is not always the case. Perhaps 8 cameras could be used to photograph all the fish at the same time. Would species identification be possible with this procedure? Can length of an individual fish be estimated with this method?

ix. Fish count accuracy can be increased by automating flow/input for 10 min sample.

x. Delta Smelt enter system in March/April. Almost no other fish in this period.

xi. Piping has been added to a holding tank to aerate the water.

xii. A water level gage has been added to the tank just a short distance downstream of the influent pipe. It is in the flow line of the influent pipe and probably damages some fish.

Fish Transport Bucket:

- 500 gallon capacity.
- Bucket has sloped bottom for drainage and is deeper then buckets used at Skinner with higher walls.
- A wire rope and pulley system operate a 12” ball valve. The ball seats in 9” opening at bottom of bucket.

Observations/comments from operators:

i. There were many dead shad in the buckets.
ii. The epoxy paint is very slick. However it does not extend to the edge of the tank sump. The higher friction on the unpainted concrete causes debris and fish to hang up on the surface irregularities. The debris is washed off with a high pressure hose. The high pressure could damage fish.
iii. When lifted, the clear space between the 12” ball valve and the outlet pipe of the fish transfer bucket is 5 inches. Brent Bridges would prefer it to be 14” to allow easier passage of the debris
iv. Bucket (handling) is the part of the process causing mortality in the fish salvage process. This is due to in part to the increased size of the dead panel at the base of the circular screen in the holding tanks. The larger dead panel has increased the volume of water held back behind the circular screen to triple that of the volume of the bucket. The high velocities flowing through the bucket drain screen as a result lead to fish impingement on the bucket screen.
v. The transfer from holding tank can be a very gentle process if certain control protocols are followed (e.g. reverse filling of bucket from effluent pipe).
vi. High mortality results from fish crowding within bucket. Fish get densely crowded into bucket and concentration of oxygen drops rapidly. Crowding also causes mortality due to high levels of contact between fish and debris. Usually 50,000 individuals in a bucket load.

Fish Sample Bucket:

- Similar in design to transport bucket but smaller 50 gal capacity. Design differs from sample bucket at SWP, being steel, as well as being smaller in diameter, but with greater depth. Sample bucket is cylindrical with conical base, whereas SWP sample bucket is a wide shallow conical shape.

Observations/comments from operators:

i. There were many dead shad in the buckets.
ii. Sample counts with species identification are made every 2 hours or when a change in flow through the project occurs.
iii. Listed species / Tagged Salmon recorded and measured for length.

Fish Transfer from Tank

- Shut off influent (collect pipe)
- Open effluent pipe (fill pipe) and 16-in drain pipe.
- Water drains through circular screen to the level of the dead panel in the holding tank.
- Water drains from the sump on the downstream side of the circular screen.
- At this stage the sump can be backwatered to cushion the fish's plunge into the bucket. It is backwatered by opening the effluent pipe (fill pipe).
- Lower the sample bucket or the transfer bucket into the sump.
- Lift screen (approx 6 inches)
- Fish drain into sample bucket or transfer bucket.
- Fish and debris stranded on the tank floor are flushed into the sample hopper or transfer bucket by opening the collect pipe which creates a swirl of water and washes the stranded fish from the bottom of the tank.
- Lift bucket and move it to the counting station or the transport truck.

Fish Transfer to Truck:

- The truck is partially filled with water from a high pressure hose.
- Bucket is positioned over the hatch.
- A wire rope is pulled, raising the ball that seals the transfer bucket.
- This provides a clear space of approx 5 inches for fish and debris to pass.
- If debris is heavy a pitch fork and a high pressure hose are used to force the debris through the outlet.

Fish Transfer to Counting Station:

- Transfer bucket is lowered onto the gasket that sits on a circular screen.
- A wire rope is pulled which raises the ball valve and drains the fish into the center of a circular screen.
- The water passes through the screen and is captured in the outer housing.
- Water drains from outer housing into the tank.
- Fish are hand picked from the screened compartment and processed.

Observations / Comments from operators

i. There is not a good seal at the bottom of the circular screen inside and the sample station. Some fish can escape.

ii. The screen mesh of the circular screen at the sample station is larger than the screen mesh of the circular screen in the holding tank. Small shad could be captured in the sample bucket yet escape (or be pureed by) the screen at the sample station.

MEMORANDUM

MWH Americas, Inc.
2353 130th Avenue N.E., Suite 200
Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
From: Peter Barton
Subject: CHTR trip rpt: DIDSON camera
Date: 2/16/04
Reference: 1520659.031807

Peter Barton (MWH), Dennis Dorratcague(MWH), Chuck Hanson (HE), Justin Taplin (HE) , Tim DeVoe (HE), Roger Churchwell (DWR) and Roger Padilla (DWR) investigated the use of the DIDSON camera at the state release site at Horse Shoe Bend and at the Skinner facility between 2/9/04 and 2/11/04. The following report is describes work accomplished at the two sites.

Day One

We met at the Brannon Is State Park boat ramps at 10:00 AM and took two small boats to the release sites. On arrival we assembled the DIDSON, attached it to the side of boat on its frame and began scanning for fish. The camera gave a clear image of the pilings and release pipe. No fish were observed.

State Site:

- A depth finder was used to determine that the pipe outlet is approximately 12 to 13 feet deep. It extends approximately 1 foot past the piers.
- Every took turns adjusting parameters on the DIDSON (image start dist, length of view window, gain, record mode, playback mode, snapshot mode, background subtraction etc).
- Viewing the computer screen in field is difficult due to glare. It was necessary to huddle under a tent of coats to see what was going on. A hood should be developed that will shield the screen and allow easy viewing.
- The frame with which the camera is attached to the boat allows the operator to pan left and right, and up and down.
- Viewing goggles would allow the operator aiming the camera to view the image at the same time.
- Several lures were dragged into the camera's field of view. Metal gives an excellent reflection, but a small soft bodied lure was difficult to discern.
- Small waves reduce clarity in the image. A stable platform is required to provide good images.
- After waiting several hours it was determined that something happened to the release truck and we moved on without witnessing a release.

Federal Site:

- The federal is site outlet pipe is in approximately 35 feet of water. The topography quickly drops off a short distance from the end of the pipe.
- The federal site is more exposed to wind and currents. The size of the waves (approximately ¾ of foot) made viewing problematic.

We returned to Brannon Is near sunset.

Day two
Skinner Facility:
We arrived at the Skinner Facility at 8:30 AM. We set up our camera in the new tank building. The camera was lowered into a holding tank and attached with uni-strut to the rail.

Observations:

- The frame that the camera attaches to is made of sections of 2-in galvanized pipe. Two sections of pipe allowed us to place the camera approximately 15-ft below the rail. Panning was to the left and right was more difficult than the setup used on the boat. Panning up and down involved pulling the camera out of the water and adjusting the angle of the camera at the end of the pipe using a couple of wrenches.
- Many fish were observed in the tank.
    - It is possible to view fish in the tank. There were double images and shadows, but fish could be observed.
    - Fish congregated in an area equidistant from the wall of the tank and the circular screen.
    - Some fish schooled and lapped the tank, traveling against the flow.
    - Some fish couldn’t keep up and were drawn to inside of the tank.
    - It was not possible to tell the difference between a dead fish encountering the screen and debris.
    - Fish were observed avoiding debris.
    - Pointing the camera upstream produced a lot of reflection from debris accumulation on the lens.
    - Pointing the camera downstream gave a good image and kept debris from accumulating on the camera lens.
    - Visibility and resolution were not adequate to enumerate or describe fish/screen interaction.

The transport truck was filled with fish and made available to us for observation.

- The camera was lowered into the tank on the back of truck.
- The concentration of debris in the truck made meaningful observation impossible.

Day Three
We met at the Skinner Facility at 8:30 AM. When the truck arrived, it was filled with clean water. We put the camera in the tank and were able to observe the outlines of the exit gate. We dragged various items in front of the camera and received a passable image. A small dead shad was attached to a wire and dragged across the camera’s field of view. It could be seen.

We then set the camera up and observed the intake area in front of the louvers. No fish were observed. However we could see debris in the flow lines.

We set up the camera between the louvers and the pilings that support the walkway. There were too many reflections from the metal structures to see anything.

We set up the camera behind the louvers on the transverse walkway at the downstream end of the bay. Viewing upstream we observed predators hanging in the shadows of the piles. Large predators could be seen cruising the length of the louver bay (just behind the louvers).

We observed a catfish with severe injuries during a fish count.

It is the general consensus of the group that debris is single most significant cause of mortality in the salvage process. It effects:

- Passage through the trash rack
- Passage through the primary louvers
- Passage through the secondary louvers
- Fish in the holding tanks
- Fish in the transfer buckets
- Fish in the transport trucks
- Fish in the release pipes

Pumps:
New Secondary Screen Pump (see photos in directory:

- Serial # 00304144
- Model # 36P26-24
- BOM 56302
- Prime Pump Corp
  Berkeley, CA
- Ph: 510-620-0950
- 30" impeller

Pump for Experiment:

- Serial # JY6145
- 30 Hp motor
- 585 rpm

Proposal Meeting
Around 1:00 PM we met to discuss the proposal task in our scope.

- Roger asked us to prepare a proposal for a new task. The task is to determine if there are benefits, measured by reduced predation, if Old River is plumbed through Clifton Forecourt to the louvers. At high tide the water could be pumped back into the Forecourt for storage. At low tides the water would be plumbed directly to the pump station. Items in the scope include:
    - Literature review on predation in the forecourt.
    - Comparison of predator distribution and predation levels in the river, in the forecourt, in the canal behind the louvers, and in the river upstream of the forecourt.
    - If the question can't be answered through he literature search, propose studies to answer the question.

At this time the major cause of fish mortality is not known. Many assume it is predation. Chuck in not sure and wants to do some preliminary studies before spending a lot of money. He wants to:

- Get a handle on the predator population at the release site.
- Calculate how much they could eat.
- Compare this figure with the numbers of fish released.

- It may be that this number is insignificant. If so the release site may not be a candidate for new technologies.

Several methods of observation were discussed:

- Build a dock to mount the camera. This would allow constant observation, independent of weather conditions.
- A barge on legs could be used.
- Installation on the bottom of the river with a cable to the top. Observations could be made from a floating platform since the camera itself would be stationary.
- Radio tags could be used
- Hatchery salmon are available, so use them in the initial studies to keep cost down.
- An onboard power source is required regardless of the platform.
- Consider man power requirements to allow timely, constant observations and protection of equipment from vandals.
- Set a net around the release site and use electro-shock in conjunction with tagged fish to determine mortality due to predation and the effects of the salvage/release process.

Any proposed experiment needs a lot of detail to pass the review process. It may be advantageous to propose a pilot study rather than a full blown experiment. This is left at our discretion by Roger Churchwell. A pilot study could be couched as a phased experimental study.

Several items were listed to look at:

- Turn pumps on and off to observe if predators get a sonic cue to come and eat.
- Survey similar looking sites (piles and pipes in the river) and compare predator populations by viewing with the DIDSON.
- Comparison of water quality between the release sites and the water in the trucks.
- Introduce hatchery fish at various points in the salvage process to determine the pinch points.
- What are the velocities in the holding tanks?
- Look at Joe Chech (UC Davis) for fish studies.

Several possibilities for new technologies are:

- A skimmer/traveling screen in the holding tank

Identify the questions to be answered:

- Do conditions at the release site result in a significant increase in mortality? Significant is defined as 10% or greater.
- What factors are causing mortality?
    - Abrasion in the holding tanks?
    - Shear effects in the release pipe?
    - Predators?
    - Crowding
        - Holding tank
        - Transfer bucket
        - Transport truck

Introduce the literature search to support the problem identification. (Compare densities in truck to hatchery standards for density for instance.)

A predation pilot study would last approx 3 months in late spring and early summer. In spring time period, spawning activities give rise to increased predation. In early summer the young are vulnerable and salvage is high.

Five areas of inquiry concerning release:

1. Outlet
2. Pipe
3. Water jets
4. Water quality difference
5. Predation

Water quality loggers could be installed in trucks. At release the quality of the receiving body could be checked.

Using the 10 minute counts to measure mortality is suggested.

Cautions:

- Include time for any required permit acquisition.
- It is the general con

Some conclusions:

- Restructure the counts at the Skinner Facility to ascertain the condition of fish at the start of the CHTR process.
- Study separate release elements in conjunction with Bob Fugimora's work and lab.
- Determine if mortality due to predation at the release is a problem
- Determine if water quality differences in the truck and in the receiving body is a significant factor in stress and mortality.

Work Split:
MWH will make proposals concerning release and debris, CH will make proposals on receiving body predation and water quality.

cc:

M E M O R A N D U M

MWH
MONTGOMERY WATSON HARZA

MWH Americas, Inc.
2353 130th Avenue N.E., Suite 200
Bellevue, WA 98005
(425) 881-1100 Fax: (425) 881-8937

To: file
Date: 2/27/04
From: Peter Barton
Reference: 1520659.031807
Subject: CHTR Trip Report: McNary Dam

In accordance with Task 2 of our scope for the CHTR New Technologies Project, Peter Barton (MWH) and Dennis Dorratcague(MWH), traveled to McNary Dam on 2/17/04 and met with Dave Hurson, a Walla Walla District COE Biologist in charge of fish trapping and transport for the four lower Snake River Dams and McNary Dam. Dave gave us a tour of the McNary Dam juvenile fish facilities, which are the newest ones that he oversees. Afterwards he sat and answered questions. Our observations and discussions with Dave are given below. The juvenile facilities were un-watered at the time of our visit.

McNary Juvenile Fish Facility

Release
<u>Fish Release Sites:</u>
A good release site is free of predators.

Dave's crew previously used to truck the fish to Bradford Island at Bonneville. However, predation got the point where the "water was boiling" with pike minnows. Now they drive to

Portland and drive aboard a barge to discharge fish in the middle of the Columbia River. The fish are released through a 6-inch diameter, 10-foot long flexible pipe. This way they can get away from the predators and vary the release location. Birds recognize the truck and congregate during release.

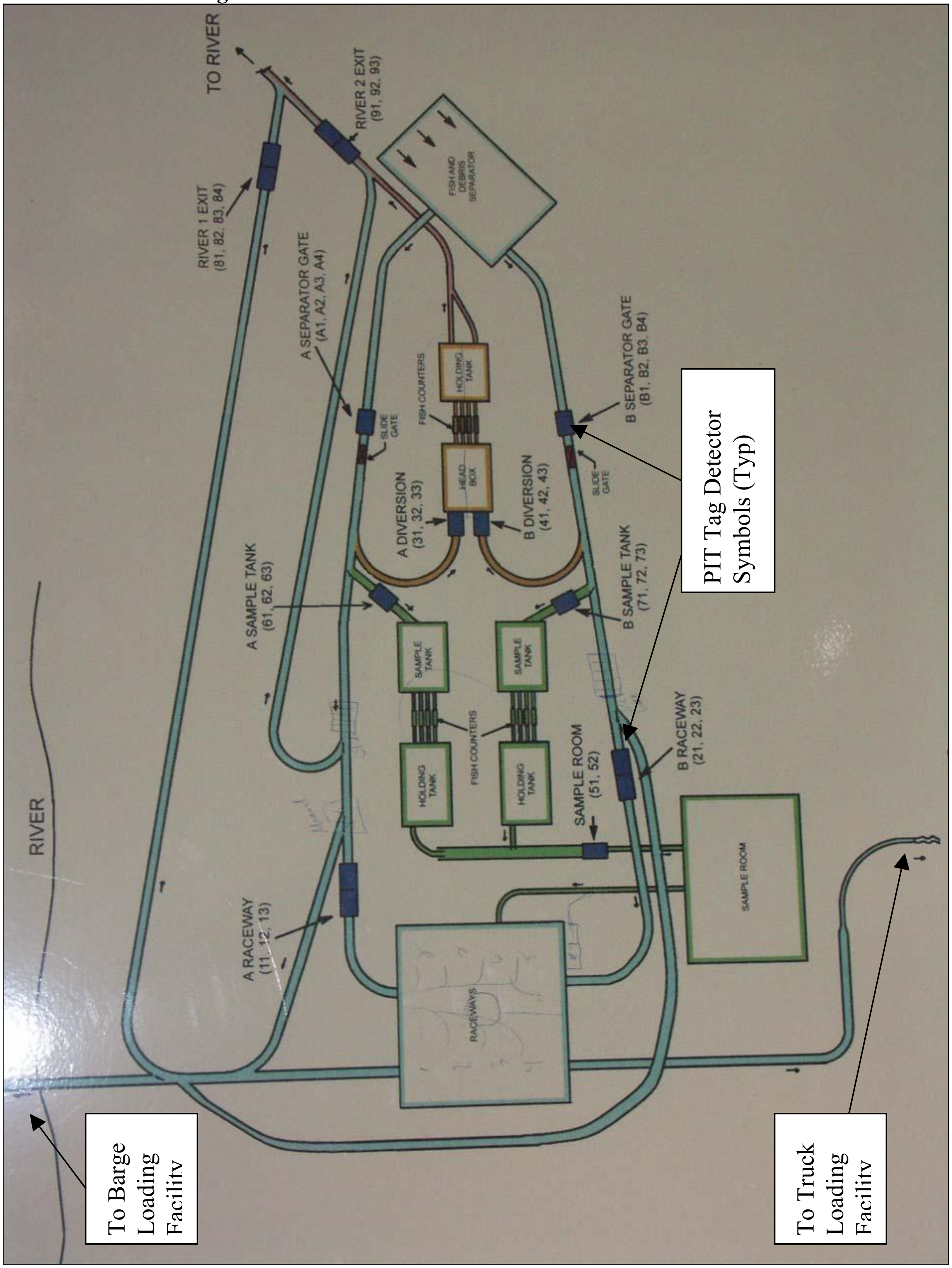
Dave is trying to arrange for release at the new Bonneville juvenile outfall. This would be safer than driving onto the barge. The Bonneville Dam juvenile facilities have two outfalls (high and low) to accommodate varying receiving water elevations. The site was selected after physical model studies determined that the velocities at the site were high enough to prevent pike minnows from feeding at the entry point. The criteria used to site the outfall were water depths greater than 20 feet and velocities greater than 3.5 feet per second. In addition, the water conditions downstream of the release site are also unfavorable to predators, allowing the released fish to reorient themselves after release without encountering fierce predation. An avian hydro-cannon is mounted on each outfall to discourage predation by birds.
<u>Salt:</u>
Dave's crew used to use salt. Now they only use it as disease prophylactic measure to act against colinaris.

Transport
<u>Fish Transport Trucks:</u>

- 3500 gallon refrigerated trucks.
- The travel distance is about 180 miles.
- Dave knows of no modern studies for densities. They use the following criteria:
    - ½ lb fish per gallon in the transport truck (static volume).
    - Flow rate for holding is determined by 5 lbs fish per gpm.
    - 48 hours holding max.

Dave prefers barging to trucking. A certain amount of fish must be present to make barging cost effective. Barging is a 4 day round trip at a cost of $18,000 per trip just for the tow boat. The barge is approximately 120 feet long by **[x]** feet wide. The semi-truck costs $550 dollars a week plus 10 cents a mile plus labor for two days.

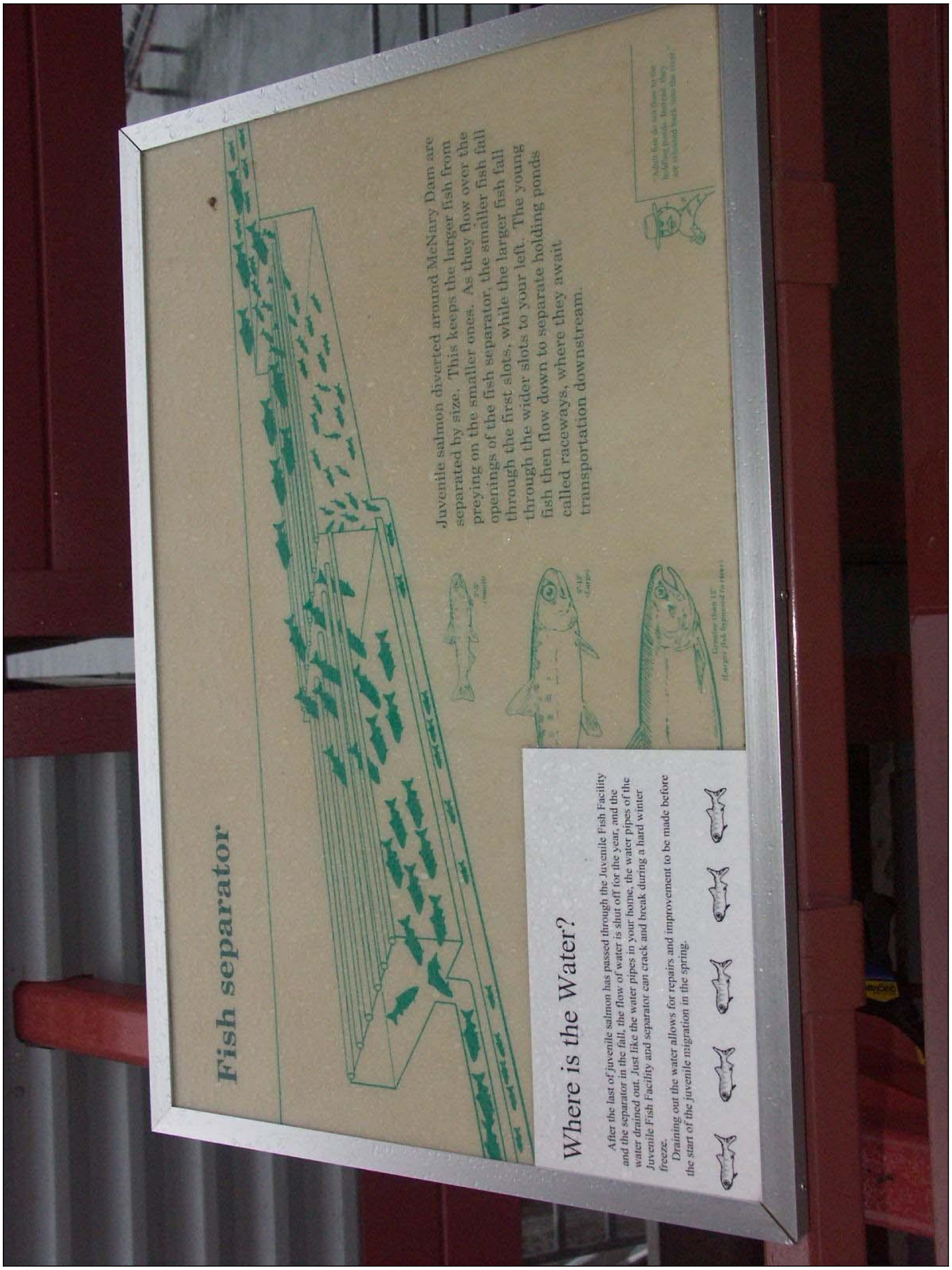
Collection and Holding



Fish Handling Schematic

Separator:

Approximately 30 cfs arrives at the fish and debris separator through a 36-in dia pipe. The separator is divided into two sections; a dewatering section followed by a fish separator. Both sections are approximately 15 feet long.



Fish Separator Schematic

- Almost all the 30 cfs is removed in the dewatering section leaving approximately 2 inches of water depth at the end of the plate. Beneath the plate are louvered gates that control the dewatering rate. Sometimes adults are present having fallen back through the juvenile bypass system. When dewatered on the separator, the adults flop around injuring themselves and the smaller fish. So, a deeper depth of water is kept on the separator.
- The fish separator section is divided into two bays. Each bay is covered by round pipes. The bays have differing on-center dimensions that separate the small fish in the first bay and larger fish in the second with the largest fish traveling to the small pool and the end. The pipes are missing in the photo having been removed for maintenance. Water is added below the bars of each bay to create enough flow to entrain fish into the down well and into the flumes.


Separator Looking D.S.


Separator from U.S.

- The dewatering section used to consist of profile wire but has been changed to perforated stainless steel plate. The change was made because the profile wire dewatered completely, leaving fish skidding across the bars. The perf plate is easier to control, however, it develops a harmonic vibration. The perf plate leaves approximately 2 inches of water on top to the plate. Beneath the plate are louvered gates that control the dewatering rate.


Dewatering Section

- Each separator bay has a down well exit in the floor leading to a flume. This is the start of two paths for fish which are to be sampled and evaluated.


First Downwell


Second Downwell

- A hand operated End Gate is in place at the end of the bars. This is operated to allow adults to slide off the end of the separator bays into a flume that leads back to the river.


Adult Release Closed


Adult Release Open


Protective Curtain

Flumes to diversion gates:

- Downwell pipes from the separator are connected to flumes, which have profile wire bottoms for dewatering. The flow drops from a foot in depth to approx 5 inches in depth to create the proper flow conditions for the PIT tag detectors in front of the diversion gates.


Post Separator Flume


Flume Dewatering Valves


Profile Wire Bottom

- PIT tag detectors are located upstream of the first gate. The first gate encountered is a bottom slide gate which can be automatically activated by the PIT tag detector. Fish diverted by the gate travel in a flume to a head box, and then to the river outfall. PIT tag detectors are also installed in front of the head box , primarily for counting purposes. Fish not diverted are held for sampling or transport as described below. These gates are typically on a timer to take samples from a known percentage of the flow volume. This facility has the older type of PIT detectors that must be within about 6 inches of the tag. Newer model detectors can be about 24 inches away from the tag.


PIT Tag Detector Entrance


Bottom Slide Gate


Side Diverter Gate

- Fish counters are installed a the head box exit pipes.
- An additional holding tank below the head box is not used. The pipes run directly through it back to the river.


Head Box


Unused Holding Tank

Flumes to Sample Tank:

- Fish not diverted back to the river encounter another gate. This one is a side to side gate as opposed to a bottom slide gate. This gate can send fish to a Sample Tank in preparation for laboratory analysis, enumeration, marking etc, or to a third gate that can send them to the river or to the transport facilities. Fish counters are installed at the Sample Holding Tank exit.


Sample Tank


Sample Tank Drain


Sample Tank Fish Exit


Fish Exit Counters


Fish Exit Counters

Sample Tank:

- The Sample Tank holds fish prior to sending them into the holding tank evaluation building and is equipped with a crowder. The crowder consists of a screen panel that can be raised and lowered into the holding tank. Hand wheels are used to move the crowder horizontally which allows the crowding motion to proceed at a deliberate pace. The screen can be lifted with a motor or by hand. The crowder works the fish to an anesthetic compartment where MS 232 is added via control valves. No fish are touched without being anesthetized in this facility.
- There are two paths for the fish to be sampled. They start in the two sides of the fish separator.


Holding Tanks w/Crowders


Holding Tank Drain


Anesthetic Compartment

Crowder:

- The fish crowder is advanced by hand. A motor can lift the screen panel.

Looking US Crowder and Anesthetic tank

Crowder Looking D.S.

- On exit from the anesthetic compartment the fish are sent by flume to the sample room inside the adjacent building. Here the fish are dewatered and the anesthetic water is recycled and chilled. Eventually the anesthetic water is released into the river.

Sample room: The sample room is equipped with a series of troughs, enumeration devices, tag detectors and marking and tagging stations. The fish enter in a trough, from which they are taken and inspected, returned to another trough for eventual transport or return to the river.

Fish Lab

Handling Troughs

Marking Station

Flumes to raceways:

- The third gate can send fish not destined for the sample holding tanks either to the raceways for holding and transport downriver or directly back to the river.

Raceways:

- Fish that will be transported are held in raceways for up to 48 hours. There are two sets of raceways with four raceways each. Data from the sample room is used to estimate the quantity of fish being held. This information is used determine transportation schedules.
- The raceways are approximately 150 feet long and 8 feet wide.
- The raceways are equipped with motor operated crowders, which span the four-raceway set. Individual crowder screens are lowered to crowd one or all raceways.
- The end of the flume bringing fish into the raceways consists of a set of flumes about eight feet long supported on rollers that travel on rails. These flume sections can be connected to direct fish into any one of raceways.
- There are two exits from each raceway. They are controlled by a single flap gate. In the down position the gate blocks entry to the flume leading to the truck loading facility and opens the flume leading to the barge. In the up position fish are routed to the trucking facility.

Raceways Looking U.S.


Raceway #1


Raceway Crowder


Raceway Water Level Control


Rolling Flume Section

Truck loading facility:

- Operation was not observed
- Water to water transfers are used.
- Trucks are near full when loaded. As fish and water flow into the truck, excess water is discharged from the truck though screened outlets.
- 10-inch pipes lead from the raceways to the loading facility.
- Just prior to reaching the barge, water is screened from the flume, and the flume is reduced to a six-inch pipe.
- No photographs of transport trucks loaded on barges in Portland are available.

Truck Loading Facility

Barge loading facility:

- Operation was not observed
- Water to water transfers are used.
- 10-inch pipes lead to loading facility.
- Just prior to reaching the barge water is screened from the flume and reduced to a six-inch pipe.

Barge Loading Facility

Other items

- 30 to 60 mm shad experience high mortality during loading and transport.
- 50 thirty gallons drums of debris are removed per day by hand from the Holding Raceways..
- Fish are sampled for a min of 10 seconds. From the samples, raceway density is estimated to determine schedule for barges or trucks.
- Talk with Carl Shreck for info on stress and predation in the process. Many articles and publications were written about mortality and stress in the holding facility.

Notable design features:

- 36-inch PIT tag detectors

- Piping – lots of dewatering and rewatering sections of flume to obtain the correct velocities and water depths for the PIT tag interrogators., lots of controlled sections.
- Fish separator
- Bottom slide gate
- Hand operated crowder
- Color coded pipes and flumes
    - Blue – water supply
    - White – fish pipe
    - Green – drain

CHTR Trip Report

Date: April 15, 2004

Participants: Roger Padilla and Dennis Dorratcague

Location: SWP and CVP Delta Release Sites

Release occurred at the SWP Horseshoe Bend site at about 12:50 on 15-April-2004. About ½ hour before, DIDSON observation showed no predators within about 30' of end of outlet pipe. This was unlike the observations when up to 20 predators were observed just east of the release pipe and eastern pilings. The current direction was from west to east.

The DIDSON camera was turned back on just as the transport truck arrived at the release site. The predators started to return to the area just east of the release pipe when the flushing water pump was turned on. The DIDSON clearly showed water and debris coming out of the release pipe. The predators dispersed during the release and were not in or around the release plume as it was moved to the west by the current. After the release, the predators moved back to the end of the pipe. There were 3 to 5 of them with their noses at the end of the pipe or in it for about ½ hour after release (see the photos). There were from 10 to 15 within 20' of the pipe outlet for the ½ hour period. The predators were approximately 0.5 to 0.8 meters long.

We ceased oberservations about 50 minutes after release. At that time, there were still about 5 to 10 predators within 20' of the end of the release pipe.

Meeting with Lev Kavvas and Roger Churchwell
At UC Davis Hydraulics Labs

April 16, 2004
1:30 to 3:00 PM

We discussed the needs to build and run the experiments at the Davis labs and toured the lab & facilities. The following was decided:

1. Use the outdoor steel flume as the receiving water and build the transport tank tower in the shotcrete forebay model.
2. Fish tank facilities are all set up inside the building and should be available for our experiment. They consisted of 11 small tanks to hold small samples of fish and 3 or more larger tanks for holding fish awaiting use in the tests. The water supply can be temperature controlled from 12 to 19 degrees C.
3. MWH would design the tower for the transport tank and pipe supports. The tower would be about 14- to 20- feet high and would contain stairs and a platform for accessing the tank. Design would include geotech exploration, surveying, and foundation and structural design.
4. The construction would be bid through DWR. Not going through UCD would save time and money in design and construction.
5. After the proposal has been approved, DWR would enter into a contract with the lab. It would take about 4 months for this contract to be signed. If the contract were written through our contract it would cost us 47% add-on fee.
6. We would use Joe Cech and his people for the fish part of the work.
7. This appears to be a much better alternative for the test site.
8. We will redo the Release schedule and proposal to reflect using the UCD lab.

APPENDIX 4

CHTR Literature Database example pages.

Example of summary search report from database.

Author	Year	Title
U.S. Fish and Wildlife Service	1995	Sacramento - San Joaquin Native Fishes Recovery Plan
Jerry Morinaka	2003	South Delta Fish Facilities: introduction and overview
South Delta Fish Facility Forum	2003	Where do we go from here?
CALFED	2000	Fish facilities and fish screening. Science conference: sessions and notes.
Baker, P.F. & J.E. Morhardt	2002?	Survival of Chinook Salmon Smolts in the Sacramento - San Joaquin Delta and Pacific Ocean
Coulston, P. & S. Foss		Fish Salvage, Status and Trends

Publisher	Keywords	Process Stage	Comments
U.S. Fish and Wildlife Service, Portland, Oregon	Sacramento River, San Joaquin, native	C,H,T,R	Good overview of local species, abundance, habitat requirements, life history etc.
California Dept. of Fish and Game		C,H,T,R	Power point presentation outlining fish salvage process
South Delta Fish Facility Forum		C,H,T,R	Power point presentation outlining fish salvage process at FWP and Skinner plants
CALFED	Proceedings, fish salvage	C,H,T,R	Many operational / biological impact considerations considered
Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179:2	Survival, Chinook salmon, smolts	C,R	Effects of flow on smolt survival
California Dept. of Fish and Game		C,H,T,R	Power point presentation discussing and presenting fish salvage data

Full Report

Author	Year	Title	Source / Publisher
Aasen, G.A.	1999	Juvenile delta smelt use of shallow-water and channel habitats in California's Sacramento-San Joaquin Estuary.	California Fish and Game 85:161-169
Aasen, Geir A.	2003	Assesment of Fish Predation Occurring in the Collection, Handling, Transport, and Release Phase of the State Water Project's John E. Skinner Delta Fish Protective Facility Fish Salvage Operation	California Department of Fish and Game
Adams, S.M., A.M. Brown, and R.W. Goede	1993	A Quantitative Health Assessment Index for Rapid Evaluation of Fish Condition in the Field	Transactions of the American Fisheries Society 122: 63-73
Adkins, R.J., and P.E. Fields	1957	Conditioning Young Steelhead Trout to Colored Lights	University of Washington, School of Fisheries, Seattle, Technical Report No. 33, 22 pp

APPENDIX 5

Species code key with native species highlighted.

SWP facility fish collection data sheets.

CVP facility fish collection data sheets.

Fish salvage summary reports generated by DFG, Stockton from fish salvage database managed by S. Foss.

FISH FACILITIES SPECIES CODES

Species Name	Codes		Species Name	Codes	
Chinook Salmon	CS	1	White Crappie	WCR	41
Steelhead Rainbow Trout	STH	2	Pacific Herring	PH	42
Striped Bass	SB	3	Yellow Perch	YP	43
White Catfish	WCF	4	Black Bullhead	BLBH	44
Brown Bullhead	BBH	5	Sacramento Perch	SP	45
Channel Catfish	CCF	6	Tui Chub	TC	46
American Shad	AS	7	Silver Salmon	SS	47
Threadfin Shad	TFS	8	Pacific Brook Lamprey	PBL	48
Splittail	SPT	9	Redear Sunfish	RSF	49
Sacramento Squawfish	SQF	10	Sacramento Sucker	SSU	50
Threespine Stickleback	TSB	11	Fathead Minnow	FHM	51
Hardhead	HH	12	California Roach	CR	52
Golden Shiner	GS	13	Speckled Dace	SD	53
Carp	CP	14	Pumpkinseed	PKS	54
Goldfish	GF	15	Blue Catfish	BCF	55
Hitch	HTC	16			
Sacramento Blackfish	SBF	17			
Black Crappie	BCR	18			
Green Sunfish	GSF	19			
Warmouth	WMB	20	White Bass	WB	60
Bluegill	BG	21	Chameleon Goby	CG	61
Largemouth Bass	LMB	22	Pink Salmon	PS	62
Bigscale Logperch	LP	23	Freshwater Eel	FS	63
Tule Perch	TP	24	Red Shiner	RS	64
Longfin Smelt	LFS	25	Wakasagi	WS	65
Delta Smelt	DS	26	Shimofuri Goby	SG	66
White Sturgeon	WST	27	Rainwater Killifish	RK	67
Green Sturgeon	GST	28	Northern Pike	NP	68
Prickly Sculpin	PSC	29			
Yellowfin Goby	YFG	30			
Inland Silverside	ISS	31			
Starry Flounder	STF	32			
Lampreys (all spp.)	LAM	33			
Mosquitofish	GAM	34	Sunfish (Generic)	SUNG	89
Yellow Bullhead	YBH	35	Miscellaneous	MISC	90
Smallmouth Bass	SMB	36			
Surf Smelt	SSM	37			
Striped Mullet	SM	38			
Staghorn Sculpin	SSC	39	Total Fish Count	TTLCNT	98
Riffle Sculpin	RSC	40	Total Fish Estimate	TTLEST	99

Fish salvage datasheets, SWP:

State of California

Fish Salvage: Hourly Actual Totals

Date:

TIME						
LENGTH OF TIME						
Chinook Salmon						
Steelehead						
Striped Bass						
White Catfish						
Channel Catfish						
American Shad						
Threadfin Shad						
Splittail						
Golden Shiner						
Common Carp						
Green Sunfish						
Bluegill						
Largemouth Bass						
Bigscale Logperch						
Delta Smelt						
White Sturgeon						
Prickly Sculpin						
Yellowfin Goby						
Inland Silverside						
Pacific Lamprey						
Shimofuri Goby						
Mosquitofish						
Rainwater Killifish						
Sacramento Blackfish						
Starry Flounder						
Longfin Smelt						
Wakasagi Smelt						
Black Crappie						
Chinese Mitten Crab						
Total Fish Count						
Projected Crab Count						
Transfer Crab Total +						
Projected Fish Total						
Transfer Fish Total +						

DATE:

SALVAGE INFORMATION

TIME	OPERATIONAL			WINTER RUN SALMON						SPLITTAIL		DELTA SMELT		MITTEN CRABS	
24 HOUR	Fish Count Length Minutes	Pumping Minutes	Pump Rate CFS	SKINNER No Tag Observed Fish	SKINNER No Tag Expanded Salvage	SKINNER No Tag Estimated Loss	SKINNER Tagged Observed Fish	SKINNER Tagged Expanded Salvage	SKINNER Tagged Estimated Loss	SKINNER Observed Fish	SKINNER Expanded Salvage	SKINNER Observed Fish	SKINNER Expanded Salvage	SKINNER Observed Crabs	SKINNER Expanded Salvage
0001															
0100															
0200															
0300															
0400															
0500															
0600															
0700															
0800															
0900															
1000															
1100															
1200															
1300															
1400															
1500															
1600															
1700															
1800															
1900															
2000															
2100															
2200															
2300															
2400															

Facility: 1 Date: ___ / ___ / ______ (MM / DD / YYYY)

Fish Salvage Length Data Sheet - *STATE FACILITY*

Time: ______________

Special Study Type : ______________

Building Code Old or New	Species Name	Code	Lengths (mm) - Indicate Adipose Clipped Salmon with a "C" next to Length											

Revised 01/17/2000

STATE FACILITY

Facility: 1 Date: ___/___/_____ (MM DD YYYY) **Fish Salvage Operations & Counts -** ***STATE FACILITY*** Daily Acre Feet: ________

Revised 01/17/2000

Sample Time												
Total Minutes Pumping												
Length of Count (Min.)												
Temperature (F)												
Channels or Bays Open												
Primary Depth (FT)												
Primary Flow (CFS)												
Building Code	**Old**	**New**	**O**	**N**	**O**	**N**	**O**	**N**	**O**	**N**	**O**	**N**
Primary Bypasses Open												
Secondary Depth (FT)												
Secondary Flow (CFS)												
Holding Tank Flow (CFS)												

Species Name	**Code**	**Old**	**New**	**Total**	**Old**	**New**	**Total**	**Old**	**New**	**Total**	**Old**	**New**	**Total**	**Old**	**New**	**Total**	**Old**	**New**	**Total**
Chinook Salmon	1																		
Steelhead Trout	2																		
Striped Bass	3																		
White Catfish	4																		
Channel Catfish	6																		
American Shad	7																		
Threadfin Shad	8																		
Splittail	9																		
Delta Smelt	26																		
Mitten Crab	80																		
Total Count	98																		
Sampler Initials																			

Comments:

STATE FACILITY

Fish salvage datasheets, CVP:

STATE OF CALIFORNIA - THE RESOURCES AGENCY GRAY DAVIS, Governor

DEPARTMENT OF FISH AND GAME
CALIFORNIA SALMONID TISSUE ARCHIVE
830 S STREET
SACRAMENTO, CA 95814
Telephone (916) 327-8119

CENTRAL VALLEY PROJECT
TISSUE COLLECTION FORM

Collection Location: Central Valley Project
Location Code: CVP

Collection Date	Time	FL (mm)	Sample ID	Ad clipped? Yes	No	Archive Date	Distribution Code
/ / 03	:		U03 CVP			/ /	- - :1-
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP				
/ / 03	:		U03 CVP			/ /	- - :1-

Data Edit: ____________________ Database Proof: ____________________

Traveling Screen 10 Minute
Mitten Crab & Fish Count Data Sheet

Date : ________ 2000

Hour	**Number of Crabs**		**Number of Fish**								
	Male	Female	Striped Bass	American Shad	Blackfish	Centrarchid	Splittail	Steelhead	Salmon	Catfish	Other
0200											
0400											
0600											
0800											
1000											
1200											
1400											
1600											
1800											
2000											
2200											
2400											

Note: Remember to record fish and crab size at every count on a fish length data sheet.

Comments:

TO-013 (Rev.12/07/94)

FISH DAILY TALLY SHEET

Date:______________

☐ Tank Change
☐ Minute Count

Fish Species	Count Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400	TOTAL
Salmon YOY	Count													
	Total													
Salmon	Count													
	Total													
Steelhead Trout	Count													
	Total													
Stripped Bass	Count													
	Total													
Threadfin Shad	Count													
	Total													
American Shad	Count													
	Total													
Catfish	Count													
	Total													
Channel Catfish	Count													
	Total													
Spiny Ray	Count													
	Total													
Carp	Count													
	Total													
Sturgeon	Count													
	Total													
Smelt	Count													
	Total													
Misc.	Count													
	Total													
	TOTAL													

Fish Salvage Operations & Counts - *FEDERAL FACILITY*

Facility: **2**　　Date: ___/___/_____ (MM DD YYYY)　　Daily Acre Feet: __________

Sample Time						
Special Study Code						
Total Minutes Pumping						
Length of Count (Min.)						
Temperature (F)						
Bypasses Open						
Primary Depth (FT)						
Primary Flow (CFS)						
Building Code	O	O	O	O	O	O
Secondary Depth (FT)						
Secondary Flow (CFS)						
Holding Tank Flow (CFS)						

Species Name	**Code**	**Count**	**Count**	**Count**	**Count**	**Count**	**Count**
Chinook Salmon	1						
Steelhead Trout	2						
Striped Bass	3						
White Catfish	4						
Channel Catfish	6						
American Shad	7						
Threadfin Shad	8						
Splittail	9						
Delta Smelt	26						
Mitten Crab	80						
Total Count	98						
Sampler Initials							

Comments:

Revised 3/21/2000

Facility: **2** Date: ___ / ___ / ______
MM DD YYYY

Fish Salvage Length Data Sheet - *FEDERAL FACILITY*

Time: ______________

Special Study Type : ________________

Building Code	Species Name	Code	Lengths (mm) - Indicate Adipose Clipped Salmon with a "C" next to Length											
O														
O														
O														
O														
O														
O														
O														
O														
O														
O														
O														
O														
O														

Revised 03/20/2000

FEDERAL FACILITY

TRACY FEDERAL FISH COLLECTION FACILITY   Page 1 of __

209-836-6233/209-833-0340

TABLE FOR TRACKING DAILY WINTER-RUN, OTHER SALMON, STEELHEAD, DELTA SMELT, and SPLITTAIL (numbers collected)

DATE __/__/__ Daily Acre Feet=

WINTER-RUN LENGTH RANGE ____-____ mm, SPRING-RUN LENGTH RANGE ____-____ mm

TIME	PUMP RATE (cfs)	COUNT MINUTES	MINUTES PUMPING	WINTER RUN	RUNNING TALLY (W-RUN)	SPRING RUN	OTHER RUNS	STEEL-HEAD	DELTA SMELT	SPLIT-TAIL	CRAB SCREEN ON? Y/N	10-min crabs
0200												
0400												
0600												
0800												
1000												
1200												
1400												
1600												
1800												
2000												
2200												
2400												
Total												

This table is to be used for FAXing the above numbers to:
Central Valley Operations (USBR); FAX 1-916-979-3080 (phone number 1-916-979-3002)

Species	Collect Time	Length Clipped?	**Winter-run Length? Y/N**	Species	Collect Time	Length Clipped?	**Winter-run Length? Y/N**	Species	Collect Time	Length Clipped?	**Winter-run Length? Y/N**

Reports Generated by S. Foss, DFG, Stockton:

Seasonal Salmon Salvage and Loss Since 01-Oct-03

Fall run at CVP facility

	Month	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
	Nov-03	0	0	13	8
	Oct-03	0	0	12	8
	Jan-04	0	0	24	14
Sum of Fall at CVP		0	0	49	30

LateFall run at CVP facility

	Month	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
	Feb-04	12	8	1	1
	Jan-04	396	258	24	16
	Dec-03	72	47	0	0
Sum of LateFall at CVP		480	312	25	16

Winter run at CVP facility

	Month	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
	Dec-03	60	38	48	31
	Feb-04	120	81	144	103
	Jan-04	1368	892	120	75
Sum of Winter at CVP		1548	1011	312	209
Sum of all races at CVP		2028	1324	386	255

LateFall run at SWP facility

	Month	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
	Dec-03	24	104	0	0
	Jan-04	284	1221	12	53
Sum of LateFall at SWP		308	1325	12	53

Spring run at SWP facility

	Month	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
	Feb-04	0	0	6	25
	Jan-04	0	0	6	25
Sum of Spring at SWP		0	0	12	50

Winter run at SWP facility

	Month	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
	Jan-04	3113	13395	132	567
	Dec-03	90	391	12	52
	Feb-04	223	1006	54	245
Sum of Winter at SWP		3426	14792	198	864

Steelhead Salvage From 01-Feb-04 to 18-Feb-04

CVP facility	SampleDate	Adipose Clipped	Not Clipped
	02/02/2004	48	0
	02/03/2004	36	0
	02/04/2004	36	12
	02/05/2004	12	0
	02/07/2004	36	24
	02/08/2004	24	0
	02/09/2004	12	0
	02/10/2004	12	12
	02/11/2004	12	0
	02/12/2004	48	24
	02/13/2004	48	36
	02/14/2004	132	24
	02/15/2004	228	24
	02/16/2004	300	0
	02/17/2004	132	0
	02/18/2004	60	12
Sum of Steelhead at CVP		1176	168
SWP facility	SampleDate	Adipose Clipped	Not Clipped
	02/02/2004	9	7
	02/03/2004	18	6
	02/05/2004	0	9
	02/06/2004	0	15
	02/07/2004	6	6
	02/08/2004	0	3
	02/09/2004	9	8
	02/10/2004	21	0
	02/11/2004	18	0
	02/12/2004	54	6
	02/13/2004	45	12
	02/14/2004	48	18
	02/15/2004	120	18
	02/16/2004	282	24
	02/17/2004	138	19
	02/18/2004	162	18
Sum of Steelhead at SWP		930	169
Total for 2/1/2004 to 2/18/2004		2106	337

14 Day Running Average

For: 18-Feb-04

Species	Salvage
Delta Smelt	4
Splittail	33

Seasonal Steelhead

Since 01-Oct-03

CVP facility		Adipose Clipped	Not Clipped
	Dec-03	0	12
	Jan-04	36	72
	Feb-04	1176	168
Sum of all steelhead at CVP		1212	252

SWP facility		Adipose Clipped	Not Clipped
	Dec-03	0	12
	Jan-04	153	108
	Feb-04	930	169
Sum of all steelhead at SWP		1083	289

Total since 10/1/2003		2295	541

Salmon Salvage and Loss   From 01-Feb-04 to 18-Feb-04

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LateFall run at CVP facility

SampleDate	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
02/01/2004	12	8	0	0
02/02/2004	0	0	1	1
Sum of LateFall run at CVP	12	8	1	1

Winter run at CVP facility

SampleDate	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
02/02/2004	24	16	0	0
02/04/2004	12	8	0	0
02/05/2004	36	23	0	0
02/07/2004	0	0	12	8
02/10/2004	0	0	24	17
02/11/2004	0	0	24	17
02/12/2004	12	9	24	17
02/14/2004	12	9	24	17
02/15/2004	12	9	0	0
02/16/2004	12	9	0	0
02/17/2004	0	0	24	17
02/18/2004	0	0	12	9
Sum of Winter run at CVP	120	81	144	103

	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
Sum of all races at CVP	132	89	145	104

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Spring run at SWP facility

SampleDate	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
02/10/2004	0	0	6	25
Sum of Spring run at SWP	0	0	6	25

Winter run at SWP facility

SampleDate	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
02/01/2004	42	188	0	0
02/02/2004	21	92	0	0
02/03/2004	15	68	0	0
02/09/2004	1	4	0	0
02/11/2004	12	53	0	0
02/12/2004	9	40	6	26
02/13/2004	6	27	0	0
02/14/2004	6	27	0	0
02/15/2004	6	28	12	54
02/16/2004	78	359	30	138
02/17/2004	12	55	0	0
02/18/2004	15	66	6	27
Sum of Winter run at SWP	223	1006	54	245

	Adipose Clipped Salvage	Adipose Clipped Loss	Not Clipped Salvage	Not Clipped Loss
Sum of all races at SWP	223	1006	60	270
Total for 2/1/2004 to 2/18/2004	355	1095	205	373

Special Species Salvage From 01-Feb-04 to 18-Feb-04

Delta Smelt

SampleDate	SWP Salvage	SWP Acre Feet	CVP Salvage	CVP Acre Feet
02/01/2004	12	9367	12	8639
02/02/2004	22	9278	12	8522
02/03/2004	15	8005	0	
02/05/2004	9	11734	12	8579
02/06/2004	3	9991	0	
02/09/2004	6	12899	0	
02/10/2004	9	12401	0	
02/13/2004	0		12	7305
Total for Delta Smelt	76	73675	48	33045

Longfin Smelt

SampleDate	SWP Salvage	SWP Acre Feet	CVP Salvage	CVP Acre Feet
02/06/2004	6	9991	0	
02/09/2004	3	12899	0	
Total for Longfin Smelt	9	22890	0	

Splittail

SampleDate	SWP Salvage	SWP Acre Feet	CVP Salvage	CVP Acre Feet
02/02/2004	1	9278	0	
02/03/2004	6	8005	0	
02/06/2004	3	9991	12	8566
02/07/2004	0		12	7591
02/09/2004	7	12899	0	
02/10/2004	0		12	7256
02/11/2004	0		24	7349
02/12/2004	15	12633	0	
02/13/2004	24	12647	0	
02/14/2004	9	12591	12	7371
02/15/2004	12	12889	0	
02/16/2004	66	12745	0	
02/17/2004	260	11227	0	
Total for Splittail	403	114905	72	38133

Sum of all races at SWP	3734	16117	222	966
Total since 10/1/2003	5762	17441	608	1221

APPENDIX 6

Web based resources for fish salvage related data and research programs.

Database	Years	Location	Parameters
Central Valley Bay Delta Branch Fish Monitoring	1995-2004	ftp://ftp.delta.dfg.ca.gov/salvage/	Wide range of fish salvage data
Bureau of Reclamation, Tracy Fish Facility Applied Research	2000-2003	http://www.usbr.gov/pmts/tech_services/tracy_research/fish-genus-species.htm	3 year species composition
Bureau of Reclamation, Tracy Fish Facility Applied Research	2000-2003	http://www.usbr.gov/pmts/tech_services/tracy_research/Semi-continuous_Water_Quality_Data.cfm	Semi continuous water quality data
DWR water data library	1930-2004	http://wdl.water.ca.gov/wq/gst/water_quality_report1_gst.asp	Water quality monitoring station data library.
Central Valley Operations Office	2000-2004	http://www.usbr.gov/mp/cvo/html/wqrpt.html	Water quality reports
Central Valley Operations Office	1999-2004	http://www.usbr.gov/mp/cvo/html/fishrpt.html	Fish reports: salmon, steelhead, delta smelt, and splittail
Central Valley Operations Office	2002-2004	http://www.usbr.gov/mp/cvo/HTML/delivrpt.html	CVC water delivery reports
Central Valley Operations Office	1996-2004	http://www.usbr.gov/mp/cvo/vungvari/Temp.html	Sacramento river temperature reports
Central Valley Operations Office	1993-2004	http://www.usbr.gov/mp/cvo/vungvari/deliv.html	Report of operations monthly delivery tables
Central Valley Operations Office	1998-2004	http://www.usbr.gov/mp/cvo/html/pmdoc.html	Water accounting reports
Bureau of Reclamation, Tracy Fish Facility Applied Research		http://www.usbr.gov/pmts/tech_services/tracy_research/Collaborators.htm	Links to State, Federal, and Dept. of Interior collaborative research.