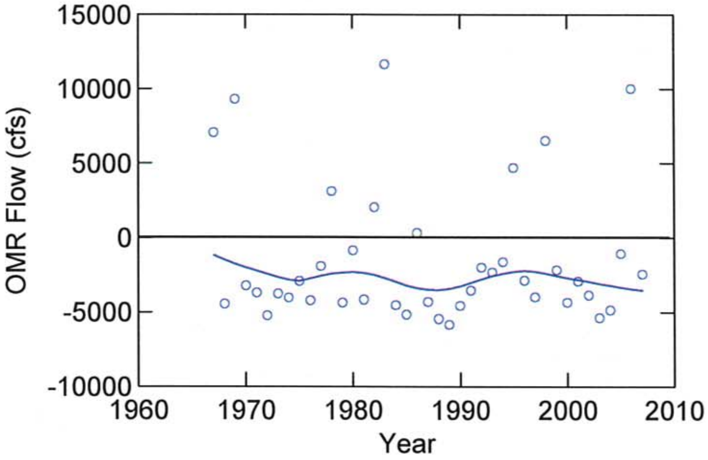

Figure 21. Trend in average spring (Apr-Jun) Old and Middle River (combined) flows 1967-2007, based on estimated (1967-1992) and measured (1993-2007) flows. See text for data sources. A LOWESS line was plotted through points to show general trend.

Delta. OMR restrictions in the delta smelt Biological Opinion and reduced exports and pulse flow associated with VAMP to assist salmon migration also benefit longfin smelt.

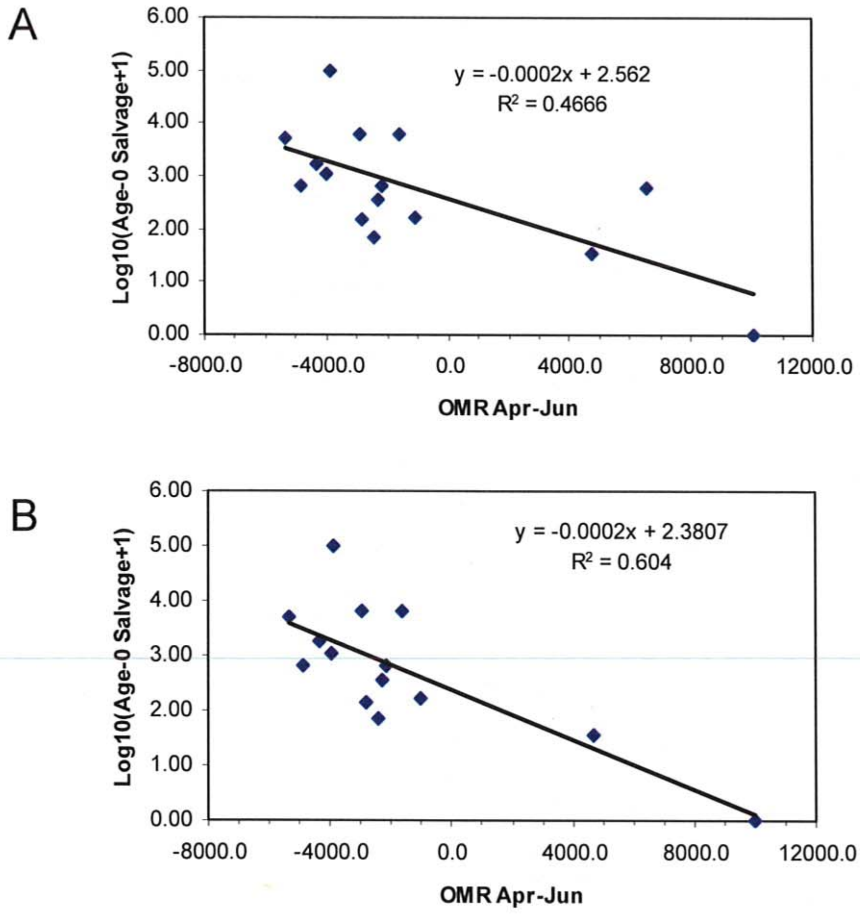

Figure 22. Relationship between spring (Apr-Jun) average Old and Middle River (combined) flows and sum of Apr-Jun combined SWP and CVP juvenile (age-0) longfin smelt salvage, 1993-2007 (A) and 1993-2007 without 1998 (B). In 1998, a protracted SWP export shut down allowed longfin smelt larvae to grow to salvageable size within Clifton Court before pumping resumed and fish salvage re-commenced; these fish would have passed through the system as larvae without recognition otherwise.

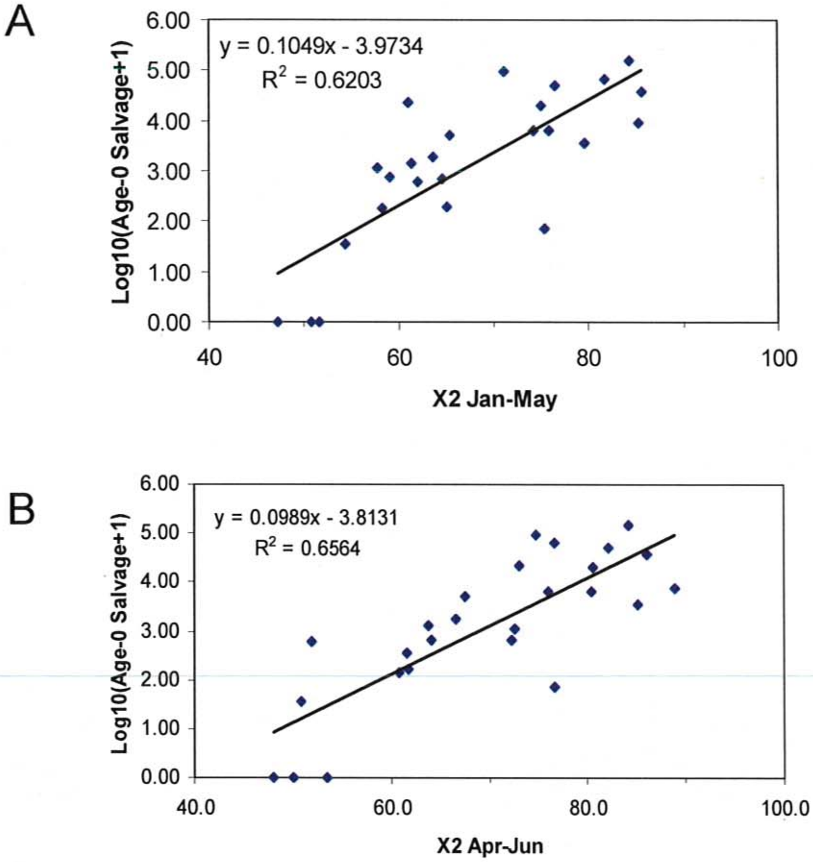

Figure 23. Relationship between winter-spring (Jan-May) average X2 location and sum of Mar-Jul combined SWP and CVP juvenile (age-0) longfin smelt salvage (A) and spring (Apr-Jun) average X2 location and Apr-Jun SWP and CVP juvenile (age-0) salvage (B). Salvage was incremented by one and log10 transformed.

Suisun Marsh Salinity Control Gates

Facility description: The SMSCG are located near the eastern confluence of Montezuma Slough and the Sacramento River near Collinsville (Figure 2). Operation of the SMSCG began in October 1988 as Phase II of the Plan of Protection for the Suisun Marsh. The objective of SMSCG operation is to decrease the salinity of the water in Montezuma Slough for multiple beneficial uses. The facility spans the 465-foot width of Montezuma Slough and consists of a boat lock, three radial gates, and removable flashboards. This array allows tidal control of the water entering Suisun Marsh, while allowing passage of watercraft. The gates reduce salinity by restricting the flow of brackish water from Grizzly Bay into Montezuma Slough during incoming tides and importing low salinity Sacramento River water during ebb tides, which results in a net movement of Sacramento River water into Suisun Marsh. The resulting net flow into Montezuma Slough is approximately 2500-2800 cfs. This net flow reduces salinity at Beldons

Landing by about 100%, and lesser amounts further west along Montezuma Slough. The net flow into the slough no longer contributes to the river flow entering Suisun Bay proper. Thus, the salinity field in Suisun Bay moves upstream when the gates are operated. However, because most of the water diverted in Suisun Marsh is circulated through its major distribution systems, net outflow past Carquinez Strait is not affected.

During the past several years, the SMSCG have not been used as frequently as they were in the past. The gates were operated approximately 40-270 days between October and May during 1988-2005 (Figure 24). Salmon passage studies between 1998 and 2003 increased the number of operating days by up to 14 to meet study requirements. Based on study findings and an agreement with NMFS, the boat lock is now always open to allow for continuous salmon passage. With increased understanding of the effectiveness of the gates at lowering salinity in Montezuma Slough, salinity standards have been met with less frequent gate operation since 2006. For instance, gate operation was not required at all in fall 2007 and was limited to 17 days in the winter of 2008. This operational frequency (10 – 20 days per year) is expected to continue, except perhaps during the most critical low outflow conditions. However, this conclusion cannot extend indefinitely due to rising sea level, which will eventually require more days of operation if salinity standards do not change.

The USACOE permit for operating the SMSCG requires that it be operated between October and May only when needed to meet Suisun Marsh salinity standards. This overlaps the spawning migration and early life stage rearing of longfin smelt.

Adult longfin smelt: Adult longfin smelt typically migrate from brackish or marine habitats into low-salinity staging and spawning habitats during December-March. The SMSCG have the potential to cause short-term delays in salmonid spawning migrations (Tillman et al 1996: Edwards et al 1996). Thus, they may do the same to migrating longfin smelt. However, given that the boat locks are now always open based on NMFS' requirements for salmonid passage, longfin smelt passage delays may already be mitigated. If the SMSCG increased adult longfin smelt residence time in Montezuma Slough, entrainment at RRDS could increase. Presumably however, the fish screen on Roaring River Distribution System prevents the entrainment of adult longfin smelt. The MIDS is unscreened, but not directly connected to Montezuma Slough, so it seems unlikely that operation of the SMSCG would influence MIDS entrainment risk.

Larval and juvenile longfin smelt (young-of-year fish from January – June): Larval and juvenile longfin smelt rear in the low-salinity waters of the upper estuary year-around, but most larvae are present January-April and many remaining juvenile fish begin dispersing downstream as water temperatures warm during summer (Rosenfield and Baxter 2007). Thus, there also is considerable temporal overlap between SMSCG operations and the presence of early life stage longfin smelt. The ptm results show

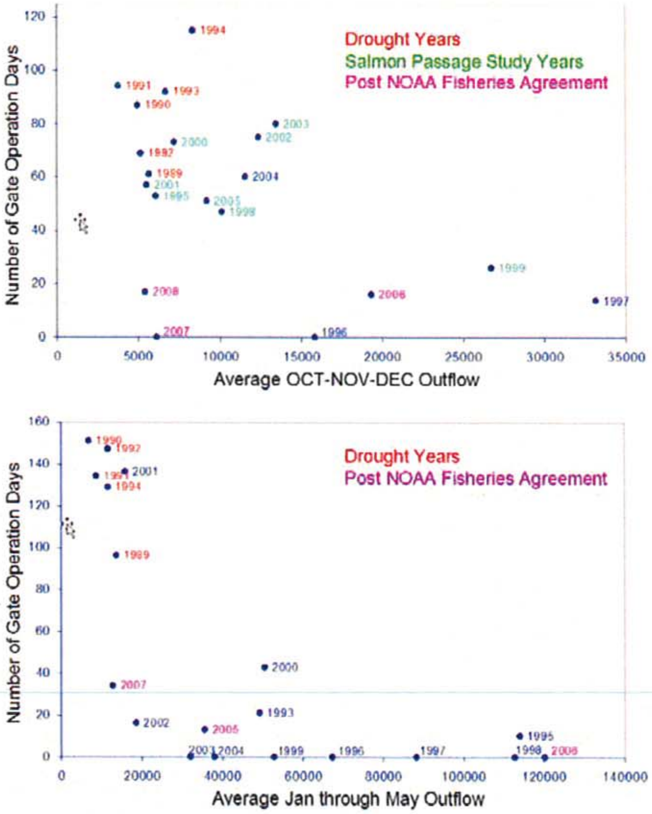

Figure 24. Scatterplots of fall and winter-spring Delta outflow versus the number of days the Suisun Marsh Salinity Control Gates were operated. Data points are labeled by year. Source: DWR permit application/2008 OCAP Biological Assessment for delta smelt.

clearly that the transport of larval longfin smelt is affected by SMSCG operation. In all three years modeled, the percentage of particles passing Chipps Island was correlated with the percentage of particles that entered Montezuma Slough (Figure 25). However, in 1992, a year when the SMSCG was operated about 150 days between January and May, over 20% of particles were predicted to enter Montezuma Slough in some instances. In 2002 and 2008, when the SMSCG were operated fewer than 20 days, ≤ 5% of particles were ever predicted to enter the marsh. The weighted ptm fluxes also show these differences. The indices were an order of magnitude higher in 1992 (Table 5).

Roaring River and Morrow Island Distribution Systems

The RRDS and MIDS were constructed in 1979 and 1980 as components of the Initial Facilities in the Plan of Protection for the Suisun Marsh. Details of these facilities are in Table 6. Immediately after the construction of RRDS and MIDS, fish densities in the UCD Suisun Marsh Otter Trawl Monitoring Program declined and they have remained comparatively low since, though longfin smelt was not a particularly dominant species,

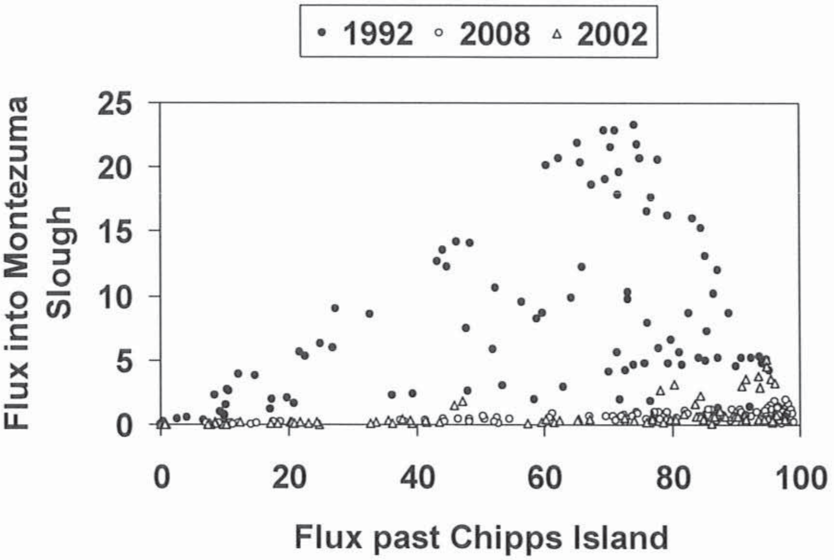

Figure 25. Scatterplot of particle flux past Chipps Island versus particle flux into Montezuma Slough for particles released Jan 1 – Apr 1, 1992 and 2008. Source: DWR particle tracking modeling in support of this permit.

Table 5. Weighted percentages for flux of particles into Montezuma Slough, 1992, 2002, and 2008.

Year	Particle behavior	Weighted flux
1992	Neutrally buoyant	10.9%
1992	Surface oriented	11.3%
2002	Neutrally buoyant	1.27%
2002	Surface oriented	0.94%
2008	Neutrally buoyant	1.1%
2008	Surface oriented	0.96%

averaging only 6% of the catch from 1979-1999 (Matern et al. 2002). The relative abundance of nonnative species has also increased through time in the UCD surveys, but this trend is due to steeper declines of native fish rather than increased nonnative fish densities. The RRDS was screened because it was recognized that it was a significant source of fish entrainment (Pickard and Kano 1982). The MIDS is not screened, mainly because it has not been demonstrated that doing so would protect special-status fishes (Culberson et al. 2004; Enos et al. 2007) such as delta smelt and salmonids.

Table 6. Comparison of the Roaring River and Morrow Island Distribution Systems in Suisun Marsh.

	Roaring River	Morrow Island
Primary purpose	Reduce salinity of water delivered to privately and publically managed wetlands used primarily for waterfowl hunting	Increase water circulation through Suisun Slough and drain high salinity water from Suisun Slough and adjancent managed wetlands used primarily for waterfowl hunting
Construction	1979-1980	1979-1980
Intake specifications	Eight 60-inch culverts	Three 48-inch culverts
Fish screens	Yes – 3/32 inch mesh operated to average approach velocity of 0.2 ft/s since 1993	No

Adult longfin smelt: During the fall, longfin smelt migrate into low-salinity waters to 'stage' before spawning. During staging and spawning some longfin smelt occupy Suisun Marsh. They should be protected from entrainment at RRDS by the fish screens, but some are entrained at MIDS (Enos et al. 2007; Figure 26). Enos et al. (2007) sampled entrained fishes at MIDS during 2004-2006. More adult longfin smelt were entrained in fall of 2004 than fall of 2005 (Figure 26). There was a correspondence of timing between maximum sampling effort by Enos et al., entrainment of longfin smelt, and relative abundance in the estuary as indexed by DFG (Table 7). In fall 2004, the highest entrainment occurred coincident with the highest amount of diverted water sampled in December. This also coincided with the highest monthly DFG catch in the FMWT, which suggests the high entrainment was due to both higher sampling effort and movement of longfin smelt into adult staging habitats. In fall 2005, the highest DFG catches occurred in September when MIDS sampling effort was low. In October 2005, sampling effort increased substantially and a few longfin smelt were observed to be entrained even though FMWT catches had dropped considerably.

Fish catch data from MIDS suggest there is an operational threshold that can minimize fish entrainment at this diversion. Few adult longfin smelt were entrained when the maximum velocity of water diverted through MIDS on a tidal cycle was less than 3 ft/s (Figure 27). However, as explained above, adult longfin smelt were not frequently observed in samples of entrained fish. Therefore, we also looked at age-0 splittail entrainment versus maximum velocity. We used age-0 splittail for two reasons. First, they were entrained more frequently and second, they were smaller than the longfin smelt, but are fairly strong swimmers, so we think this represents a comparison of two

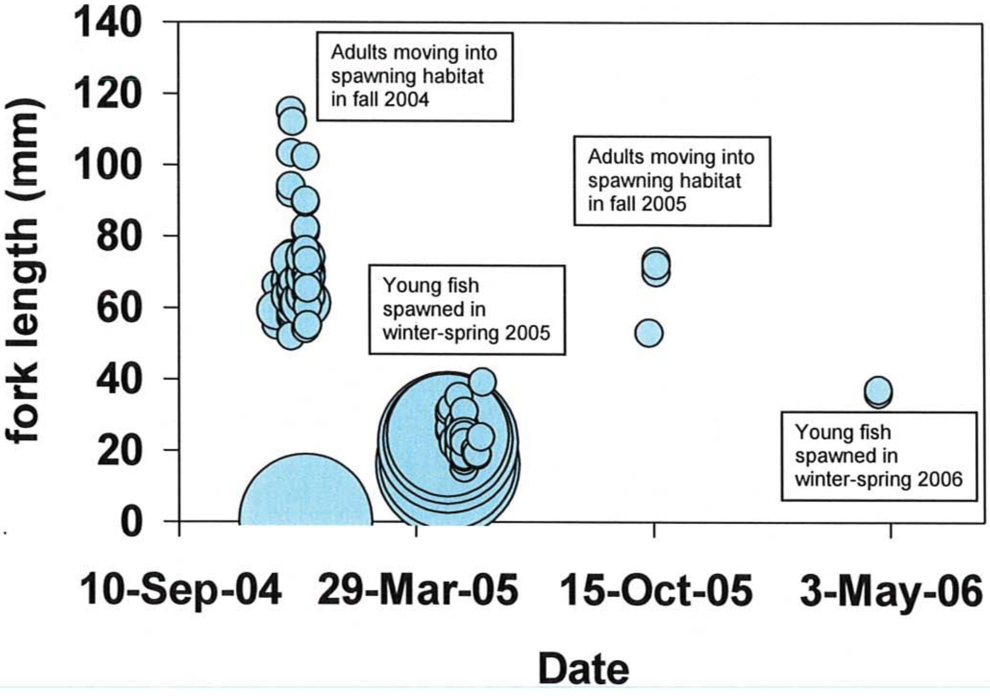

Figure 26. Bubble plot of collection date versus longfin smelt fork lengths from a study of fish entrainment at Morrow Island Distribution System. Each data point is sized by the number of fish at the length shown. The large dots at length = 0 mm correspond to fish that were counted, but not measured. Source: DWR unpublished data.

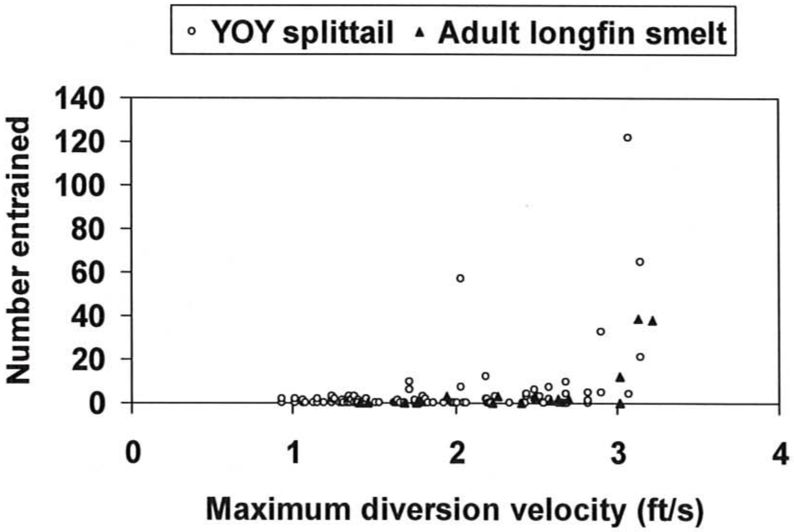

Figure 27. Scatterplot of average water velocity at the Morrow Island Distribution System intake versus numbers of age-1 and older longfin smelt and age-0 splittail entrained into the diversion.

Table 7. Comparison of adult longfin smelt entrainment at MIDS during fall 2004 and 2005 with the monthly DFG Fall Midwater Trawl relative abundance indices.

	MIDS volume sampled (ft^3)	Observed longfin smelt entrainment	FMWT index
September 2004	710,169	0	44
October 2004	0	0	9
November 2004	1,478,569	0	9
December 2004	6,729,396	104	129
September 2005	82,867	0	1563
October 2005	5,331,814	4	169
November 2005	762,157	0	184
December 2005	1,010,333	0	33

fishes with similar swimming ability. Excepting one data point near 2 ft/s, the splittail entrainment also increased when maximum velocity approached 3 ft/s.

Larval and juvenile longfin smelt: Culberson et al. (2004) used the DSM2 particle tracking model (ptm) to demonstrate that proximity to the MIDS diversion was the primary factor influencing entrainment risk. Particles released outside of the sloughs affected by MIDS were seldom if ever entrained. Similarly, none of the particles released in the Delta for simulations done by DWR for this permit were entrained into MIDS or RRDS. Thus, the weighted ptm indices for MIDS and RRDS were always zero.

The entrainment of adult longfin smelt into MIDS suggests that suitable spawning habitat exists nearby since MIDS is not predicted to entrain particles released distant from it (Culberson et al. 2004). This hypothesis is also supported by the subsequent catches of young-of-year longfin smelt at MIDS. Fewer larvae and juveniles were observed being entrained in spring 2006 following low adult entrainment the previous fall than in spring 2005, which followed the higher fall 2004 adult entrainment (Figure 26).

North Bay Aqueduct

Facility description: North Bay Aqueduct can convey up to about 175 cfs diverted from the Barker Slough Pumping Plant. North Bay Aqueduct diversions are conveyed to Napa and Solano Counties. As its name suggests, Barker Slough Pumping Plant is located in Barker Slough, which is located in the northwest part of the Cache Slough system (Figure 2). The NBA intake is located approximately 10 miles from the main stem Sacramento River. The diversion is operated year-round and is located in or near longfin smelt spawning habitat (see below). Per DFG screening criteria, each of the ten NBA pump bays is individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch. This configuration is designed to exclude fish approximately 25 mm or larger from being entrained. The bays tied to the two smaller units have an approach velocity of about 0.2

ft/s. The larger units were designed for a 0.5 ft/s approach velocity, but actual approach velocity is about 0.44 ft/s.

Adult longfin smelt: Longfin smelt use the Cache Slough region as spawning habitat more during low outflow winter/springs when the low-salinity zone encompasses parts of the Delta, but DFG has not found evidence that longfin smelt spawn extensively in the Cache Slough region like delta smelt do. As mentioned above, the Barker Slough Pumping Plant diversions are screened and approach velocities are fairly low, so entrainment and impingement of adult longfin smelt staging or spawning in Barker Slough should be minimal. Further, the flooding of Little Holland Tract and Liberty Island seems to have decreased the NBA/Yolo Bypass flow ratio, greatly reducing the risk of false attraction flows toward the Barker Slough Pumping Plant during the longfin smelt spawning season (Figure 28).

Larval and juvenile longfin smelt: Water diversions into NBA have typically been less than 100 cfs with maximum diversion rates occurring during the summer months (Figure 29) when longfin smelt are not present or present only at very low densities. Annual diversions into NBA have generally increased since the facility came online in 1988 (Figure 29). However, diversions have not increased during January-March when most larval longfin smelt are nearby (Figure 30). The winter diversions have usually averaged about 40 cfs and have seldom exceeded 80 cfs on a daily basis.

However, the projected winter diversions into NBA presented in the OCAP Biological Assessment are much higher (Figure 31). In future scenarios in which full SWP water demand is assumed, the Barker Slough Pumping Plant is expected to frequently operate to full capacity (175 cfs) during January-March except in very wet years. This would mean water diversion rates up to 4-5 times higher than current conditions.

Station 716, located in Cache Slough (Figure 2), was the only station in the ptm analyses DFG requested for this permit from which particles were entrained at Barker Slough. The ptm results indicated that the loss of surface-oriented particles to NBA ranged from 1.5% to 37% depending on release date; particle loss was nonlinearly related to the average pumping rate the particles were exposed to (Figure 32). The weighted ptm percent fluxes into NBA were very consistent among years, and suggested this diversion currently has only a very minor effect on longfin smelt larvae; less than 1% of longfin smelt larvae are expected to be entrained into NBA in dry years under current operations even if the fish screens provide no protection to larvae (Table 8). In wet years, entrainment has probably been lower still because even fewer longfin smelt spawn in the Cache Slough region in wet years. Based on Figure 32, NBA diversions ≤ 40 cfs during low outflow winter-springs are unlikely to entrain larvae spawned in the greater Cache Slough region.

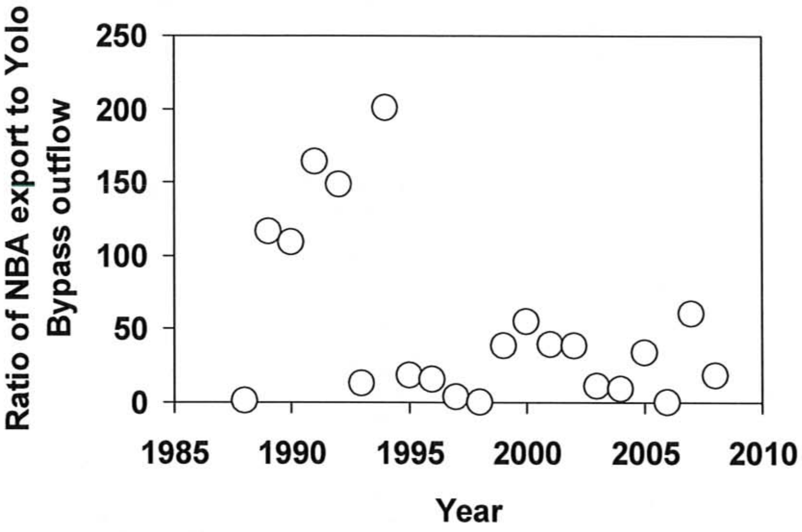

Figure 28. Average January-March ratio of water diversion into the North Bay Aqueduct relative to outflow from Yolo Bypass. Source: DAYFLOW.

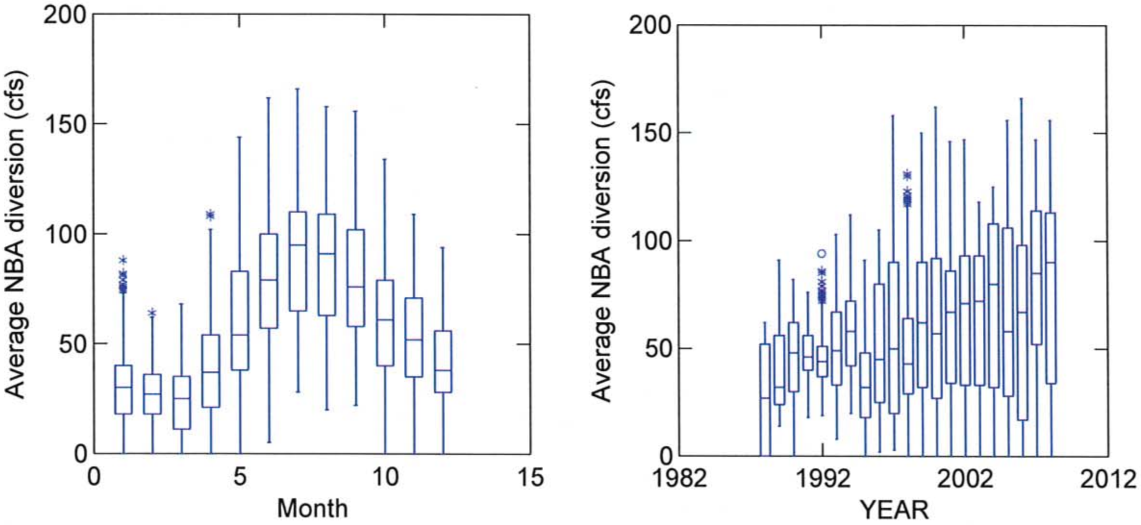

Figure 29. Boxplots summarizing water diversions at Barker Slough Pumping Plant into the North Bay Aqueduct. Left panel = monthly diversion summaries. Right panel = annual diversion summaries. The boxplots show monthly median values (1988-2008) and quartile ranges and the whiskers and asterisks show more extreme values. Source: DAYFLOW.

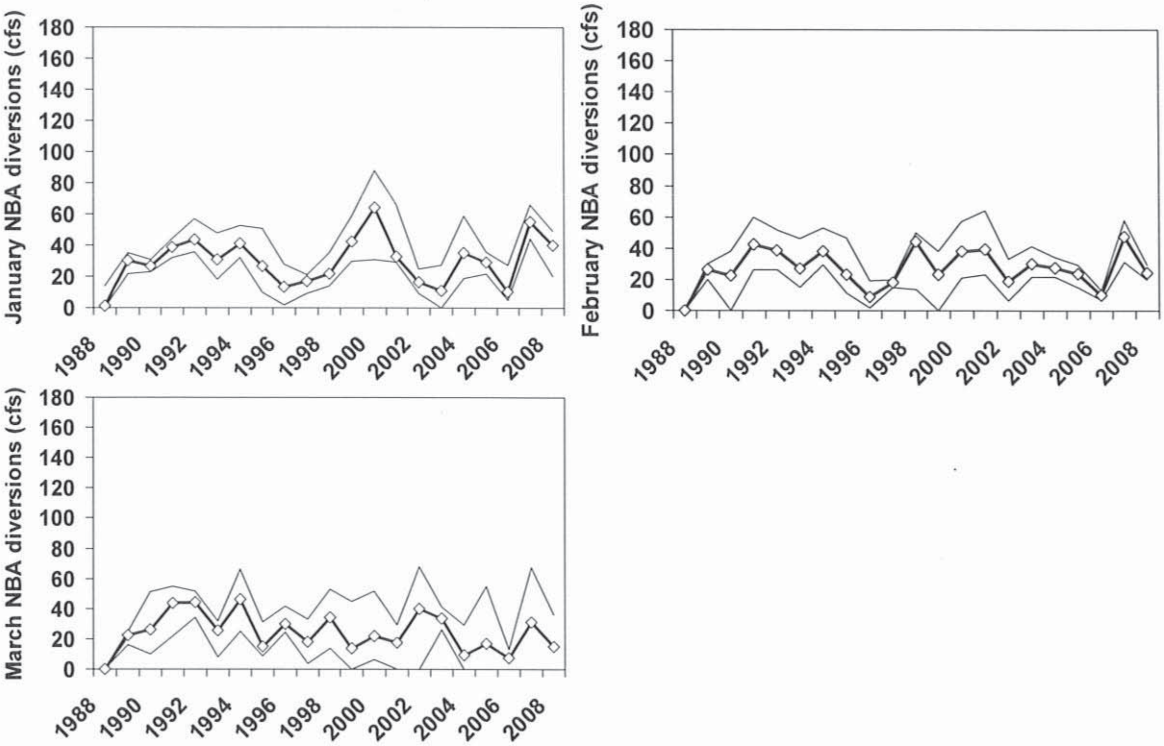

Figure 30. Time series of minimum, average, and maximum water diversions at Barker Slough Pumping Plant into the North Bay Aqueduct during January, February, and March, 1988-2008. Source: DAYFLOW.

The proposed increases in Barker Slough diversion rate are beyond what DFG can evaluate based on the commissioned ptm runs because historical divesions during the modeled periods have not been so high. However, we can conclude that about 100% of particles would be entrained from Cache Slough in low outflow years under the proposed operations. This would include the peak larval hatching months of January-March, which are not currently exposed to high diversion rates. The evidence for 100% entrainment loss comes from April-June ptm simulations in which about 100% of particles wound up entrained in NBA and local ag diversions (Figure 33) even though average Barker Slough diversion rates during these simulations never exceeded 100 cfs (Figure 32). Positive barrier fish screens similar to those in Barker Slough have been shown to exclude larval fishes smaller than their design criteria (Nobriga et al. 2004). However, it has not been demonstrated that they can do so when placed at the back of a dead-end slough like the Barker Slough screens. Thus, the proposed future operations of NBA might severely degrade longfin smelt spawning success in low outflow years.

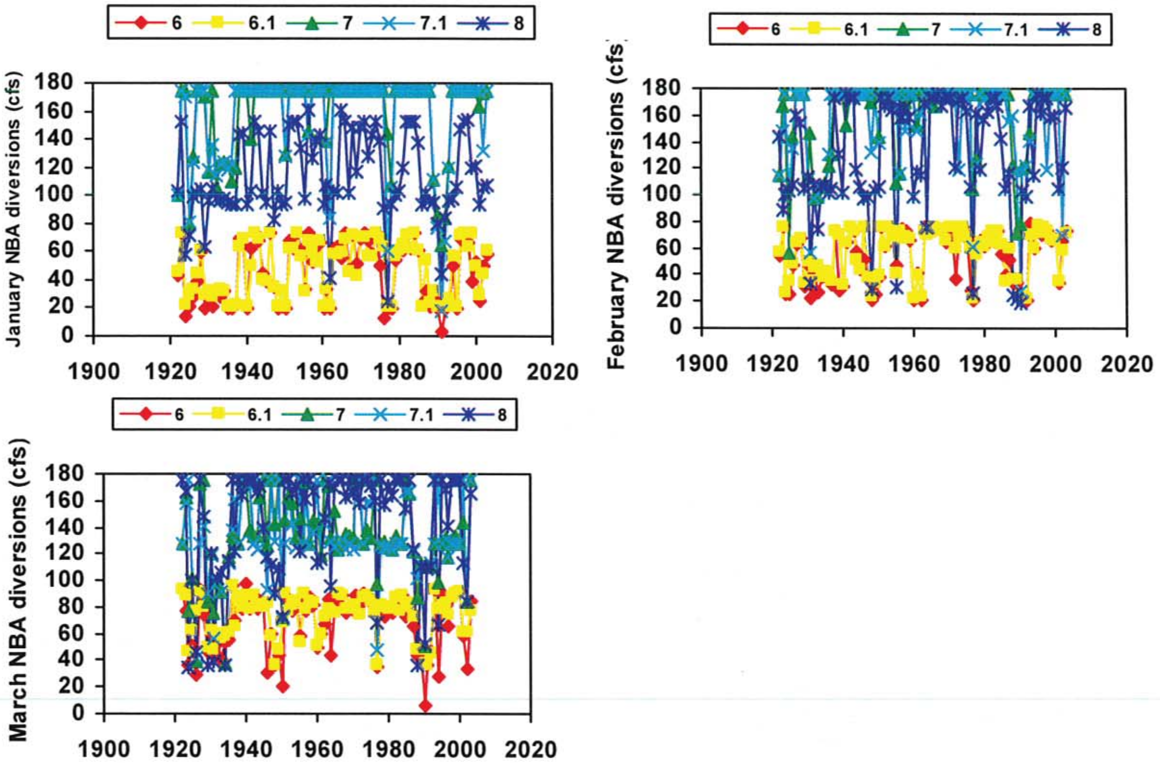

Figure 31. Pseudo-time series plots of predicted (future demand) water diversions at Barker Slough Pumping Plant into the North Bay Aqueduct during January, February, and March. Source: CalSim modeling presented in Appendix E of the OCAP biological assessment prepared by USBR and DWR.

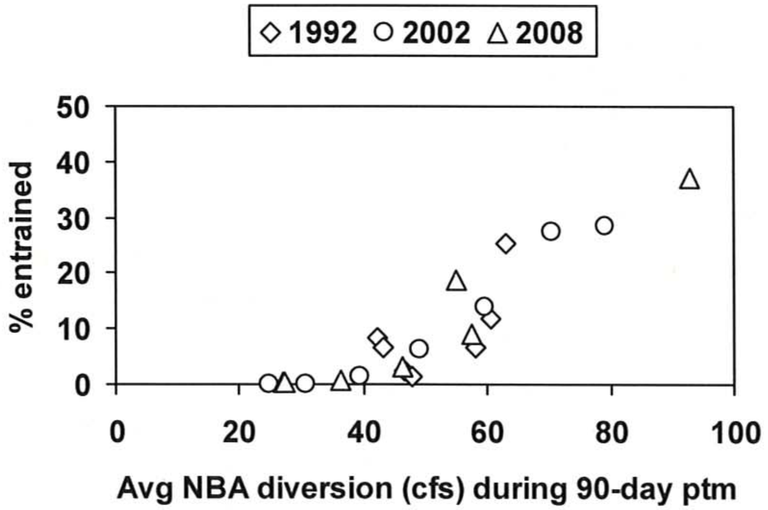

Figure 32. Scatterplot of average water diversion rate (cfs) into North Bay Aqueduct versus percentage of particles released at station 716 in particle tracking simulations. The averaging periods for the NBA diversions are the same as the particle tracking simulations so they range from Jan 1 – Mar 30 and Apr 1 – Jun 29, 1992. Source: DAYFLOW and DWR permit application.

Table 8. Weighted percentages for flux of particles into the North Bay Aqueduct, 1992, 2002, and 2008.

Year	Particle behavior	Weighted flux
1992	Neutrally buoyant	0.73%
1992	Surface oriented	0.70%
2002	Neutrally buoyant	0.76%
2002	Surface oriented	0.81%
2008	Neutrally buoyant	0.59%
2008	Surface oriented	0.58%

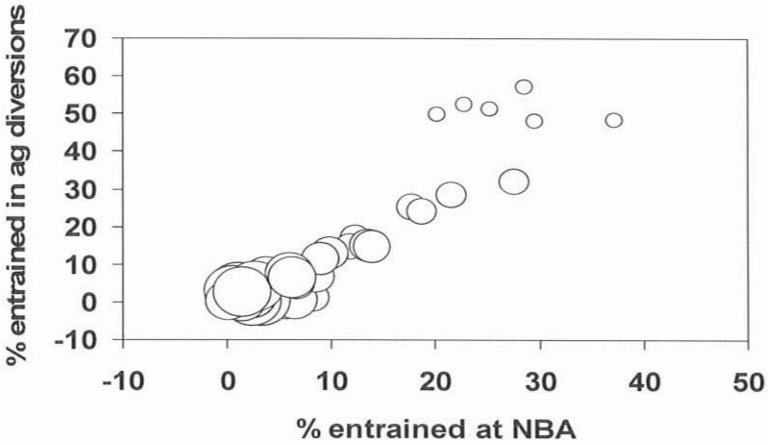

Figure 33. Bubble plot showing the relationship between percentages of particles released at station 716 that were predicted to be entrained into NBA and into Delta irrigation diversions, presumably in the Cache Slough region. The data points are sized by the proportion of larval hatching expected to be represented by each simulation. Source: DWR particle tracking modeling in support of this permit. The hatch date distribution for longfin smelt is based on DFG Bay Study egg and larval sampling.

Indirect effects of the SWP on longfin smelt

The springtime X2 standard: Water Rights Decision D-1641 codified an estuarine habitat standard based on X2, the distance in km from the Golden Gate Bridge to the location in the estuary where the average near-bottom salinity is 2 psu (Jassby et al. 1995). The X2 standard was implemented to improve estuarine habitat conditions by restoring springtime Delta outflows. This water quality standard was adopted due to statistical correlations between variation in X2 and responses of the estuarine ecosystem such as abundance and survival of numerous organisms including longfin smelt (CDFG 1992, Jassby et al. 1995; Kimmerer 2002). The X2 standard is in effect each year from February-June. Thus, the Delta outflows required to meet the X2 standard overlap considerably with the spawning and early life stage rearing of longfin smelt. The X2 standard enhances outflow during low-flow winter-springs and can extend very high outflow periods during wetter winter-springs by requiring X2 to remain at Roe Island in Suisun Bay. This extra increment of outflow displaces spawning and rearing longfin smelt seaward, reducing entrainment in water diversions, increasing transport to the low-salinity zone and enhancing rearing habitat suitability. Since the overbite clam invasion (discussed below) longfin smelt abundance is only demonstrably higher on average in years when average X2 was at or downstream of Roe Island (Figure34).

During the approximate history of the SWP (1967-2007), there is a nearly linear relationship between estimates of the unimpaired runoff[1] in Central Valley rivers and the average X2 during February-June (Figure 35). The residuals from a linear regression of Figure 35 have a distinct time trend (Figure 36) that shows what the X2 standard accomplished. Residuals greater than zero depict years when X2 was upstream of where it was expected to be based on unimpaired runoff; negative residuals depict years when X2 was downstream of where it was expected to be based on unimpaired runoff. Both the frequency and magnitude of positive residuals increased from the latter 1960s to the early 1990s because more unimpaired runoff was being diverted from the Delta. The initial adoption of an X2 standard in 1995 reversed this trend; positive residuals have been rare since, occurring only in the very wet springs of 1995, 1998, and 2000. Note that wet year residuals tend to be positive because Central Valley reservoirs are operated to attenuate flood flows by capturing portions of major runoff events. The net effect of the X2 standard is that more runoff flows out of the Delta under present SWP springtime operations than typically did during the 1970s and 1980s.

Habitat and food supply for longfin smelt: The primary indirect mechanism by which the SWP could affect longfin smelt is through effects on abiotic habitat quality and food supply that might occur when the SWP has control over X2. When Banks pumping is entraining longfin smelt, it follows that it is also entraining longfin smelt habitat (water of suitable quality) and co-occurring food. These direct effects are analyzed as appropriate in other sections of this effects analysis. This section describes what is known about longfin smelt habitat and food at times of year when longfin smelt are not being entrained (summer and fall) and provides a rationale for why DFG does not think the SWP strongly affects habitat or food when longfin smelt are not also being entrained. We contrast this conclusion with those recently drawn for delta smelt during the OCAP consultation (USFWS 2008).

The statistical relationship between X2 and longfin smelt abundance suggests winter-spring river flow generates some kind of habitat opportunity, but not all of the mechanisms are known (Jassby et al. 1995; Kimmerer 2002). The drop in longfin smelt abundance after the estuary was invaded by overbite clam suggests a big part of the mechanism was prey availability for young fish, but food production is not the only factor involved because the X2 response has persisted (Kimmerer 2002, Kimmerer et al. 2009).

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[1] Unimpaired runoff is the amount of water that would theoretically enter the Delta if there were no dams or water diversions to capture the water.

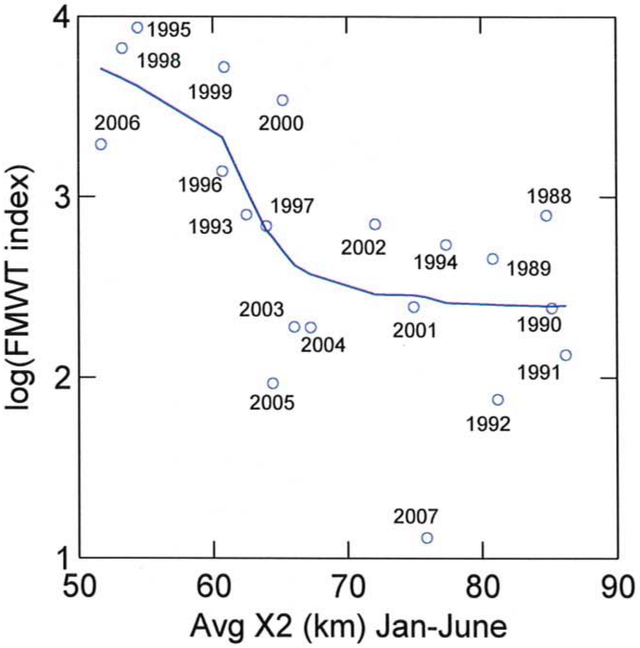

Figure 34. Scatterplot of average January-June X2 versus the log10-transformed FMWT abundance indices for longfin smelt for 1988-2007 (the period of food web change precipitated by the overbite clam invasion following Kimmerer 2002). The smoother is a LOWESS regression line.

Fishes generally eat larger prey as they grow. Longfin smelt are no exception – their diet shifts from small zooplankton (copepods) to larger mysid shrimp as the season progresses because the fish are getting larger (Figure 37). The USFWS (2008) concluded that Banks and Jones likely influenced prey availability for delta smelt during the summer because Banks and Jones pumping affected the flux of the copepod *Pseudodiaptomus forbesi* out of the central and south Delta. This argument does not hold for longfin smelt because longfin smelt do not eat very much *Pseudodiaptomus* (Figure 37). *Pseudodiaptomus* blooms begin in late spring and continue into summer. By that time of year, longfin smelt are targeting larger prey – mainly mysids.

Both of longfin smelt's primary prey items – the copepod *Eurytemora affinis* and mysid shrimp - have populations that bloom in the vicinity of X2 and both were greatly depleted by the overbite clam (Kimmerer et al. 1994; Kimmerer and Orsi 1996; Kimmerer 2002). Apparent suppression of phytoplankton blooms by free ammonium ion in the Sacramento River and Suisun Bay may also affect the abundance of the phytoplankton that feeds longfin smelt's prey (Wilkerson et al. 2006; Dugdale et al. 2007). The estuary's food web consumes most of the available supply of phytoplankton (Jassby et al. 2002). For instance, Jassby et al. (2002) estimated that water diversions at Banks and Jones removed about 8 tons of phytoplankton per day, about 14% of the potentially available primary production, while the food web and settling into the substrate removed about 38 tons per day. Note that most primary production in the Delta occurs during summer when most longfin smelt are feeding in brackish and

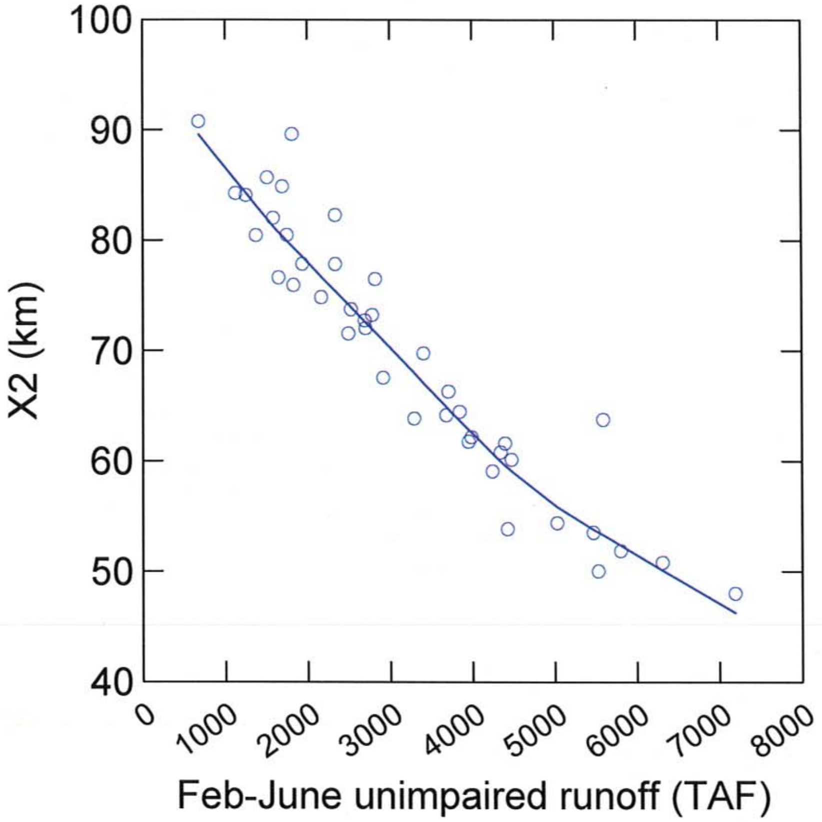

Figure 35. Scatterplot of estimated unimpaired Central Valley runoff (8 river index) versus X2 (February-June averages for both axes). The smoother is a LOWESS regression line.

marine habitats.

If entrainment of phytoplankton that feeds zooplankton or entrainment of the zooplankton that feed longfin smelt were strongly affected by SWP diversions, then food availability should correlate with X2. The abundance of *Eurytemora* did not vary with X2 prior to the overbite clam invasion (Kimmerer 2002). This means that flow variation among years, which is partly under the control of SWP did not cause differences in availability of this prey item for longfin smelt, but longfin smelt abundance did vary with X2. Thus, *Eurytemora* availability was not the underlying reason for the longfin smelt response to X2. Note that since the overbite clam invasion, X2 does predict *Eurytemora* abundance during spring, but not during summer when its abundance is always near zero due to grazing by overbite clam (Kimmerer et al. 1994).

Historically, average March-November X2 predicted mysid shrimp abundance over the same averaging period; mysid abundance was higher in wet years (Jassby et al. 1995). This relationship changed after the clam invasion. Mysid abundance was suppressed in all water year types, but highest in low outflow years (Kimmerer 2002). If mysid

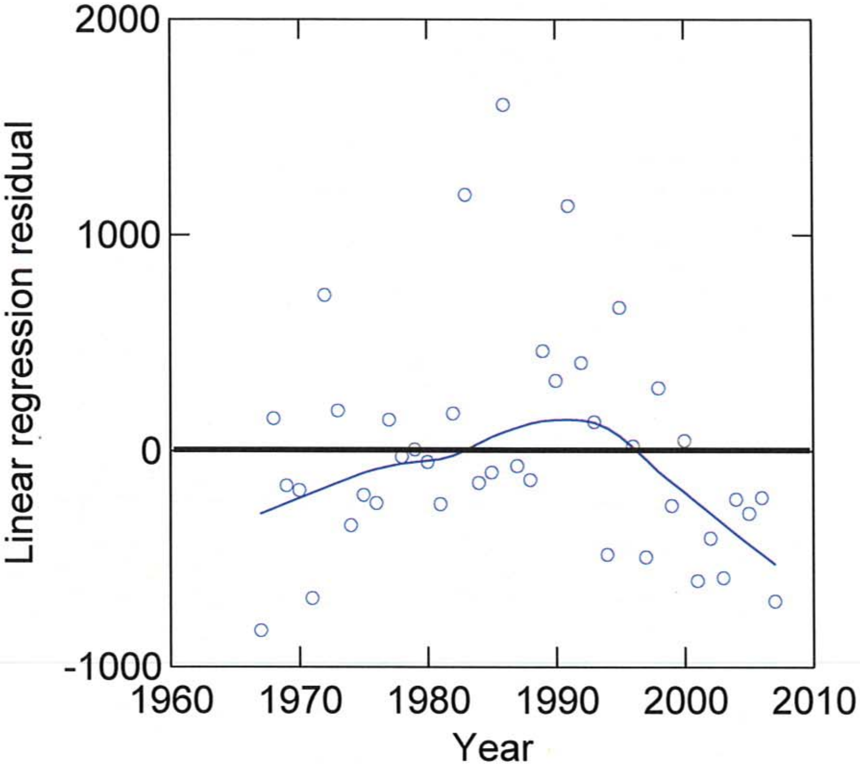

Figure 36. Time trend in the linear regression residuals between the variables shown in Figure 35. The smoother is a LOWESS regression line. The zero line depicts each year's predicted value of X2.

entrainment were the mechanism driving the historical relationship, post-clam abundance would not be highest in low outflow years because more mysids are probably entrained when low outflows cause X2 to get closer to Banks and Jones. As stated above, most of the variation in X2 is caused by climatic variation in precipitation (Figure 35) and the mysid decline was strongly driven by overbite clams (Orsi and Mecum 1996; Kimmerer 2002). Thus, DFG cannot find any conceptual evidence that the SWP affects food availability for longfin smelt strongly enough to influence the species' population dynamics. The effects of the overbite clam swamp any signals that might be due to entrainment of zooplankton.

Another possible mechanism for the SWP to influence longfin smelt is via effects on abiotic habitat suitability. Longfin smelt is a pelagic fish, so abiotic habitat in open-water is water with suitable levels of salinity, temperature and other characteristics is much more important than structural aspects. Since its implementation, the X2 standard has enhanced Delta outflow during the February-June period (Figure 36), which should have improved abiotic habitat suitability in the open-water environment during these months.

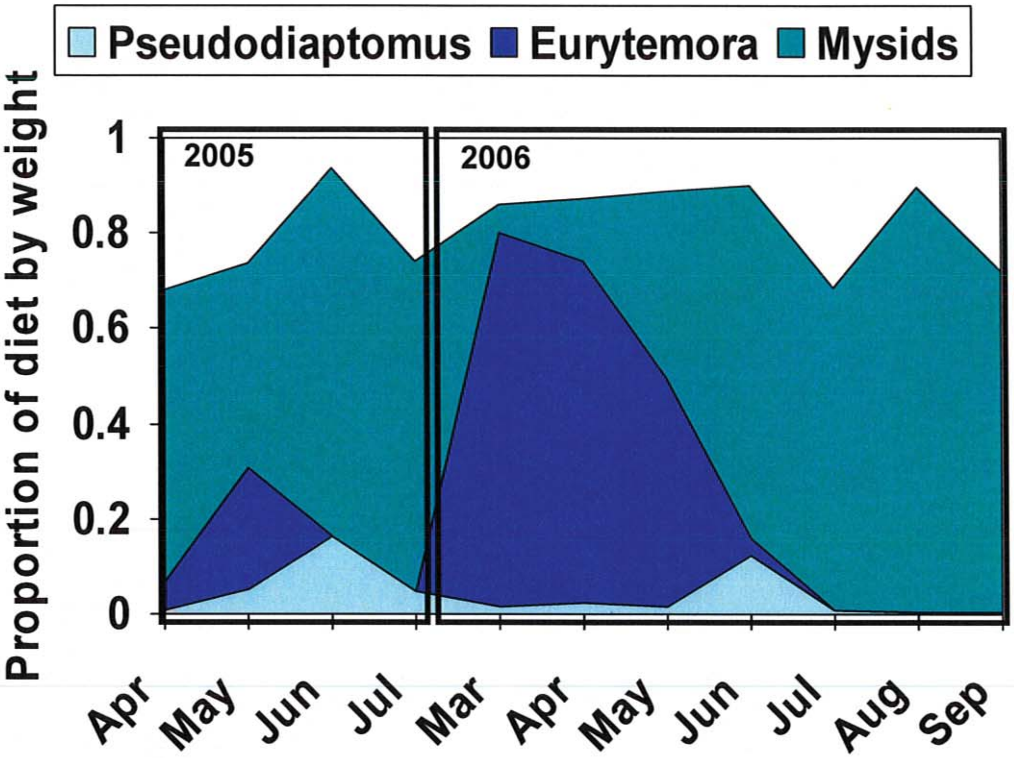

Figure 37. Proportions of age-0 longfin smelt stomach contents accounted for by the copepods Eurytemora and Pseudodiaptomus, and by mysid shrimp, April-July 2005 and March-September 2006. Source: Steve Slater, DFG unpublished data.

However, there is a long-term increase in fall X2 that has resulted from increasing exports relative to inflows (USFWS 2008). This has reduced abiotic habitat suitability for delta smelt and age-0 striped bass (Feyrer et al. 2007). The influence of this trend on longfin smelt has not been determined, but longfin smelt have higher salinity tolerance than either delta smelt or age-0 striped bass and thus, they often occur in marine habitats during summer and fall (Rosenfield and Baxter 2007). The portion of the longfin smelt population rearing in Suisun Bay during summer and fall has declined through time; Rosenfield and Baxter 2007). However this may just reflect the greatly reduced mysid abundance caused by the overbite clam – a similar hypothesis was posed for northern anchovy (Kimmerer 2006). Because longfin smelt can and do rear in marine habitats during summer and fall, DFG does not think lower fall outflow has significantly lowered abiotic habitat suitability for longfin smelt like it has for delta smelt and age-0 striped bass. This conclusion is supported by the recent flow versus habitat volume analysis for longfin smelt by Kimmerer et al. (2009).

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Personal Communications

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Appendix A

Longfin smelt winter distributions (Dec-Mar) from CDFG midwater trawl sampling in relation to the locations of X2 and X0.5

Source: Randall Baxter DFG, 209 942-6081
December 2008

Longfin Distribution by Month and Year for several outflow years (LFSMWT WinterDist.ppt revised from Longfin smelt distribution select year.ppt)

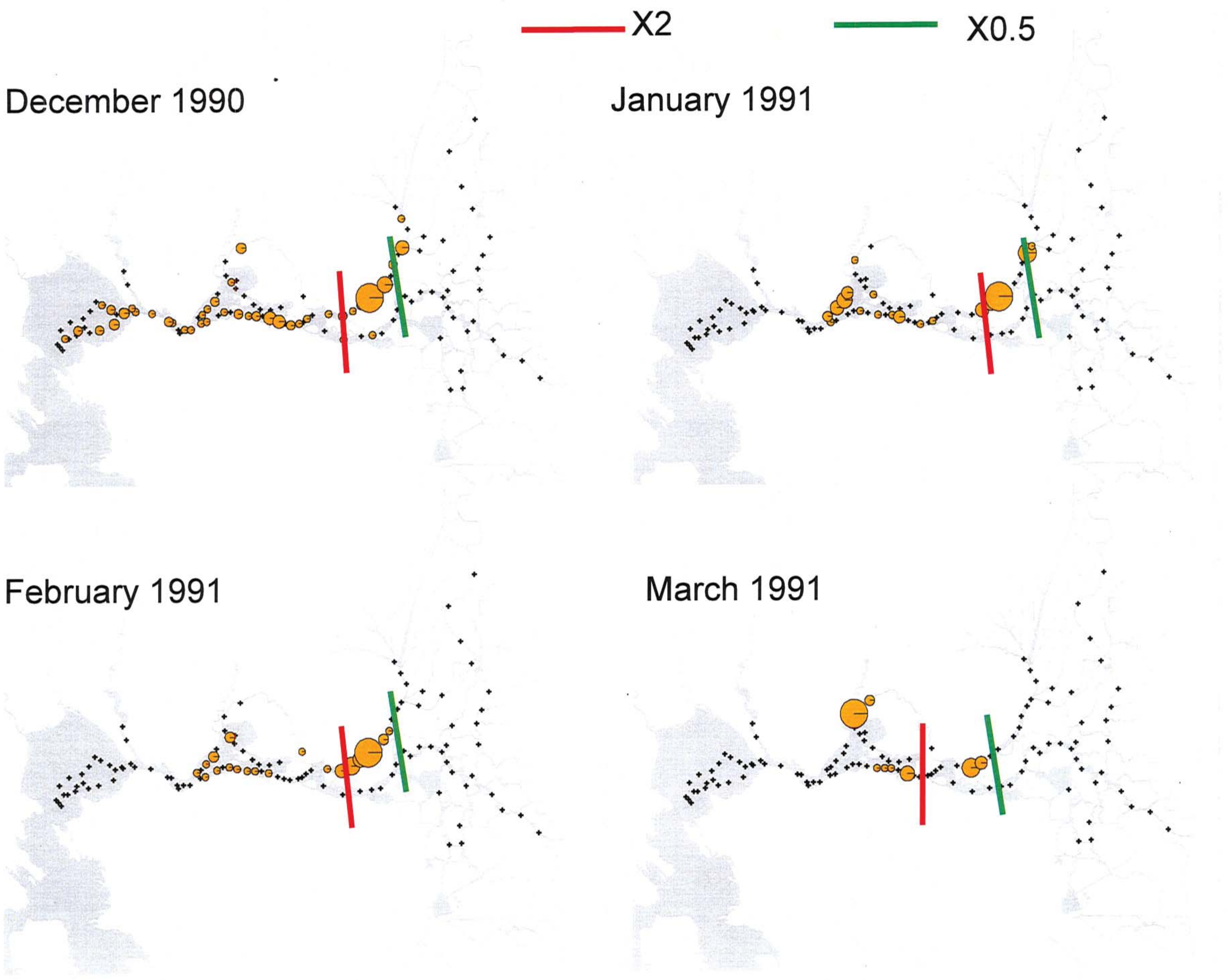
Midwater trawl longfin smelt catches by month for select years when trawling was conducted December through March. Years with all three months of Spring MWT available are: 1968, 1969, 1971, 1972, 1991-1997, 2000 and 2001. Spring Kodiak Trawl was initiated in 2002 and Spring MWT terminated.

Graphics provided by Kelly Souza May 21, 2008 from ArcView 3.2 plots. Revised June 6, 2008. Graphics depict variable scale of catch per station and month. Only years from 1991 through 2001 were plotted, because X2 locations were only calculated back to 1980 (Chris Enright calculation from Lenny Grimaldo January 2008).

X2 position determined by averaging daily values for each month from DAYFLOW data and monthly X0.5 was estimated using monthly X2 value and the relation:
X0.5 = -(X2 position) *(Ln((31-(target salinity))/(515.67* (target salinity)))/-7)-1.5)

Where 0.5 is the target salinity.

Monthly average X2 (red line) and X0.5 (green line) were plotted by eye referencing the X2 map in Jassby et al. 1995.



December 1990

January 1991

February 1991

March 1991