June 6, 2008

Mr. Marty Gingras
Supervising Biologist
California Department of Fish and Game
4001 North Wilson Way
Stockton, CA 95205-2486

Re: Public Input on Longfin Smelt draft 2084 regulation

Dear Mr. Gingras:

On behalf of the member agencies (see Appendix) of the State Water Contractors (SWC) and the San Luis & Delta-Mendota Water Authority (SLDMWA) (collectively, "California Water Agencies"), please accept these comments on the Longfin smelt. The California Water Agencies appreciate this opportunity to provide the Department of Fish and Game (DFG) input as the DFG prepares to make a recommendation to the Fish and Game Commission to either extend or amend the existing emergency regulation authorizing take of Longfin smelt. Cal. Code Regs., tit. 14, § 749.3.

The SWC is a non-profit association of 27 public agencies from Northern, Central, and Southern California that purchase water under contract from the California State Water Project (SWP). The SWP is the state's largest water delivery system, and collectively, members of the SWC deliver SWP water to more than 25 million residents throughout the state and more than 750,000 acres of highly productive agricultural land. The SLDMWA is a joint powers authority comprised of 32 member agencies under contract with the United States Bureau of Reclamation for approximately 3,300,000 acre-feet of Central Valley Project (CVP) water. On an average annual basis, the Water Authority delivers 2,500,000 acre-feet to about 1,200,000 acres of highly productive agricultural land, 2,000,000 Californians primarily residing in the "Silicon" valley, and 100,000 acre of publicly and privately managed wetlands.

The California Water Agencies support DFG's effort to solicit information from interested stakeholders on Longfin smelt. While there is uncertainty regarding the absolute population of Longfin smelt in the Sacramento-San Joaquin Delta (Delta), as well as elsewhere in the state, and the extent to which various factors have contributed to the recent decline in abundance of the Longfin smelt, there has been much analysis of the species over recent years, and intensive review of factors affecting the Delta fishery in recent months. Earlier this year, the California

Water Agencies submitted letters to the Fish and Game Commission on issues related to the Fish and Game Code Section 2084 permits. California Water Agencies representatives also testified at the February 7, 2008, Fish and Game Commission hearing in San Diego (SWC PowerPoint presentation enclosed as Attachment 1). Most recently, the California Water Agencies have initiated a review of the science on the Longfin smelt and an evaluation of the potential effects of SWP and CVP pumping upon the species (Attachment 2).

Summarizing the attached information, the California Water Agencies are concerned that the existing emergency regulation focuses primarily on SWP and CVP pumping operations, to the exclusion of all other factors that result in take of Longfin smelt, including a number that may be having population level effects. As described in Attachment 1 and more completely in Attachment 2, an important characteristic of Longfin smelt is their minimal presence in areas of the Delta subject to significant influence by export pumps. For most of their life, Longfin smelt are in San Francisco Bay, or downstream of the Delta. Their winter migration upstream is normally centered in Suisun Bay, or farther west.

As expected by its distribution, salvage of Longfin smelt by the SWP and CVP pumps is correspondingly very small and extremely episodic. Estimates of percentage distribution in Attachment 2 show that the portion of juvenile Longfin smelt located in the vicinity of Old and Middle Rivers, south of Connection and Rock Sloughs, exceeded one percent in only one survey of one year since the 20 millimeter surveys began in 1995. Given this low presence of Longfin smelt in the south Delta, export pumping salvage would be expected to be low, and salvage data confirm that this is the case. DFG's data over the last fifteen years demonstrates that on average salvage by the SWP and CVP pumps has only been a combined annual median of 746 fish per year, excluding the worst salvage year 2002. In that extraordinary year, total take of Longfin smelt was 97,473, which represented a little more than 1/100th of one percent of the estimated total population that year.

Export operations are strictly managed consistent with numerous state and federal regulations to protect a large variety of fisheries, including Longfin smelt. These regulations significantly restrict export operations from December through June for the purpose of protecting Delta smelt, which has the effect of further reducing the low entrainment risk for Longfin smelt.

In contrast to the already significant restrictions on export operations, for a species that has minimal exposure to export pumping impacts, a wide variety of other stressors have been identified that have only minimal or no restrictions to protect Longfin smelt. As identified in the Interagency Ecological Program's "Pelagic Organism Decline Synthesis Report: 2007 Synthesis of Results", there are a large number of other stressors that contribute to reduced population for Longfin smelt and other pelagic species. The POD 2007 report identifies these other stressors as including introduced species, such as striped bass and large-mouthed bass, which are predators of Longfin smelt, toxics, wastewater discharges that affect phytoplankton production in the estuary, and 1,800 agricultural diversions, which are mostly unscreened. These other stressors are currently not subject to any restrictions under the existing DFG emergency Longfin smelt regulation.

As described in Attachment 2, a strong statistical association ($r^2 = 0.82$) has been identified between the Longfin smelt population and a combination of factors including February to April X-2 position, February to April air temperatures (at Davis), and average ammonia concentrations in the Sacramento River at Greene's Landing. The X-2 position is already recognized as a consideration in the DFG's proposed Longfin smelt Risk Assessment matrix and its position is also already subject to existing regulation. Air temperature during the spring, causing increases in water temperature, also has a statistically significant impact on Longfin smelt populations, likely through adverse impacts on phytoplankton and food production. The last factor identified, ammonia concentrations in the Sacrament River at Greene's Landing, is an important new variable that should be managed to improve Longfin smelt conditions. In contrast to export entrainment, which is the focus of the risk assessment matrix, and which does not have a statistically significant correlation to Longfin populations, there are currently no 2081 permit requirements for the wastewater discharges that cause increased ammonia presence in the Sacramento River. DFG should be working with other agencies to identify these wastewater discharges and require California Endangered Species Act take authorization for the impacts that they have on Longfin smelt.

In summary, the California Water Agencies encourage DFG to carefully review the attachments submitted with this letter in developing its Section 2084 permit requirements. We believe that these attachments demonstrate that existing regulations on SWP and CVP operations provide a sufficient level of protection for Longfin smelt. Further, we believe the Risk Assessment Matrix, identified by DFG as the basis for the existing 2084 regulations, should be modified in at least one significant way. In determining when actions are triggered based on Longfin smelt distribution, we believe that the trigger should be based on a fraction of the population located in the Southeast Delta. This is in contrast to the RAM which relies on a trigger showing only presence of Longfin smelt in the Southeast Delta. For example, requiring restrictions on export operations at times when one or two Longfin smelt are identified, which may represent a small fraction that is significantly less than one percent of the total population, is an unnecessarily restrictive approach to minimizing and mitigating Longfin smelt take. We believe that setting a trigger based on some specified criteria of relative abundance would be a more effective approach.

In contrast to the existing emergency regulation that considers only export project impacts, the California Water Agencies believe that a revised regulation should be developed that addresses a broad range of factors that have direct take, including factors that impact Longfin smelt population levels. Further, we believe that the information included in the attachments to this letter demonstrate that DFG should develop a revised regulation that imposes minimization and mitigation responsibilities, including the responsibility to monitor take, on **<u>all</u>** the parties that are affecting Longfin smelt. Such a revised regulation could include conditions regulating operations such as:

- Requiring 1,800 mostly unscreened agricultural diversions in the Delta to monitor for their take of Longfin smelt and be subject minimization and mitigation measures.

- Restricting dredging operations in the Delta during periods when Longfin smelt are present and requiring monitoring during such operations.
- Identifying wastewater discharges that contribute ammonia to Delta inflows and requiring those dischargers to comply with appropriate minimization and mitigation measures.

We appreciate DFG's interest in obtaining public input relating to Longfin permit conditions and are interested in maintaining a dialog with DFG as these regulations are being prepared. If you have any questions about these comments, please contact Terry Erlewine at (916) 447-7357 and/or Dan Nelson at (209) .

Sincerely,

Daniel G. Nelson
Executive Director
San Luis & Delta-Mendota Water Authority

Terry Erlewine
General Manager
State Water Contractors

APPENDIX

San Luis & Delta-Mendota
Water Authority Member Agencies:

Banta-Carbona Irrigation District
Byron-Bethany Irrigation District
Centinella Water District
City of Tracy
Del Puerto Water District
Patterson Irrigation District
Westside Irrigation District
West Stanislaus Irrigation District
Panoche Water District
Pleasant Valley Water District
San Luis Water District
Westlands Water District
Central California Irrigation District
Columbia Canal Company
Firebaugh Canal Water District
Grassland Water District
San Luis Canal Company
Pajaro Valley Water Management Agency
San Benito County Water District
Santa Clara Valley Water District
Broadview Water District
Eagle Field Water District
Fresno Slough Water District
James Irrigation District
Laguna Water District
Mercy Springs Water District
Oro Loma Water District
Pacheco Water District
Reclamation District 1606
Tranquillity Irrigation District
Turner Island Water District
Widren Water District

State Water Contractors
Member Agencies:

Alameda County Flood Control and Water Conservation District Zone 7
Alameda County Water District
Antelope Valley-East Kern Water Agency
Casitas Municipal Water District
Castaic Lake Water Agency
Central Coast Water Authority
City of Yuba City
Coachella Valley Water District
County of Kings
Crestline-Lake Arrowhead Water Agency
Desert Water Agency
Dudley Ridge Water District
Empire-West Side Irrigation District
Kern County Water Agency
Littlerock Creek Irrigation District
Metropolitan Water District of Southern California
Mojave Water Agency
Napa County Flood Control and Water Conservation District
Oak Flat Water District
Palmdale Water District
San Bernardino Valley Municipal Water District
San Gabriel Valley Municipal Water District
San Gorgonio Pass Water Agency
San Luis Obispo County Flood Control and Water Conservation District
Santa Clara Valley Water District
Solano County Water Agency
Tulare Lake Basin Water Storage District

Longfin Smelt Candidacy and Incidental Take Authorization

State Water Contractors

February 7, 2008

Candidate Status

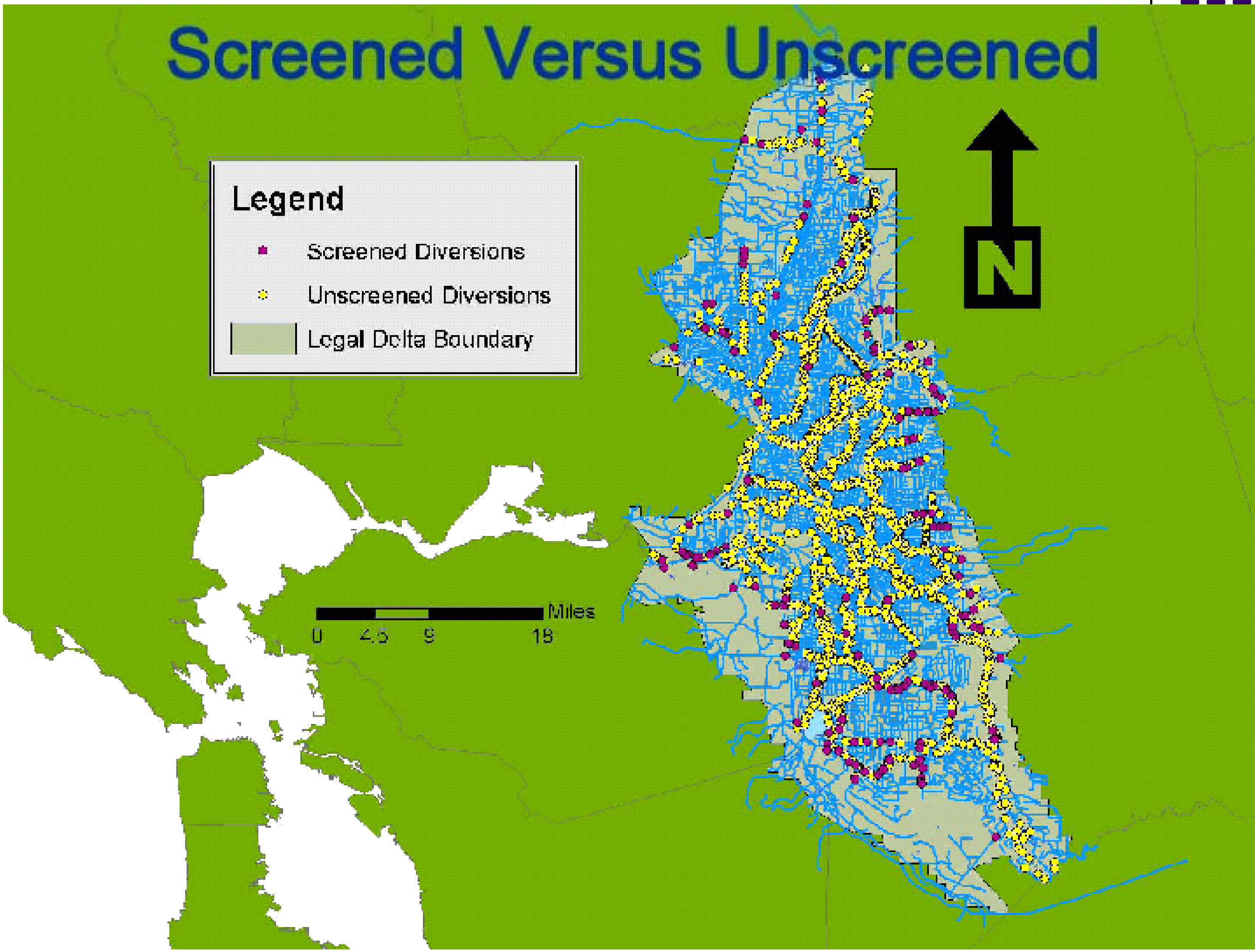
- Commission has discretion whether to consider actual range or California-only range
- If consider actual range – longfin smelt not threatened with extinction
- Commission should not restrict California's water supply for a species not actually threatened with extinction

Incidental Take Regulations

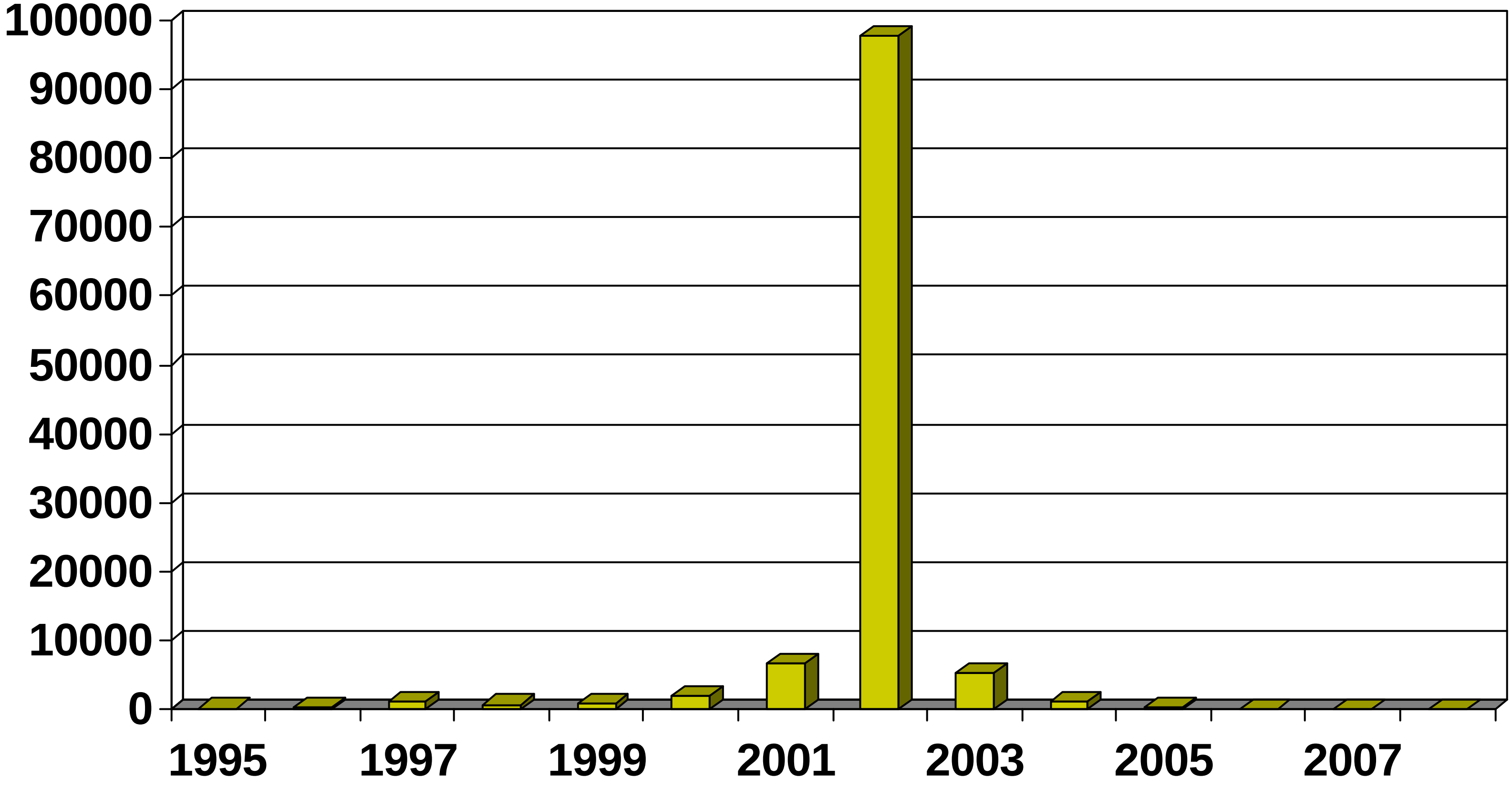
- Commission should not impose further restrictions on SWP or CVP
  - Biological benefits are low
  - Potential water costs are high
- Federal Injunction in place
  - Reduces entrainment risk
  - Established to protect a species (delta smelt) with more limited range

Incidental Take Regulations

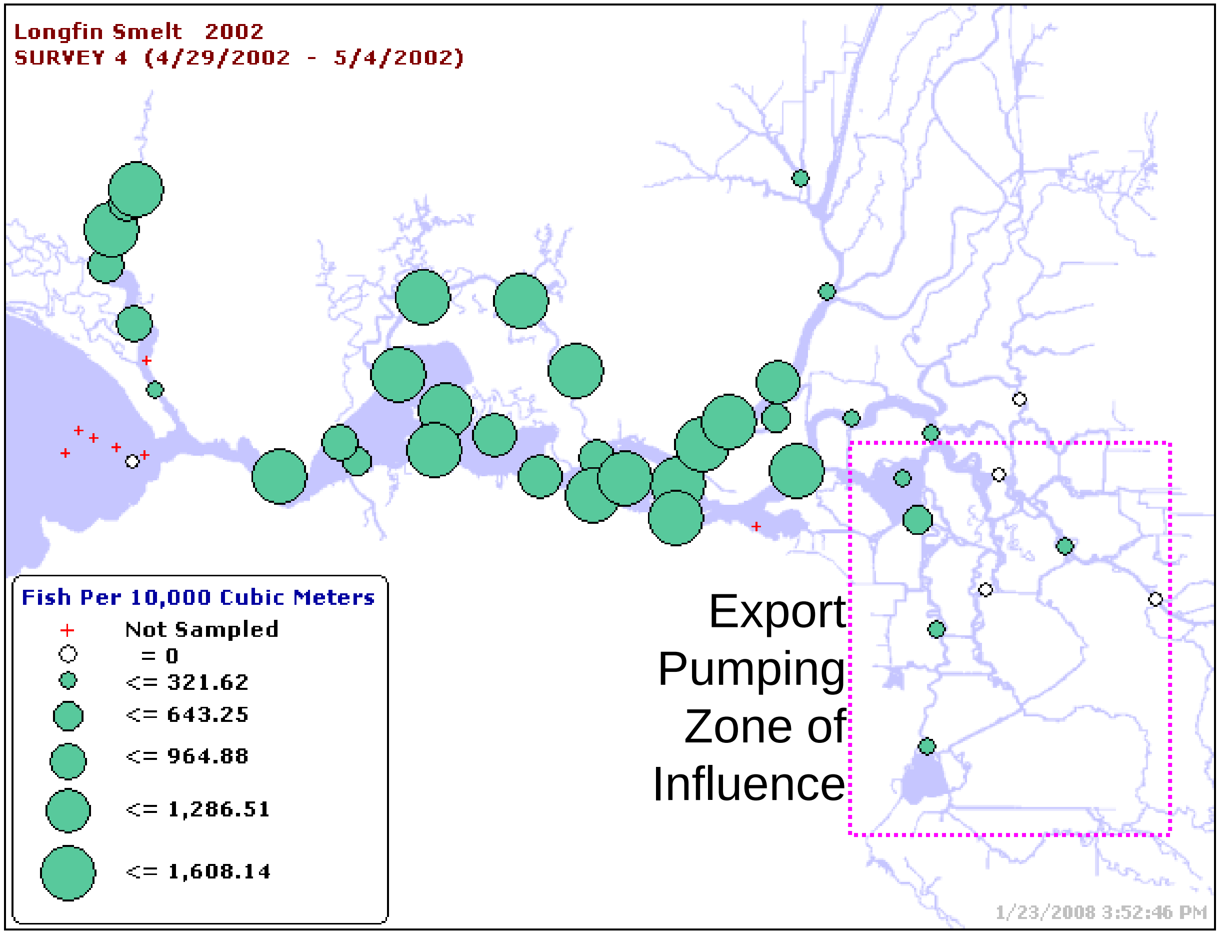
- The disparate treatment of the SWP and CVP compared to other stressors is arbitrary
  - SWP and CVP already heavily regulated
  - DFG proposes no requirements for other stressors
  - If other take is allowable, why are further limits on SWP and CVP essential?


Screened Versus Unscreened
Legend
Screened Diversions
Unscreened Diversions
Legal Delta Boundary
N
Miles
0
4.5
9
18

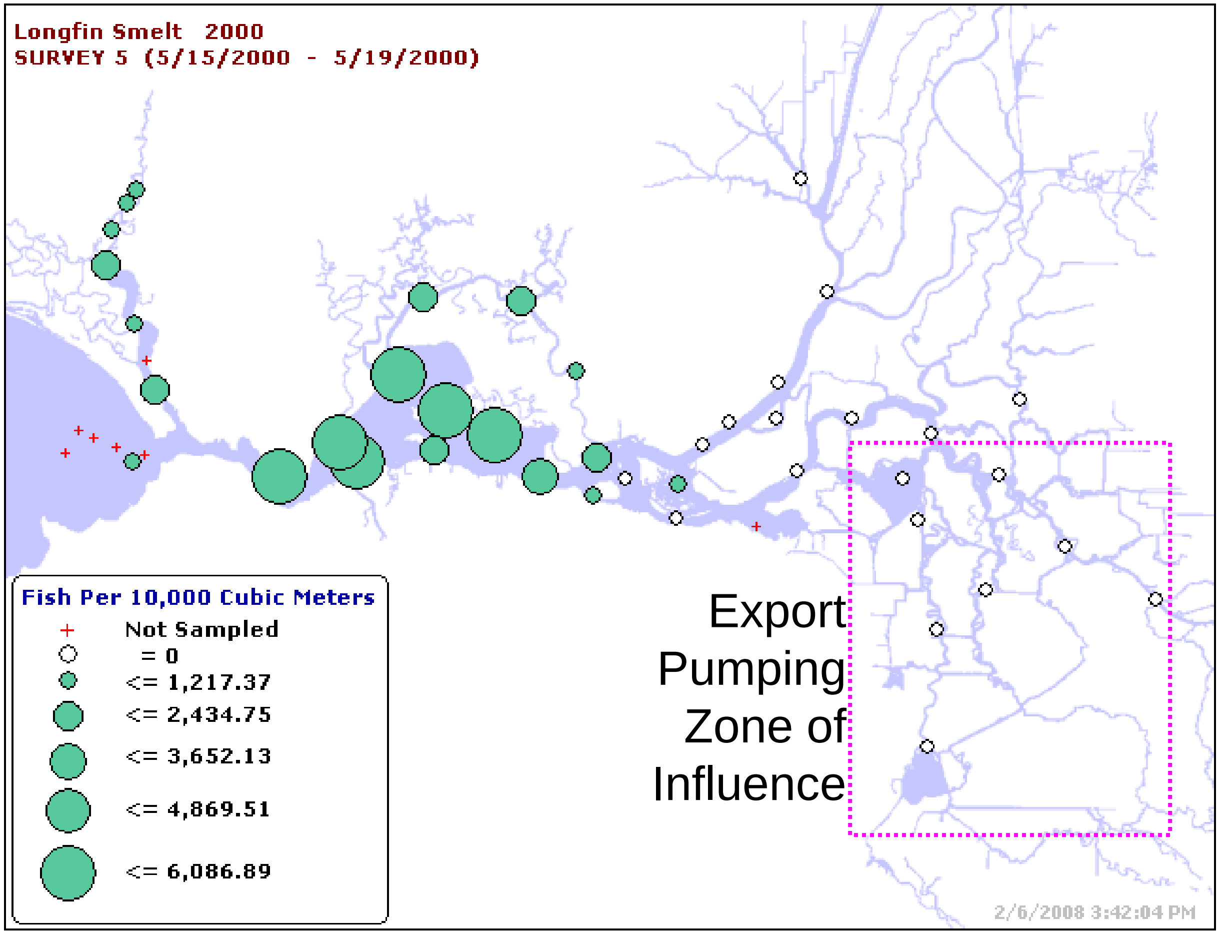
Longfin Smelt
CVP and SWP Annual Take



Most Longfin Smelt Were Away From the Pumps During 2002 High-Take Event



Longfin Smelt Away from Pumps in Wet Years



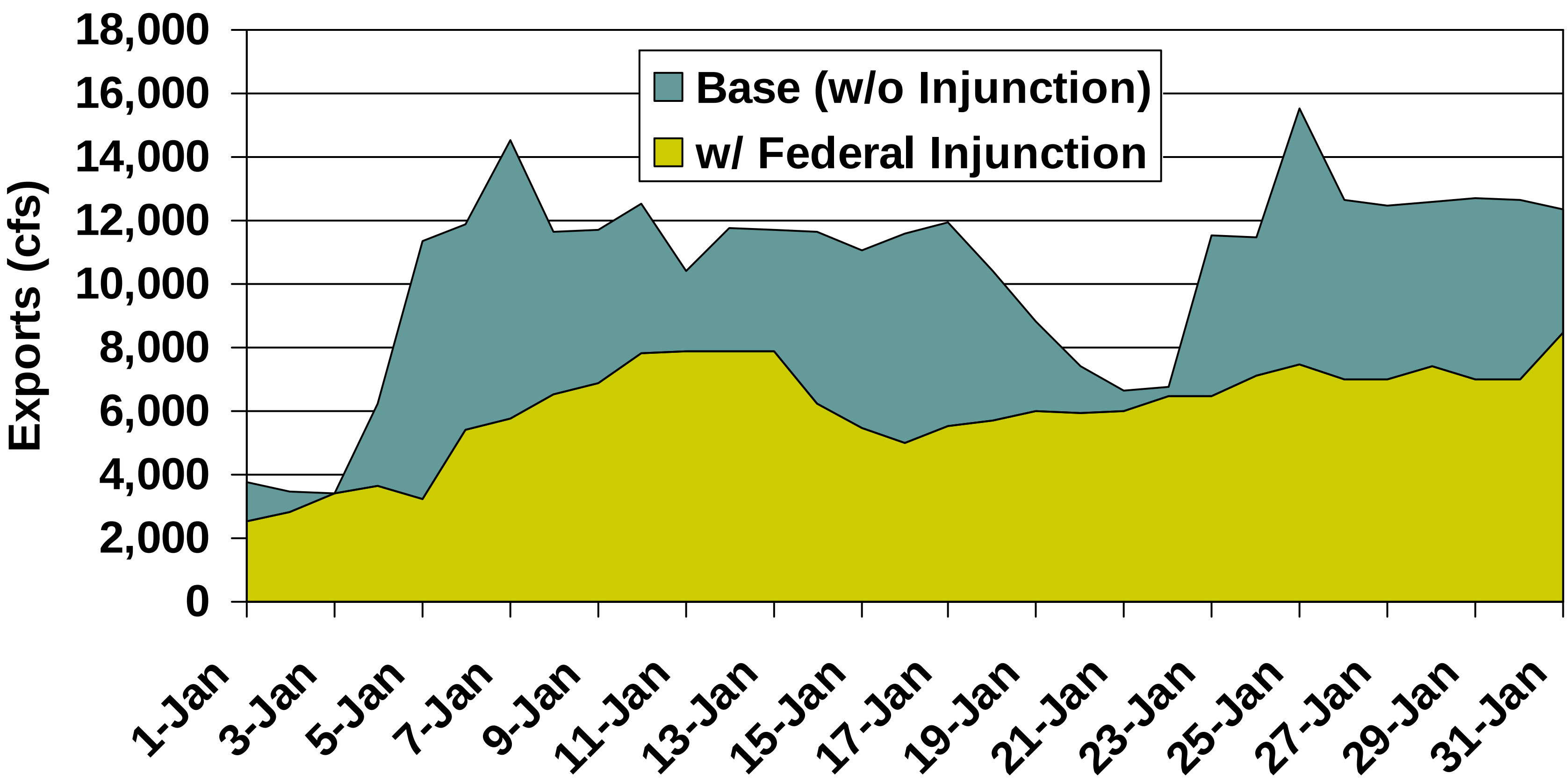
Multiple Factors Impact Longfin Smelt Abundance

- Hydrology
- Exposure to toxics
- Predation mortality
- Competition from invasive species
- Habitat (e.g., reduced wetlands)
- Reduced food supply
- Entrainment

SWP Contractors

1 Crestline - Lake Arrowhead Water Agency
2 Littlerock Creek Irrigation District
3 San Gabriel Valley Municipal Water District
4 San Gorgonio Pass Water Agency

January 2008 Export Impacts w/ Federal Injunction



2008 SWP Water Supply Impacts

- Federal Injunction – deliveries reduced up to 27%
- Water Supply Uncertainty
- Far reaching effects
  - Mandatory rationing
  - Development Proposals Deferred – Riverside County, City of San Diego

DFG's Proposed Regulations

- Reject Option 1 – Unnecessary and Costly
- Reject Option 2 – Unnecessary, costly, inappropriate given 180-day timeframe
- Reject Option 3 – Take limits inflexible, arbitrary, and unrelated to population impacts

State Water Contractors' Recommended Regulation

- Existing Federal Injunction more than adequately protects longfin smelt during next 180 days
- No further restrictions beyond Federal Injunction
- Consistent with DFG Option 4

Stakeholder Input on Drafting a Longfin Smelt Section 2084 Regulation

INTRODUCTION

The California Department of Fish and Game (Department) is "seeking stakeholder input" to the process of drafting a" Section 2084 regulation to protect longfin smelt during August 2008 through February 2009." A "final draft" regulation will go to the Fish & Game Commission in time for its August 7 meeting. Section 2084 states:

> **2084**. The commission may authorize, subject to terms and conditions it prescribes, the taking of any candidate species, or the taking of any fish by hook and line for sport that is listed as an endangered, threatened, or candidate species.
> (http://www.leginfo.ca.gov/cgi-in/waisgate?WAISdocID=61392411368+0+0+0&WAISaction=retrieve)

The following are comments on the science related to longfin smelt and the effects of the State Water Project (SWP) and Central Valley Project (CVP) (collectively, the "Projects") export facilities in the southeast Delta. These effects are addressed on two scales:

- First, in terms of entrainment risk and salvage at the pumps, and
- Second in the broader context of what factors are most associated with the long term changes in longfin smelt abundance, as measured by the Fall Midwater Trawl index.

Salvage and entrainment risks are discussed first and relate to two periods; subadults and spawners salvaged in the late fall and winter, and larvae and juvenile longfin smelt salvaged January through June. The data indicates almost all longfin smelt are far from the pumps, whether spawners, larvae or juveniles, year after year. In terms of abundance, the fraction near the pumps is so small as to appear to have little capacity to affect overall abundance. Other factors including temperature, ammonia and very high X2 levels are strongly associated with the long term trend and recent decline in longfin smelt.

SWP AND CVP SALVAGE AND ENTRAINMENT RISK

Salvage of Subadults and Spawners

The proportion of the population of longfin smelt salvaged at the SWP and CVP is small. Actual salvage data collected for the SWP and CVP from 1993 through 2007 are presented on Figure 1 and provided in Table 1. As shown, over the last 15 years, average salvage by the Projects has been a combined annual average of 8,202 fish. Excluding 2002 data, which is an atypical high salvage year, the average salvage rate equates to 1,805 longfin. The median annual salvages of all life stages for the Projects during 1993 through 2007, with and without 2002, were 805 and 746 longfin smelt, respectively.

Figure. 1 Longfin smelt annual salvage at SWP and CVP facilities.

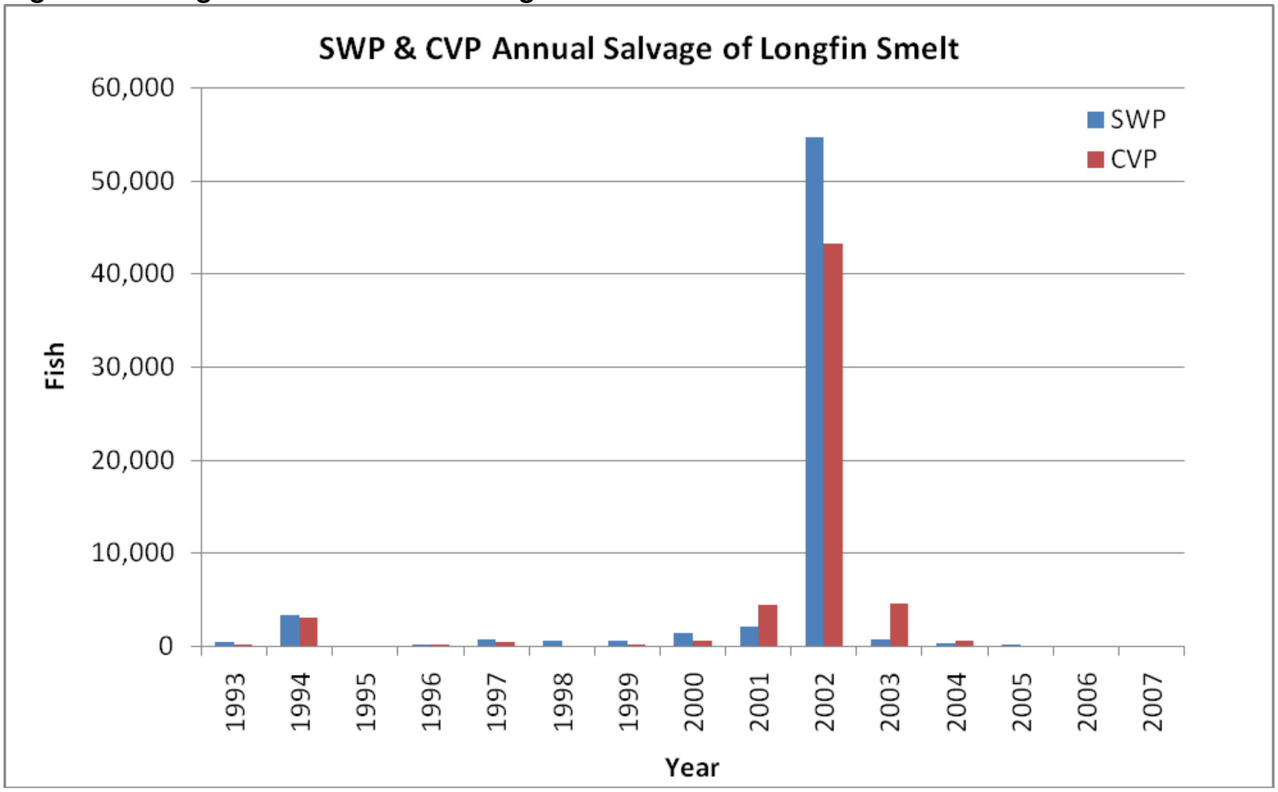
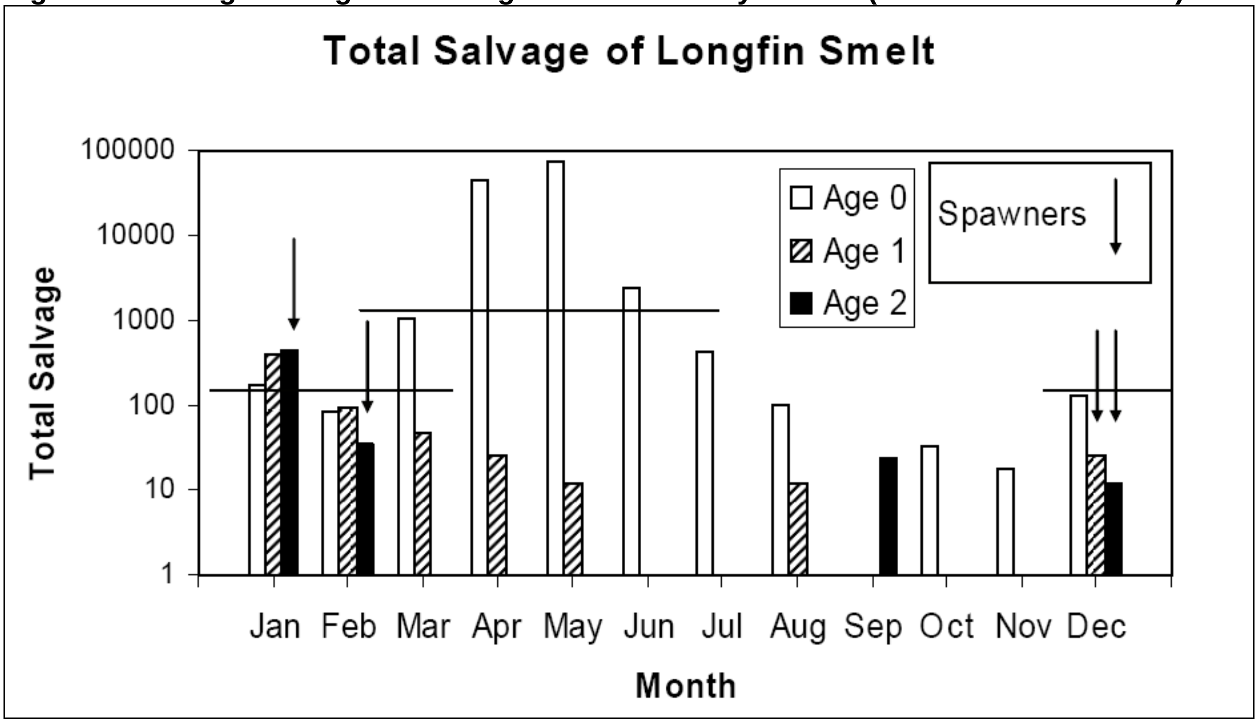


Table 1. Longfin smelt annual salvage for the SWP and CVP.

Year	SWP	CVP
1993	516	132
1994	3,400	3,015
1995	102	0
1996	137	156
1997	742	444
1998	628	60
1999	673	132
2000	1,455	528
2001	2,175	4,404
2002	54,582	43,188
2003	706	4,562
2004	333	648
2005	183	36
2006	0	0
2007	60	36

Salvage of longfin smelt by the SWP and CVP operations is further illustrated by information presented by the Department (Baxter 2008a) (Figure 2). Figure 2 shows 15-year cumulative monthly salvage estimates. The 15-year cumulative monthly salvages of Age-1 and Age-2 longfin smelt total 1,133 longfin smelt (Baxter 2008b). This equates to an average of 76 fish year and 6 fish/month, and a median of 1 fish/month over 1993 to 2007. Cumulative salvage was greatest in January at 833 Age 1&2 longfin smelt, which averages out at 56 fish/year for the month of January. If subadults (Age-0) are included, the annual average January salvage is 67 longfin. Annual Age 1&2 salvage rates for the remaining months average 2 longfin smelt/year.

Figure 2. Salvage during 1993 though 2007 totaled by month. (Source: Baxter 2008a)

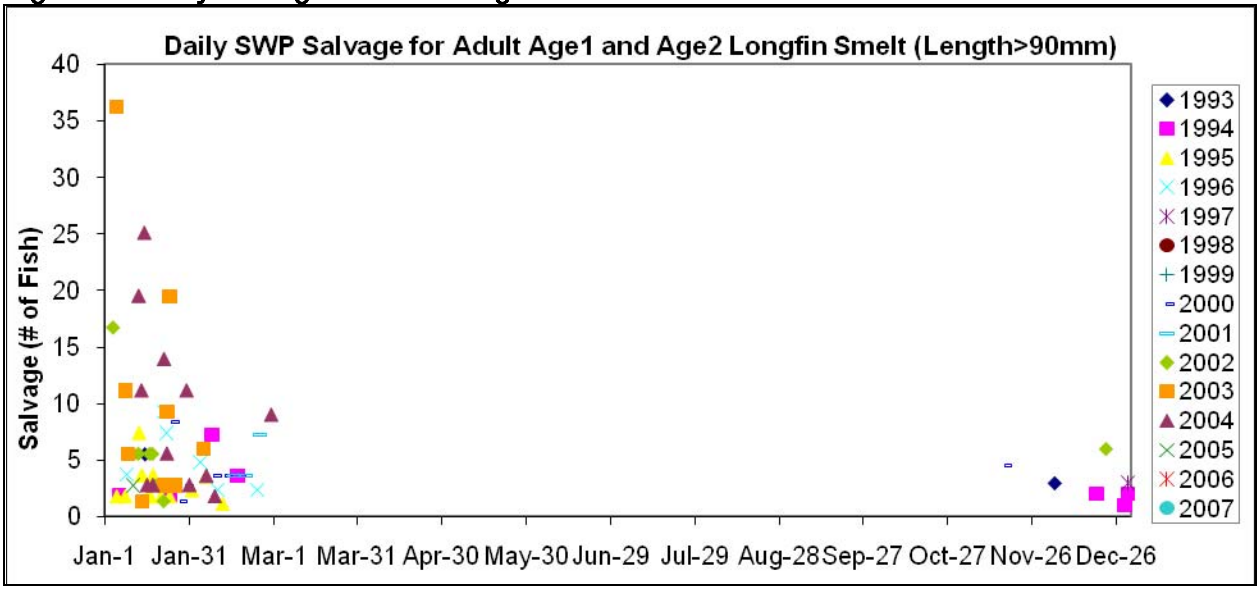


Daily winter salvage data for 1993-2007, show January with the highest daily rates (Figure 3). Also, there is considerable variation in salvage within months of a given year and over the years within months (Figure 3). Adult daily salvage is absent during March-October and rare in November and December.

Geographic Distribution

It appears that only a very small fraction of the subadult and adult longfin population is in the southeast Delta and thus most subject to potential effects of the Projects. The Department conducts a number of surveys at various times of the year that provide information on the location and numbers of subadult and adult longfin smelt. Surveys that monitor subadult and adult fish include the Fall Midwater Trawl (FMWT), Winter Midwater Trawl (WMWT), and Spring Kodiak Trawl (SKT) surveys. (The spring 20mm survey samples for larval and juvenile longfin). Each of these surveys samples throughout much of the Delta and Suisun Bay year after year. We obtained the Departments datasets for each of these surveys for this analysis (Appendix A). For analysis purposes, we grouped the sampling stations to represent five-major geographic regions; the Napa-River-Carquinez Strait (NapaCarq), Suisun Bay and Marsh (Suisun), North Delta, South Delta, and Southeast Delta (Figure 4). Note that six of the many FMWT and WMWT stations are in the southeast Delta, while only stations 914 and 915 are sampled by the SKT (Figure 5). Based on the Department's survey data, from 1993 to 2007, there is no evidence of longfin smelt being caught in the FMWT, WMWT or SKT samplings at southeast Delta stations.

Figure 3. Daily salvage of adult longfin smelt for the SWP and CVP.



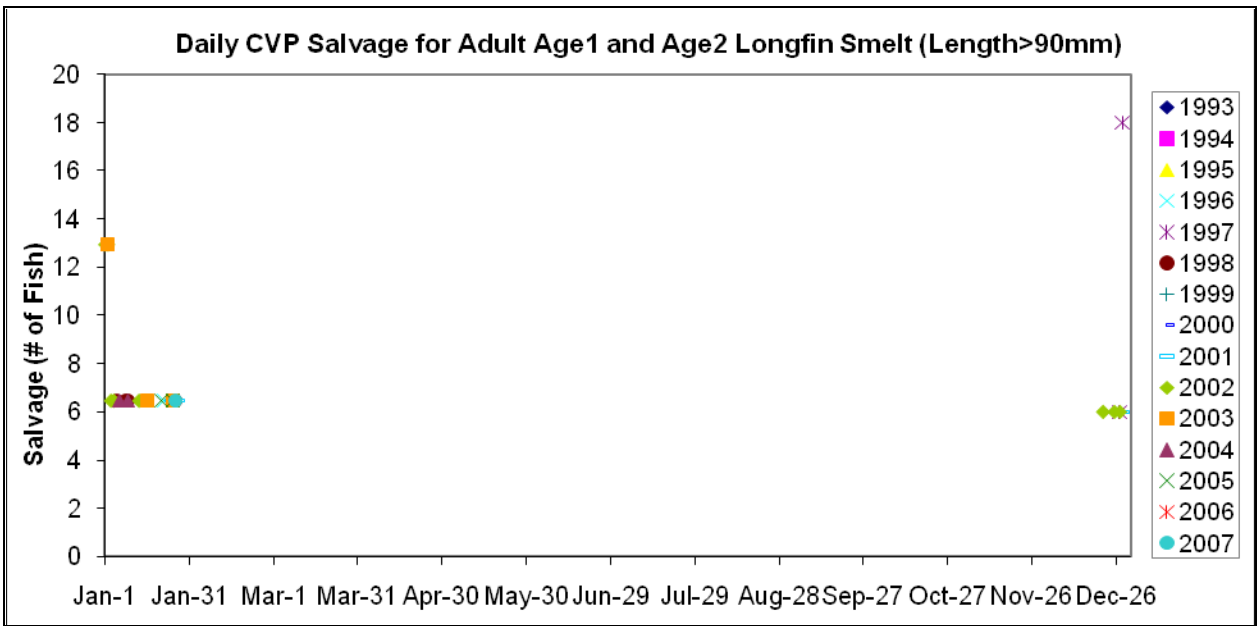


Figure 4. Five regions for allocating sampling stations of the FMWT, SKT, and 20mm survey (using the 20mm as a base map here).

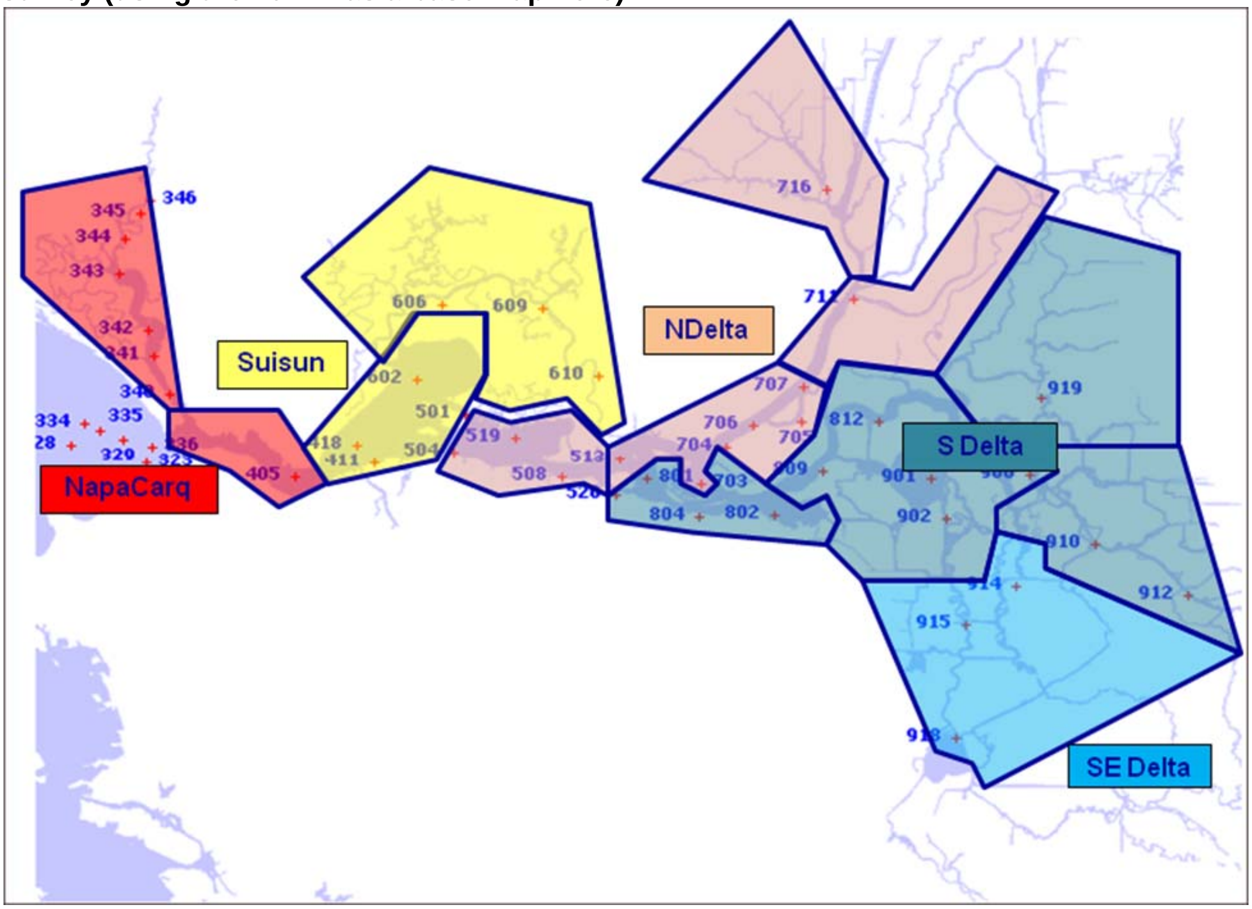
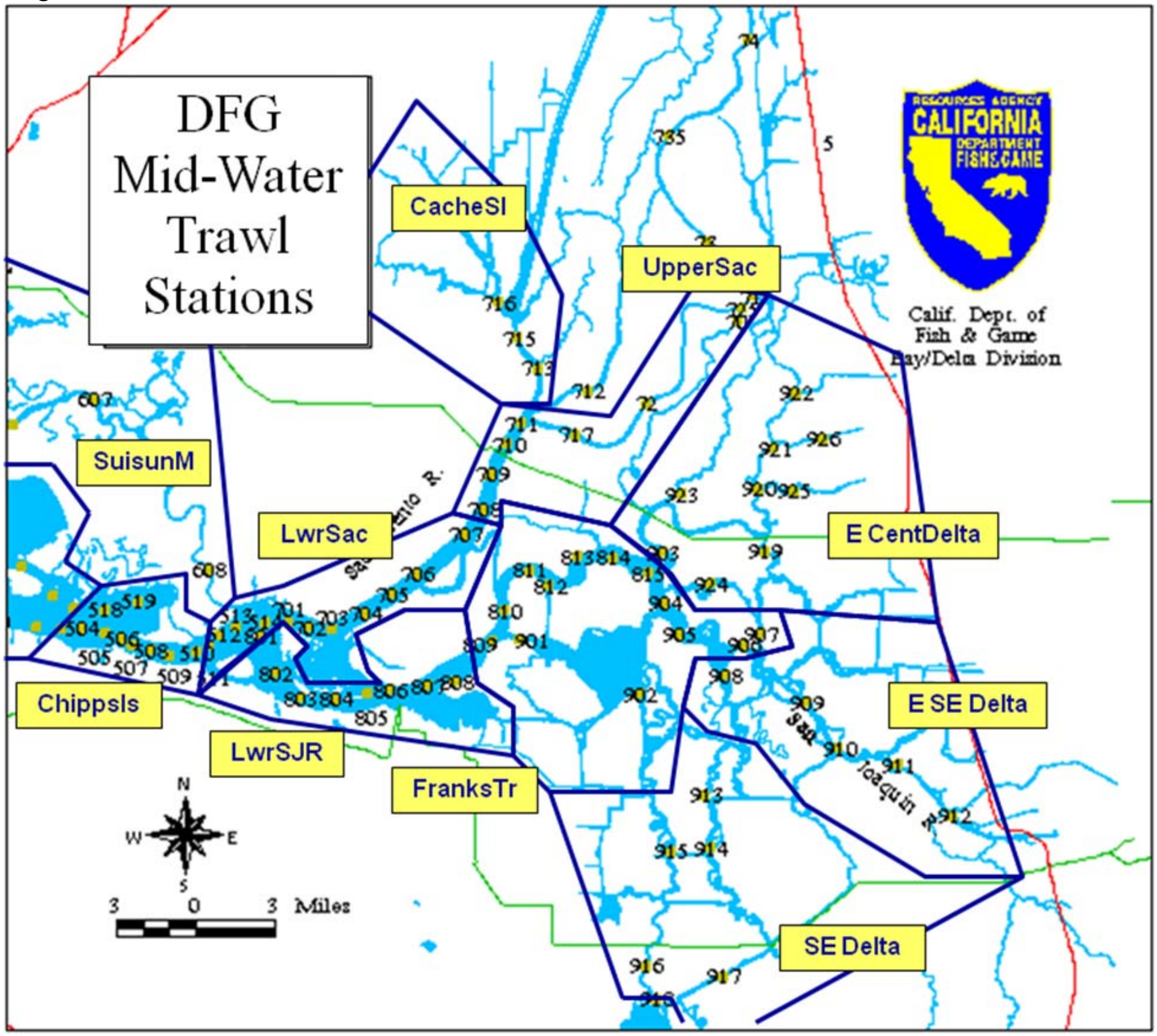


Figure 5. Fall and Winter Midwater Trawl survey stations and the Southeast (SE) Delta Region.



We used the trawl data to estimate regional abundance indices. Briefly, we used the catch and volume of the tow data to estimate average densities within each region. Then, these average densities were multiplied by the region volume to yield regional abundance values. Summing regional abundances provided an estimate of overall abundance index. By dividing the Southeast Region abundance index by the overall abundance value, we obtained an indication of the risk of entrainment. Details on the data and the calculations are provided in Appendix A. Unfortunately, the surveys do not sample upstream of the pumps or Stockton, so we cannot tell if longfin were there. Note however, that there is no claim here that any of the abundance indices are accurate estimates or that any of the differences among indices are statistically significant. Note also, that comparisons of abundance indices among regions or over a survey program, can be more reliable when considered on a relative basis, that is, relative to each other. This removes the issue of accuracy in absolute abundance estimates.

Overall longfin smelt abundance indices vary within and between years as well as between sampling programs (Figure 6). The WMWT indices averaged 940,398 fish, had a median of 456,858, ranged from 0 to 7.1 million longfin. The SKT indices averaged 161,039 fish, had a median of 57,485, and ranged from 0 to 1.3 million. Most of these winter longfin were far from the pumps. While zero longfin smelt are estimated for the southeast Delta region, up to 4 million was estimated for the Napa-Carquinez region for January 2001 (Figure 7). Few were in ever in the South Delta region. For the winter of 2002, up to 0.4M was estimated, and for the Suisun region. Again, the South Delta region had few while the Southeast Delta region had no longfin.

Population Effects from SWP and CVP

Focusing on just January, the highest spawner salvage month (Figure 2), subadult and spawner salvage over 1993-2007 averaged 67 longfin smelt, as mentioned above. January abundance indices for longfin could be made for all but four years over 1993-2007 (Table 2). The average for the 11 years with data is 1.6 million, for which an average January salvage of 67 longfin amounts to 0.004%. Switching from a 15-year perspective to just the January 2002 (and late December 2001), salvage totaled 177 longfin, which amounts to 0.03% of the concurrent SKT abundance index of the 626,459 longfin (Figure 8). These percentages indicate controlling salvage will do little to influence winter abundance of longfin smelt.

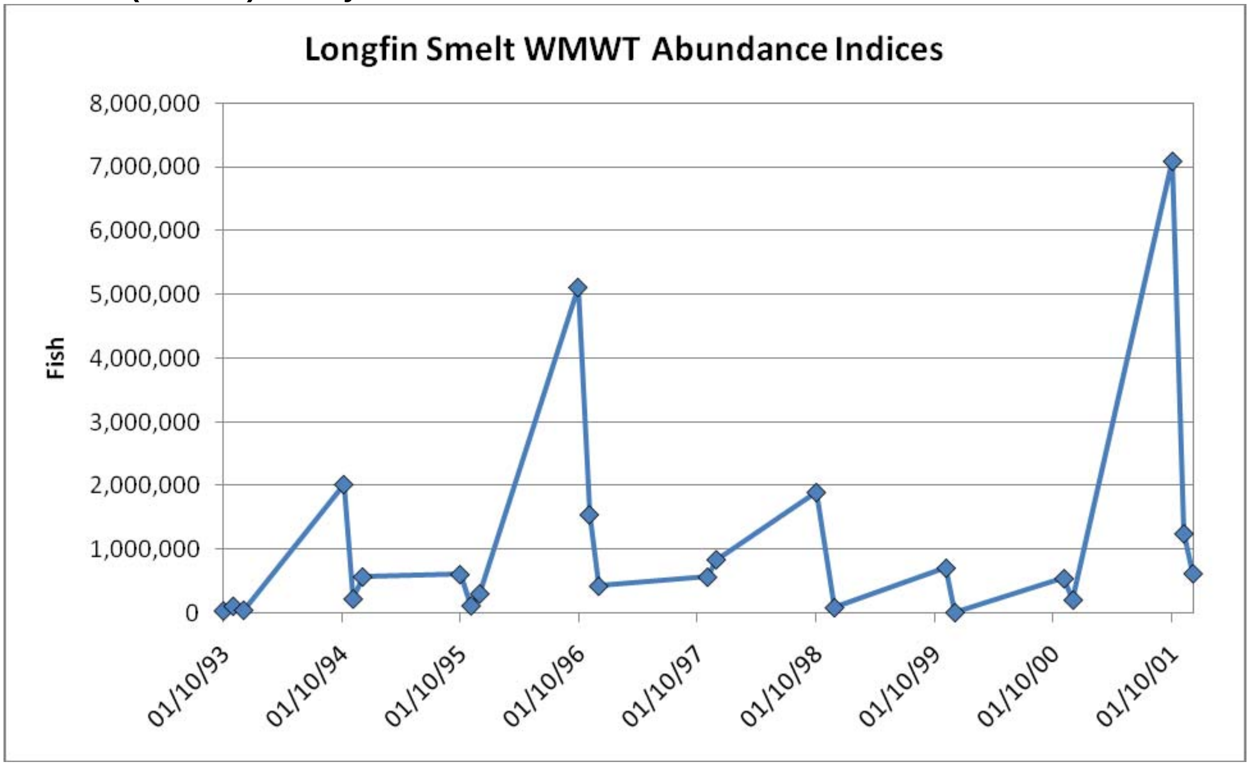
Conclusion on Subadults and Spawners

In conclusion, it seems difficult to manipulate winter salvage with the expectation of making a difference in the winter population. Few subadult and adult longfin smelt are salvaged, most longfin are far from the pumps, and salvage numbers seem small relative to abundance indices.

Table 2. January abundance indices for longfin smelt.

January	Longfin smelt indices of abundance from WMWT or SKT
1993	35,525
1994	2,019,298
1995	605,417
1996	5,115,441
1997	No survey
1998	1,895,058
1999	No survey
2000	No survey
2001	7,095,904
2002	626,459
2003	No survey
2004	314,409
2005	11,724
2006	10,752
2007	369,043

Figure 6. Longfin smelt abundance indices based on data from the WMWT (1993-2001) and SKT (2002-07) surveys.



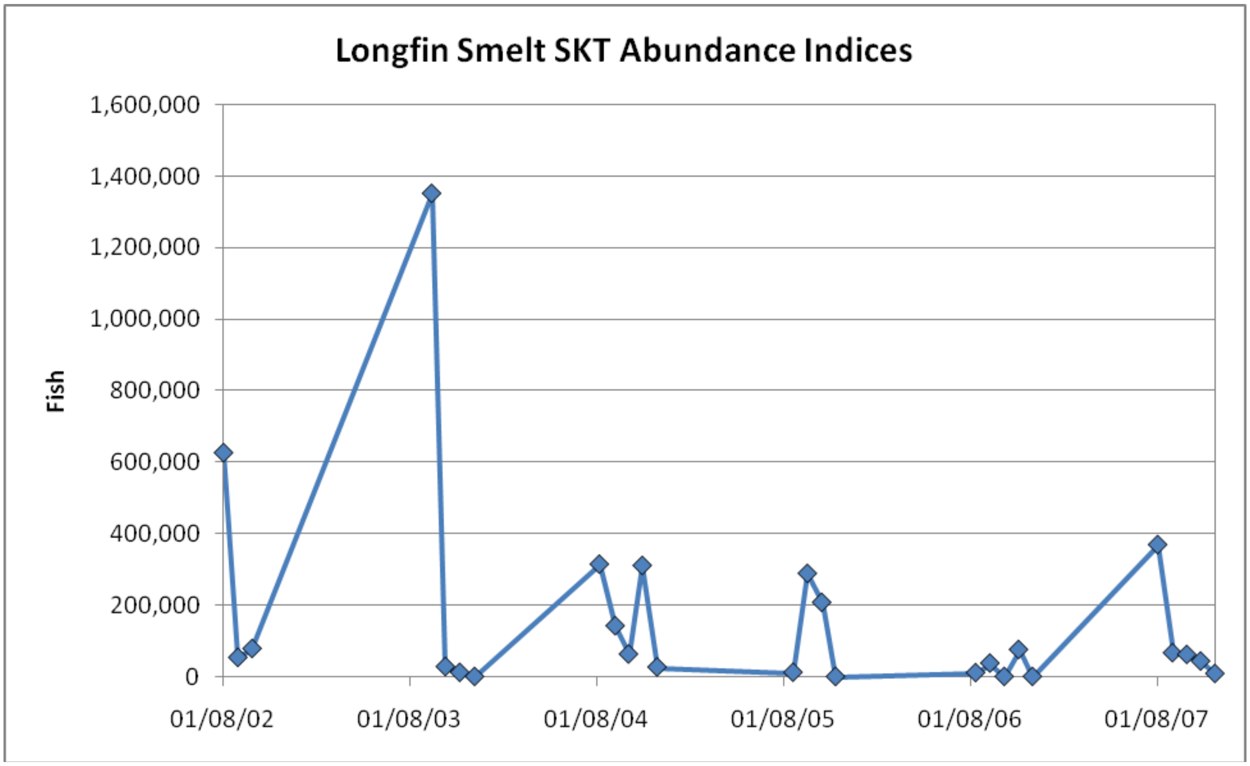
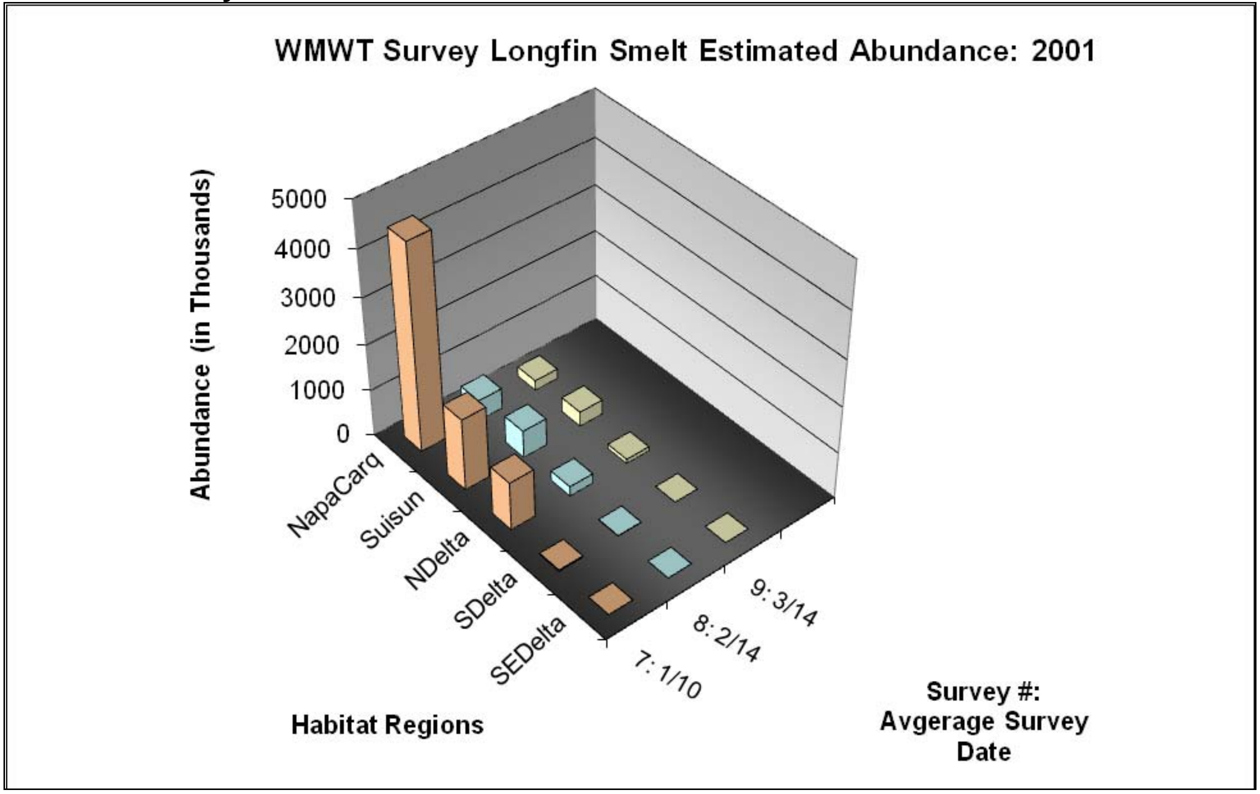


Figure 7. Regional abundance indices for longfin smelt during the 2001 WMWT and the 2002 SKT surveys.



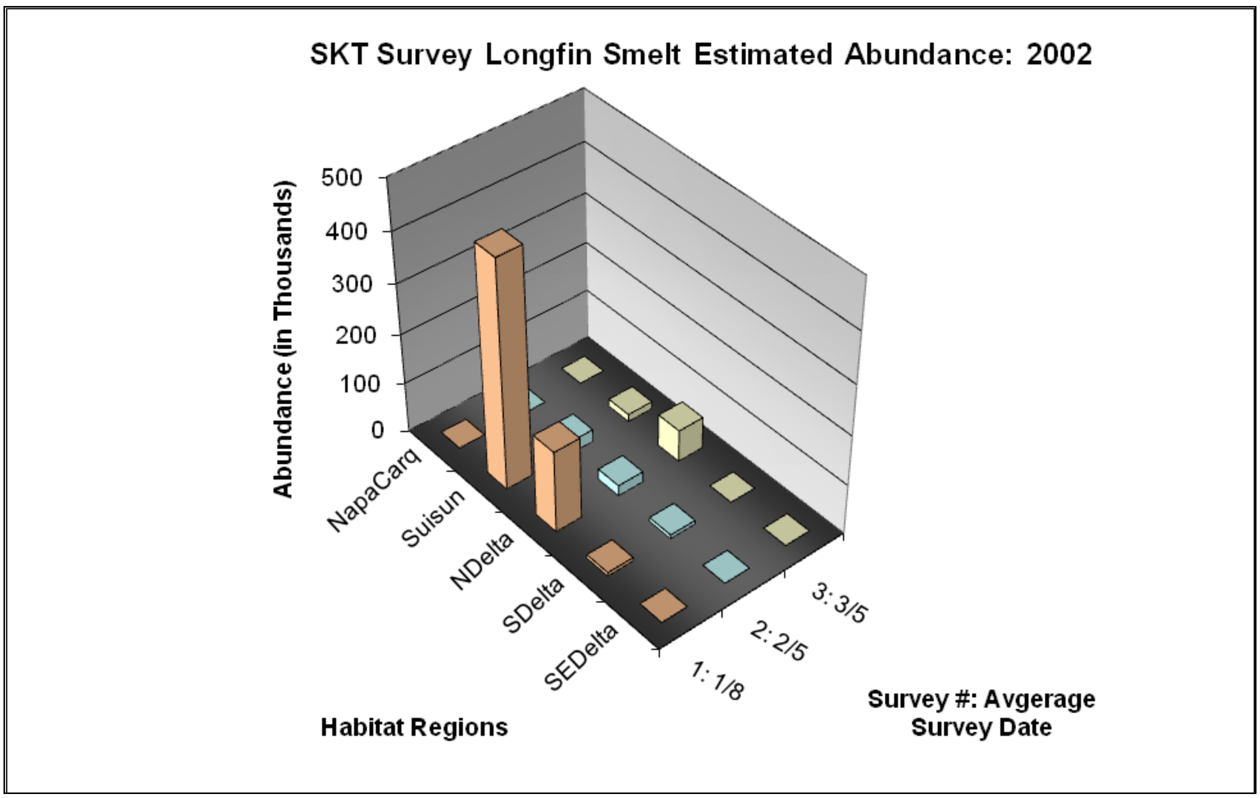
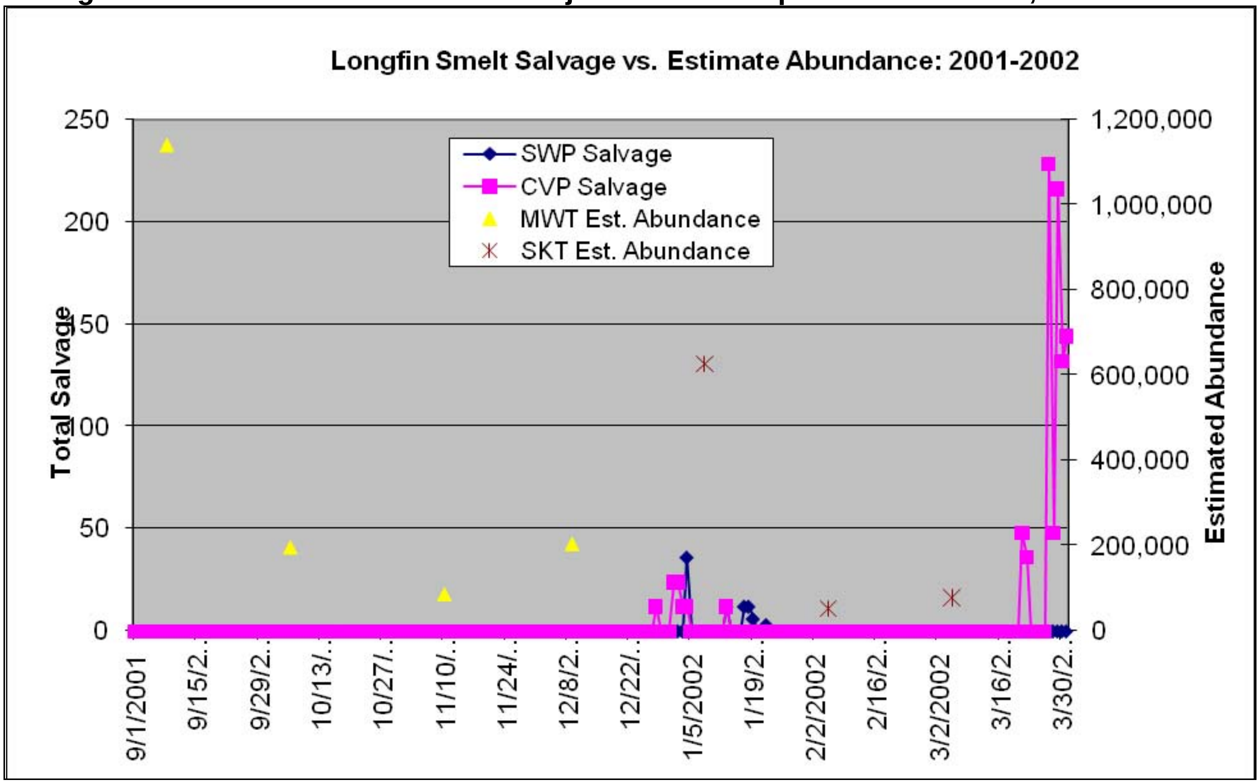


Figure 8. Longfin smelt daily salvage and WMWT or SKT abundance indices for the average survey dates during fall and winter of 2001 and 2002. Salvage in December and January was subadults and adults, except for maybe 3 juveniles in December, while CVP salvage in March was >=95% larvae and juveniles and up to 5% subadults, and no adults.

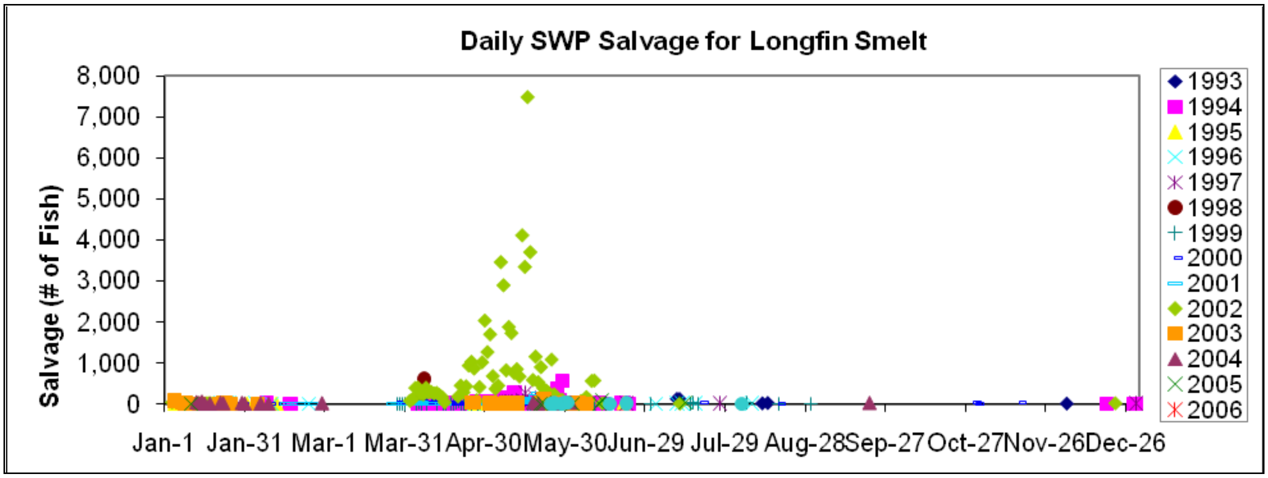


Larvae and Juveniles and Entrainment.

Salvage

Although larvae are abundant in the Bay/Delta during January-April (Baxter 2008a), salvage operations do not detect longfin smelt until March, when fish reach 20mm or more in length (Figures 9 and 10). Larvae (<20mm) are likely to be entrained although the numbers are unknown.

Figure 9. SWP and CVP longfin smelt daily salvage. Most of these fish are juveniles, and larvae are too small to be detected.



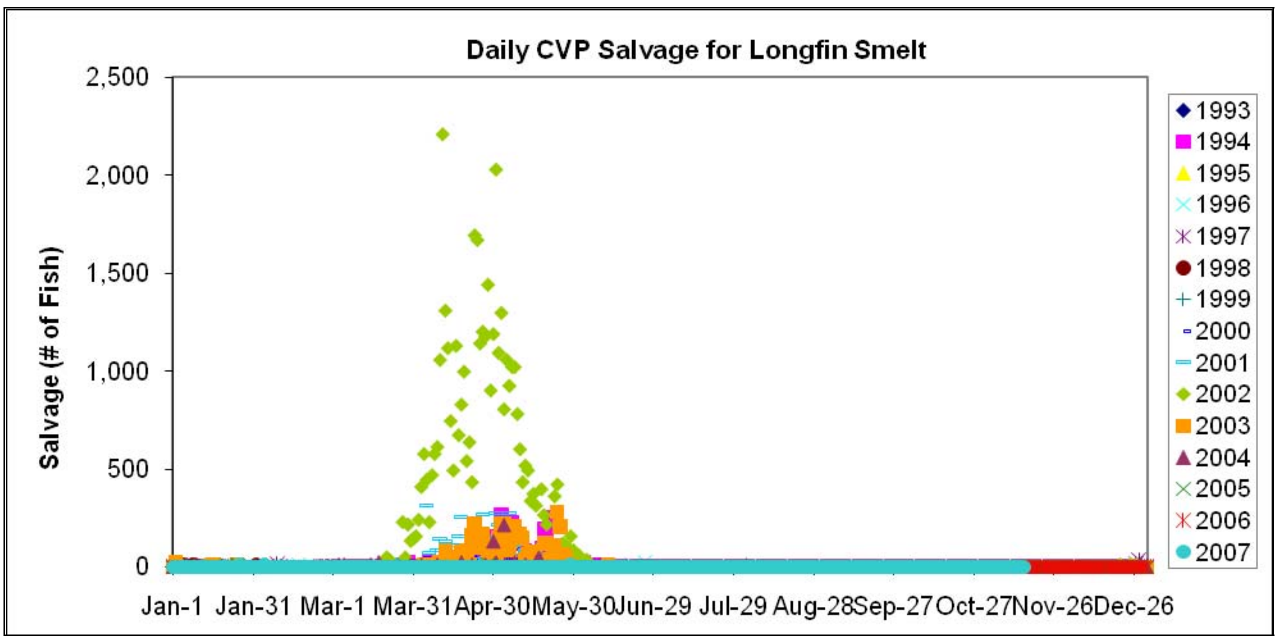
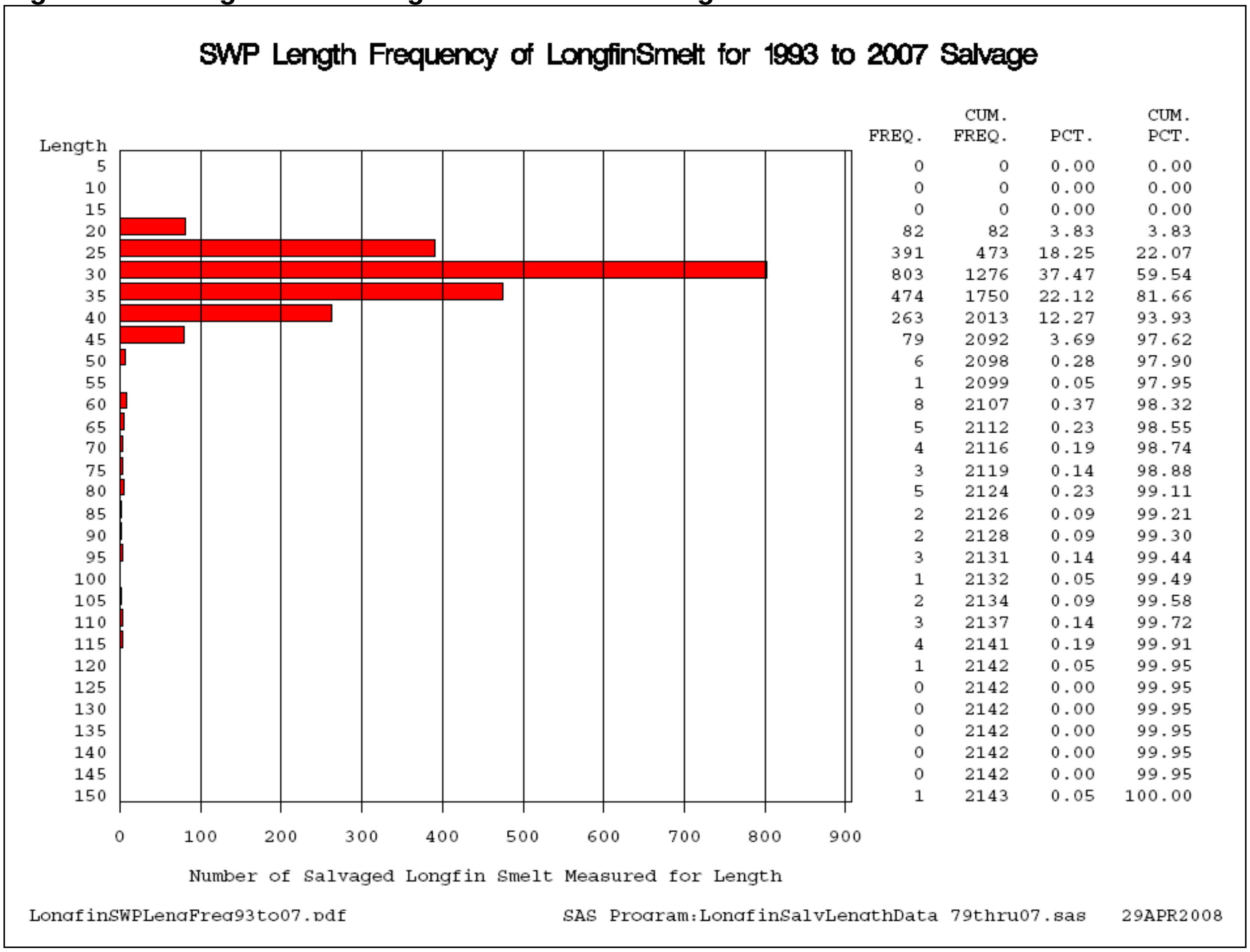


Figure 10. Longfin smelt lengths from SWP salvage.



Length	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
5	0	0	0.00	0.00
10	0	0	0.00	0.00
15	0	0	0.00	0.00
20	82	82	3.83	3.83
25	391	473	18.25	22.07
30	803	1276	37.47	59.54
35	474	1750	22.12	81.66
40	263	2013	12.27	93.93
45	79	2092	3.69	97.62
50	6	2098	0.28	97.90
55	1	2099	0.05	97.95
60	8	2107	0.37	98.32
65	5	2112	0.23	98.55
70	4	2116	0.19	98.74
75	3	2119	0.14	98.88
80	5	2124	0.23	99.11
85	2	2126	0.09	99.21
90	2	2128	0.09	99.30
95	3	2131	0.14	99.44
100	1	2132	0.05	99.49
105	2	2134	0.09	99.58
110	3	2137	0.14	99.72
115	4	2141	0.19	99.91
120	1	2142	0.05	99.95
125	0	2142	0.00	99.95
130	0	2142	0.00	99.95
135	0	2142	0.00	99.95
140	0	2142	0.00	99.95
145	0	2142	0.00	99.95
150	1	2143	0.05	100.00

Entrainment Risk

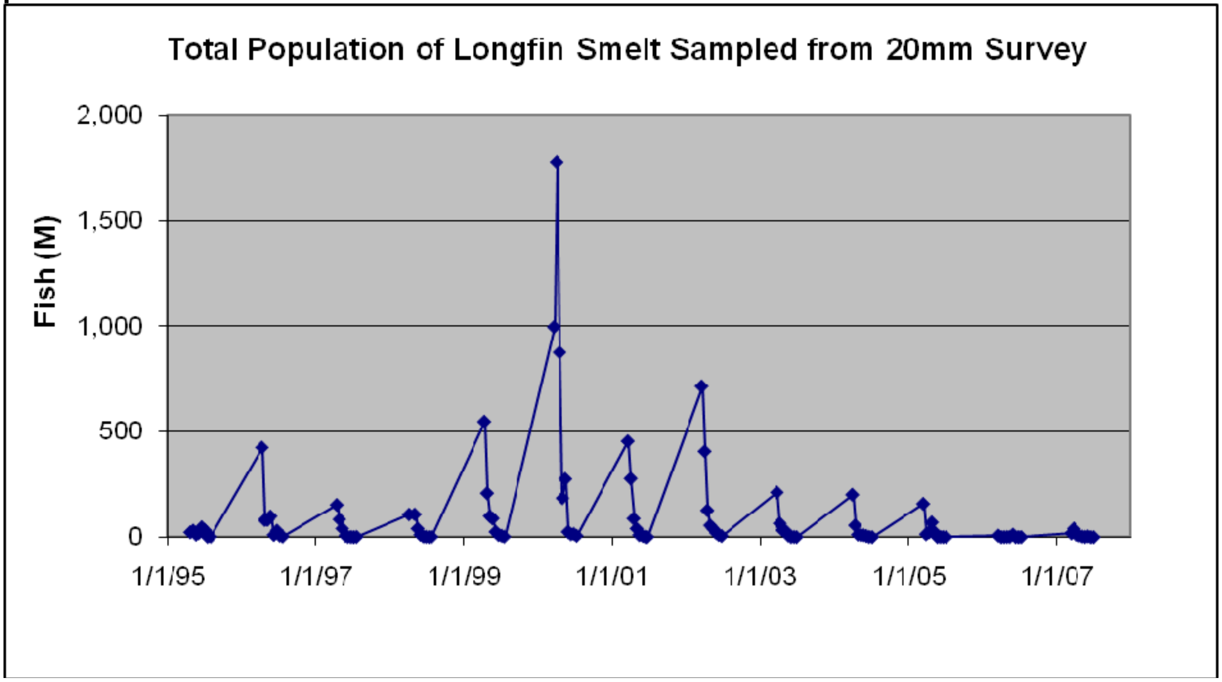
Larval-plus-juvenile longfin smelt abundance indices for the Southeast region relative to over all regions can be useful in gauging entrainment risk and potential population effects. Although the 20mm surveys data are conducted March-June, two to three months after longfin start hatching, it is the only source of data available for evaluating the distribution and abundance of these life stages. Using the methodology described above in Appendix A for the WMWT- and SKT-based adult abundance indices, the 20mm survey catch data was expanded to provide total as well as regional larvae and juvenile abundance estimates.

A small portion of the larval and juvenile longfin smelt population has resided in the southeast region of the Delta. Overall larval and juvenile longfin smelt abundance indices range from the hundreds of thousands to over 1.5 billion, with most years in the 10s of millions range. (Figure 11). The fraction of the overall longfin smelt abundance indices accounted for by longfin in the southeast Delta range from 0 to 2%, with most values at 0% (Figure 11). Instead of being in the Southeast Delta, most longfin appear to have been seaward. In 2002, the highest salvage year, and the two preceding years, for example, most longfin smelt were in the North Delta, Suisun, and Napa-Carquinez areas (Figure 12).

Conclusion

Based on available data, only a small fraction of the longfin smelt population resides in the South or Southeast Delta near the pumps. The fraction likely to be salvaged this coming winter appears to be a small part of the overall population. Project operation criteria for protection of delta smelt would provide protection for longfin smelt as well. Consequently, further manipulation of operations this winter for longfin smelt protection seems unlikely to provide much benefit to the population.

Figure 11. Longfin smelt larval and juvenile abundance indices over all regions and the percent in the Southeast Delta.



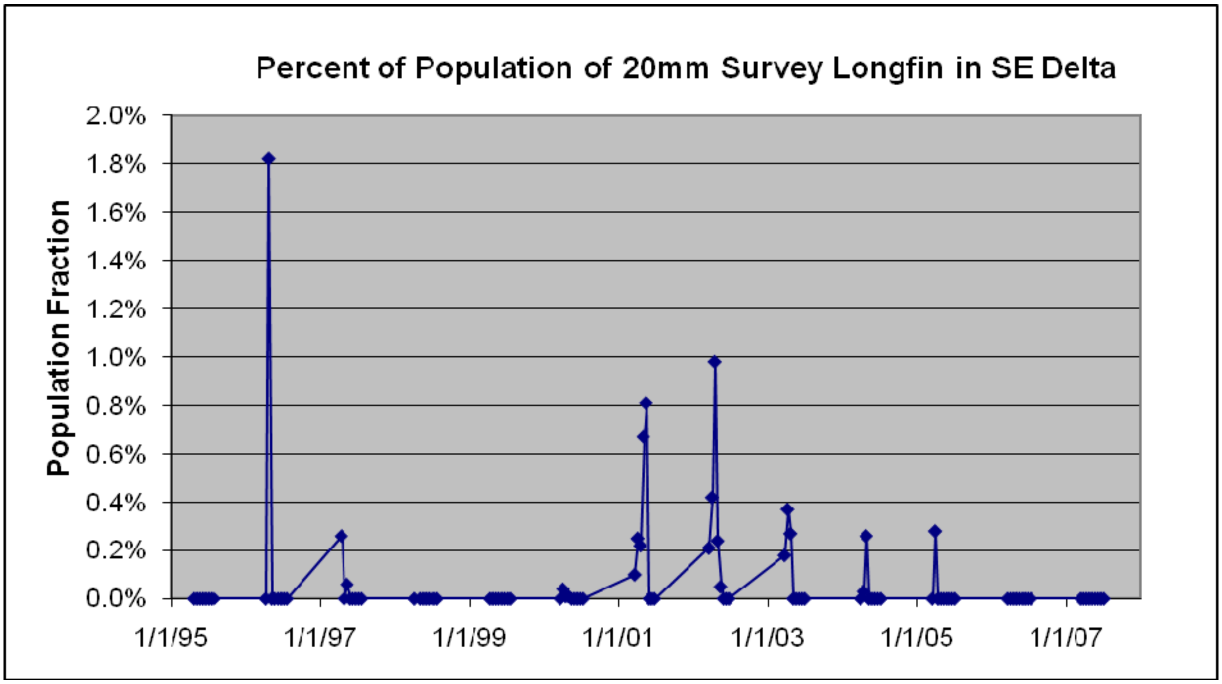
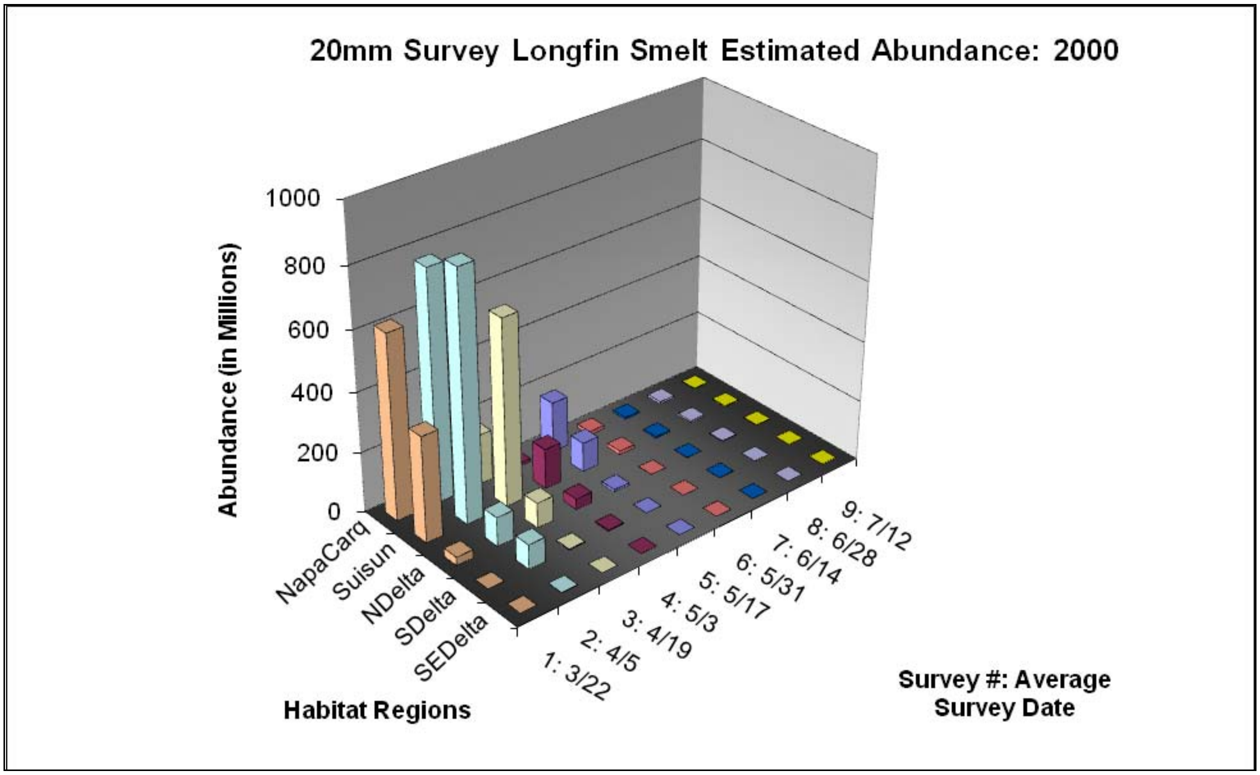


Figure 12. Larval and juvenile longfin smelt abundance indices across regions for 2000, 2001 and 2002.



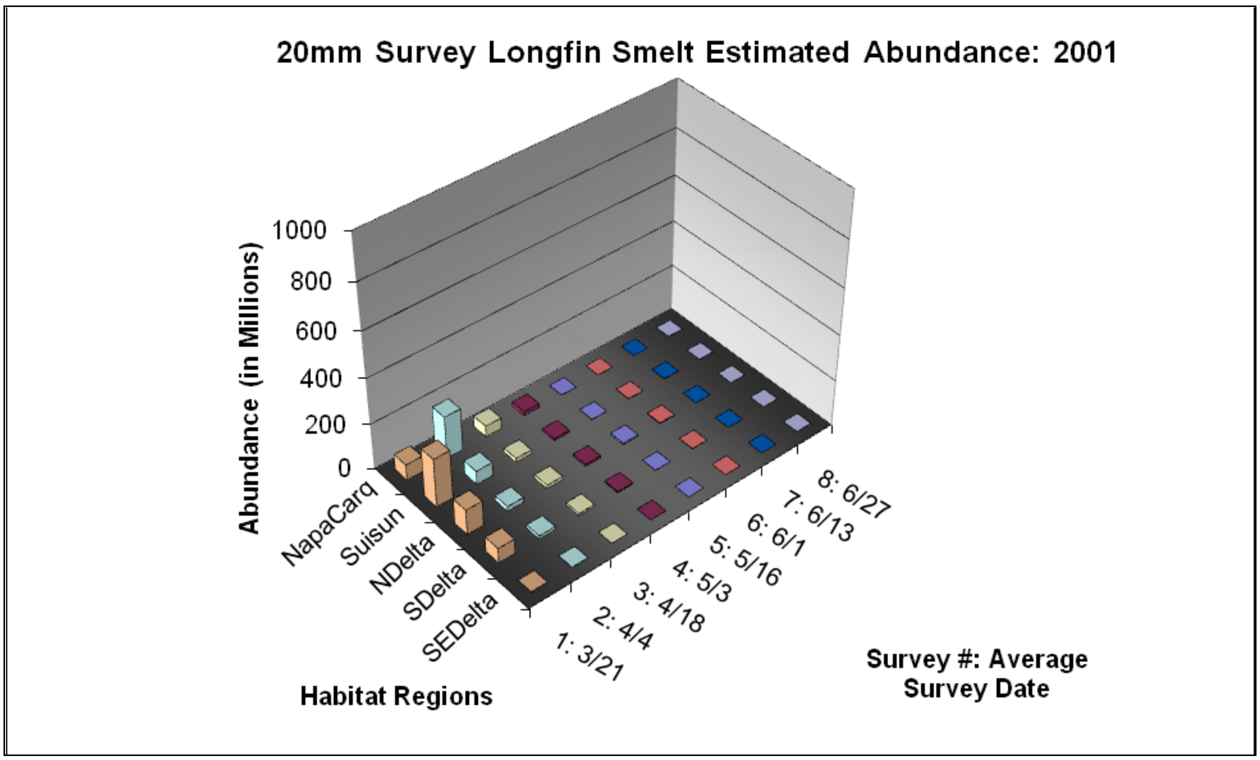
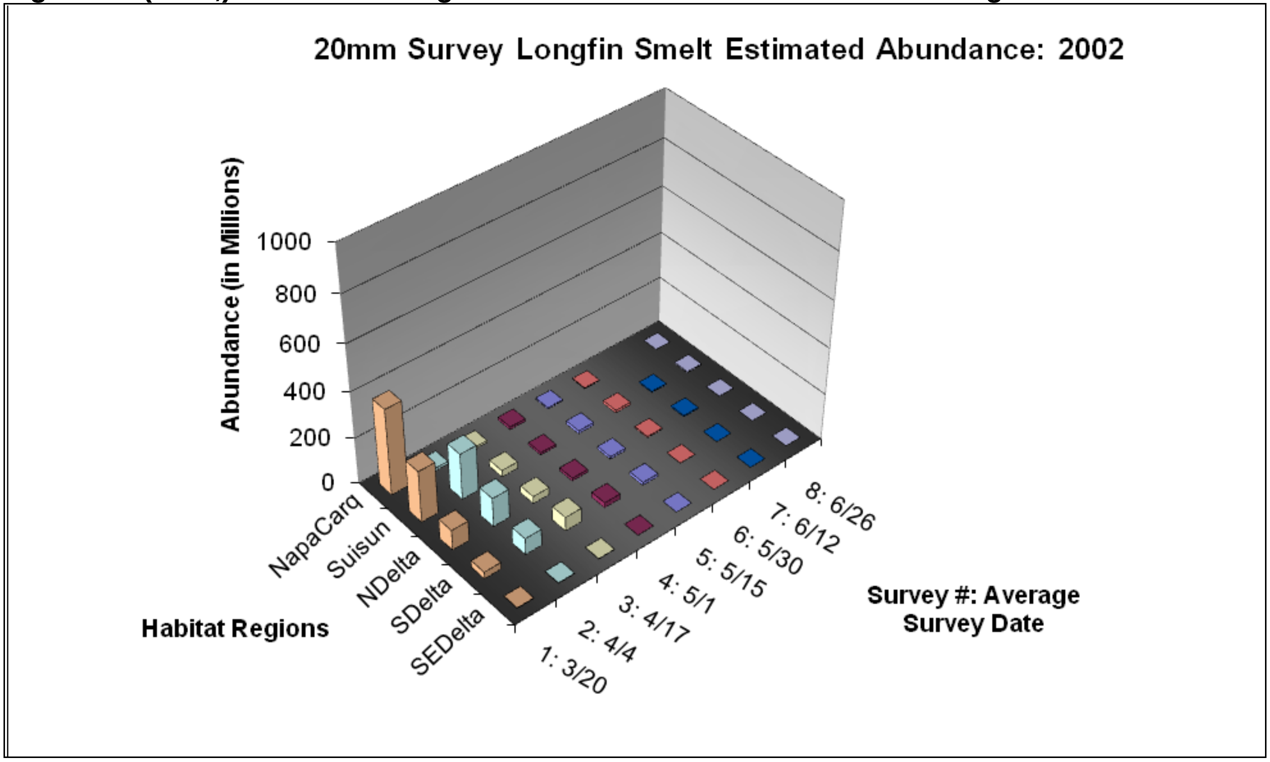


Figure 12 (cont,). Juvenile Longfin smelt abundance indices across regions.



OTHER STRESSORS STRONGLY ASSOCIATED WITH THE FMWT LONGFIN SMELT ABUNDANCE INDEX.

Other stressors besides losses at the pumps may be operating to control longfin abundance. Several potential stressors have been identified by the POD as potentially effecting longfin smelt (Baxter et al. 2008). New analyses of the longfin smelt abundance, as represented by its FMWT index show strong associations of this index with three independent factors:

- The average value of X2 during the winter/spring of the current year. The period February through April appears to account for the most variability. The X2 data used here was generated by applying the daily X2 equation to outflows in the DAYFLOW dataset.
- The average value of air temperature (F) at Davis from February through April of the current year. Regional air temperature, as represented by Davis air temperature, has an influence on water temperatures in the Delta and Suisun Bay and water temperature may influence species abundance. This temperature data can be found at http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2294.
- Average ammonia loading at Hood/Greenes
- Landing during March and September of the current and previous years. Loading can be estimated from DAYFLOW data and concentration data found at http://bdat.ca.gov/.

The data used for the correlations is given in Table 3. The data begins in 1977 because ammonia data is only available since 1975, while FMWT data is not available for 1976. Note that there is no FMWT available for 1979 either.

The time trends in X2, temperature, and ammonia loading are shown in Figure 13-15. X2 shows no time trend. Davis air temperature shows an upward trend at about 0.05 degrees F per year. Ammonia loading shows an upward time trend of about 10 Tons/m each year.

Table 3. Data used in evaluating other stressors.

Year	Longfin FMWT	Ln (LongfinFMWT)	Average February-April X2 (km)	Average Davis Air Temp February - April (F)	NH4-N Sacramento River at Hood/Greenes Landing (tons/month). Average of March and September for the Current and Previous Year
1977	210	5.3	91.0	53.6	143.0
1978	6619	8.8	56.9	54.1	175.0
1980	31184	10.3	53.7	53.9	165.2
1981	2202	7.7	70.3	54.1	167.8
1982	62905	11.0	51.6	51.7	192.5
1983	11864	9.4	44.0	52.5	206.9
1984	7408	8.9	61.0	54.2	240.6
1985	992	6.9	75.3	54.1	247.9
1986	6160	8.7	53.4	56.0	216.5
1987	1520	7.3	74.1	55.0	277.3
1988	791	6.7	84.5	55.4	288.3
1989	456	6.1	77.3	53.6	265.4
1990	243	5.5	86.8	54.4	295.2
1991	134	4.9	81.1	53.6	334.9
1992	76	4.3	76.1	57.3	369.8
1993	798	6.7	58.6	54.7	405.3
1994	545	6.3	74.6	54.1	399.9
1995	8205	9.0	50.8	53.7	316.4
1996	1346	7.2	54.0	55.9	249.9
1997	690	6.5	56.3	56.9	255.9
1998	6654	8.8	48.2	53.1	308.1
1999	5243	8.6	55.7	52.3	300.2
2000	3437	8.1	58.4	56.2	299.6
2001	245	5.5	72.0	54.9	358.0
2002	707	6.6	72.5	54.9	463.9
2003	467	6.1	67.3	53.9	512.7
2004	191	5.3	62.3	57.5	430.4
2005	129	4.9	64.7	55.9	459.8
2006	1949	7.6	50.6	52.7	438.9
2007	13	2.6	73.9	56.9	

Figure 13. Average X2 for February to April 1977-2006.

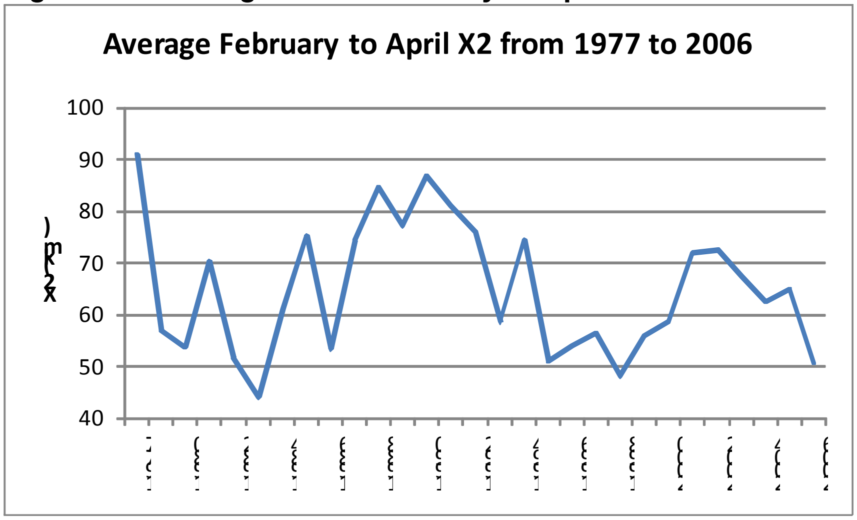


Figure 14. Average Davis air temperature for February to April 1977-2006.

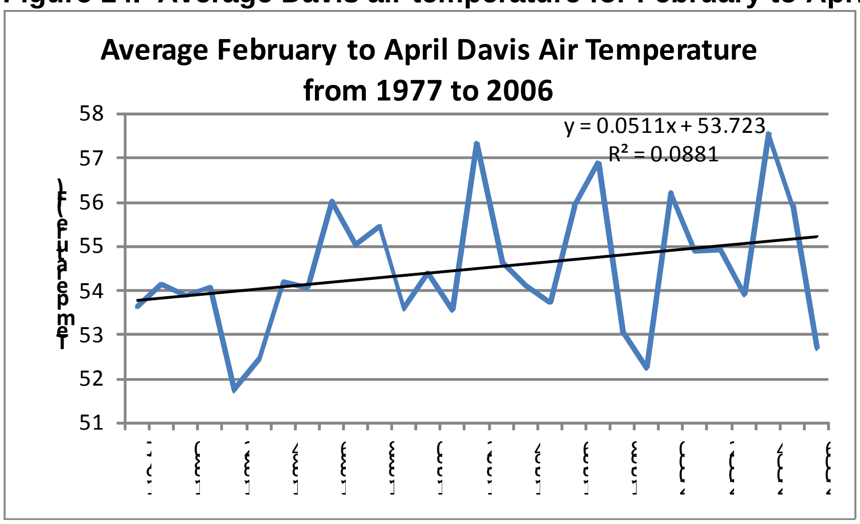
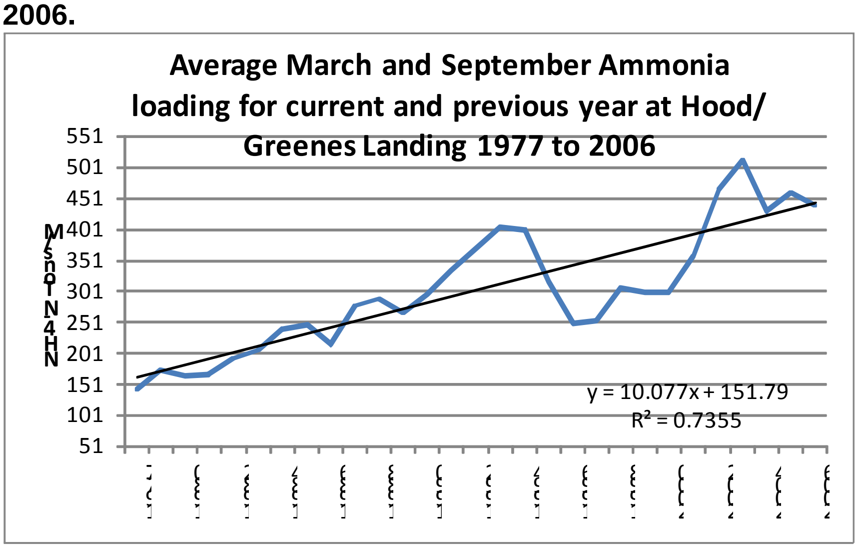


Figure 15. Average March and September ammonia loading at Greenes Landing 1977-2006.



The individual relationships between the X2, temperature, and ammonia variables and longfin FMWT index are shown below as Figures 16-18. One inference from the figures is that very high longfin abundances are rare when average X2 is greater than 65 km, when average Davis air temperatures are greater than 54.5 degrees F, or when average March/September ammonia loading is greater than about 250 tons per month.

Figure 16. Longfin FMWT and February to April X2.

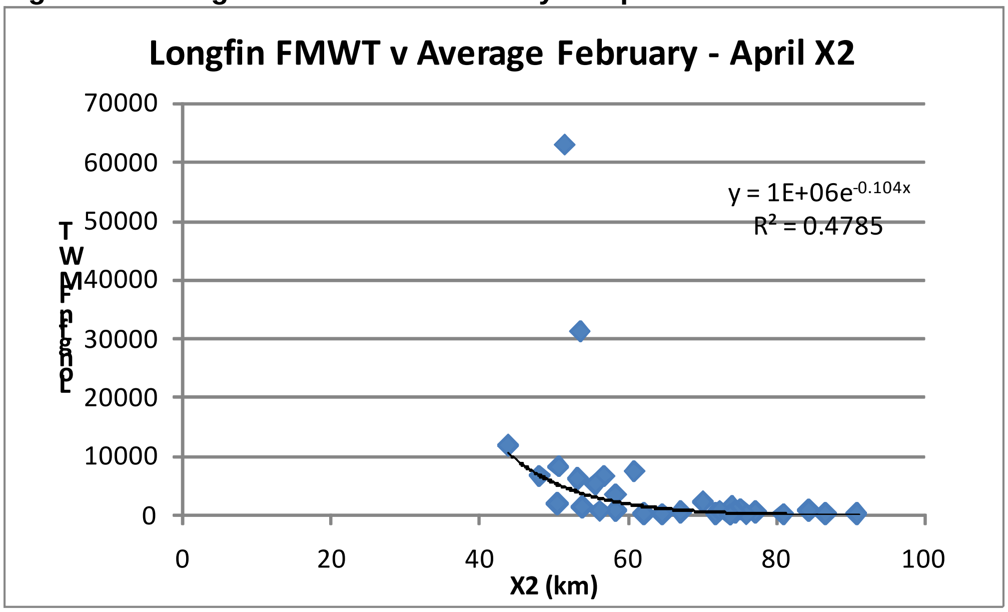


Figure 17. Longfin FMWT and February to April air temperature at Davis.

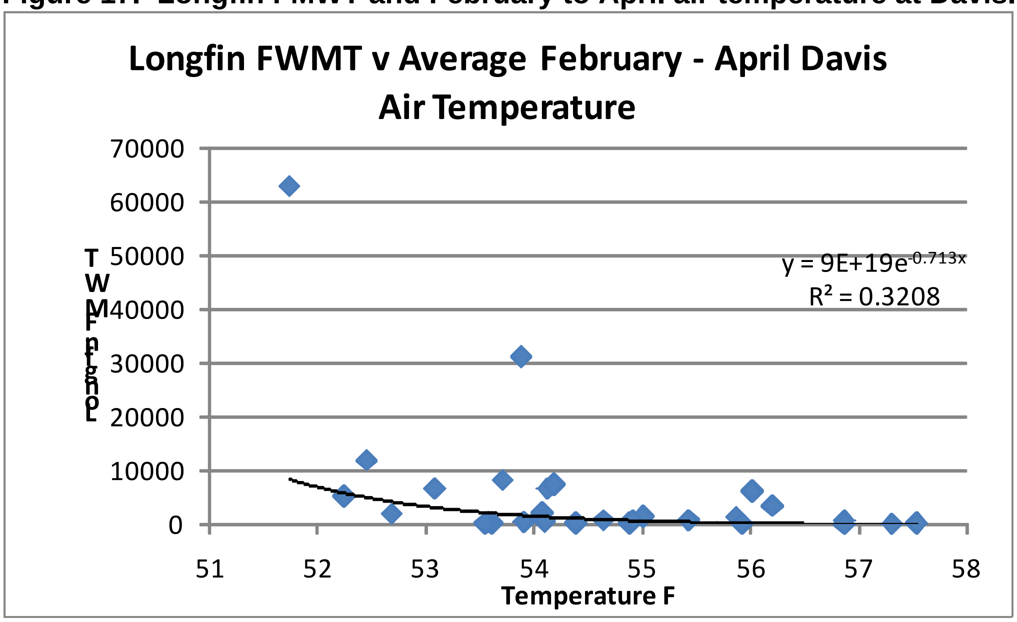
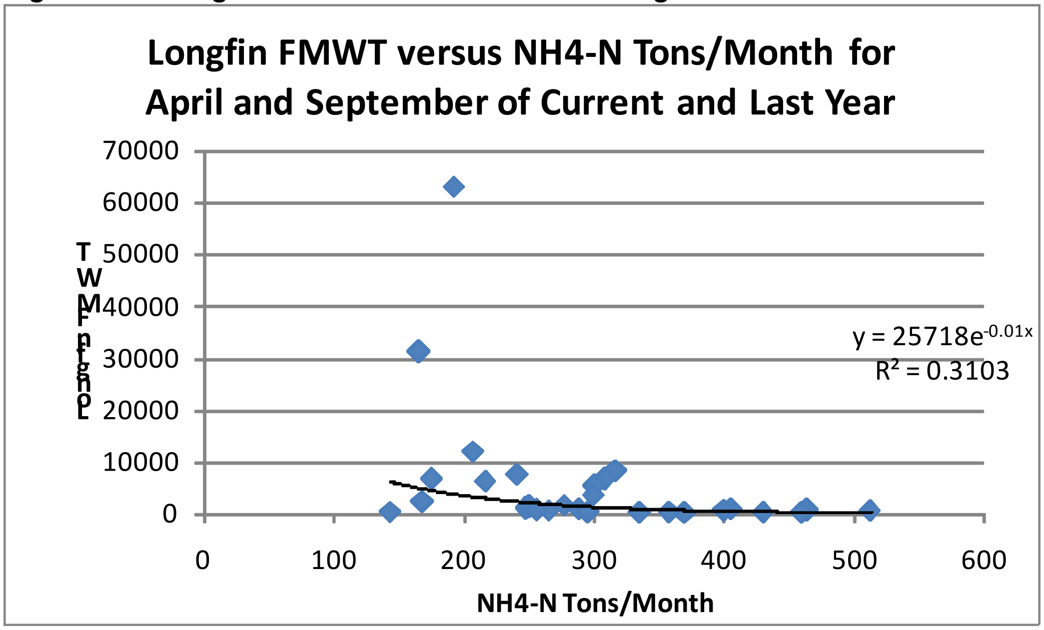


Figure 18. Longfin FMWT and ammonia loading.



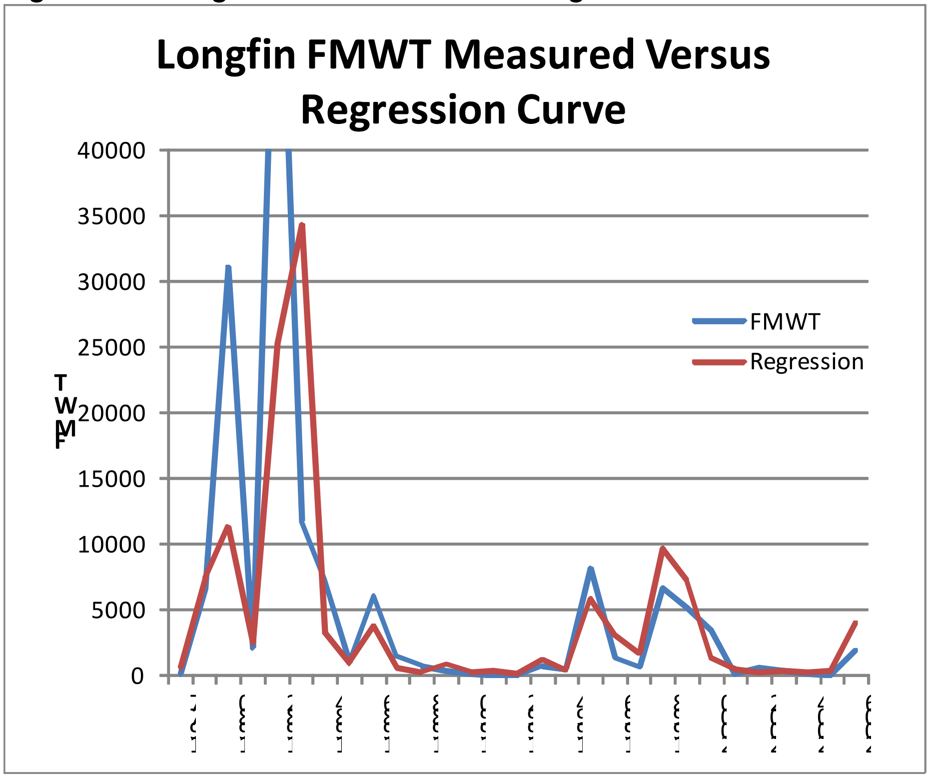
The effects of X2, Temperature, and Ammonia loading can be analyzed together using correlation. The natural log of the FMWT is used for purposes of the correlation to emphasize the percent change in abundance from year rather than the absolute change in population. Results are returned to arithmetic values for further interpretation. Note that 2007 is not included in Figure 19 due to the lack of ammonia data for 2007.A correlation of ln(FWMT) versus the X2, temperature, and ammonia data listed in Table 3 gives the following results:

- Ln(FMWT) = 35.2 - 0.087 (X2) – 0.37 (Temperature) – 0.0065 (Ammonia)
- R^2 0.82
- P values:
    - .0000002 for X2
    - .003 for temperature
    - .0006 for ammonia

Thus, the correlation both explains most of the variation in longfin abundance and is highly significant.

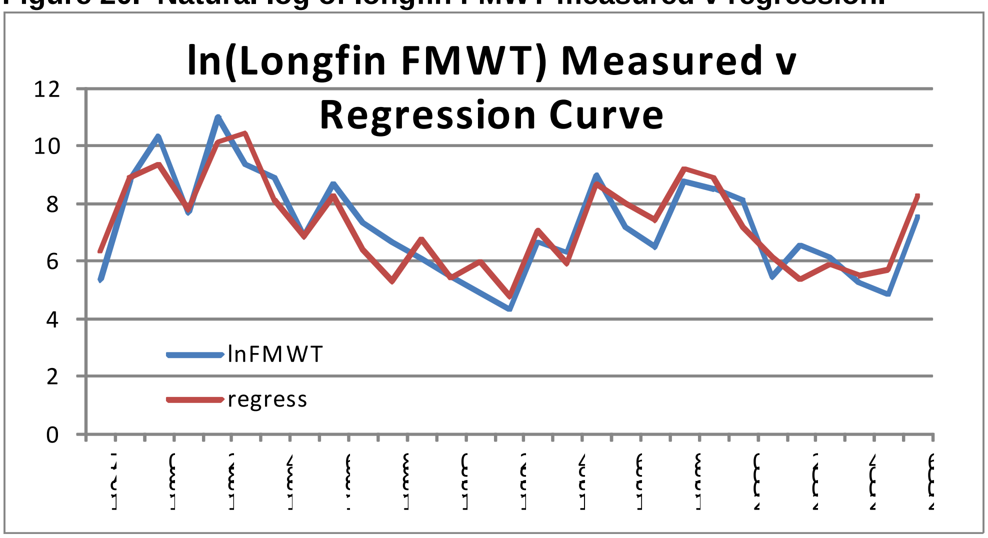
The fit between the regression and the measured FMWT values is shown in Figure 19

Figure 19. Longfin FMWT measured v regression.



The same data, but plotted using the natural logarithm of the FMWT is shown in Figure 20.

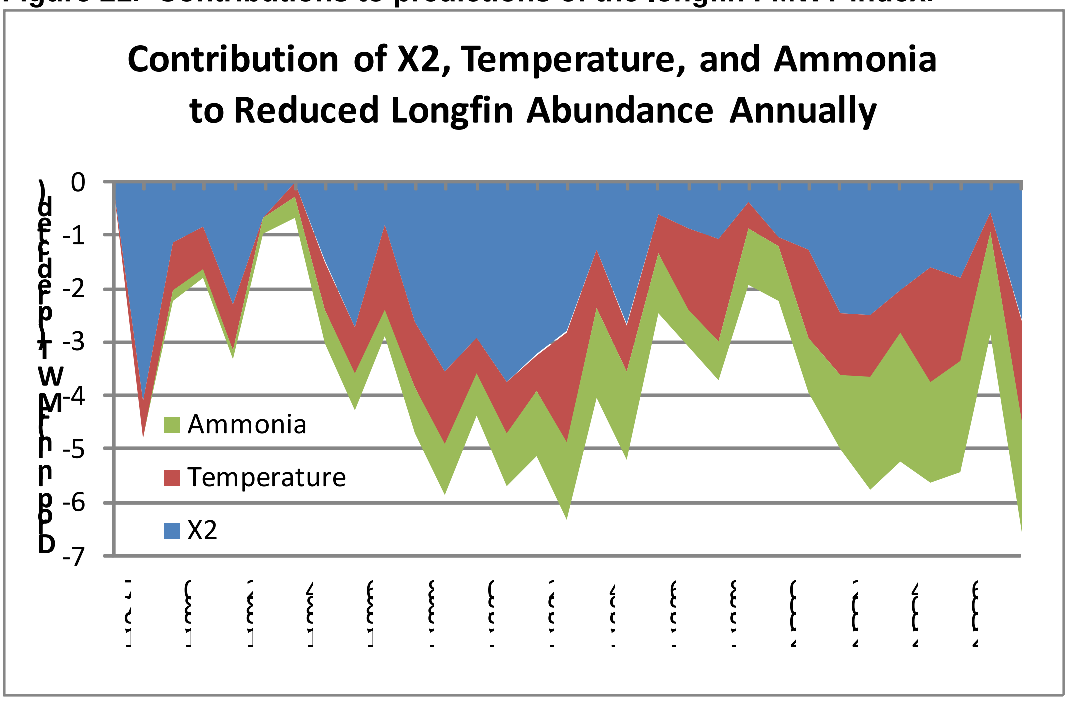
Figure 20. Natural log of longfin FMWT measured v regression.



All upward and downward spikes in abundance are captured since 1977. Although no ammonia data is available yet for 2007, if ammonia is close to the value from recent years, then the regression would correctly predict the major downward spike in abundance in the 2007 FMWT survey (2007 is discussed below and projected in Figure 21).

The relative contribution to declines in longfin abundance can be seen in Figure 21. The thickness of each band represents the degree to which that factor (X2, temperature, or ammonia) is dropping longfin abundance from the value it would have if each factor were at its optimum value over the period 1977 – 2006. If the thickness of any band is one, this means that longfin FMWT index has dropped by 2.7. If the thickness is 2, then FMWT index has dropped by 2.7 squared or about 7. A thickness of three means that FMWT index has dropped by a factor of 2.7 cubed or about 20. Figure 21 shows that in the 1970s, high longfin abundance was associated with low temperatures and low ammonia loading. Years when X2 was downstream were associated with extremely high longfin populations. Even years with high X2 had relatively good longfin abundance and temperature and ammonia are indicated as not suppressing the population. However, while X2 has remained generally stable since the 1970s, temperature, and particularly ammonia loading have increased. Now, even when X2 is far downstream, high temperatures and high ammonia loading could suppress population. When all three factors are unfavorable, then abundance can drop to very low levels. Figure 21 includes a projection for 2007 assuming that ammonia loading in 2007 is similar to levels of recent years. Thus, the extremely low longfin FMWT index in 2007 may represent the confluence of three separate factors X2, temperature, and ammonia acting together. Given low Delta outflow during 2008 and continued high ammonia loading, 2008 is also likely to have a low longfin FMWT index, though it does appear that Davis air temperatures were somewhat below average during 2008, which should help somewhat.

Figure 21. Contributions to predictions of the longfin FMWT index.



CONCLUSION

Although longfin smelt are entrained at the SWP and CVP facilities, historic data offer reasons to believe that very small portions of the widespread longfin population were involved. This applies to subadults and spawners, as well as larvae and juveniles at least during the spring. The fraction in the southeast Delta might be one of the metrics for assessing risks of entrainment at the Projects. Further, incremental changes in operations to protect longfin smelt beyond protections for delta smelt, probably would save some longfin smelt but not with detectable effects on the overall population. Finally, other environmental factors besides entrainment appear more likely to control the abundance of longfin smelt. Therefore, given the limited benefits to the longfin smelt population, additional water operations restrictions beyond those anticipated for delta smelt do not seem warranted.

REFERENCES

Baxter, R. 2008a. PowerPoint slide 27 at 2084 workshop on May 30. CDFG.

Baxter, R. 2008b. email to R. Sitts (MWDSC). June 11, 12:59pm

Baxter, R. et al. 2007. Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. Interagency Ecological Program of the San Francisco Estuary. January.

Appendix A
Data Sources and Abundance and Salvage Analyses

Three sources were used for assessing longfin smelt abundances. These include the 20-mm survey, fall and winter midwater trawl (FMWT & WMWT), and spring Kodiak trawl (SKT). Additionally, salvage from the SWP Skinner Delta Fish Protective Facility and the CVP Tracy Fish Collection Facility are used to assess impact of exports on longfin smelt.

- Original 20mm agency data, stored in Microsoft Access, was downloaded from DFG's 20mm survey website, http://www.delta.dfg.ca.gov/data/20mm/, in November of 2007.
- Original MWT agency data, stored in Microsoft Access, was downloaded from DFG's FTP site, ftp://ftp.delta.dfg.ca.gov/, on 03/13/08.
- Original SKT agency data, stored in Microsoft Access, was downloaded from DFG's FTP site, ftp://ftp.delta.dfg.ca.gov/, in October of 2007.
- Salvage count data was downloaded from the DFG Central Valley Bay-Delta Branch Salvage FTP website, http://www.delta.dfg.ca.gov/Data/Salvage/, on 02/21/08 and length data was downloaded on 03/12/08.

Since datasets are managed with different software programs (e.g. Access, dBase, etc.), we used SAS software to consolidate the different datasets onto one platform so abundance programs and queries can be made efficiently. Output data is then copied into Excel for sharing and graphing. To make sure original data were not inadvertently modified during the conversion process to SAS, we subjected the SAS data to quality control measures and had independent reviewers check a random subset of the data. The SAS data were also subjected to a data quality QA/QC analysis for missing, extreme, and other questionable values.

Abundance Estimation

Abundance is the basic parameter used to assess population levels and dynamics. The basic estimation procedure was the same for the 20mm, MWT, and SKT surveys. The generic steps are as follows.

Length-specific catch, expressed as number of fish, was divided by net efficiency yielding an expanded catch. Net efficiency was determined separately for each survey net as described in detail below. Expanded catch was divided by the volume sampled per tow to determine densities. The sample volumes were computed from flow data obtained by DFG with a General Oceanics flow meter mounted in the mouth of the net. If more than one tow was taken, then densities were averaged over the replicate tows (varying between 1 and 3, depending on the survey) at each station for each sampling event. Station densities were averaged over sub-regions (Table A1 and Figure A1) and then multiplied by the sub-region's water volume over the whole water column to produce the sub-regional abundance estimates. Sub-regional water volumes, Table A2, were estimated by BJ Miller (unpublished). At this stage, the sub-regional abundances are still length-specific; hence total abundance is derived by summing overall length classes. For easier graphical interpretation, sub-regions were combined into five main regions, shown in Table A1 and main report Figure 4. All densities and abundances were calculated using SAS.

Table A1. Assignment of Sampling Stations to Regions for Each Survey.[1]

Regions	Sub-Region	20mm	Fall and Winter Midwater Trawl	Spring Kodiak Trawl
Napa-Carquinez	**Napa River**	340, 342, 343, 344, 345, 346	340, 341	340
	Carquinez Strait	405	401, 403, 404, 405, 406, 407, 408	405
Suisun	**Suisun Bay**	411, 418, 501, 602	409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 501, 502, 503, 515, 516, 517, 601, 602, 603, 604	411, 418, 501, 602
	Suisun Marsh*	606, 609, 610	605, 606, 608	606, 609, 610
North Delta	**Chipps Island**	504, 508, 519	504, 505, 507, 508, 509, 510, 518, 519	504, 508, 519
	Lower Sacramento River	513, 703, 704, 705, 706, 707	511, 512, 513, 701, 703, 704, 705, 706, 707	513, 704, 706, 707
	Cache Slough	716	713, 715, 716	713, 715, 716
	Upper Sacramento River	711	708, 709, 710, 711, 717, 724, 72	711, 712, 725
South Delta	**Lower San Joaquin River**	520, 801, 804	802, 804, 806, 807, 808	520, 801, 804
	Near Franks Tract	809, 812, 815, 901, 902, 906	809, 810, 811, 812, 813, 814, 815, 902, 904, 905, 906	809, 812, 815, 902, 906
	East-Southeast Delta	910, 912	908, 909, 910, 911, 912	910, 912
	East-Central Delta	919	903, 919, 920, 921, 922, 923	919, 920, 921, 922, 923
Southeast Delta	**Southeast Delta**	914, 915, 918	913, 914, 915	914, 915

[1] Every station was not sampled during each survey date

[2] Density at Cache Slough was assumed to be the same as at Upper Sacramento River

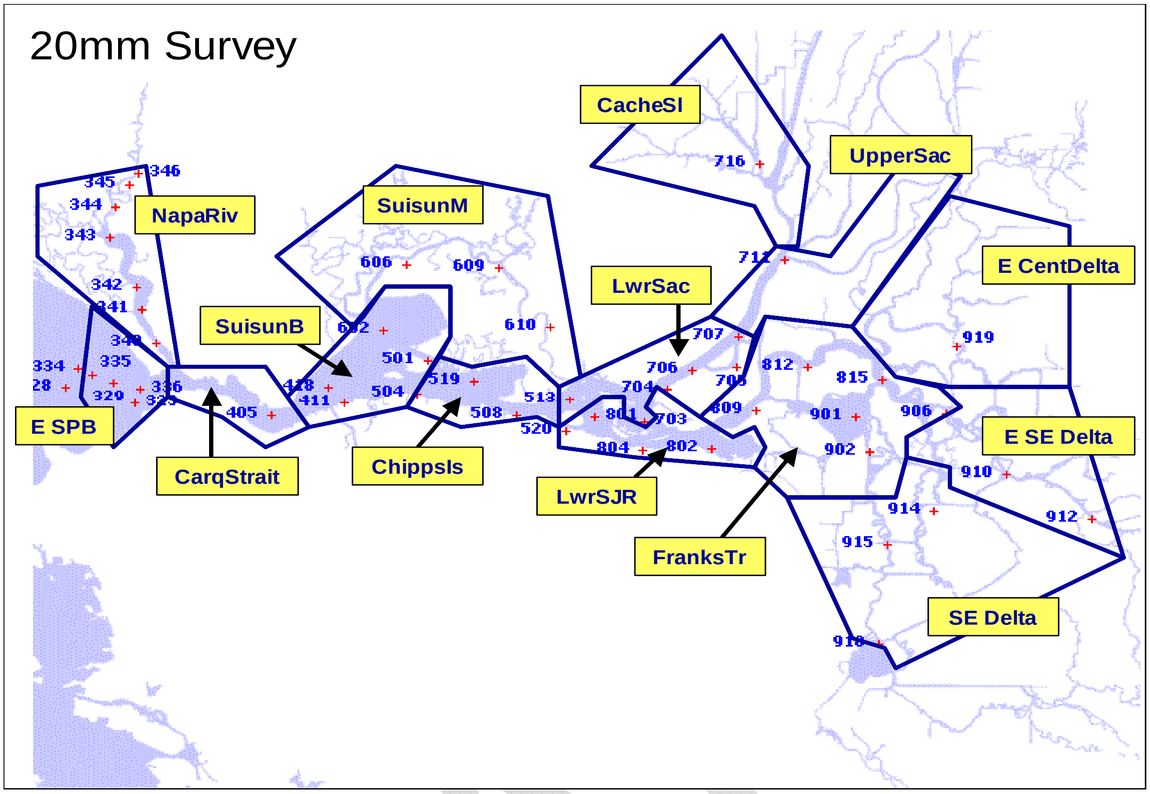


Figure A1. Sub-Regions Used for Abundance Calculations. 20mm survey station map used to illustrate regions for all surveys. ***(Map source: DFG 20mm website, http://www.delta.dfg.ca.gov/data/20mm/stations.asp)***

Table A2. Estimated Volume for 14 Regions of the Delta.[1]

Region	Full Depth Volume (m^3)
East San Pablo Bay	390,531,700
Napa River	59,440,550
Carquinez Strait	262,820,350
Suisun Bay	362,324,300
Suisun Marsh[2]	46,333,495
Chipps Island	125,562,450
Lower Sacramento River	187,942,300
Cache Slough	42,718,650
Upper Sacramento River	56,069,000
Lower San Joaquin River	132,873,650
Near Franks Tract	243,023,300
East-Southeast Delta	94,526,900
East-Central Delta	68,678,350
Southeast Delta	89,315,200
Total Volume	2,162,160,195

[1] Volumes are based on BJ Miller(unpublished)
[2] Suisun Marsh volumes only included Montezuma Slough, not smaller tributaries

The basic calculation steps for the abundance estimate require further steps to correct for sampling biases of the sampling nets. Since delta smelt and longfin smelt are similar in body shape (i.e. width to length proportion) and size, we applied net efficiency equations that were developed for delta smelt to longfin smelt abundance calculations. For the delta smelt net efficiency estimation, we collected available information about the mesh sizes of the survey nets and previous gear efficiency field studies. A summary of the net efficiency estimation procedure for each survey are described here.

MWT - A field study performed by DFG (Sweetnam and Stevens 1993) evaluated MWT net efficiency by placing a larger, finer mesh net outside of the standard MWT net to catch any fish passing through the standard net. Only results from the August 1991 experiment were evaluated, as the other experiment conducted in January 1992 collected few delta smelt. Catch values taken from published graphs were used to calculate the ratio of the standard net catch to the total catch. Resulting data showed a threshold point for retaining smelt at about 70mm. Hence, the net was assumed to be 100% efficient at retaining all delta smelt caught above a fork length of 70mm. Regression analysis was used to determine the best fit equation for net efficiencies for fork lengths below 70mm. A linear regression (Equation A1) had the best fit with a R^2 value of 0.67 and was selected for estimating the MWT net efficiency for delta smelt less than 70mm FL (Figure A2).

Equation A1   Net Efficiency = 0.0088 * Fork Length – 0.1422

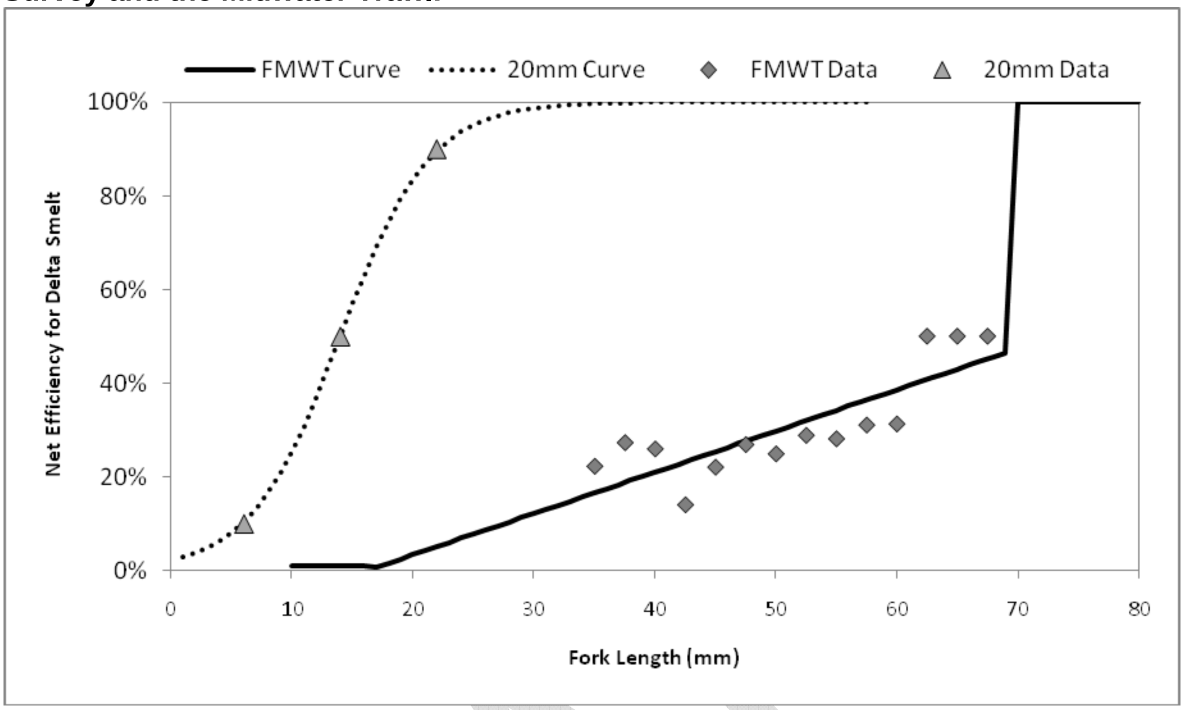
A second DFG field study was also performed in 2005 (unpublished). The second study also used a finer mesh outside net over the standard net. Since very few delta smelt were caught during the trawls, northern anchovies, which have a similar body shape and size, and were abundant, were used as a surrogate in the analysis for delta smelt net efficiencies. There was very little overlap in size of fish collected in the standard net catch versus the outside net catch, so no net efficiency curve could be generated. Still, the utility of this study was that it affirmed a threshold effect at about 70mm.

20mm Survey – Three data points were taken from an unpublished 20mm net efficiency graph[1] and a logistic equation was reconstructed from those points. The fitted logistic curve (Equation A2) was used for lengths up to 39 mm. For lengths 40 mm and greater, a gear efficiency of 100% was assumed (Figure A2).

Equation A2   Net Efficiency = (1 / (1 + EXP (-0.27 * (Fork Length – 14)))

[1] The unpublished graph is from one of the earlier drafts for Kimmerer (2008). The net efficiency curve in Kimmerer (2008) was updated from the draft efficiency curve. The update equation would have increased the 20mm longfin smelt abundance from levels in this report.

Figure A2. Regression relationships between net efficiency and fork length for the 20mm Survey and the Midwater Trawl.



Kodiak – No information was available to determine an efficiency curve or smelt size thresholds for the Kodiak trawl net, so no SKT efficiency was applied. The net was assumed 100% efficient.

Salvage by Life Stage Estimation

To estimate salvage by life stage, total daily salvage was divided into groups based on the measured lengths of longfin smelt. Since only a few salvaged longfin smelt were measured for length, the length data from 1993 to 2007 was pooled together and an average monthly life stage frequency was calculated. Life stage groups, based from data in Rosenfield and Baxter (2007), are defined here as 0-20mm for larvae, 20-59mm for juveniles, 60-89mm for subadults, 90-124mm for adults, and greater than 125mm for age2-adults. The monthly frequencies used to segregate daily salvage into life stage groups are listed in Tables A3 and A4.

Table A3. Monthly Life Stage Frequencies Averaged over 1993-2007 for SWP

	Larvae	Juvenile	Subadult	Adult	Age2Adult
January	0%	0%	53.57%	42.86%	3.57%
February	0%	0%	40%	60%	0%
March	0%	100%	0%	0%	0%
April	0%	100%	0%	0%	0%
May	0%	100%	0%	0%	0%
June	0%	100%	0%	0%	0%
July	0%	33.33%	66.67%	0%	0%
August	0%	0%	100%	0%	0%
September[1]	0%	0%	100%	0%	0%
October	0%	0%	100%	0%	0%
November[1]	0%	25%	50%	25%	0%
December	0%	50%	0%	50%	0%

[1] Although 41 fish were counted in salvage, no fish were measured for length, so the life stage frequency was estimated using the frequency of the previous and subsequent months.

Table A4. Monthly Life Stage Frequencies Averaged over 1993-2007 for CVP

	Larvae	Juvenile	Subadult	Adult	Age2Adult
January	0%	0%	46.15%	46.15%	7.69%
February	0%	0%	100%	0%	0%
March	2.22%	93.33%	4.44%	0%	0%
April	0%	99.88%	0.12%	0%	0%
May	0%	100%	0%	0%	0%
June	0%	100%	0%	0%	0%
July[2]					
August	0%	100%	0%	0%	0%
September[2]					
October[2]					
November[2]					
December	0%	25%	25%	25%	25%

[2] No fish were salvaged in the months of July, September, October, or November, so no life stage frequency needed.

References

Kimmerer, W. 2008. Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science [Internet]. 6(2). http://repositories.cdlib.org/jmie/sfews/vol6/iss2/art2/

Rosenfield and Baxter. 2007. Population Dynamics and Distribution Patterns of Longfin Smelt in the San Francisco Estuary. Transactions of the American Fisheries Society **136**: 1557-1592.

Sweetnam and Stevens 1993. A status of the delta smelt (*Hypomesus transpacificus*) in California. Report to the Fish and Game Commission. Candidate Species Report 93-DS. 98 pp.