Status of Species

Delta Smelt

There is a high level of concern for Delta Smelt due to the effects of sustained drought in California now entering a fourth consecutive year. The population may presently be at its lowest level of abundance ever recorded (Figure 1). The 2014 CDFW Fall Midwater Trawl (FMWT) Survey Index was 9, which is a new historic low and about half the second and third lowest values of 17 and 18 recorded in 2009 and 2013, respectively. A special Spring Kodiak Trawl survey that was completed in the third week of December to assess the distribution of adult Delta Smelt found that most fish were located in the Sacramento River near Decker Island (Figure 2), but the January SKT survey observed a more typical dry year distribution ranging from Montezuma Slough to the Sacramento shipping channel (Figure 13). SmeltCam and trawl surveys in the north Delta have observed a zero presence of Delta Smelt in the Cache Slough / Liberty Island complex, a location that in previous years has been considered a spatial refuge. This has shifted the centroid of the population distribution south, making the condition of and risks to the Delta Smelt in the lower Sacramento River and San Joaquin River of greater importance to the overall status of the species. Delta Smelt captured in trawl surveys during 2014 were reported at the Smelt Working Group meetings to have been in relatively poor condition and of smaller size than in previous years, which indicates a potential for lower fecundity and survival of offspring in 2015. Early warning Kodiak Trawl surveys at Jersey Point and Prisoner's Point in the lower San Joaquin River began on December 1, 2014 at a daily sampling rate through January 5th, 2015, followed thereafter by weekly sampling. Delta Smelt were regularly caught at Jersey Point and spikes in catch were closely correlated with highly turbid flow events out of the Sacramento River. In contrast, catches at Prisoner's Point tended to be low, but consistent once the presence of Delta Smelt was established at this location. A relative increase in Delta Smelt presence at Prisoner's Point, in particular, during the last week of December followed a spike in turbidity associated with the first and thus far, only large storms of the season. This set of storms is thought to have stimulated a pre-spawning migration of Delta Smelt that has expanded the population west and east of its centroid. As of January 27th, an expanded total of 56 Delta Smelt have been observed in salvage (52 at the Tracy Fish Collection Facility; 4 at the Skinner Collection Facility). Salvage efficiency has probably been compromised by the accumulation of water hyacinth in Old River and related debris accumulation at the state and federal pumping facilities, resulting in shorter count intervals, challenging fish count conditions, and reduced screen efficiency; and thus the possibility of greater uncertainty regarding estimated loss due to facility entrainment. Considered together, these distributional and operational observations suggest that a greater proportion of the population may be at risk of entrainment than has been assumed based on salvage alone at the facilities.

The proposed action will take place in February and March 2015. If the drought persists, water temperatures are expected to rise, which historically raises water temperature to a range suitable for spawning earlier in the year. Given the pre-spawning movement associated with the December storms and subsequent movement into the central and south Delta in early January, there is a strong likelihood that some Delta Smelt will have started spawning in February; spent female Delta Smelt have been observed during February Spring Kodiak Trawl Surveys (SKTS) in 2003, 2005, and 2012. Thus, adults and eggs are the two life stages expected to be exposed to the proposed action. This year, the onset of salvage corresponded to elevated catch at the Prisoner's Point Early Warning Survey location on the same day, following a series of days with high wind conditions that increased turbidity in the central and south Delta. Delta Smelt often move during "first flush" periods when inflow and turbidity increase on the Sacramento and San Joaquin Rivers (Grimaldo et al. 2009, Sommer et al. 2011). The Smelt Working Group expects that Delta Smelt will remain in the central and south Delta in preparation for spawning as long as conditions remain turbid (~ 10 ntu) during February and March (Smelt Working Group notes, January 5, 2015). Continued minimal reservoir releases allowed through the proposed modification to the NDOI are expected to cause the centroid of the Delta Smelt population that is associated with the 2 ppt isohaline to shift inland, exposing a greater proportion of the population to entrainment if distribution does not shift back into the Sacramento River and its shipping channel in response to lower outflow and higher water transparency.

Longfin Smelt

Longfin Smelt experienced reduced recruitment from the 2014 spawning, as evidenced by their 2014 Fall Mid Water Trawl (FMWT) index being the second lowest on record (Figure 6). While the fish reproducing in the winter of 2015 are mostly from the 2013 spawning, the low recruitment in 2014 indicates that 2015 may also see low recruitment if conditions remain dry and outflow is low. The results from the December 2014 Bay Study trawls indicate that Longfin Smelt continued to occur at relatively low population densities throughout the estuary at the start of winter (Figure 7, Figure 8). In Bay Study trawls conducted during the week of January 5-9, 2015, the majority of adult Longfin Smelt were detected in Suisun Bay, the Confluence area, and the lower Sacramento River, with overall catches remaining low (from Randy Baxter, CDFW, sent to Smelt Working Group on 1/12/2015). In Spring Kodiak Trawl #1, conducted during the week of 1/12/15, adult Longfin Smelt were detected only in areas downstream of the confluence (presented to the SWG on 1/20/15). The reduced catches in these surveys indicates that the spawning stock of Longfin Smelt in 2015 is at low abundance. As of 1/27/2015, no Longfin Smelt salvage has been detected at either the CVP or SWP fish facilities. Over the past few years (WY2012-WY2014), the majority of Longfin Smelt salvage does not typically occur until February or March when young of year Longfin begin showing up at the export facilities (WY2014 salvage, Figure 9).

The most recent fish surveys indicate that Longfin Smelt have begun spawning in the lower San Joaquin River and elsewhere in the Delta. On January 6, 2015, FWS "Early Warning" sampling collected two ripe adult Longfin Smelt in trawls at Jersey Point. The first Smelt Larval Survey (SLS), conducted during the week of 1/5/2015, collected one larval Longfin (6mm) at station 809 (Jersey Point) and two larvae (6mm) at station 723 (Sacramento Deep Water Ship Channel), and the remainder of the catch was downstream between the confluence and Suisun Bay (Figure 10). The second SLS, from the week of 1/20/2015, detected Longfin Smelt larvae at Jersey Point (809, n=3) and at station 906 further upstream on the San Joaquin River (n=1). Sample processing is ongoing for this survey, but based on results from previous year's SLS trawls, the start of spawning in 2015 is reduced or delayed as densities of larvae are much lower than expected. For example, 2014's SLS #1 detected robust densities of larval Longfin Smelt, up to five times those detected in the 2015 SLS #1, across much of the western Delta and well into the Sacramento and San Joaquin Rivers (Figure 11). This reduced or delayed spawning may increase risks to 2015 cohort for Longfin Smelt affected bycontinued low outflow and dry conditions.

Proposed Action

See "Central Valley Project and State Water Project Drought Contingency Plan, January 15, 2015 - September 30, 2015" as submitted to the State Water Resources Control Board on January 15, 2015.

Analytical Framework

Methods and Metrics

To assess the additional risk to each smelt species imposed by the proposed actions, potential exposure of adults, larvae, and juveniles to environmental conditions resulting from the actions was evaluated based on the current and expected geographic distributions of key life stages (larvae, juvenile, adult) and species abundance trends (together comprising "status of species"), and on existing conceptual models for each species' life cycle and behavioral responses to environmental conditions. For Delta Smelt we used the IEP POD conceptual model. For Longfin Smelt we used conceptual models described in the "IEP 2010 Pelagic Organism Decline Work Plan and Synthesis of Results" (IEP 2010), and the California Department of Fish and Game (CDFG) analysis of "State Water Project effects on longfin smelt" (CDFG 2009). In addition to the empirical evidence supplied by fish surveys, the DSM2 particle tracking model was used to estimate entrainment risk for larval smelt under several operational and regulatory scenarios (Culberson et al. 2004; Kimmerer and Nobriga 2008; Kimmerer 2008).

Several monitoring surveys provided information on the species' geographic distributions and abundance trends. For the purposes of this evaluation, the most relevant survey for current distributions of adults and expected distributions of larvae was the Spring Kodiak Trawl. Additional distribution information was provided by the Bay Study Trawl and Fall Midwater Trawl surveys, and by salvage at the export facilities. Although the Biological Opinion for Delta Smelt and the 2081 permit for Longfin Smelt calculate endangered species take levels from an abundance index based on the Fall Midwater Trawl, we also considered abundance trends in the other monitoring surveys to assess population status. Like the SKT, these surveys regularly sample fixed stations throughout the San Francisco Estuary and together serve as consistent indicators of both seasonal and annual trends in the abundance and distribution of both smelt species. The SKT survey also assesses the condition of adults, including size, weight, and spawning stage (pre spawn, gravid, post spawn). Real-time developmental and geographic distribution assessments of larvae and juvenile smelt are typically based on the Smelt Larval Survey beginning in January and 20 mm trawl beginning in March, with additional information provided by samples taken at the salvage facilities beginning in April or May. However, as of this assessment, the majority of longfin smelt larvae may not have hatched and Delta Smelt have not yet started spawning. Therefore expected larval and juvenile distributions were based on the conceptual models given current distributions of spawning adults and expected environmental conditions resulting from the drought and the proposed actions (e.g. OMR, outflow, X2). Detailed descriptions of these surveys, as well as updated survey data, are available at the "Studies and Surveys" website maintained by California Department of Fish and Wildlife (http://www.dfg.ca.gov/delta/data/).

For the purposes of this assessment, particle "entrainment" was assessed for the operational and regulatory conditions described in the proposed action. Although the DSM2 particle tracking model does not currently incorporate a behavioral component, particles are considered dependable proxies for the relative effect of hydrological conditions on early-stage larval movement because larvae are weak swimmers and are only minimally capable of selectively maintaining a position in the water column (i.e. they tend to behave a lot like neutrally buoyant particles; see Kimmerer 2008 for evidence this is true for larval delta smelt). The estimation of larval Longfin Smelt entrainment used information from a 2009 particle tracking study that incorporated observational information on the geographical distribution of Longfin Smelt spawning sites in low outflow years, and used surface orientation of particles to more explicitly imitate the surface orientation of Longfin Smelt larvae (CDFG 2009).

Assumptions and Methods

Table 1 below summarizes the assumptions and methods that were utilized in the Biological Review.

Table 1. Summary of assumptions and citations where they originated.

Attribute	Delta Smelt	Longfin Smelt	Citation(s)
Peak adult salvage	December-March	December-January	Grimaldo et al. (2009; Fig. 5)
Statistical tool for predicting changes in adult salvage	Grimaldo et al. (2009; Table 3)	Grimaldo et al. (2009; Table 3)	Grimaldo et al. (2009; Table 3)
Spawning temperatures (typical spawning months)	12°-20° C (March-May)	7°-14.5° C (December-March)	Bennett (2005); Moyle (2002)
Anticipated initial hatch distributions of larvae	1991-1994 hatch distribution	1991-1994 hatch distribution	SWG notes; Baxter (2009)
Larval entrainment	PTM weighted by initial distribution assumption(s)	PTM weighted by initial distribution assumption(s)	Kimmerer (2008); CDFW (2009)
Effect of proposed change in Delta outflow[1]	IEP (2015; Fig. 82)		MAST report

[1]These studies used X2 or outflow averaging periods that included February-March, but were not limited to these two months.

Particle Tracking Model Results

Old and Middle River (OMR) flows will have a different impact on the likelihood of entrainment in February than in March because March represents the end of the spawning window and therefore a larger proportion of the population is likely to spawn in February. Therefore a smaller proportion of breeding adults are likely to spawn in the entrainment zone in March where their offspring will recruit into vulnerable habitat.

The percentage of particle fates at various outflow locations in the Delta is summarized in Table 2. Particle flux past Montezuma Slough and Chipps was positive in all NDOI / OMR scenarios, with the highest percent of particles originating from station 707 and 809, which are closer to the confluence of the Sacramento and San Joaquin rivers than station 815. Particles seeded at Jersey Point flowed east at NDOI 7100 and 11400 cfs, but flowed west at NDOI 4000 cfs. For station 815, particles in all scenarios tended to flow into Franks tract. At Holland cut, particles experienced negative flux in all outflow scenarios, suggesting that particles that get into the south Delta remain there. Few particles from station 707 and 809 were observed near Old River near Frank's tract and Middle River, but station 815 had a high percentage of particles flux at those locations in all scenarios.

At an NDOI of 4000 cfs, the fate of most of the particles could not be determined after 60 days and likely resided in the vicinity where they were injected. However, given an unweighted initial distribution in all outflow scenarios with an NDOI of 7100 or above, particles seeded at Prisoner's Point had greater than 70% likelihood to be entrained at the state and federal pumping facilities within 60 days regardless of the modeled OMR value. Particles seeded at Jersey Point had a 25% chance of entrainment at an NDOI of 7100 cfs (Figure 14a). Less than 10% of particles originating from the Sacramento River at Decker Island were likely to be entrained in the facilities. However, when particle distributions were weighted using 1991-1994 hatch distributions that encompass 3 dry years and 1 wet year (Baxter, 2009), the relative proportion of particles from Prisoner's Point (station 815) fell below the proportion entrained from Jersey Point (station 809) under high OMR (-5000 cfs) and outflow scenarios (7100 and 11400 cfs). At an NDOI of 5500 proportional entrainment was relatively low and appeared to correlate with proximity to the south Delta, while very few particles had a known fate at 4000 cfs NDOI with a corresponding OMR flow of -1500 cfs.

Effects Analysis

Contextualizing Outflow under the Proposed Action

Including 2014, there have been a total of 13 water years with a critical designation since 1929. Mean February outflow in these critical water years has ranged from a high of 27,223 cfs in 1934 to a low of 3,007 cfs in 1977. The Net Delta Outflow Index (NDOI) of the proposed action of no less than 4000 cfs) and the D-1641 standard (7,100 cfs) all more closely resemble the drought years of 1976, 1977, 1988, 1990 and 1991 than the other years in the record (Figure 5).

Adult and Larval Delta Smelt Entrainment

With the Delta Cross Channel (DCC) gates closed, it is expected that adult Delta Smelt entrainment will be very low and will stay well under the established ITL if NDOI is between 4000 and 5500 cfs and pumping remains at 1500 cfs. However, under turbid conditions, if pumping increases on the ascending limb of the hydrograph in response to increased NDOI between 5500 and 7100 cfs, particle tracking model results indicate that if Delta Smelt are east of Franks Tract, upwards of 70% of adults are at risk of entrainment after 60 days as the population redistributes in response to increased flows (Appendix 1).

To better understand how differences in particle entrainment risk overlapped with expected distributions of larval smelt, particle entrainment rates (% total particles entrained among all three release locations) were weighted by the proportional distribution of expected hatch between those locations (i.e. proportional entrainment was multiplied by proportional hatch for each site). For Delta Smelt, expected hatch distribution was estimated from the adult distributions based on recent surveys. The latest Spring Kodiak Trawl survey was used to compare catch per trawl of Delta Smelt between Decker Island (we used catch at station 706 as the closest approximation of station 711 used in the PTM) and Jersey point (station 809), which was a 1:1 ratio. We then used the latest two weeks of early warning surveys to compare Prisoner Point (station 815) catch per trawl to Jersey Point catch per trawl; the ratio for January 5th to 6th and January 13th to 12th for these two stations was 0.2 and 0.25, averaging 0.225. The catch ratio between all three stations, 706, 809, 811 was 1:1:0.225. Therefore the Delta Smelt hatch proportional distribution weights used for these stations in the PTM were 0.45, 0.45, and 0.10.

Delta Smelt Spawning

Water temperature drives the timing of Delta Smelt spawning. Delta outflow in the proposed action will not modify Delta water temperatures, which are principally driven by ambient air temperature (Wagner et al. 2011). However, Delta water temperatures are likely to warm early in 2015, given recent climatic conditions. It is likely that many delta smelt that spawn in February during the proposed action timeframe could survive 1-2 additional months and spawn again should water temperatures remain suitable into April.

Delta Smelt Habitat & Food Supply

The small size and poor condition of adult Delta Smelt sampled in early warning surveys (and presumably low fecundity) is likely a reflection of poor food supplies and constrained habitat suitability (Feyrer, et al. 2011) due to the prolonged drought. On-going drought will subject the 2015 year-class and future year-classes to on-going poor habitat conditions.

Delta Smelt Population Growth Rate

The 2011 FMWT index (343) was the greatest value in many years. Due to multiple years of drought, the index has declined to a record low index of 9 in 2014 (Figure 1). Such a pattern highlights the fact that Delta Smelt are an annual species that has endured extended droughts and can rebound quickly when wet hydrology provides favorable recruitment conditions. The outflow-recruitment relationship shown in Figure 12 is from a preliminary analysis in the recently released MAST report (IEP 2015). The plot indicates that since 2003, springtime flow conditions have had a positive influence on the number of larval delta smelt produced per adult. The relationship is based on a continuous function, so more flow is predicted to be incrementally better, and less flow is predicted to be incrementally worse, for initial reproductive success. The proposed action is to modify the NDOI standard during February and March from a minimum of 7100 cfs to 4000 cfs presuming continued drought hydrology.

Using the above preliminary regression analysis presented in the MAST report, reducing outflow from 7100 to 4000 cfs predicts a negative effect on larval production. Specifically, if the baseline assumption is that outflow will be 7100 cfs, the predicted spring 20 mm survey to FMWT ratio is 0.048. Given that we know that the FMWT index is 9, the predicted 20 mm survey index would be 0.43, which is lower than the lowest on record (1 in 2007 or 1.1 in 2014). If NDOI is reduced to 4000 cfs, the corresponding spring predicted 20 mm to FMWT ratio would be 0.03, and the 20 mm index would be 0.29, which is 33% lower than the baseline expectation at 7100 cfs. Certainly, because the MAST report calls for more sophisticated life cycle modeling and publication in a peer review journal, to draw firm conclusions these larval abundance calculations are at best preliminary; the calculations simply provide context for possible species population growth rate information during this multi-year drought. An adult spawning stock that may be at a historical low is predicted to have a negative impact on larval production, but it is likely that the proposed outflow change would produce predictions with confidence intervals that overlap the predictions based on the D-1641 baseline 7100 cfs condition. Delta Smelt are experiencing environmental conditions in the baseline that are poor for larval Delta Smelt recruitment, and therefore, based on the precautionary principle, the proposed outflow reduction is expected to have a further impact.

There is an inherent difficulty trying to manage environmental conditions for an annual fish because every season is a potential bottleneck. Thus, a hot summer could undo any benefit of maintaining D-1641 outflow levels (e.g. 20mm indices may not be closely correlated with FMWT indices) due to important influences of summer and fall conditions on the latter.

Given the FMWT abundance index and predicted recruitment, it is likely that the population will continue to decline in 2015. The multi-year drought has degraded habitat conditions for Delta Smelt. With the anticipated negative population growth rate, continued drought, and future drought response actions, a population effect is expected even with improved hydrology. If there is a significant rain event, adults are likely to redistribute, making them vulnerable to flows drawn down from the Sacramento River into the San Joaquin River. If this happens in February, a larger proportion of the population is likely to redistribute than if this happens in March, which is towards the end of the spawning window.

Adult Longfin Smelt Entrainment

Reductions in reservoir releases in response to relaxed salinity control standards are expected to further shift the centroid of the Longfin Smelt population inland. This shift is likely to expose a greater proportion of the adult population to entrainment. Given their current distribution and continued upstream movement past Chipps Island in January, the proposed action may result in salvage of adult Longfin Smelt located within the lower San Joaquin.

Larval Longfin Smelt Entrainment

During the period of the proposed action (Feb-March), the primary consideration regarding the Longfin Smelt population is for entrainment risk of age-0 fish (larvae and juveniles). Based on current Longfin Smelt distributions, a reduction in outflow may result in an elevated risk of entrainment of larvae and juveniles distributed in the central and south Delta during the effected periods. The detection of larva in the San Joaquin River, particularly at more upstream stations (i.e. 906), suggests salvage of larval LFS is likely. In addition, reduced outflow is expected to negatively affect survival of juveniles to age-1 because February through June X2 has been strongly and consistently associated with Longfin Smelt recruitment into this age class (Jassby et al. 1995, Kimmerer 2002, McNally et al. 2010). However, detection of larval Longfin Smelt in the Cache Slough Complex and the current distribution of adults indicate that the larval population is likely to be widely dispersed during the action period. Therefore operations are not expected to affect the species population as heavily as may be the case with Delta Smelt unless a greater percentage of the population migrates into the lower San Joaquin River.

Due to the low efficiency of the Spring Kodiak Trawl for Longfin Smelt, Longfin Smelt hatch was estimated using larval catch distributions from the Smelt Larval Survey. For comparison, three different sets of years were used to estimate catch. Following the approach described in CDFG (2009), catch was compared between stations 706, 809, and 815, combining catch for years 1991-1994, which included 3 low outflow years. Also following CDFG (2009), another set was comprised of only 2005, representing a post-POD year. Finally, we compared relative larval catch between these stations for the last two years combined, as the closest representation of hatch distribution under current drought conditions (Figures 15a-c).

Summary of Proposed Action's Effects

Water year 2015 is unique in that there is no evidence of a sub-population in the Cache Slough Complex and Sacramento Shipping Channel (Feyrer, pers. comm.). Both December FMWT and January SKT surveys have yielded the lowest abundance indices on record. Extreme drought conditions are well known to stress the aquatic resources of the San Francisco estuary and its watershed. Thus, the present drought condition will stress the Delta Smelt and Longfin Smelt populations. However, the available data are insufficient to isolate the effects of reduced outflow for a single month during a drought on the Smelt populations. Thus, although the proposed action is likely to have a negative impact on these populations, the ability to quantitatively estimate the incremental effect of February-March outflow under the proposed action is limited.

Unlike 2014, Delta Smelt have been salvaged this water year at the South Delta fish facilities. This was expected due to the high turbidity observed throughout the central and southern Delta resulting from elevated outflow from the Sacramento River following December storms and high wind events in early January. Yet, December and January SKT surveys in 2015 showed that the majority of Delta Smelt were distributed around Decker Island and confluence region (Figure 2 & 13). Adult Delta Smelt are unlikely to shift their distribution towards the south Delta unless another rain event occurs and turbidity is dispersed again into the southern Delta. As long as the proposed operations do not draw Delta Smelt into the San Joaquin River in the vicinity of Prisoner's Point, it is highly unlikely that Delta Smelt distribution will change in a way that increases their entrainment risk. Entrainment risk of adult Longfin Smelt is likely to be low unless their distribution narrows and shifts further into the interior and South Delta.

The status of Delta Smelt and Longfin Smelt will be closely monitored during the proposed action. Key oversight groups (e.g. Smelt Working Group; WOMT; Delta Conditions Team) will continue to evaluate conditions on a weekly basis, or more frequently if necessary. Under the proposed modified operations, the IEP will continue to monitor abundance and distribution of Delta Smelt using SmeltCAM, a promising new monitoring tool with multiple applications (e.g. take reduction, habitat assessments).

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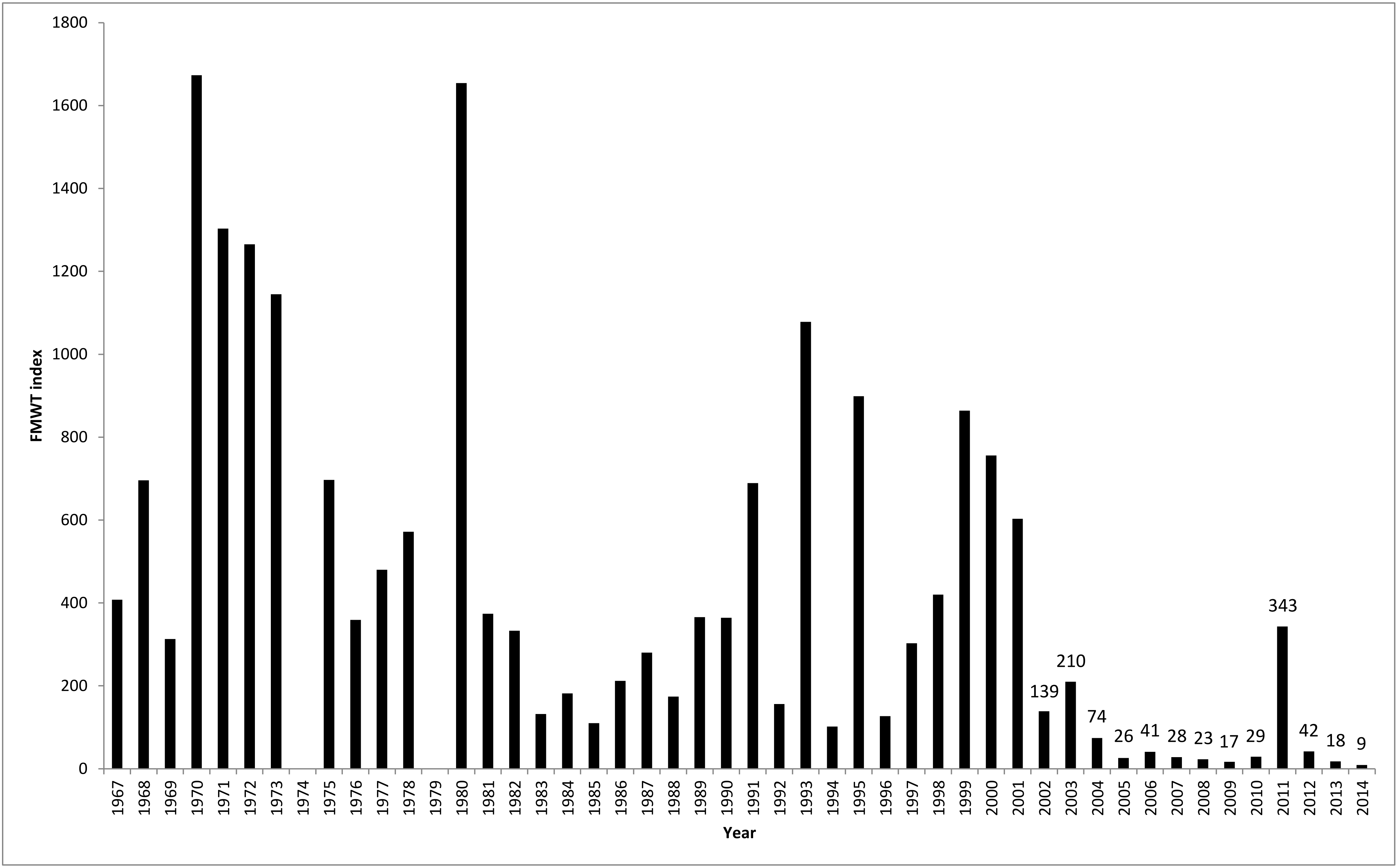


Figure 1. Fall Midwater trawl Delta Smelt indices from 1967-2014. No indices were calculated for 1974 and 1979.

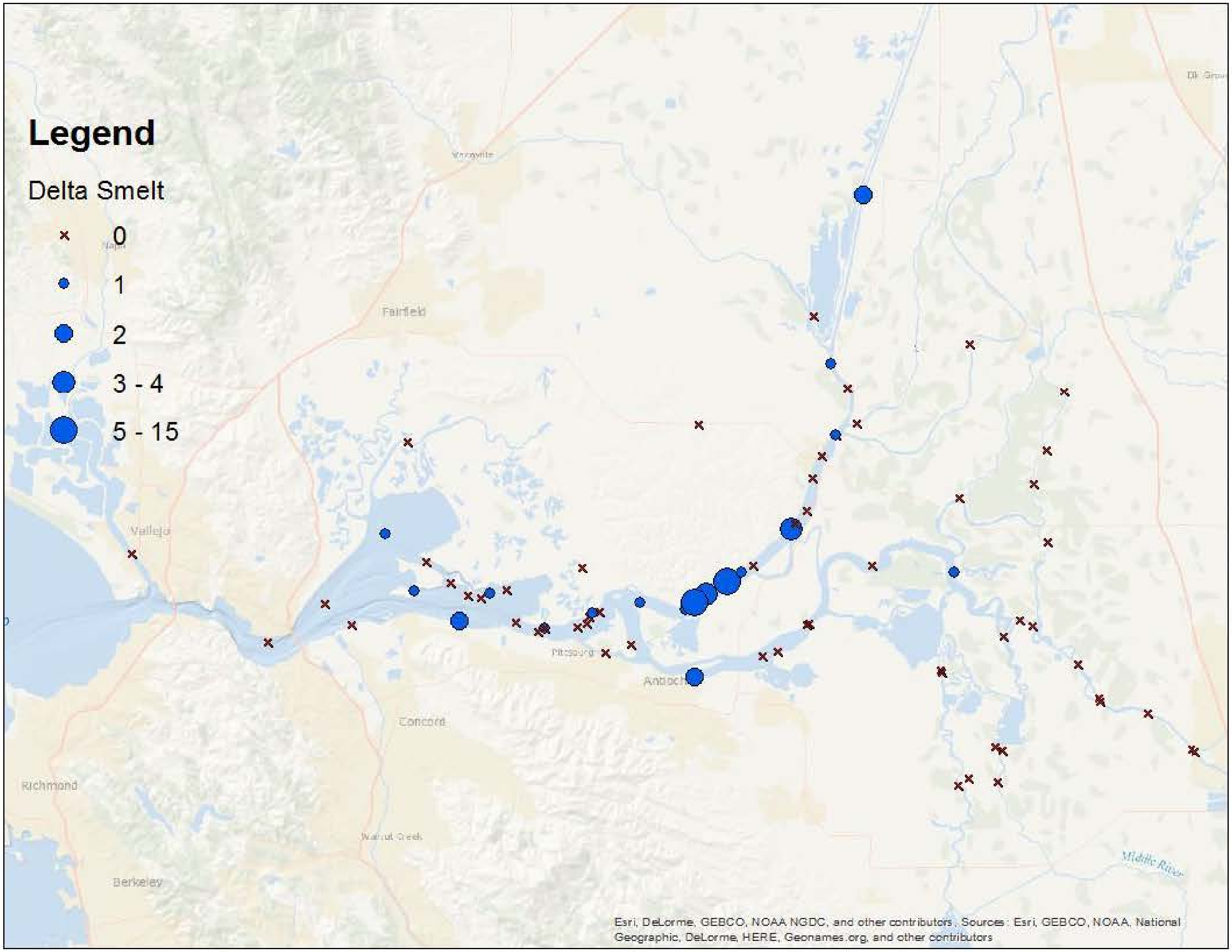


Figure 2. December 2014 Spring Kodiak Trawl (SKT) drought monitoring of Delta Smelt distribution from the Fall Midwater Trawl shadow survey and from the supplemental SKT survey.

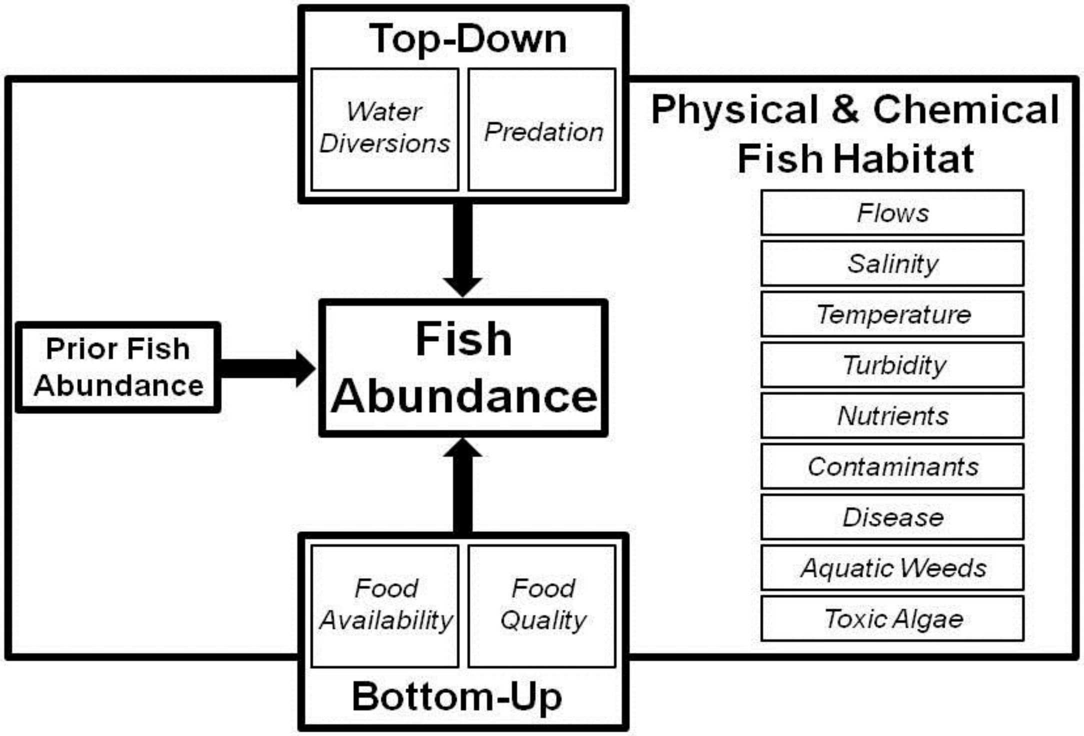


Figure 3. The basic IEP conceptual model for the pelagic organism decline.

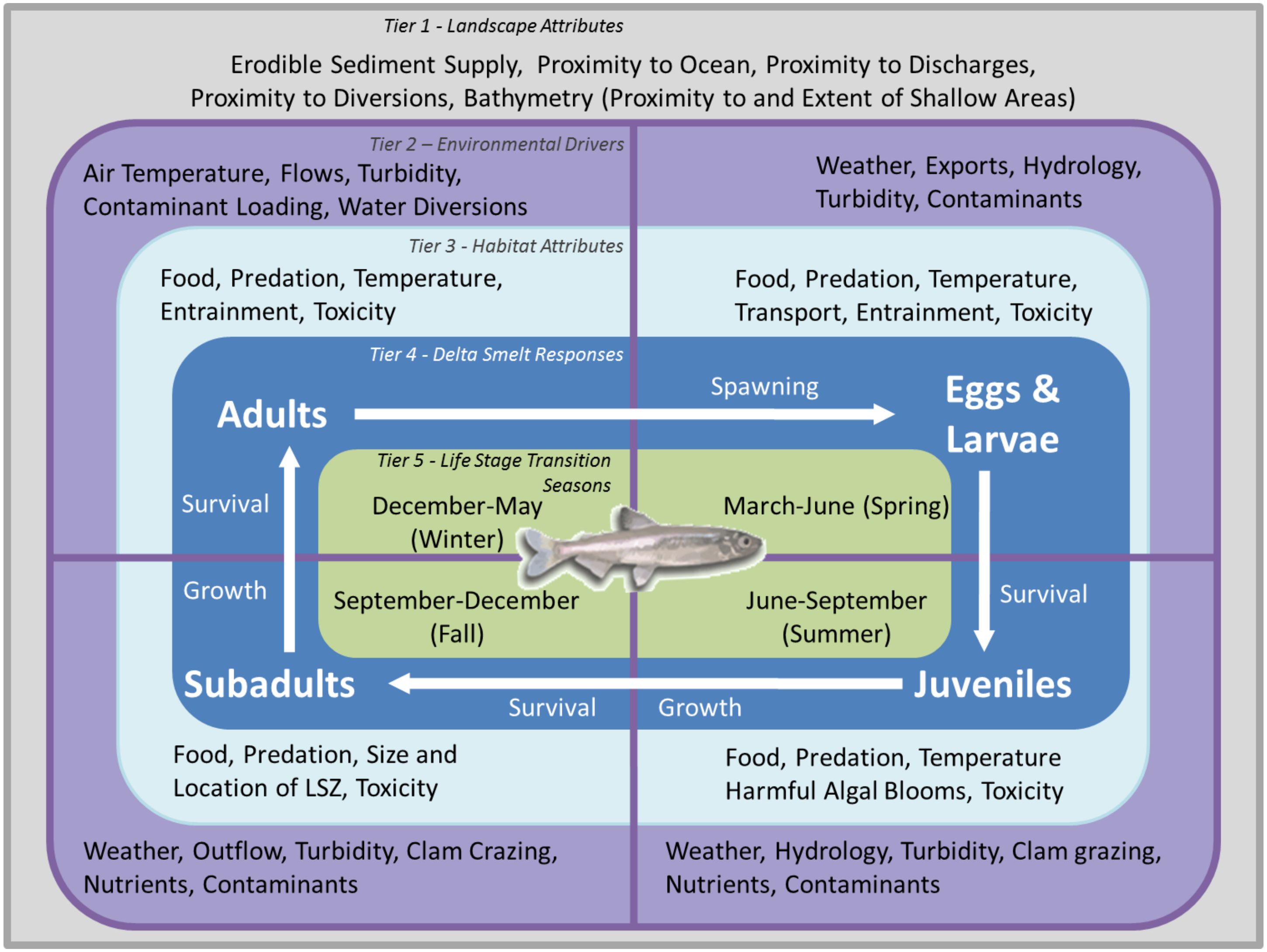


Figure 4. A new conceptual model for Delta Smelt showing Delta Smelt responses (dark blue box) to habitat attributes (light blue box), which are influenced by environmental drivers (purple box) in four “life stage seasons” (green box). Adapted from the MAST report (2015).

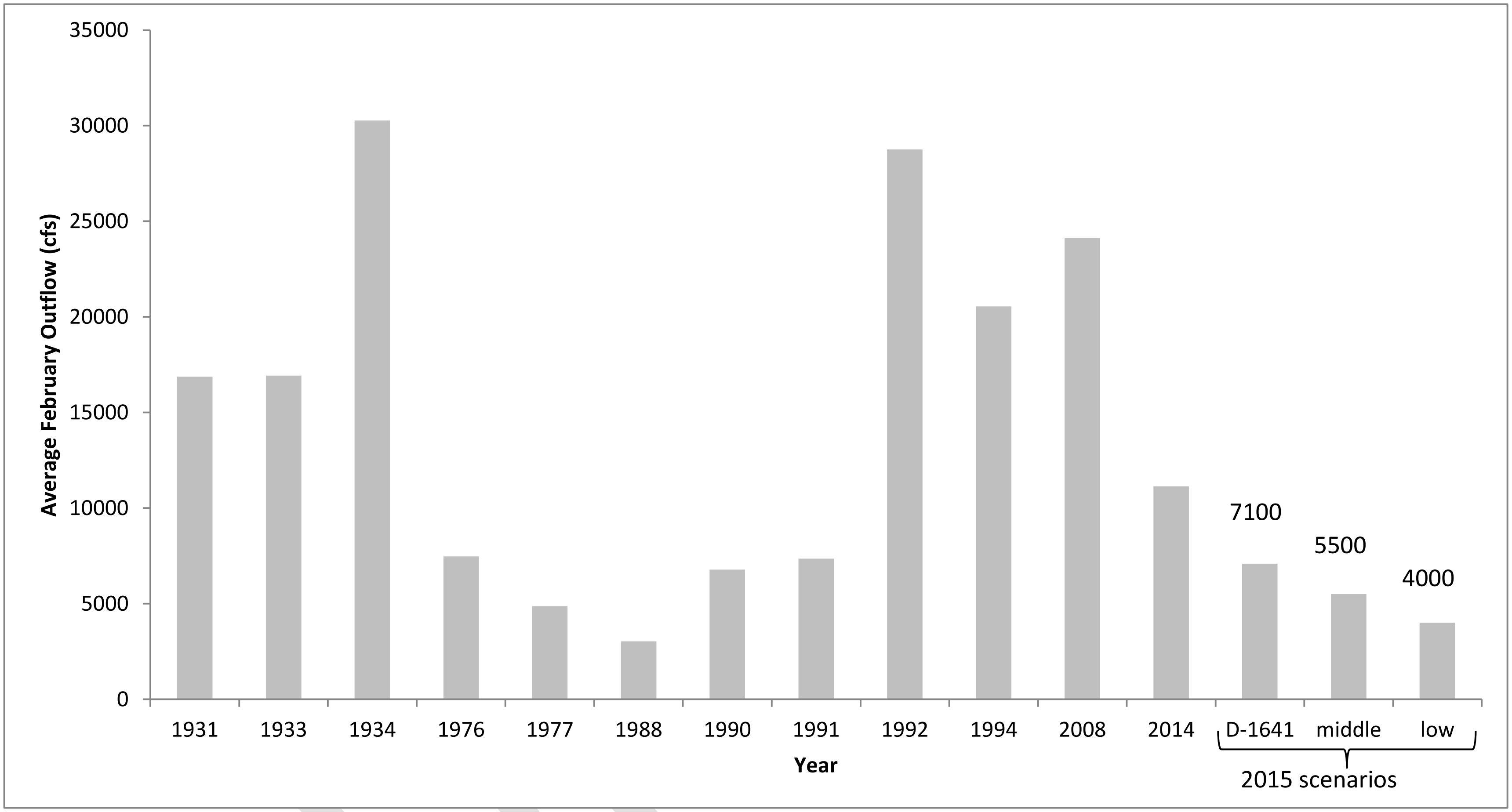


Figure 5. Mean February Delta outflow for critically dry water years 1931-2014, including February outflow scenarios for 2015.

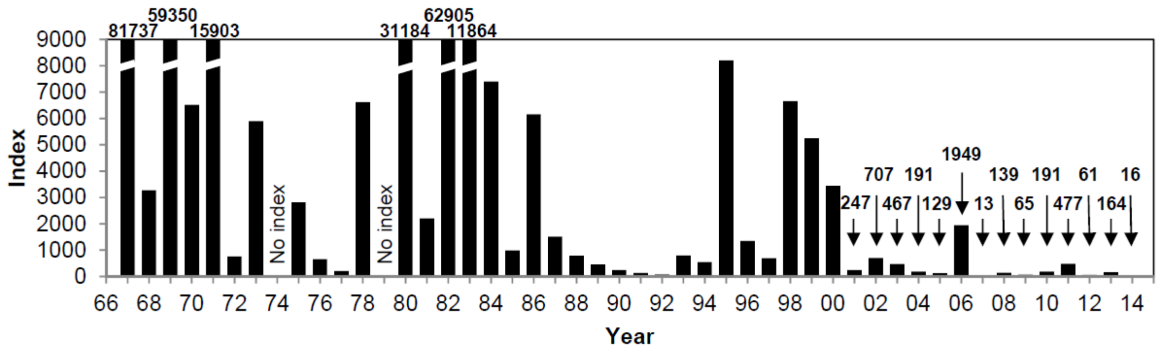


Figure 6: 2014 FMWT index for Longfin Smelt was 16, the second lowest in history. Copied from the DFW Fall Midwater Trawl 2014 Annual Fish Abundance Summary memo dated January 7, 2015. No indices were calculated for 1974 and 1979.

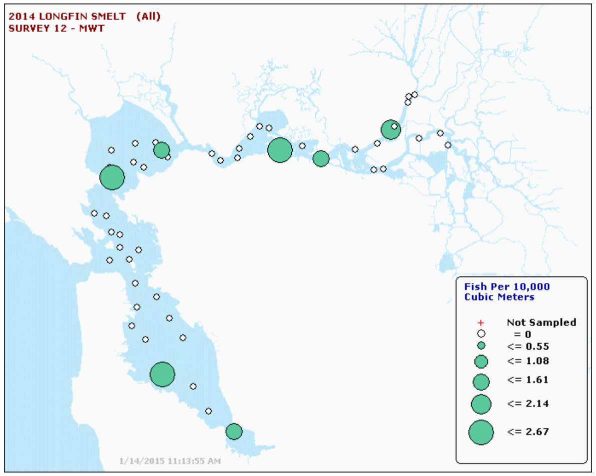


Figure 7: Longfin distribution in the Bay Study mid-water trawl from December 2014. Retrieved from http://www.dfg.ca.gov/delta/data/BayStudy/CPUE_Map.asp on 1/14/2015.

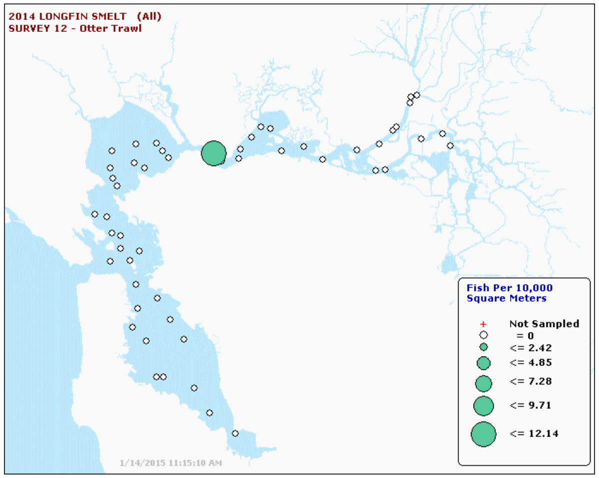


Figure 8: Longfin distribution in the Bay Study otter trawl from December 2014. Retrieved from http://www.dfg.ca.gov/delta/data/BayStudy/CPUE_Map.asp on 1/14/2015.

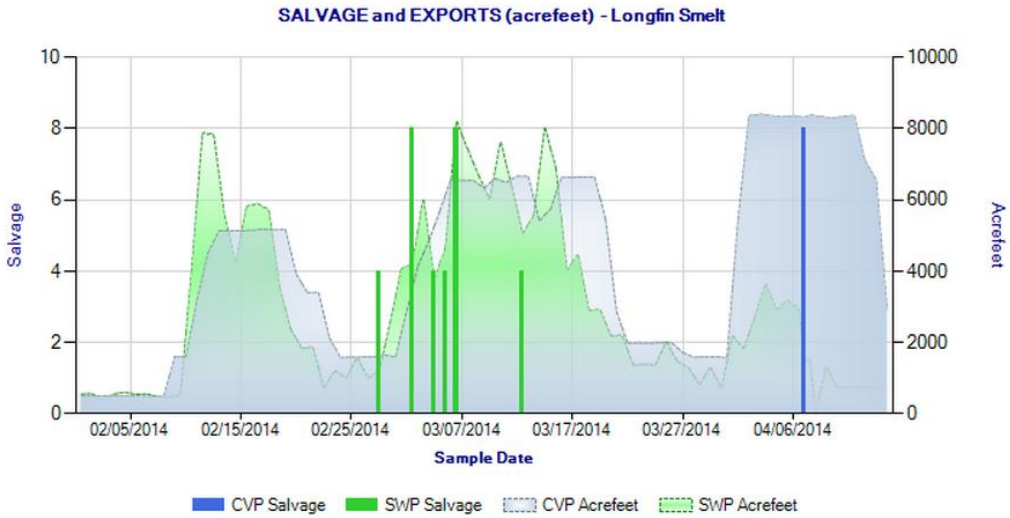


Figure 9: Longfin Smelt salvage in WY2014. Retrieved from http://www.dfg.ca.gov/delta/apps/salvage/Default.aspx on 1/14/2015.

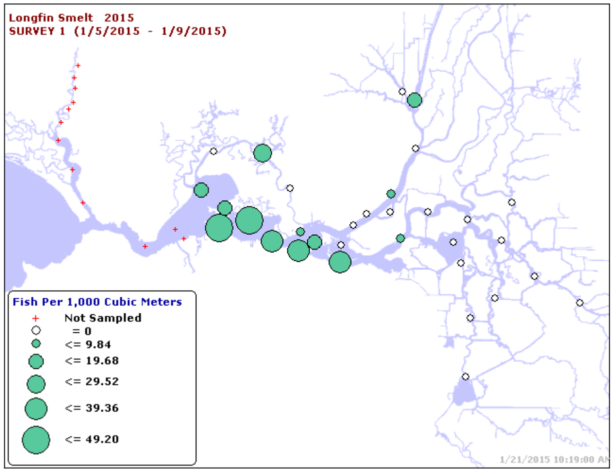


Figure 10: Smelt Larval Survey 1 from 2015. Distribution of larval Longfin Smelt during the period of 1/5/2015 – 1/9/2015. Retrieved from http://www.dfg.ca.gov/delta/data/sls/CPUE_map.asp on 1/21/2015.

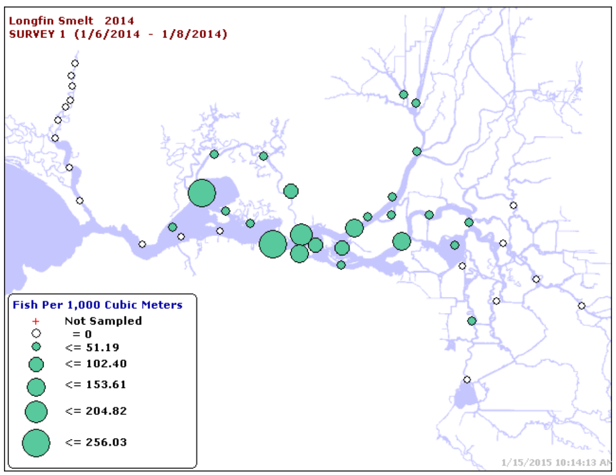


Figure 11: Smelt Larval Survey 1 from 2014. Distribution of larval Longfin Smelt during the period of 1/6/2014 – 1/8/2014. Retrieved from http://www.dfg.ca.gov/delta/data/sls/CPUE_Map.asp on 1/15/2015.

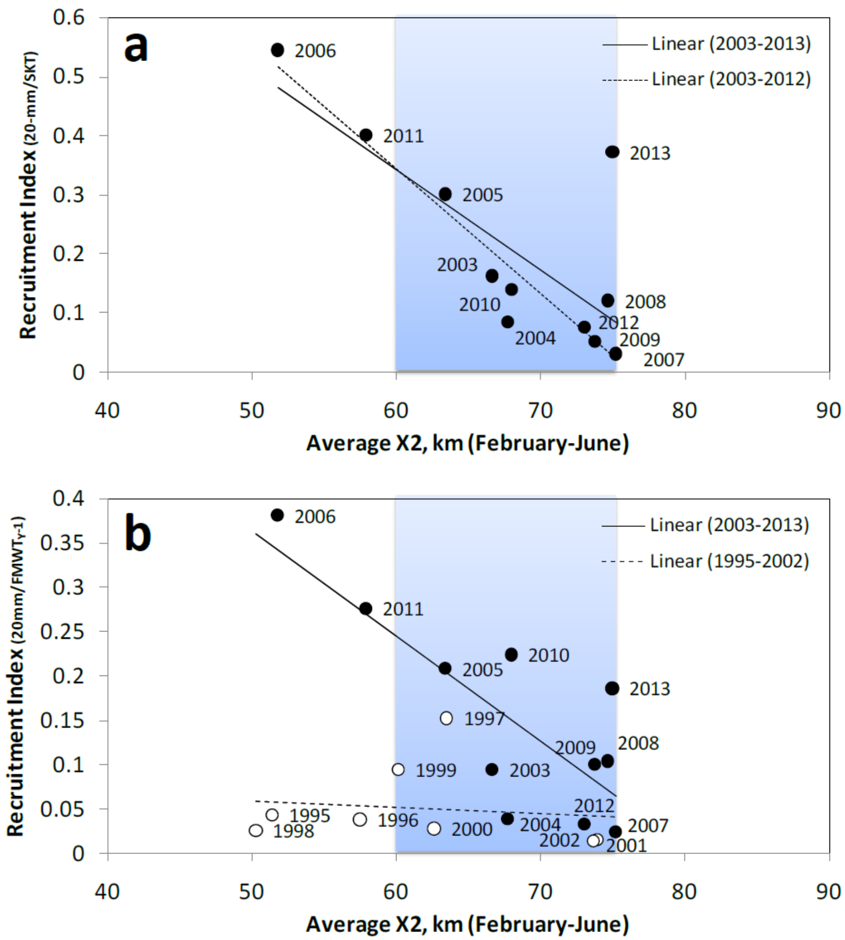


Figure 12. Adult (panel a, SKT) and subadult (panel b, FMWT the previous year) to larvae (20 mm Survey) recruitment indices (abundance index ratios) for Delta Smelt as a function of spring X2 (February-June). For 20 mm/SKT a linear regression was calculated with and without 2013, which appears to be an outlier. For 20 mm/FMWT the previous year separate regressions were calculated for the POD period (2003-2013), the period before the POD (1995-2002), and the entire data record (notshown). (This figure was copied from the MAST report, figure 82).

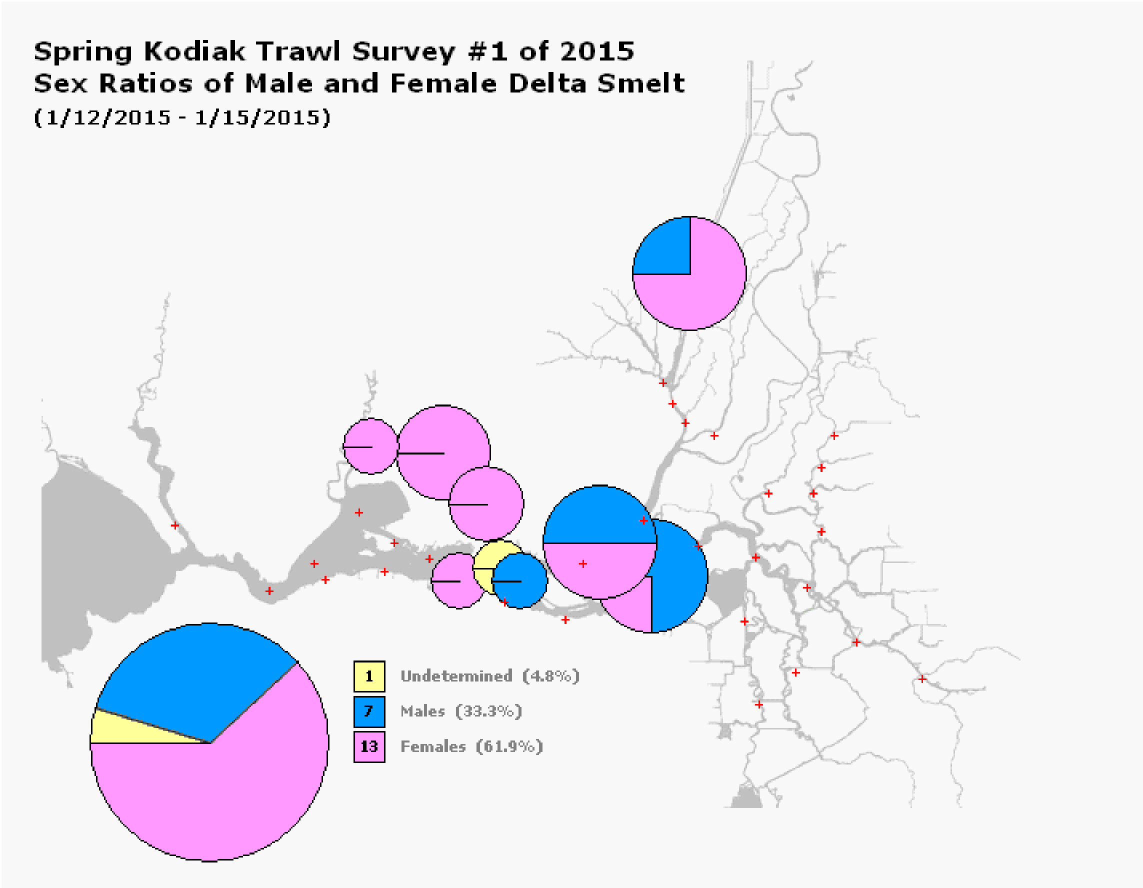


Figure 13. The distribution of male and female adult Delta Smelt shown in this map represent the lowest catch (n = 20) ever recorded during this period of time.

Table 1. Summary of the percent of particles fluxing past various output locations in the Sacramento-San Joaquin Delta. Particles were injected at Delta Smelt survey stations corresponding to Decker Island (707), Jersey Point (809), and Prisoner's Point (815).

Output Location	NDOI	OMR	707	809	815
Montezuma Slough	4000	-1500	35	31	13
	11400	-5000	19	15	4
	7100	-5000	25	18	5
	5500	-3200	29	25	9
Chipps Island	4000	-1500	48	45	19
	11400	-5000	71	55	15
	7100	-5000	53	39	9
	5500	-3200	57	47	17
Jersey Point	4000	-1500	12	5	27
	11400	-5000	-5	-27	6
	7100	-5000	-10	-38	3
	5500	-3200	3	-15	10
Holland	4000	-1500	-1	-2	-8
	11400	-5000	-5	-17	-41
	7100	-5000	-8	-19	-38
	5500	-3200	-4	-10	-27
Old River - Franks Tract	4000	-1500	0	-1	92
	11400	-5000	4	12	88
	7100	-5000	7	15	88
	5500	-3200	3	6	84
Middle River	4000	-1500	1	2	10
	11400	-5000	3	7	35
	7100	-5000	4	9	39
	5500	-3200	2	4	27

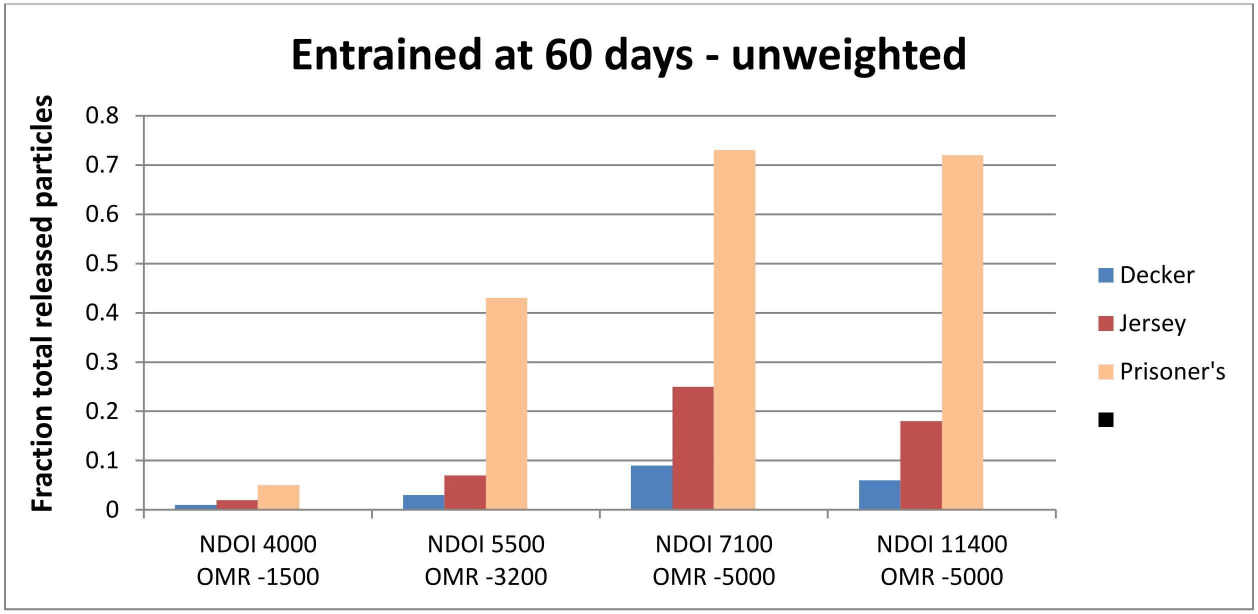


Figure 14a. Unweighted fate of particles seeded at three locations in the Sacramento-San Joaquin Delta after 60 days.

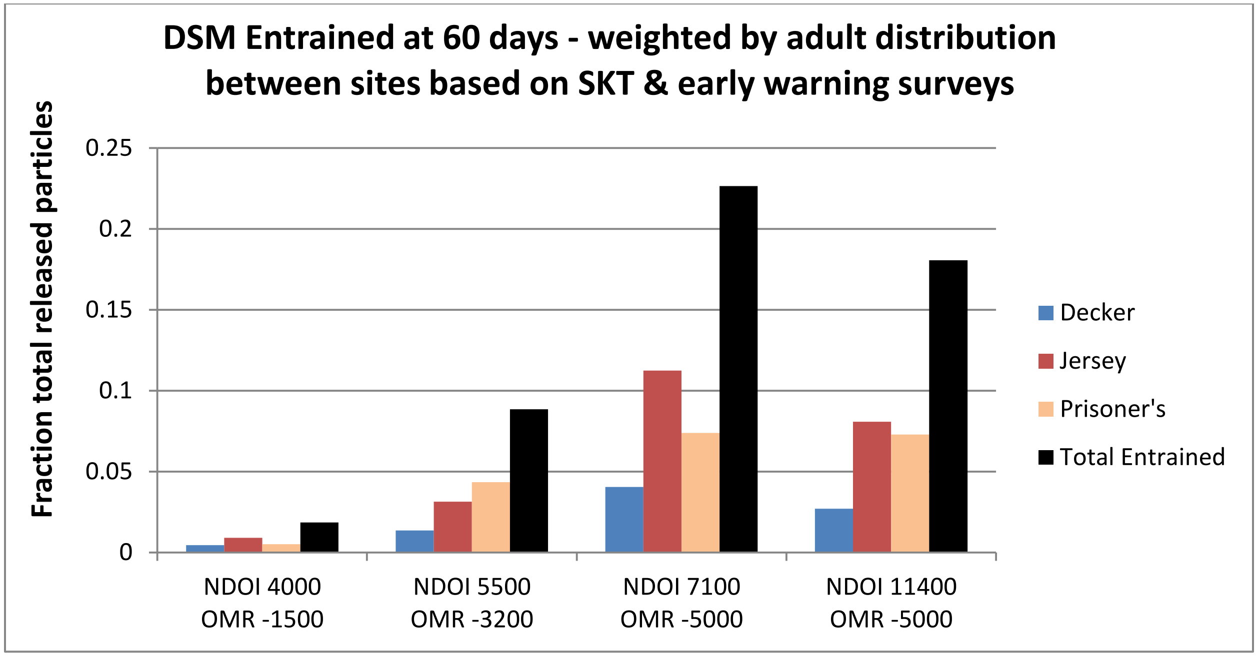


Figure 14b. Weighted fraction of particles entrained at the pumping facilities after 60 days. Weightings were based on 1991-1994 hatch distribution of adult Delta Smelt from Baxter (2009).

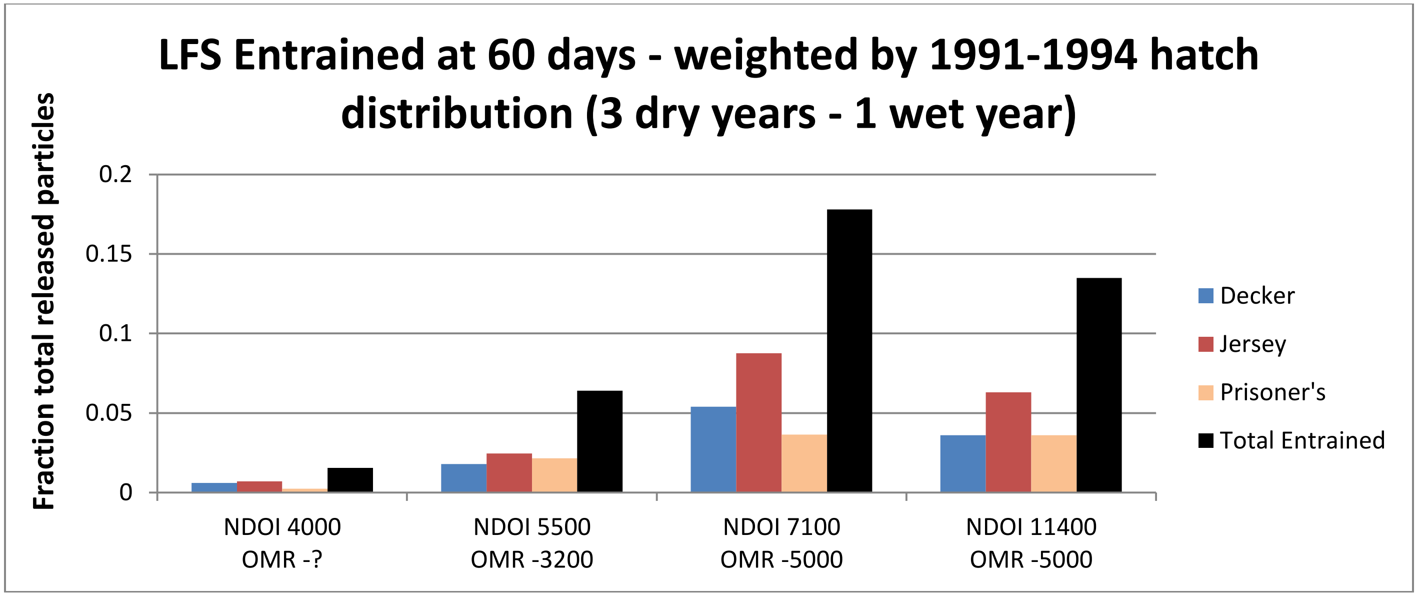
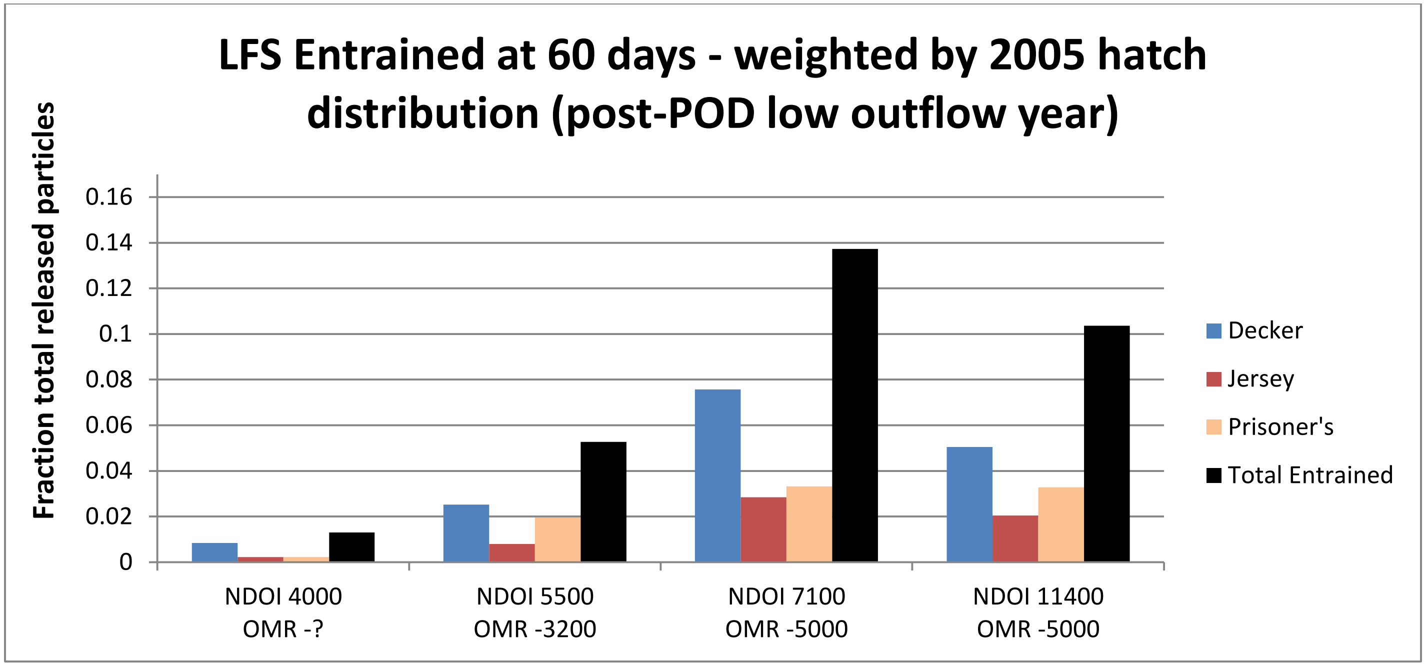
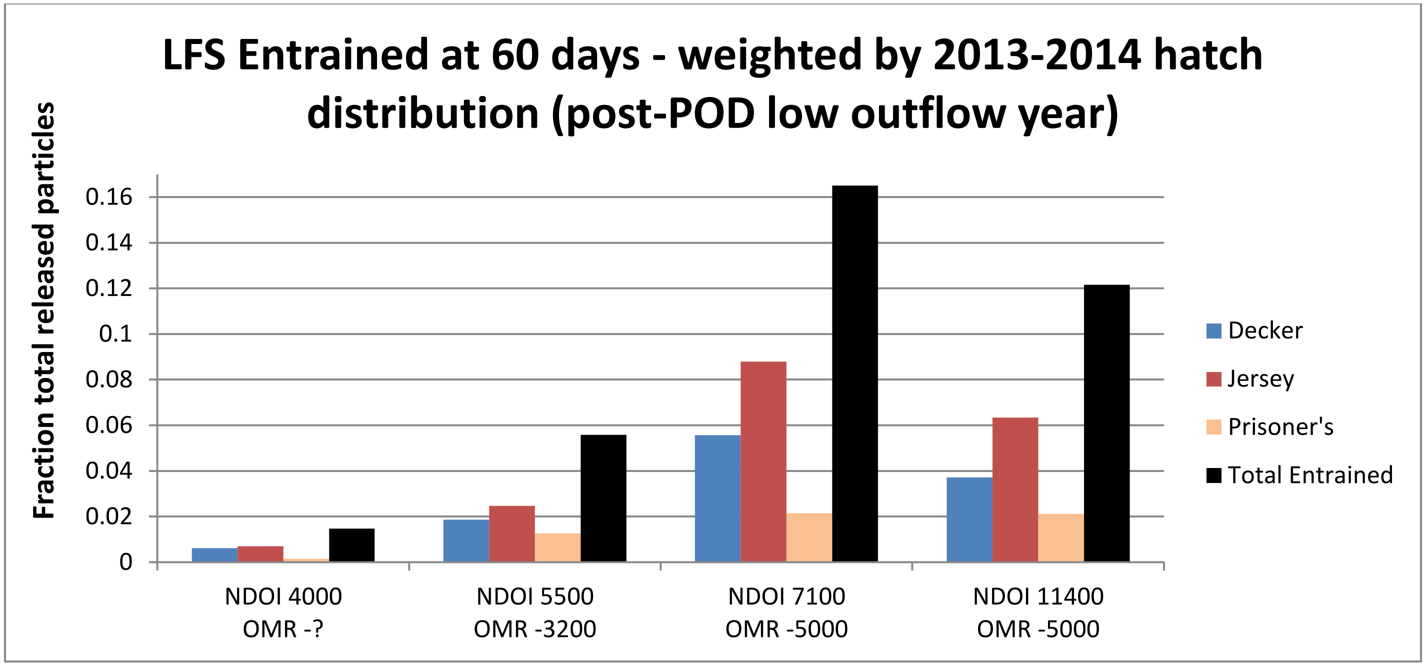

LFS Entrained at 60 days - weighted by 1991-1994 hatch distribution (3 dry years - 1 wet year)
Fraction total released particles
0.2
0.15
0.1
0.05
0
NDOI 4000
OMR -?
NDOI 5500
OMR -3200
NDOI 7100
OMR -5000
NDOI 11400
OMR -5000
Decker
Jersey
Prisoner's
Total Entrained

Figure 15a



LFS Entrained at 60 days - weighted by 2005 hatch distribution (post-POD low outflow year)
Fraction total released particles
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
NDOI 4000 OMR -?
NDOI 5500 OMR -3200
NDOI 7100 OMR -5000
NDOI 11400 OMR -5000
Decker
Jersey
Prisoner's
Total Entrained

Figure 15b


LFS Entrained at 60 days - weighted by 2013-2014 hatch distribution (post-POD low outflow year)
Fraction total released particles
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
NDOI 4000
OMR -?
NDOI 5500
OMR -3200
NDOI 7100
OMR -5000
NDOI 11400
OMR -5000
Decker
Jersey
Prisoner's
Total Entrained
Figure 15c