Appendix A Delta Smelt Risk Assessment Matrix Footnotes

1 The Recovery index is calculated from a subset of the September and October Fall Midwater Trawl sampling (http://www.delta.dfg.ca.gov/). The number in the matrix, 74, is the median value for the 1980-2002 Recovery Index (Figure 1)

2 The temperature range of 12 to 18 degrees Celsius is the range in which most successful delta smelt spawning occurs. This has been analyzed by using observed cohorts entering the 20-mm Survey length frequency graphs (1996-02). Cohorts were defined by having a noticeable peak or signal and occurring over three or more surveys during the rearing season. Temperature data from DWR's CDEC web site was compiled using three stations representing the south Delta (Mossdale), confluence (Antioch), and north Delta (Rio Vista). Spawning dates for each cohort was back-calculated by applying an average daily growth rate (wild fish) of 0.45 mm/day (Bennett, DFG pers. comm.) and egg incubation period of 8-14 days (Baskerville-Bridges, Lindberg pers. comm.)(Mager et al. 2004) from the median value of the analyzed cohort. Each spawning event was then plotted against temperature over time (Figure 2). While spawning does occur outside of the 12-18 degree range, larval survival is most likely reduced when temperatures are either below (DFG pers. comm.) or above this range (Baskerville-Bridges & DFG pers. comm.).

Critical thermal maxima for delta smelt was reached at 25.4 degrees Celsius in the laboratory (Swanson et al., 2000); however, in 2007 delta smelt were observed in the delta and in salvage at temperatures up to about 28 degrees Celsius.

Websites for the temperature data: http://cdec.water.ca.gov/cgi-progs/queryF?MSD
http://cdec.water.ca.gov/cgi-progs/queryF?ANH
http://cdec.water.ca.gov/cgi-progs/queryF?RIV

Mager RC, Doroshov SI, Van Eenennaam JP, and Brown RL. 2004. Early Life Stages of Delta Smelt. American Fisheries Society Symposium 39:169-180.

Swanson C, Reid T, Young PS, and Cech JJ. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced Wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123:384-390.

3 Figure 3: The working hypothesis for delta smelt is that spawning only occurs when temperatures are suitable during the winter and spring. In years with few days having suitable spawning temperatures, the spawning "window" is limited, so the species produces fewer cohorts of young smelt. Few cohorts increase the risk that mortality

sources such as entrainment may have population level effects. The figures below were used to help define years when there were relatively days with suitable temperatures. For April 15 and May 1, the figures show the cumulative spawning days for each year during 1984-2002. The cumulative spawning days for each year were calculated based on the number of days that the mean water temperature for three Delta stations (Antioch; Mossdale and Rio Vista) was in the 12 - 18 C range starting on February 1. The results are plotted in terms of the ranks to identify the lower quartile. In other words, years in the lower quartile represent examples of years with relatively few spawning days.

4 The adult spawning stage is determined by the Spring Kodiak Trawl and/or fish salvaged at the pumping facilities (http://www.delta.dfg.ca.gov/). A stage greater than or equal to 4 indicates female delta smelt are ripe and ready to spawn or have already spawned (Mager 1996).

Mager RC. 1996. Gametogenesis, Reproduction and Artificial Propogation of Delta Smelt, *Hypomesus transpacificus.* [Dissertation] Davis: University of California, Davis. 115 pages. Published.

5 The spring kodiak trawl will be used to help generally determine the distribution of adult smelt. However, since the spring kodiak trawl is not intended to be a survey for abundance or distributions, no definitive trigger for concern can be determined at this time.

Juveniles (March-July) – distribution of juvenile delta smelt where the centroid is located upstream (negative) or downstream (positive) of the Sacramento-San Joaquin River confluence (Figure 4). The 20-mm Survey (or Summer Townet Survey) centroid is calculated by multiplying the observed delta smelt station CPUE (fish/10,000 m3) by a distance parameter in km from the confluence. The summed result (summed over a survey) is divided by the survey CPUE which gives the survey centroid position (Figure 5)

Low juvenile abundance will also be a trigger. Abundance (total cumulative count) will be monitored throughout the sampling season with low values based upon median values of historic cumulative 20-mm Survey catch (1995-2003). Each survey within a season has a median value associated with it and when catch is equal to or below that value, concern is high (Table 1).

6 Salvage trigger: the salvage trigger for December through March is determined by calculating the ratio of adult salvage to the fall MWT index. This ratio will increase as fish are salvaged during the winter months. If the ratio exceeds the median of what was observed during December-March 1980-2002, then the trigger was met (see Figure 6 for more explanation of the calculation)

During May and June, if delta smelt salvage at the salvage facilities is greater than zero, then the working group will meet. This is because May and June are the peak of smelt salvage and salvage densities cannot be predicted. Therefore, during these two months,

the smelt working group will meet proactively to protect these fish by looking at relevant information such as salvage, delta temperatures, delta hydrology and smelt distributions.

7 The tools for change are actions that the working group can recommend to the DAT and WOMT group to help protect delta smelt. Exports may be reduced at one or both of the south delta export facilities and a proposed duration of the reduction would be recommended by the working group. Export reductions and changes in San Joaquin River flows may be covered by (b)(2) or EWA assets. Details of past fish actions can be found at the CALFED Ops website: http://wwwoco.water.ca.gov/calfedops/index.html; >Operations [year]

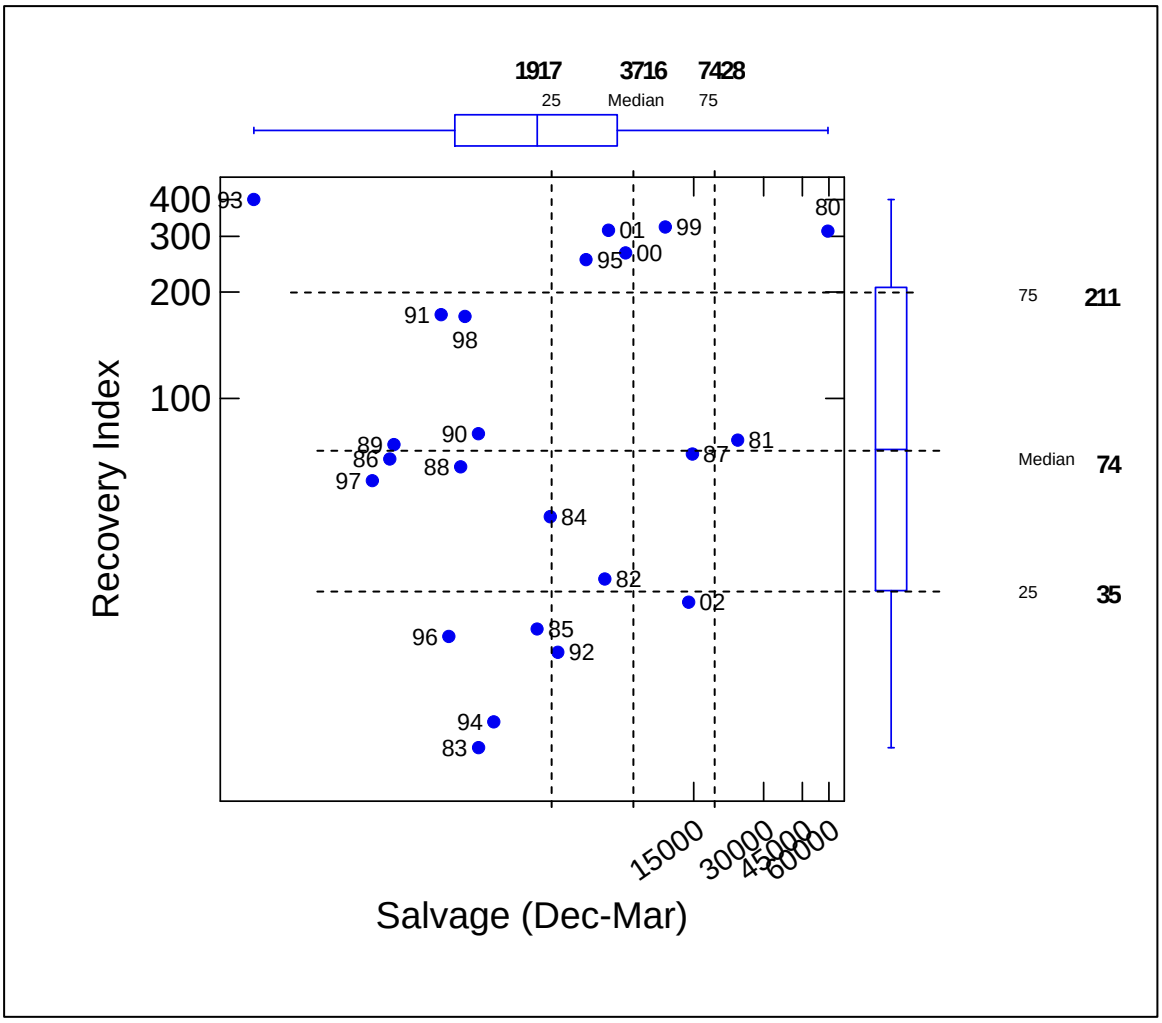

Figure 1 1980-2002 Recovery Index

Figure 1 points are labeled with the year representing the recovery index.
The winter salvage is for this analysis starts in December of the recovery index year and carries through March of the following year.

Figure 2 shows the successful delta smelt spawning periods (black bars) and start and end of spawning season (yellow bars) determined by the 20-mm Survey catch results (1996-2002). Temperature data (^{o}C) was compiled from CDEC using mean daily temperatures from the south Delta (Mossdale), north Delta (Rio Vista), and confluence (Antioch).

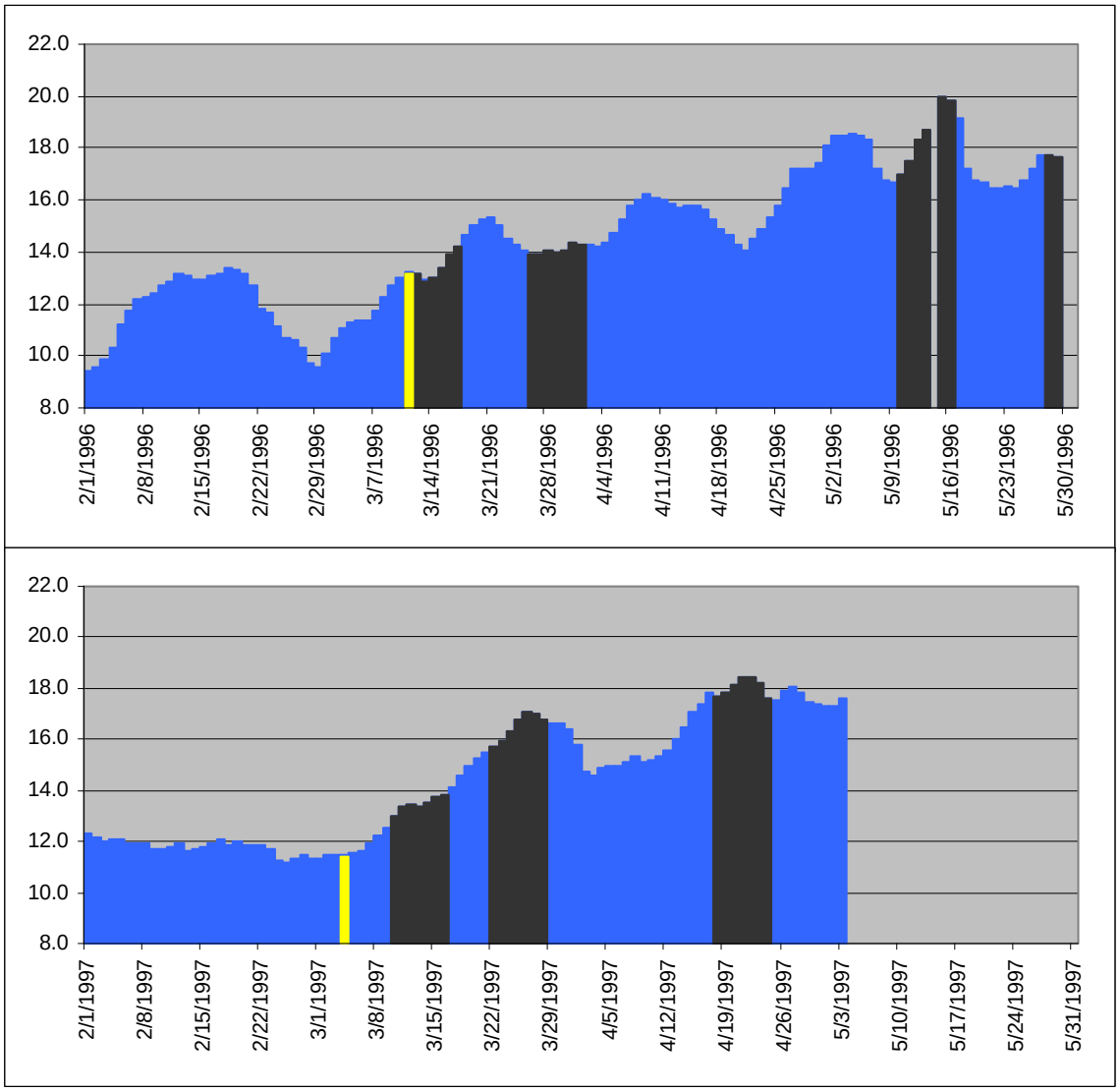

Figure 2 Successful delta smelt spawning periods

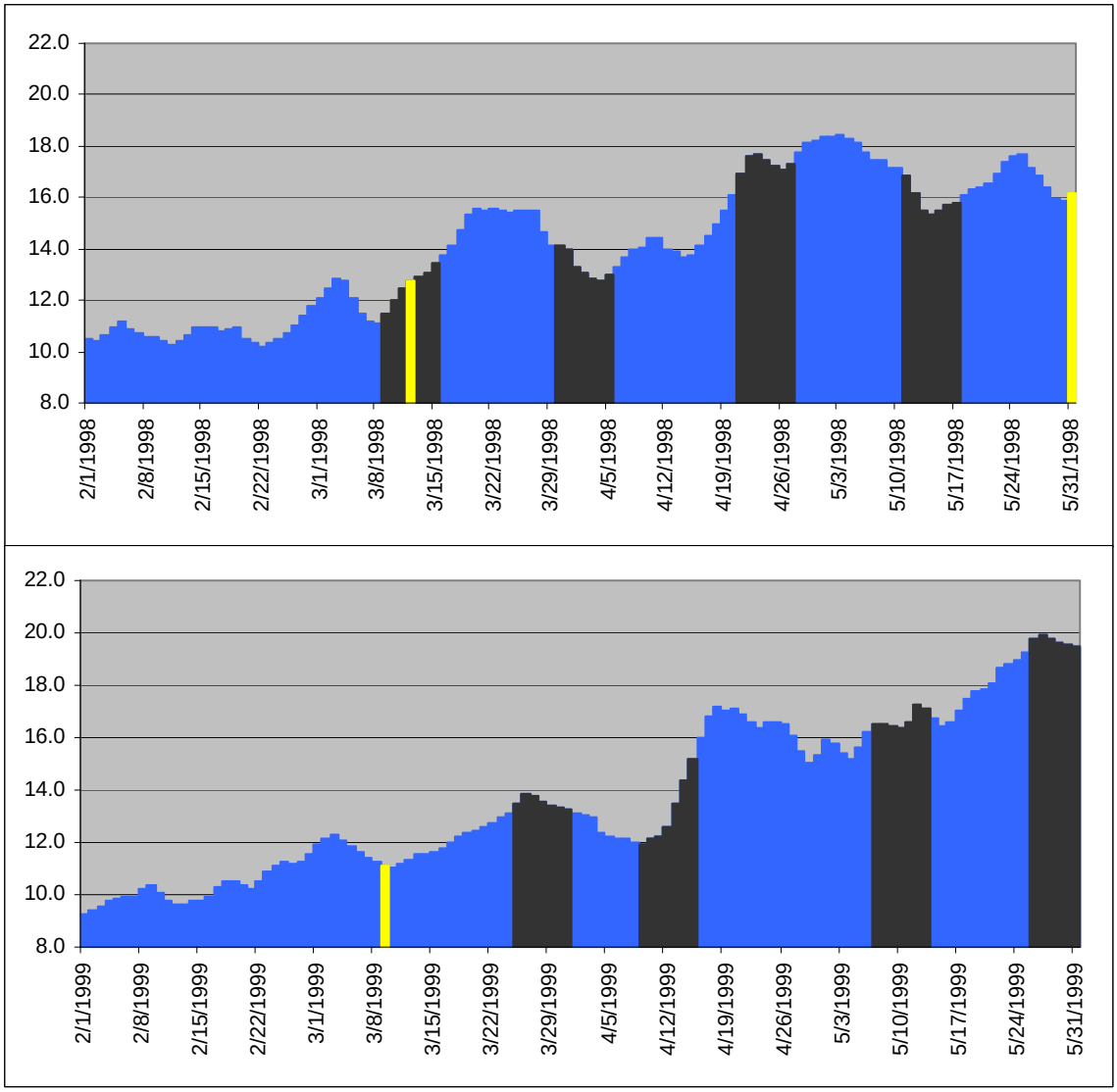

Figure 2 cont.

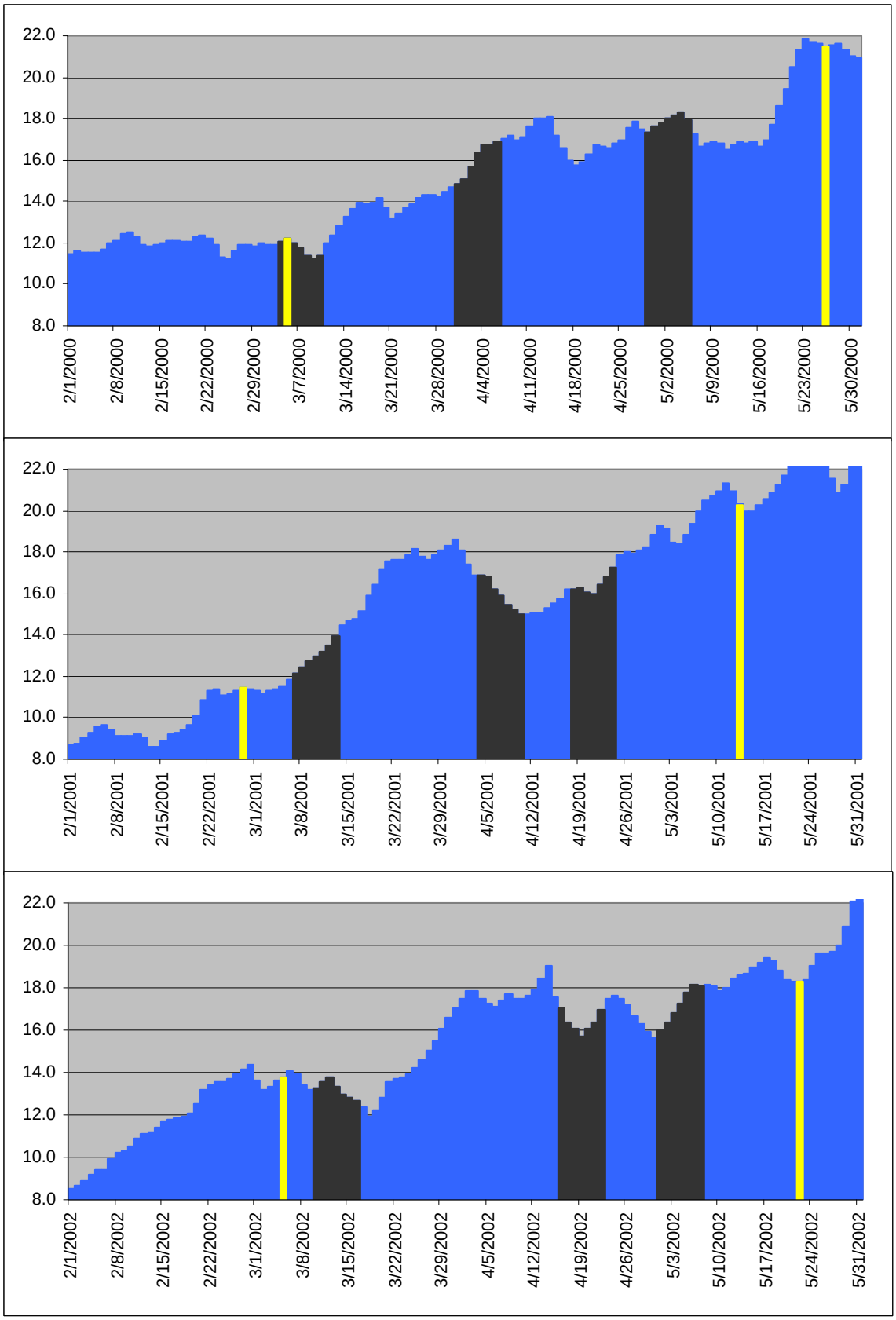

Figure 2 cont.

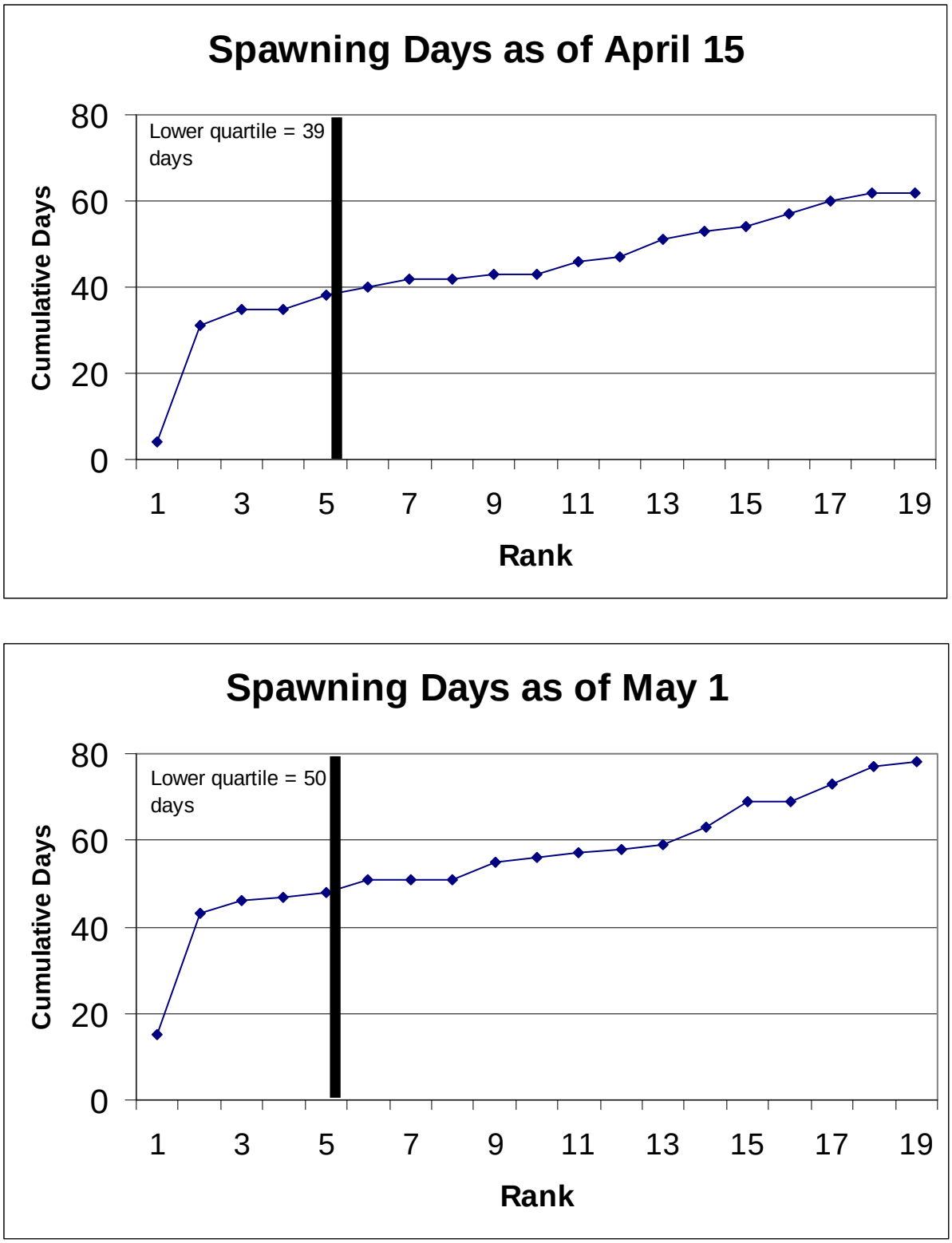

Figure 3 Delta smelt spawning days

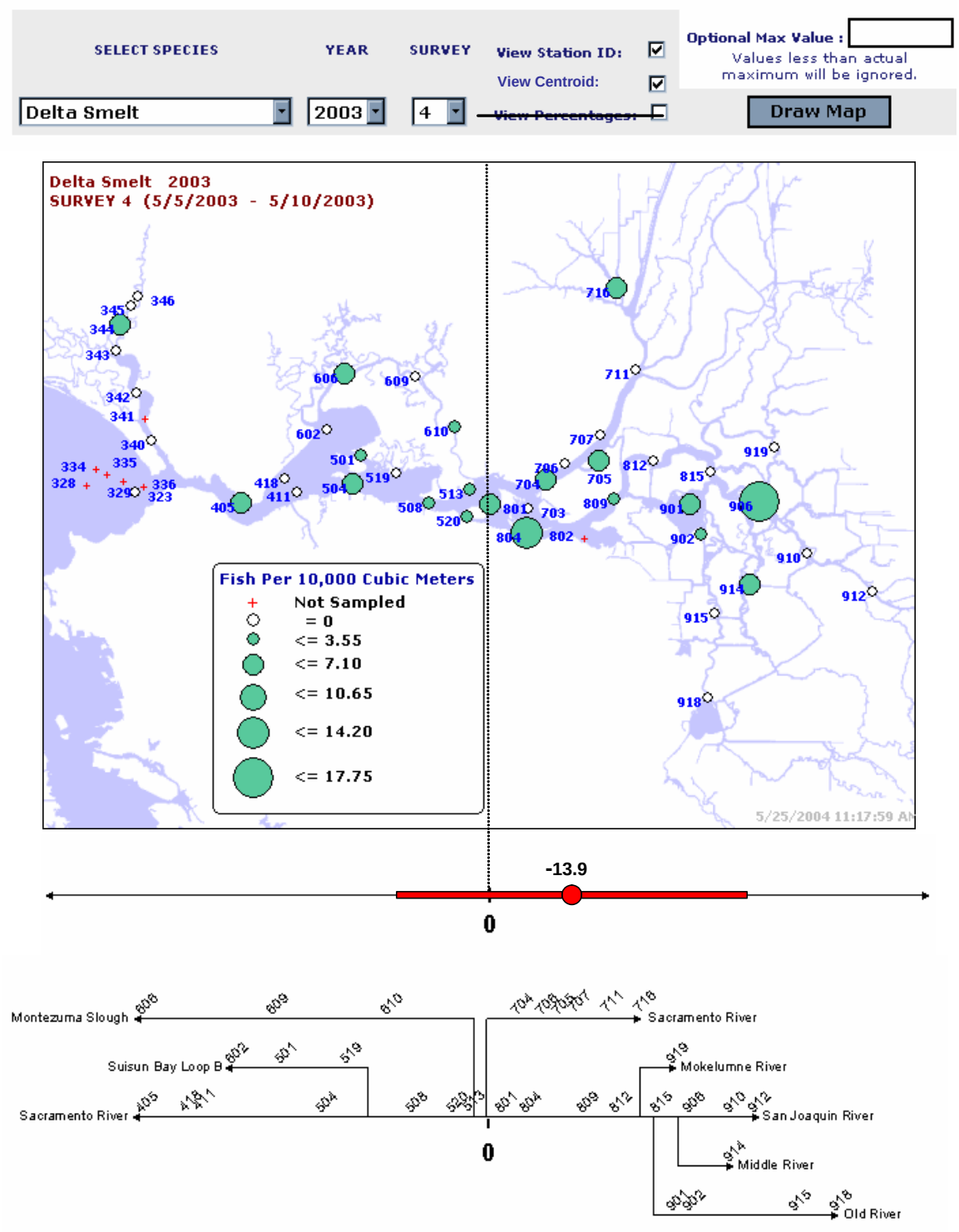

Figure 4 A 20-mm Survey delta smelt bubble plot map with calculated centroid position from the confluence of Sacramento-San Joaquin Rivers with one standard deviation.

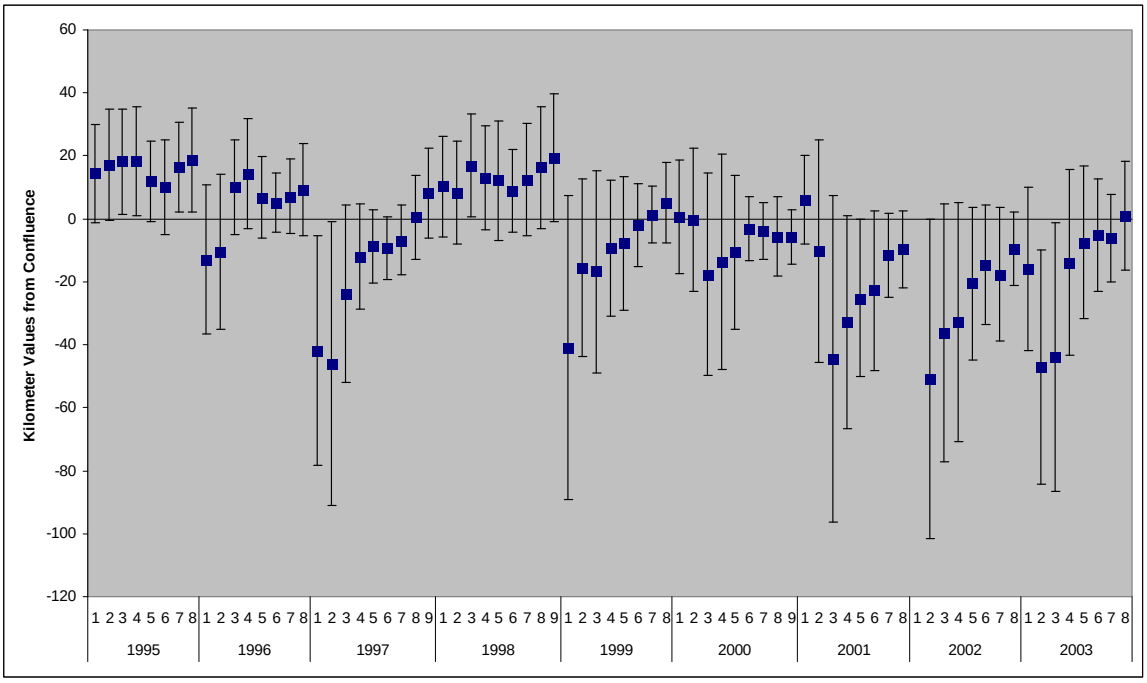

Figure 5 Historic juvenile centroid position (20-mm Survey) with one standard deviation.

Table 1 Lower quartile values of cumulative catch from the 20-mm Survey. When cumulative catch per survey during a season is at or below the calculated value, concern is high.

	survey 1	survey 2	survey 3	survey 4	survey 5	survey 6	survey 7	survey 8
lower quartile	12	40	144	188	346	500	924	1019

In Figure 6**,** the objective is to quantify a level of concern for adult delta smelt during the winter, that is based upon not only the number of fish salvaged but also accounts for the overall abundance of smelt. Whatever quantifier we select should reflect that when the abundance is low and salvage is high concern is high and conversely, when abundance is high and salvage is low that concern is low.

Below is a Quantile plot of the ratio of winter salvage to MWT index (ln (winter salvage/MWT index)). Winter salvage is defined as the total salvage from December through March. In the figure below, the size of the bubbles is proportional to the log of the fall midwater trawl just to give some indication of relative abundance. The resulting quartiles of the ratio are as follows:

25% =: 2.950; 50%= 3.575; 75% 5.029.

If we were to use this approach to calculate winter concern levels and use the median value, then all years above the 1999 point in the graph would have been years of concern. In other words, these are the years in which we may have recommended some protection. Comparing it to the protection afforded adult delta smelt in the winter by the 1995 Biological Opinion ("red light" was, or would have been reached in the following winters of 1980, 1981, 1982, 1984 and 1999) .

If the median was selected as the measure of concern it would be calculated by:

concern level = anti ln(3.575)* MWT index

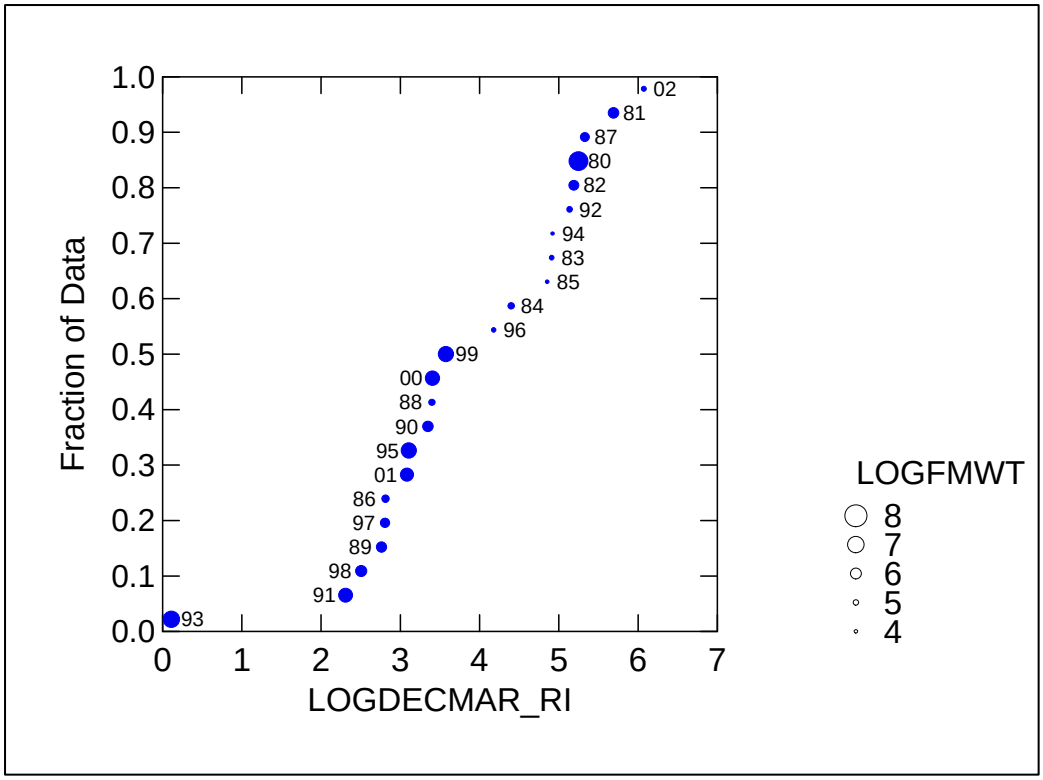

Figure 6 Quantile plot of the ratio of winter salvage to MWT index

The goal for the DSRAM is to avoid the upper quartile of the above graph, in general, to avoid high salvage events when the MWT index is low. Actions would be taken prior to salvage events and ideally, high salvage events would not occur.