Delta Flow Criteria Informational Proceeding

Before the

State Water Resources Control Board

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Questions on Written Testimony

Submitted on behalf of

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Delta Flow Criteria Informational Proceeding

Question for State Water Board's "Delta Environmental Flows Group of Experts"

Suppression of *Egeria densa* by reducing Delta outflow and increasing salinity intrusion

CCWD respectfully submits the following information and requests that, in light of this information, the State Water Board's expert witness group discuss and reconsider the recommendation for flows to suppress *Egeria densa* in the State Water Board's staff exhibit "On Developing Prescriptions for Freshwater Flows to Sustain Desirable Fishes in the Sacramento-San Joaquin Delta" by William E. Fleenor, William A. Bennett, Peter B. Moyle, and Jay R. Lund (hereafter "authors").

The authors recommend an experimental Delta outflow to "allow the western and parts of the central Delta to become much more saline to suppress the invasive Brazilian waterweed, *Egeria densa*". However, this approach is unlikely to meet the desired goal of suppressing growth of *Egeria densa* for the following reasons: (1) the recommended flows would not increase Delta salinity; (2) even extreme salinity intrusion such as that experienced during the drought of 1924 would be unlikely to significantly reduce the distribution of *Egeria densa*; (3) for nearly 2,500 years before the droughts of the 1920's and 1930's, native Delta species thrived in a relatively fresh system; (4) to increase salinity in the central Delta to the 10 ppt necessary to begin suppression of *Egeria densa*, Delta outflow would need to be reduced for 4 to 5 months to levels that create a net reverse flow from San Francisco Bay to the Delta; and (5) such reduced Delta outflow levels to increase salinity intrusion would likely encourage other harmful invasive species and cause additional harm to the ecosystem.

1. The recommended flows would not increase Delta salinity

The recommended flow (8,000 cfs in July and August during the driest 3 out of 10 years) is actually much greater than the recently observed daily Delta outflow (Figure 1). From 1995 though 2009, in dry and critically dry water years, Delta outflow during July and August averaged just 4,300 cfs and exceed the recommended flow of 8,000 cfs on 2 days (out of 310 days). In fact, during all water year types from 1995 through 2009 (including 9 above normal and wet water years), Delta outflow exceeded the recommended dry year flow of 8,000 cfs just 42% of the time.

The method used to develop the flow recommendation (i.e. recreation of unimpaired hydrology during dry years) is likely valid for providing conditions to which natives aquatic species evolved and may dominate over invasive species. However, substantial upstream development and water use has significantly reduced summer Delta outflow, such that the current summer outflows are significantly below unimpaired conditions. Thus, the recommended outflow would freshen the western and central Delta rather than making the region more saline; therefore, the recommended flow would not meet the desired goal of suppressing *Egeria densa* growth. It could, however, discourage the invasive overbite clam (*Corbula amurensis*), which is found to thrive in low flow (high salinity) conditions found in dry years.

2. Even extreme salinity intrusion experienced during the drought of 1924 would be unlikely to significantly impact the distribution of *Egeria densa*

Experimental studies on the effects of salinity on *Egeria densa* revealed that both root formation and growth decline with increasing salinity (Obrebski and Booth, 2003); however, even at 6 parts per thousand (ppt) salinity, the plant shoots continued to grow, with an average growth of 10% to 40% over 18 days, depending on temperature (Figure 2). Hauenstein and Ramirez (1986) found no growth of roots or stems at salinity greater than 10 ppt.

Egeria densa is present throughout the Delta (Figure 3), with dense patches in regions far removed from the San Francisco Bay, such as within White Slough (in the eastern Delta, north of Empire Tract and Kings Island) and Old River (in the south Delta around Coney Island). Even during the extreme drought of 1924,[1] salinity in White Slough near Kings Island and Old River near Coney Island peaked[2] at approximately 3.0 ppt and 1.5 ppt (DPW, 1931), respectively, at levels far below the salinity tolerance of *Egeria densa*. During the 1924 drought, salinity peaked on False River near Franks Tract at approximately 7.5 ppt for a single day and remained above 5.5 ppt for approximately 1 month (DPW, 1931). Based on the experiments by Obrebski and Booth (2003), if *Egeria densa* had been present in 1924, this location may have experienced inhibited growth, but salinity levels were unlikely to have eradicated plants in the area.

3. For nearly 2,500 years before the droughts of the 1920's and 1930's, native Delta species thrived in a relatively fresh system.

As discussed in CCWD Exhibit 6, salinity intrusion during the drought in the 1920's and 1930's had been exacerbated by anthropogenic changes, including reclamation of Delta islands, straightening and deepening of the Sacramento River near Decker Island, and diversion of water upstream of the Delta to irrigate over 4 million acres of crops. An investigation by the state (DPW, 1931) declared that "[d]uring certain years of the thirteen-year period, 1917 to 1929, the extent of saline invasion into the Sacramento-San Joaquin Delta has been greater than ever before known to have occurred."

These observations were confirmed by plant pollen studies from sediment cores in Suisun Bay and the western Delta, revealing that salinity increased abruptly about 100 years ago, reaching or exceeding salinity levels at any other time in the last 2,500 years. Based on sediment cores at Browns Island, the western Delta was predominately a freshwater system for the entire length of record (approximately 2,500 years), until the early 1900's. Although salinity intrusion is evident in Suisun Bay at Roe Island during earlier long drought periods, salinity did not affect the western Delta to the same degree. This suggests a change in spatial salinity gradient characteristics, and is possibly due to the effect on salinity intrusion of the vast tidal marshes that existed in the Delta until the early 20th Century (see Figure 2-5 in CCWD Exhibit 6).

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[1] Total annual unimpaired net Delta outflow for water year 1924 is the second lowest on record (1921-2003). Hydrological reconstruction from tree rings (Meko *et al.*, 2001) indicates that water year 1924 was the worst single year drought in nearly 350 years, covering the reconstructed time period (1629-1977).

[2] Salinity measurements were taken from a surface sample, usually at 2 hours after high tide, approximating the daily maximum salinity. Sampling locations are indicated by blue diamonds in Figure 3.

4. To increase salinity in the central Delta to the 10 ppt necessary to begin suppression of *Egeria densa*, Delta outflow would need to be substantially reduced for 4 to 5 months to levels that create a net reverse flow from San Francisco Bay to the Delta.

Estimates of daily Delta outflow are available from the Department of Water Resources' Dayflow model[3] from October 1929 through October 2009. Water year 1931 had similar unimpaired hydrology to the drought of 1924, but water year 1931 was also proceeded by two dry water years and was impacted by seven additional years of upstream development and increased diversions. For example, in 1924, capacity of reservoirs in the Sacramento and San Joaquin river basins totaled approximately 1.5 million acre feet (MAF); by 1931, reservoir capacity in the basins exceeded 3.6 MAF (DWR, 1993).

In 1931, net Delta outflow was negative (on average, water from San Francisco Bay was flowing into the Delta) for 4 months, from early June through the first week in September (with the exception of a few days in mid-June), such that the average outflow for June through September was -1,000 cfs (eastward). During this period, unimpaired outflow averaged +3,900 cfs (seaward); salinity intrusion was exacerbated by the nearly 5,000 cfs reduction in outflow due to upstream and within Delta diversions.

In 1931, salinity peaked in September and began decreasing when net Delta outflow returned to the natural, seaward direction. Salinity peaked around 13 ppt near Franks Tract, while on White Slough near Empire Tract and Old River near Coney Island peaked near 4.5 ppt and 3.0 ppt, respectively (DPW, 1931). If *Egeria densa* had been present in 1931, salinity may have caused necrosis in some of the plants near Franks Tract. However, dense growth of *Egeria densa* within Franks Tract (typical in September of dry years) reduces lateral mixing such that salinity levels would need to remain elevated for weeks to months in the vicinity of Franks Tract to mix into the dense stands of vegetation. Given the widespread growth of *Egeria densa* within the Delta, *Egeria densa* is likely to reinvade any areas potentially affected by elevated salinity. For instance, following herbicide treatments to control *Egeria densa*, some stems that became chlorotic or exhibited defoliation, later exhibited regrowth (Ruch *et al.*, 2006).

To increase salinity in the central Delta to 10 ppt in an attempt to suppress *Egeria densa*, Delta outflow would need to be reduced to near zero or negative (reverse flow) conditions for 4 to 5 months.

5. Reduced Delta outflow to increase salinity intrusion could encourage invasive species and cause other harm to the ecosystem.

Since salinity intrusion during the drought of the 1920's and 1930's was increased due to anthropogenic activities, it seems inappropriate to assume native estuarine species would prefer this manipulation of the salinity regime. In fact, increased salinity intrusion may trigger unintentional consequences that are detrimental to the ecosystem. In response to increased salinity intrusion, any organisms that have preferential salinity ranges such as delta smelt may move eastward, into the Delta, which may become increasingly inhospitable. Increased residence time will increase the potential for accumulation of toxics, increase nutrient

[3] http://www.water.ca.gov/dayflow/

concentrations, and raise the water temperature, which, in turn, will affect algal growth patterns. Certain algal species (e.g. *microcystis*) are known to be detrimental to sensitive aquatic species.

In addition, increased salinity may allow the overbite clam (*Corbula amurensis*) to expand its range, potentially shrinking the range of the Asiatic freshwater clam (*Corbicula fluminea*). The overbite clam has a higher food uptake rate than the Asiatic freshwater clam; Asiatic freshwater clams did not historically suppress annual spring-summer phytoplankton blooms throughout the upper estuary like overbite clams do in the brackish water zone today (Thompson, 2007). The dynamics of clam-phytoplankton interactions under different salinity regimes are not currently predictable. Therefore, the food web responses of fishes feeding on clams or competing with them for food are likewise not currently predictable.

Finally, if elevated salinity does exterminate large areas of *Egeria densa*, depending on the rate of necrosis and the movement of detritus, dissolved oxygen levels could be depleted with anoxic conditions in the sediments and release of toxic metals. This scenario is more likely to occur in areas where the beds of submerged vegetation have less mixing with the adjacent open water areas (e.g. Franks Tract during the summer and fall seasons).

In summary, based on experiments on salinity tolerance, even if an artificially high level of salinity is recreated in the present Delta, the distribution of *Egeria densa* is not likely to be significantly reduced, yet the reduction in Delta outflow necessary to increase salinity may adversely affect the ecosystem. Therefore, salinity intrusion is not an effective method to control *Egeria densa*.

References

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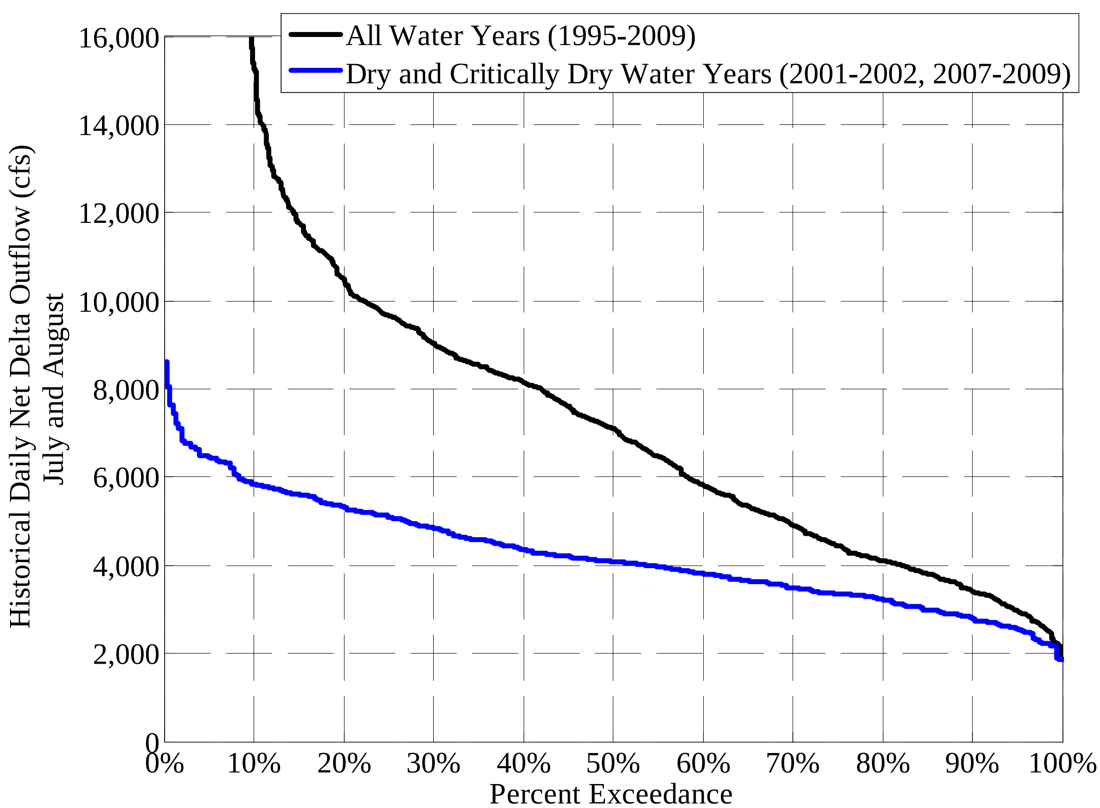

Figure 1 – Historical daily Delta outflow during July and August (1995 through 2009)

Data from the Dayflow model (http://www.water.ca.gov/dayflow/)

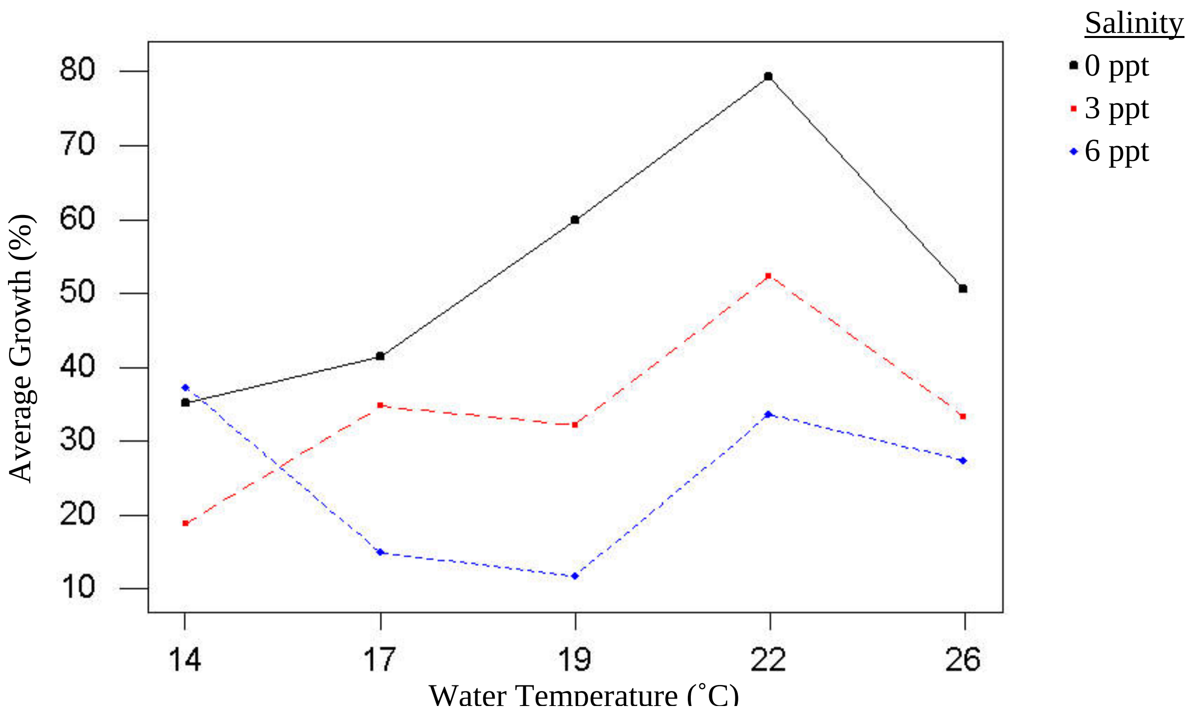

Figure 2 – Effects of Temperature and Salinity on growth of *Egeria densa*

Figure adapted from Figure 3 in Obrebski and Booth (2003)

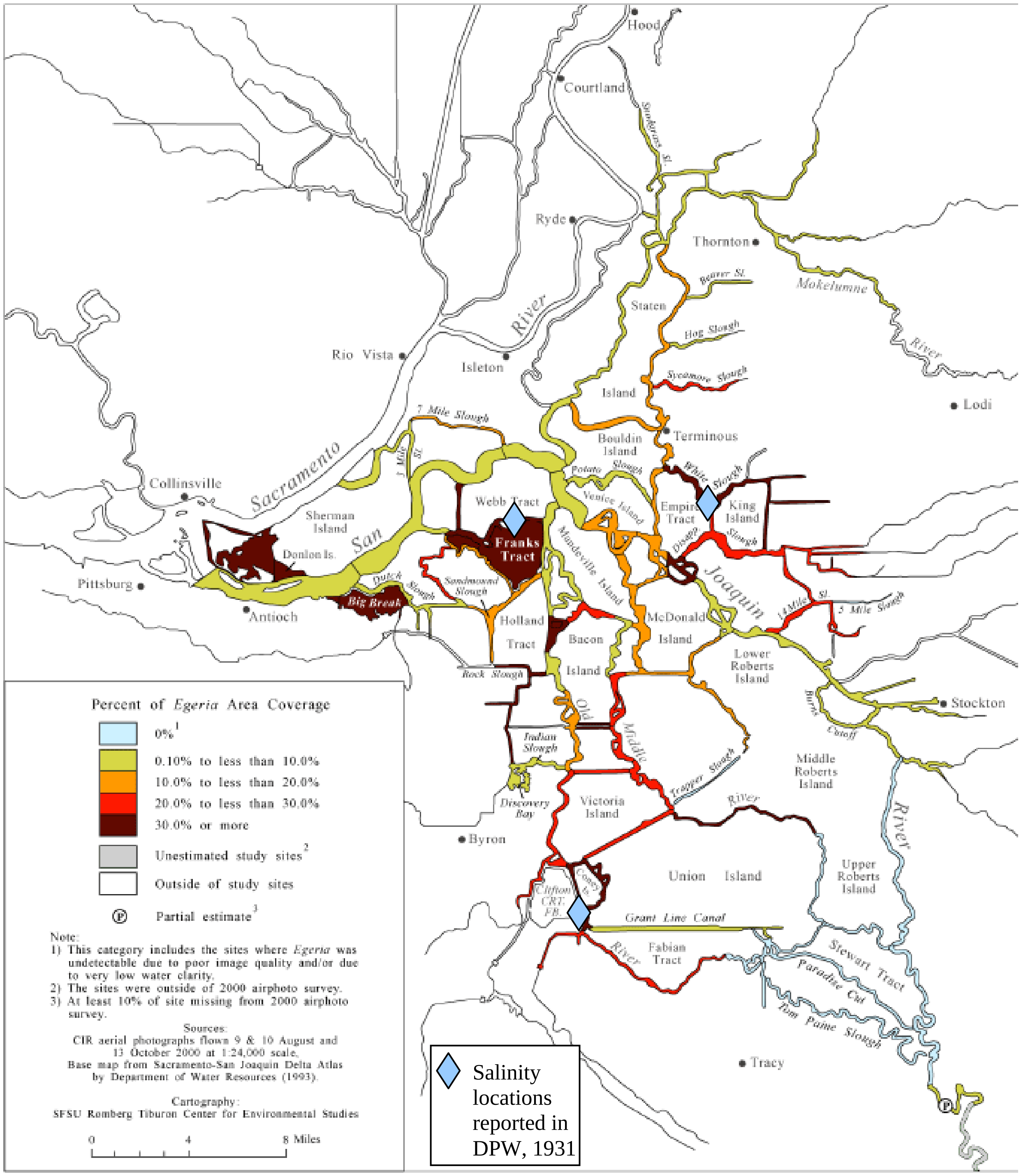

Figure 3 – Areal Coverage of *Egeria densa*, 2000

Created by P.G. Foschi et al., SFSU Romberg Tiburon Center, cartographer: M. Odaya. Locations of salinity measurements reported from DPW (1931) are indicated with blue diamonds.

Question for Dr. Gregory Gartrell, Contra Costa Water District

Old and Middle River flow to prevent entrainment at the export facilities

Dr. Greg Gartrell provided information to the National Research Council (NRC) Committee on Sustainable Water and Environmental Management (Technical Memorandum dated January 25, 2010) regarding the use of Old and Middle River flow to prevent salvage at the export facilities and regarding the information provided by various parties to both the NRC Committee and the SWRCB in this proceeding. Please discuss the utility of using net flow on Old and Middle River flow as a criterion for internal Delta hydrodynamics and the various proposals regarding the relationships between salvage and flow.