Effects of Exports on Delta Smelt Population Abundance - Preliminary Analyses

Tina Swanson
The Bay Institute
November 2005

Introduction

This report provides a brief description and some background information for a PowerPoint presentation to be presented at the December 2005 Review Workshop for the Environmental Water Account.

This examination of the effects of exports on delta smelt abundance was begun to further explore analyses and results presented by Dr. Bruce Herbold (recent trends in winter export rates and fish salvage; presented at the Pelagic Organism Decline (POD) Workshop, November 2005) and by scientists at Contra Costa Water District (trends in exports rates and effects of seasonal export rates on delta smelt population abundance; reported via email to the POD research group, and pers. comm.). The analyses presented in this report and the accompanying PowerPoint presentation are preliminary, incomplete, and have not been peer-reviewed; they are presented with the objective of stimulating discussion and further analysis.

Background

Delta smelt are present in the Delta (as compared to lower in the estuary) and exposed directly to the effects of water export operations at two critical times during their life cycle: during the winter when pre-spawning adults migrate to the upper Delta to spawn, and during the spring and summer when larvae and juveniles move downstream from the upper Delta to low-salinity rearing habitat, usually located in Suisun Bay (Slide 2: average [1969-2005] number of delta smelt salvaged at the state and federal fish facilities per month). This report and the accompanying PowerPoint presentation focus on the effects of winter exports, which for the purposes of these analyses are for the December-March period (Slide 3). Brief results for the effects of spring-summer exports are also presented (March-July, Slide 4).

Since the late 1960s, export rates during these two seasons have varied and generally increased with time (Slide 5: trends in winter and spring-summer exports).

Delta smelt abundance is measured at two times during the species' typical single year life-cycle. Abundance of subadult and adult fish is measured using catch data from the Fall Midwater Trawl (FMWT; 1967-2004, excluding 1974 and 1979). Abundance of juvenile fish is measured during June and July using data from the Summer Townet Survey (TNS; 1969-2005). For each of these surveys, abundance is calculated as a non-dimensional "index".

Methods

For all analyses, abundance indices were log (10) transformed. In this report and accompanying PowerPoint presentation, abundance of adult delta smelt is referred to as

"FMWT" and abundance of juvenile delta smelt as "TNS". Exports were expressed as either average cfs, or as total thousands of acre-feet (TAF) exported for the specific multi-month period. The effects of winter and spring-summer exports on the abundance of adult and juvenile delta smelt were examined using general linear models.

Results

Relationships between adult and juvenile abundance: The abundance of juvenile delta smelt is significantly correlated with the abundance of adult delta smelt measured the previous year (Slides 6 and 7); more juvenile delta smelt are collected by the TNS following years with higher abundances of adult delta smelt as measured by the FMWT. The abundance of adult delta smelt is also significantly correlated with the abundance of juvenile delta smelt measured earlier in the same year; in general, in years when juvenile delta smelt were abundant, adult delta smelt are also more abundant later in the fall (Slide 8). This correlation is significant when calculated for the 1969-2004 period, the longest period for which data from both surveys are available. In more recent years (e.g., post-*Corbula*, 1987-2004), the relationship between juvenile and subsequent adult abundance has weakened (Slide 9) and is not significantly correlated.

Effects of winter exports: The abundances of adult and juvenile delta smelt were significantly affected by December-March export rates; for both life stages, abundance decreased with increases in exports (Slide 10).

Log FMWT = 3.039 – 0.00007(exports, average cfs)
$p=0.003$; $r^2=0.0236$, standard error of the estimate (SEE)=0.00002

log TNS = 1.387 – 0.0001 (exports, average cfs)
$p=0.01$, $r^2=0.175$, SEE=0.00004

Analyses for the alternative winter periods (November-February, November-March, and December-February) yielded similar and statistically significant results (although p values were somewhat higher and r^2 values were somewhat lower).

Linear regression using smaller subsets of more recent years (e.g., post-*Corbula* invasion, 1987-2004 or 2005; post-1995 WQCP, 1996-2004 or 2005) were not statistically significant but both the slopes and intercepts of the relationships were very similar to those generated using the entire dataset (Slides 11 and 12).

The relationship between winter exports and abundance was not "driven" by the low abundances measured during the past three or four years: after excluding of the three most recent years (2002-2004 for FMWT, 2003-2005 for TNS) from the dataset, the regressions were still significant ($p=0.02$ for FMWT; $p=0.05$ for TNS) and the intercepts and slopes were similar. Given that the significant relationship between winter exports and adult abundance was detectable by 2002, this indicates that the low abundances measured during the past three years, a period during which winter exports were at near record high levels, were predictable.

Implications for delta smelt recovery: High winter exports (defined as >8000 cfs) have occurred in nine of 39 years since 1967 (1983, 1988, 1989, 1990, 2000, 2002, 2003, 2004, and 2005). For those years, average FMWT was 292 and the median FMWT was 210 (Slide 13). Given that the delta smelt Recovery Index (which is calculated using only the first two months of the four-month survey and whose value is usually less than 50% of the FMWT measured for that year) has a threshold value of 239 that must be achieved in two of five sequential years for recovery of the species, this suggests that a conservative estimate for a target FMWT value for recovery would be approximately 500 in at least half of all years. Using the regression equation for the relationship between winter exports and adult delta smelt abundance, this corresponds to average winter exports of approximately 4000-7000 cfs, similar to the range of exports measured during the 1995-1999 period (average: 5850 cfs). These results also suggest that recent winter export levels (2000-2005 average: 9150 cfs) are incompatible with recovery of delta smelt.

Effects of spring-summer exports: The abundance of juvenile delta smelt was significantly affected by spring-summer exports (note: for this analysis exports are measured as total TAF for the March-July period). The linear regression for this relationship is:

Log TNS = 1.542 – 0.00045(exports, total TAF)
$p=0.021$; $r^2=0.143$; SEE=0.00019.

However, based on the graph, the relationship may be curvilinear rather than linear.

Closing Thoughts

Although these analyses are incomplete and many other variables should be tested (singly and as incorporated into multivariate models), these preliminary results have implications for delta smelt management and recovery, evaluation of the effects of ongoing and future water management operations on the species, and the use and utility of the Environmental Water Account to protect and promote recovery of delta smelt.