Interagency Ecological Program for the San Francisco Estuary

IEP NEWSLETTER

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Evaluation of Adding Index Stations in Calculating the 20-mm Survey Delta Smelt Abundance Index

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The California Department of Fish and Wildlife (CDFW) conducts the 20-mm Survey annually to monitor the distribution and abundance of post-larval and juvenile Delta Smelt (*Hypomesus transpacificus*), a State and federally listed species. The survey began in 1995, and in the early 2000s CDFW used this data to develop an annual spring abundance index of young Delta Smelt. This article examines the inclusion of additional stations in determination of the index.

Delta Smelt are exclusively found in the upper San Francisco Estuary (Estuary). The 20-mm Survey samples this region annually from mid-March to early July via biweekly surveys to provide near-real-time data to water managers as outlined in the U.S Fish and Wildlife Service (USFWS) biological opinion (U.S. Fish and Wildlife Service 2008). The 20-mm Survey provides spatial and temporal data for young of the year (YOY) Delta Smelt, and generates an index of relative abundance. The index is calculated and distributed each year to provide a means of comparing annual changes in the Delta Smelt population.

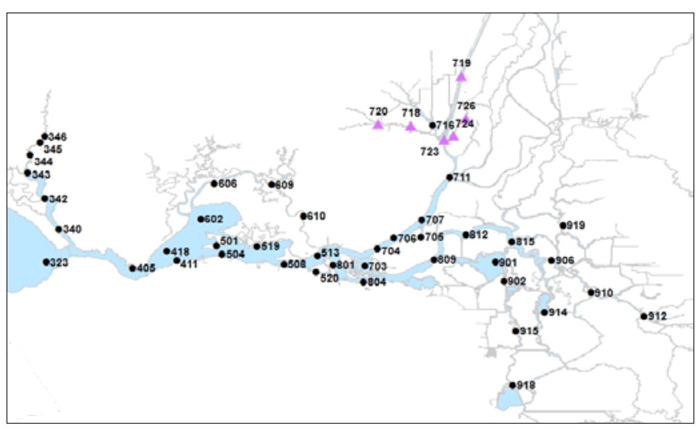
The index calculation uses data from 41 index stations, which are stations that have been routinely sampled since the inception of the Survey (Figure 1). In 2008, six stations in the north Delta were permanently added to the routine sampling regime, but in order to maintain consistency, data from these stations has not been included in the index calculation. Since 2008, 25–84 percent of the annual Delta Smelt catch has occurred at these non-index stations, with the highest proportions observed during drought years (Figure 2). Delta Smelt tend to spawn and rear further upstream during drought years (Wang 2007), as reflected in 20-mm Survey catches (Morris 2016). Recent low Delta Smelt catches, particularly at historic index stations, prompt an increasing need to understand Delta Smelt use of all regions of the estuary. This pattern asks the question, “How would the annual Delta Smelt index be affected if data from these non-index stations were included in the calculation?”

The index is calculated by summing the geometric means of Delta Smelt catch-per-unit-effort (CPUE) over four selected surveys (see steps below). To begin, the mean length of Delta Smelt is calculated for each survey. The index is composed of the two surveys just before and the two surveys just after the average fork length of Delta Smelt has reached 20 mm. The timing of this index period varies annually, but is always composed of the four surveys when YOY Delta Smelt are most efficiently retained by the gear. Once the index period is identified, the geometric mean is calculated for each of these four surveys. This is done taking the following steps:

For each of the four identified surveys:

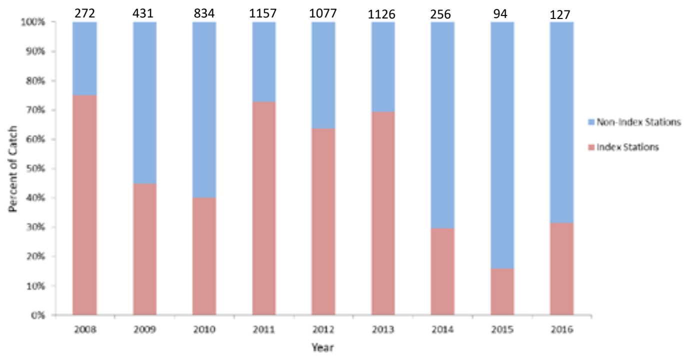
1. Calculate the Delta Smelt CPUE for each of the 41 index stations sampled as number

Figure 1 The 2016 CDFW 20-mm Survey station map, showing current routine sampling locations in the upper San Francisco Estuary.



Note: Stations marked with a black dot are index stations. Stations marked with a purple triangle are non-index stations.

Figure 2 The proportion of Delta Smelt catch at index stations and non-index stations by year.



Note: Data includes all surveys and annual catch is listed above the graph. Non-index stations have been sampled regularly since 2008.

of fish per 10,000 cubic meters of water sampled.

2. Add 1 to each station CPUE value and $\log_{10}$ transform the data.
3. Average all $\log_{10}$ transformed data in a survey to obtain one value.
4. Calculate the geometric mean of the survey by taking the back transformation of the single value and subtracting 1.

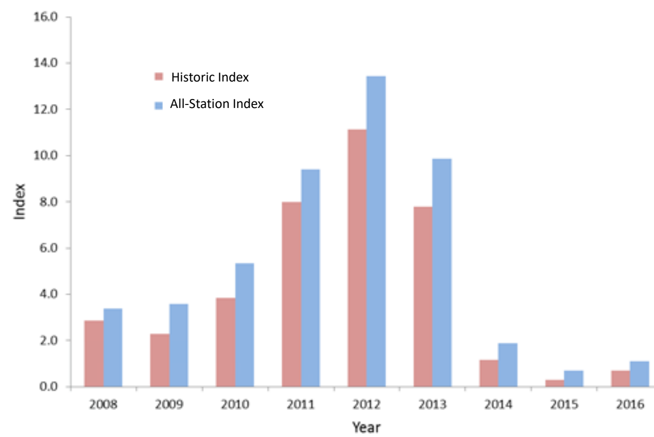
The annual index is the sum of these four geometric means.

Non-index stations were incorporated into the index calculation by making a single adjustment to the calculation. This was done by first calculating the Delta Smelt CPUE for all 47 routinely sampled stations, instead of just the 41 index stations. Then, the geometric mean was calculated for all routine stations sampled during each survey using the same equations described above (steps 2–4). For the purposes of this article, we define the index calculated with the 47 routinely sampled stations as the *all-station index*, and the index calculated with 41 index stations as the *historic index*.

I investigated how well the historic index can predict the all-station index for the 2008–2016 period. Specifically, I used least squares regression with the historic index as the independent variable and the all-station index as the dependent variable to examine the amount of variance explained by the coefficient of determination.

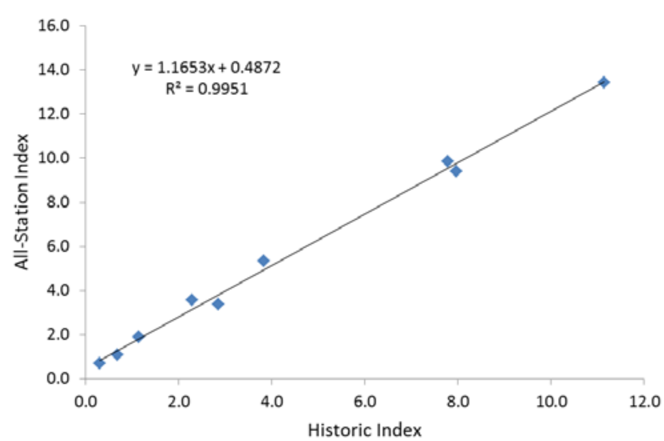
When all routinely sampled stations (n = 47) are incorporated into the index calculation, the index increases each year, but the overall trend does not change (Figure 3). For years 2008–2016, the results of the regression analysis revealed the dependent variable (historic index) could explain 99.5 percent of the variance in the all-station index (Figure 4) ($R^2 = 0.9951$, n = 9, P = < 0.0001). On average, the all-station index added a value of 1.2 to the historic index (Table 1). The percent change between the historic index and the all-station index was greatest during the drought years of 2014, 2015, and 2016, which may suggest that a higher proportion of Delta Smelt spawned and reared in the North Delta under those conditions.

Figure 3 The historic index and the all-station index calculated for each year.



Note: Non-index stations have been sampled regularly since 2008.

Figure 4 Scatterplot of the annual historic index and the annual all-station index.



Note: Non-index stations have been sampled regularly since 2008.

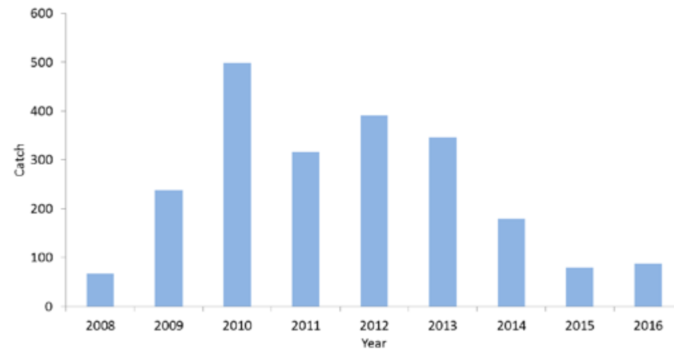
Table 1 Annual difference and percent change between the historic index and the all-station index.

Year	*Historic Index*	*New Index*	*Difference*	*Percent Change*
2008	2.9	3.4	0.5	18.7
2009	2.3	3.6	1.3	56.0
2010	3.8	5.3	1.5	39.0
2011	8.0	9.4	1.4	17.9
2012	11.1	13.4	2.3	20.5
2013	7.8	9.9	2.1	26.7
2014	1.1	1.9	0.7	65.1
2015	0.3	0.7	0.4	132.6
2016	0.7	1.1	0.4	60.6

Delta Smelt are regularly observed in the North Delta. In recent years, we have seen higher proportions of annual Delta Smelt catch at non-index stations; however, annual total Delta Smelt catch at these stations has generally decreased since 2012 (Figure 5). During the time of sampling, Delta Smelt abundance has decreased throughout the Estuary, but this decrease has been less extreme in the North Delta, including our non-index stations (Morris 2016). This suggests that Delta Smelt are likely facing similar, but possibly less extreme, challenges in the North Delta as they are throughout the Estuary during this time period.

Our data confirm that the use of historic 20-mm Survey index stations continues to be an appropriate way of calculating the annual Delta Smelt abundance index. Our current method allows for consistent calculations across the history of the survey, while simultaneously capturing the trends we see across the entire survey area. Because of the stability of

Figure 5 Delta Smelt catch at non-index stations by year.



Note: Non-index stations have been sampled regularly since 2008.

the overall trend in both index calculations, the interpretation of the annual 20-mm index does not change when non-index stations are included in the calculation. This suggests that the current index calculation is a good metric for describing annual abundance trends across the Estuary, as it is not heavily influenced by the exclusion or inclusion of north Delta stations.

More information on the 20-mm Survey methods, protocols, prior year indices, and data are available on our webpage: https://www.wildlife.ca.gov/Conservation/Delta/20mm-Survey.

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Wang, J. 2007. "Spawning, Early Life Stages, and Early life Histories of the Osmerids Found in the Sacramento-San Joaquin Delta of California." U.S. Department of the Interior, Bureau of Reclamation, Tracy Series Volume 38.

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