The following supplement accompanies the article

Abiotic and biotic controls on the copepod *Pseudodiaptomus forbesi* in the upper San Francisco Estuary

Karen Kayfetz*, Wim Kimmerer

*Corresponding author: karen.kayfetz@deltacouncil.ca.gov

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Analysis of change-points in the time series of salinity distribution of *Pseudodiaptomus forbesi*

INTRODUCTION

Starting in 1994 the zooplankton monitoring program was reduced to about 40% of its previous level of sampling effort. Stations were removed from the program or, in a few cases, replaced with nearby stations. Additional stations were added that moved with the salinity field to sample at salinity ~1 and 3, and sampling effort decreased from twice to once monthly. This reduction was nearly concurrent with the change we are trying to detect, so it was essential to take this into account when analyzing the data. Here we examine the influence of this reduction on our analysis of the change in distribution of *Pseudodiaptomus forbesi*

METHOD

Metadata for the zooplankton monitoring program is at http://www.water.ca.gov/bdma/meta/zooplankton.cfm (accessed 7 June 2017).

We used four different versions of the data set to ensure the analysis was robust (Table S1). Data set 0 was the full data set. Data set 1 included only stations that were sampled at least part of both time periods, except that two stations established in 1994 were close to previously sampled stations and were considered substitutes (NZD06 for NZ020 and NZ042, and NZD41 for NZ300 series). Data set 2 was identical to data set 1 except that we deleted one of each pair of surveys conducted each month before 1994 to make the temporal sampling effort the same throughout. Data set 3 was identical to data set 2 but excluded a group of stations that were sampled for less than half of either time period and all samples in San Pablo Bay and those that were positioned by salinity, leaving stations NZ020, NZ028, NZ032, NZ042, NZ048, NZ054, NZ060, NZ064, NZ074, NZ086, NZ092, NZD06, NZD19, NZD28, NZM10, and NZS42.

The shift in distribution of *P. forbesi* was quantified using each of the above sets of abundance data from June–October 1989–2014. Methods are described in the Methods of the main text.

RESULTS

For all four data sets and for the 25%, 50%, and 100% cutoffs for abundance the changepoint was identified between 1992 and 1993, and for the 10% cutoff it fell either between 1992 and 1993 or (in two cases) 1993 and 1994 (Table S1).

Confidence intervals did not overlap. For example, for Data Set 2 with 100% of the median used for a cutoff, the mean salinity before 1993 was 9.6 ± 0.9 and that during 1993 and later

was 2.9 ± 0.8. The changes in salinity were between 7 and 11 among all data sets and cutoffs. Using 10% and 50% cutoffs gave a similar result except that the 10% cutoff (with few data points at the high-salinity end of the distribution) showed the change to occur between 1993 and 1994.

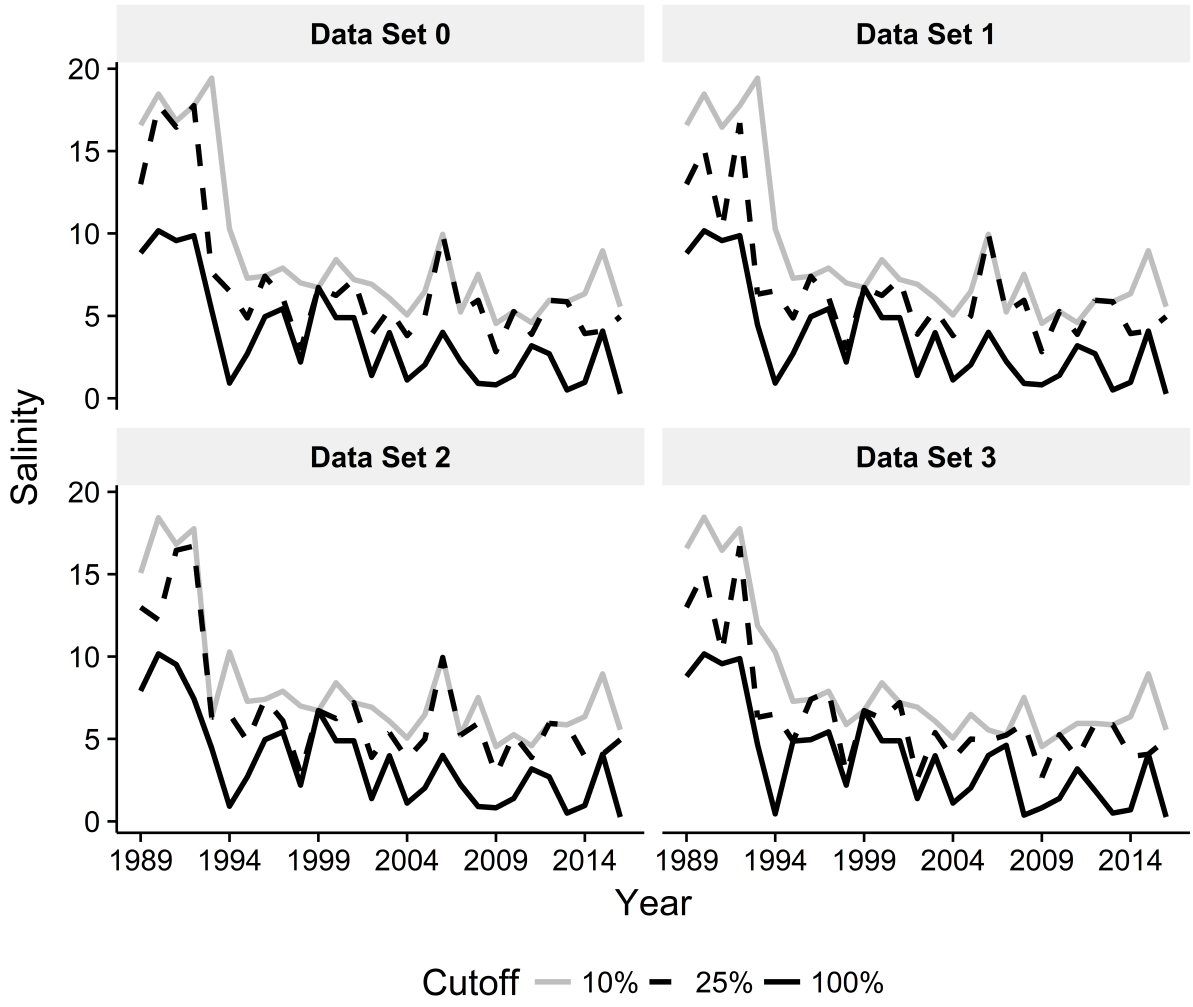

Figure S1. Results of change-point analysis of the high-salinity limb of the distribution of *P. forbesi* in salinity space. Data sets have been progressively reduced to try to eliminate bias due to changing sampling effort (see text and Table S1). The line for a cutoff of 100 gives the highest salinity at which the abundance of *P. forbesi* adults is at least 100% of the median in freshwater (S < 0.5) for June–October of that year.

Table S1. or each data set in Figure S1, the mean salinity values with 95% confidence intervals were calculated for the periods before and after 1993. None of the confidence intervals overlapped between the two time periods.

Data Set	N	Cutoff	1989-1992	1993-2016	Change
0	3958	100	9.6 ± 0.9	2.8 ± 0.8	–6.8
		25	16.2 ± 3.6	5.5 ± 0.7	–10.8
		10	17.4 ± 1.4	7.3 ± 1.3	–10.1
1	2767	100	9.6 ± 0.9	2.8 ± 0.8	–6.8
		25	13.8 ± 4.5	5.4 ± 0.7	–8.3
		10	17.3 ± 1.5	7.3 ± 1.3	–10.0
2	2373	100	8.8 ± 2.1	2.8 ± 0.8	–6.0
		25	14.6 ± 3.7	5.4 ± 0.7	–9.2
		10	17.0 ± 2.3	6.8 ± 0.6	–10.2
3	2209	100	9.6 ± 0.9	2.9 ± 0.8	–6.7
		25	13.8 ± 4.5	5.2 ± 0.6	–8.5
		10	17.3 ± 1.5	6.8 ± 0.7	–10.5