

New Bedford Harbor (NBH)
Long Term Monitoring (LTM) Program:
Comparative analysis of the 2014 LTM collection

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The NBH long-term monitoring (LTM) data are analyzed by EPA's Office of Research and Development, Atlantic Ecology Division (AED, Narragansett, RI), to assess spatial and temporal chemical and biological data trends and to evaluate the effects and effectiveness of Site remedial activities. In Nelson and Bergen (2012), there was a detailed analysis of the LTM data from the first five long term monitoring collections (1993, 1995, 1999, 2004, and 2009). The primary conclusions from this analysis were: 1) a significant spatial gradient in surficial PCB concentrations exists from the upper harbor (UH) to the lower harbor (LH), to the outer harbor (OH) and this spatial pattern was consistent in each of the five long-term monitoring collections, and 2) along this gradient, there is an increase in biological condition of the benthic community as PCB concentrations decreased. Further, since the initiation of large scale remediation in NBH, PCB surface concentrations have significantly decreased site wide. In addition to benthic community indices, blue mussels deployed twice yearly since 1993 have exhibited a consistent spatial gradient in bioaccumulated PCB concentration that has been maintained over time. Because the 2014 LTM collection did not analyze for sediment toxicity or metals, the present data analysis is focused on surficial sediment PCB concentrations, the EMAP benthic index, and blue mussel bioaccumulation data.

PCB concentrations

Spatial trends in NBH surficial sediment PCB concentrations were consistent with previous collections (decreasing from the UH to the OH). The differences between 2009 and

2014 concentrations are shown visually in the interpolated sediment PCB concentration maps (Figures 1-3) and show that in all areas of the Site, the PCB surface concentrations continue to decline. In the UH, 7 stations did exhibit significant decreases while the average concentration for the area remained the same (Figure 1). However, the % of surface area below the cleanup level of 10 ppm has continued to increase from 11% in 2009 to 19% in 2014 (Table 1). There were several UH stations that demonstrated increased PCB concentrations from '09 to '14 (Stations 109, 115, 128, 130); however, this is consistent with previous years and is probably due to small pockets of higher concentration deeper sediment exposed due to dredging. As in past remedial operations, these increases are localized and the surrounding areas remain lower indicating that the last 5 years of upper harbor dredging has not caused any appreciable recontamination across the sediment surface. In the LH (Figure 2), 10% of the surface sediment was above 10 ppm in 2009 and in 2014 that percentage dropped to zero, demonstrating that LH CAD cell work and flux from the UH have not caused surface sediment PCB values to increase. The LH did exhibit a statistically significant decrease ($p < 0.05$) in overall average PCB concentration from 5.1 ppm to 2.8 ppm with 21 of 29 stations exhibiting decreasing PCB concentrations. In the OH (Figure 3), the differences were smaller given the overall lower concentrations; however, the area greater than 1.0 ppm decreased from 0.7% in 2009 to zero in 2014. The data showed that 20 of 23 stations had decreased total PCB concentrations and the mean concentration dropped from 0.24 to 0.17 ppm although this decrease is not statistically significant. The totality of the PCB surface sediment data demonstrate a positive decrease in overall PCB concentration between 2009 and 2014.

EMAP benthic index

There are several benthic indices that can be calculated from the LTM benthic infauna data. One that has been used at this Site, is the Environmental Monitoring and Assessment Program's (EMAP) benthic index for the Virginian Biogeographical Province (Paul, *et. al*, 2001). This biodiversity index was developed to assess estuarine benthic condition from Cape Cod, MA to the mouth of Chesapeake Bay, VA. The original index was based on three metrics: salinity-normalized Gleason's D, salinity-normalized tubificid abundance, and abundance of spionids. For the NBH study, only two of these metrics are used: Gleason's D and Spionid abundance. Tubificid abundance is only considered important in low salinity waters (close to zero salinity), and the New Bedford Harbor study area is saline. A value of zero is considered the cut-off for distinguishing "Good" and "Poor" conditions (i.e., positive values are good, negative values are poor).

Consistent with the other LTM variables, there is a similar spatial pattern for the EMAP benthic index; the UH exhibited the worst condition, as evidenced by the large negative values observed in each collection year (i.e., degraded condition), the LH was significantly improved relative to the UH, with values near zero, and the OH was always significantly highest with positive values, indicative of a good benthic community (Figures 4-6). Temporally, the percent of stations in each harbor segment exhibiting a positive or "good" benthic index for each year of the LTM program are shown in Figure 7. The OH (Figure 6) stations are almost all positive for every year. A consistent increase in the number of stations with "good" benthic condition can be seen in the LH (Figure 5) and this is consistent with the observed decreasing PCB surface concentrations. Even in the UH (Figure 4), an increase in the percent of stations with "good" benthic readings can be seen in 2009 and 2014. The overall increase in benthic health, combined

with the decreasing PCB concentrations, indicates improvement in the Site condition. It is reasonable to think that increased removal of PCB contaminated sediment will continue, and possibly accelerate, these positive trends.

Mussel PCB bioaccumulation

The seafood monitoring program is augmented by the deployment of blue mussels (*Mytilus edulis*) as part of the comprehensive long-term monitoring program for the Site (Nelson and Bergen, 2012). Mussel deployments have been conducted twice annually since 1993 by EPA's Office of Research and Development's Atlantic Ecology Division (AED Narragansett, RI) at three stations: NBH-2 (Coggeshall St Bridge), NBH-4 (Hurricane Barrier), and a reference site in Buzzards Bay NBH-5 (West Island). In addition, there were monthly deployments during the 1994-1995 Hot Spot remediation for a total of 51 28-day deployments. The mean total PCBs (as the sum of 18 congeners) in the blue mussel tissue for all three stations are shown in Figure 8. Consistent with the PCB water column concentration gradient across this area, there is a significant spatial gradient among stations in PCB tissue concentrations. There is an approximate five-fold decrease in overall mean concentration between stations NBH-2 (35 ppm) and NBH-4 (8 ppm) and over an order of magnitude decrease between station NBH-4 (8 ppm) and NBH-5 (0.5 ppm). The PCB differences among stations are maintained over time; however, all stations exhibit seasonal variability due to the mussel reproductive cycle, where lipid-rich gametes increase during the year (along with lipophilic organic contaminants such as PCBs), then decrease during spawning (Figure 9). This pattern has also been observed in the NBH indigenous ribbed mussel population as well (Bergen et al., 2001). Monthly deployments during

the Hot spot remediation demonstrated that increases in mussel bioaccumulation were more closely linked to storm events than to dredging activities (Bergen et al., 2005).

The data indicate that in the time period between 1993 and 2014, no net change in PCB water column concentration and subsequent mussel bioaccumulation has occurred, primarily because the exposure to PCBs has not been altered dramatically along this gradient over time. While the overall mass of PCBs removed from the harbor has been significant, especially during the Hot Spot removal, the average water column PCB concentrations near the mussel stations have not appreciably decreased. It is reasonable to expect that once full remediation is complete, surface water PCB concentrations will decrease, leading to a concomitant decrease in mussel PCB tissue concentrations.

References:

Bergen, B.J., W.G. Nelson, J.G. Quinn, and S. Jayaraman. 2001. Relationships among total lipids, lipid classes and PCB concentrations in two indigenous populations of ribbed mussels (*Geukensia demissa*) over an annual cycle. *Environmental Toxicology and Chemistry* 20 (3): 575-581.

Bergen, B.J., W.G. Nelson, J. Mackay, D. Dickerson, and S. Jayaraman. 2005. Environmental Monitoring of Remedial Dredging at the New Bedford Harbor, MA, Superfund Site. *Environmental Monitoring and Assessment* 111:257-275.

Nelson, W.G. and B.J. Bergen (2012) The New Bedford Harbor Superfund site long-term monitoring program (1993-2009). *Environmental Monitoring and Assessment* 184: 7531-7550.

Paul, J.F., K.J. Scott, D.E. Campbell, J.H. Gentile, C.S. Strobel, R.M. Valente, S.B. Weisberg, A.F. Holland, J.A. Ranasinghe. 2001. Developing and applying a benthic index of estuarine condition for the Virginian Biogeographic Province. *Ecological Indicators* 1: 83-99.

Table 1: Comparison of NBH sediment surface area (percent) for various PCB concentration ranges (as sum of 18 congeners) between the 2009 and 2014 LTM collections.

	Upper		Lower		Outer	
	2009	2014	2009	2014	2009	2014
< 1 ppm	0.1	0.3	2	9	99	100
1-10 ppm	11	19	88	91	1	-
10-50 ppm	46	40	10	-	-	-
50-100 ppm	8	18	-	-	-	-
>100 ppm	34	22	-	-	-	-

Figure legends:

Figure 1: Spatial distributions of the interpolated sediment PCB concentration data for the upper harbor for the 2009 (a) and 2014 (b) long-term monitoring collections. Total PCB concentrations are for the sum of 18 congeners.

Figure 2: Spatial distributions of the interpolated sediment PCB concentration data for the lower harbor for the 2009 (a) and 2014 (b) long-term monitoring collections. Total PCB concentrations are for the sum of 18 congeners.

Figure 3: Spatial distributions of the interpolated sediment PCB concentration data for the outer harbor for the 2009 (a) and 2014 (b) long-term monitoring collections. Total PCB concentrations are for the sum of 18 congeners.

Figure 4: Values of the EMAP benthic index for each of the upper harbor long-term monitoring stations in 2009 (a) and 2014 (b).

Figure 5: Values of the EMAP benthic index for each of the lower harbor long-term monitoring stations in 2009 (a) and 2014 (b).

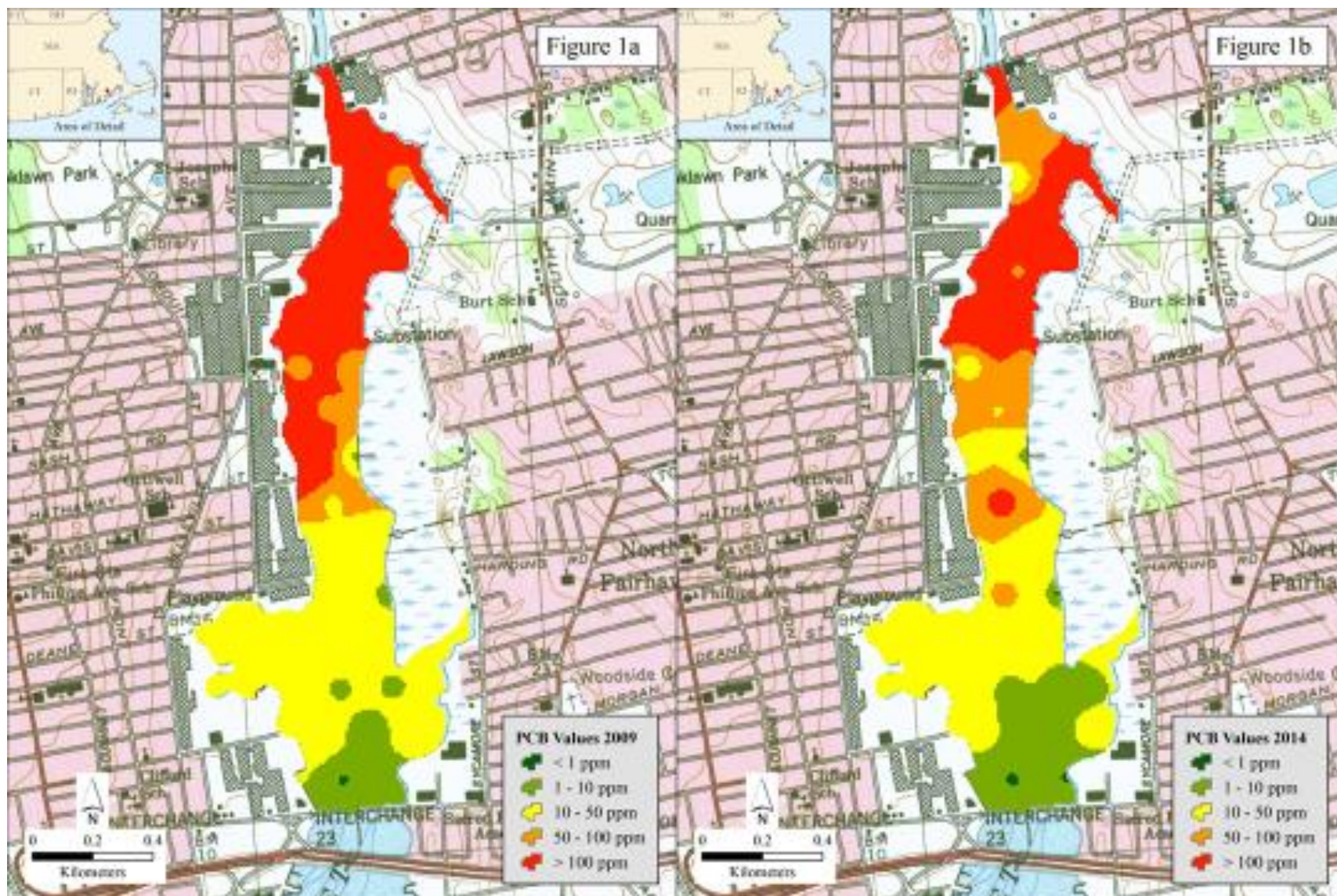
Figure 6: Values of the EMAP benthic index for each of the outer harbor long-term monitoring stations in 2009 (a) and 2014 (b).

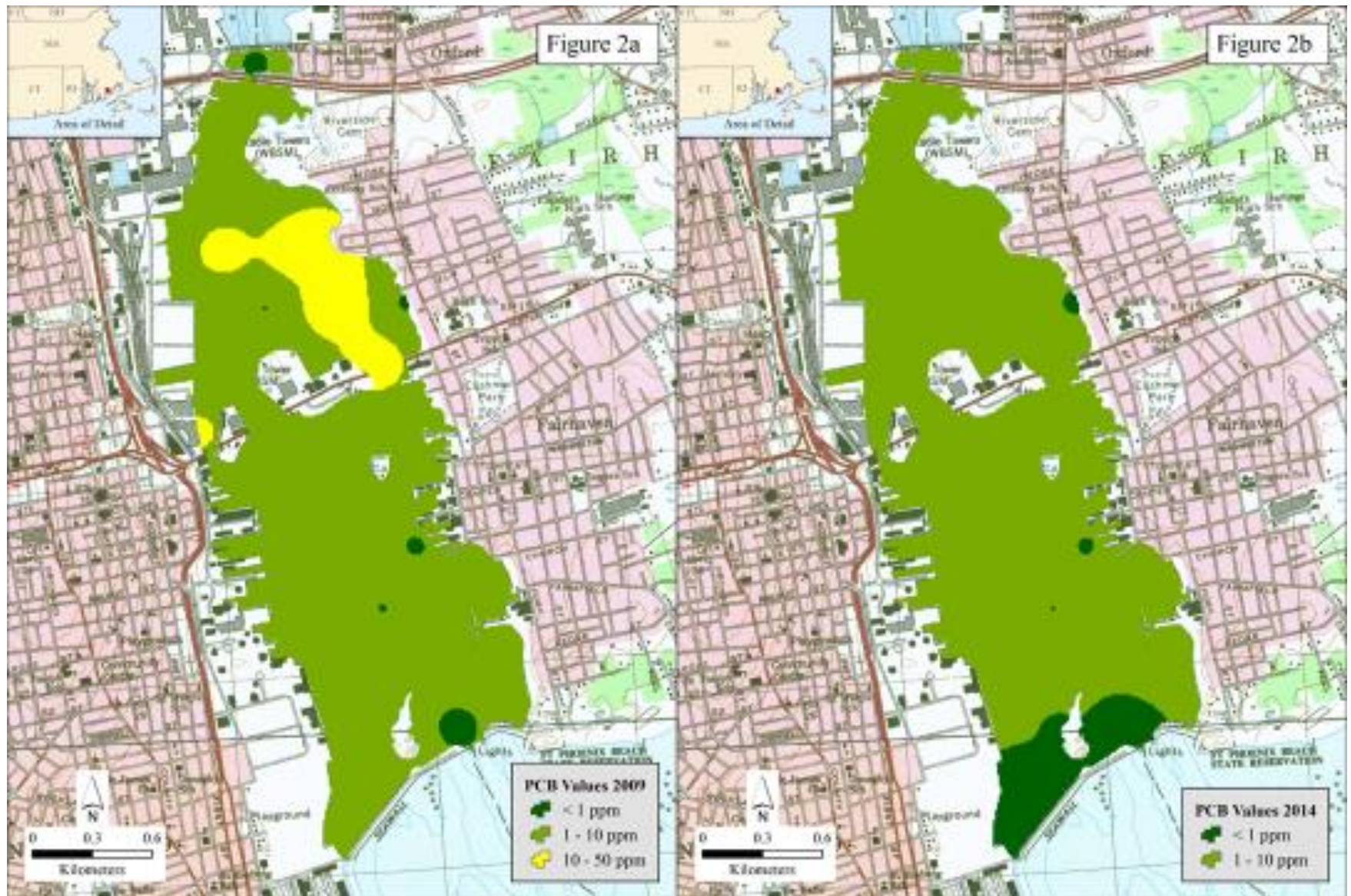
Figure 7: Percent of stations exhibiting a positive (good) EMAP benthic index for each of the six

NBH long-term monitoring collections.

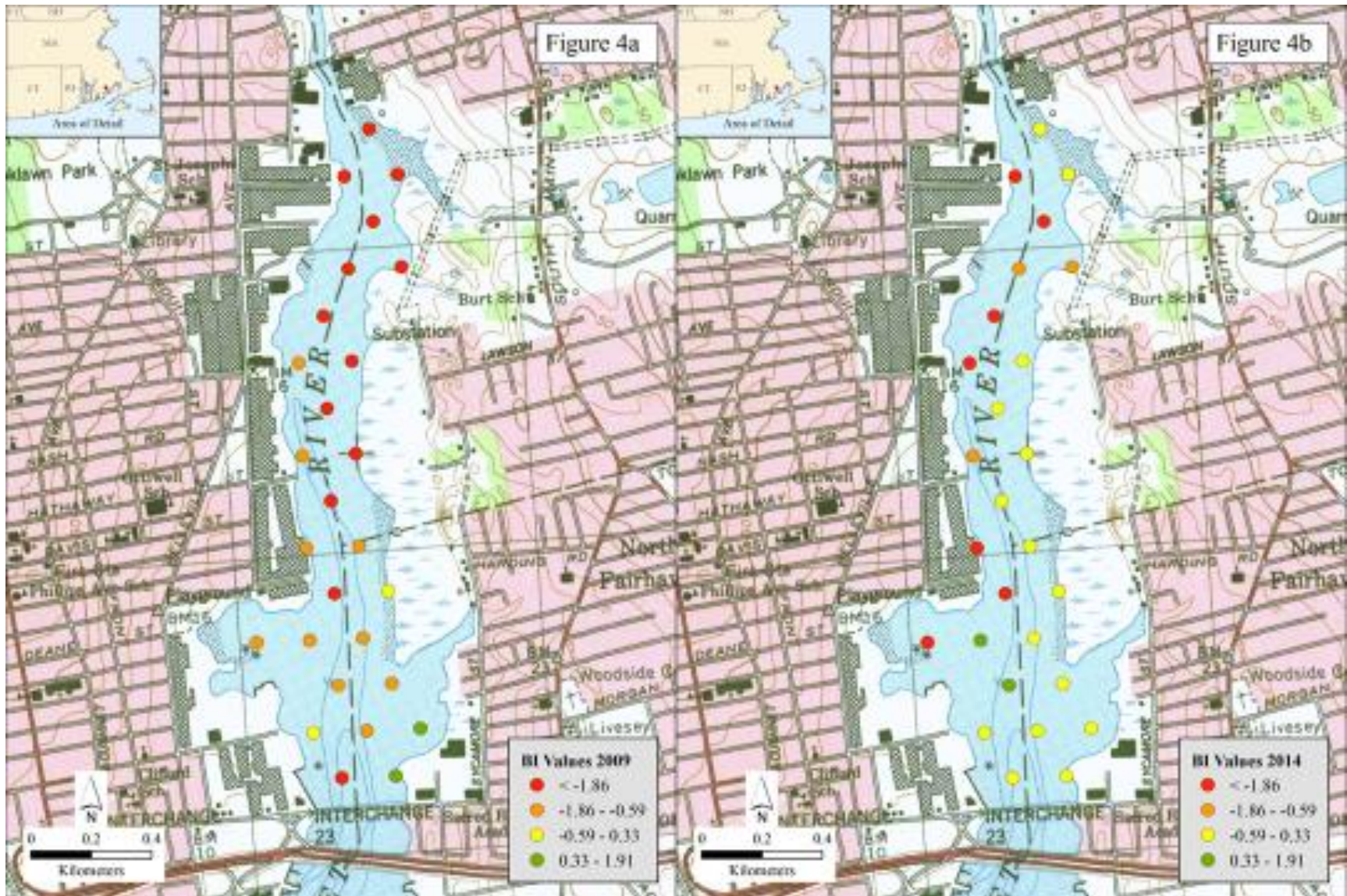
Figure 8: Overall mean (\pm standard deviation) in blue mussel PCB tissue concentrations measured at three stations for all deployments since 1993 baseline collection.

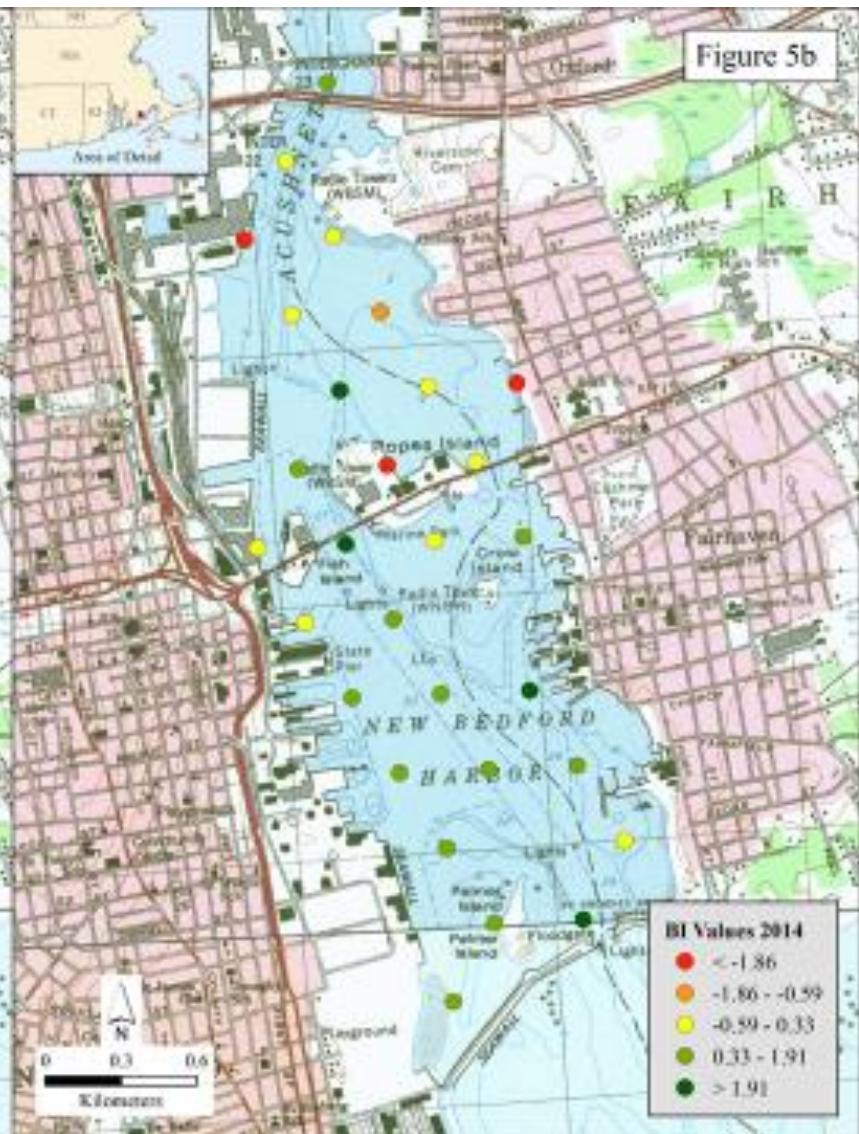
Figure 9: Mean (\pm standard deviation) in blue mussel PCB tissue concentration for each deployment at Coggeshall St NBH-2 (a), the Hurricane barrier NBH-4 (b) and West Island NBH-5 (c).











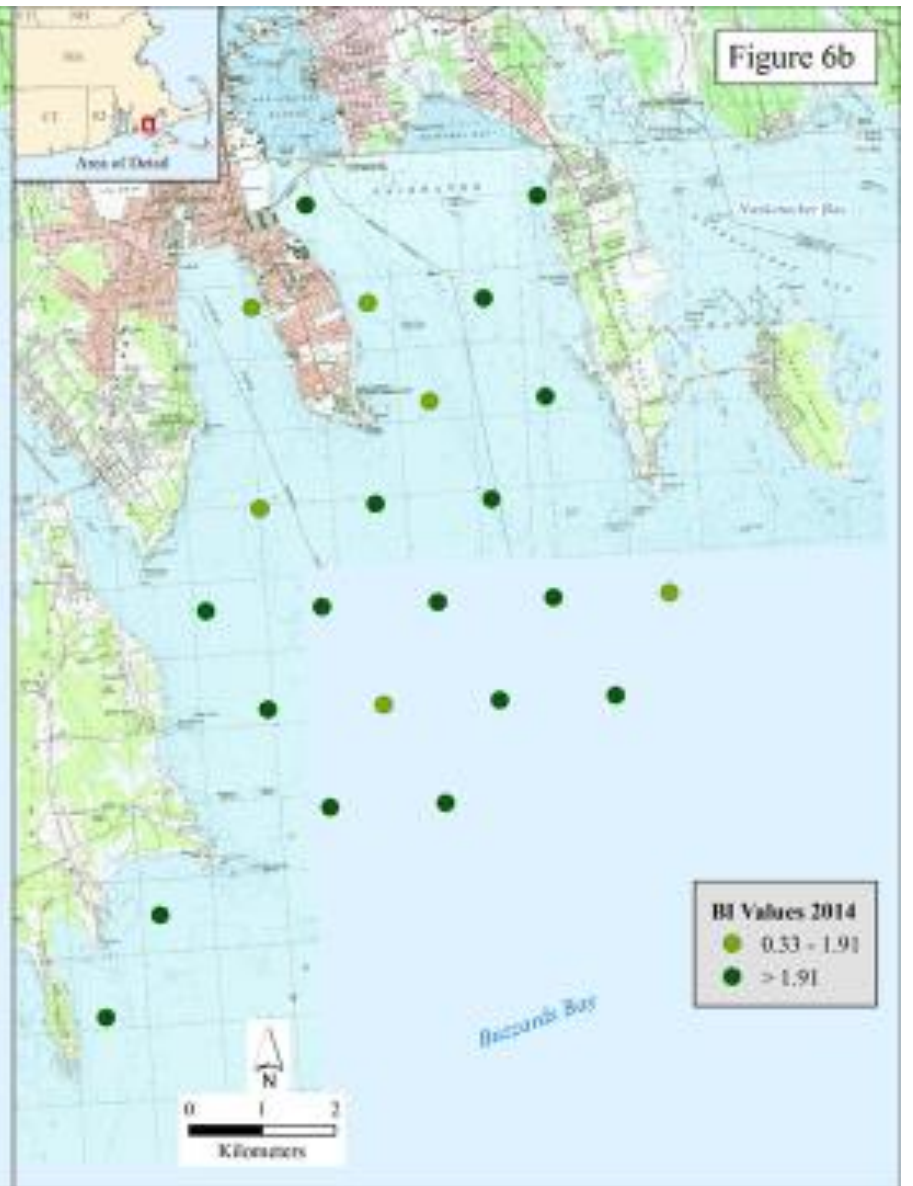
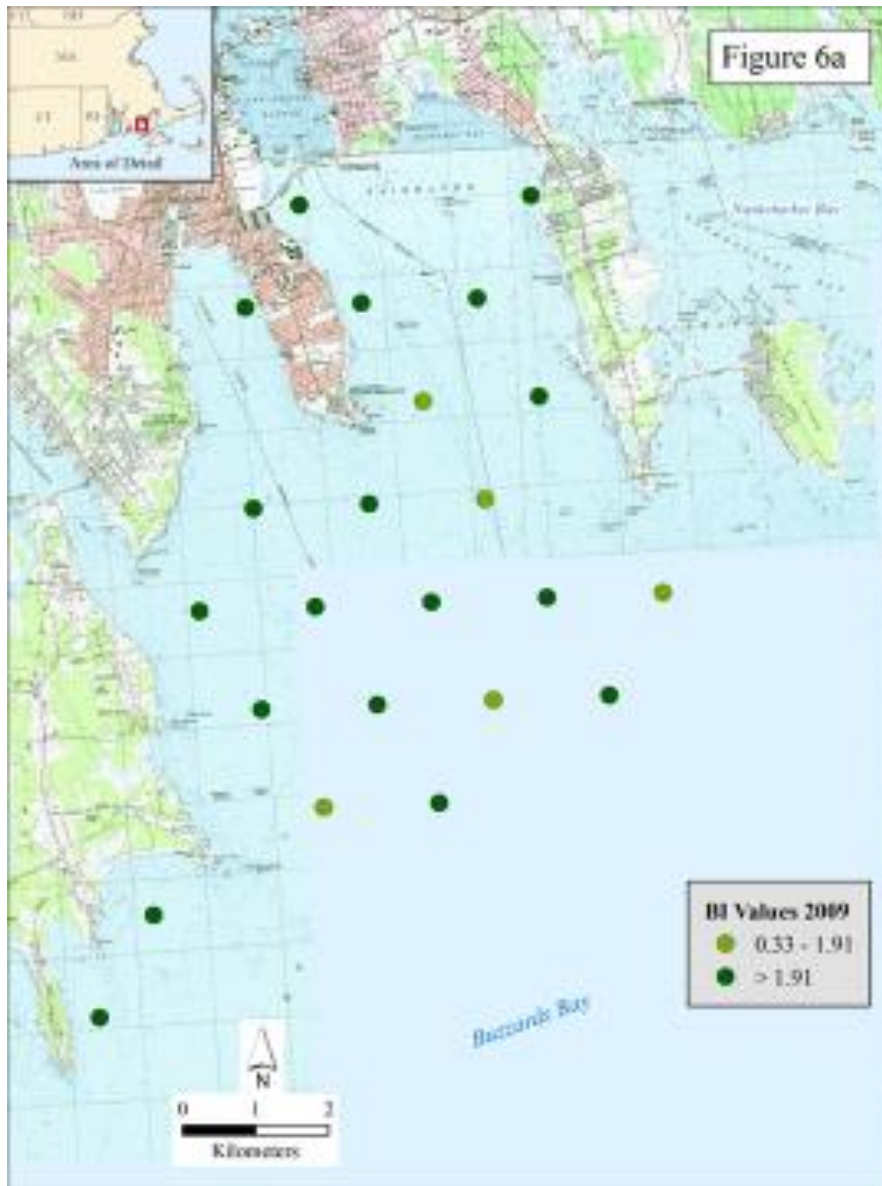


Figure 7

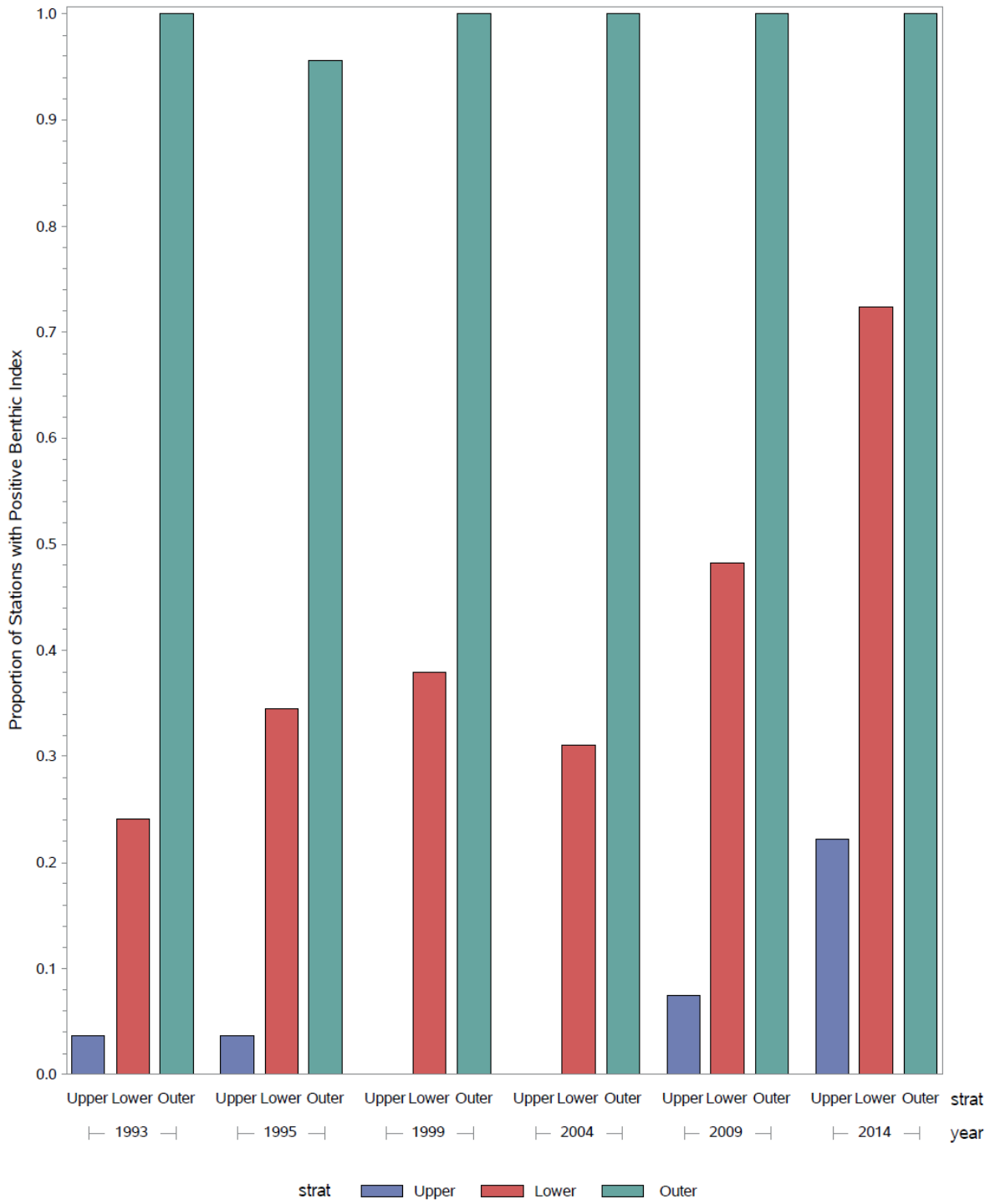
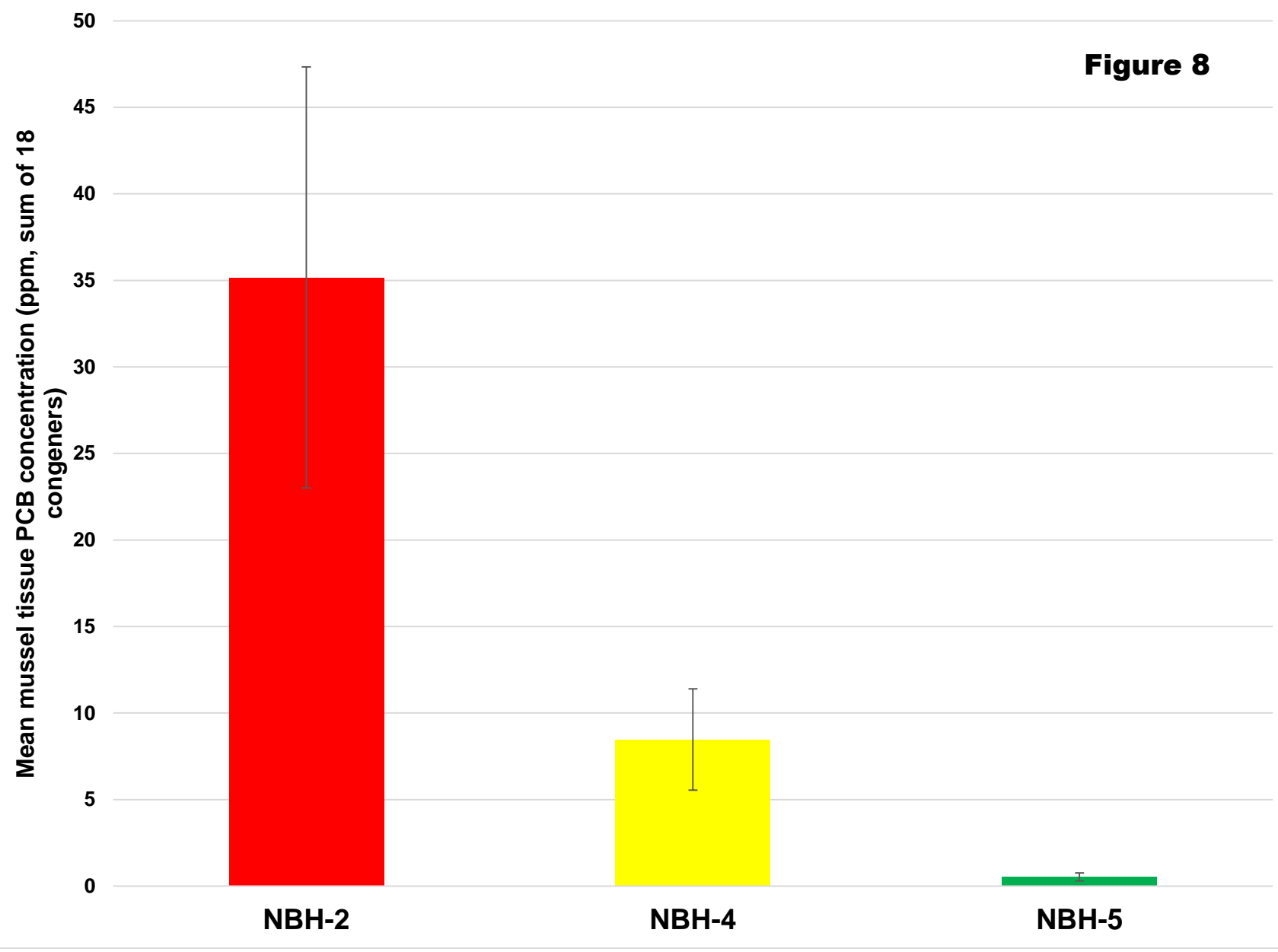
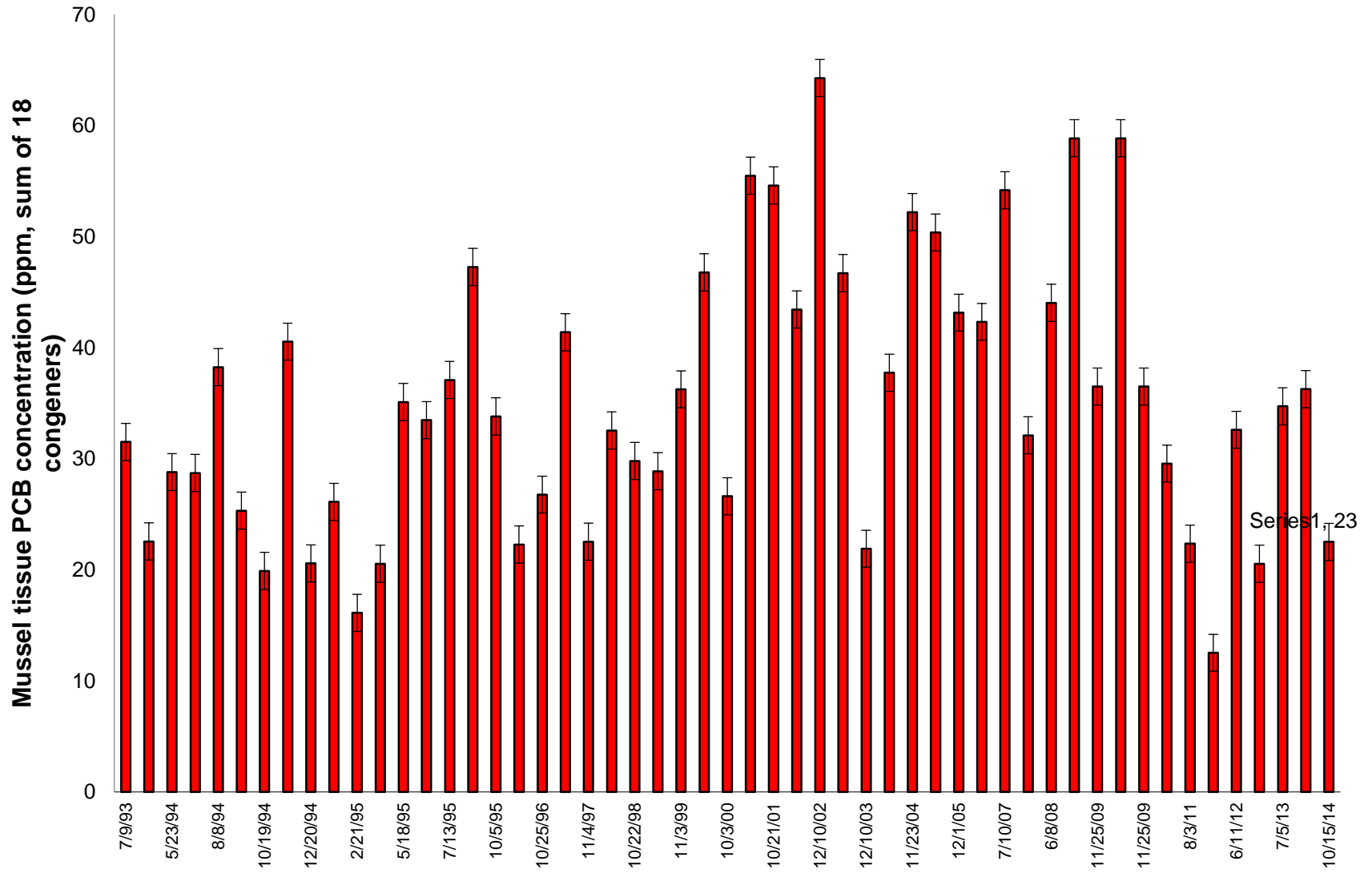


Figure 8



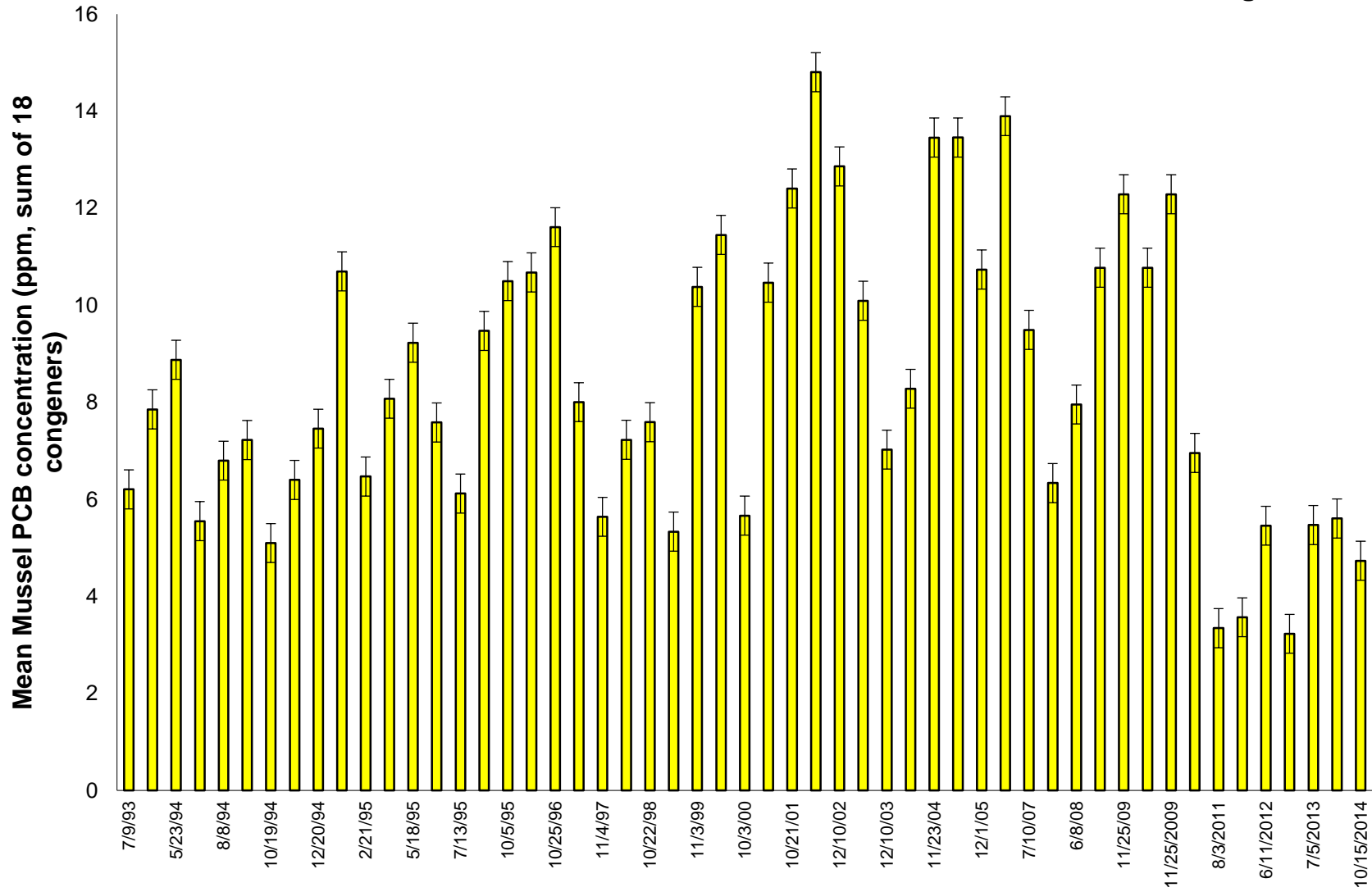
Station NBH-2

Figure 9a



Station NBH-4

Figure 9b



Station NBH-5

Figure 9c

