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NIAGARA RIVER AREA OF CONCERN CONTAMINATED SEDIMENT SITE ASSESSMENT

LYON'S CREEK EAST PCB DECAY STUDY

Submitted to:
Niagara Peninsula Conservation Authority
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REPORT

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1.0 INTRODUCTION

The Phase IV studies identified Monitored Natural Recovery as the preferred option for addressing PCB contaminated sediments in Lyon's Creek East. In order for MoNR to be an appropriate and effective option for sediment management, additional studies have been undertaken to assess sediment dynamics within the system to understand whether sediment accrual is occurring, and at what rate, in order to assess the potential reduction in exposure to PCBs of the receptors assessed in the Ecological Risk Assessment.

Since PCBs can also undergo reductive dechlorination, the potential future exposure of receptors is dependent not only on sediment accrual, but is influenced by potential decay of the PCBs. As a result, the current assessment has been conducted to satisfy the following objectives:

■ Develop an understanding of the mechanisms by which PCB decay can occur, and whether the factors influencing these mechanisms would be present in Lyon's Creek East;

■ To understand the rate at which PCB decay may occur, and the factors affecting the rate of decay; and

■ To assess whether PCB decay through the known mechanisms has occurred, and how this may affect exposure of biota in the future.

The assessment is conducted through the following steps:

■ Section 2 provides a review of the current understanding of PCB decay, including the factors influencing the decay, and the mechanisms by which decay occurs.

■ Section 3 provides an assessment of whether decay has been a factor in sediments of Lyon's Creek East.

■ Section 4 provides an estimate of the time required for reduction of PCBs to dichlorinated congeners through dechlorination in Lyons' Creek East sediments.

2.0 THEORETICAL REVIEW OF PCB DECAY

In order to assess whether natural decay of PCB compounds in sediments is a significant contributor to reduction of exposure of biota to PCBs, a review of the current understanding of the mechanisms of PCB decay is provided in this section of the report. The review summarizes the processes by which PCB decay is believed to occur, a review of approaches to assessing PCB decay, and the availability of predictive models by which PCB decay could be quantified.

The basic structure of PCBs consists of two benzene rings, with variable placement of chlorines around the ring. PCBs can contain from 1 to 10 chlorines, resulting in the possible formation of 209 individual congeners. The basic structure, and the numbering of the chlorine atoms is shown in the figure below:
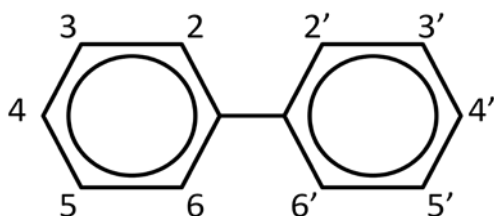
Toxicity of PCBs can vary with the placement of the chlorine atoms. Among the more toxic of the PCB congeners are those that are structurally similar to dioxins, and these are typically characterized by having chlorines in the *meta* positions (i.e., 3, 3', 5, 5') and *para* positions (i.e., 4, 4'). These are commonly referred to as the co-planar non-ortho PCBs. Placement of PCBs in the ortho positions (i.e., 2, 2', 6, 6'), alters the 3-dimensional configuration of the molecule (i.e., it is no longer co-planar), with the result that the molecule is no longer structurally similar to dioxins. The position that the chlorines occupy can also affect the decay characteristics. A described in the remainder of this section, dechlorination appears to favour removal of chlorines from certain positions.

Rhee *et al.* (1993) conducted a series of tests to assess PCB decay rates using spiked sediments. Their studies found that over the course of the seven month tests, there was a dramatic change in the PCB profile characterized by a shift from high-molecular weight congeners to low-molecular weight congeners. These changes occurred despite a lack of change in the total molar concentration of the PCBs, indicating that the transformation involved only dechlorination and not a loss of PCB molecules. They also observed that at the intermediate PCB concentrations (300-500 µg/g PCB dry weight) 21-25% of the total PCB was dechlorinated in the first three months, but that this rate decreased considerably in the remaining 4 months. They noted as well that the dechlorination involved the chlorines in the *meta* and *para* positions, but that there was no observed dechlorination of chlorines in the *ortho* positions over the course of the tests. They noted that at the optimum concentration (500 µg/g d.w.), approximately 54% of the *meta*-chlorine was removed in the initial three months, a further 5% was removed in the following 1.5 months [i.e., a total of 59%], with a total of 65% removal attained after 7 months. As well, they observed an increase in trichlorobiphenyl initially as higher chlorinated congeners were dechlorinated, and that further dechlorination of these intermediate products only occurred late in the tests.

Rhee *et al.* (1993b) noted there was clear evidence of dechlorination of PCBs in spiked sediments after a 6 month incubation period, under methanogenic conditions. In contrast, there was evidence of partial inhibition of dechlorination under sulfidogenic and nitrate-reducing conditions, with complete inhibition noted under conditions of nitrate enrichment. Under methanogenic conditions, the authors noted a 80% decrease in pentachlorinated biphenyls, and a 50% reductions in tetrachlorinated biphenyls. In comparison, under sulfidogenic conditions, the penta- and tetrachlorinated biphenyls decreased by 20% and 16% respectively. The authors observed that there was no quantitative difference in the congeners involved under either methanogenic or sulfidogenic conditions. However, the authors noted that methanogenic conditions were not required for PCB dechlorination, and under tests where methanogenesis was artificially inhibited, there was little effect on dechlorination, at least for the single congener (2,3,4-TCB) used in the test. The authors concluded that natural sediment conditions, particularly the presence of inhibitory compounds, could affect PCB dechlorination, and that it could not be assumed that PCBs would naturally undergo biotransformation in all sediments.

Rhee *et al.* (1993c) observed that chlorine removal was determined by the pattern of chlorine substitution rather than the substitution position. They further determined the dechlorination sequence and products for a number of individual congeners through spiked sediment tests conducted over a period of 15 months.

Quensen *et al.* (1998) used EROD induction potencies to assess whether reductive dechlorination resulted in a change in calculated TEQs (as compared to that of TCDD), and thereby reduced potential toxicity of the PCBs. Testing was performed using two different sediments with different microbial constituents, spiked with Aroclor 1242 and 1254. Among the results was the observation that there were substantial differences between the dechlorination rates in the two test sediments. After a 9 month period, the authors noted that for Aroclor 1242

there was 56% removal of *meta* and *para* chlorines in the one sediment compared to 40% removal in the other, while for Aroclor 1254 there was 54% removal vs. 42% removal in the same sediments. The authors noted that removal of chlorines appeared to be confined to those in the *meta* and *para* positions, with no evidence of removal of chlorines in the *ortho* position. Thus, the study indicated that microbial competence was a clear factor in the dechlorination of PCBs.

The authors noted that the dechlorination resulted in a reduction of the calculated TEQ for the PCB mixture resulting in a reduction of coplanar PCBs. The coplanars have been described as most dioxin-like in their mode of toxicity and are potent AhR agonists. Thus, the results of the study suggested that dechlorination could reduce potential toxicity of the PCB mixture.

Willman *et al.* (1997) noted that PCBs substituted at two *para*, two or more *meta* and no *ortho* positions have exhibited maximum TCDD-like activities (e.g., IUPAC congeners 77 [3,3',4,4'-tetrachlorobiphenyl], 126 [3,3',4,4',5-pentachlorobiphenyl] and 169 [3,3',4,4',5,5'-hexachlorobiphenyl]). They also noted that the mono-*ortho* congeners [i.e., those congeners with a single chlorine in the *ortho* position] (IUPAC 105 [2,3,3',4,4'-pentachlorobiphenyl], 114 [2,3,4,4',5-pentachlorobiphenyl], 118 [2,3',4,4',5-pentachlorobiphenyl], 123 [2,3',4,4',5'-pentachlorobiphenyl], 156 [2,3,3',4,4',5-hexachlorobiphenyl] and 157 [2,3,3',4,4',5'-pentachlorobiphenyl]) produced toxic responses in mammals but that these were less active in fish. [*Note*: 2,2',6 and 6' are *ortho* positions, 3,3',5 and 5' are *meta* positions, and 4 and 4' are *para* positions].

Sokol *et al.* (1998) undertook studies to assess the concentration dependence of PCB dechlorination in sediments that was prompted by earlier studies in which a substantial reduction in the dechlorination rate at low PCB concentrations was noted. Using sediments spiked with PCBs across a range of concentrations from 1-200 µg/g, the authors determined that a clear threshold in dechlorination was found between 35 and 45 ppm of PCBs. Below 35 ppm, no dechlorination was found to have taken place over the 58 week test period. Above the threshold concentration, an initial lag period was noted where no dechlorination took place, followed by a period of rapid dechlorination, which reached a plateau below which no further dechlorination occurred. The tests also showed the greatest dechlorination occurred at the highest concentrations. The authors attributed the difference in part to limited dechlorination of the accumulating congeners at low PCB concentrations, while at higher PCB concentrations there was accumulation of intermediate dechlorination products that were subsequently dechlorinated further to dichlorobiphenyls.

Cho *et al.* (2003) using sediments spiked with Aroclor 1248 noted a threshold level for dechlorination of 40 µg/g below which no dechlorination was observed. Above this threshold, two groups of congeners were noted: those that dechlorinated at concentrations above 40 µg/g and a second group that dechlorinated at concentrations above 60 µg/g. They observed that for both groups, the dechlorination rate was a linear function of initial sediment concentration. The authors noted that the threshold concentration for Aroclor 1248 appeared to be related to the growth of dechlorinating microorganisms, and the studies suggested that dechlorination was effected by multiple types of dechlorinating microorganisms with distinct dechlorinating capabilities that could lead to differences in the dechlorination kinetics of individual congeners.

Magar *et al.* (2005a) assessed whether dechlorination had occurred in sediments at the Lake Hartwell Superfund Site. The authors compared PCB congener distribution in core samples between surficial layers and deeper, older layers to determine whether there was a measurable change in the distribution of congeners. In particular, they focused on whether there was a shift in congener distribution toward the end products of reductive dechlorination, i.e., the mono- through trichlorinated biphenyls. They noted that the mono- through trichlorinated

biphenyls comprised 80% of the PCBs in the deeper sediments of those sediment cores that underwent maximum dechlorination, compared to 20% in surface sediments, with the major decreases occurring in the tetra- through hexachlorinated biphenyls. The approach used by the authors permitted a general assessment of dechlorination at the site, and through radiological dating, permitted calculation of a rate of decay. The authors compared the congener distribution in surface sediments to the congener distributions in deeper sections of the same core. Any changes in congener distribution were considered to be a result of dechlorination. The approach was predicted on the understanding that PCBs in the surface sediments had not been subjected to the same physical conditions (i.e., anoxic conditions) that would promote dechlorination in the subsurface layers. The study results indicated that dechlorination occurred over time, and that there was a demonstrable change form higher to lower chlorinated congeners with increasing sediment depth and age. The results were presented graphically by subtracting the congener concentrations in the deeper sections of the core from the surface concentrations. The changes (positive or negative) for each congener, showed the changes that had occurred over time. The most pronounced changes were the increases in the relative concentrations of the mono-, di-, and trichlorinated congeners, and a corresponding decrease in the penta- through octachlorinated congeners.

Magar *et al.* (2005b), continuing the studies initiated at Lake Hartwell, noted that reductive dechlorination resulted in the preferential loss of chlorines from the *meta-* and *para-* positions, but no measurable loss of chlorines from the *ortho* positions. Based on their studies, they calculated an average dechlorination rate of 0.094±0.063 mol of Cl/mol of PCB/yr that indicated 16.4±11.6 years were required per *meta+para* chlorine removal (meta- and para chlorine removal could not be calculated separately due to coeluting congeners). The range reported varied from 4.3 years to 43.5 years per chlorine removal. In contrast to other studies, they reported evidence of dechlorination even at low PCB concentrations (0.1 to 0.7 mg/kg). They observed that in the deeper cores that had undergone maximum dechlorination, the mono- through trichlorobiphenyls comprised approximately 80% of the total PCBs with the tetra- through hexachlorobiphenyl homologues comprising the remaining 20%. They noted this represented a 50% shift from the tetra- through hexachlorobiphenyls to the mono- through trichlorobiphenyls. However, they noted that the extent of dechlorination was inconsistent among cores collected at different locations in their study site, and that these inconsistencies were not related to PCB concentration, or the presence of organic carbon (TOC), indicating that other factors were also involved.

Pakdeesusuk *et al.* (2005) investigated PCB decay under natural conditions in the sediments of Twelve Mile Creek Arm of Lake Hartwell in South Carolina. The authors noted that assessment of PCB decay is typically based on comparison of the congener composition between the parent compound and the congener pattern in the environmental samples. This is based on the understanding that PCB decay proceeds through reductive dechlorination of PCB congeners, with the higher chlorinated compounds generally more susceptible to dechlorination than the lower chlorinated compounds. The authors note that dechlorination generally proceeds through removal of chlorines from the *para-* and *meta-* positions, while the chlorines in the *ortho-* positions are more resistant to removal. As a result, aged PCBs that have undergone dechlorination typically show a greater accumulation of lower chlorinated congeners relative to the original product.

The authors noted, however, that comparison of environmental congener composition to the original PCB congener composition suffered from a number of difficulties that could affect the assessment. In particular, they noted that there was considerable variation in the physico-chemical properties of the individual congeners that resulted in variation in their susceptibility to volatilization, solubilisation, sorption or microbial degradation. Both solubilisation and volatilization, particularly of the lower chlorinated congeners that are the end product of the dechlorination of higher chlorinated congeners, could provide misleading interpretations. Their approach

therefore consisted of comparison of congener concentrations at "equivalent" depths between samples collected in 1987 and 1998. "Equivalent" depths were determined through matching the total PCB concentration profiles for the two time periods [i.e., the approach is based on the assumption that PCB decay occurs through reductive dechlorination, with no overall reduction in PCB concentrations].

The results indicated that while in general there was no overall decrease in PCB concentrations at equivalent depths, there was a shift in congener distribution, expressed as an increase in the percent of lower chlorinated congeners. Based on their results, the authors concluded that reductive dechlorination may proceed through an initial rapid phase when the PCBs are released to the environment, followed by an extended period where there is little or no detectable activity, which the authors described as a plateau phase that was not likely to result in any further significant decrease in total PCBs. Finally, the authors noted that slow dechlorination can continue at very low PCB concentration, contrary to other reports in the literature (Sokol *et al.* 1998) that note a threshold of 35 µg/g to 45 µg/g for dechlorination.

Bzdusek *et al.* (2006) conducted studies on the sediments of the Sheboygan River Inner Harbour (Wisconsin). Cores were collected form a number of locations, and analysis of surficial and deeper sediments was undertaken for a total of 39 congeners. The historical use of PCBs at the site had been documented previously, and was known to consist of Aroclors 1248 and 1254. The authors reported that the congener profiles from the deeper sediments did not resemble the original Aroclor profiles for 1248 or 1254, nor a 50%:50% mixture of these two Aroclors, and appeared to be a dechlorinated profile of a mixture of the two Aroclors. In particular, they noted low concentrations of congeners 25 [2,3',4-trichlorobiphenyl] and 26 [2,3',5-trichlorobiphenyl] in the sample, though both are important contributors to the average PCB concentrations in the original Aroclors. The authors also noted that there was evidence of downward migration of the lower chlorinated congeners in some of the cores, and explained this phenomenon on the basis of the higher aqueous solubility and hence mobility of these congeners. They noted in their studies on the 39 congeners, that the most important dechlorination reactions included:

■ PCB 66 [2,3',4,4'-tetrachlorobiphenyl] to PCB 25 [2,3',4-trichlorobiphenyl],

■ PCB 18 [2,2',5-trichlorobiphenyl] to PCB 4 [2,2'-dichlorobiphenyl],

■ PCB 44 [2,2',3,5'-tetrachlorobiphenyl] to PCB 16 [2,2',3-trichlorobiphenyl],

■ PCB 118 [2,3',4,4',5-pentachlorobiphenyl] to PCB 67 [2,3',4,5-tetrachlorobiphenyl], and

■ PCB 67 [2,3',4,5-tetrachlorobiphenyl] to PCB 26 [2,3',5-trichlorobiphenyl].

They further noted that the reduction of some dioxin-like PCBs was demonstrated in their study, including:

■ PCB 118 to PCB 67 to PCB 26, and

■ PCB 110 [2,3,3',4',6-pentachlorobiphenyl] to PCB 59 [2,3,3',6-tetrachlorobiphenyl].

2.1   Summary of PCB Decay

A number of conclusions can be drawn from these studies regarding PCB decay:

■ PCB dechlorination appears to occur under anaerobic conditions, and is mediated by microbial activity. Dechlorination does not appear to result in an overall reduction of total PCBs, just a re-distribution of the concentrations of individual congeners;

■ PCB dechlorination has been suggested as being concentration dependent, with little dechlorination observed at low concentrations in some studies, but other studies have reported dechlorination even at low PCB concentrations (<1 μg/g);

■ Decay is mediated by microbial activity, and the rate at a given site is in part determined by microbial competence;

■ Dechlorination favours higher chlorinated congeners over lower chlorinated congeners resulting in the accumulation of mono-, di-, and trichlorobiphenyls;

■ Dechlorination from the *para* and *meta* positions appears to be favoured with different congeners showing different preferences;

■ Dechlorination appears to follow an initial lag period, after which dechlorination initially proceeds at a rapid rate, but then slows and appears to plateau;

■ Dechlorination does not appear to involve the chlorines in the *ortho* positions;

■ Dioxin-like toxicity (i.e., AhR induced toxicity) is highest in the congeners with chlorines in the para and *meta* positions, and no chlorines in the *ortho* positions (i.e., the coplanar congeners); congeners with chlorines in the *para* and *meta* positions, and one chlorine in the *ortho* position demonstrate reduced dioxin-like toxicity; congeners with chlorines only in the *ortho* positions have not been shown to induce dioxin-like toxicity;

■ Dechlorination can reduce the potential AhR induced toxicity through reduction in *meta-* and *para-*substituted congeners in dioxin-like PCBs.

3.0   APPROACH TO ASSESSING PCB DECAY IN LYON'S CREEK EAST
3.1   Assessment of Available Data

Two methods of assessing PCB decay have been reported in the literature reviewed in Section 2:

■ Comparison of congener concentrations at "equivalent" depths in samples from the same locations taken a number of years apart; and

■ Comparison of congener concentrations between surface and deeper sediment layers.

The limited congener data available for Lyon's Creek East indicate that the second method could be applied to Lyons' Creek East sediment. However, this method does have a number of limitations.

The data used for the assessment were sediment cores collected by MOE in 200? (Table X). Congener analysis results were available for 55 congeners, and included a number of congeners with *para-*, *meta-*, and *ortho-*substitution. However, the data set was limited in that analysis results were not available for the mono- and

dichlorobiphenyls, and as such the assessment of dechlorination end products is limited to assessing the changes in percentages of the trichlorobiphenyls.

Magar *et al.* (2005a) noted that the greatest decrease in deeper sediments was in the tetra- to hexachlorobiphenyls at the Lake Hartwell site. A review of the data for Lyon's Creek East indicates that a similar reduction has occurred in the deepest core sections. The greatest percentage decrease was observed in these congeners. The authors also noted that dechlorination occurred at very low PCB concentrations. Since concentrations of PCBs in Lyons' Creek East surficial sediments averaged between 4-5 ug/g, and deeper sediment concentrations were in the range of 35-40 ug/g that were shown in other studies to be susceptible to dechlorination, this approach was considered suitable as a means be which to assess whether decayof PCBs had occurred in the sediments.

Following the general approach used by Magar *et al.* (2005b), the percentage change in the concentrations of PCB congeners with depth was used as a marker to determine whether there had been dechlorination of PCBs in Lyon's Creek East sediments. Since dating of the cores was not available, the actual time period over which any dechlorination would have occurred cannot be reliably estimated. However, since the source of PCBs is postulated to have been upstream in the southeast section of the City of Welland, the residence time for PCBs in LCE sediments has to pre-date the construction of the Welland Canal By-Pass in the early 1970's. As a result, the changes that have occurred in the sediments represent dechlorination activity that has proceeded for at least 30 years (based on the date the sample was collected), and likely longer. The furthest downstream location, LC29, was not used, since concentrations of PCBs in both surface and at depth were very low.

The distribution of the congeners in each of the core samples is provided in Table 1. Cores LC01, LC03, LC16 and LC17 were located within the reach from the canal by-pass to Hwy 140 (LC17 was located just downstream of the culvert under Hwy 140, and PCB concentrations were considered to be sufficiently elevated to be suitable for assessment of PCB decay (as noted in the preceding review, PCB decay appears in some studies to be concentration dependent).

The distribution of the congeners in the surficial sections of each of the four core locations were compared, and the results are shown on Figure 1. The distribution of congeners shows that the congener distribution in the 0-10 cm section of core LC03 is biased towards the lower chlorinated congeners, and suggests that the sediments in this location may have been re-suspended and deposited from upstream locations, or were recently disturbed. The pattern of congener distribution observed in this core is more consistent with that noted in the deeper sections at the remaining three locations. As a result, this core was not considered suitable for analysis, and the remaining three cores were selected for analysis of congener patterns:

■ LC01 – located at the furthest upstream end of Zone 1 in the pump pond;

■ LC16 – located at the downstream end of Zone 3 immediately upstream of the Hwy 140 culvert; and

■ LC17 – located at the upstream end of Zone 4, immediately downstream of the Hwy 140 culvert.

The cores were selected on the basis of the total PCB concentrations. Those cores in which total PCB concentrations were very low (i.e., those further downstream), were not plotted on the graphs.

The changes in congener distribution were calculated using the following procedure:

- The concentrations of each of the 55 congeners were summed for each sediment core section (Table 1). Values reported as less than the detection limit were assigned a value of zero.

- Each congener concentration was converted to a percentage of the total PCBs for each reported core interval. These are shown in Figures 2, 4, and 6 for each of the three cores noted above.

- The percentage of each congener in the surface layer (0-10 cm section) was subtracted from the percentage of each congener in the deepest section (typically reported as >25 cm) to derive the amount of change. Values were either positive (indicating that particular congener formed a greater percentage of the total PCBs present in the deeper section relative to surficial sediments), or were negative (indicating that the percentage of the total contributed by the particular congener had decreased in the deeper sediments relative to the surface sediments).

- The changes were plotted on graphs, and these are provided in Figures 3, 5, and 7.

The results of the above calculations are provided in Table 1. The graphs show that there has been an increase in the percentage of total PCBs present as trichlorobiphenyls with depth (mono- and dichlorobiphenyls were not analysed for in the MOE samples) together with a concurrent decrease in the relative percentage of some of the PeCBs, HeCBs and HpCBs. There was also an increase in relative percentage of some of the PeCBs, which may represent intermediate decay products from dechlorination of the HeCBs and/or HpCBs. The results indicate that there is a measurable change in the congener patterns between surficial and bottom sediments and suggest that reductive dechlorination of PCBs may have occurred in the deeper sediments. Whether this is still an on-going process cannot be determined with the available data.

Figure 2 shows the change in congener patterns for LC01. The changes in congener pattern showed a reduction in the penta- and hexachlorobiphenyls, and a concurrent increase in the tri and tetrachlorobiphenyls with increased depth in the sediments. The greatest increase was in the tetrachlorobiphenyls, suggesting that dechlorination was an ongoing process. The pattern at this location contrasted with the patterns at LC16 and LC17, where the increase in the tetrachlorobiphenyls was lower and the increase in the trichlorobiphenyls was higher, and suggest that the dechlorination process was slower, or may have stopped.

Figure 3 shows the shift in congener pattern with depth. The figure shows an increase in the percentage of total PCB comprised of the tri- and tetrachlorinated biphenyls, and a decrease in the penta- and hexachlorinated biphenyls with depth. Both changes are consistent with those noted by Magar *et al.* (2005b), and are indicative of dechlorination of higher chlorinated PCBs.

Figure 4 shows the change in congener patterns for all three sections analyzed in the core from LC16. Again, there is an increase in the percent of total PCB comprised of the tri- and tetrachlorinated biphenyls with depth, and a decrease in the pentachlorinated biphenyls. Hexachlorobiphenyls comprised a relatively smaller percentage of the total PCB at this location, suggesting perhaps that dechlorination has progressed further in all core sections. Figure 5 shows the shift in congener patterns. The increase in trichlorobiphenyl percentage, and the actual decrease in the tetrachlorobiphenyl percentage contrast with the results of the core from LC01, and again, may indicate that dechlorination has progressed further at this location, and may indicate that dechlorination of the tetrachlorobiphenyls has occurred. Data were not available for the mono- and dichlorobiphenyls, but it would be interesting to note whether there had also been an increase in the percentage composition of these congeners.

Figure 6 shows the change in congener patterns for all three sections analyzed in the core from LC17. The distribution of the congeners is very similar to that noted for LC16, with a depth related increase in the tri- and tetrachlorinated biphenyls, and a decrease in the pentachlorinated congeners. As noted at core location LC16, hexachlorinated congeners comprised a smaller percentage of total PCBs than at LC01, with pentachlorobiphenyls comprising the majority of the higher chlorinated PCBs. Figure 7 shows a similar increase in the trichlorobiphenyl percentage, although the overall increase was lower than in core LC16.

In summary, all three cores demonstrate that a shift in congener distribution has occurred with depth, though the actual changes (percent shift for each congener) were variable. This result is consistent with the literature reviewed in Section 2 that indicated there was considerable variation among sampling sites. Microbial competence was identified in some of the studies as a factor that could be responsible for the observed differences among core locations from Lyon's Creek East.

It should be noted that the above approach provides just a rough estimate of PCB dechlorination. The depth of the surface core (10 cm), will include some anoxic sediments, and may not accurately represent the original PCB congener distribution, since some of the PCBs in the lower part of this section may also have undergone some reductive dechlorination.

Since the original source of the PCBs has not been defined, and the specific Aroclor used at the source is unknown, the distribution of PCBs cannot be assessed relative to the original product to assess how much dechlorination of higher chlorinated PCBs has occurred since they were originally released to the environment.

It is interesting to note that the dioxin-like PCBs were generally present in both surficial and deeper sediments at very low concentrations, or below the detection limits. Thus, while these show on some of the graphs as unchanged, this is most likely due to the low or non-detect concentrations of these congeners.

Since dating is not available for the cores, it is not possible to calculate the period of time over which the observed changes occurred and thereby obtain an approximation of the rate of decay.

4.0   PREDICTED PCB DECAY IN LYON'S CREEK EAST

Magar *et al.* (2005b), provide a range of PCB dechlorination rates based on their work in Lake Hartwell. At the rate of 0.094 mol Cl/mol PCB/yr, the authors predicted a time period of 16.4 yrs/*meta*+*para* chlorine removal (based on a range of 4.3 years to 43.5 years). Based on this rate, the following prediction can be calculated:

■ 16.4 yrs for 1 molecule of PeCB to be reduced to TCB (i.e., removal of 1 *meta* and 1 *para* chlorine);

■ 32.8 years for 1 molecule of HeCB to be reduced to DCB (i.e., removal of 2 meta and 2 para chlorines);

■ 41 years for 1 molecule of HpCB to be reduced to DCB

If reductive dechlorination is predicted to occur within the range provided above, to reduce HpCB to DCB (i.e., removal of 5 chlorines from *meta* and *para* positions) could take 41 years at the average rate of 16.4 years cited by Magar et al (2005b), and up to 109 years at a maximum rate of 43.5 years provided by Magar *et al.* (2005b). It should be noted that this provides a general rate of PCB decay that may have occurred and should be used with caution. It is not known whether the rate of PCB decay in Lyons Creek East is similar to the rate of decay measured in Lake Hartwell.

Current data from the cores indicates that potential risks to biota from dioxin-like PCBs is likely to be minimal, since these comprise a small percentage of total PCBs, and are also present at low concentrations. Since these are comprised of congeners with chlorines in the *meta* and *para* positions only, these are most likely to undergo reductive dechlorination in the future. Similarly, the mono-*ortho* congeners are likely to undergo reduction through removal of chlorines from the *meta* and *para* positions, reducing the potential dioxin-like toxicity of these congeners.

Report Signature Page

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TABLE

Golder
Associates

			LC01							LC03							LC16						
	# ortho Cl	# para+meta Cl	<10 cm [ ] ng/g	% of total PCB	10-25 cm [ ] ng/g	% of total PCB	>25 cm [ ] ng/g	% of total PCB	% change from surface to bottom	<10 cm [ ] ng/g	% of total PCB	10-25 cm [ ] ng/g	% of total PCB	>25 cm [ ] ng/g	% of total PCB	% change from surface to bottom	<10 cm [ ] ng/g	% of total PCB	10-25 cm [ ] ng/g	% of total PCB	>25 cm [ ] ng/g	% of total PCB	% change from surface to bottom
2,2',5-trichlorobiphenyl	2	1	14	3.3	43	3.8	84	6.4	3.1	9500	8.8	4200	8.3	310	7.3	-1.4	92.0	4.4	350.0	8.1	4100	7.9	3.5
2,2',6-trichlorobiphenyl	3	0	0	0.0	0	0.0	3.6	0.3	0.3	780	0.7	330	0.7	0	0.0	-0.7	0.0	0.0	11.0	0.3	180	0.3	0.3
2',3,4-trichlorobiphenyl	1	2	15	3.6	21	1.8	52	3.9	0.4	8000	7.4	3100	6.1	250	5.9	-1.5	49.0	2.3	200.0	4.6	3300	6.4	4.0
2,3,4'-trichlorobiphenyl	1	2	3.3	0.8	3.5	0.3	20	1.5	0.7	3100	2.9	1300	2.6	57	1.3	-1.5	5.1	0.2	70.0	1.6	1200	2.3	2.1
2,4,4'-trichlorobiphenyl	1	2	19	4.5	38	3.3	87	6.6	2.1	9300	8.6	3800	7.5	330	7.8	-0.8	160.0	7.6	360.0	8.3	4000	7.7	0.1
3,4,4'-trichlorobiphenyl	0	3	12	2.8	12	1.1	48	3.6	0.8	12000	11.1	4900	9.7	180	4.3	-6.8	17.0	0.8	140.0	3.2	3700	7.1	6.3
2,2',3,5'-tetrachlorobiphenyl	2	2	18	4.3	50	4.4	120	9.1	4.8	8500	7.8	4000	7.9	420	9.9	2.1	110.0	5.2	380.0	8.8	4200	8.1	2.9
2,2',4,5'-tetrachlorobiphenyl	2	2	20	4.7	48	4.2	84	6.4	1.6	6800	6.3	3200	6.3	330	7.8	1.5	160.0	7.6	290.0	6.7	3300	6.4	-1.2
2,2',5,5'-tetrachlorobiphenyl	2	2	35	8.3	100	8.8	130	9.9	1.6	9400	8.7	4500	8.9	490	11.6	2.9	230.0	10.9	420.0	9.7	4700	9.1	-1.9
2,2',6,6'-tetrachlorobiphenyl	4	0	2.8	0.7	2.9	0.3	7.8	0.6	-0.1	1700	1.6	660	1.3	3.7	0.1	-1.5	15.0	0.7	39.0	0.9	780	1.5	0.8
2,3',4',5-tetrachlorobiphenyl	1	3	27	6.4	76	6.7	120	9.1	2.7	1000	0.9	4400	8.7	470	11.1	10.2	230.0	10.9	430.0	9.9	5000	9.6	-1.3
2,4,4',5-tetrachlorobiphenyl	1	3	11	2.6	28	2.5	55	4.2	1.6	4600	4.2	2100	4.2	210	5.0	0.7	110.0	5.2	200.0	4.6	2200	4.2	-1.0
3,3',4,4'-tetrachlorobiphenyl	0	4	1.1	0.3	1.1	0.1	2.9	0.2	0.0	30	0.0	0	0.0	0	0.0	0.0	0.0	0.0	12.0	0.3	0	0.0	0.0
3,4,4',5-tetrachlorobiphenyl	0	4	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
2,2'3,4,5'-pentachlorobiphenyl	2	3	0	0.0	46	4.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
2,3,3'4,4'-pentachlorobiphenyl	1	4	11	2.6	26	2.3	22	1.7	-0.9	1900	1.8	760	1.5	74	1.7	0.0	21.0	1.0	65.0	1.5	830	1.6	0.6
2,3,3'4,6-pentachlorobiphenyl	2	3	32	7.6	71	6.2	65	4.9	-2.6	5100	4.7	2500	5.0	160	3.8	-0.9	57.0	2.7	170.0	3.9	2700	5.2	2.5
2,3,4,4',5-pentachlorobiphenyl	1	4	2.1	0.5	2.8	0.2	1.6	0.1	-0.4	140	0.1	70	0.1	0	0.0	-0.1	3.5	0.2	5.7	0.1	84	0.2	0.0
2,3'4,4',5-pentachlorobiphenyl	1	4	22	5.2	78	6.9	39	3.0	-2.3	2500	2.3	1000	2.0	110	2.6	0.3	89.0	4.2	120.0	2.8	1100	2.1	-2.1
2,3'4,4',6-pentachlorobiphenyl	2	3	0	0.0	0	0.0	0	0.0	0.0	69	0.1	0	0.0	0	0.0	-0.1	3.3	0.2	4.9	0.1	19	0.0	-0.1
2,2'3,5',6-pentachlorobiphenyl	3	2	44	10.4	120	10.5	160	12.1	1.7	13000	12.0	5500	10.9	560	13.2	1.2	340.0	16.2	620.0	14.3	5900	11.4	-4.8
2,2'4,4',5-pentachlorobiphenyl	2	3	13	3.1	50	4.4	36	2.7	-0.3	1600	1.5	750	1.5	53	1.3	-0.2	89.0	4.2	81.0	1.9	800	1.5	-2.7
2,2'4,5,5'-pentachlorobiphenyl	2	3	33	7.8	89	7.8	53	4.0	-3.8	3200	3.0	1400	2.8	140	3.3	0.4	100.0	4.8	140.0	3.2	1700	3.3	-1.5
2,2'4,6,6'-pentachlorobiphenyl	4	1	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
2'3,4,4',5-pentachlorobiphenyl	1	4	4.1	1.0	4.1	0.4	2	0.2	-0.8	470	0.4	180	0.4	0	0.0	-0.4	9.4	0.4	15.0	0.3	190	0.4	-0.1
3,3'4,4',5-pentachlorobiphenyl	0	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
2,2'3,44'5-hexachlorobiphenyl	2	4	16	3.8	57	5.0	26	2.0	-1.8	980	0.9	330	0.7	5.8	0.1	-0.8	40.0	1.9	0.2	0.0	350	0.7	-1.2
2,2'3,4'5'6-hexachlorobiphenyl	3	3	11	2.6	47	4.1	20	1.5	-1.1	720	0.7	270	0.5	25	0.6	-0.1	40.0	1.9	48.0	1.1	270	0.5	-1.4
2,2'3,5,5'6-hexachlorobiphenyl	3	3	4.4	1.0	7.8	0.7	5.1	0.4	-0.7	300	0.3	110	0.2	0.1	0.0	-0.3	7.4	0.4	9.3	0.2	100	0.2	-0.2
2,3,3'4,4'5-hexachlorobiphenyl	1	5	4.4	1.0	6.5	0.6	1.7	0.1	-0.9	170	0.2	30	0.1	0.2	0.0	-0.2	1.6	0.1	5.1	0.1	48	0.1	0.0
2,3,3'4,4'6-hexachlorobiphenyl	2	4	2.4	0.6	9.2	0.8	3.4	0.3	-0.3	130	0.1	47	0.1	5.8	0.1	0.0	6.2	0.3	7.3	0.2	51	0.1	-0.2
2,3,3'4,4'5'-hexachlorobiphenyl	1	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
22',33',44'-hexachlorobiphenyl	2	4	4	0.9	8	0.7	3.7	0.3	-0.7	260	0.2	73	0.1	30	0.7	0.5	0.2	0.0	0.2	0.0	96	0.2	0.2
22',44',55'-hexachlorobiphenyl	2	4	12	2.8	33	2.9	13	1.0	-1.9	700	0.6	240	0.5	0	0.0	-0.6	27.0	1.3	32.0	0.7	250	0.5	-0.8
22',44',66'-hexachlorobiphenyl	4	2	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	160	0.3	0.3
23',44',55'-hexachlorobiphenyl	1	5	0	0.0	2	0.2	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.5	0.0	0.0	0.0	0	0.0	0.0
23',44',5'6-hexachlorobiphenyl	2	4	11	2.6	33	2.9	13	1.0	-1.6	910	0.8	340	0.7	0	0.0	-0.8	27.0	1.3	32.0	0.7	310	0.6	-0.7
3,3'4,4'55'-hexachlorobiphenyl	0	6	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
22'33'44'5-heptachlorobiphenyl	2	5	3.7	0.9	5.5	0.5	5.8	0.4	-0.4	210	0.2	66	0.1	1.3	0.0	-0.2	8.9	0.4	10.0	0.2	51	0.1	-0.3
22'33'44'6-heptachlorobiphenyl	3	4	0.29	0.1	0.29	0.0	0	0.0	-0.1	63	0.1	1.5	0.0	0	0.0	-0.1	1.2	0.1	1.6	0.0	0	0.0	-0.1
22'33'4'56-heptachlorobiphenyl	3	4	0.78	0.2	0.78	0.1	1.2	0.1	-0.1	88	0.1	15	0.0	0	0.0	-0.1	2.8	0.1	4.1	0.1	0	0.0	-0.1
22'33'55'6-heptachlorobiphenyl	3	4	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
22'344'55'-heptachlorobiphenyl	2	5	4.2	1.0	0	0.0	10	0.8	-0.2	410	0.4	130	0.3	12	0.3	-0.1	17.0	0.8	19.0	0.4	110	0.2	-0.6
22'344'5'6-heptachlorobiphenyl	3	4	1.2	0.3	3.5	0.3	3.1	0.2	0.0	98	0.1	0	0.0	0	0.0	-0.1	6.0	0.3	6.1	0.1	28	0.1	-0.2
22'34'55'6-heptachlorobiphenyl	3	4	1.5	0.4	3	0.3	4.4	0.3	0.0	200	0.2	91	0.2	0	0.0	-0.2	8.4	0.4	9.2	0.2	39	0.1	-0.3
22'34'566'-heptachlorobiphenyl	4	3	0.62	0.1	4.1	0.4	2.1	0.2	0.0	100	0.1	26	0.1	0	0.0	-0.1	7.1	0.3	8.2	0.2	15	0.0	-0.3
233'44'55'-heptachlorobiphenyl	1	6	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
233'44'5'6-heptachlorobiphenyl	2	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
22'33'44'55'-octa(Cl)biphenyl	2	6	2.2	0.5	2.2	0.2	2.7	0.2	-0.3	120	0.1	22	0.0	1.8	0.0	-0.1	3.8	0.2	3.8	0.1	22	0.0	-0.1
22'33'455'6'-octa(Cl)biphenyl	3	5	0.9	0.2	0.9	0.1	2.7	0.2	0.0	110	0.1	0	0.0	0	0.0	-0.1	3.0	0.1	3.2	0.1	11	0.0	-0.1

			LC01							LC03							LC16						
	# ortho Cl	# para+meta Cl	<10 cm [] ng/g	% of total PCB	10-25 cm [] ng/g	% of total PCB	>25 cm [] ng/g	% of total PCB	% change from surface to bottom	<10 cm [] ng/g	% of total PCB	10-25 cm [] ng/g	% of total PCB	>25 cm [] ng/g	% of total PCB	% change from surface to bottom	<10 cm [] ng/g	% of total PCB	10-25 cm [] ng/g	% of total PCB	>25 cm [] ng/g	% of total PCB	% change from surface to bottom
22'33'45'66'-octa(Cl)biphenyl	4	4	2	0.5	4	0.4	6.3	0.5	0.0	0	0.0	26	0.1	0	0.0	0.0	4.3	0.2	10.0	0.2	0	0.0	-0.2
22'33'55'66'-octa(Cl)biphenyl	4	4	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
233'44'55'6-octachlorobiphenyl	2	6	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
22'33'44'55'6-nona(Cl)biphenyl	3	6	0	0.0	0	0.0	0	0.0	0.0	28	0.0	0	0.0	0	0.0	0.0	0.5	0.0	0.4	0.0	0	0.0	0.0
22'33'455'66'-nona(Cl)biphenyl	4	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0
Total PCB (sum of 55 congeners)			422.0		1138.2		1317.1			108286.0		50467.5		4229.7			2103.3		4333.3		51894.0		
% trichloro			8.1		5.4		12.6		4.5	24.5		21.2		15.4		-9.2	8.3		15.0		18.9		10.6
% higher than Trichloro			91.9		94.6		87.4		-4.5	75.5		78.8		84.6		9.2	91.7		85.0		81.1		-10.6

Concentrations < detection limit are assigned a value of zero.

Non-ortho substituted congeners are shown in bold type.

Mono-ortho substituted congeners are shown in italics

2,2',6,6' are ortho chlorine positions

3,3',5,5' are meta chlorine positions

4,4' are para chlorine positions

April 2011

Table 1: Distribution of PCB Congeners in Core Samples Collected from Different Depths in Lyon's Creek East. MOE 2002-3.

03-1112-059 (8000)

			LC17						LC29					
	# ortho Cl	# para+meta Cl	<10 cm [ ] ng/g	% of total PCB	10-25 cm [ ] ng/g	% of total PCB	>25 cm [ ] ng/g	% of total PCB	% change from surface to bottom	<10 cm [ ] ng/g	% of total PCB	10-25 cm [ ] ng/g	% of total PCB	>25 cm [ ] ng/g	% of total PCB	% change from surface to bottom
2,2',5-trichlorobiphenyl	2	1	52	4.1	42	4.7	110	6.5	2.4	35	8.0	20	5.3	40	7.3	-0.8
2,2',6-trichlorobiphenyl	3	0	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
2',3,4-trichlorobiphenyl	1	2	34	2.7	24	2.7	59	3.5	0.8	14	3.2	9.6	2.5	16	2.9	-0.3
2,3,4'-trichlorobiphenyl	1	2	8.5	0.7	3.5	0.4	20	1.2	0.5	4.4	1.0	2	0.5	1.6	0.3	-0.7
2,4,4'-trichlorobiphenyl	1	2	91	7.2	68	7.6	140	8.3	1.2	32	7.4	26	6.9	53	9.6	2.3
3,4,4'-trichlorobiphenyl	0	3	24	1.9	10	1.1	40	2.4	0.5	5.2	1.2	2.9	0.8	2.9	0.5	-0.7
2,2',3,5'-tetrachlorobiphenyl	2	2	88	6.9	48	5.4	120	7.1	0.2	29	6.7	23	6.1	31	5.6	-1.0
2,2',4,5'-tetrachlorobiphenyl	2	2	100	7.9	72	8.0	120	7.1	-0.7	27	6.2	26	6.9	44	8.0	1.8
2,2',5,5'-tetrachlorobiphenyl	2	2	130	10.2	100	11.2	170	10.1	-0.1	39	9.0	38	10.1	63	11.4	2.5
2,2',6,6'-tetrachlorobiphenyl	4	0	8.2	0.6	5.7	0.6	15	0.9	0.2	1.1	0.3	0	0.0	3.5	0.6	0.4
2,3',4',5-tetrachlorobiphenyl	1	3	130	10.2	96	10.7	170	10.1	-0.1	30	6.9	29	7.7	45	8.2	1.3
2,4,4',5-tetrachlorobiphenyl	1	3	66	5.2	52	5.8	86	5.1	-0.1	16	3.7	15	4.0	24	4.4	0.7
3,3',4,4'-tetrachlorobiphenyl	0	4	0	0.0	0	0.0	0.31	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
3,4,4',5-tetrachlorobiphenyl	0	4	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
2,2'3,4,5'-pentachlorobiphenyl	2	3	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
2,3,3'4,4'-pentachlorobiphenyl	1	4	18	1.4	9.7	1.1	24	1.4	0.0	5.9	1.4	4.7	1.2	4.2	0.8	-0.6
2,3,3'4,6-pentachlorobiphenyl	2	3	45	3.5	25	2.8	59	3.5	0.0	17	3.9	13	3.4	11	2.0	-1.9
2,3,4,4',5-pentachlorobiphenyl	1	4	2.1	0.2	1.2	0.1	2.4	0.1	0.0	0	0.0	0	0.0	0	0.0	0.0
2,3'4,4',5-pentachlorobiphenyl	1	4	50	3.9	36	4.0	58	3.4	-0.5	13	3.0	12	3.2	15	2.7	-0.3
2,3'4,4',6-pentachlorobiphenyl	2	3	1.4	0.1	0	0.0	1.9	0.1	0.0	0	0.0	0	0.0	0	0.0	0.0
2,2'3,5',6-pentachlorobiphenyl	3	2	200	15.7	140	15.6	250	14.8	-0.9	55	12.6	53	14.0	70	12.7	0.0
2,2'4,4',5-pentachlorobiphenyl	2	3	48	3.8	40	4.5	39	2.3	-1.5	15	3.4	14	3.7	17	3.1	-0.4
2,2'4,5,5'-pentachlorobiphenyl	2	3	61	4.8	45	5.0	69	4.1	-0.7	19	4.4	18	4.8	24	4.4	0.0
2,2'4,6,6'-pentachlorobiphenyl	4	1	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
2'3,4,4',5-pentachlorobiphenyl	1	4	3.9	0.3	1.4	0.2	5	0.3	0.0	0	0.0	0	0.0	0	0.0	0.0
3,3'4,4',5-pentachlorobiphenyl	0	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
2,2'3,44'5-hexachlorobiphenyl	2	4	23	1.8	16	1.8	26	1.5	-0.3	13	3.0	12	3.2	13	2.4	-0.6
2,2'3,4'5'6-hexachlorobiphenyl	3	3	22	1.7	15	1.7	27	1.6	-0.1	14	3.2	13	3.4	16	2.9	-0.3
2,2'3,5,5'6-hexachlorobiphenyl	3	3	4.4	0.3	3.4	0.4	5.5	0.3	0.0	3.5	0.8	3.5	0.9	4.3	0.8	0.0
2,3,3'4,4'5-hexachlorobiphenyl	1	5	0.86	0.1	0.66	0.1	0.96	0.1	0.0	0.87	0.2	0.7	0.2	0.84	0.2	0.0
2,3,3'4,4'6-hexachlorobiphenyl	2	4	3.6	0.3	3.1	0.3	4.2	0.2	0.0	2.2	0.5	2	0.5	2.6	0.5	0.0
2,3,3'4,4'5'-hexachlorobiphenyl	1	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
22',33',44'-hexachlorobiphenyl	2	4	2	0.2	0.67	0.1	0.2	0.0	-0.1	0.76	0.2	0.3	0.1	0	0.0	-0.2
22',44',55'-hexachlorobiphenyl	2	4	14	1.1	9.6	1.1	16	1.0	-0.2	9.7	2.2	9.4	2.5	12	2.2	-0.1
22',44',66'-hexachlorobiphenyl	4	2	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
23',44',55'-hexachlorobiphenyl	1	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
23',44',5'6-hexachlorobiphenyl	2	4	14	1.1	9.6	1.1	16	1.0	-0.2	9.7	2.2	9.6	2.5	9.4	1.7	-0.5
3,3'4,4'55'-hexachlorobiphenyl	0	6	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
22'33'44'5-heptachlorobiphenyl	2	5	4.6	0.4	2.9	0.3	4.8	0.3	-0.1	4.5	1.0	4.1	1.1	4.8	0.9	-0.2
22'33'44'6-heptachlorobiphenyl	3	4	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
22'33'4'56-heptachlorobiphenyl	3	4	0.76	0.1	0	0.0	1.1	0.1	0.0	1.2	0.3	0.69	0.2	0.81	0.1	-0.1
22'33'55'6-heptachlorobiphenyl	3	4	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
22'344'55'-heptachlorobiphenyl	2	5	8.7	0.7	6.3	0.7	9.6	0.6	-0.1	8.8	2.0	8.3	2.2	10	1.8	-0.2
22'344'5'6-heptachlorobiphenyl	3	4	2.9	0.2	1.6	0.2	3.5	0.2	0.0	2	0.5	1.7	0.4	2.4	0.4	0.0
22'34'55'6-heptachlorobiphenyl	3	4	3.7	0.3	2.4	0.3	4.6	0.3	0.0	4.1	0.9	3.8	1.0	5	0.9	0.0
22'34'566'-heptachlorobiphenyl	4	3	3.1	0.2	1.4	0.2	4	0.2	0.0	0	0.0	0	0.0	0	0.0	0.0
233'44'55'-heptachlorobiphenyl	1	6	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
233'44'5'6-heptachlorobiphenyl	2	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
22'33'44'55'-octa(Cl)biphenyl	2	6	1.5	0.1	0.78	0.1	1.5	0.1	0.0	1.2	0.3	1	0.3	1.5	0.3	0.0
22'33'455'6'-octa(Cl)biphenyl	3	5	0.57	0.0	0	0.0	0.57	0.0	0.0	0.29	0.1	0	0.0	0.66	0.1	0.1

	# ortho Cl	# para+meta Cl	LC17							LC29						
			<10 cm [ ] ng/g	% of total PCB	10-25 cm [ ] ng/g	% of total PCB	>25 cm [ ] ng/g	% of total PCB	% change from surface to bottom	<10 cm [ ] ng/g	% of total PCB	10-25 cm [ ] ng/g	% of total PCB	>25 cm [ ] ng/g	% of total PCB	% change from surface to bottom
22'33'45'66'-octa(Cl)biphenyl	4	4	0	0.0	2.8	0.3	0	0.0	0.0	1.7	0.4	1.8	0.5	3.2	0.6	0.2
22'33'55'66'-octa(Cl)biphenyl	4	4	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
233'44'55'6-octachlorobiphenyl	2	6	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
22'33'44'55'6-nona(Cl)biphenyl	3	6	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
22'33'455'66'-nona(Cl)biphenyl	4	5	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0	0.0	0	0.0	0.0
Total PCB (sum of 55 congeners)			1270.8		895.7		1684.1			435.1		378.1		551.7		
% trichloro			9.0		9.0		12.3		3.3	11.6		8.7		11.5		-0.2
% higher than Trichloro			91.0		91.0		87.7		-3.3	88.4		91.3		88.5		0.2

Concentrations < detection limit are assigned a value of zero.

Non-ortho substituted congeners are shown in bold type.

Mono-ortho substituted congeners are shown in italics

2,2',6,6' are ortho chlorine positions

3,3',5,5' are meta chlorine positions

4,4' are para chlorine positions

FIGURES

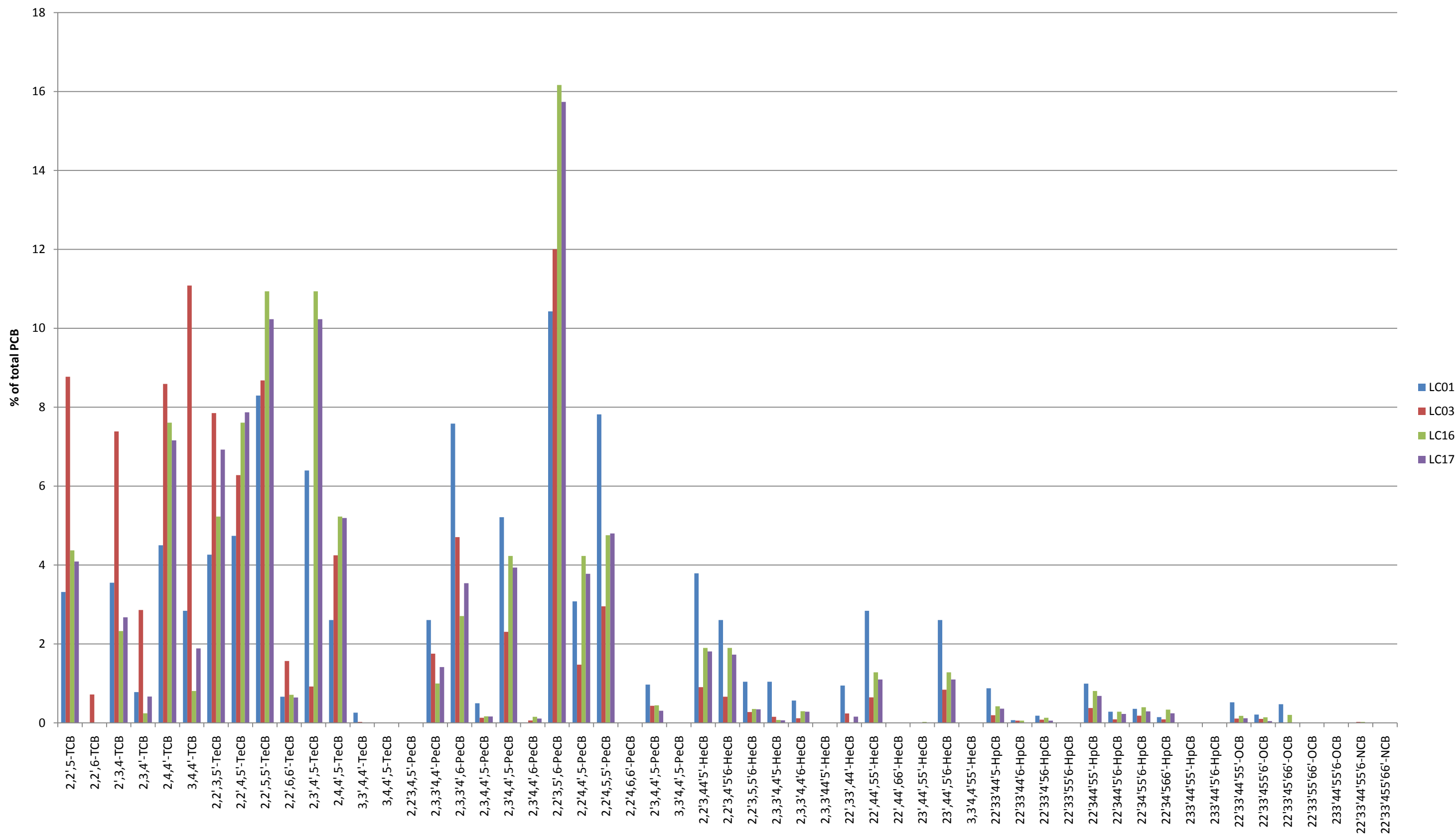Figure 1: Relative Distribution of PCB Congeners in 0-10 cm Core Sections. MOE 2002-3.

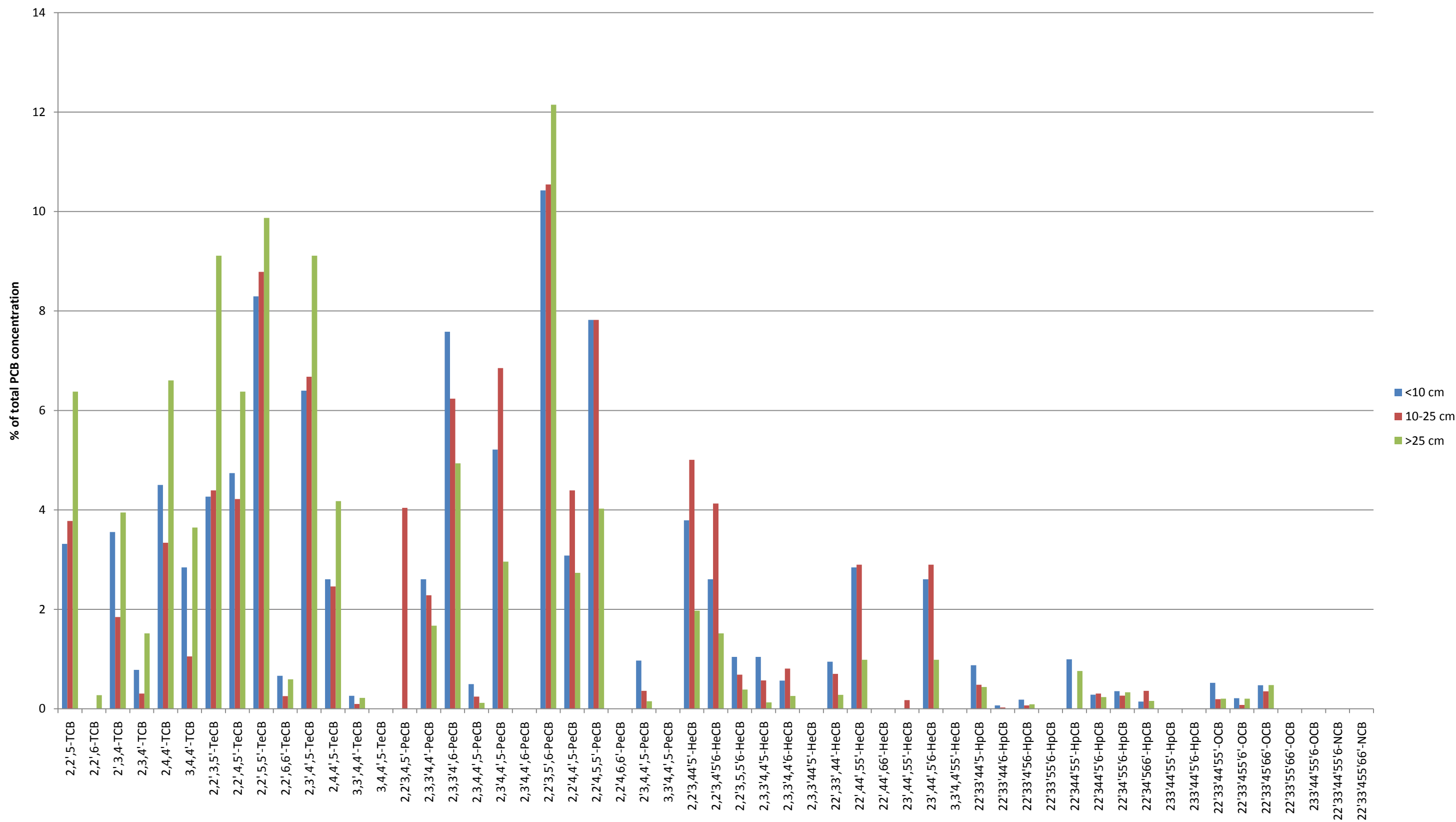Figure 2: Distribution of PCB Congeners with Depth at LC01. MOE 2002-3

Figure 3: Congener Shifts Between Surface (0-10 cm) and Bottom (>25 cm) Sections at LC01. MOE 2002-3.
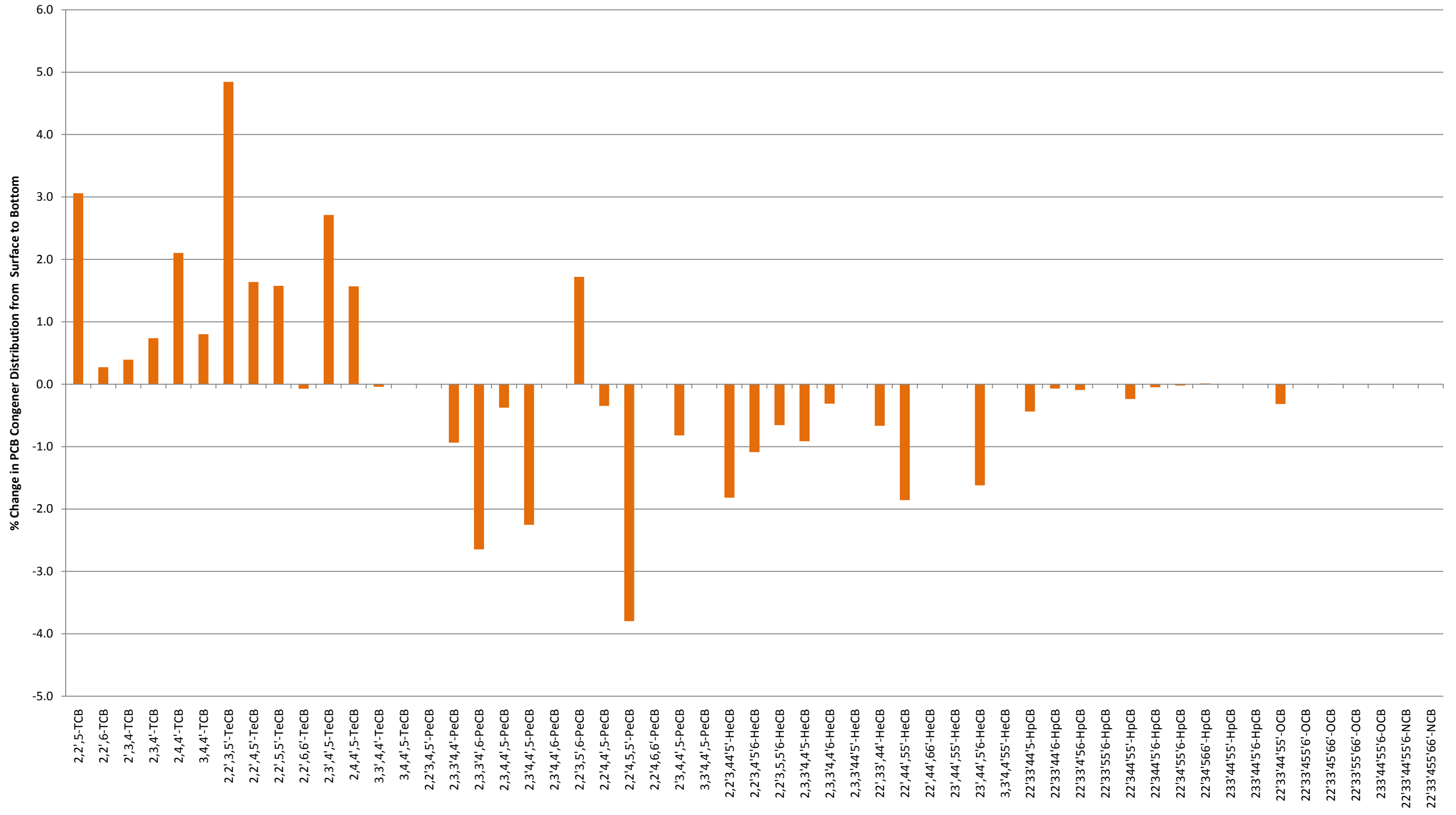
Figure 4: Distribution of PCB Congeners with Depth at LC16. MOE 2002-3.
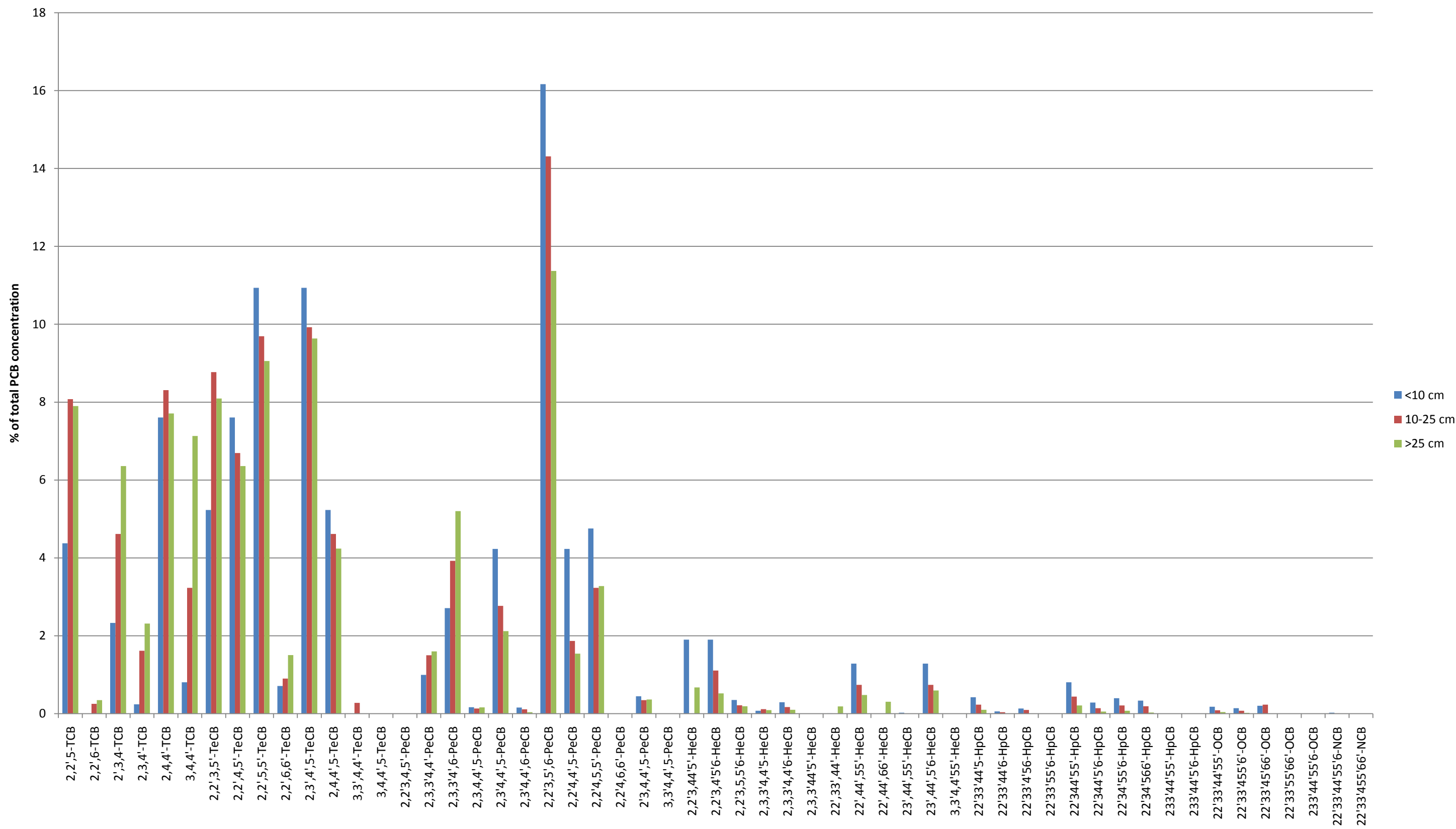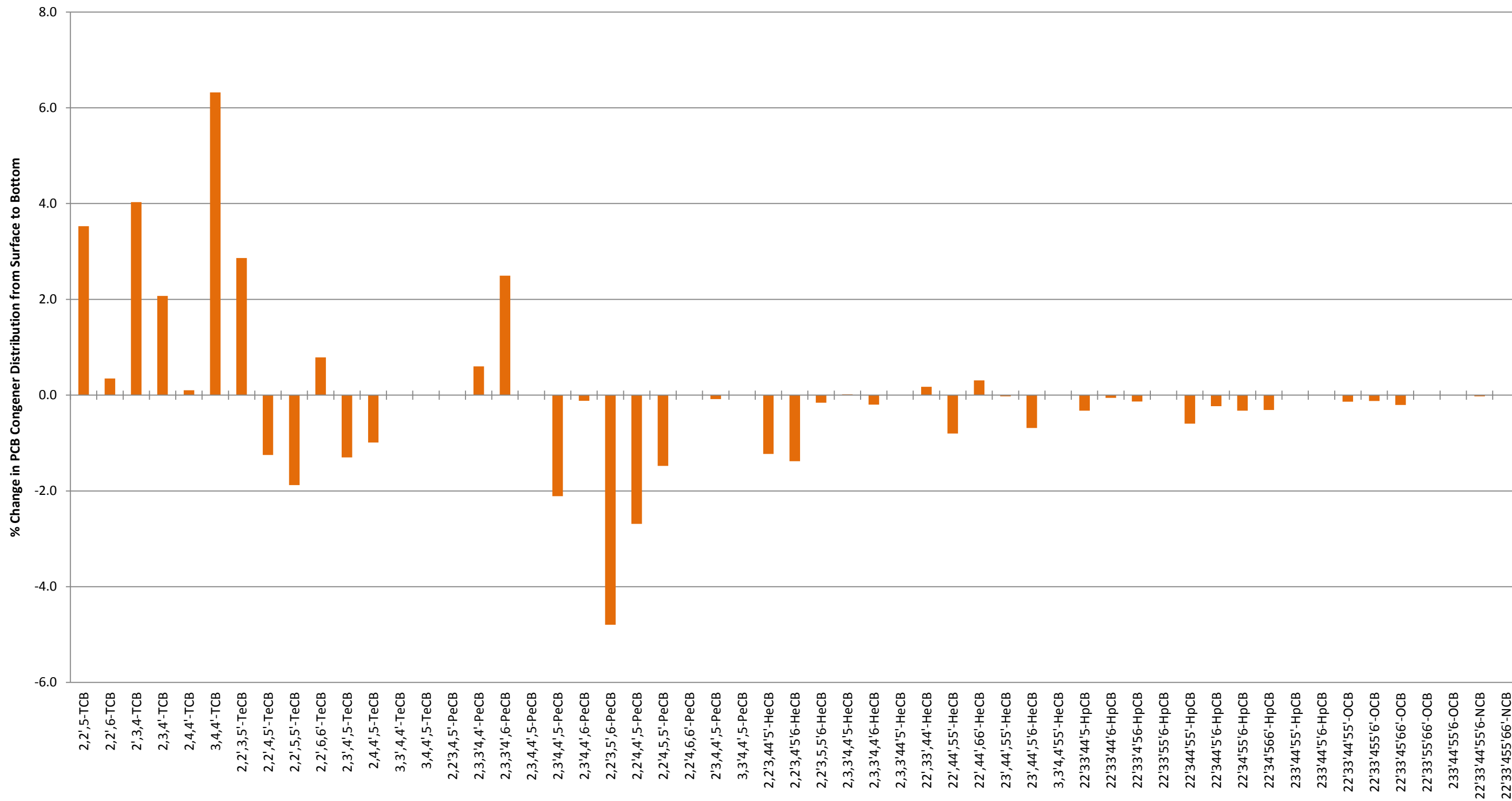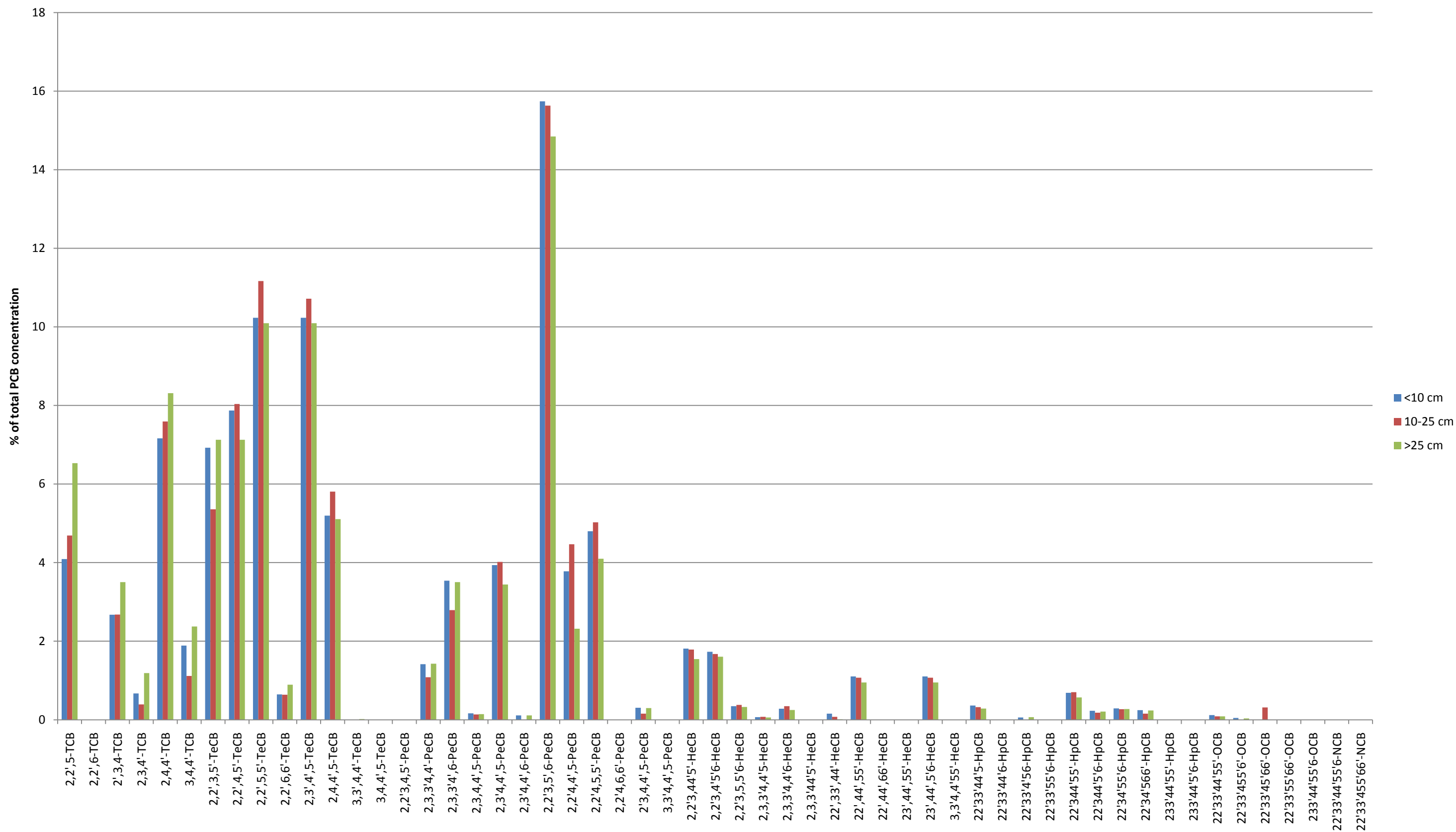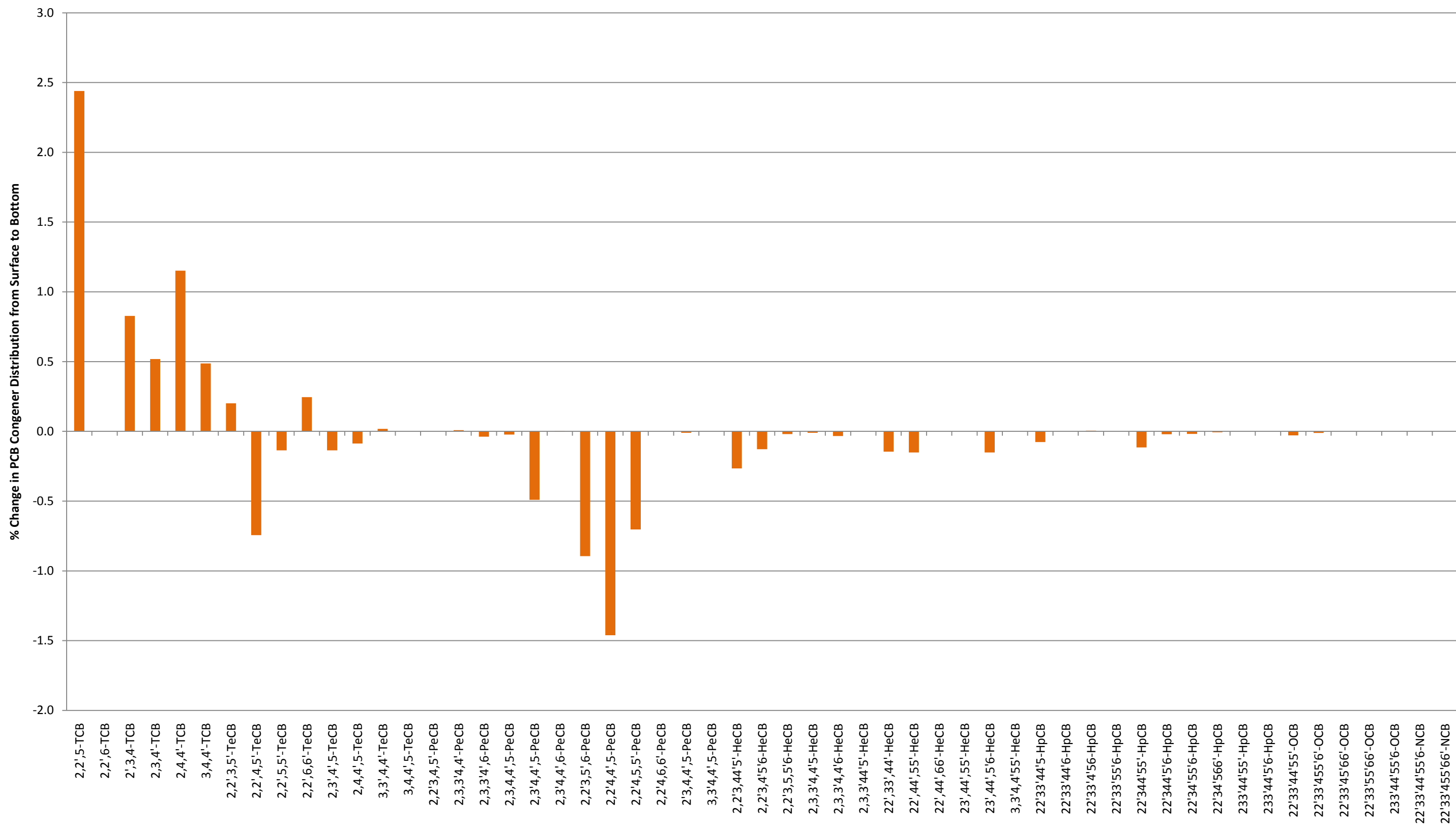
Figure 5: Congener Shifts Between Surface (0-10 cm) and Bottom (>25 cm) Sections at LC16. MOE 2002-3.

Figure 6: Distribution of PCB Congeners with Depth at LC17. MOE 2002-3.

Figure 7: Congener Shifts Between Surface (0-10 cm) and Bottom (>25 cm) Sections at LC17. MOE 2002-3.

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