BIOMONITORING CALIFORNIA
DATA SUMMARY REPORT
July 1, 2012

This is the second Data Summary Report of the California Environmental Contaminant Biomonitoring Program, also called Biomonitoring California. The Program was established in 2006, and is required by law to make its summarized results available to the public every two years.[1] Many of the projects and collaborations described herein are not yet complete, so the current report offers a preliminary view of the anticipated findings. The Program plans to provide detailed findings from individual studies as the results are finalized. This report reflects substantial progress in the magnitude and complexity of Program activities since the initial report was released in 2010.

Report Highlights

- The Program has developed laboratory capacity and infrastructure to analyze more than 100 different chemicals, and has tested samples from more than 700 California residents.

- The Program has measured many chemicals, including heavy metals, flame retardants, pesticides, and plasticizers, in Californians. Because high levels of flame retardants have previously been found in Californians, the Program has made it a priority to measure recently banned flame retardants, some of their breakdown products (metabolites), and some substitutes of concern.

- The preliminary results presented in this report come from studies of eight groups of participants in California, including pregnant women, firefighters, residents of agricultural communities, and pre-adolescent girls.

- The Program identified elevated levels of mercury in a mother and her newborn, who had been exposed via face cream purchased and altered in Mexico and brought back to the U.S. In addition to reducing the family's exposure to this toxic metal, this finding led to considerable media coverage and a national consumer alert to increase public awareness about mercury exposure hazards from some face creams.

- The Program adds significant value to national biomonitoring efforts by providing information about chemicals of particular concern in California and by studying the diverse populations in the state.

[1] The Data Summary Report is required to be issued biennially by California Health & Safety Code (HSC) section 105459(d). The first Biomonitoring California Data Summary Report is available at: http://www.oehha.ca.gov/multimedia/biomon/pdf/BiomonitoringDataSumJuly2010.pdf.

Background

What is Biomonitoring? Why is It Important?

"Biomonitoring" refers to measuring chemicals in people. It can give us a better understanding of many human exposures than monitoring chemicals in air, water, food, soil, or other environmental media.

Every day people are exposed to thousands of chemicals in California's environment as well as in common consumer products. Some of these chemicals have been associated with toxic effects, such as decreased fertility in women or impaired learning in children. California residents may have different patterns of exposure to certain environmental chemicals, such as flame retardants, compared to people in the rest of the country.

To date, the Program has selected approximately 100 chemicals for biomonitoring based on the likelihood of exposure and potential health concerns. These chemicals are a small subset of the tens of thousands of chemicals that can be found in the environment and consumer products. The Program has been developing extensive analytical capabilities to measure low levels of these chemicals in people and has already begun to produce results for the public and policy-makers. As more results are produced, they can help regulators evaluate which policies and public health efforts are most effective in reducing exposures to harmful chemicals.

The measurement of an environmental chemical in a person's blood or urine indicates exposure, and does not in itself mean that the chemical causes disease. Additional studies are required to determine the extent to which specific levels and duration of exposure to that chemical may contribute to disease or other adverse health effects. For a few environmental chemicals, such as lead or mercury, existing research provides a good basis for understanding health risks associated with different blood levels. For most environmental chemicals, however, more research is needed to evaluate potential health risks of specific levels measured in blood, urine, or other biological samples. Biomonitoring data can help California researchers who are working to understand how chemical exposures can affect health.

About the Program

Biomonitoring California is the only ongoing legislatively mandated state biomonitoring program in the country. The Program is a collaborative effort of three departments: the California Department of Public Health (CDPH), the Office of Environmental Health Hazard Assessment (OEHHA), and the Department of Toxic Substances Control (DTSC). The principal mandated goals of the Program are to monitor levels of specific environmental chemicals in a representative statewide sample of Californians; to conduct studies of targeted subpopulations within the state; and to help assess the effectiveness of existing public health and environmental programs in reducing these chemical exposures. The Program has a five-year Cooperative Agreement with the U.S. Centers for Disease Control and Prevention (CDC); this support has been critical in enabling the Program to produce the results presented in this report.

Biomonitoring California has found many chemicals, including heavy metals, flame retardants, pesticides, and plasticizers, in California residents.

The Program has detected a number of chemicals selected for biomonitoring, such as heavy metals (including mercury and lead), pesticides, phthalates, and perfluorochemicals (PFCs). The Program has also measured persistent chemicals that have been banned, including some flame retardants that were widely used in furniture and electronics (e.g., penta- and octa-polybrominated diphenyl ethers [PBDEs]) and some pesticides (e.g., DDT and its metabolite[2], DDE). Some of the chemicals measured were found in 100% of the people tested. Table 1 provides more details on how frequently the Program detected all of the chemicals measured so far. The detection frequencies in Table 1 are not necessarily representative of chemicals in the state's population as a whole. This table does not indicate the levels of chemicals measured in participants individually or as a group.

Mother and newborn baby exposed to mercury in tainted face cream

In January 2011 Biomonitoring California measured high levels of blood mercury in a mother and her newborn infant. The mother's mercury level was nearly three times higher than the reporting threshold used by the CDC[3] for females aged 49 and younger. This was of particular concern because mercury can be toxic to the nervous systems of pregnant women and infants.

The Program conducted a follow-up investigation in collaboration with the University of California, San Francisco, the San Francisco Department of Public Health, the U.S. Environmental Protection Agency, and CDPH's Food and Drug Laboratory Branch. The source of mercury was found to be a face cream that had been purchased in Mexico, taken to a local store in Mexico (farmacia) where mercury and other ingredients were added to the cream, and then brought into the U.S. in personal luggage.

CDPH and others had previously identified elevated mercury levels in imported face creams.[4] The Department had also issued a health alert on mercury in face creams that was distributed to local clinics and health departments throughout the state in May 2010 and

[2] A metabolite is a chemical produced by the body when it breaks down another chemical, such as a drug or an environmental contaminant.

[3] The reporting threshold is used by CDC in the National Health and Nutrition Examination Survey (NHANES) that it conducts to decide when to follow up with a study participant because measured levels are high. The CDC NHANES is used to assess the health and nutritional status of adults and children in the U.S.

[4] For more information on earlier cases of mercury exposure from face creams, see the following reports: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6102a3.htm and http://www.cdc.gov/mmwr/preview/mmwrhtml/00041544.htm

updated in February 2011.[5] The case detected by Biomonitoring California, together with earlier findings, generated considerable media coverage.

After identifying the source of mercury, Biomonitoring California, other CDPH staff, and other agencies and partners requested assistance from the U.S. Food and Drug Administration (FDA) to increase public awareness. The FDA subsequently issued a national Consumer Update in March 2012[6].

By identifying the participants' source of mercury exposure, Biomonitoring California not only reduced exposures for the mother and baby involved, but also helped raise state and national awareness of mercury in some imported face creams.

Program finds low blood lead levels in Californians tested so far

One of Biomonitoring California's goals is to help assess the effectiveness of existing public health programs in reducing chemical exposures. Lead has been known for centuries to be a health hazard. As scientists have continued to learn about lead's harmful health effects at low levels, the threshold of concern has been lowered several times. Currently, no measurable level of lead in humans is considered "safe." Blood lead levels in the U.S. population have been declining since lead's use in residential paint and gasoline was phased out in the 1970s. However, exposure to lead still occurs. State efforts aimed at reducing lead exposure include activities of CDPH's Childhood Lead Poisoning Prevention Branch and Occupational Lead Poisoning Prevention Program, as well as enforcement of required warnings for lead exposures under Proposition 65.

Thus far, the measured levels of blood lead have been low in samples from participants analyzed by Biomonitoring California. Participants have included pregnant women and pre-adolescent girls, who are not routinely tested for lead. All 529 individuals tested by the Program's laboratories had blood lead values below the levels of concern[7]. While these results provide additional evidence that government initiatives have been successful in reducing lead exposure, the groups studied in the Program's projects are not representative of the state as a whole. For example, our results did not include young children under six years of age, who are among the highest risk populations for lead poisoning. More than 2,000 children under age six in California are still identified annually with elevated blood lead levels (defined as at least 10 µg/dL according to the CDC). Approximately 20,000 young children in California are still identified with levels of at least 5 µg/dL, a stricter

[5] http://www.ehib.org/papers/CDPH_Mecury_Health_Alert_Skin_Cream.pdf
[6] http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm294849.htm.
[7] Biomonitoring California uses the more stringent level of concern for children up to age 6 (at least 5 µg /dL) recommended by CDC's Advisory Committee on Childhood Lead Poisoning Prevention; for women of child-bearing age, the Program's level of concern is ≥5 µg/dL; for all other adults, ≥10 µg/dL.

definition of elevated blood lead level recommended by CDC's Advisory Committee on Childhood Lead Poisoning Prevention.[8]

While quite a lot is known about lead levels in children, much less is known about lead levels in other populations. Biomonitoring California's efforts to measure lead in a wide range of Californians will fill some gaps in our understanding of how these levels may be changing over time in populations in which lead has not been well studied.

Biomonitoring California now has the ability to measure more than 100 chemicals in people and has tested more than 700 Californians.

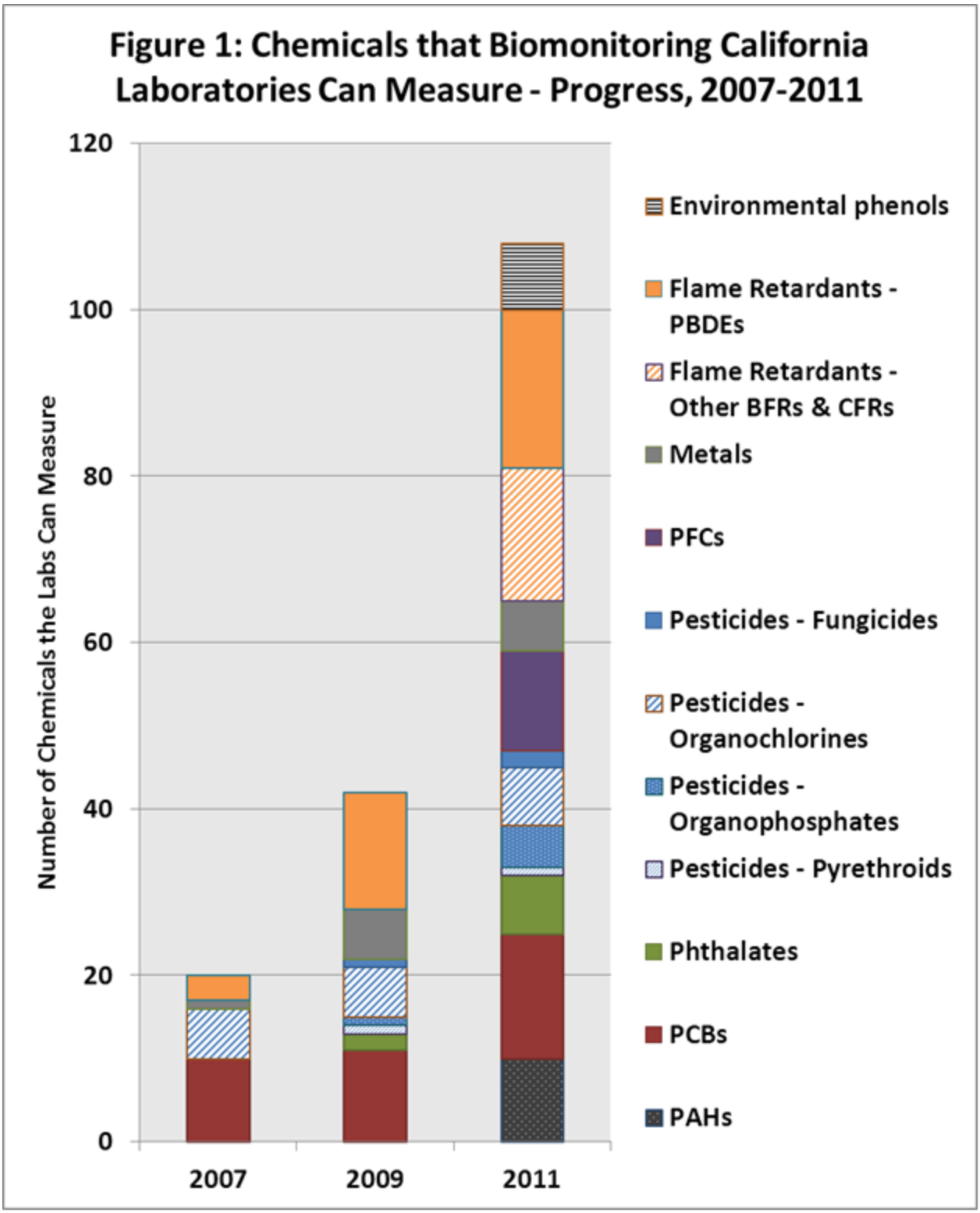
Since 2007 the Program's laboratories have made significant advances in their ability to measure chemicals in people (see Figure 1 on next page). The Program's laboratories can now analyze approximately 100 different chemicals in blood and/or urine (see Table 2) and are developing methods to test for additional chemicals of particular importance to California. The Program had tested more than 700 Californians as of May 2012 and anticipates being able to test up to 1,000 people annually in the foreseeable future.

Chemicals that the Program chooses to measure are selected based on several factors, including their known or suspected health effects; the likelihood that the public comes into contact with them; and whether methods exist to measure them.[9] A committee of independent experts, the Scientific Guidance Panel, advises the Program on chemicals that are priorities for measuring in California residents. The Program's laboratories are developing new methods to measure chemicals of increasing concern in California, such as new flame retardants that are being used extensively as PBDE substitutes.

In 2006 the National Academy of Sciences (NAS) called for improvements in state infrastructure to enable more extensive use of biomonitoring as a public health tool. According to the NAS, biomonitoring could be used in large-scale epidemiological studies and responses to chemical releases, whether accidental or intentional. The Association for Public Health Laboratories has identified a critical need to develop a network of public health laboratories in the U.S. able to respond to state and local environmental health concerns. The improved infrastructure and increased capacity of Biomonitoring California's laboratories provide an important link in this growing network.

[8] California Department of Public Health, Childhood Lead Poisoning Prevention Branch, Number of Individual Children Screened for Lead, by Highest Level: California 2010, Response and Surveillance System for Childhood Lead Exposures, data archived January 12, 2012 .

[9] Other criteria include: the need to assess the efficacy of public health actions to reduce exposure; availability of adequate specimens; and cost associated with analysis. Criteria are described in H&SC Section 105449(c).



Abbreviations: **BFRs** - brominated flame retardants; **CFRs** - chlorinated flame retardants; **PAHs** - polyaromatic hydrocarbons; **PBDEs** - polybrominated diphenyl ethers; **PCBs** - polychlorinated biphenyls; **PFCs** - perfluorinated chemicals

Measuring Flame Retardants – Responding to an Urgent Need in California

California's unique furniture flammability regulations have resulted in the extensive use of chemical flame retardants in upholstered furniture and infant products containing polyurethane foam. These chemicals are not chemically bound to the foam and over time migrate into the environment. Polybrominated diphenyl ethers (PBDEs) were the principal flame retardants used to comply with California's regulations for more than 20 years. Levels of PBDEs measured in Californians' blood have been consistently among the highest in the world, as shown particularly in studies of women and children. PBDEs can interfere with the functioning of hormones, including estrogen, testosterone, and thyroid, and may affect children's learning ability and behavior. In addition to their use in furniture foam and infant products, PBDEs have been used in personal computers, small appliances, televisions, and other electronic devices.

Due to concerns about health effects, especially in children, and the accumulation of PBDEs in the environment and in people, the California Legislature banned two types of PBDEs (pentaBDE and octaBDE mixtures), effective in 2006. U.S. manufacturers have since stopped producing these PBDEs. Many millions of pounds of pentaBDE remain in furniture and infant products (such as strollers, nursing pillows, and infant carriers) made prior to 2006. DecaBDE, which is still used in hard plastic casings for television sets and other electronic products, is scheduled to be phased out in 2013. Substitutes for PBDEs are now being used in polyurethane foam and electronics. Many of these substitutes have not been well studied, but there are significant concerns about their potential to persist in the environment and their possible long-term toxicity. One widely used replacement, called "chlorinated tris" (tris[1,3-dichloro-2-propyl] phosphate), is a known carcinogen.

The Program has made it a priority to develop laboratory capabilities to measure flame retardants. Biomonitoring California is measuring PBDEs and their breakdown products (or metabolites) called hydroxy-PBDEs in blood. Measuring metabolites gives scientists a better understanding about what happens to the chemicals once they are in people's bodies. The Program is also developing analytical methods for newer non-PBDE flame retardants. By tracking the levels of these chemicals in California residents, Biomonitoring California will monitor the effectiveness of the ban in reducing PBDE exposures and should be able to identify population exposures to PBDE substitutes. This information can help policy-makers and regulators make informed decisions to improve the safety of consumer products.

Biomonitoring California's collaborations include studies of ten different groups of participants throughout the state.

The Program's collaborations include studies of ten different groups of participants, including pregnant women, firefighters, teachers, residents of agricultural communities, and pre-adolescent girls. The initial results from eight of these studies are included in this report. Results from the other two studies are not included here because samples were still being collected when this report was prepared. Through these studies, the Program is developing the capacity to survey participants, collect and analyze samples, and communicate individual results in an efficient manner. These efforts are helping to build our capacity to produce data representative of the state's population.

The Program has been able to study these diverse populations and advance its laboratory capability by leveraging state resources. Critical to our accomplishments has been a five-year (2009-2014) Cooperative Agreement with the CDC. Funding from this Cooperative Agreement has more than doubled existing state biomonitoring resources. Another essential component of the Program's progress has been its collaboration with a variety of organizations, including several campuses of the University of California, labor and management groups, and Kaiser Permanente.

The Program's ongoing studies and collaborations will lay the groundwork for better characterizing chemical exposures in California's diverse population, including racial and ethnic groups underrepresented in other studies.

Description of Biomonitoring California Project Collaborations

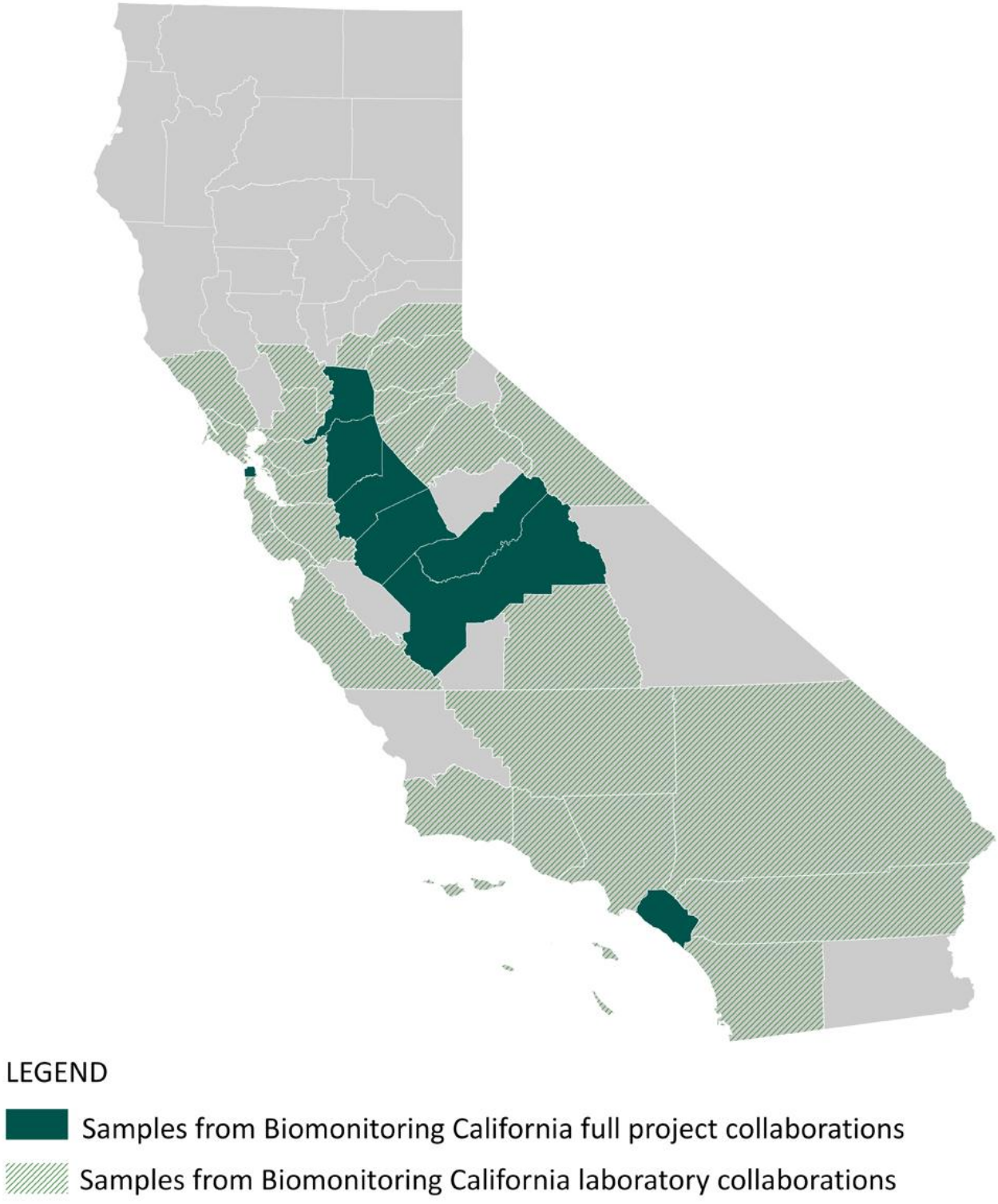
Over the past five years, the Program has collaborated with partners in two ways:

1. Full Project Collaborations: Biomonitoring California designed and carried out the entire study in partnership with other organizations. This involved choosing the population; recruiting participants; collecting survey information and blood and urine samples; conducting laboratory analyses; and reporting results to participants.

2. Laboratory Collaborations: Biomonitoring California conducted laboratory analyses of blood and urine samples collected by outside partners as part of other research projects.

Counties where samples have been collected, as of May 2012, are shown in Figure 2 on the next page.

Figure 2: Location of samples collected, by county, as of May 2012*



*Includes all counties where at least one sample has been collected; analysis is ongoing.

The following descriptions and Table 3 provide information about the Program's collaborative projects.

Full Project Collaborations

The **Biomonitoring Exposures Study** (**BEST**) is a joint effort between the Program and the Kaiser Permanente Northern California (KPNC) Division of Research. BEST will initially measure environmental chemical exposures in about 100 adult KPNC members living in California's Central Valley. This is the first Biomonitoring California study to collect regionally representative samples with participants randomly selected across gender, age, race/ethnicity, and location. Questionnaire and medical information as well as blood and urine samples are being collected in 2011-2012. The study will be expanded to include more participants and diverse populations over the next year.

The **Firefighter Occupational Exposures (FOX) Project** is a study of environmental chemical exposures in firefighters. This study is being conducted in partnership with the University of California (UC) Irvine's Center for Occupational and Environmental Health, the Orange County Fire Authority (OCFA), and the Orange County Professional Firefighters Association, International Association of Fire Fighters Local 3631. The OCFA Wellness and Fitness (WEFIT) Oversight Committee, which includes members of the OCFA and Local 3631, reviews study updates on a quarterly basis. Questionnaire information and blood and urine samples were collected in 2010-2011 from 101 firefighters in Orange County. Firefighters were chosen because they are likely to be exposed to many toxic chemicals in the performance of their duties.

The **Maternal and Infant Environmental Exposure Project (MIEEP)**, also known as the Chemicals in our Bodies Project, is a collaborative study involving Biomonitoring California, the UC San Francisco Program on Reproductive Health and the Environment (UCSF/PRHE), and the UC Berkeley School of Public Health. The project measures chemical exposures in 65 mother-infant pairs and an additional 27 pregnant women. English- and Spanish- speaking pregnant women were recruited at San Francisco General Hospital in 2010-2011. Urine samples and questionnaire information were collected in the third trimester of pregnancy, and maternal and umbilical cord blood samples were collected at delivery.

Laboratory Collaborations

The **California Teachers Study** is a large, multi-institutional, statewide cohort study conducted by the Cancer Prevention Institute of California, the City of Hope, the University of Southern California, and UC Irvine to study factors influencing women's health among active and retired female school teachers and administrators in California. In a substudy focusing on links between chemical exposures and breast cancer, Biomonitoring California laboratories are analyzing PFCs, persistent organic pollutants (PCBs, organochlorine pesticides [OCPs], PBDEs, and new brominated flame retardants [BFRs]) in serum samples from approximately 1,360 women with breast cancer and 1,360 women without breast cancer.

The **Center for the Health Assessment of Mothers and Children of Salinas** (**CHAMACOS**), a study conducted by researchers at UC Berkeley, is following a cohort of children in the agricultural communities of the Salinas Valley. Their mothers were enrolled in the study during pregnancy, and the children have been followed to age 12 to learn more about potential impacts of chemical and other environmental exposures on children's health. Biomonitoring California laboratories analyzed phthalates in urine samples from a subset of participants.

The **Cohort of Young Girls' Nutrition, Environment, and Transitions** (**CYGNET**) study is conducted by the KPNC Division of Research, CDPH, and Zero Breast Cancer as part of the Breast Cancer and the Environment Research Program sponsored by the National Institutes of Health. CYGNET identifies chemical exposures in girls in the San Francisco Bay Area and assesses the relationships of these exposures to possible health effects, such as timing of puberty. Biomonitoring California laboratories analyzed metals in blood samples from a subset of CYGNET participants.

The **Environmental Chemistry Laboratory Pilot Study**[10] is an ongoing study that recruits volunteers in order to help refine procedures used by Biomonitoring California (sample collection, shipping, and laboratory analyses). The Program collects and analyzes all samples for this study. Some of these data have been included in a publication tracing levels of perfluorochemicals (PFCs) in California women over the last 50 years.[11]

Markers of Autism Risk in Babies–Learning Early Signs (**MARBLES**) is a longitudinal study, conducted by researchers at UC Davis, of pregnant women who previously had a child diagnosed with an autism spectrum disorder. The study is investigating possible biological and environmental exposures during pregnancy and after delivery, as well as other risk factors that may contribute to the development of autism. Biomonitoring California analyzed phthalates in urine samples from a subset of study participants.

The **Pesticide Drift 2 Study** assessed exposure from pesticide drift among adults and children in a rural agricultural community in Tulare County. The study was a collaboration with CDPH'S Environmental Health Tracking Program, as well as the nongovernmental organizations Pesticide Action Network of North America, El Quinto Sol, and Commonweal. Biomonitoring California analyzed breakdown products of the pesticide chlorpyrifos in urine samples collected as part of this study.

The UCSF Pilot Study of Second-Trimester Pregnant Women collected samples from 25 pregnant women seeking care at San Francisco General Hospital. The study population consisted of ethnically diverse and predominantly low-income women in their second trimesters of pregnancy. This study investigated various relationships, including associations between PBDE exposures and measures of thyroid function during the second

[10] There are no external project collaborators on this study. The entire study is being conducted by Biomonitoring California staff.

[11] Wang M, Park J-S, Petreas M. Temporal changes in the levels of perfluorinated compounds in California women's serum over the past 50 Years. Environ Sci Technol 2011;45: 7510-7516.

trimester of pregnancy. This study was a collaboration between Biomonitoring California and UCSF/PRHE. The Program laboratories analyzed blood samples for persistent organic pollutants (PCBs, pesticides, and PBDEs), their metabolites (hydroxy-PCBs and hydroxy-PBDEs), and PFCs. Results from the PBDE and hydroxy-PBDEs analyses have already been published.[12]

Looking Forward

- Biomonitoring California will release more detailed findings about its project collaborations in the near future.
- As the Program continues to follow up on cases of elevated levels of chemicals, there will be more opportunities for public health intervention and increasing public awareness on how to avoid contact with toxic chemicals. The efforts carried out following identification of high levels of mercury in a mother and her newborn baby (described on pp. 3 – 4 of this report) demonstrate the program's ability to conduct timely follow-up.
- Our laboratories are continuing to analyze study samples and expand their overall capacity. In the foreseeable future, we envision being able to test up to 1,000 people annually.
- By tracking the levels of banned PBDE flame retardants and developing laboratory methods for important emerging substitutes, the Program will help policy-makers evaluate the effectiveness of the PBDE ban and some possible consequences of the substitutes introduced.
- The Program will launch studies that will help us learn more about chemical levels in populations from various ethnic groups underrepresented in other biomonitoring studies in the U.S.
- The Program has developed the laboratory capacity and infrastructure to measure chemicals as well as the skills to recruit and survey participants. In addition, the Program has launched a pilot study in the Central Valley with participants selected to approximately represent the adult population of that area. These developments are building program capacity to produce data representative of the state's general population.
- The Program's advances are responding to the NAS recommendation for development of state-based laboratory infrastructure. Our laboratories also represent an important link in the national network of laboratories able to respond to biomonitoring needs, as called for by the CDC and the Association for Public Health Laboratories.

[12] Zota AR, Park J-S, Wang Y, Petreas M, Zoeller RT, Woodruff TJ. Polybrominated diphenyl ethers (PBDEs), hydroxylated PBDEs (OH-PBDEs), and measures of thyroid function in second trimester pregnant women in California. Environ Sci Technol 2011;45:7896-905. (http://www.ncbi.nlm.nih.gov/pubmed/21830753)

As the Program continues to develop, it will be poised to inform state policy and public health efforts, such as California's new Safer Consumer Products Program, to prevent exposure to potentially harmful chemicals.

TABLES AND ACKNOWLEDGMENTS

Table 1. Initial Combined Results from Biomonitoring California Collaborations

Table 1 displays the percentages of people in whom biomonitored chemicals were found (known as the detection frequency). The detection frequency does not indicate the measured level of a chemical.

The measurement of an environmental chemical in a person's blood or urine indicates exposure, and does not in itself mean that the chemical causes disease. Additional studies are required to determine the extent to which specific levels and duration of exposure to that chemical may contribute to disease or other adverse health effects. For a few environmental chemicals, such as lead or mercury, existing research provides a good basis for understanding health risks associated with different blood levels. For most environmental chemicals, however, more research is needed to evaluate potential health risks of specific levels measured in blood, urine, or other biological samples.

Table 1 combines results from eight individual studies. These studies include full project collaborations as well as laboratory collaborations. The table shows the chemicals the Program has found in California residents as of May 2012.[13] The number of samples analyzed per chemical varies. In some cases, this is because of the timing of when new analytical methods were available; in other cases, collaborators only requested analyses for a subset of chemicals.

The detection frequencies for some chemicals were very high. For example, some PFCs were found in everyone tested (100%). However, the detection frequencies in this table are not necessarily representative of chemicals in the state's population as a whole.

The Program's collaborations are in various stages, from data collection to completed projects. Every study is being analyzed separately, and the results from each study will be reported when they are available. These reports will include data on the levels measured as well as results for more chemicals.

[13] Additional analyses are underway on samples from Biomonitoring California projects that are still in progress. For more information on which chemicals are being analyzed in the different projects, see Table 2. Chemicals that Biomonitoring California Laboratories Can Measure as of May 2012.

Table 1. Initial Combined Results from Biomonitoring California Collaborations

Chemical[14]	Study[15]	Number of People Tested	Detection Frequency[16]
Flame Retardants (brominated and chlorinated)			
Polybrominated Diphenyl Ethers (PBDEs) [17]			
BDE 28	D,F	102	56%
BDE 47	D,E,F	136	91%
BDE 66	D,F	102	7%
BDE 85	D,F	102	25%
BDE 99	D,E,F	135	70%
BDE 100	D,F	102	91%
BDE 153	D,E,F	135	90%
BDE 154	D,F	102	17%
BDE 183	D,F	102	5%
BDE 197	D,F	102	36%
BDE 206	D,F	102	4%
BDE 207	D,F	102	33%
BDE 208	D,F	102	12%
BDE 209	D,F	102	46%
Hydroxy-PBDEs (metabolites[18] of PBDEs)			
4'-Hydroxy-BDE 17	F	24	58%
5-Hydroxy-BDE 47	F	24	83%
6-Hydroxy-BDE 47	F	24	92%
4'-Hydroxy-BDE 49	F	24	50%

[14] For more information on these chemicals, see Table 2. Chemicals that Biomonitoring California Laboratories Can Measure as of May 2012.

[15] Studies: (A) CYGNET; (B) FOX; (C) MARBLES; (D) MIEEP, maternal results only (cord blood results were excluded from the combined results); (E) Environmental Chemistry Lab Pilot Study; (F) UCSF Pilot Study of Second Trimester Pregnant Women; (G) Pesticide Drift 2 Study; (H) CHAMACOS

[16] Detection frequency is the percentage of people who had a measurable level of a chemical out of the total number of people in whom the chemical was measured. If someone had multiple measurements, then only the first measurement (chronologically) was used to calculate the detection frequency.

[17] The Program analyzed components of three major commercial PBDE formulations: PentaBDE consists primarily of BDE-47 and BDE-99; other chemicals in the pentaBDE mixture include BDE-100, -153, -154, -85, -66, and -28. The main components of octaBDE are BDE-183, -197, -207, and -153; other chemicals in the octaBDE mixture include BDE-154, -206, -209, and -208. DecaBDE is almost entirely BDE-209, but also contains small amounts of BDE-206, -207 and -208.

[18] A metabolite is a chemical produced by the body when it breaks down another chemical, such as a drug or an environmental contaminant.

Chemical[14]	Study[15]	Number of People Tested	Detection Frequency[16]
Metals			
Cadmium	A,B,D	529	61%
Lead	A,B,D	529	100%
Manganese	A,B	452	100%[19]
Mercury	A,B,D	529	97%
Perfluorochemicals (PFCs)			
2-(N-Ethyl-perfluorooctane sulfonamido) acetic acid	B,D,F	203	49%
2-(N-Methyl-perfluorooctane sulfonamido) acetic acid	B,D,F	203	99%
Perfluorobutane sulfonic acid	B,D,F	203	4%
Perfluorodecanoic acid	B,D,F	203	72%
Perfluorododecanoic acid	B,D,F	203	1%
Perfluoroheptanoic acid	B,D,F	203	58%
Perfluorohexane sulfonic acid	B,E,F	137	100%
Perfluorononanoic acid	B,D,F	203	100%
Perfluorooctane sulfonamide	B,D,F	203	83%
Perfluorooctane sulfonic acid (PFOS)	B,D,E,F	236	100%
Perfluorooctanoic acid (PFOA)	B,D,E,F	236	86%
Perfluoroundecanoic acid	B,D,F	203	97%
Pesticides			
Organochlorine Pesticides			
2,4'-Dichlorodiphenyltrichloroethane (DDT)	D,E	98	12%
4,4'-DDT	D,E,F	123	28%
4,4'-Dichlorodiphenyldichloroethene (DDE)[20]	D,E,F	136	99%
beta-Hexachlorocyclohexane (b-HCH)	D,E,F	123	65%
Hexachlorobenzene (HCB)	D,E,F	135	96%
Oxychlordane[21]	D,E,F	136	66%
trans-Nonachlor[22]	D,E,F	136	88%
Organophosphate Insecticides			
3,5,6-Trichloro-2-pyridinol[23]	G	34	94%

[19] The 100% detection frequency of manganese was expected because it is an essential nutrient. It can also be toxic at higher exposure levels.

[20] DDE is a metabolite and environmental breakdown product of DDT.

[21] Oxychlordane is a metabolite and environmental breakdown product of chlordane.

[22] t-Nonachlor was a component of the commercial chlordane mixture.

[23] 3,5,6-Trichloro-2-pyridinol is a metabolite of chlorpyrifos.

Chemical[14]	Study[15]	Number of People Tested	Detection Frequency[16]
Phthalates			
Mono-butyl phthalate[24]	C,H	64	100%
Mono-ethyl phthalate[25]	C,H	64	100%
Polychlorinated Biphenyls (PCBs)			
PCB 66	D,E,F	123	14%
PCB 74	D,E,F	136	38%
PCB 99	D,E,F	136	35%
PCB 101	D,F	102	14%
PCB 118	D,E,F	136	53%
PCB 138	D,E,F	136	89%
PCB 153	D,E,F	136	93%
PCB 156	D,F	102	19%
PCB 170	D,E,F	136	64%
PCB 180	D,E,F	125	92%
PCB 187	D,E,F	136	51%
PCB 194	D,E,F	136	32%
PCB 203	D,E	111	32%

[24] Mono-butyl phthalate is a metabolite of benzylbutyl phthalate and dibutyl phthalate.
[25] Mono-ethyl phthalate is a metabolite of diethyl phthalate.

Table 2. Chemicals that Biomonitoring California Laboratories Can Measure as of May 2012

Table 2 provides a list of the chemicals that the Program can currently measure and a brief description of the chemicals individually or by class. This table also summarizes the number of analytes in each group and whether the chemicals are analyzed in blood or urine.

Table 2. Chemicals that Biomonitoring California Laboratories Can Measure as of May 2012		
Environmental phenols	Environmental phenols share a common chemical structure, and are analyzed as a group. They have a wide variety of uses, described briefly below.	*Analyzed in urine:* Benzophenone-3 BPA 4-t-OP 4 parabens Triclosan *Analyzed in serum:* BPA Triclosan
Benzophenone-3	Benzophenone-3 blocks ultraviolet radiation and is used in sunscreens and plastics.	
Bisphenol A (BPA)	BPA is used to make protective coatings, like those inside metal food cans that prevent rust and corrosion. It is also the building block for a hard plastic called polycarbonate.	
4-t-Octylphenol (4-t-OP)	4-t-OP is used in rubber and has been found in recycled tires. 4-t-OP is also used to make ingredients for protective coatings, paints, varnishes, and detergents.	
Parabens	Parabens are widely used as preservatives in cosmetics, lotions, shampoos, deodorants, pharmaceuticals, foods, and beverages.	
Triclosan	Triclosan is used to kill bacteria. It is added to soaps and other consumer products labeled “antibacterial” or “antimicrobial.”	
Flame retardants (brominated and chlorinated)	Flame retardants are added to products such as furniture foam (e.g., cushions), textiles, and electronics, often to meet flammability standards.	
Polybrominated diphenyl ethers (PBDEs)	Since 2006 penta- and octaBDEs have been banned in products sold in California; decaBDE is being phased out. PBDEs last a long time in the environment and people. Research studies have measured the world’s highest PBDE levels in Californians. PBDEs were extensively used to meet the state’s furniture flammability standards.	*Analyzed in serum:* 19 PBDEs 8 hydroxy-PBDE metabolites[26]
Other brominated or chlorinated flame retardants (BFRs and CFRs)	BFRs and CFRs are widely used in consumer products and for industrial applications. Some are replacements for PBDEs.	*Analyzed in serum:* 15 BFRs 1 CFR

[26] A metabolite is a chemical produced by the body when it breaks down another chemical, such as a drug or an environmental contaminant.

Chemicals that Biomonitoring California Laboratories Can Measure as of May 2012, continued		
Metals	Metals occur in nature and are used in many industries and products.	*Analyzed in blood:* 6 metals (*Methods under development for metals analyzed in urine*)
Arsenic	Arsenic occurs naturally in some foods and in drinking water in some geographic areas. Arsenic compounds are used as pesticides, although this use has declined considerably in recent years. One arsenic compound is used in semi-conductors.	
Cadmium	Cadmium is found in cigarette smoke, some cheap metal jewelry, nickel-cadmium batteries, and some paints and pigments.	
Lead	Lead was formerly used in paint and gasoline and is still used in many consumer products, including some dishes and pottery, and some plastic products. It is found in dust and soil in and around houses built before 1978 and at some job sites, such as painting, construction, and battery recycling.	
Manganese	Manganese is an essential nutrient found mainly in food. It can be toxic at higher exposure levels, which can occur in metalworking occupations like welding. Manganese is also a component of two fungicides widely used in California.	
Mercury	Mercury occurs naturally in much of California, and in the past was released into the environment from mining operations. It is also found in emissions from coal-burning plants. Mercury in the environment builds up in certain types of fish. It is used in silver dental fillings and fluorescent light bulbs. It has also been found in some imported skin-lightening and anti-aging creams.	
Uranium	Uranium occurs naturally in drinking water sources in some geographic areas. Uranium is processed for use as fuel in nuclear power plants. Depleted uranium, a byproduct of uranium processing, is used in military applications.	
Perfluorochemicals (PFCs)	PFCs are used to make various products resistant to oil, stains, grease, and water. Example products include: stain-resistant carpets, wrinkle-free clothing, and grease-proof food containers.	*Analyzed in serum:* 12 PFCs

Chemicals that Biomonitoring California Laboratories Can Measure as of May 2012, continued		
Pesticides	Pesticides are chemicals used to control or kill pests, such as insects, fungi, and unwanted plant species.	
Fungicides	Ortho-phenylphenol (OPP) is used to control fungus on agricultural crops, such as citrus fruit. Pentachlorophenol (PCP) was used in the past mainly as a wood preservative, to control fungal rot and wood-boring insects. PCP is no longer registered for sale in California.	*Analyzed in urine and serum:* OPP PCP
Organochlorine pesticides (OCPs)	The OCPs measured by Biomonitoring California are no longer used in the U.S. Because OCPs last a long time in the environment, they can still be found in high-fat fish, meat and dairy products. DDT, which is still used in some other countries, and chlordane are examples of OCPs.	*Analyzed in serum:* 7 OCPs, including metabolites and breakdown products *Analyzed in urine:* 4 OCP metabolites
Organophosphate pesticides (OPs)	OPs are used to kill insects on agricultural crops, such as alfalfa, almonds, and cotton. Chlorpyrifos was one of the top 20 agricultural pesticides used in California in 2010. Some OPs, such as malathion, are used for landscape maintenance.	*Analyzed in urine:* 4 nonspecific metabolites of more than 20 OPs Chlorpyrifos metabolite
Pyrethroid pesticides	Pyrethroid pesticides are used to kill insects in agriculture. Two pyrethroids were in the top 100 agricultural pesticides used in California in 2010. They are also used in products for home use, including some flea control products for pets.	*Analyzed in urine:* 1 metabolite of at least 6 pyrethroids
Phthalates	Phthalates are added to vinyl to make it soft and flexible. Vinyl products include shower curtains, flooring, and plastic tubing. Phthalates are also in some nail polish and scented products.	*Analyzed in urine*: 6 phthalate metabolites
Polychlorinated biphenyls (PCBs)	PCBs were banned in the late 1970s, but last a long time in the environment. They are found in high-fat fish and high-fat animal products. PCBs are also found in old caulk and old fluorescent light fixtures.	*Analyzed in serum:* 15 PCBs 10 PCB metabolites
Polycyclic aromatic hydrocarbons (PAHs)	PAHs occur naturally in petroleum products, like gasoline and diesel fuel, and are formed when these products are burned. PAHs are found in cigarette and wood smoke, and in grilled meat. Volcanic eruptions and forest fires are also sources of PAHs.	*Analyzed in urine:* 10 PAH metabolites

Table 3. Biomonitoring California Full Project and Laboratory Collaborations

Study Name	Number of Participants	Population	Catchment Area	Chemicals Being Biomonitored[27]												Dates Samples Collected
				PBDEs	Other BFRs & CFRs	Cadmium	Lead	Manganese	Mercury	PFCs	Pesticides	Phenols, e.g., BPA & Triclosan	Phthalates	PCBs	PAHs	
Full Project Collaborations																
Biomonitoring Exposures Study (BEST)	Approximately 100	Adults	Central Valley	X	X	X	X	X	X	X	X	X	X	X	X	2011-2012
Firefighter Occupational Exposures (FOX) Project	101	Firefighters	Orange County	X	X	X	X	X	X	X	X	X	X	X	X	2010-2011
The Maternal and Infant Environmental Exposure Project (MIEEP)	92 maternal-infant pairs	Pregnant women and their babies	San Francisco	X	X	X	X		X	X	X	X	X	X	X	2010-2011
Laboratory Collaborations																
California Teachers Study	Approximately 2,720	Female professional school employees	Northern California	X	X					X	X			X		2010-2013
The Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS) Study	49	5-year-old children	Salinas Valley										X			2005-2006

[27] For full project collaborations, this list represents all chemicals being biomonitored in study participants. For laboratory collaborations, this list represents only the chemicals that were tested by Biomonitoring California laboratories.

Table 3. Biomonitoring California Full Project and Laboratory Collaborations, continued

Study Name	Number of Participants	Population	Catchment Area	Chemicals Being Biomonitored[24]												Dates Samples Collected
				PBDEs	Other BFRs & CFRs	Cadmium	Lead	Manganese	Mercury	PFCs	Pesticides	Phenols, e.g., BPA & Triclosan	Phthalates	PCBs	PAHs	
Cohort of Young Girls' Nutrition, Environment, and Transitions (CYGNET) Study	351	Girls 6-8 years old	San Francisco Bay Area			X	X	X	X							2005-2007
Environmental Chemistry Lab Pilot Study	50	Adults	California	X	X					X	X			X		2008-ongoing
Markers of Autism Risk in Babies-Learning Early Signs (MARBLES) Study	15	Pregnant women who have a biological child with autism spectrum disorder	Northern California										X			2007-2008
Pesticide Drift 2 Study	34	Farmworkers and their children	Tulare County								X					2009-2010
UCSF Pilot Study of Second Trimester Pregnant Women	25	Pregnant women	Northern California	X						X	X			X		2008-2009

Biomonitoring California would like to acknowledge the following collaborators and partners:

Biomonitoring Exposures Study (BEST)

Kaiser Permanente Northern California (KPNC) Division of Research
Stephen Van Den Eeden, PhD

California Teachers Study

Cancer Prevention Institute of California
Peggy Reynolds, PhD
City of Hope
UC Irvine
University of Southern California
http://www.calteachersstudy.org/

Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS)

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Cohort of Young Girls' Nutrition, Environment, and Transitions (CYGNET)

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Firefighter Occupational Exposures (FOX) Project

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Markers of Autism Risk in Babies–Learning Early Signs (MARBLES)

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Maternal and Infant Environmental Exposure Project (MIEEP)

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Pesticide Drift 2 Study

California Environmental Health Tracking Program
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Commonweal
El Quinto Sol
Pesticide Action Network of North America
http://www.rwjf.org/files/research/63378.pdf

UCSF Pilot Study of Second Trimester Pregnant Women

UC San Francisco Program on Reproductive Health and the Environment
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http://www.ncbi.nlm.nih.gov/pubmed/21830753

We would like to thank the following staff for their contributions to Biomonitoring California:

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Biomonitoring California would also like to thank the members of the Scientific Guidance Panel:

Asa Bradman, MS, PhD
B. Dwight Culver, MD
Marion H. E. Kavanaugh-Lynch, MD, MPH
Ulrike Luderer, MD, PhD
Thomas McKone, PhD
Julia Quint, PhD
Gina Solomon (12/2007 - 4/2012), MD, MPH
Michael P. Wilson, PhD, MPH

For more information on the Scientific Guidance Panel, please go to:
http://oehha.ca.gov/multimedia/biomon/sgpbios.html