ENVIRONMENTAL RADIATION FROM NUCLEAR REACTORS: EFFECTS ON CHILDREN'S HEALTH FROM STARTUPS AND SHUTDOWNS

By
The Radiation and Public Health Project

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RPHP Research Associates

Jay M. Gould, PhD, Director
Ernest J. Sternglass, PhD, Chief Scientist

Jerry Brown, PhD
Joseph Mangano, MPH, MBA
William McDonnell, MA
Marsha Marks, ACSW, LCSW
Janette Sherman, MD

EXECUTIVE SUMMARY

Operations at the seven nuclear reactors in California (four of which are still in operation) have added considerable radioactivity to the local environment, raising concerns of potential harm to local residents. The Radiation and Public Health Project (RPHP) research group has investigated this issue, and has documented facts that suggest such harm is occurring. A number of these findings have been published in peer-reviewed medical journals.

Findings

- From 1970 to 1993, the Diablo Canyon, Humboldt Bay, Rancho Seco, and San Onofre reactors emitted 7.71 trillion picocuries of radioactivity into the air.

- In 105 baby teeth of persons born in California since 1979, RPHP documented an average concentration of radioactive Strontium-90 (Sr-90) higher than that in Connecticut, New Jersey, and New York (but lower than Florida).

- The average Sr-90 concentration in baby teeth of children born in San Luis Obispo County increased 49.6% since the Diablo Canyon 1 and 2 reactors began operations.

- In 1984-85, the first two years in which the Diablo Canyon reactors were operating, infant mortality in San Luis Obispo and Santa Barbara Counties rose 12.9%. In the 1990-91, the first two years after the Rancho Seco reactor closed, the infant death rate fell 16.0%.

- After 1990, the incidence of cancer in children under age five rose 30.8% near Diablo Canyon, but fell 20.7% near Rancho Seco.

- After 1990, the cancer death rate in children under age 20 rose 74.5% near Diablo Canyon, but fell 18.1% near Rancho Seco.

- After 1990, the death rate in children under age 20 near Diablo Canyon increased for birth defects, pneumonia, and infectious diseases.

Recommendations

- The recent evidence suggesting that radioactive chemicals emitted from nuclear power reactors in California are one cause of rising rates of cancer and other childhood diseases is significant and merits more detailed study.

- The Tooth Fairy Project will provide critical data on levels of in-body radioactivity, which will allow researchers to better understand the link between environmental radiation and cancer, especially in young persons. The Project is especially important in the San Luis Obispo area (near the Diablo Canyon reactors, which opened in 1984-85) and the Sacramento area (near the Rancho Seco reactor, which closed in 1989).

- Information on the radiation-cancer link should be considered in federal policies regulating the operation of nuclear reactors, in California and across the U.S.

- Information on the radiation-cancer link should be considered in the U.S. Nuclear Regulatory Commission's environmental review of utility applications to renew and extend the licenses of aging nuclear power plants in California and across the U.S.

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INTRODUCTION

Nuclear power reactors have been operating in the U.S. since 1957. Each of the 103 reactors currently operating in the U.S. (at 72 plants) emits radioactive chemicals into the air and water, from routine operations and from accidents. This radioactivity enters the food chain through precipitation, and is consumed by humans. Most emissions involve chemicals that are not found in nature, but are produced only by atomic bomb explosions and nuclear reactor operations.

Of the 103 nuclear reactors, four are located in California. At one time, 14 reactors to be located in California were projected. However, seven of these facilities were cancelled before startup, and three more shut down by operating utilities (Table 1).

Table 1
Nuclear Power Reactors in California

Reactor	County of Location	Startup Date*	Shutdown Date
Humboldt Bay 3	Humboldt	2/16/63	7/ 2/76
Rancho Seco	Sacramento	9/16/74	6/ 7/89
San Onofre 1	Orange	3/27/67	11/30/92
San Onofre 2	Orange	7/26/82	
San Onofre 3	Orange	9/16/83	
Diablo Canyon 1	San Luis Obispo	4/29/84	
Diablo Canyon 2	San Luis Obispo	8/19/85	
Bolsa Island 1	Orange		
Bolsa Island 2	Orange		
Mendocino 1	Mendocino		
Mendocino 2	Mendocino		
Malibu	Los Angeles		
Sundesert 1	Riverside		
Sundesert 2	Riverside		

Source: U.S. Nuclear Regulatory Commission

The four reactors account for 24% of the state's capacity to produce electricity. (1) These facilities, and the three now closed, have had a spotty record of safety and health concerns, including:

- The Rancho Seco reactor in southeast Sacramento County was closed for over two years after an accident on December 26, 1985. It was shut permanently by a vote taken by local citizens in 1989, after less than 15 years in operation.

- The Humboldt Bay 3 reactor was closed in 1976, after only 13 years in operation.

- The San Onofre 1 reactor had difficulties with its steam generators before the reactor closed in 1992. In 1983, Southern California Edison filed joined a series of legal actions against the Westinghouse Corporation due to the breakdown of these parts; the suit was eventually settled.

- Steam generators for the Diablo Canyon 1 and 2 reactors are also manufactured by Westinghouse.

- San Onofre Unit 2 will be closed from February to June 2001 due to a fire in the switchgear room

II. RADIOACTIVITY

1. Radioactive Releases into the Environment. Utilities operating nuclear power plants are required to submit annual reports on radioactive releases to the federal government. California reactors have emitted substantial amounts (**7.71 trillion picocuries**) of radioactivity into the air from 1970-93. (2) These totals do not include rapidly-decaying radioactive chemicals (i.e., half-life under eight days). The greatest releases have been from the Humboldt 3 and San Onofre reactors.

   By comparison, the Three Mile Island 2 reactor released 14.20 trillion picocuries of radioactive chemicals during the March 1979 accident. Thus, releases from California reactors are just over one-half of that from the Three Mile Island accident.

2. Dietary Levels of Radioactivity. These releases, in the form of tiny particles, are returned to earth in precipitation and enter the drinking water, milk, and food. The federally-mandated program to measure radioactivity in the diet was started by the Eisenhower administration in 1957, during the time of large-scale atomic bomb testing above the Nevada desert.

   Levels of bomb test fallout in the California diet were relatively low, compared to most of the continental U.S. The prevailing winds in southern Nevada move from the west to the east, bypassing California. In addition, most of California receives relatively little precipitation.

   Average concentrations of Strontium-90 (Sr-90), a carcinogen only produced in atomic bomb explosions and nuclear reactors, were measured in the milk of nine U.S. cities from 1958-66. Levels in Sacramento (along with Austin TX) were the lowest of all cities; the average of 6.4 picocuries of Sr-90 per liter of milk was less than half of the national average of 15.9 (Table 2). After the signing of the Partial Test Ban Treaty by the U.S., U.S.S.R., and Great Britain in 1963, dietary levels of Sr-90 and other radioactive chemicals began to fall. (3) (4)

Table 2
Average Concentrations of Strontium-90
In Raw Milk
August 1958 - December 1966

City	Average Sr-90*
St. Louis	30.6
Atlanta	22.8
Cincinnati	15.4

Spokane	14.6
New York City	13.6
Chicago	13.1
Salt Lake City	10.8
Sacramento	6.4
Austin	6.1
U.S. average (9 cities, without Sacramento)	15.9

Source: U.S. Public Health Service

* Defined as average picocuries of Sr-90 per liter of raw milk from monthly measurements

In the 1970s, responsibility for reporting Sr-90 concentrations in milk passed from the U.S. Public Health Service to the U.S. Environmental Protection Agency. Instead of reporting monthly figures, EPA provides only a single measurement each July. From 1983-94, average Sr-90 levels in Los Angeles, Sacramento, and San Francisco (0.37, 0.70, and 0.39 picocuries of Sr-90 per liter of milk) continued to fall well below that of the U.S. (1.64, an average of 23 cities with complete data). (5)

The EPA also calculates another, broader measure of radioactivity, namely the level of all radioactive chemicals emitting beta particles (radioactive chemicals can either emit alpha particles, beta particles, or gamma rays). This measure, made in precipitation in Berkeley each month, shows a decline in levels during the 1980s, but an increase in the early and mid-1990s. (5)

This pattern indicates that a current source of radioactivity is preventing levels from declining due to old, decaying fallout from atomic bomb tests. No weapons detonations in Nevada have occurred above the ground since 1962, and below ground since 1992. Thus, the only source of these man-made products is nuclear reactors.

3. Radioactivity Levels in the Body.

In the 1950s and 1960s, the St. Louis Committee for Nuclear Information tested 60,000 baby teeth for levels of radioactive Sr-90 at birth. Sr-90 is one of dozens of radioactive chemicals found only in atomic bomb tests and nuclear reactor emissions. It is like calcium, seeking out bone and teeth, and resides in the body for many years (half-life of 28.7 years), making it possible to test in-body levels. Sr-90 impairs cells in the bone and bone marrow (in which the immune system defenses are built) making it a risk factor for all cancers.

The St. Louis group found that for children born in 1964, just after above-ground bomb testing ended, the average Sr-90 level was **50 times greater** than for those born in 1950, just before testing began. After 1964, Sr-90 averages declined sharply until the federal government discontinued the study in 1970 (see Figure 1).

From 1961-82, the U.S. Atomic Energy Commission (later the U.S. Department of Energy) operated a program, in which it measured Sr-90 concentrations in the vertebrae of healthy adults in San Francisco who had died in accidents. About 50 such measurements were made each year, and a similar program was conducted in New York City. From 1965-74, after the Partial Test Ban Treaty reduced levels of fallout in diet, the average concentration of Sr-90 declined by 50%; but did not change from 1974-82. (6)

Again, this pattern suggests that a current source of radioactivity was preventing expected declines from decay of old bomb test fallout. The Energy Department terminated its program in 1982. Since then, the U.S. has been without a systematic government program of testing humans for radioactivity levels in their bodies.

In 1996, the Radiation and Public Health Project (RPHP) research group initiated a baby tooth study measuring Sr-90 levels, known as the Tooth Fairy Project. The study is patterned on the St. Louis effort, which provides historical data on Sr-90 levels in the U.S. The RPHP study represents the first study in the U.S. of in-body radioactivity for persons living near nuclear reactors.

As of April 2001, RPHP has collected over 2500 teeth, mostly from California, Connecticut, Florida, New Jersey, and New York. It has measured Sr-90 concentrations in 1352 of these. **The average concentration of 1.53 picocuries Sr-90 per gram of calcium is equivalent to the level found in St. Louis children born in 1956** (1.57), in the midst of the program of nuclear weapons tests above the Nevada desert.

Concentrations of Sr-90 in 105 baby teeth of persons born in California have been measured thus far by RPHP. Most (105) of these are persons born after 1979, long after large-scale atmospheric atomic bomb testing ceased in 1963 with the ratification of the Partial Test Ban Treaty. **The average Sr-90 level in California of 1.72 picocuries per gram calcium trails only Florida (2.08) as the highest of the five regions near reactors producing most of the study teeth**. This finding is surprising, as current Sr-90 levels in California milk are among the lowest in the U.S.

Average Sr-90 concentrations in each region of California exceeds the 1.53 U.S. average, except for the 1.35 figure for San Diego (based on five teeth). The highest average concentration (3.06) is in the Sacramento area, the location of the now-closed Rancho Seco reactor (Table 3). The area with the greatest number of teeth (40) is the Monterey County - San Luis Obispo County - Santa Barbara County area near the Diablo Canyon plant.

Table 3
Average Concentrations of Strontium-90 in Baby Teeth
At Time of Birth, Births After 1979
By State and Region of California

State / Region	Teeth	Average Sr-90*
New York	784	1.41
New Jersey	225	1.55
Florida	121	2.08
California	105	1.72
Connecticut	44	0.96
All Other	73	
TOTAL	1352	1.53
Sacramento	6	3.06
San Luis Obispo	40	1.80
Los Angeles	26	1.65
San Francisco Bay	20	1.64

San Diego	5	1.35
All Other+	8	0.97
TOTAL	105	1.72

* Average picocuries (one trillionth of a curie) of Sr-90 per gram of calcium in baby teeth at birth

+ All other include teeth from persons born in Cohasset (2), Fresno (2), Grass Valley, Reseda, Ridgecrest, and Yosemite Park.

Average Sr-90 concentrations in California increased from 1.51 to 2.05 from the late 1980s to the early 1990s, suggesting again that a current source of radioactive emissions is affecting averages.

III. RADIATION AND HEALTH IN CALIFORNIA

1. Introduction

Since the atomic era began in the 1940s, scientists have been studying effects of exposures to man-made radioactivity. Elevated levels of illness and death are attributed to the Hiroshima and Nagasaki bombs; bomb tests in Nevada, the South Pacific, and the former Soviet Union; and the 1986 accident at the Chernobyl nuclear power plant. Each of these involved relatively high levels of exposure to radioactivity.

In addition, researchers have addressed effects of relatively low doses of radioactivity. The first to scientifically document hazards of low-dose exposures was Alice Stewart, a British physician. In the 1950s, Stewart showed that a pelvic Xray examination to a pregnant woman doubled the chance that the baby would die of cancer before age 10. (7)

Studies of low-dose exposures have addressed many diseases, but often focus on cancer in children. Radioactive chemicals are known to be more harmful to the young, particularly the developing fetus and infant. Body growth and cell division is most rapid early in life, and thus a damaged cell is most likely to cause harm.

The federal government does no systematic tracking of health patterns for persons living near nuclear plants. The only known federal study on cancer near nuclear reactors was a 1990 effort prepared by the National Cancer Institute (NCI), at the insistence of Senator Edward M. Kennedy. NCI concluded there was no cancer risk from reactors, but its designation of counties near reactors as "unexposed controls" is highly controversial. Since 1990, the federal government conducted no studies on health effects of reactor operations.

2. Breast Cancer Mortality

RPHP's Jay Gould performed additional research on cancer near nuclear reactors. In his book *The Enemy Within*, Gould found that women living within 100 miles of nuclear reactors are at the greatest risk of dying of breast cancer. These findings inspired the baby tooth study, designed to gather clinical evidence of the presence of environmental radiation in children's teeth. (8)

Gould found that for each California county in which a nuclear reactor is located, the breast cancer death rate for white women rose substantially from the early 1950s to the late 1980s (Table 4). The rates in Humboldt, Orange, and Sacramento Counties rose 6%, 27%, and 25%, respectively. By contrast, rates for all of California and the U.S. were virtually unchanged (increase of 1%). This

analysis does not include the Diablo Canyon reactors, which began operations in the mid-1980s, thus making it unlikely that breast cancer death rates had been affected by the late 1980s.

Table 4
Breast Cancer Mortality Rates, White Females, All Ages
California Counties With Nuclear Reactors
1950-54 to 1985-89

		Age-Adj Mortality (Deaths)		
County	Reactor	1950-54	1985-89	% Change
Humboldt	Humboldt Bay 3	25.6 (42)	27.3 (96)	+ 6%
Orange	San Onofre 1,2,3	20.3 (163)	25.9 (1554)	+27%
Sacramento	Rancho Seco	21.8 (153)	27.3 (675)	+25%
California		25.5 (7653)	25.9 (18541)	+ 1%
U.S.		24.4 (91932)	24.6 (178868)	+ 1%

Source: National Center for Health Statistics, in *The Enemy Within*, Gould JM et al. New York: Four Walls Eight Windows, 1996.

3. Effects of Reactor Startup / Shutdown on Infant Mortality

In 2000, RPHP's Joseph Mangano published an article showing that when nuclear power plants shut down, deaths to infants under one year in the local downwind counties decline very rapidly immediately after shutdown. (9) Because the developing fetus and infant are especially sensitive to biological effects of radiation exposure, any change in health from adding or removing environmental radioactivity will first be observed in the youngest.

In California, infant deaths **fell 16%** in the downwind counties closest to Rancho Seco after the reactor closed in 1989. But in San Luis Obispo and Santa Barbara Counties, the home county and downwind county closest to the Diablo Canyon plant, infant deaths **increased 13%** in the first two years that the plant was operating (Table 5). In the U.S., two-year infant death rates have declined at about a 6.4% average. The difference between changes in both areas and the U.S. fall short of statistical significance.

Table 5
Change in Mortality Age 0-1
Two Years Before and Two Years After Reactor Startup / Shutdown*

	Infant Deaths		Live Births		Mort. Rate*		
Plant	Before	After	Before	After	Before	After	% Ch
Rancho Seco (close)	418	390	44500	49414	9.39	7.89	**-16.0%** p <.14
Diablo Canyon (open)	112	132	14537	15174	7.70	8.70	**+12.9%** p <.13
U.S. (average two year change, 1985-98)							- 6.4%

* Infant mortality rate represents deaths per 1000 live births. Rancho Seco analysis compares infant mortality 1988-89 vs. 1990-91 for Amador, El Dorado, Placer, and Sacramento Counties. Diablo Canyon analysis compares infant mortality 1982-83 vs. 1984-85 for San Luis Obispo and Santa Barbara Counties.

Source: National Center for Health Statistics

4. Effects of Reactor Startup / Shutdown on Childhood Cancer Incidence

In California, the rate cancer diagnosed in children under five years old has been unchanged from 1988 to 1998 (the period for which the California Cancer Registry has collected statewide data). The U.S. rate is generally unchanged as well. Each year, just over 500 California children under five (20 cases per 100,000 persons) receive a diagnosis of cancer. Medical experts consider most cancers diagnosed early in childhood to originate in the fetal period, when sensitivity to radioactive and other harmful chemicals is greatest.

However, cancer incidence in the downwind counties near Rancho Seco **fell 20.7%** after the reactor closed in 1989. This difference between this decline and the U.S. trend is statistically significant. By contrast, cancer incidence in children residing in San Luis Obispo and Santa Barbara Counties **rose 30.8%** after 1990 (Table 6).

Table 6
Change in Cancer Incidence, Age 0-4
Before and After Reactor Startup / Shutdown*

	Cases		Population		Inc. Rate*		
Plant	Before	After	Before	After	Before	After	% Ch
Rancho Seco (close)	50	207	208302	1087187	24.0	19.0	**-20.7%** p <.01
Diablo Canyon (open)	18	69	124234	363984	14.5	19.0	**+30.8%** p <.12
U.S. change, 1988-89 vs. 1990-97							- 0.2%

* Incidence rate represents newly-diagnosed cases of cancer per 100,000 persons age 0-4. Rancho Seco analysis compares cancer incidence 1988-89 vs. 1990-98 for Amador, El Dorado, Placer, and Sacramento Counties. Diablo Canyon analysis compares cancer incidence 1988-90 vs. 1991-98 for San Luis Obispo and Santa Barbara Counties. National rates are for states with 47% of the 1990 U.S. population. Source: California Cancer Registry.

5. Effects of Reactor Startup / Shutdown on Childhood Cancer Mortality

Cancer deaths in American children have been declining since the 1960s, due to advances in treatments. These improvements have occurred in California as well. However, in San Luis Obispo and Santa Barbara Counties, **an unexpected and highly significant 74.5% increase in cancer deaths among children has occurred from the late 1980s to 1990s**. In the Sacramento area, the rate declined 18.1%, more than the state (-12.9%) and national (-14.1%) declines (Table 7).

Table 7
Change in Cancer Mortality, Age 0-19
Before and After Reactor Startup / Shutdown*
1985-89 vs. 1990-98

	Deaths		Population		Mort. Rate*			
Plant	85-89	90-98	85-89	90-98	85-89	90-98	% Ch	
Rancho Seco (close)	76	138	1774496	3936322	4.28	3.51	**-18.1%**	
Diablo Canyon (open)	16	57	742569	1515911	2.16	3.76	**+74.5%**	p <.001
Other California					4.31	3.75	-12.9%	
U.S.					4.05	3.48	-14.1%	

* Mortality rate represents deaths from cancer (ICD-9 codes 140.0-239.9) per 100,000 persons age 0-19. Rancho Seco analysis includes Amador, El Dorado, Placer, and Sacramento Counties. Diablo Canyon analysis includes San Luis Obispo and Santa Barbara Counties. Source: National Center for Health Statistics (www.cdc.gov, Data and Statistics, CDC Wonder).

This increase in cancer affects not just the youngest children, but all children and adolescents. The fact that the Diablo Canyon reactors opened in 1984 / 1985 and cancer deaths began to increase not immediately after startup, but about five years later is consistent with the pattern near many nuclear reactors studied by the National Cancer Institute in 1990.

6. Effects of Reactor Startup / Shutdown on Childhood Deaths, Other Immune Diseases

The pattern of rising cancer death rates near Diablo Canyon and declining rates near Rancho Seco were matched for other conditions that may be affected by radioactive emissions. Birth defects are, along with childhood cancer, the disease most sensitive to radiation exposure. The risk of dying from pneumonia is dependent on the strength of the immune response in infected patients. Finally, the category of "infectious diseases" includes a variety of bacterial and viral infections that also are dependent on the immune system for survival.

For each of these disease categories, death rates increased near Diablo Canyon and decreased near Rancho Seco in the 1990s among children age 1-19, except for a 12% infectious diseases increase near Rancho Seco. Infants are not included in this analysis.

While only the rise in infectious disease deaths in San Luis Obispo / Santa Barbara was significant due to the relatively small number of deaths, the percentage of increase (e.g., 144.0% for infectious diseases and 95.4% for pneumonia) are noteworthy, especially since state and national rates are declining (Table 8).

Table 8
Change in Mortality from Various Causes, Age 1-19
Before and After Reactor Startup / Shutdown*
1985-89 vs. 1990-98

	Deaths		Population		Mort. Rate*		
Plant	85-89	90-98	85-89	90-98	85-89	90-98	% Ch
Birth Defects							
Rancho Seco (close)	41	79	1670141	3724646	2.45	2.12	**-13.6%**
Diablo Canyon (open)	10	22	742569	1515911	1.43	1.53	**+ 7.5%**
Other California					2.67	2.30	-13.7%
U.S.					2.40	2.00	-17.3%
Infectious Diseases							
Rancho Seco (close)	14	35	1670141	3724646	0.84	0.94	**+12.0%**
Diablo Canyon (open)	4	20	7425691515911		0.57	1.39	**+144.0%** p <.05
Other California					1.28	1.10	-14.0%
U.S.					1.08	1.28	+18.5%
Pneumonia							
Rancho Seco (close)	13	27	1670141	3724646	0.78	0.72	**- 6.8%**
Diablo Canyon (open)	2	8	7425691515911		0.29	0.56	**+95.4%** p <.14
Other California					0.61	0.45	-25.6%
U.S.					0.61	0.52	-15.8%

* Mortality rate represents deaths per 100,000 persons age 0-19. ICD-9 codes include 740.0-759.9 (birth defects); 000.1-139.9 (infectious diseases); and 480.0-486.9 (pneumonia). Rancho Seco analysis includes Amador, El Dorado, Placer, and Sacramento Counties. Diablo Canyon analysis includes San Luis Obispo and Santa Barbara Counties. Source: National Center for Health Statistics (www.cdc.gov, Data and Statistics, CDC Wonder).

Increases in death rates among children are unexpected in San Luis Obispo and Santa Barbara Counties. These areas can be considered "low-risk" according to a number of indicators often used in public health (Table 9). They have a relatively low proportion of minorities, which often are at greater risk for many diseases. They have a more educated population, which often indicates a greater ability to understand the need for good health habits. They have relatively low poverty and unemployment rates, and a rate of physicians per population similar to California - suggesting that access to primary health care is not a large problem. Thus, potential reasons for the increases in childhood cancer and deaths should be investigated further.

Table 9
Selected Demographic Characteristics
San Luis Obispo and Santa Barbara Counties

Indicator	San Luis Obispo	Santa Barbara	California
2000 Population	246,681	399,347	33,871,648
1997 % Black	2.9	3.0	7.4
1997 % Hispanic	16.9	32.8	30.8
1997 % Asian	3.7	5.9	11.7
1993 Physicians / 1000 Pop.	217	246	238

1990 % > 25 Finished HS	83.3	80.0	76.2
1995 % Below Poverty	13.2	13.8	16.5
1997 % Unemployed	4.7	5.0	6.3

Sources: U.S. Census Bureau, 2000 Census of the Population (www.census.gov). Littman and Gaquin. 1999 County and City Extra, 8th Edition, 1999.

IV. THE LINK BETWEEN CANCER RISK AND SR-90 IN TEETH

1. Background

The St. Louis study of Sr-90 in baby teeth was designed to measure the increased burden of radiosensitivity in the body from atomic bomb testing, and not to consider cancer risk of this radioactivity. However, the rise in Sr-90 levels in teeth corresponded to a rise in cancer incidence in children under five years old in the 1950s and early 1960s. In the late 1960s, after above-ground testing ended, both Sr-90 in teeth and childhood cancer declined.

The rise in childhood cancer during bomb testing contributed to President Kennedy's decision to sign the historic 1963 Partial Test Ban Treaty with the former Soviet Union and Great Britain. At that time, the Kennedy White House asked Ernest Sternglass, now chief scientist of RPHP, to testify before a Congressional committee on the health effects of nuclear weapons testing. Dr. Sternglass' work played a key role in the passage of the historic treaty, which prohibited above ground and under water nuclear weapons tests.

Initial results of RPHP's Tooth Fairy Project were published in three peer-reviewed medical journals. (10) (11) (12) In Suffolk County NY, which contributed over 500 teeth to the study, an increase in average Sr-90 averages was followed by an increase in childhood cancer - and a drop in Sr-90 was followed by lower childhood cancer rates (see Figure 2). Thus, **RPHP has found a statistical link between Sr-90 in teeth and childhood cancer**, which it also has done for Ocean County NJ, location of the Oyster Creek reactor, based on 113 teeth.

2. Childhood Cancer and Sr-90 in Teeth Near Diablo Canyon

RPHP has analyzed 34 teeth for children born in San Luis Obispo County. Of these, 15 were born from 1979-85, before any radioactive emissions from the Diablo Canyon reactors could build up in children's bodies. **The average Sr-90 concentration increased 49.6% for the 19 San Luis Obispo children born after 1985** who contributed teeth (Table 9).

Table 9
Change in Average Sr-90 Concentrations
In Baby Teeth At Birth
Children Born in San Luis Obispo County
Before and After Reactor Startup / Shutdown*

Birth Year	No. Teeth	Average Sr-90*
1979-85	15	1.35
1986-94	19	2.02
% Change		**+49.6%**

The increase in Sr-90 in teeth corresponds to the 30.8% rise in cancer incidence for San Luis Obispo / Santa Barbara children age 0-4 about five years later (Table 6). As RPHP collects more teeth

from the Diablo Canyon region, it will be able to further test this link between Sr-90 and childhood cancer, in a manner similar to that used in Suffolk County NY and Ocean County NJ.

In addition, collection of more teeth from the Sacramento region will enable RPHP to assess what change in Sr-90 concentrations occurred after the shutdown of Rancho Seco. All teeth from the Sacramento region are from persons born while the reactor was still operating.

V. SUMMARY

Minimizing adverse health effects of emissions from nuclear power reactors is an important element in any effective strategy to prevent disease and death. Studies show that radioactivity from nuclear plants is getting into the environment and human body, and may be hurting the health of Americans, especially its youngest members.

Because of the need to minimize risk and prevent disease, RPHP has initiated a national study of Strontium-90 in baby teeth, with the goal of collecting and testing 5,000 teeth and correlate radioactivity levels with cancer risk. A complete study of in-body radioactivity levels in persons living near nuclear reactors is the most effective means of studying whether radioactivity emitted from nuclear reactors is affecting cancer levels in the U.S. To date there have been no such studies from government or private researchers.

After reviewing the initial findings of the Tooth Fairy Project in 1999, Dr. Victor W. Sidel, past president of the American Public Health Association, and Dr. H. Jack Geiger, past president of Physicians for Social Responsibility, stated:

"If the levels of Strontium-90 in children's teeth and the variations in levels by geographic area reported in this study are validated by appropriate repetition, these findings would appear to justify intensive follow-up and continuing large-scale surveillance. Given the biological risk associated with body burdens of even small amounts of long-lived radioactive Strontium-90, it would be prudent to regard these findings as suggestive of a potential threat to human health."

In California, there has been an increase in radioactive Strontium-90 in baby teeth and a rise in local infant and childhood cancer mortality after the Diablo Canyon reactors began operations in the mid-1980s. Likewise, there has been a reduction in local infant and childhood cancer deaths after the Rancho Seco reactor closed in 1989. Thus, the need for additional analysis of in-body levels of radioactivity to more fully understand these trends is essential.

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