Implications of radioactivity in seawater to desalination in Santa Cruz County California

Michael E. Boyd -Soquel, CA, January 11, 2014

Introduction

The seawater off the California coastline in Santa Cruz County is contaminated with elevated levels of radiation. While the elevated radiation levels are not in dispute, the controversy is over the source of that elevated radiation. Is it due to natural sources or due Fukushima Japan's TEPCO nuclear power plant melting down and dumping 300 tons of radioactive water into the ocean every day? What ever the source, the removal of such radiation will be a concern to the public that needs to be examined in the final EIR process on the proposed regional desalination facility being conducted by the City of Santa Cruz and Soquel Creek Water District.

This report examines, the understanding of radiation, discusses the controversy over the source of the elevated radiation levels between scientists and government officials, possibly attempting to downplay the seriousness of the Fukushima TEPCO nuclear power plant as the source of elevated radiation levels in seawater and air born emissions of radiation near the tide line. The report contains fact about radiation, the method of calibration and analysis of the results of air and seawater samples collected at the Capitola Beach seashore.

Understanding the radiation

Understanding the radiation doses to the public from the Fukushima nuclear power plant is difficult without an explanation of and way to convert the various dose measurement units being reported. The amount of radioactivity in a quantity of material can be determined by noting how many curies of the material are present. More curies = a greater amount of radioactivity A large amount of material can have a very small amount of radioactivity; a very small amount of material can have a lot of radioactivity. In the International System of units (SI), the becquerel (Bq) is the unit of radioactivity. One Bq is 1 disintegration per second (dps). One curie is 37 billion Bq.

SI Units and Prefixes

The International System of Units has been given official status and recommended for universal use by the General Conference on Weights and Measures.

Radiation Measurements

	Radioactivity	Absorbed Dose	Dose Equivalent	Exposure
Common Units	curie (Ci)	rad	rem	roentgen (R)
SI Units	becquerel (Bq)	gray (Gy)	sievert (Sv)	coulomb/kilogram (C/kg)

Following is a list of prefixes and their meanings that are often used in conjunction with SI units:

Multiple	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n

Conversions

Conversion Equivalence

1 curie = 3.7×10^{10} disintegrations per second		1 becquerel = 1 disintegration per second
1 millicurie (mCi)	=	37 megabecquerels (MBq)
1 rad	=	0.01 gray (Gy)
1 rem	=	0.01 sievert (Sv)
1 roentgen (R)	=	0.000258 coulomb/kilogram (C/kg)
1 megabecquerel (MBq)	=	0.027 millicuries (mCi)
1 gray (Gy)	=	100 rad
1 sievert (Sv)	=	100 rem
1 coulomb/kilogram (C/kg)	=	3,880 roentgens

OSHA uses REMs (Roentgen Equivalent Man) to define the maximum allowable amounts of radiation exposures in the work place that nuclear power workers, medical technologists, and airline employees should receive in a year and a lifetime. The whole body maximum exposure is 1.25 REM over any 3 month period or 5 REM per year. Restricted areas are considered to be 200 milliREM per hour.

There are three types of radiation coming from Fukushima – Protons (alpha particles), Electrons (beta particles), and Photons (gamma). These particles travel varying distances catching rides in air currents and clouds. Each type of radiation has a different level of penetration into the body; Alpha for instance can be stopped by clothing, Beta by metal, whereas Gamma is difficult to stop. If the radiation is ingested in water or food, then radiation may be absorbed more directly by the internal organs.

Damage to the body is measured by RAD, a measure of the actual amount of radiation absorbed by the body. Just because a person is exposed to radiation, does not mean that it

was fully absorbed. 1 REM creates 1 RAD of damage, except in the case of Alpha particles where 1 REM creates 20 RAD of damage

A Sievert (Sv) is used by the medical industry to measure the dose based on the exposure time, volume and part of the body. Japanese monitoring sites are reporting in Gray (Gy), a measurement of the absorption of one joule of energy in the form of ionizing radiation by one kilogram of matter.

However, the differences between all the radiation dose unit measurements become irrelevant when there is a nuclear disaster like Fukushima because the entire body is exposed and the exposure is constant, not quick zaps from an Xray machine or single injections for a medical procedure. Being able to convert the various units allows an understanding of the dosage from various locations within Japan and around the world.

Fukushima or naturally occurring radiation? The controversy

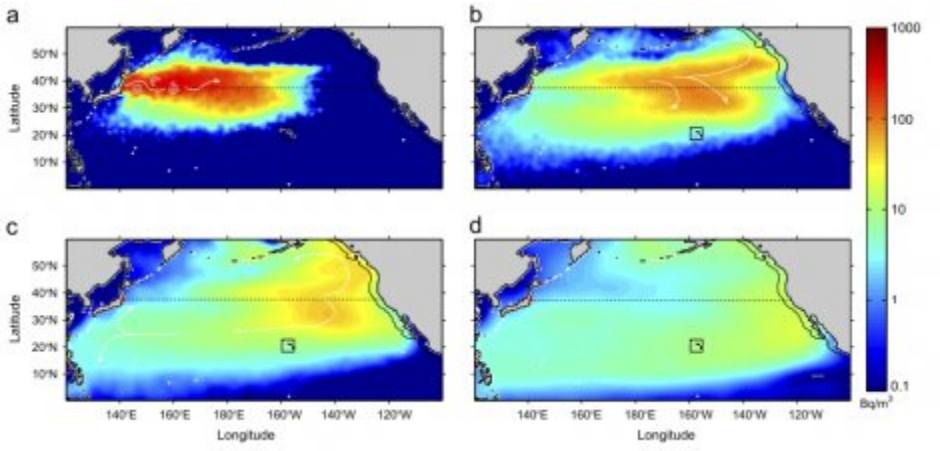
In the January 9, 2014 Santa Cruz Sentinel article[1] *State rebuffs radiation concerns at beach*, the controversy is over the source of elevated levels of radiation on the Northern California coast "The state of California is rebuffing Internet theories that a 2011 nuclear disaster in Fukushima, Japan is now causing alarming levels of radiation on West Coast beaches. [...] 'There is no public health risk at California beaches due to radioactivity related to events at Fukushima,' the California Department of Public Health stated emphatically this week. [...] 'The California Department of Public Health is not aware of any recent activity at Fukushima, or any new data that would cause elevated radioactivity on California shores from the Fukushima incident,' the state said. [...] 'Recent tests by the San Mateo County Public Health Department and CDPH show that elevated levels of radiation at Half Moon Bay are due to naturally occurring materials and not radioactivity associated with the Fukushima incident.' "

Why is the government down playing the seriousness of the Fukushima TEPCO nuclear power plant as the source of elevated radiation levels in seawater and air born emissions of radiation near the tide line?

According to UPI Asia "Fukushima plume to reach U.S. West Coast in months; Measurable increase in radioactive material — Study: Prolonged exposure for California lasting 10 years; Hits Hawaii early 2014"… UPI[2], Aug. 28, 2013: "*Fukushima radioactive plume being tracked toward U.S. West Coast* [...] The radioactive plume from the 2011 Fukushima nuclear disaster will reach U.S. shores within 3 years of the date of the incident, Australian researchers say. [...] 'Observers on the West Coast of the United States will be able to see a measurable increase in radioactive material three years after the event,' researcher Erik van Sebille said in an ARC release Wednesday. 'However, people on those coastlines should not be concerned as the concentration of radioactive

[1] http://www.santacruzsentinel.com/santacruz/ci_24880766/state-rebuffs-radiation-concerns-at-beach
[2] http://www.upiasia.com/Science-Technology/2013/08/28/Fukushima-radioactive-plume-being-tracked-toward-US-West-Coast/UPI-70741377719719/

material quickly drops below World Health Organization safety levels as soon as it leaves Japanese waters.' [...] "



Surface (0-200m) of Cesium-137 concentrations (Bq/m3) by (a) April 2012, (b) April 2014 (c) April 2016 and (d) April 2021 — Hawaii seen in black square (SOURCE: Rossi, et al.)

Also in the scientific journal Phys.org[3] points to Fukushima as the possible source of higher radiation levels of California's coast, on Aug. 28, 2013: "[...] [Eddies and giant whirlpools] direct the radioactive particles to different areas along the US west coast. 'Although some uncertainties remain around the total amount released and the likely concentrations that would be observed, we have shown unambiguously that the contact with the north-west American coasts will not be identical everywhere,' said Dr Vincent Rossi. 'Shelf waters north of 45°N will experience higher concentrations during a shorter period, when compared to the Californian coast. [...] The plume will be forced down deeper into the ocean toward the subtropics before rising up again along the southern Californian shelf.' [...] Eventually over a number of decades, a measurable but otherwise harmless signature of the radiation will spread into other ocean basins, particularly the Indian and South Pacific oceans. [...] "

According to a more recent Abstract of Multi-decadal projections of surface and interior pathways of the Fukushima Cesium-137 radioactive plume[4], October 2013: "[...] The simulations suggest that the contaminated plume would have been rapidly diluted below 10,000 Bq/m^3 by the energetic Kuroshio Current and Kurushio Extension by July 2011. Based on our source function of 22 Bq/m^3, which sits at the upper range of the published estimates, waters with Cs-137 concentrations >10 Bq/m^3 are projected to reach the northwestern American coast and the Hawaiian archipelago by early 2014. Driven by quasi-zonal oceanic jets, shelf waters north of 45°N experience Cs-137 levels of 10–30 Bq/m3 between 2014 and 2020, while the Californian coast is projected to see lower concentrations (10–20 Bq/m^3) slightly later (2016–2025). This late but prolonged exposure is related to subsurface pathways of mode waters, where Cs-137 is subducted

[3] http://phys.org/news/2013-08-fukushima-radioactive-plume-years.html
[4] http://www.sciencedirect.com/science/article/pii/S096706371300112X

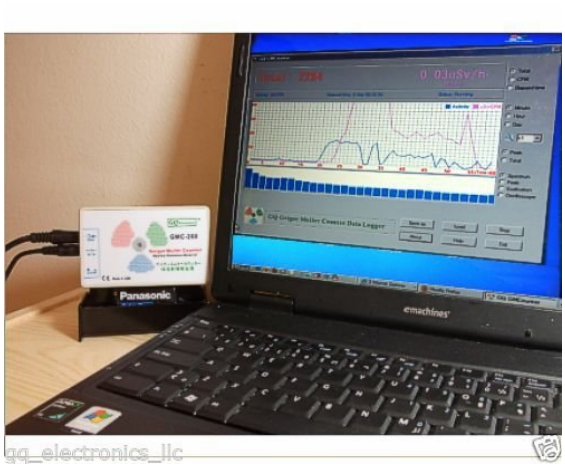
toward the subtropics before being upwelled from deeper sources along the southern Californian coast. The model suggests that Fukushima-derived Cs-137 will penetrate the interior ocean and spread to other oceanic basins over the next two decades and beyond. [...]"

There is no controversy that seawater is contaminated with elevated levels of radiation whether due to Fukushima Japan emissions by the TEPCO nuclear power plant melting down, or due to natural sources, as suggested by the State of California and local health officials.

This report examines the methods for measurement of radiation and results from examining air samples taken at Capitola Beach in California on January 9, 2014 and seawater test samples examined after the fact with a GMC200 Geiger Muller Counter Nuclear Radiation Detector.

Equipment and Calibration

Air water and biological material samples were taken at Capitola Beach in California on January 9, 2014 and test samples subsequently where examined after the fact with the GMC200 Geiger Muller Counter Nuclear Radiation Detector software for USB data logging. A photo of the equipment and sample data log is provided below.



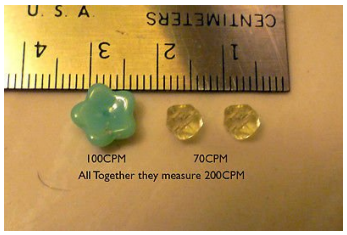
Microsoft Excel - 20110609_21_44_41.csv

	A	B	C	D	E	F	G
1	GQ ガイガーミューラーデータロガー						
2	日 時間	uSv/h	CPM	1秒	2秒	3秒	4秒
3	2011/06/09 21:44	5.66	283	0	4	0	15

Microsoft Excel - 20110606_20_11_23.csv

	A	B	C	D	E	F
1	GQ Geiger Muller Counter Data Logger					
2	Date Time	uSv/h	CPM	1s	2s	3s
3	2011/06/06 20:11	6.24	312	3	1	0
4	2011/06/06 20:12	7.18	359	6	1	0
5	2011/06/06 20:13	6.6	330	14	2	1
6	2011/06/06 20:14	6.4	320	3	3	3
7	2011/06/06 20:15	6	300	17	1	11
8	2011/06/06 20:16	7.72	386	6	7	4
9	2011/06/06 20:17	8.54	427	13	12	18
10	2011/06/06 20:18	7.9	395	17	6	6
11	2011/06/06 20:19	7.6	380	13	0	1
12	2011/06/06 20:20	6.64	332	11	2	2

Three control samples where utilized to calibrate the GMC200 Geiger Muller Counter Nuclear Radiation Detector. The photograph of each Calibration Sample is shown with the calibration results of measurements listed next to each

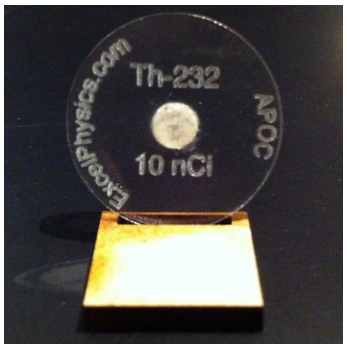


Uranium Vaseline Beads

	uSv/h	CPM
Median	1.22	243.50
StdDev	0.43	85.05
MIN	0.71	141.00
MAX	3.24	648.00
Duration(minutes)	108	

Thorium Lantern Mantle

	uSv/h	CPM
Median	2.69	537.50
StdDev	0.23	45.72
MIN	2.27	453.00
MAX	3.54	708.00
Duration(minutes)	70	



Check Source, Thorium Radioactive Sample Disk

	uSv/h	CPM
Median	4.82	964.50
StdDev	0.87	174.30
MIN	1.23	246.00
MAX	5.33	1065.00
Duration(minutes)	60	

A summary of the Check source data is shown in Table 1.

Description	CPM	StDev_CPM	uSv/h	StDev_uSv/h	Duration(min)
Calibration Thorium Disk(10nCi)	964.50	174.30	4.82	0.87	60
Calibration Thorium Mantel	537.50	45.72	2.69	0.23	70
Calibration Au beads ~220cpm 1/10 after dark	243.00	85.05	1.22	0.43	108
Calibration Au beads ~220cpm ~1pm 1/11	236.00	102.94	1.01	0.57	15

Table 1 - Calibration standards results

Methodology

Prior to driving to Capitola, once at 2:54pm and again at 3:13pm, background measurements where taken inside my home in Soquel California. One background measurement was conducted at that same location on that evening at 6:17pm, after dark, and again two days later on January 11 at around 2pm. The background results are each listed in Table 2.

At Capitola Beach parking about 230 feet from the tide line a measurement was taken from the inside of my car with the windows closed.

After exited the vehicle a measurement was taken at the tide line for eight minutes duration as shown if the photograph. Additional a sea water sample was collected in a quart sized plastic bag from a high turbidity tidal back wash for later analysis. Several samples of sea-weeds, shells, and crab remains, where also collected in plastic bags.

The equipment was then moved to the center point of the beach. This was around 100 feet from the tide line. Another measurement was taken for six minutes and additional biological samples where collected at this location.

The equipment was again moved to the wall on the beach. This was located around 200 feet from the tide line and a final measurement was taken for a duration of five minutes at this location. The biological and sea water samples were sorted and tagged for further analysis later. The biological samples are not part of this report. The report will become revised and updated once this data becomes available.

A summary of the results are listed in Table 2.

Description	CPM	StDev_CPM	uSv/h	StDev_uSv/h	Duration(min)
Background 2:54pm 1/9	20.5	9.24	0.205	0.09	6
Background 3:13pm 1/9	52.50	65.39	0.43	0.27	18
Background 6:17pm 1/9	140.50	253.43	0.83	0.60	25
Background 2:00pm 1/11	25.00	41.22	0.23	0.14	62
Capitola Inside Car	124.00	74.34	0.34	0.12	3
Capitola at Tide Line	862.00	58.63	2.37	0.16	8
Capitola at ~100ft from Tide Line	350.00	193.71	1.12	0.42	6
Capitola at Wall ~ 200ft	831.00	291.57	2.29	0.80	5

Table 2 - Capitola seashore analysis

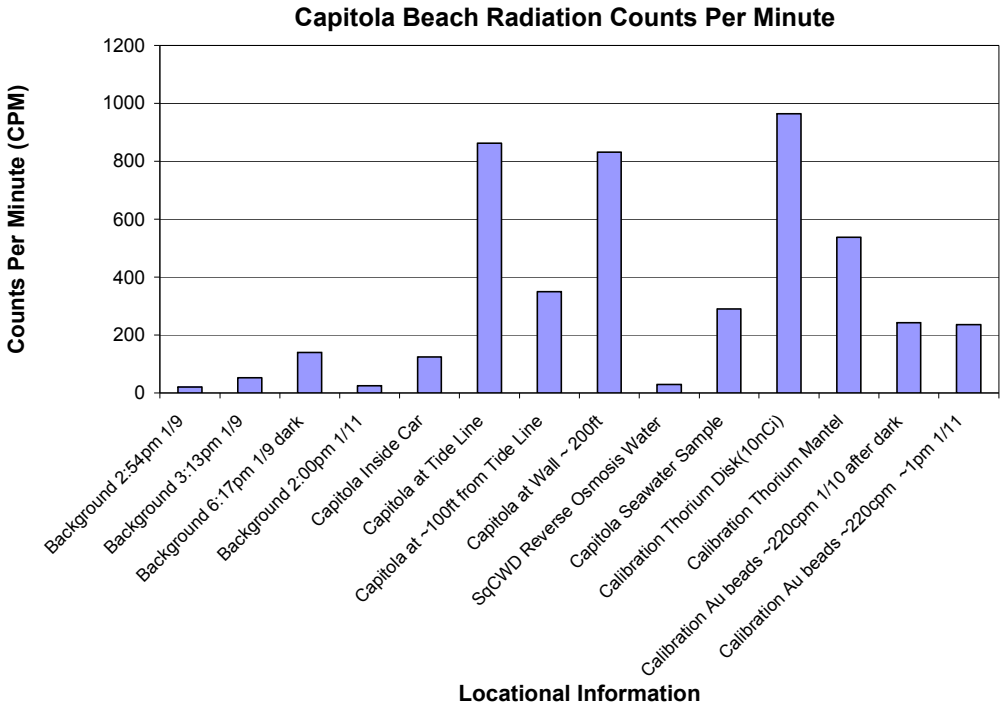
The sea water sample taken at the tide line from high turbidity tide water was examined in comparison to a sample taken from an reverse osmosis filtration system in my home. The tap water is supplied by the Soquel Creek Water District. A summary of the results is listed in Table 3.

Description	CPM	StDev_CPM	uSv/h	StDev_uSv/h	Duration(min)
SqCWD Reverse Osmosis Water	30.00	99.45	0.30	0.35	21
Capitola Seawater Sample	290.00	162.99	1.45	0.81	61

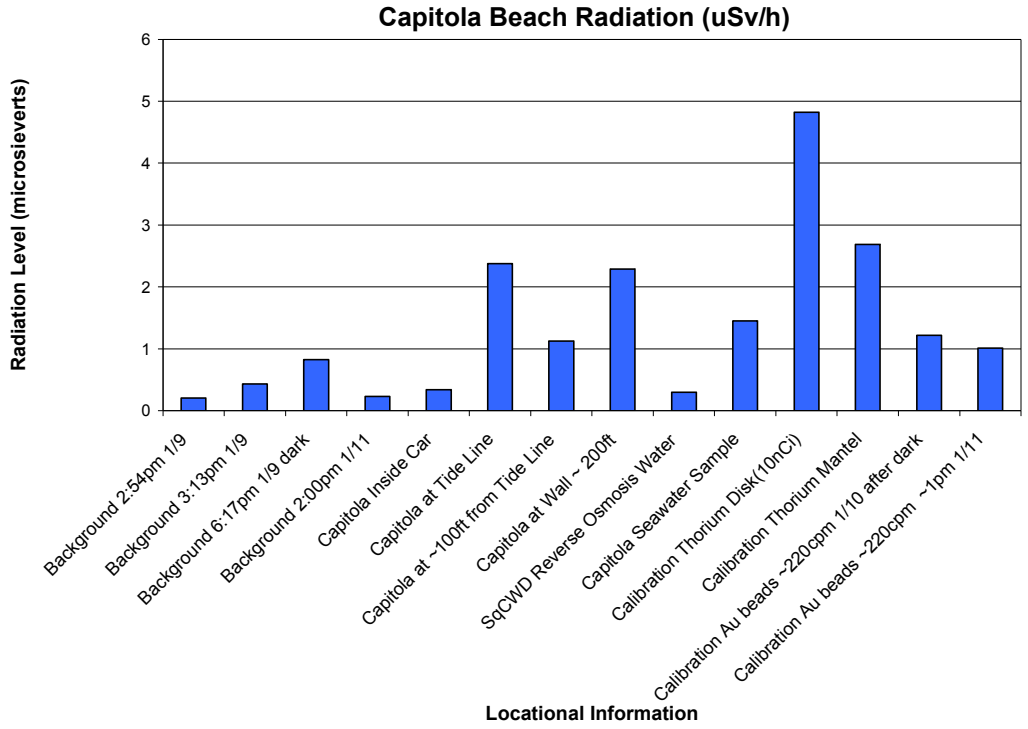
Table 3 - seawater analysis

Review and Analysis of Results

A graphical presentation of all the measurement results are presented based on various attributes listed below each. The graph shows results in units of Count Per Second (CPM).



The second graph shows results for those same attributes. The units of measured dose are in Sievert (Sv) where 1 RAD =0.01 Sv.



TEPCO estimated that between 20 trillion and 40 trillion becquerels (units of radioactivity representing decay per second) of radioactive tritium have leaked into the ocean since the disaster, according to the Japanese newspaper Asahi Shimbun. The Fukushima plant is still leaking about 300 tons of radioactive water into the ocean every day, according to Japanese government officials. [Infographic: Inside Japan's Nuclear Reactors.[5]]

The analysis conducted demonstrates significant elevation of radiation at the Capitola tide line of 862 CPM or 2.37 uSv/h respectively in comparison to 52.5 CPM or 0.43 uSv/h background levels. This radiation exposure is ***eight to sixteen times*** the slightly elevated ***background*** of 52.5 CPM or 0.43 uSv/h. At the Capitola Beach sea wall the radiation exposure is eight to fifteen times and half way in between the tide and the wall on the beach the radiation exposure is four to six times the slightly elevated background of 52.5 CPM or 0.43 uSv/h. For a comparison the typical radiation exposure level on a jet flight is around 950 CPM or 5 uSv/h so this exposure level is comparable to a jet flight's exposure level on an hourly basis in time.

The sea water sample taken at the tide line from high turbidity tide water shows elevated radiation levels in comparison to a sample taken from an reverse osmosis filtration system in my home where the tap water is supplied by the Soquel Creek Water District. The measurement results showed ***seawater was nearly ten times more radioactive then RO tap water***. This means there is something in the sea water to cause the radiation levels to rise.

No government agency has offered any explanation for this phenomena's natural source, while scientists worldwide point to the cause as due to Fukushima Japan's TEPCO nuclear power plant melting down.

More confounding to the analysis is the fact that as the sun set in the evening at Capitola Beach the background radiation was observed to rise sharply as shown in Table 4.

Description	CPM	StDev_CPM	uSv/h	StDev_uSv/h
Background 2:54pm 1/9	20.5	9.24	0.205	0.09
Background 3:13pm 1/9	52.50	65.39	0.43	0.27
Background 6:17pm 1/9	140.50	253.43	0.83	0.60

Table 4 - background radiation

This author postulates on cool dry days, like January 9, 2014 around sunset, a cloud of fine particulates that had been suspended at a higher elevation, due to the sun's heat, settled down to the ground level. This exposes the public to "fine particulates" particulate matter of 2.5 microns diameter or less, which containing elevated levels of radioactive contaminants, thereby increasing the level of radiation exposure to the public. The source of this particulate is unknown but likely the elevated radiation in seawater has something to do with this.

[5] http://www.livescience.com/13230-infographic-japan-nuclear-reactors.html

Conclusion

Fukushima Japan's TEPCO nuclear power plant melting down must be the cause of higher radiation levels on the Pacific seashore, not the government compelled speech on the subject, that natural sources are the cause, as reported by the media. Irrespective, the fact remains that radiation levels are elevate, what ever the cause. As far as seawater desalination goes; instead of the government telling us how higher radiation levels are not a threat to our health, they should be explaining why it's safe enough for us to drink that sea water instead. Juxtaposition that fact, with the fact that the City of Santa Cruz dumps up to ten million gallons of secondary treated effluent a day polluting the bay, water that could be recycled. That's ten million gallons wasted every day of the year.