

Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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Fukushima Radiation—What's Going On?

On March 11, 2011, a Friday afternoon at 2:46 p.m., the first of three sequential disasters struck the northeast coast of Japan. The first was a massive 9.0 magnitude earthquake generated when the Pacific plate slid west beneath the Eurasian plate along a subduction zone 45 miles offshore. This was the largest earthquake to hit Japan in recent history and the 4th most powerful earthquake in the world since modern record keeping began in 1900.

The seafloor displacement of 20 to 25 feet created a massive tsunami, which hit the coastline of Japan's northern islands in less than an hour. This was disaster No. 2. These waves reached elevations of up to 128 feet above sea level and moved inland as far as 6 miles, flooding over 200 square miles of low-lying coastal land. The earthquake and tsunami led to the deaths of over 18,000 people, mostly from drowning.

This was neither the largest nor the deadliest earthquake and tsunami to strike this century, however. That unfortunate record goes to the 2004 magnitude 9.1 Sumatra events, which killed more than 230,000 people.

The 2011 Japan tsunami spread out across the Pacific and damaged coastal areas from Alaska to Chile. Waves began to hit the California coast about 10 hours later and were most damaging where the tsunami was funneled into coastal harbors, like Santa Cruz and Crescent City, raising water levels and battering boats and damaging floating docks.

Although four Japanese nuclear power plants were automatically shut down following the earthquake, the reactors still required cooling water to remove heat. At the Fukushima Daiichi nuclear plant, tsunami waves overtopped a 33-foot high seawall protecting the diesel backup cooling facility, flooding and disabling the system.

The loss of cooling water led to three large explosions followed by nuclear meltdowns at three of the plant's six reactors. Radioactivity was released from the reactor containment vessels due to uncontrolled leakage, but also from deliberate

venting to the atmosphere to reduce pressure, and from deliberate discharge of coolant water to the adjacent ocean. This started disaster No. 3.

Combined with the approximately 440 tons/day of cooling water that has been pumped into the reactors, an additional estimated 300 tons of groundwater/day has been flowing beneath the reactors, picking up radiation and carrying it to the adjacent ocean. Over the subsequent months, over 1000 large tanks were set up in an attempt to collect the contaminated water, and treatment facilities were constructed in an effort to partially clean the water.

This is a complicated story, which is still underway. One troubling problem has been how to cut off the subsurface flow of groundwater beneath the plant, which mixes with radioactive water leaking from the reactors and flow towards the ocean. The plan that was finally developed, nearly 3 years after the earthquake, tsunami and meltdown, was to freeze the ground and groundwater beneath the site and build an ice dam to contain the flow. This complex project is now underway and expected to be completed in March 2015, four years after the initial disaster.

Concerns along our west coast about potential radiation exposure arose soon after the release of radiation from the plant was reported. Traces of radiation in the atmosphere were detected over the west coast of the US within 5 days as atmospheric circulation carried the releases around the world.

The greatest amount of radiation (primarily cesium and iodine) entered the ocean off Japan in the first several months after the reactor failures, and was described as the most important individual emission of artificial radiation into the sea ever observed. While there were high levels of radiation that were well-documented in coastal waters around Japan very soon after the incident, circulation across the North Pacific to the west coast is a relatively slow process.

There were a number of larger floating objects that could be traced back to Japan, including a derelict 164-ft fishing boat found and then sunk off the coast of British Columbia in April 2012, and a large section of a floating steel dock that ended up on the Oregon coast in June 2102. Surface winds and currents moved these objects relatively rapidly, however, to make the roughly 5000-mile voyage across the north Pacific. What happened to the radiation in the water? The answer is going to have to wait 2 weeks.