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# Effects of Radiation from Fukushima Daiichi on the U.S. Marine Environment

**Eugene H. Buck**  
Specialist in Natural Resources Policy

**Harold F. Upton**  
Analyst in Natural Resources Policy

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## Summary

The massive Tohoku earthquake and tsunami of March 11, 2011, caused extensive damage in northeastern Japan, including damage to the Fukushima Daiichi nuclear power installation, which resulted in the release of radiation. Some have called this incident the biggest manmade release ever of radioactive material into the oceans. Concerns have arisen about the potential effects of this released radiation on the U.S. marine environment and resources.

Both ocean currents and atmospheric winds have the potential to transport radiation over and into marine waters under U.S. jurisdiction. It is unknown whether marine organisms that migrate through or near Japanese waters to locations where they might subsequently be harvested by U.S. fishermen (possibly some tuna in the western Pacific and, less likely, salmon in the North Pacific) might be exposed to radiation in or near Japanese waters, or might consume prey that have accumulated radioactive contaminants.

High levels of radioactive iodine-131 (with a half-life of about 8 days), cesium-137 (with a half-life of about 30 years), and cesium-134 (with a half-life of about 2 years) have been measured in seawater adjacent to the Fukushima Daiichi site.

EPA rainfall monitors in California, Idaho, and Minnesota have detected trace amounts of radioactive iodine, cesium, and tellurium consistent with the Japanese nuclear incident, with current concentrations below any level of concern. It is uncertain how precipitation of radioactive elements from the atmosphere may affect radiation levels in the marine environment.

Scientists have stated that radiation in the ocean will very quickly become diluted and should not be a problem beyond the coast of Japan. The same is true of radiation carried by winds. Barring a major unanticipated release, radioactive contaminants from Fukushima Daiichi should become sufficiently dispersed over time that they will not prove to be a serious health threat elsewhere, unless they bioaccumulate in migratory fish or find their way directly to another part of the world through food or other commercial products.

Currently, it appears that radioactive contamination of seafood from the recent nuclear disaster in Japan is not a food safety problem for consumers in the United States. According to the U.S. Food and Drug Administration (FDA), the damage to infrastructure in Japan has limited food production and associated exports from areas near the Fukushima nuclear facility. Food products from the areas near the Fukushima nuclear facility, including seafood, are also to be tested by FDA before they can enter the U.S. food supply.

Based on computer modeling of ocean currents, debris from the tsunami produced by the Tohoku earthquake is projected to spread eastward from Japan in the North Pacific Subtropical Gyre. In three years, the debris plume likely will reach the U.S. West Coast, dumping debris on California beaches and the beaches of British Columbia, Alaska, and Baja California. Although much of the radioactive release from Fukushima Daiichi is believed to have occurred after the tsunami, there is the possibility that some of the tsunami debris might also be contaminated with radiation.

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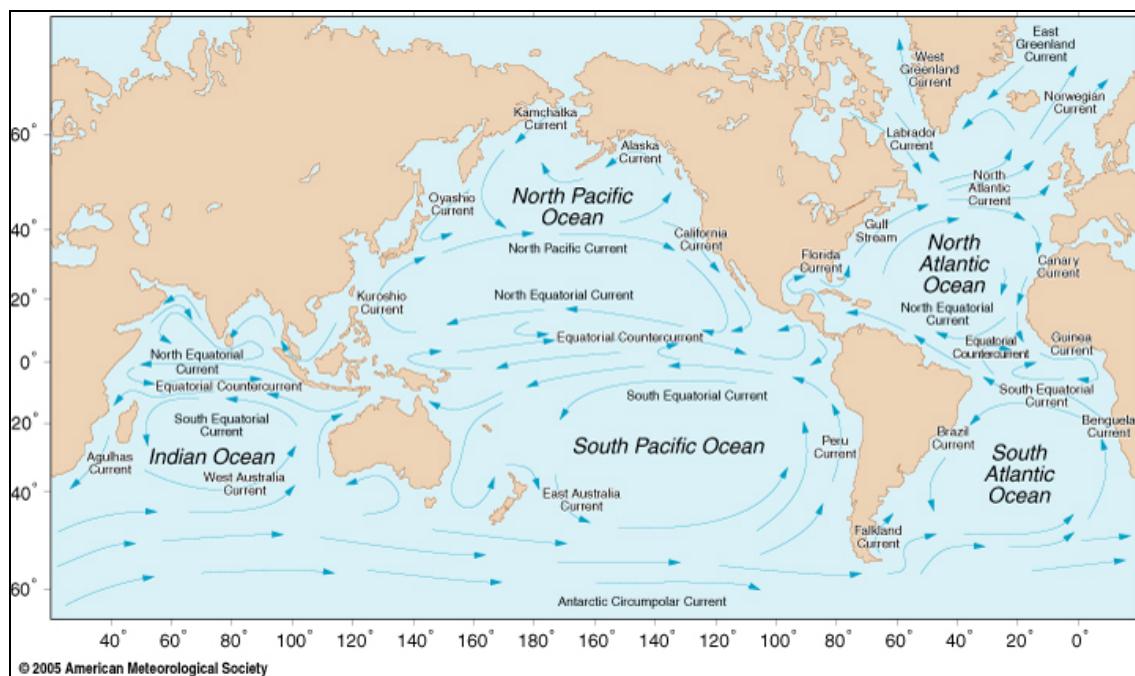
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## Situation

The massive Tohoku earthquake and tsunami of March 11, 2011, caused extensive damage in northeastern Japan, including damage to the Fukushima Daiichi nuclear power installation, which resulted in the release of radiation.<sup>1</sup> Some have called this incident the biggest manmade release ever of radioactive material into the oceans.<sup>2</sup> Concerns have arisen about the potential effects of this released radiation on the U.S. marine environment and resources.

The North Pacific Current is formed by the collision of the Kuroshio Current, running northward off the east coast of Japan in the eastern North Pacific, and the Oyashio Current, running southward from Russia (**Figure 1**). As it approaches the west coast of North America, the North Pacific Current splits into the southward California Current and the northward Alaska Current. Although these currents have the potential for bringing radiation from Japan's Fukushima Daiichi nuclear accident to U.S. waters, their flow is slow, and no radiation above background levels has yet been detected in marine waters under U.S. jurisdiction. Regardless of the slow flow, radioactive contaminants having long half-lives (e.g., cesium-137, with a half-life of about 30 years) could still pose concerns when transported over long distances by ocean currents.

**Figure 1. Ocean Currents**



**Source:** American Meteorological Society.

Seawater is monitored by the Tokyo Electric Power Company (TEPCO) near the discharge points of the Fukushima Daiichi plant. Water with a dose rate of greater than 1,000 millisievert per hour was confirmed by TEPCO on April 2, 2011, in a pit located next to Fukushima Daiichi's Unit 2

<sup>1</sup> For additional background on this incident, see CRS Report R41694, *Fukushima Nuclear Crisis*, by Richard J. Campbell and Mark Holt.

<sup>2</sup> Quirin Schiermeier, "Radiation Release Will Hit Marine Life," *Nature*, v. 472 (April 12, 2011): 145-146.

seawater inlet point. A cracked sidewall of this pit is leaking water from the pit directly into the ocean.<sup>3</sup> Analyses of seawater taken from near the discharge from Fukushima Daiichi Units 1-4 have yielded readings of 130,000 Becquerels/liter (Bq/l) of iodine-131 (half-life of about 8 days), 32,000 Bq/l of cesium-137 (half-life of about 30 years), and 31,000 Bq/l of cesium-134 (half-life of about 2 years).<sup>4</sup> Although the leak in the cracked sidewall was stopped after several days,<sup>5</sup> the total amount of radioactive contaminants that have entered the ocean is unknown, and discharges, both accidental and deliberate,<sup>6</sup> are continuing.<sup>7</sup> Radioisotope concentrations at offshore sampling points appear to be decreasing with time; at sampling points about 30 km east of Fukushima Daiichi, concentrations are between 5 and 18 Bq/l for iodine-131 and between 1 and 11 Bq/l for cesium-137. The highest concentrations, found closest to the coast, were about 38 Bq/l for iodine-131 and 4.5 Bq/l for cesium-137.<sup>8</sup> The occurrence of cesium-137 is of greater concern because of its much longer half-life. The natural radioactivity of seawater is 13 or 14 Bq/l, of which 95% comes from potassium-40.<sup>9</sup>

Atmospheric transport (i.e., wind) also is capable of transporting radiation eastward, where it may settle or precipitate into U.S. marine waters (**Figure 2**).<sup>10</sup> The U.S. Department of Energy and the U.S. Environmental Protection Agency (EPA) monitor atmospheric radiation. As of April 2, 2011, EPA monitors in California, Idaho, and Minnesota have detected trace amounts of radioactive iodine, cesium, and tellurium in rainwater, consistent with the Japanese nuclear incident; to date, concentrations have been far below any level of concern.<sup>11</sup>

It is unknown whether marine organisms that migrate through or near Japanese waters to locations where they might subsequently be harvested by U.S. fishermen (possibly some tuna in the western Pacific and, less likely, salmon in the North Pacific) might be exposed to radiation in or near Japanese waters, or might consume prey that have accumulated radioactive contaminants.

A British scientist reportedly has stated that, “given the scale of the Pacific—the world’s vastest body of water—radioactivity in the sea at Fukushima will be flushed out beyond the local area by tides and currents and dilute to very low levels. It [radioactive contamination] will get into the (ocean) food chain but only in that vicinity. Should people in Hawaii and California be concerned? The answer is no.”<sup>12</sup> However, this view does not consider the possibility of

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<sup>3</sup> Fukushima Nuclear Accident Update Log (April 2, 2011), at <http://www.iaea.org/newscenter/news/2011/fukushima020411.html>.

<sup>4</sup> Fukushima Nuclear Accident Update Log (March 31, 2011), at <http://www.iaea.org/newscenter/news/2011/fukushima310311.html>.

<sup>5</sup> Fukushima Nuclear Accident Update Log (April 6, 2011), at <http://www.iaea.org/newscenter/news/2011/fukushima060411.html>.

<sup>6</sup> Water with comparatively lower radioactive contamination is being discharged to the sea to provide room at and near Fukushima Daiichi to store water with higher levels of radioactivity in a safer manner.

<sup>7</sup> Quirin Schiermeier, “Radiation Release Will Hit Marine Life,” *Nature*, v. 472 (April 12, 2011): 145-146.

<sup>8</sup> Fukushima Nuclear Accident Update Log (April 5), at <http://www.iaea.org/newscenter/news/2011/fukushima050411.html>.

<sup>9</sup> Idaho State University, *Radioactivity in Nature*, at <http://fizisist.web.cern.ch/fizisist/funny/NaturalRadioactivity.pdf>.

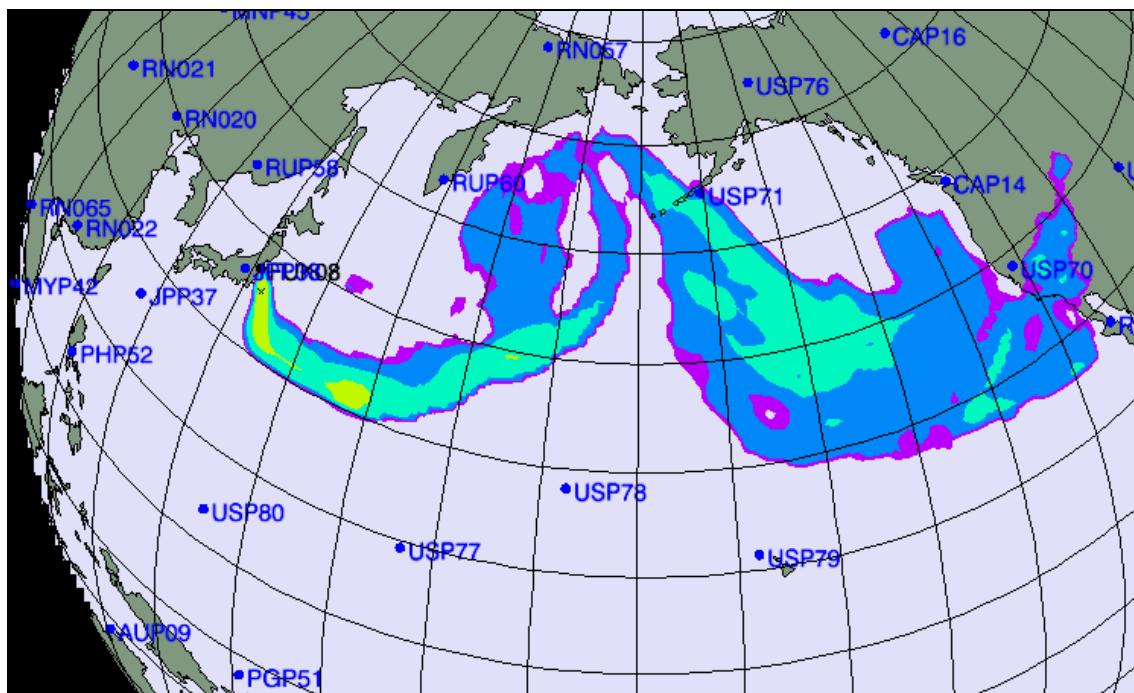
<sup>10</sup> Other projections of atmospheric trajectories can be found at <http://www.atmos.umd.edu/~tcanty/hysplit/>.

<sup>11</sup> See <http://www.epa.gov/radiation/data-updates.html>; also see <http://yosemite.epa.gov/opa/admpress.nsf/d0cf618525a9efb85257359003fb69d/3724de8571e1b03f8525785c00041a7a%21OpenDocument>.

<sup>12</sup> Simon Boxall, a lecturer at Britain’s National Oceanography Centre at the University of Southampton, England, quoted in <http://news.discovery.com/earth/japan-seafood-110330.html>.

bioaccumulation of radioactive elements by fish whose migratory habits subsequently may take them far from Japanese waters.

**Figure 2. Atmospheric Radiation Forecast for March 18, 2011**



**Source:** Comprehensive Nuclear Test Ban Treaty Organization, Vienna, Austria.

**Notes:** This forecast shows how weather patterns might be expected disperse radiation from a continuous source in Fukushima, Japan. **The forecast does not show actual levels of radiation.** The colors correspond to the projected intensity of radiation, with yellow being most intense and progressing to less intensity through the green, blue, to violet end of the spectrum.

Scientists at the Woods Hole Oceanographic Institution advise that radiation levels in seafood should continue to be monitored, but state that radiation in the ocean will very quickly become diluted and should not be a problem beyond the coast of Japan. The same is true of radiation carried by winds around the globe. Barring a major unanticipated release, radioactive contaminants from Fukushima should become sufficiently dispersed over time that they will not prove to be a serious health threat elsewhere, unless they bioaccumulate in migratory fish or find their way directly to another part of the world through food or other commercial products.<sup>13</sup> However, there remains the potential for a relatively narrow corridor of highly contaminated water leading away from Japan and a very patchy distribution of contaminated fish—only extensive monitoring will be able to determine the exact dispersion of these radioactive contaminants.

<sup>13</sup> See <http://www.whoi.edu/page.do?pid=56076&tid=282&cid=94989>.

## Concerns

### Are There Implications for U.S. Seafood Safety?

It does not appear that nuclear contamination of seafood will become a food safety problem for consumers in the United States. Among the main reasons are that:

- damage from the disaster has limited seafood production in the affected areas,
- radioactive material will be diluted before reaching U.S. fishing grounds, and
- seafood imports from Japan are being examined before entry into the United States.

According to the U.S. Food and Drug Administration (FDA), because of damage from the earthquake and tsunami to infrastructure, few if any food products are being exported from the affected region.<sup>14</sup> For example, according to the National Federation of Fisheries Cooperative Associations, the region's fishing industry has stopped landing and selling fish.<sup>15</sup>

U.S. fisheries are unlikely to be affected because radioactive material that enters the marine environment will be greatly diluted before reaching U.S. fishing grounds. However, some advocate vigilance, especially for seafood from areas near the damaged nuclear facility. It has been suggested that cesium-137 may move up the food chain and become concentrated in fish muscle or that radiation hot spots may occur.<sup>16</sup> The Fisheries Research Agency (Japan) has tested samples from areas south of the damaged nuclear facility, and it has been reported that radiation levels are far below the standards set by Japan's health ministry.<sup>17</sup>

The most common foods imported from Japan include seafood, snack foods, and processed fruits and vegetables. In 2010, the United States imported 49.0 million pounds of seafood from Japan with a value of \$258.9 million.<sup>18</sup> The FDA has primary responsibility for the safety of all domestic and imported seafood, under the Federal Food, Drug, and Cosmetic Act (FFDCA), as amended (21 U.S.C. § 301 et seq.). The FFDCA requires that all foods be safe, wholesome, and accurately labeled. FDA's general approach to ensuring the safety of seafood imports is based on identifying risks from the production process, from specific types of seafood, and from certain countries or firms.

FDA's import tracking system is being used to identify all shipments of FDA-regulated products from Japan, with special attention to shipments from companies within the affected area. On March 25, 2011, an import alert was updated for food items from specific regions of Japan, but

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<sup>14</sup> U.S. Dept. of Health and Human Services, Food and Drug Administration, *Radiation Safety*, March 29, 2011, <http://www.fda.gov/newsevents/publichealthfocus/ucm247403.htm>.

<sup>15</sup> “Tsukiji wholesaler thinks it may take a year for the market to stabilize,” *Reuters*, March 23, 2011.

<sup>16</sup> Elizabeth Rosenthal, “Radiation, Once Free, Can Follow a Tricky Path,” *New York Times*, March 21, 2011.

<sup>17</sup> Frederik Balfour, “Sushi Safe From Japan Radiation as Ocean Dilution Makes Risk Negligible,” *Bloomberg*, March 31, 2011.

<sup>18</sup> U.S. Dept. of Commerce, National Marine Fisheries Service, Fisheries Statistics and Economics Division, “U.S. Foreign Trade Query,” March 31, 2011, <http://www.st.nmfs.noaa.gov/st1/trade/index.html>.

seafood was not included.<sup>19</sup> Food products not included on the import alert, but from the areas near the Fukushima nuclear facility, including seafood, are also to be tested by FDA before they can enter the U.S. food supply. For these products, FDA is to conduct field examinations and collect samples for radionuclide analysis by FDA laboratories.<sup>20</sup> FDA also reports that it is increasing surveillance for all food products imported from Japan.

## **How Likely Is It That Radiation Will Reach U.S. Marine Waters, Through Either Ocean Currents or Atmospheric Transport?**

Since radiation has been detected reaching various U.S. locations by atmospheric transport, rainfall is likely to already be introducing radioactive elements from the Fukushima Daiichi accident into U.S. marine waters. Transport by ocean currents is much slower, and additional radiation from this source might eventually also be detected in North Pacific waters under U.S. jurisdiction, weeks or even months after its release. Regardless of slow ocean transport, the long half-life of radioactive cesium isotopes means that radioactive contaminants could remain a valid concern for years.

## **What Are the Likely Responses If Radiation Is Detected?**

If only low levels of radiation are detected, continued monitoring of the situation will be the likely response. In the unlikely event that higher levels of radiation are detected, measures (e.g., removal of contaminated products from commerce) are to be taken to prevent or minimize human exposure to the contaminated media.

For background information on radiation and its potential for harm, see CRS Report R41728, *The Japanese Nuclear Incident: Technical Aspects*, by Jonathan Medalia.

## **What Are Other Possible Effects of the Tohoku Earthquake and Tsunami on the U.S. Marine Environment?**

Based on computer modeling of ocean currents, debris from the tsunami produced by the Tohoku earthquake of March 11, 2011, is projected to spread eastward from Japan in the North Pacific Subtropical Gyre. In a year, debris could reach the Northwestern Hawaiian Islands Marine National Monument; in two years, the remaining Hawaiian islands could see this debris; in three years, the debris plume likely will reach the U.S. West Coast, dumping debris on California beaches and the beaches of British Columbia, Alaska, and Baja California.<sup>21</sup> An animation of the projected movement of the marine debris is available at [http://iprc.soest.hawaii.edu/users/nikolai/2011/Pacific\\_Islands/Simulation\\_of\\_Debris\\_from\\_March\\_11\\_2011\\_Japan\\_tsunami.gif](http://iprc.soest.hawaii.edu/users/nikolai/2011/Pacific_Islands/Simulation_of_Debris_from_March_11_2011_Japan_tsunami.gif). Although much of the radioactive release from Fukushima Daiichi is believed to have occurred after the

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<sup>19</sup> All products identified by the import alert will not be allowed to enter the United States unless it is shown they are free from radionuclide contamination.

<sup>20</sup> FDA, *Radiation Safety*, March 29, 2011, <http://www.fda.gov/newsevents/publichealthfocus/ucm247403.htm>.

<sup>21</sup> Press release from the International Pacific Research Center (IPRC) of the School of Ocean and Earth Science and Technology (SOEST) at the University of Hawaii at Manoa, available at [http://www.sciencedaily.com/releases/2011/04/110406102203.htm?utm\\_source=feedburner&utm\\_medium=feed&utm\\_campaign=Feed%3A+sciencedaily+\(ScienceDaily%3A+Latest+Science+News\)](http://www.sciencedaily.com/releases/2011/04/110406102203.htm?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+sciencedaily+(ScienceDaily%3A+Latest+Science+News)).

tsunami, there is the possibility that some of the tsunami debris might also be contaminated with radiation from Fukushima Daiichi.

## **Author Contact Information**

Eugene H. Buck  
Specialist in Natural Resources Policy  
[gbuck@crs.loc.gov](mailto:gbuck@crs.loc.gov), 7-7262

Harold F. Upton  
Analyst in Natural Resources Policy  
[hupton@crs.loc.gov](mailto:hupton@crs.loc.gov), 7-2264