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Effects of Radiation from Fukushima Dai-ichi on the U.S. Marine Environment

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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 Dai-ichi 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 albacore tuna or 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) were measured in seawater adjacent to the Fukushima Dai-ichi site after the March 2011 events. EPA rainfall monitors in California, Idaho, and Minnesota detected trace amounts of radioactive iodine, cesium, and tellurium consistent with the Japanese nuclear incident, at 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 very quickly becomes 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 Dai-ichi should be 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.

Radioactive contamination of seafood from the nuclear disaster in Japan has not emerged as 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 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 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 Dai-ichi 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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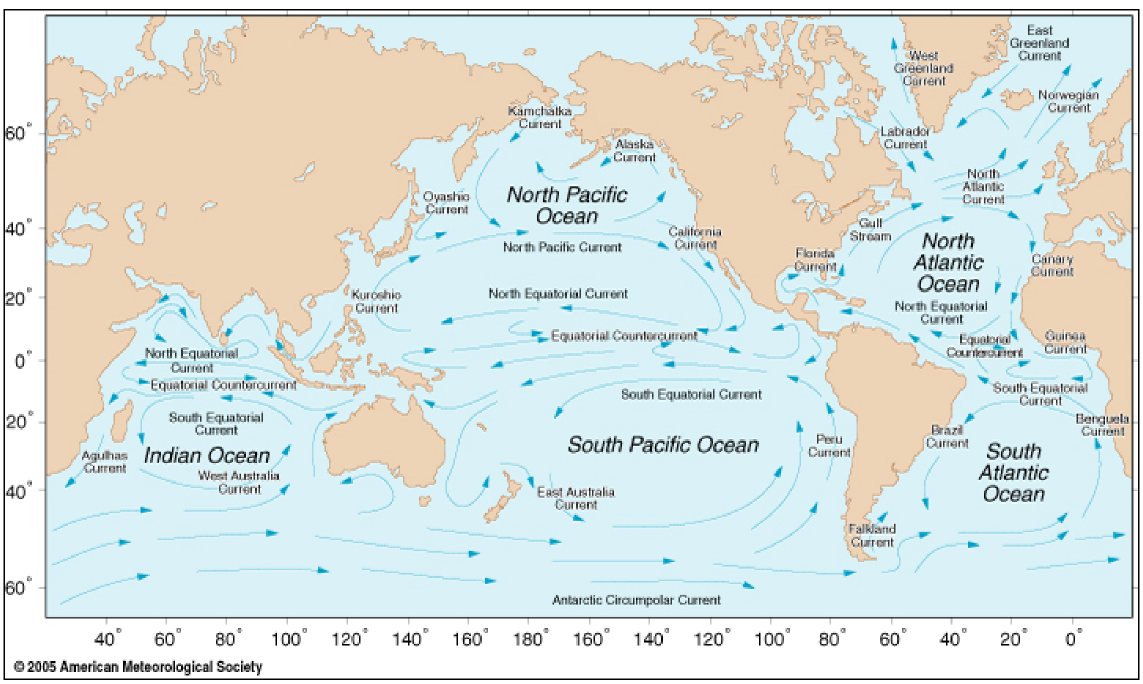
Situation

The massive Tohoku earthquake and tsunami of March 11, 2011, caused extensive damage in northeastern Japan, including damage to the Fukushima Dai-ichi nuclear power installation, which resulted in the release of radiation.[1] Some have called this incident the biggest manmade release ever of radioactive material into the oceans.[2] Concerns arose 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 Dai-ichi 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 with long half-lives (e.g., cesium-137, with a half-life of about 30 years) could still pose concerns if transported over long distances by ocean currents.

Figure 1. Ocean Currents



Source: American Meteorological Society.

Seawater was monitored by the Tokyo Electric Power Company (TEPCO) near the discharge points of the Fukushima Dai-ichi plant following the March 2011 events. Water with a dose rate of greater than 1,000 millisievert per hour was confirmed by TEPCO on April 2, 2011, in a pit

[1] For additional background on this incident, see CRS Report R41694, *Fukushima Nuclear Disaster*, by Mark Holt, Richard J. Campbell, and Mary Beth Nikitin.

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

located next to Fukushima Dai-ichi's Unit 2 seawater inlet point. A cracked sidewall of this pit was leaking water from the pit directly into the ocean.[3] Analyses of seawater taken from near the discharge from Fukushima Dai-ichi Units 1-4 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).[4] Although the leak in the cracked sidewall was stopped after several days,[5] the total amount of radioactive contaminants that entered the ocean was unknown, and discharges, both accidental and deliberate,[6] continued for several weeks.[7] Radioisotope concentrations at offshore sampling points decreased with time; by early April 2011, at sampling points about 30 km east of Fukushima Dai-ichi, concentrations were 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.[8] 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.[9] Experts cite this incident as the largest recorded accidental release of radiation to the ocean.[10]

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**).[11] The U.S. Department of Energy and the U.S. Environmental Protection Agency (EPA) monitor atmospheric radiation. In early April 2011, EPA monitors in California, Idaho, and Minnesota 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.[12] One study estimated a total atmospheric release of 35.8 petabecquerels of cesium-137, with the highest release from March 12 to 19 and about 79% of subsequent deposition over the North Pacific Ocean.[13]

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 albacore tuna or salmon in the North Pacific) might be exposed to radiation in or near Japanese waters, or might consume prey that have accumulated radioactive contaminants. Two minke whales harvested by Japanese whalers off the coast of Hokkaido in May 2011 were found to have slightly

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

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

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

[6] Water with comparatively lower radioactive contamination is being discharged to the sea to provide room at and near Fukushima Dai-ichi to store water with higher levels of radioactivity in a safer manner.

[7] Quirin Schiermeier, "Radiation Release Will Hit Marine Life," *Nature*, v. 472 (April 12, 2011): 145-146.

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

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

[10] Ken Buesseler, Michio Aoyama, and Masao Fukasawa, "Impacts of the Fukushima Nuclear Power Plants on Marine Radioactivity," *Environmental Science & Technology*, v. 45 (December 1, 2011): 9931-9935.

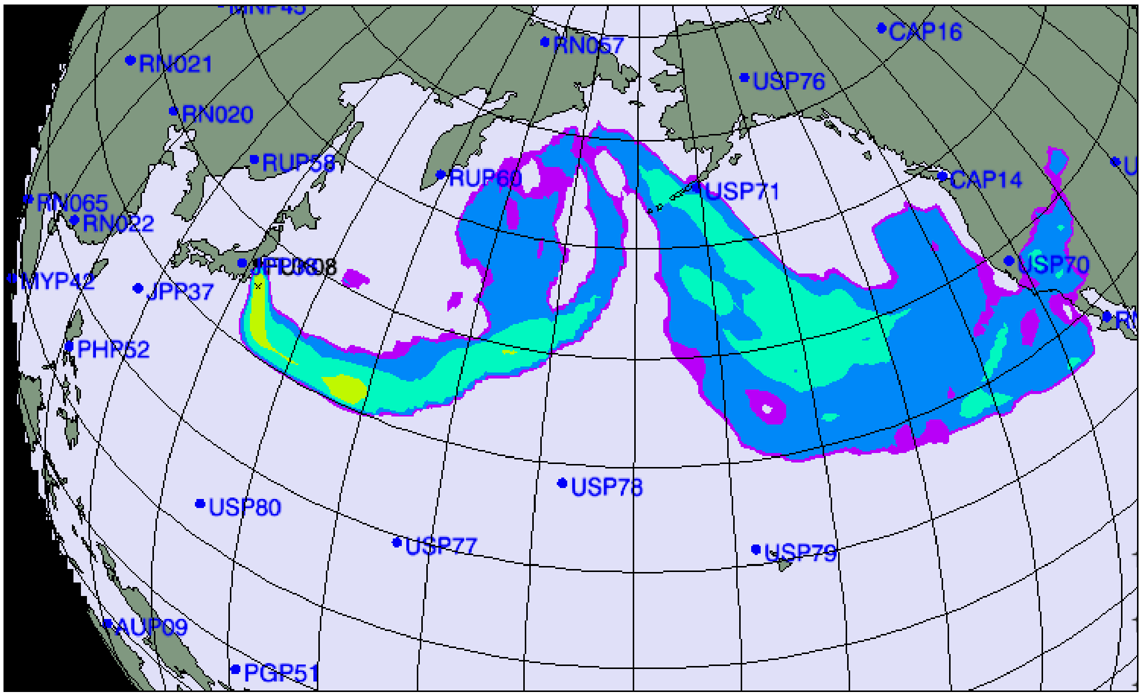
[11] Other projections of atmospheric trajectories can be found at http://www.atmos.umd.edu/~tcanty/hysplit/.

[12] See http://www.epa.gov/radiation/data-updates.html; also see http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/3724de8571e1b03f8525785c00041a7a%21OpenDocument.

[13] Andreas Stohl, et al. "Xenon-133 and Caesium-137 Releases into the Atmosphere from the Fulushima Dai-ichi Nuclear Power Plant: Determination of the Source Term, Atmospheric Dispersion, and Deposition," *Atmospheric Chemistry and Physics Discussion*, v. 11, no. 10 (2011): 2819-394.

elevated radioactive cesium-137 levels.[14] To monitor for longer-term effects, NOAA's National Ocean Survey and EPA are exploring monitoring of seawater and sediment along the U.S. west coast.[15]

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.

A British scientist reportedly 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."[16] However, this view does not consider the possibility of bioaccumulation of radioactive elements by fish whose migratory habits subsequently may take them far from Japanese waters.

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 very quickly becomes diluted and should not be a problem beyond the coast of Japan. The same is true of radiation

[14] Mary Yamaguchi, *Traces of Radiation Found in 2 Whales Off Japan*, Associated Press, June 15, 2011.

[15] Jeff McMahon, "EPA Halts Extra Radiation Monitoring; Focus Shifts to Imported Seafood," *Forbes*, May 5, 2011; available at http://www.forbes.com/sites/jeffmcmahon/2011/05/04/epa-halts-extra-radiation-monitoring-focus-shifts-to-seafood/.

[16] 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.

carried by winds around the globe. Radioactive contaminants from Fukushima appear to have 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.[17] However, there remains the slight potential for a relatively narrow corridor of highly contaminated water leading away from Japan and a very patchy distribution of contaminated fish—extensive monitoring will determine the exact dispersion of these radioactive contaminants.

Concerns

Are There Implications for U.S. Seafood Safety?

It does not appear that nuclear contamination of seafood will be a food safety problem for consumers in the United States.[18] 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.[19] For example, according to the National Federation of Fisheries Cooperative Associations, the region's fishing industry has stopped landing and selling fish.[20]

U.S. fisheries are unlikely to be affected because radioactive material that enters the marine environment would 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.[21] 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.[22]

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

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[17] See http://www.whoi.edu/page.do?pid=56076&tid=282&cid=94989.

[18] For additional information, see U.S. Environmental Protection Agency, U.S. Food and Drug Administration, and National Oceanic and Atmospheric Administration, *U.S. Seafood Safe and Unaffected by Radiation Contamination from Japanese Nuclear Power Plant Incident; U.S. Monitoring Control Strategy Explained*, available at http://www.nmfs.noaa.gov/mediacenter/docs/2011/may/seafoodsafetyfactsheet_03may2011.pdf.

[19] 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.

[20] "Tsukiji wholesaler thinks it may take a year for the market to stabilize," *Reuters*, March 23, 2011.

[21] Elizabeth Rosethal, "Radiation, Once Free, Can Follow a Tricky Path," *New York Times*, March 21, 2011.

[22] Frederik Balfour, "Sushi Safe From Japan Radiation as Ocean Dilution Makes Risk Negligible," *Bloomberg*, March 31, 2011.

with a value of $258.9 million.[23] 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 seafood was not included.[24] Food products not included on the import alert, but from the areas near the Fukushima nuclear facility, including seafood, are also 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.[25] 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 have introduced radioactive elements from the Fukushima Dai-ichi 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, 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.

[23] 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.

[24] 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.

[25] FDA, *Radiation Safety*, March 29, 2011, http://www.fda.gov/newsevents/publichealthfocus/ucm247403.htm.

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. Initial models suggested that 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 would reach the U.S. west coast, dumping debris on California beaches and the beaches of British Columbia, Alaska, and Baja California.[26] 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. Although much of the radioactive release from Fukushima Dai-ichi is believed to have occurred after the tsunami, there is the possibility that some of the tsunami debris might be contaminated with radiation from Fukushima Dai-ichi.

More recent observations indicate that some debris could be traveling faster than predicted. The debris field has been estimated to contain possibly millions of tons of debris and be approximately 3,700 kilometers long and 1,800 kilometers wide.[27] In mid-November 2011, Canadian ocean modelers predicted that initial debris from the Tohoku earthquake and tsunami, especially large debris more subject to wind effects, might soon begin appearing on Pacific Northwest beaches.[28] Fishing vessels and other large pieces of debris could pose hazards to navigation. Items that some believe might be initial debris from the tsunami began to be reported on Pacific Northwest beaches in early December 2011.[29] The majority of the debris is still not anticipated to reach U.S. shores before 2013. British Columbia has established a provincial tsunami debris coordinating committee to plan how to manage arriving debris, and is communicating with Japanese authorities for guidance on how best to treat debris items of potential personal, symbolic, and cultural value. NOAA is requesting that reports of significant debris sightings be e-mailed to disasterdebris@noaa.gov for compilation.[30]

[26] 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).

[27] Steve Herman, "Tsunami Debris Could Hit Mid-Pacific Island Soon," November 22, 2011; available at http://www.voanews.com/english/news/asia/east-pacific/Tsunami-Debris-Could-Hit-Mid-Pacific-Island-Soon-134312748.html.

[28] Yasmin Aboelsaud, "Japanese Tsunami Debris Could Soon Reach Local Coastline," November 17, 2011; available at http://www.canada.com/story_print.html?id=5723823.

[29] "Flotsam from Japanese Tsunami Reaches West Coast; Wind Pushes Drum-Size Debris to Wash. Beach," *Washington Post*, December 15, 2011; Dennis Ryan, "Debris from Japan Tsunami Washes Up on B.C. Shores," *Vancouver Sun*, December 29, 2011.

[30] For additional information, see http://marinedebris.noaa.gov/info/japanfaqs.html.

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