# The Fukushima Dai-ichi accident:

Photo: Tokyo Electric Power Company

## Radioactive releases have caused little apparent harm to the marine ecosystems of the Pacific Ocean, but uncertainties remain

**Four years after the Fukushima Dai-ichi accident the radioactive releases have caused little apparent harm to the marine ecosystems of the Pacific Ocean. The contamination in seafood remains low throughout the greater Pacific Ocean (> 30 km away) and does not pose a risk to human health or the environment. In the near shore area of Fukushima, however, the contamination is still significant and the radiation is high enough to warrant fishing restrictions and continued monitoring and research to investigate possible negative effects on the marine ecosystems in the future.**

www.star-radioecology.org
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# Releases to the Pacific Ocean from the Fukushima Dai-ichi accident

Large amounts of radioactive substances were released from the Fukushima Dai-ichi reactors in the aftermath of the earthquake and tsunami on 11 March 2011. The total releases from Fukushima Dai-ichi have been estimated to be around one fifth of the releases from the Chernobyl accident. Unlike the Chernobyl accident, a significant amount was released to the nearby marine area—the Pacific Ocean. According to the United Nations Scientific Committee on the Effects of Atomic Radiation (www.unscear.org), the releases to the Pacific Ocean in 2011 were about 6 to 12 million GBq (Giga becquerels) of radioactive caesium due to direct liquid discharges from the crippled Fukushima Dai-ichi plant and 10 to 16 million GBq from atmospheric releases that deposited onto the ocean waters. There has been a much smaller, but continuous contribution of radioactive substances from river runoff and water leakage from the Fukushima Dai-ichi power plant since then.

# Radioactive substances can be both natural and man-made

Like any ecosystem around the world, oceans contain radioactive substances of natural origin. Small amounts of man-made radionuclides are also present in the oceans due to fallout from atmospheric nuclear weapons testing in the 1950-1970`s. Some marine areas have higher amounts of man-made radioactive substances – examples being the Irish Sea due to discharges from the Sellafield reprocessing plant, the Baltic Sea due to fallout and river runoff of Chernobyl origin and the east coast of Japan due to the Fukushima Dai-ichi accident. Both natural and man-made radioactive substances are incorporated in the environmental processes and food webs of marine ecosystems. In most ecosystems, the natural radioactive substances largely dominate over man-made ones.

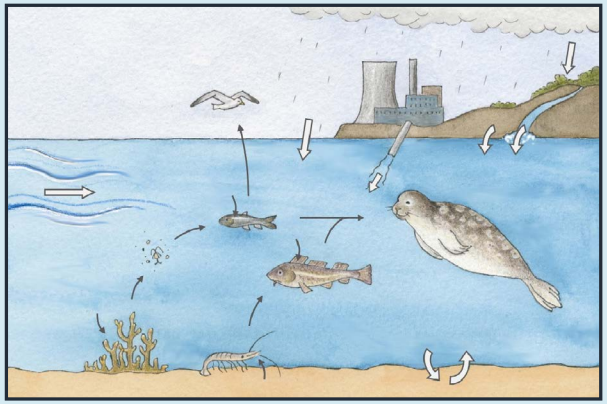


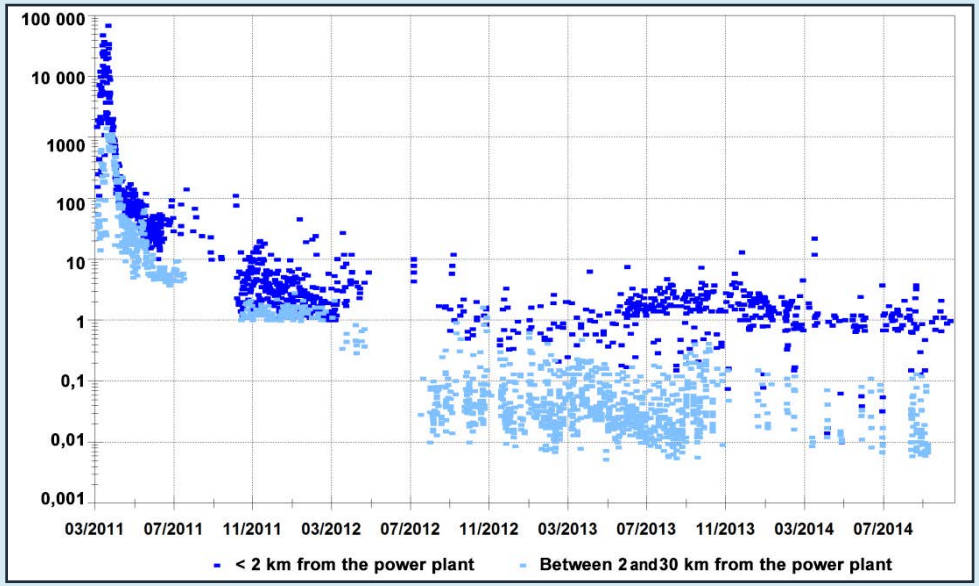
*Illustration: Mari Komperød, NRPA*



# Monitoring and research after Fukushima

Samples of water, bottom sediments and marine organisms have been collected and analysed by Japanese authorities, the plant operator TEPCO, and Japanese and foreign researchers during the last 4 years. STAR partners are active participants in this ongoing research. Due to ocean currents and the vastness of the Pacific Ocean, the radioactive substances have been rapidly dispersed over large areas and substantially diluted in the large water masses. The levels of radioactive caesium decrease with time and distance in sea water and plankton, and thus in fish species living in the open sea. Close to the Fukushima Dai-ichi power plant, however, the amounts of radioactive caesium remain higher. As radioactive substances bind to particles that sink to the sea floor, they accumulate in the bottom sediments where they remain an important source of radiation exposure to bottom-dwelling organisms and a secondary source for water contamination. The levels of radioactive caesium in sediments and bottom-dwelling fish show very little reduction at the moment in the near shore area.

*Plankton sampling near the Fukushima Dai-ichi power plant. Photo: Jun Nishikawa, Tokai University*



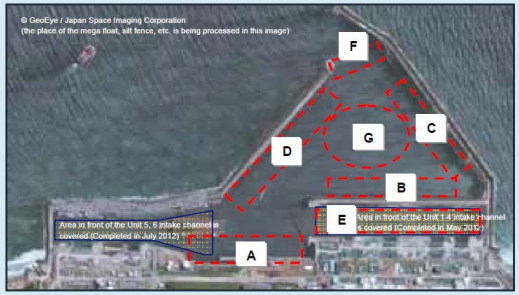

*Radioactive caesium-137 (Bq/L) in seawater from 2011 to 2014. www.irsn.fr*

# Radioactive caesium in seafood — from tiny amounts to concentrations of possible concern?

Traces of radioactive substances from Fukushima have been found in fish caught far away in the Pacific Ocean. For instance, bluefin tuna captured in California in 2011 contained 2-3 Bq/kg of radioactive caesium in the fresh fish fillet. This is a very small amount. If you were to eat 25 kg of bluefin tuna during a year, the received radiation dose would only be a fraction of the radiation dose you receive from a normal X-ray examination at your dentist. The dose received from radioactive caesium in the tuna would be hundred times lower than the radiation dose from natural radioactive substances in the same fish. In general, the amounts of radioactive caesium due to the Fukushima Dai-ichi accident are very low in fish and other seafood in the Pacific Ocean today, proven by the sampling and analysis in Japan, Australia, California, Alaska and elsewhere. Moderately elevated levels are present in the near shore area of the Fukushima Dai-ichi power plant, and only inside the port are the levels high enough to be of possible radiological concern.

## Elevated levels in the near shore area

Sampling inside the port area and at a point 3 km east of the port has been performed regularly by the operator TEPCO with oversight from the Japanese Nuclear Regulation Authority since 2012. These data are freely available on the JNRA and TEPCO web sites:




*Sampling points inside the port. Photo: Tokyo Electric Power Company*

http://radioactivity.nsr.go.jp/en/list/205/list-1.html
http://www.tepco.co.jp/en/nu/fukushima-np/f1/index2-e.html

Analyses of sampled fish have shown elevated levels of radioactive caesium, for example in the greenling, a popular fish among Japanese consumers. Being a bottom-dwelling fish, it is assumed to be among the fish species with the highest levels of radioactive caesium, often 10-1000 times higher than in fish living in the open sea. Samples of this fish caught in 2012—2014, 3 km east of the power plant, showed an average of around 170 Bq/kg in fresh fish fillet.



The quantity of radioactive caesium in greenling thus exceeded the Japanese limit of 100 Bq/kg in food for human consumption[1]. Consequently, fishing is still restricted within a radius of 20 km from the Fukushima Dai-ichi power plant. The doses received by the greenling, however, are well below the doses linked to harmful effects on fish populations.

*Greenling (H otakii)*
*http://flickr.com/photos/40507965@N03/4241221660*

## Levels of concern in the port area

Greenling caught inside the port showed much higher levels, some above 100 000 Bq/kg of radioactive caesium in fresh fillet. For other fish species the levels were generally lower, but still in the order of several thousands of Bq/kg. The doses received by the most exposed fish species are high enough to potentially cause negative effects e.g. on reproduction. Other bottom-dwelling marine organisms might be exposed to similar or higher levels. Continued monitoring and research of the marine ecosystem in the port area is necessary to determine if chronic radiation exposure will be harmful or not. Regular consumption of fish from the port area could potentially have negative effects on human health, thus justifying the current fishing restrictions. There are currently nets in place inside the port to prevent fish from swimming out into the ocean.

## Unresolved issues

Fukushima Dai-ichi was the first nuclear accident to cause massive contamination of the marine ecosystem. There are still knowledge gaps concerning the behaviour of radioactive substances in this marine environment, like dispersion by ocean currents, dilution in the water masses, uptake in the marine food webs in the Pacific Ocean, and possible harmful effects inside the port. The continued leakage of contaminated water from river runoff and the Fukushima Dai-ichi power plant adds to the uncertainty for both scientists and the public. Fishing is still prohibited in some coastal areas which continues to be a large economic and societal detriment to the fishermen and local inhabitants in the Fukushima Prefecture.

*Please consult the Fukushima page of the Radioecology Exchange for links to scientific publications on the Fukushima Dai-ichi accident: https://wiki.ceh.ac.uk/display/radex/Fukushima+Research*

**Questions?**
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1 Ten times stricter than the international guideline level (1000 Bq/kg for caesium-137).