The Solution of stop the Contaminated Water and The Safety of Fishery Products at TEPCO’s Fukushima Daiichi Nuclear Power Station (provisional translation)

Oct. 2019
Fisheries Agency of Japan
For the effective implementation, landing of the species subject to the restriction and/or suspension is prohibited (except samples for monitoring). In addition, market people confirm that the species are not sold at ports.

Framework for Radioactive Cesium Monitoring for Fishery Products

- Target species: Major commercial species and species that has record of detection with more than 50 Bq/kg (Cs-134 and 137) in the previous year. Due consideration is given to, inter alia: ① living layers of species (surface, mid water and bottom), ② fishing season, ③ results of neighboring prefectures’ monitoring
- Monitoring is strengthened when detected level of contamination is a smaller, but approximate to the standard limit (100 Bq/kg), or detected levels of contamination exceed the limit in the neighboring prefectures.
- In case of exceeding the limit, a relevant local government requires distribution restriction of the species and/or the Nuclear Emergency Response Headquarters directs distribution suspension order to the species.
Monitoring Results for Marine Fishery Products

- Immediately after the nuclear power station accident, about 21% of samples in Japan prefecture exceeded the current standard limit (100 Bq/kg) in Mar.–Jun. 2011. But the number of samples that exceeded the standard limit then gradually decreased with the passage of time. In Fukushima, on Jan. 2019, only one sample exceeded the standard limit for the first time in 3 years 10 months.

- Coastal fishing and trawl fishing off Fukushima have been operated on a reduced scale while the inspection of radioactive materials in the fish being caught by there fisheries have been implemented.

**Marine fish species**

<table>
<thead>
<tr>
<th>Number of Samples</th>
<th>More than 100Bq/kg</th>
<th>Less than 100Bq/kg</th>
<th>Excess Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>142</td>
<td>539</td>
<td>16.2%</td>
</tr>
<tr>
<td>2012</td>
<td>414</td>
<td>323</td>
<td>16.2%</td>
</tr>
<tr>
<td>2013</td>
<td>2,147</td>
<td>3,631</td>
<td>8.3%</td>
</tr>
<tr>
<td>2014</td>
<td>4338</td>
<td>4,422</td>
<td>20.9%</td>
</tr>
<tr>
<td>2015</td>
<td>4,346</td>
<td>4,485</td>
<td>16.2%</td>
</tr>
<tr>
<td>2016</td>
<td>4,365</td>
<td>4,202</td>
<td>8.3%</td>
</tr>
<tr>
<td>2017</td>
<td>4,240</td>
<td>3,950</td>
<td>6.2%</td>
</tr>
<tr>
<td>2018</td>
<td>3,978</td>
<td>3,520</td>
<td>5.0%</td>
</tr>
<tr>
<td>2019</td>
<td>3,828</td>
<td>3,486</td>
<td>4.0%</td>
</tr>
<tr>
<td>Total</td>
<td>123,505</td>
<td>121,230</td>
<td></td>
</tr>
</tbody>
</table>

Total: 123,505 samples
No. of samples more than 100Bq/kg: 2,275
No. of samples less than 100Bq/kg: 121,230
Immediately after the nuclear power station accident, about 37% of samples in Japan prefecture exceeded the current standard limit (100 Bq/kg) in Apr.–Jun. 2011. But the number of samples that exceeded the standard limit then gradually decreased with the passage of time.

**Monitoring Results for Freshwater Fishery Products**

- **Total:** 21,533 samples
  - **No. of samples more than 100Bq/kg:** 744
  - **No. of samples less than 100Bq/kg:** 20,789
Monitoring Results for Fishery Products

As a result of radioactive cesium monitoring, almost all main fishery products are confirmed to be under the Standard Limit in whole Japan including Fukushima prefecture.

Main fishery products have confirmed to be under the Standard limit in all prefectures since 1 Apr. 2012

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algae</td>
<td>All species</td>
</tr>
<tr>
<td>Mollusks</td>
<td>All species</td>
</tr>
<tr>
<td>Squid/Octopus</td>
<td>All species</td>
</tr>
<tr>
<td>Crustaceans</td>
<td>All species</td>
</tr>
<tr>
<td>Pelagic fish</td>
<td>Sardines, Pacific Saury, Juvenile Japanese Sand Lance, Juvenile Anchovy, Barracuda, Flying Fish</td>
</tr>
<tr>
<td>Mid-water pelagic fish</td>
<td>Mackerel, Swordfish, Skipjack, Tunas, Coho Salmon, Chum Salmon</td>
</tr>
<tr>
<td>Japanese Amberjack, Mako Shark, Blue Shark, Amberjack, Dotted gizzard Shad, Japanese Spanish Mackerel</td>
<td></td>
</tr>
<tr>
<td>Mahi mahi, Capelin, Crimson Sea Bream, Yellowtail Amberjack</td>
<td></td>
</tr>
<tr>
<td>Demersal fish</td>
<td>Blackthroat Seaperch, Horse Mackerel, Greeneyes, Striped Beakfish, Threadfin Hakeling, Black Scraper</td>
</tr>
<tr>
<td>Red Bream (Beryx splendens), Broadbanded Thornyhead (Sebastolobus macrochir), Tiger Puffer, Herring, Yellowfin Goby, Purple Puffer</td>
<td></td>
</tr>
<tr>
<td>Rikuzen flounder, Japanese Flounder</td>
<td></td>
</tr>
<tr>
<td>Marine mammal</td>
<td>Whales</td>
</tr>
</tbody>
</table>

The list of fishery products and area subject to distribution suspension order as of 11 Oct. 2019
Ocellate spot skate, Stimpson’s hard clam.
After the Great East Japan Earthquake, Fukushima Prefectural Federation of Fisheries Co-operative Association has decided to stop fishing activities of all the coastal and trawl fisheries off Fukushima Prefecture.

Fukushima prefectural government conducts particularly intensive monitoring. It carries out monitoring for 150 samples of major marine species in every week.

Fish species covered by the fishing operation must be determined after confirming that: 1) the species is not under distribution suspension order by the Chief of the Nuclear Emergency Response Headquarters, and 2) the levels of radioactive cesium remain lower than the Standard for a certain time period.
Responses to the recent Water Leakage

○ In response to recent leakage of contaminated water from F1NPS, the fishing operation for actual human consumption was not resumed on 1 Sep. 2013 even after the opening of fishery season (please see the next page for more information).

○ During the suspension period, Fukushima prefectural government monitored water samples of coastal sea off Fukushima prefecture, and confirmed that the level of radioactive cesium and total beta ray in water samples were the same level before the accident. Fukushima prefectural government also confirmed that concentration of radioactive Cs in fishery products were still in trend of decrease.

○ After the confirmation by Fukushima prefectural government, the fishing operation for actual human consumption was resumed in offshore bottom trawling fishery on 25 Sep. 2013.

Future of fishing operation

○ Fukushima Prefectural Federation of Fisheries Co-operative Association intends to expand species of the fishing operation for actual human consumption subject to confirmation of food safety through monitoring.
**The target species of fishing operation: as of 11 Oct. 2019**

Taking into account the results of the inspection on radioactive material in fisheries products, in the sea area off Fukushima Prefecture, fishing operation has been operated targeting those fish species whose radioactivity levels are low (Ocellate spot skate, Stimpson’s hard clam of which distribution are restricted by Nuclear Emergency Response Headquarters are excluded from the target). All fishery products are monitoring fish species as Fukushima prefecture fishing operation, and the concentrations of ratio cesium are confirmed less than 50 Bq/kg which is the voluntary standard of the Fukushima Prefectural Federation of Fisheries Co-operative Associations (standard limit: 100 Bq/kg).

- **Fishing methods and main target species**
  - Offshore bottom trawlers: Yellowstriped flounder, Willowy flounder, Japanese flounder, Pacific cod, Angler fish, Conger eel, etc.
  - Coastal gillnet fishery: Yellowstriped flounder, Japanese flounder, Dogsalmon, Swimming crab, etc.
  - Coastal driftnet fishery: Japanese Spanish mackerel, Yellowtail, etc.
  - Octopus pot fishery: Giant Pacific octopus, Chestnut octopus, etc.
  - Coastal pot fishery: Hiratsume-gani (*Ovalipes punctatus*), Common octopus, etc.
  - Longline fishery: Green ling, Seabass, Pacific cod, etc.
  - Fishing: Rockfish, Japanese flounder, etc.
  - Coastal pelagic trawlers: *Salangichthys isikawae*, Kounago (Juvenile of Japanese sandlance), Whitebait, Halfbeak and Noodlifish
  - Diving fishery: Abalone and Northern sea urchin
  - Dredge net fishery: Sakhalin Surf Clam, Clam (*Gomphina melanegis*)
  - Aquacultual fishery: Asari clam, Green laver
  - Conger eel Pot and Trap fishery: Conger eel
Inspection of radioactive materials and the distribution management of the fish products are conducted under the initiative of the Fukushima Prefectural Federation of Fishery Cooperative Association.

- Since Jun. 2012 to Oct. 2019, 42,189 products (fresh or boiled) are inspected for radioactive cesium after being landed.
- These results are publicized on the home page of Fukushima Prefectural Federation of Fisheries Co-operative Association (Japanese only)
  http://www.jf-net.ne.jp/fsgyoren/siso/sisotop.html
Strontium-90

○ The influence of strontium-90 in food to human health was fully considered when the current standard limit for radioactive cesium (100 Bq/kg-wet) was established.

○ Therefore, there is no need to worry about influence of strontium-90 when the level of radioactive cesium is below 100 Bq/kg-wet.

Concept of standard limit

○ The current standard limits were established with full consideration of the influence to human health from both radioactive Cs (134+137) and radionuclides other than Cs (i.e. Sr-90, Ru-106, Pu) because it takes a lot of time to measure those radionuclides other than Cs (ref. Ministry of Health, Labour and Welfare HP).

○ The effective dose from radionuclides other than Cs is assumed to be about 12% of the total effective dose from food (i.e. 0.9 mSv/year).

1 mSv (the same value of annual effective dose for food and drink set by Codex)

<table>
<thead>
<tr>
<th>Drinking water</th>
<th>0.1 mSv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>ca. 0.9 mSv</td>
</tr>
</tbody>
</table>

(88% of 0.9 mSv from radioactive Cs, 12% of 0.11 mSv from radionuclides other than Cs)

Strontium-90 in fishery products

○ Most of the survey results of Sr-90 ※1 were below the detection limit in the fishery products (especially in fish). In case of the detection of Sr-90, the concentrations of Sr-90 in such samples were low, ranging from 0.015 to 1.2 Bq/kg-wet.

○ Based on these Sr-90 levels, and assuming daily consumption of 2.1 kg (adult male’s average food consumption (except drinking water)) ※2, the annual exposure dose of Sr-90 for human was estimated to be from 0.00032 to 0.026 mSv. These levels do not raise concern.

※1 Strontium data: [http://www.jfa.maff.go.jp/j/housyanou/kekka.html](http://www.jfa.maff.go.jp/j/housyanou/kekka.html), ※2 Average food intake of adult male: [http://www.caa.go.jp/jisin/food_s.html](http://www.caa.go.jp/jisin/food_s.html)
Strontium-90 and Tritium

Strontium-90 (half-life: 28.8 years)
- Conversion factor (Bq to Sv) of effective dose for strontium-90 is about 2.2 times higher than that of cesium-137 (by the factor for adult in ICRP Publication 72).
- However, the concentration factors (the ratio of the concentration in organism to that in water) for strontium-90 in marine aquatic organisms were lower than those for cesium. That indicates that most of strontium-90 taken in organism is rarely absorbed and is excreted out.

Tritium (half-life: 12.3 years)
- The standard limits do not consider effect from tritium because the influence of tritium in food to human health is considered to be sufficiently small (ref. Ministry of Health, Labour and Welfare HP).
- Conversion factor of effective dose for tritium is about 1/700 of that of cesium-137 (by the factor for adult in ICRP Publication 72).
- Tritium mainly exists as water in nature. Therefore, tritium taken in organism is rarely kept in the body and is excreted out promptly. Consequently, the concentration factors for marine organisms are about 1.

Concentration factor (ref. IAEA TRS 422; Bio-concentration, Edit. N. Yamagata)

<table>
<thead>
<tr>
<th></th>
<th>Fish</th>
<th>Mollusks</th>
<th>Macroalgae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cesium</td>
<td>5 ~ 100</td>
<td>10 ~ 60</td>
<td>10 ~ 50</td>
</tr>
<tr>
<td>Strontium</td>
<td>1 ~ 3</td>
<td>1 ~ 10</td>
<td>10</td>
</tr>
<tr>
<td>Tritium</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
**Countermeasures to Manage Contaminated Water**

- Approximately 150 tons of groundwater, which naturally runs from the mountain side to the ocean, flow into reactor buildings and become newly contaminated water.
- Based on the three basic principles for water management, various countermeasures are taken against the estimated risks that the contaminated water may flow out to the port or that the contaminated water may leak from the storing tanks.

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### The three basic principles

1. **REMOVE contamination source**

   ① Decontamination of contaminated water using multi-nuclide removal equipment, etc.
   ② Removal of highly contaminated water in the underground tunnels (trenches)

2. **ISOLATE water from contamination**

   ③ Pumping from the well on the land-side of the building into the sea (groundwater bypassing system)
   ④ Pumping of groundwater from wells around buildings (sub-drains) and draining of the water to the sea after decontamination
   ⑤ Installation of land-side impermeable frozen walls
   ⑥ Waterproof pavement to prevent groundwater inflow

3. **PREVENT leakage of contaminated water**

   ⑦ Ground improvement by sodium silicate (water glass)
   ⑧ Installation of sea-side impermeable walls
   ⑨ Increase the number of tanks

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※ TEPCO HP: http://www.tepco.co.jp/en/index-e.html

(prepared by Fisheries Agency based on information from TEPCO)
Influence of the contaminated water in the port of F1NPS

- May 2013, a high level of tritium was detected in ground water at the seawall area between intakes of unit 1 and unit 2 of Fukushima Daiichi Nuclear Power Station (F1NPS). TEPCO investigated this case and confirmed that the contaminated water had leaked into the port of F1NPS in Jul. 2013.
- Though a certain level of radionuclides was detected in the seawater within the port, the level in outside is below detection limit at most sampling points. No significant influence of the contaminated water has been detected outside of the port.
- In order to prevent the contaminated fish in the port moving outside, TEPCO constructed the fence and net at the port entrance. TEPCO also have been catching the fish in the port (ref. TEPCO HP).
- After the seaside impermeable wall was constructed in the port in Oct. 2015, the radionuclides in the seawater of the port was further reduced.

Comparison of the amount of radionuclides in the contaminated water leaked in Apr.2011 with that in the contaminated water leaked from May 2011 to Aug.2013, which was estimated by TEPCO.

<table>
<thead>
<tr>
<th>radionuclide</th>
<th>the amount of radionuclides in the contaminated water leaked in Apr.2011</th>
<th>the amount of radionuclides in the contaminated water leaked since May 2011, which was estimated by TEPCO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>leak periods</td>
<td>leak amount (unit : Bq)</td>
</tr>
<tr>
<td>cesium-134+137</td>
<td>6 days</td>
<td>ca. $18 \times 10^{14}$</td>
</tr>
<tr>
<td>cesium-137</td>
<td>6 days</td>
<td>ca. $9.4 \times 10^{14}$</td>
</tr>
<tr>
<td>strontium-90*</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>tritium</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

*Note : 220 Bq/L (2013/8/19 sampling), 49 Bq/L (2013/8/19) and 0.29 Bq/L (2013/6/26) of strontium-90 were detected at the Station. "Point north side of Unit1-4 water intake channel (north side of East Seawall Break)", "Entrance of the port" and "Point near the south discharge channel ", respectively.

(prepared by Fisheries Agency based on information from TEPCO)
The values of detection limit were plotted in the cases when the detected radioactivity concentration was lower than the limit.
(prepared by Fisheries Agency based on information from TEPCO)