United Nations Scientific Committee on the Effects of Atomic Radiation

ATTACHMENT F-3

FRESHWATER ECOSYSTEM APPLICATION OF ASSESSMENT METHODOLOGY

UNSCEAR 2013 Report, Annex A, Levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-Japan earthquake and tsunami, Appendix F (Assessment of doses and effects for non-human biota)

Notes

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This publication has not been formally edited.

Contents

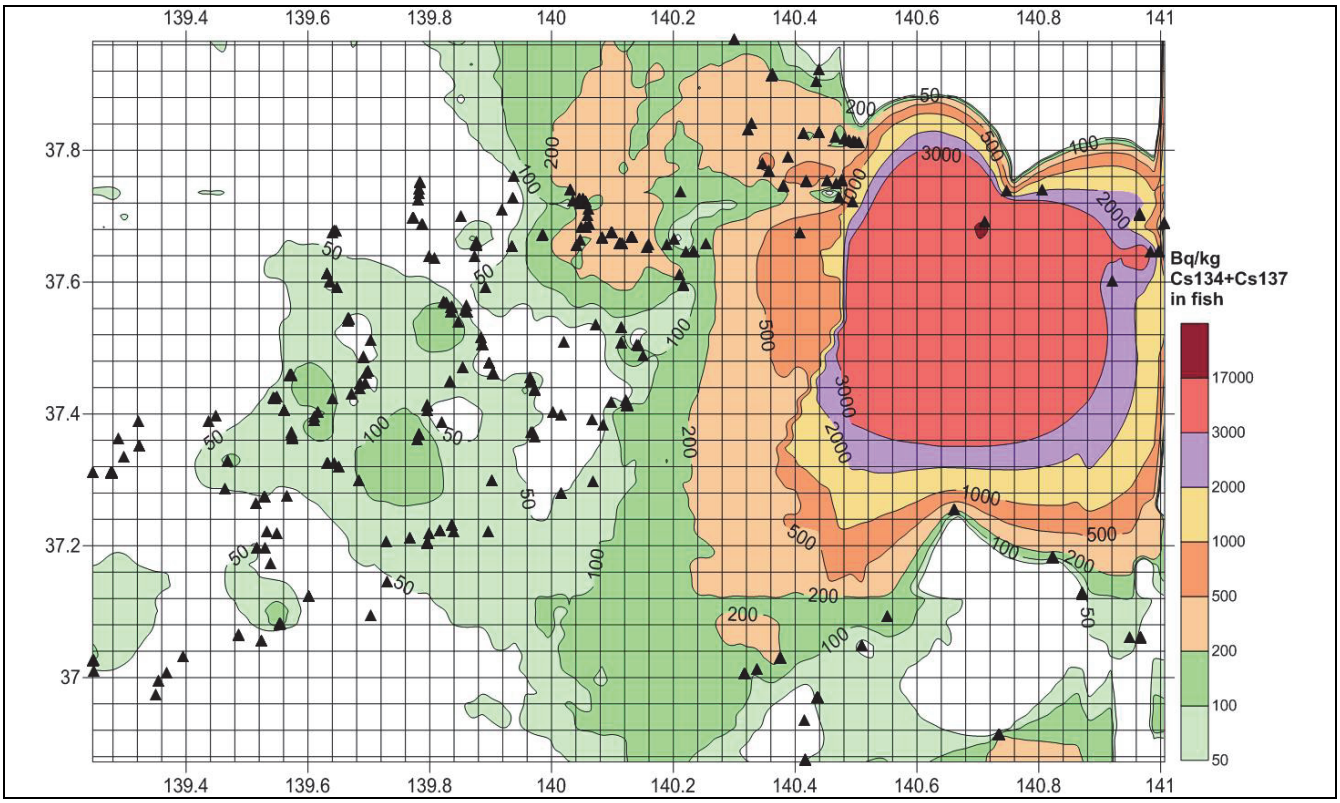
I. METHODOLOGY APPLIED TO THE ASSESSMENT ON FRESHWATER ECOSYSTEM

1. As a result of atmospheric deposition from the Fukushima-Daiichi nuclear power station (FDNPS) in March 2011, freshwater ecosystems had elevated levels of ^{131}I, ^{134}Cs, and ^{137}Cs in Fukushima Prefecture and also in Iwate, Miyagi, and Ibaraki prefectures.

2. Monitoring of concentrations of radionuclides in inland waters was organized by the Japanese Ministry of Environment and a database providing information on activity concentrations in freshwater biota was provided to the Committee. This database contained measured radionuclide activity concentrations in biota samples (mainly radiocaesium in fish) from Japanese freshwater ecosystems (2011–2012) and some data on radionuclide activity concentrations in water and sediments. The typical fish species for which data were reported were the common carp (*Cyprinus carpio),* ayu *(Plecoglossus altivelis),* Seema *(Oncorhynchus masou masou),* Japanese smelt *(Hypomesus nipponensis),* Japanese dace *(Tribolodon hakonensis),* char *(Salvelinus),* kokanee *(Oncorhynchus nerka*) and others. These species were expected to represent critical groups of fish, i.e. those which would have higher radionuclide concentrations among more than 20 species of fish inhabiting Japanese lakes and rivers. Locations of freshwater sampling stations were indicated by their geographical coordinates, without local names of lakes/rivers.

3. The locations of sampling stations on lakes and rivers of Japan affected by radioactive deposition from FDNPS are shown in figure I. The concentration levels of radiocaesium (^{134}Cs+^{137}Cs) in fish are also shown in figure I together with their geographical location within the Fukushima region. The sampling points presented in the database did not cover the area of maximum deposition density (above 1,000 kBq/m^2). Therefore, the activity concentration in fish in this area was reconstructed using the correlation between deposition density and concentrations in fish in Japanese lakes that had been studied.

Figure I. Concentration of radiocaesium ($^{134}Cs+^{137}Cs$) in freshwater fish in the Fukushima region according to the monitoring data from Japan (2011–2012) [Fukushima Prefecture, 2012]



4. From the database, the highest levels of radiocaesium in fish were measured in a local area situated to the north and north-west of FDNPS (within coordinates 37.6°–37.7°N; 140.5°–140.9°E); characterized by ^{137}Cs deposition density from the atmosphere in the range 100,000–200,000 Bq/m^2. A representative lake in this area is Dam Lake Hayama (38 km to the north-north-west of FDNPS covering an area of 80.8 km^2). Radiocaesium activity concentrations in fish from Lake Hayama are presented in table 1. A representative river was provided by Abukuma River, entering the sea 70 km to the north of FDNPS; Mano River and others were also considered. Typical activity of radiocaesium in fish in this contaminated local area was approximately 2,000–3,000 Bq/kg; a maximum level of 18,700 Bq/kg was measured in a single fish sample in March 2012. Very limited data on concentrations in sediment indicated levels of 4,400 Bq/kg d.w. of ^{134}Cs, and 5,500 Bq/kg d.w. of ^{137}Cs in water bodies from this area.

5. Some rivers within the local area with highest deposition densities flow into the marine coastal zone near FDNPS. Many fish species in these rivers are migratory types that spend part of the year in the marine environment and enter rivers to spawn. Therefore, the sources of activity levels in fish were both inland waters and seawater.

6. Fishing had not been stopped in lakes and rivers, but the Japanese Nuclear Emergency Response Headquarters had imposed capture self-control and shipping restriction of fish as foodstuffs — as exemplified by ayu (*Plecoglossus altivelis*), char, Japanese dace, Japanese eel, common carp, gin-buna (*Carassius auratus langsdorfi*), seema and eperla (Japanese smelt) — pursuant to the Act on Special Measures Concerning Nuclear Emergency Preparedness.

7. Outside the local area with highest deposition densities, activity concentrations in fish from inland waters were lower by a considerable margin, reflecting the reduced levels of radiocaesium deposition at these locations (see figure I).

8. In the area with ^{137}Cs deposition density characterized by the range 50,000–100,000 Bq/m^2, a representative lake is Lake Akimoto (83 km to the west-north-west from FDNPS). Lake Akimoto is mezotrophic, its area is 3.6 km^2 and volume 0.04 km^2. Radiocaesium activities in fish from Lake Akimoto are presented in table 1. In sediments, the ^{137}Cs activity concentration was 180 Bq/kg d.w., and that of ^{134}Cs was 130 Bq/kg d.w.

9. In the area with ^{137}Cs deposition density in the range 10,000–50,000 Bq/m^2, a representative lake is Lake Inawashiro (83 km to the west from FDNPS; area 103.3 km^2, volume 5.4 km^2). Radiocaesium activities in fish from Lake Inawashiro are presented in table 1.

10. Using data from three representative lakes (Inawashiro, Akimoto and Hayama), linear equations between the levels of ^{137}Cs deposition density and the radiocaesium activity concentrations in lake fish were constructed (see table 1). Using these equations, missing data on concentrations in fish in areas of maximum deposition density (5,000 kBq/m^2) were reconstructed. The results are reported in table 1.

Table 1. Parameters of correlation between deposition density and concentration in fish for representative Japanese lakes (2011–2012)

Name of lake	*Location (lat, long)*	*Average deposition density of ^{137}Cs (Bq/m^2)*	*Average activity of radiocaesium in fish (Bq/kg)*	*Highest activity of radiocaesium in fish (Bq/kg)*
Hayama	37.716°N, 140.81°E	187,190	560 ± 186	1,100
Akimoto	37.65°N, 140.135°E	51,350	305 ± 120	670
Inawashiro	37.48°N, 140.1°E	13,990	116 ± 78	250
Hypothetical lake in the zone of highest deposition density		500,000	12,000*	22,000*

*Predicted values. Relations between the deposition density and concentrations in fish follow linear equations: y=2.379x+127.1 (for average); and y=4.439x+300.4 (for maximal values); y [Bq/kg]; x [kBq/m^2].

II. DOSE RATES TO FRESHWATER FISH FROM FUKUSHIMA REGION

11. Dose rates to fish from radiocaesium in Japanese lakes and rivers were calculated using the ERICA Tool on the basis of monitoring data.

12. Dose rates to fish from Lake Akimoto (summer 2011–2012) were in the range 0.05–0.1 µGy/h for fish with average activity concentration levels. For fish with maximum activity concentration levels, dose rates were in the range 0.17–0.2 µGy/h (depending on the period fish were assumed to stay near the lake-bottom sediments).

13. Estimated dose rates for fish from local areas with ^{137}Cs deposition density in the range 100,000–200,000 Bq/m^2 fell between 0.4 and 3 µGy/h; dose rates to the fish sample with the maximum measured activity concentration were within the range 3.7–6.2 µGy/h (depending on the period the fish were assumed to stay near the lake-bottom sediments).

14. Dose rates were calculated for hypothetical fish inhabiting a lake within local areas with maximum deposition density. For pelagic fish, an average dose rate of 2.3 µGy/h, and a maximum of 4.3 µGy/h were calculated. For benthic fish, the average dose rate was 34 µGy/h, and the maximum was 36 µGy/h. These levels exceeded the threshold believed to be protective

of vertebrate organisms [ICRP, 2008; Hosseini et al., 2010]. At chronic exposures at these dose rates some negative effects on fitness, reproduction and life shortening could be expected in individual fish, although population effects should not be observed.

The dose rates to fish in freshwater ecosystems in the majority of other areas receiving deposition from the FDNPS accident did not reach the threshold levels for chronic exposure above which deterministic effects of radiation are expected in freshwater biota [ICRP, 2008; Hosseini et al., 2010]. Only in the local zone of maximum deposition density was there a substantial hypothetical risk that some negative effects of radiation might appear in individual organisms under conditions of chronic exposure.

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