Radiological Environmental Impact Assessment Report
for One Year after the Commencement of Discharge
Regarding the Discharge of ALPS Treated Water into the Sea

The Japanese version shall prevail

December 2024

Tokyo Electric Power Company Holdings, Inc.

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Executive summary

This report compiles the results of the assessment of the radiological impacts on humans and the environment during the one year after operation commenced resulting from the discharge of the water treated by the Advanced Liquid Processing System ("ALPS") Multi-Nuclide Removal Facility (hereinafter "ALPS treated water") from the Fukushima Daiichi Nuclear Power Station (hereinafter "FDNPS") into the sea in accordance with the standards and guidelines established by internationally recognized organizations such as International Atomic Energy Agency (hereinafter called "IAEA") and International Commission on Radiological Protection (hereinafter called "ICRP").

In this report, Chapter 1 explains the process leading up to the radiological environmental impact assessment for one year after the commencement of discharge of ALPS treated water into the sea.

Next, Chapter 2 explains the purpose of the radiological environmental impact assessment in the operation stage.

Chapter 3 explains the discharge result of ALPS treated water for one year after the commencement of discharge into the sea and the addition of nuclides to be measured and assessed.

Chapter 4 explains the assessment concept in this report, especially the changes from the Radiological Environmental Impact Assessment Report (Construction stage / Revised version) (hereinafter "previous assessment"), such as the handling of the discharge period and assessment period in the assessment.

Chapters 5 and 6 explain the radiological environmental impact assessment on humans and marine animals and plants. These chapters explain the results of the assessment using the methodology used in the previous assessment, based on the results of ALPS treated water discharge into the sea for one year after the commencement of discharge. The results of the dispersion simulation for tritium in the discharged ALPS treated water were presented, using meteorological and oceanographic data actually observed over the one year period following the commencement of discharges. The results were also compared with the results of the predictive assessment made in the previous assessment.

The results of the radiological environmental impact assessment for one year after the commencement of discharge of ALPS treated water into the sea yielded the following three findings:

① When ALPS treated water is discharged from the seabed approximately 1 km offshore from the FDNPS, the discharged ALPS treated water will be dispersed and diluted in the sea, and in areas away from the discharge point, the tritium concentration will be approximately the same as the normal concentration in the sea.

② The radiological impact on people expected to be most affected near the discharge point is sufficiently small, at approximately 1/50,000 of the level of radiation exposure, compared to Japan's safety standards established in accordance with international guidelines. The results are also comparable to the predicted assessment results in the previous assessment.

③ The exposure level to animals and plants living in the 10km x 10km sea area around the FDNPS is about 1/10 million to 1/1 million of the lower limit of the ICRP-proposed level (derived consideration reference level) above which there is concern that some kind of impact may be caused to the relevant animals and plants. The results were also about the same as the predicted results of the previous assessment compiled before the commencement of the discharge.

This shows that the advanced water treatment by ALPS and the discharge plan that makes effective use of the period required for decommissioning will limit the impact on humans and marine animals and plants, and will be well within Japan's safety standards, which are established in line with international guidelines.

Chapter 7 describes the status of environmental monitoring and compares it with a dispersion simulation, confirming that both results indicate that dispersion and dilution of the ALPS treated water is progressing after discharge into the sea.

Chapter 8 summarizes the overall results.

Prior to discharging the ALPS treated water, we analyze the radioactive materials contained in the undiluted ALPS treated water and make the results public. In addition, when discharging the water into the sea, we begin by carefully discharging small amounts while monitoring the impact on the surrounding environment. In the unlikely event that the dilution equipment malfunctions due to a breakdown or power outage, or if the situation is determined to be different from normal through strengthened monitoring after the commencement of the discharge, we will suspend the discharge until we can confirm that the conditions for safe discharge have been established, and will make our utmost efforts to ensure the safety of people and marine animals and plants.

We will continue to review our assessment further, reflecting knowledge gained through progress in operational studies, opinions from various parties, and cross-checks by third-party assessments, and will revise our Radiological Environmental Impact Assessment Report as necessary, and will reflect the findings in our discharge plan, etc., if necessary.

Table of Contents

Attachment

1. Background

In April 13, 2021, the government, based on a long period of consideration and opinions received from residents and experts, outlined its basic policy regarding the disposal of the water treated by the Advanced Liquid Processing System (hereinafter “ALPS treated water”) in the “Basic Policy on the Disposal of Multi-nuclide Removal Facility Treated Water at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.” (Meeting of Ministers Related to Decommissioning, Contaminated Water, and Treated Water Measures, April 13, 2021) (hereinafter “Basic Policy”) [1], which stated its basic policy to discharge the water into the sea only after ensuring safety.

Based on this policy, on April 16 of the same year, we published "TEPCO Holdings’ Action in Response to the Basic Policy" [2] and proceeded with the design of specific equipment. In November 2021, we compiled the Radiological Impact Assessment Report (Design stage) [3], published it on our website, and invited public comments from both within Japan and overseas. After that, in December 2021, we submitted an application for a change to the implementation plan for the ALPS treated water dilution and discharge equipment, and the Nuclear Regulation Authority commenced its review.

In parallel, the IAEA conducted a review, and based on public comments, comments from the Nuclear Regulation Authority's review, and comments from the IAEA and related organizations, the Radiological Impact Assessment Report (Design stage / Revised version) [4] was published in April 2022.

After further consideration of the design and operation, the Radiological Environmental Impact Assessment Report (Construction stage) [5] was published in November 2022 along with the application for change of the implementation plan, and after review by the Nuclear Regulation Authority and the IAEA, the Radiological Environmental Impact Assessment Report (Construction stage / Revised version) [6] (hereinafter “previous assessment”) was published in February 2023, reflecting the comments from these reviews. In addition, approval was received for the application to change the implementation plan regarding the design of the ALPS treated water dilution and discharge facilities, etc.

In addition, the IAEA published the Comprehensive Report [7] in July 2023, stating that the impact on people and the environment from the discharge of ALPS treated water into the sea is negligible.

On August 22, 2023, the government decided when to commence the discharge of ALPS treated water into the sea and instructed our company to begin preparations for the discharge, and our company commenced the discharge of ALPS treated water into the sea on August 24, 2023.

On August 24, 2024, one year has passed since the commencement of the discharge, so we decided to conduct a radiological environmental impact assessment based on the discharge results from this past year, as well as actual meteorological and oceanographic data.

2. Objectives of the assessment

The objectives of this Radiological Environmental Impact Assessment is as follows:

Objective 1: An assessment will be conducted in light of internationally recognized methods (IAEA Safety Standards Documents, ICRP Recommendations) on the impact of radiation on people and the environment, based on the ALPS treated water actually discharged during the first year after the commencement of discharge into the sea, as well as actual meteorological and oceanographic data.

Objective 2: The Assessment results will be compared with the results of the previous assessment and environmental monitoring results.

3. Discharge results for one year after the commencement of ALPS treated water discharge

3-1. Discharge results of ALPS treated water

A total of eight discharges of ALPS treated water into the sea were carried out between August 24, 2023, when the discharge commenced, and August 23, 2024, one year later. Table 3-1-1 shows the eight discharge periods and amounts of tritium discharged.

The total amount of tritium discharged over the one year period was approximately 1.0E+13 Bq, less than half of the upper limit of 2E+13 Bq set by government policy.

Table 3-1-1 Discharge results of ALPS treated water

Target discharge (The number on right is the total number of discharge.)	Discharge period	Tritium concentration (Bq/L)	Discharged water volume (m3)	discharged tritium volume (Bq)
FY2023 1st-1	Aug 24, 2023～Sep 11, 2023	1.4E+05	7.8E+03	1.1E+12
FY2023 2nd-2	Oct 5, 2023～Oct 23, 2023	1.4E+05	7.8E+03	1.1E+12
FY2023 3rd-3	Nov 2, 2023～Nov 20, 2023	1.3E+05	7.8E+03	9.8E+11
FY2023 4th-4	Feb 28, 2024～Mar 17, 2024	1.7E+05	7.8E+03	1.3E+12
FY2024 1st-5	Apr 19, 2024～May 7, 2024	1.9E+05	7.9E+03	1.5E+12
FY2024 2nd-6	May 17, 2024～Jun 4, 2024	1.7E+05	7.9E+03	1.3E+12
FY2024 3rd-7	Jun 28, 2024～Jul 16, 2024	1.7E+05	7.8E+03	1.3E+12
FY2024 4th-8	Aug 7, 2024～Aug 25, 2024	2.0E+05	7.9E+03	1.6E+12
Total			6.3E+04	1.0E+13

3-2. Nuclides other than tritium

When discharging ALPS treated water, the concentrations of radioactive materials (nuclides to be measured and assessed[1] and tritium) in the ALPS treated water are measured and assessed before dilution and discharged, and the results are made public. In the measurement and assessment, the tritium concentration of the ALPS treated water to be dischaeged is confirmed, and the analysis results of the nuclides to be measured and assessed are confirmed to ensure that the sum of the notification concentration ratios of radioactive materials other than tritium is less than 1.

In the previous assessment, TEPCO reviewed and changed the nuclides to be measured and assessed. The review of the nuclides to be measured and assessed was carried out after review by the Nuclear Regulation Authority, and five new nuclides were added from the 63 nuclides (excluding tritium) before the review, while 39 nuclides were excluded, leaving a final

[1] This refers to nuclides other than tritium that are subject to measurement and assessment before the diluted discharge of ALPS treated water to confirm that their levels are below regulatory standards.

total of 29 nuclides to be measured and assessed. TEPCO continues to voluntarily measure the 39 nuclides that were excluded from the measurement and assessment. In addition, although there is a possibility that they may be present in contaminated water, past analysis of strontium-treated water confirmed that the concentration was less than 1/100 of the notification concentration, and as such, it was decided to confirm once a year that these nuclides are not significantly present in the contaminated water as monitored nuclides. After that, we commenced discharging ALPS treated water into the sea on August 24, 2023. However, in February 2024, an analysis of untreated water collected from the ALPS inlet for the measurement of monitored nuclides revealed that Cd-113m, one of the monitored nuclides, was detected at a significant concentration. Therefore, we announced that we would add Cd-113m to the nuclides to be measured and assessed on August 1, 2024 [8], and this will apply from the fourth discharge in FY2024 (the eighth discharge in total).

In this report, we decided to retroactively assess Cd-113m from the first discharge in FY2023. Voluntary measurements were used to measure the Cd-113m concentration in the discharges conducted before the addition to the nuclides to be measured and assessed, but all were undetectable.

The background to the addition of Cd-113m to the nuclides to be measured and assessed is summarized in Attachment I.

The analysis results of the nuclides to be measured and assessed for each discharge are shown in Tables 3-2-1 to 3-2-2.

Figures 3-2-1 and 3-2-2 show the average concentrations of the seven main nuclides, Tc-99, tritium, and C-14 in the ALPS treated water discharged over the one year period since discharges commenced, compared with the concentration distribution in the analysis results for the ALPS treated water stored in the tank group (Previous Assessment Figure 6-1-2). The average concentrations for the eight discharges were near the center of the concentration distribution for the ALPS treated water stored in the tank group.

Table3-2-1 Concentrations of radionuclides in ALPS treated water by type for each discharge (FY2023 discharges)

No.	Target nuclide	FY2023 1st-1		FY2023 2nd-2		FY2023 3rd-3		FY2023 4th-4	
		Concentration* (Bq/L)		Concentration (Bq/L)		Concentration (Bq/L)		Concentration (Bq/L)	
1	H-3		1.4E+05		1.4E+05		1.3E+05		1.7E+05
2	C-14		1.4E+01		1.3E+01		1.4E+01		1.4E+01
3	Mn-54	<	2.6E-02	<	2.3E-02	<	2.5E-02	<	2.4E-02
4	Fe-55	<	1.5E+01	<	1.4E+01	<	1.6E+01	<	1.4E+01
5	Co-60		3.5E-01		2.4E-01		3.3E-01		3.4E-01
6	Ni-63	<	8.8E+00	<	8.9E+00	<	9.0E+00	<	9.7E+00
7	Se-79	<	9.3E-01	<	8.7E-01	<	8.9E-01	<	1.1E+00
8	Sr-90		4.1E-01	<	3.2E-02		4.1E-02		3.1E-01
9	Y-90		4.1E-01	<	3.2E-02		4.1E-02		3.1E-01
10	Tc-99		6.8E-01	<	1.9E-01	<	2.0E-01		3.4E+00
11	Ru-106	<	2.5E-01	<	2.1E-01	<	2.3E-01	<	2.5E-01
12	Cd-113m	<	8.4E-02	<	8.5E-02	<	9.3E-02	<	8.8E-02
13	Sb-125		1.8E-01	<	8.8E-02	<	9.4E-02		1.1E-01
14	Te-125m		6.4E-02	<	3.1E-02	<	3.3E-02		4.0E-02
15	I-129		2.0E+00		1.8E+00		1.9E+00		2.5E+00
16	Cs-134	<	3.3E-02	<	3.0E-02	<	2.9E-02	<	3.4E-02
17	Cs-137		4.7E-01		4.5E-01		3.8E-01		5.0E-01
18	Ce-144	<	3.6E-01	<	3.6E-01	<	4.0E-01	<	3.7E-01
19	Pm-147	<	3.1E-01	<	3.2E-01	<	3.4E-01	<	3.3E-01
20	Sm-151	<	1.2E-02	<	1.2E-02	<	1.3E-02	<	1.3E-02
21	Eu-154	<	7.0E-02	<	7.1E-02	<	7.7E-02	<	7.4E-02
22	Eu-155	<	1.9E-01	<	2.4E-01	<	2.6E-01	<	2.0E-01
23	U-234	<	2.1E-02	<	3.0E-02	<	2.4E-02	<	2.5E-02
24	U-238	<	2.1E-02	<	3.0E-02	<	2.4E-02	<	2.5E-02
25	Np-237	<	2.1E-02	<	3.0E-02	<	2.4E-02	<	2.5E-02
26	Pu-238	<	2.1E-02	<	3.0E-02	<	2.4E-02	<	2.5E-02
27	Pu-239	<	2.1E-02	<	3.0E-02	<	2.4E-02	<	2.5E-02
28	Pu-240	<	2.1E-02	<	3.0E-02	<	2.4E-02	<	2.5E-02
29	Pu-241	<	5.8E-01	<	8.1E-01	<	6.5E-01	<	7.0E-01
30	Am-241	<	2.1E-02	<	3.0E-02	<	2.4E-02	<	2.5E-02
31	Cm-244	<	2.1E-02	<	3.0E-02	<	2.4E-02	<	2.5E-02

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

Table 3-2-2 Concentrations of radionuclides in ALPS treated water by type for each discharge (FY2024 discharges)

No.	Target nuclide	FY2024 1st-5		FY2024 2nd-6		FY2024 3rd-7		FY2024 4th-8	
		Concentration* (Bq/L)		Concentration (Bq/L)		Concentration (Bq/L)		Concentration (Bq/L)	
1	H-3		1.9E+05		1.7E+05		1.7E+05		2.0E+05
2	C-14		1.6E+01		1.3E+01		9.9E+00		1.2E+01
3	Mn-54	<	2.9E-02	<	2.4E-02	<	2.6E-02	<	2.6E-02
4	Fe-55	<	1.5E+01	<	1.6E+01	<	1.9E+01	<	1.6E+01
5	Co-60		4.1E-01		3.0E-01		5.0E-01		4.4E-01
6	Ni-63	<	9.2E+00	<	8.9E+00	<	9.1E+00	<	8.1E+00
7	Se-79	<	1.1E+00	<	1.3E+00	<	8.8E-01	<	9.8E-01
8	Sr-90		3.9E-01		2.8E-01		1.4E+00		1.2E+00
9	Y-90		3.9E-01		2.8E-01		1.4E+00		1.2E+00
10	Tc-99		3.5E+00		5.5E-01		8.0E-01		7.3E-01
11	Ru-106	<	2.4E-01	<	2.6E-01	<	2.5E-01	<	2.2E-01
12	Cd-113m	<	8.5E-02	<	8.6E-02	<	8.6E-02	<	7.7E-02
13	Sb-125		9.7E-02		1.4E-01		2.6E-01		2.3E-01
14	Te-125m		3.6E-02		5.2E-02		9.6E-02		8.7E-02
15	I-129		2.3E+00		1.0E+00		7.8E-01		2.9E-01
16	Cs-134	<	3.2E-02	<	3.0E-02	<	3.3E-02	<	3.4E-02
17	Cs-137		3.9E-01		3.0E-01		2.9E-01		2.2E-01
18	Ce-144	<	3.8E-01	<	5.1E-01	<	3.8E-01	<	3.8E-01
19	Pm-147	<	3.5E-01	<	3.3E-01	<	3.3E-01	<	3.3E-01
20	Sm-151	<	1.3E-02	<	1.3E-02	<	1.3E-02	<	1.3E-02
21	Eu-154	<	7.8E-02	<	7.4E-02	<	7.4E-02	<	7.4E-02
22	Eu-155	<	3.1E-01	<	2.1E-01	<	2.6E-01	<	2.1E-01
23	U-234	<	2.2E-02	<	2.5E-02	<	2.8E-02	<	2.9E-02
24	U-238	<	2.2E-02	<	2.5E-02	<	2.8E-02	<	2.9E-02
25	Np-237	<	2.2E-02	<	2.5E-02	<	2.8E-02	<	2.9E-02
26	Pu-238	<	2.2E-02	<	2.5E-02	<	2.8E-02	<	2.9E-02
27	Pu-239	<	2.2E-02	<	2.5E-02	<	2.8E-02	<	2.9E-02
28	Pu-240	<	2.2E-02	<	2.5E-02	<	2.8E-02	<	2.9E-02
29	Pu-241	<	5.9E-01	<	7.0E-01	<	7.8E-01	<	7.9E-01
30	Am-241	<	2.2E-02	<	2.5E-02	<	2.8E-02	<	2.9E-02
31	Cm-244	<	2.2E-02	<	2.5E-02	<	2.8E-02	<	2.9E-02

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

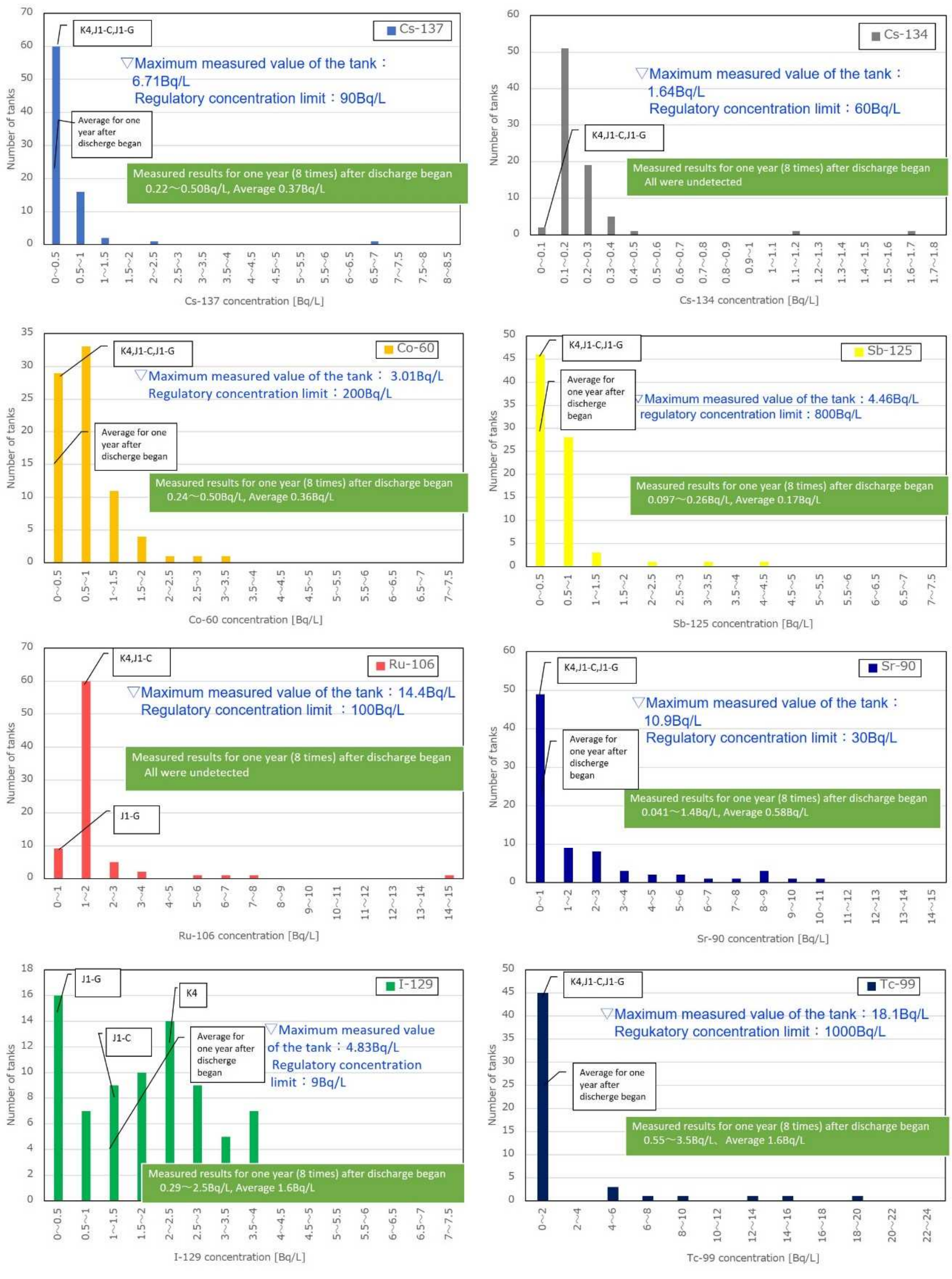

Figure 3-2-1 Concentration distribution of the seven major nuclides and Tc-99 in the analysis result of ALPS treated water(as of the end of March 2021) versus average concentration of ALPS treated water discharged during the assessment

※ The analysis results in which the sum of the ratios to regulatory concentrations limits of the 7 major nuclides is less than 0.59 (for 80 tanks) (excluding secondary treated test water)
※ The vertical axis indicates the number of tanks
※ Some maximum values are the detection limit values if they were not detected.
※ Values are measured values at the times and no half-life correction is considered.

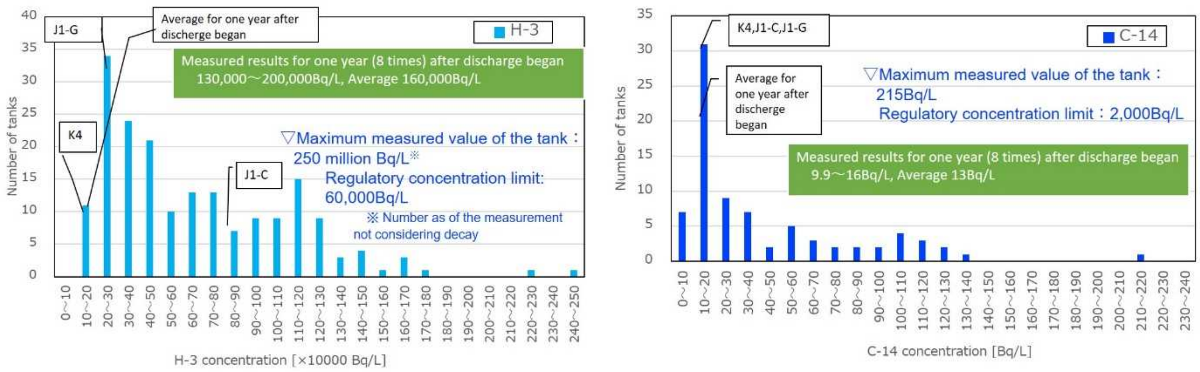

Figure 3-2-2 Concentration distribution of tritium and C-14 in the analysis result of ALPS treated water, etc. (as of the end of March 2021) versus average concentration of ALPS treated water discharged during the assessment

※The analysis results of the tank group (189 tanks for tritium and 81 tanks for C-14) are plotted (excluding secondary treatment test water)

※The vertical axis indicates the number of tanks (counted as the detection limit if not detected)

※Values are measured values at the times and no half-life correction is considered

4. Concept of assessment

In this report, we have assessed radiation exposure to representative persons and reference animals and plants, following the methodology of the previous assessment, based on the discharge results of ALPS treated water and as actual meteorological and oceanographic data over the one year period since discharges commenced.

The concept of the assessment is outlined below.

4-1. Assessment Period

A total of eight discharges were conducted over the one-year period from August 24, 2023, when the discharge of ALPS treated water into the sea commenced, to August 23, 2024, one year later. As the eighth discharge was completed on August 25, the assessment period was set to be from August 24, 2023 to August 25, 2024.

On the other hand, in terms of radiation exposure assessment, as the nuclide composition of the ALPS treated water discharged differs for each discharge, a source term was set for each discharge, and the assessment period was decided from the commencement date of the discharge to the day before the commencement date of the next discharge. Note that for the final, eighth discharge, the assessment period was set to the completion date of the discharge. The discharge records and assessment periods are shown in Table 4-1-1.

Table 4-1-1 ALPS treated water discharge into the sea and assessment period

Target discharge (The number on right is the total number of discharge.)	Discharge period	Assessment period
FY2023 1st-1	Aug 24, 2023～Sep 11, 2023	Aug 24, 2023～Oct 4, 2023
FY2023 2nd-2	Oct 5, 2023～Oct 23, 2023	Oct 5, 2023～Nov 1, 2023
FY2023 3rd-3	Nov 2, 2023～Nov 20, 2023	Nov 2, 2023～Feb 27, 2024
FY2023 4th-4	Feb 28, 2024～Mar 17, 2024	Feb 28, 2024～Apr 18, 2024
FY2024 1st-5	Apr 19, 2024～May 7, 2024	Apr 19, 2024～May 16, 2024
FY2024 2nd-6	May 17, 2024～Jun 4, 2024	May 17, 2024～Jun 27, 2024
FY2024 3rd-7	Jun 28, 2024～Jul 16, 2024	Jun 28, 2024～Aug 6, 2024
FY2024 4th-8	Aug 7, 2024～Aug 25, 2024	Aug 7, 2024～Aug 25, 2024
Total of Assessment period		Aug 24, 2023～Aug 25, 2024

4-2. Assessment method

(1) Source term[2]

As shown in 3-2, with the addition of Cd-113m, the number of new nuclides to be assessed has increased to 31, including tritium.

In addition, the amount of each nuclide discharged was calculated as the product of the analytical result (concentration) of each nuclide and the amount of water discharged, and used as the source term. Undetectable nuclides were conservatively assumed to be present at the detection limit, and were calculated as the product of the detection limit and the amount of water discharged.

(2) Discharge method and tritium dispersion simulation

The ALPS treated water will be diluted 100 times or more with seawater and discharged upward from a discharge outlet installed on the seabed about 1 km offshore (see Figures 4-2-1 to 4-2-2). There are no changes to the discharge method from the previous assessment, and the same model was used for the dispersion simulation.

However, the Input of tritium discharge amount into dispersion simulation was set to an upper limit of 2.2E+13 Bq for the annual tritium discharge amount, evenly distributed throughout the year, in the previous assessment, whereas in this report it was set based on the discharge results (discharge rate, discharge period). The difference between the two is shown in Figure 4-2-3.

The tritium dispersion simulation also uses the model from the previous assessment as is, but tritium discharge is based on the discharge results (discharge rate, discharge period) and meteorological and oceanographic data from the assessment period was also used for calculations.

The results of the dispersion simulation was compared with the results of the previous assessment and the results of environmental monitoring.

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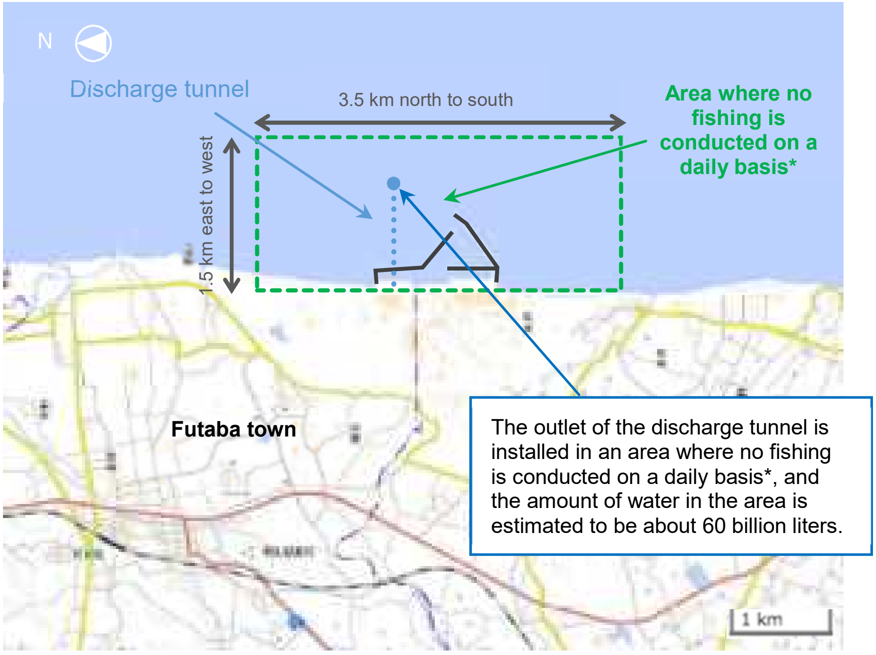
[2] In this assessment, the source term refers to the total amount of each nuclide contained in the ALPS treated water discharged into the sea during the assessment period.



*Areas where common fishery rights are not established

Source: the Geographical Survey Institute map (national land electronic website) revised by Tokyo Electric Power Company Holdings Corporation

https://maps.gsi.go.jp/#13/37.422730/141.044970/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f

Figure 4-2-1 Water discharge location map

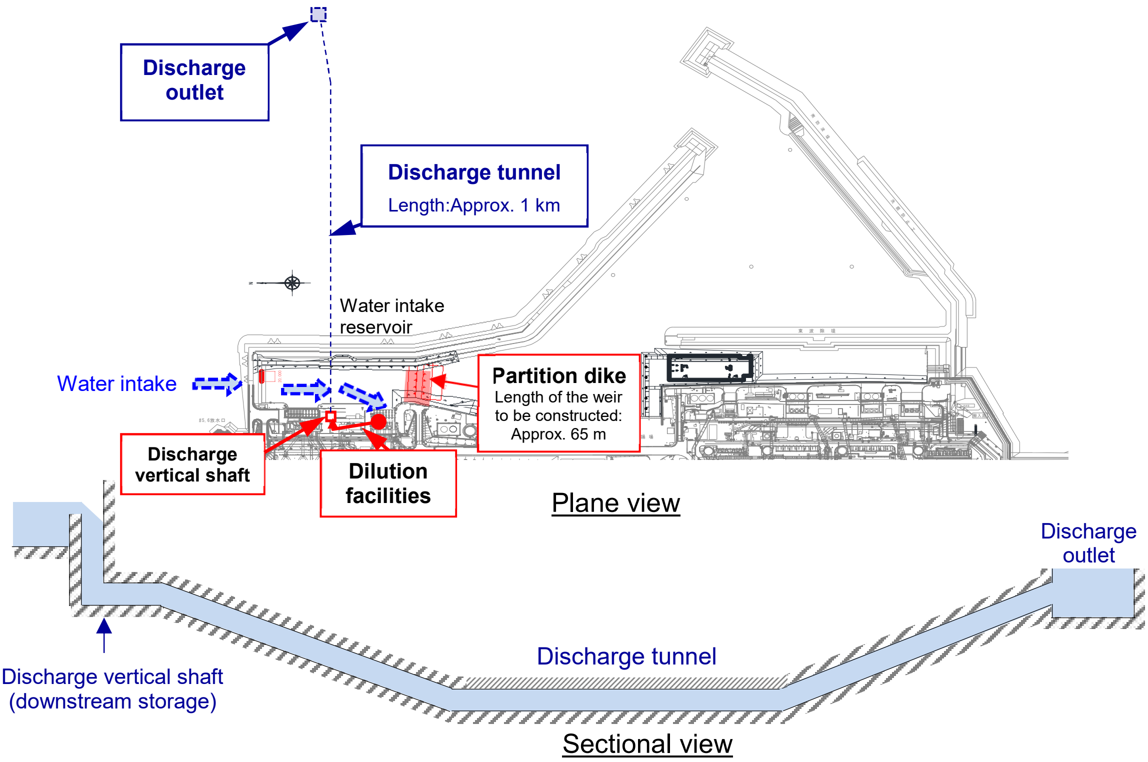


Figure 4-2-2 Overall view of the intake and discharge facilities

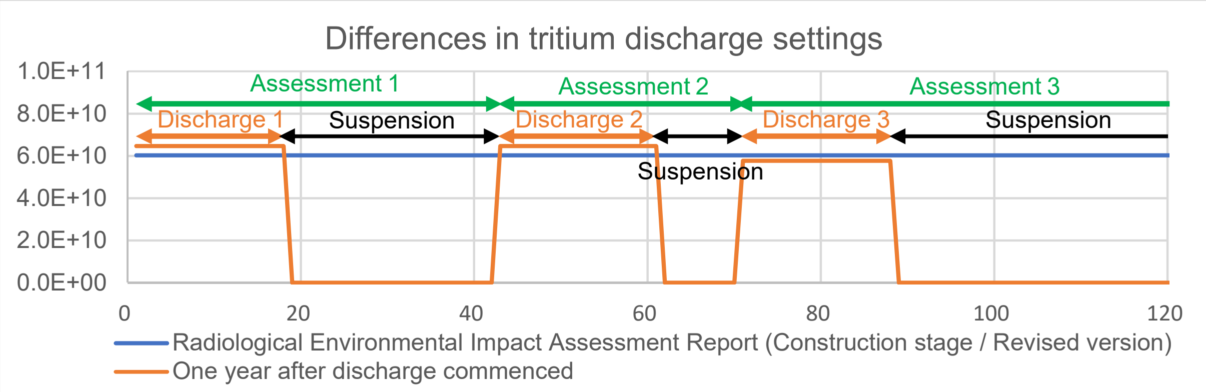


Figure 4-2-3 Differences in the settings of tritium discharge amount input into dispersion simulation

(3) Transfer pathways of radioactive materials and exposure pathways

Since the previous assessment was prepared, there have been no changes to the discharge method of ALPS treated water, and there have been no major changes to the environment surrounding the FDNPS. Therefore, the exposure route is set to be the same as in the previous assessment.

(4) Representative person[3] and reference animals and plants[4]

As there have been no major changes to the environment surrounding the FDNPS, the characteristics of the representative individual (e.g., the assessment location of the concentration of radioactive materials in seawater used in the assessment, the annual exposure time, and the amount of seafood ingestion) were the same as those in the previous assessment. However, as exposure calculations are performed for each discharge, the exposure time and the amount of seafood ingestion were allocated according to the number of days in the annual assessment period for each discharge.

In addition, the reference animals and plants used in the assessment of environmental protection were also the same as those in the previous assessment.

(5) Dose assessment

The method and assessment criteria for radiation exposure calculations are the same as those in the previous assessment. In addition, the results of the radiation exposure

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[3] Representative person: Virtual person set as the target in the exposure assessment. Consider environments, life habits, etc., in which the exposure amounts increase, etc.
[4] Reference animals and plants: Specific types of animals and plantss, with assumed sizes and shapes, for the purpose of assessing radiation exposure from the environment.

calculations were compared with the results of the predicted assessment in the previous assessment.

The differences between the assessment in this report and the previous assessment are shown in Table 4-2-1.

Table 4-2-1 Changes from the assessment method in the previous assessment

Contents	Previous assessment	This report (Assessment for one year after discharge commenced)
Assessment period	One year (using 2019 meteorological data)	Approximately one year (368 days from August 24, 2023 to August 25, 2024) Assessment was conducted for each discharge in separate assessment periods
Discharge method	Even discharge throughout the year	Discharge in 8 times based on records
Source term	- Three types of source terms based on the analysis results of three tank groups - Assessment targets 30 nuclides, including tritium	- Source terms are set for each discharge based on the analysis results - Assessment targets 31 nuclides, including tritium, (Cd-113m has been added)
Transfer pathways	- Human exposure: Seawater, ship hull, beach sand, fishing nets, splashes, seafood - Environmental protection: Seawater, seabed soil	No changes
Dispersion simulation	A regional sea area model was applied to the area off the coast of Fukushima.	No changes
Exposure pathways (external exposure)	- Human exposure: Sea surface, ship hull, seawater, beach sand, fishing nets - Environmental protection: Seawater, seabed soil	No changes
Exposure pathways (internal exposure)	- Human exposure: drinking seawater, inhalation of seawater spray, ingestion of seafood - Environmental protection: ingestion of seawater	No changes
Representative persons Reference animals and plants	- Human exposure: A virtual person who engages in fishing in the waters around the FDNPS and consumes only seafood from the area around the FDNPS - nvironmental protection: Flatfish, crabs, and brown seaweeds	No changes
Assessment method	- Human exposure: Compare with dose constraints and dose limits[5] - Environmental protection: Compare with the Derivation Consideration Reference Level (DCRL) [9]	In addition to the left, the results of the Radiological Environmental Impact Assessment (construction stage / revised version) and comparison with the results of sea area monitoring

[5] While dose limits are limits on the total radiation exposure that an individual receives from multiple actions or radiation sources, dose constraints are used as restrictions on radiation exposure from individual actions or radiation sources. In Japan, the Nuclear Regulation Authority has determined that the dose target value of 0.05 mSv/year for power reactor facilities during normal operation corresponds to the dose constraint, and this report also uses 0.05 mSv/year.

5. Assessment of protection of humans (general public)

5-1. Assessment procedure

Assessment procedures radiation protection for human were conducted in accordance with the procedures described in Fig. 5-1-1 as shown in IAEA Safety Standards Document GSG-10 "Prospective Radiological Environmental Impact Assessment for Facilities and Activities" [10] (hereinafter referred to as "GSG-10"), as well as the previous assessment.

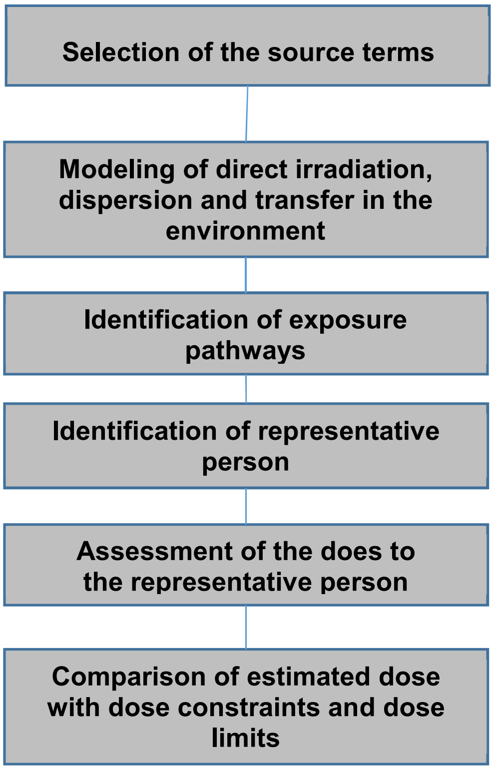

Figure 5-1-1 Exposure assessment procedure (prepared from GSG-10)

5-2. Assessment method

(1) Source term (annual discharge amount of each nuclide)

The source term for each discharge (amounts discharged by nuclide for each of the 31 nuclides) was calculated by multiplying the nuclide composition (concentration of each nuclide) of the ALPS treated water by the amount of discharged water. In addition, when the concentration of each nuclide was undetectable, the amount discharged was calculated by conservatively assuming that it was included at the detection limit. The source terms for each discharge are shown in Tables 5-2-1 to 5-2-8, the total amount discharged for each nuclide for one year after the commencement of discharge is shown in Table 5-2-9, and a comparison with the source terms in the previous assessment is shown in Figure 5-2-1. The amount of tritium discharged was 1.0E+13 Bq, less than half of the upper limit of the annual discharge amount of 2.2E+13 Bq in the previous assessment, but there are some undetectable nuclides whose discharge amount in the assessment has increased due to the difference in the detection limit.

In addition, as shown in 3-2., in this report, Cd-113m, which was added to the nuclides to be measured and asssessed, was added to the nuclides to be assessed, and 31 nuclides were assessed, but it was not detected in the analysis results of the ALPS treated water discharged one year after the commencement of discharge.

When the ALPS treated water is actually discharged, it is diluted by more than 100 times with seawater before being discharged into the sea so that the tritium concentration falls below 1,500 Bq/L, which is the operational target value for the groundwater bypass and sub-drain. Therefore, the sum of the notification concentration ratios[6] of nuclides other than tritium in the discharged water will be less than 0.01.

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[6] When multiple radioactive materials are included, the sum of the ratios of the concentrations of each nuclide to the legal concentration limit set for each nuclide. When multiple radioactive materials are included, the sum of the ratios of the concentrations to the legal concentration limit set for each nuclide must be less than 1. The legal concentration limit is the standard for discharging radioactive discharged into the environment, set for each radioactive nuclide in the "Notice Prescribing Dose Limits, etc. Based on the Provisions of the Rules Concerning the Business of Refining Nuclear Source Materials or Nuclear Fuel Materials." It is set so that the average radiation exposure dose is 1 mSv/year if you drink 2 liters of water equal to the legal concentration limit every day for your lifetime (70 years for adults).

Table 5-2-1 Source term for the first discharge in FY2023 (1st time in total)

No.	Nuclide	FY2023 1st-1				
		Concentration* (Bq/L)		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3		1.4E+05	7.8E+06	1.1E+12	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		1.4E+01		1.1E+08	
3	Mn-54	<	2.6E-02		2.0E+05	
4	Fe-55	<	1.5E+01		1.1E+08	
5	Co-60		3.5E-01		2.7E+06	
6	Ni-63	<	8.8E+00		6.8E+07	
7	Se-79	<	9.3E-01		7.3E+06	
8	Sr-90		4.1E-01		3.2E+06	
9	Y-90		4.1E-01		3.2E+06	
10	Tc-99		6.8E-01		5.3E+06	
11	Ru-106	<	2.5E-01		2.0E+06	
12	Cd-113m	<	8.4E-02		6.6E+05	
13	Sb-125		1.8E-01		1.4E+06	
14	Te-125m		6.4E-02		5.0E+05	
15	I-129		2.0E+00		1.5E+07	
16	Cs-134	<	3.3E-02		2.5E+05	
17	Cs-137		4.7E-01		3.6E+06	
18	Ce-144	<	3.6E-01		2.8E+06	
19	Pm-147	<	3.1E-01		2.4E+06	
20	Sm-151	<	1.2E-02		9.3E+04	
21	Eu-154	<	7.0E-02		5.5E+05	
22	Eu-155	<	1.9E-01		1.5E+06	
23	U-234	<	2.1E-02		1.6E+05	
24	U-238	<	2.1E-02		1.6E+05	
25	Np-237	<	2.1E-02		1.6E+05	
26	Pu-238	<	2.1E-02		1.6E+05	
27	Pu-239	<	2.1E-02		1.6E+05	
28	Pu-240	<	2.1E-02		1.6E+05	
29	Pu-241	<	5.8E-01		4.5E+06	
30	Am-241	<	2.1E-02		1.6E+05	
31	Cm-244	<	2.1E-02		1.6E+05	

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

Table 5-2-2 Source term for the second discharge in FY2023 (2nd time in total)

No.	Nuclide	FY2023 2nd-2				
		Concentration* (Bq/L)		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3		1.4E+05	7.8E+06	1.1E+12	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		1.3E+01		1.0E+08	
3	Mn-54	<	2.3E-02		1.8E+05	
4	Fe-55	<	1.4E+01		1.1E+08	
5	Co-60		2.4E-01		1.9E+06	
6	Ni-63	<	8.9E+00		6.9E+07	
7	Se-79	<	8.7E-01		6.8E+06	
8	Sr-90	<	3.2E-02		2.5E+05	
9	Y-90	<	3.2E-02		2.5E+05	
10	Tc-99	<	1.9E-01		1.5E+06	
11	Ru-106	<	2.1E-01		1.7E+06	
12	Cd-113m	<	8.5E-02		6.7E+05	
13	Sb-125	<	8.8E-02		6.9E+05	
14	Te-125m	<	3.1E-02		2.4E+05	
15	I-129		1.8E+00		1.4E+07	
16	Cs-134	<	3.0E-02		2.3E+05	
17	Cs-137		4.5E-01		3.5E+06	
18	Ce-144	<	3.6E-01		2.8E+06	
19	Pm-147	<	3.2E-01		2.5E+06	
20	Sm-151	<	1.2E-02		9.4E+04	
21	Eu-154	<	7.1E-02		5.5E+05	
22	Eu-155	<	2.4E-01		1.9E+06	
23	U-234	<	3.0E-02		2.3E+05	
24	U-238	<	3.0E-02		2.3E+05	
25	Np-237	<	3.0E-02		2.3E+05	
26	Pu-238	<	3.0E-02		2.3E+05	
27	Pu-239	<	3.0E-02		2.3E+05	
28	Pu-240	<	3.0E-02		2.3E+05	
29	Pu-241	<	8.1E-01		6.4E+06	
30	Am-241	<	3.0E-02		2.3E+05	
31	Cm-244	<	3.0E-02		2.3E+05	

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

Table 5-2-3 Source term for the third discharge in FY2023 (3rd time in total)

No.	Nuclide	FY2023 3rd-3				
		Concentration* (Bq/L)		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3		1.3E+05	7.8E+06	9.8E+11	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		1.4E+01		1.1E+08	
3	Mn-54	<	2.5E-02		1.9E+05	
4	Fe-55	<	1.6E+01		1.3E+08	
5	Co-60		3.3E-01		2.5E+06	
6	Ni-63	<	9.0E+00		7.0E+07	
7	Se-79	<	8.9E-01		6.9E+06	
8	Sr-90		4.1E-02		3.2E+05	
9	Y-90		4.1E-02		3.2E+05	
10	Tc-99	<	2.0E-01		1.5E+06	
11	Ru-106	<	2.3E-01		1.8E+06	
12	Cd-113m	<	9.3E-02		7.2E+05	
13	Sb-125	<	9.4E-02		7.3E+05	
14	Te-125m	<	3.3E-02		2.6E+05	
15	I-129		1.9E+00		1.5E+07	
16	Cs-134	<	2.9E-02		2.3E+05	
17	Cs-137		3.8E-01		2.9E+06	
18	Ce-144	<	4.0E-01		3.1E+06	
19	Pm-147	<	3.4E-01		2.7E+06	
20	Sm-151	<	1.3E-02		1.0E+05	
21	Eu-154	<	7.7E-02		5.9E+05	
22	Eu-155	<	2.6E-01		2.0E+06	
23	U-234	<	2.4E-02		1.8E+05	
24	U-238	<	2.4E-02		1.8E+05	
25	Np-237	<	2.4E-02		1.8E+05	
26	Pu-238	<	2.4E-02		1.8E+05	
27	Pu-239	<	2.4E-02		1.8E+05	
28	Pu-240	<	2.4E-02		1.8E+05	
29	Pu-241	<	6.5E-01		5.0E+06	
30	Am-241	<	2.4E-02		1.8E+05	
31	Cm-244	<	2.4E-02		1.8E+05	

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

Table 5-2-4 Source term for the fourth discharge in FY2023 (4th time in total)

No.	Nuclide	FY2023 4th-4				
		Concentration* (Bq/L)		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3		1.7E+05	7.8E+06	1.3E+12	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		1.4E+01		1.1E+08	
3	Mn-54	<	2.4E-02		1.9E+05	
4	Fe-55	<	1.4E+01		1.1E+08	
5	Co-60		3.4E-01		2.6E+06	
6	Ni-63	<	9.7E+00		7.6E+07	
7	Se-79	<	1.1E+00		8.6E+06	
8	Sr-90		3.1E-01		2.4E+06	
9	Y-90		3.1E-01		2.4E+06	
10	Tc-99		3.4E+00		2.6E+07	
11	Ru-106	<	2.5E-01		1.9E+06	
12	Cd-113m	<	8.8E-02		6.9E+05	
13	Sb-125		1.1E-01		8.6E+05	
14	Te-125m		4.0E-02		3.1E+05	
15	I-129		2.5E+00		1.9E+07	
16	Cs-134	<	3.4E-02		2.6E+05	
17	Cs-137		5.0E-01		3.9E+06	
18	Ce-144	<	3.7E-01		2.9E+06	
19	Pm-147	<	3.3E-01		2.6E+06	
20	Sm-151	<	1.3E-02		1.0E+05	
21	Eu-154	<	7.4E-02		5.8E+05	
22	Eu-155	<	2.0E-01		1.6E+06	
23	U-234	<	2.5E-02		1.9E+05	
24	U-238	<	2.5E-02		1.9E+05	
25	Np-237	<	2.5E-02		1.9E+05	
26	Pu-238	<	2.5E-02		1.9E+05	
27	Pu-239	<	2.5E-02		1.9E+05	
28	Pu-240	<	2.5E-02		1.9E+05	
29	Pu-241	<	7.0E-01		5.5E+06	
30	Am-241	<	2.5E-02		1.9E+05	
31	Cm-244	<	2.5E-02		1.9E+05	

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

Table 5-2-5 Source term for the first discharge in FY2024 (5th time in total)

No.	Nuclide	FY2024 1st-5				
		Concentration* (Bq/L)		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3		1.9E+05	7.9E+06	1.5E+12	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		1.6E+01		1.3E+08	
3	Mn-54	<	2.9E-02		2.3E+05	
4	Fe-55	<	1.5E+01		1.2E+08	
5	Co-60		4.1E-01		3.2E+06	
6	Ni-63	<	9.2E+00		7.2E+07	
7	Se-79	<	1.1E+00		8.6E+06	
8	Sr-90		3.9E-01		3.1E+06	
9	Y-90		3.9E-01		3.1E+06	
10	Tc-99		3.5E+00		2.7E+07	
11	Ru-106	<	2.4E-01		1.9E+06	
12	Cd-113m	<	8.5E-02		6.7E+05	
13	Sb-125		9.7E-02		7.6E+05	
14	Te-125m		3.6E-02		2.8E+05	
15	I-129		2.3E+00		1.8E+07	
16	Cs-134	<	3.2E-02		2.5E+05	
17	Cs-137		3.9E-01		3.1E+06	
18	Ce-144	<	3.8E-01		3.0E+06	
19	Pm-147	<	3.5E-01		2.7E+06	
20	Sm-151	<	1.3E-02		1.0E+05	
21	Eu-154	<	7.8E-02		6.1E+05	
22	Eu-155	<	3.1E-01		2.4E+06	
23	U-234	<	2.2E-02		1.7E+05	
24	U-238	<	2.2E-02		1.7E+05	
25	Np-237	<	2.2E-02		1.7E+05	
26	Pu-238	<	2.2E-02		1.7E+05	
27	Pu-239	<	2.2E-02		1.7E+05	
28	Pu-240	<	2.2E-02		1.7E+05	
29	Pu-241	<	5.9E-01		4.6E+06	
30	Am-241	<	2.2E-02		1.7E+05	
31	Cm-244	<	2.2E-02		1.7E+05	

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

Table 5-2-6 Source term for the second discharge in FY2024 (6th time in total)

No.	Nuclide	FY2024 2nd-6				
		Concentration* (Bq/L)		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3		1.7E+05	7.9E+06	1.3E+12	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		1.3E+01		1.0E+08	
3	Mn-54	<	2.4E-02		1.9E+05	
4	Fe-55	<	1.6E+01		1.3E+08	
5	Co-60		3.0E-01		2.4E+06	
6	Ni-63	<	8.9E+00		7.0E+07	
7	Se-79	<	1.3E+00		1.0E+07	
8	Sr-90		2.8E-01		2.2E+06	
9	Y-90		2.8E-01		2.2E+06	
10	Tc-99		5.5E-01		4.3E+06	
11	Ru-106	<	2.6E-01		2.1E+06	
12	Cd-113m	<	8.6E-02		6.8E+05	
13	Sb-125		1.4E-01		1.1E+06	
14	Te-125m		5.2E-02		4.1E+05	
15	I-129		1.0E+00		7.9E+06	
16	Cs-134	<	3.0E-02		2.4E+05	
17	Cs-137		3.0E-01		2.4E+06	
18	Ce-144	<	5.1E-01		4.0E+06	
19	Pm-147	<	3.3E-01		2.6E+06	
20	Sm-151	<	1.3E-02		1.0E+05	
21	Eu-154	<	7.4E-02		5.8E+05	
22	Eu-155	<	2.1E-01		1.7E+06	
23	U-234	<	2.5E-02		2.0E+05	
24	U-238	<	2.5E-02		2.0E+05	
25	Np-237	<	2.5E-02		2.0E+05	
26	Pu-238	<	2.5E-02		2.0E+05	
27	Pu-239	<	2.5E-02		2.0E+05	
28	Pu-240	<	2.5E-02		2.0E+05	
29	Pu-241	<	7.0E-01		5.5E+06	
30	Am-241	<	2.5E-02		2.0E+05	
31	Cm-244	<	2.5E-02		2.0E+05	

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

Table 5-2-7 Source term for the third discharge in FY2024 (7th time in total)

No.	Nuclide	FY2024 3rd-7				
		Concentration* (Bq/L)		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3		1.7E+05	7.8E+06	1.3E+12	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		9.9E+00		7.8E+07	
3	Mn-54	<	2.6E-02		2.0E+05	
4	Fe-55	<	1.9E+01		1.5E+08	
5	Co-60		5.0E-01		3.9E+06	
6	Ni-63	<	9.1E+00		7.1E+07	
7	Se-79	<	8.8E-01		6.9E+06	
8	Sr-90		1.4E+00		1.1E+07	
9	Y-90		1.4E+00		1.1E+07	
10	Tc-99		8.0E-01		6.3E+06	
11	Ru-106	<	2.5E-01		2.0E+06	
12	Cd-113m	<	8.6E-02		6.7E+05	
13	Sb-125		2.6E-01		2.0E+06	
14	Te-125m		9.6E-02		7.5E+05	
15	I-129		7.8E-01		6.1E+06	
16	Cs-134	<	3.3E-02		2.6E+05	
17	Cs-137		2.9E-01		2.3E+06	
18	Ce-144	<	3.8E-01		3.0E+06	
19	Pm-147	<	3.3E-01		2.6E+06	
20	Sm-151	<	1.3E-02		1.0E+05	
21	Eu-154	<	7.4E-02		5.8E+05	
22	Eu-155	<	2.6E-01		2.0E+06	
23	U-234	<	2.8E-02		2.2E+05	
24	U-238	<	2.8E-02		2.2E+05	
25	Np-237	<	2.8E-02		2.2E+05	
26	Pu-238	<	2.8E-02		2.2E+05	
27	Pu-239	<	2.8E-02		2.2E+05	
28	Pu-240	<	2.8E-02		2.2E+05	
29	Pu-241	<	7.8E-01		6.1E+06	
30	Am-241	<	2.8E-02		2.2E+05	
31	Cm-244	<	2.8E-02		2.2E+05	

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

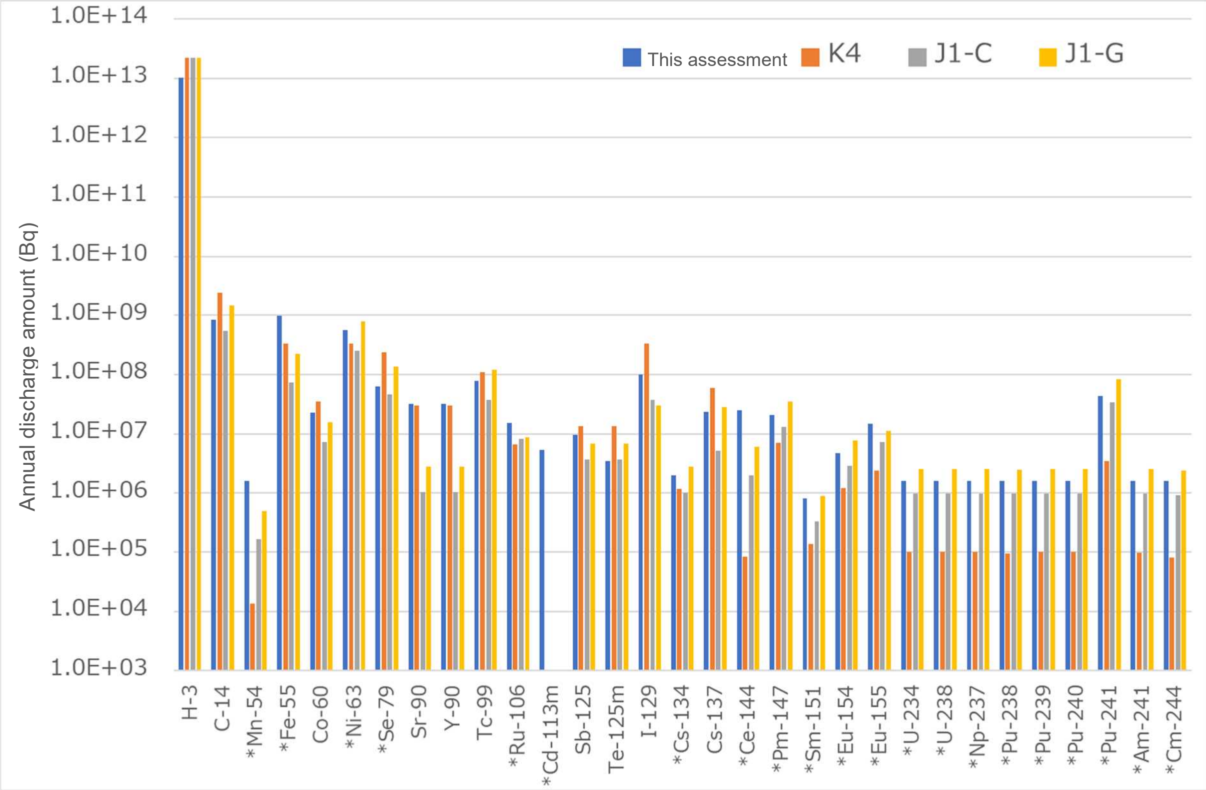
Table 5-2-8 Source term for the fourth discharge in FY2024 (8th time in total)

No.	Nuclide	Concentration* (Bq/L)		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3		2.0E+05	7.9E+06	1.6E+12	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		1.2E+01		9.5E+07	
3	Mn-54	<	2.6E-02		2.1E+05	
4	Fe-55	<	1.6E+01		1.3E+08	
5	Co-60		4.4E-01		3.5E+06	
6	Ni-63	<	8.1E+00		6.4E+07	
7	Se-79	<	9.8E-01		7.7E+06	
8	Sr-90		1.2E+00		9.5E+06	
9	Y-90		1.2E+00		9.5E+06	
10	Tc-99		7.3E-01		5.8E+06	
11	Ru-106	<	2.2E-01		1.7E+06	
12	Cd-113m	<	7.7E-02		6.1E+05	
13	Sb-125		2.3E-01		1.8E+06	
14	Te-125m		8.7E-02		6.9E+05	
15	I-129		2.9E-01		2.3E+06	
16	Cs-134	<	3.4E-02		2.7E+05	
17	Cs-137		2.2E-01		1.7E+06	
18	Ce-144	<	3.8E-01		3.0E+06	
19	Pm-147	<	3.3E-01		2.6E+06	
20	Sm-151	<	1.3E-02		1.0E+05	
21	Eu-154	<	7.4E-02		5.8E+05	
22	Eu-155	<	2.1E-01		1.7E+06	
23	U-234	<	2.9E-02		2.3E+05	
24	U-238	<	2.9E-02		2.3E+05	
25	Np-237	<	2.9E-02		2.3E+05	
26	Pu-238	<	2.9E-02		2.3E+05	
27	Pu-239	<	2.9E-02		2.3E+05	
28	Pu-240	<	2.9E-02		2.3E+05	
29	Pu-241	<	7.9E-01		6.2E+06	
30	Am-241	<	2.9E-02		2.3E+05	
31	Cm-244	<	2.9E-02		2.3E+05	

* A "<" to the left of the concentration indicates that the concentration was not detected, and the number indicates the detection limit.

Table 5-2-9 Source term for the first year after the commencement of discharge (total)

No.	Nuclide	one year after the commencement of discharge		
		Discharged water volume (L)	Discharge amount (Bq/year)	Remarks
1	H-3	6.3E+07	1.0E+13	・In discharging, it was diluted about 740 times by sea water, and then the discharge was carried out.
2	C-14		8.3E+08	
3	Mn-54		1.6E+06	
4	Fe-55		9.8E+08	
5	Co-60		2.3E+07	
6	Ni-63		5.6E+08	
7	Se-79		6.3E+07	
8	Sr-90		3.2E+07	
9	Y-90		3.2E+07	
10	Tc-99		7.9E+07	
11	Ru-106		1.5E+07	
12	Cd-113m		5.4E+06	
13	Sb-125		9.4E+06	
14	Te-125m		3.4E+06	
15	I-129		9.8E+07	
16	Cs-134		2.0E+06	
17	Cs-137		2.3E+07	
18	Ce-144		2.5E+07	
19	Pm-147		2.1E+07	
20	Sm-151		8.0E+05	
21	Eu-154		4.6E+06	
22	Eu-155		1.5E+07	
23	U-234		1.6E+06	
24	U-238		1.6E+06	
25	Np-237		1.6E+06	
26	Pu-238		1.6E+06	
27	Pu-239		1.6E+06	
28	Pu-240		1.6E+06	
29	Pu-241		4.4E+07	
30	Am-241		1.6E+06	
31	Cm-244		1.6E+06	



Note: Nuclide names marked with an * are those that were not detected in any of the eight discharges. The amount discharged was assessed assuming that they were present at the detection limit concentration.

Figure 5-2-1 Comparison of discharge amount by nuclide (total of source term) for the first year after the commencement of discharge and source terms in the previous assessment

(2) Modeling of dispersion and transfer after discharge

① Selection of the transfer model

As the transfer model of radioactive materials discharged into the sea, the transfer model selected in 6-1-2.(2)① of the previous assessment was used as it is.

② Assessment of advection and dispersion in the sea area

For the calculation of dispersion radioactive material in the sea area, the model shown in 6-1-2.(2)② of the previous assessment was used, and calculations were carried out based on meteorological and oceanographic data during the assessment period.

In this report, the tritium concentration in sea water during the assessment period for each discharge set in 4-1. was calculated by this model based on the discharge record of tritium for each discharge, and the concentration in sea water was calculated for the other nuclides by the proportional calculation of the discharge amount with tritium. The tritium concentration in sea water at the end of the assessment period will be taken over to the start of the next assessment period and used for calculation.

(3) Setting of exposure pathways and assessment method

The exposure pathways and assessment methods were the same as the 8 pathways set in the previous assessment 6-1-2.(3). The assessment method of 8 pathways is shown below.

Sea water concentrations, exposure times, and seafood ingestion used for the assessment are shown in (4) Settings of the representative person subject to the exposure assessment.

① External exposure from sea surface

Selected as an exposure pathway because external exposure may occur from radiation from radioactive materials in the seawater during offshore navigation by ship or offshore work.

The assessment methodology is the same as in 6-1-2.(3) of the previous assessment, but the effective dose conversion factor with Cd-113m added is shown in Table 5-2-10.

② External exposure from hulls

Selected as an exposure pathway because external exposure may occur from radiation from radioactive materials that have migrated from the seawater to hulls (deck) during offshore navigation by ship or offshore work.

The assessment methodology is the same as in 6-1-2.(3) of the previous assessment, but the effective dose conversion factor with Cd-113m added is shown in Table 5-2-11.

③ Underwater external exposure during swimming, etc.

Selected as an exposure pathway because external exposure may occur from radiation from radioactive materials in the surrounding seawater during swimming, etc.

The assessment methodology is the same as in 6-1-2.(3) of the previous assessment, but the effective dose conversion factor with Cd-113m added is shown in Table 5-2-12.

④ External exposure from beach sand

Selected as an exposure pathway because external exposure may occur from radiation from radioactive materials that have migrated from seawater to beach sand.

The assessment methodology is the same as in 6-1-2.(3) of the previous assessment, but the effective dose conversion factor with Cd-113m added is shown in Table 5-2-13.

⑤ External exposure from fishing nets

Selected as an exposure pathway because external exposure may occur from radiation from radioactive materials that have migrated from the seawater to fishing nets because fishing nets are used in the seawater for fishing.

The assessment methodology is the same as in 6-1-2.(3) of the previous assessment, but the effective dose conversion factor with Cd-113m added is shown in Table 5-2-14.

⑥ Internal exposure from ingestion of seawater

Selected as an exposure pathway because internal exposure may occur from radiation from radioactive materials in the seawater due to accidental ingestion of seawater.

The assessment methodology is the same as in 6-1-2.(3) of the previous assessment, but the effective dose conversion factor due to oral ingestion with Cd-113m added is shown in Table 5-2-15.

⑦ Internal exposure from inhalation of seawater spray

Selected as an exposure pathway because internal exposure may occur from radiation from radioactive materials in the seawater due to inhalation of seawater spray caused by waves on beaches.

The assessment methodology is the same as in 6-1-2.(3) of the previous assessment, but the effective dose conversion factor for inhalation intake with Cd-113m added is shown in Table 5-2-16.

⑧ Internal exposure from ingestion of seafood

Selected as an exposure pathway because internal exposure may occur from ingestion of seafood that radioactive materials in the seawater have moved to and concentrated.

The assessment methodology is the same as in 6-1-2.(3) of the previous assessment. The concentration factor for fish and shellfish with Cd-113m added is shown in Table 5-2-17. Table 5-2-15 is used as the effective dose conversion factor to be used for the assessment.

Table 5-2-10 Dose conversion factor for the effective dose of radiation from the sea surface
(Decommissioning handbook [11], and others are shown in remarks)

Nuclide	Dose conversion factor for the effective dose ((mSv/h)/(Bq/L))	Remarks
H-3	0.0E+00	Defined 0 due to pure β nuclide.
C-14	0.0E+00	Defined 0 due to pure β nuclide.
Mn-54	1.7E-07	
Fe-55	0.0E+00	
Co-60	5.0E-07	
Ni-63	0.0E+00	Defined 0 due to pure β nuclide.
Se-79	4.8E-12	
Sr-90	1.6E-09	
Y-90	—	Contained in the parent nuclide Sr-90
Tc-99	1.5E-11	
Ru-106	4.5E-08	
Cd-113m	7.4E-11	
Sb-125	8.7E-08	
Te-125m	6.6E-09	
I-129	4.6E-09	
Cs-134	3.1E-07	
Cs-137	1.2E-07	
Ce-144	1.3E-08	
Pm-147	8.2E-12	
Sm-151	1.7E-12	
Eu-154	2.5E-07	
Eu-155	5.0E-07	Conservatively, the same value as that of Co-60 is set because no value is given to this nuclide in the source
U-234	5.9E-11	
U-238	5.2E-09	
Np-237	4.4E-08	
Pu-238	4.7E-11	
Pu-239	2.6E-11	
Pu-240	4.6E-11	
Pu-241	2.9E-08	
Am-241	4.6E-09	
Cm-244	4.5E-11	

Table 5-2-11 Dose conversion factor for the effective dose of radiation from hulls (Decommissioning handbook, and others are shown in remarks)

Nuclide	Dose conversion factor for the effective dose ((mSv/h)/ (Bq/L))	Remarks
H-3	0.0E+00	Defined 0 due to pure β nuclide.
C-14	0.0E+00	Defined 0 due to pure β nuclide.
Mn-54	1.4E-09	
Fe-55	0.0E+00	
Co-60	3.5E-09	
Ni-63	0.0E+00	Defined 0 due to pure β nuclide.
Se-79	1.5E-12	
Sr-90	5.8E-11	
Y-90	—	Contained in the parent nuclide Sr-90
Tc-99	2.8E-12	
Ru-106	4.0E-10	
Cd-113m	7.2E-12	
Sb-125	8.3E-10	
Te-125m	4.4E-10	
I-129	3.0E-10	
Cs-134	2.4E-09	
Cs-137	9.5E-10	
Ce-144	1.6E-10	
Pm-147	1.9E-12	
Sm-151	8.7E-13	
Eu-154	1.8E-09	
Eu-155	3.5E-09	Conservatively, the same value as that of Co-60 is set because no value is given to this nuclide in the source
U-234	9.4E-11	
U-238	2.5E-10	
Np-237	1.4E-09	
Pu-238	1.1E-10	
Pu-239	3.9E-11	
Pu-240	1.0E-10	
Pu-241	7.7E-10	
Am-241	2.0E-10	
Cm-244	1.0E-10	

Table 5-2-12 Dose conversion factor for the effective dose of radiation from seawater during swimming and underwater work (Decommissioning handbook, and others are shown in remarks)

Nuclide	Dose conversion factor for the effective dose ((mSv/h)/ (Bq/L))	Remarks
H-3	0.0E+00	
C-14	0.0E+00	
Mn-54	4.8E-07	
Fe-55	9.7E-10	
Co-60	1.4E-06	
Ni-63	0.0E+00	
Se-79	0.0E+00	
Sr-90	7.2E-13	
Y-90	—	Contained in the parent nuclide Sr-90
Tc-99	4.0E-13	
Ru-106	1.2E-07	
Cd-113m	4.2E-11	
Sb-125	2.5E-07	
Te-125m	2.0E-08	
I-129	1.4E-08	
Cs-134	9.0E-07	
Cs-137	3.4E-07	
Ce-144	2.8E-08	
Pm-147	2.5E-12	
Sm-151	8.3E-12	
Eu-154	6.4E-07	
Eu-155	1.4E-06	Conservatively, the same value as that of Co-60 is set because no value is given to this nuclide in the source
U-234	1.0E-09	
U-238	1.6E-08	
Np-237	1.5E-07	
Pu-238	1.1E-09	
Pu-239	5.2E-10	
Pu-240	9.9E-10	
Pu-241	8.1E-08	
Am-241	1.9E-08	
Cm-244	9.0E-10	

Table 5-2-13 Dose conversion factor for the effective dose of radiation from beach sand (Decommissioning handbook, and others are shown in remarks)

Nuclide	Dose conversion factor for the effective dose ((mSv/h)/ (Bq/L))	Remarks
H-3	0.0E+00	Defined 0 due to pure β nuclide.
C-14	0.0E+00	Defined 0 due to pure β nuclide.
Mn-54	1.6E-07	
Fe-55	0.0E+00	
Co-60	4.7E-07	
Ni-63	0.0E+00	Defined 0 due to pure β nuclide.
Se-79	1.8E-12	
Sr-90	1.2E-09	
Y-90	—	Contained in the parent nuclide Sr-90
Tc-99	6.3E-12	
Ru-106	4.3E-08	
Cd-113m	4.1E-11	
Sb-125	8.3E-08	
Te-125m	1.9E-09	
I-129	1.3E-09	
Cs-134	3.1E-07	
Cs-137	1.2E-07	
Ce-144	1.0E-08	
Pm-147	3.5E-12	
Sm-151	6.3E-13	
Eu-154	2.3E-07	
Eu-155	4.7E-07	Conservatively, the same value as that of Co-60 is set because no value is given to this nuclide in the source
U-234	4.1E-11	
U-238	3.9E-09	
Np-237	3.7E-08	
Pu-238	3.6E-11	
Pu-239	2.1E-11	
Pu-240	3.5E-11	
Pu-241	2.0E-08	
Am-241	1.7E-09	
Cm-244	3.6E-11	

Table 5-2-14 Dose conversion factor for the effective dose of radiation from fishing nets
(Decommissioning handbook, and others are shown in remarks)

Nuclide	Dose conversion factor for the effective dose ((mSv/h)/ (Bq/L))	Remarks
H-3	0.0E+00	Defined 0 due to pure β nuclide.
C-14	0.0E+00	Defined 0 due to pure β nuclide.
Mn-54	3.2E-08	
Fe-55	0.0E+00	
Co-60	9.9E-08	
Ni-63	0.0E+00	Defined 0 due to pure β nuclide.
Se-79	2.0E-13	
Sr-90	2.1E-10	
Y-90	—	Contained in the parent nuclide Sr-90
Tc-99	7.9E-13	
Ru-106	8.2E-09	
Cd-113m	5.9E-12	
Sb-125	1.5E-08	
Te-125m	2.3E-10	
I-129	1.6E-10	
Cs-134	5.9E-08	
Cs-137	2.2E-08	
Ce-144	2.0E-09	
Pm-147	4.2E-13	
Sm-151	5.8E-14	
Eu-154	4.7E-08	
Eu-155	9.9E-08	Conservatively, the same value as that of Co-60 is set because no value is given to this nuclide in the source
U-234	2.9E-12	
U-238	7.1E-10	
Np-237	6.2E-09	
Pu-238	1.7E-12	
Pu-239	1.9E-12	
Pu-240	1.8E-12	
Pu-241	3.1E-09	
Am-241	2.1E-10	
Cm-244	2.1E-12	

Table 5-2-15 Effective dose factor of ingestion (GSR Part 3 [12])

Target Nuclide	Effective dose factor (mSv/Bq)			Remarks
	Adult	Child under school age	Infant	
H-3 (THO)	1.8E-08	3.1E-08	6.4E-08	Used for the assessment of ingestion of water
H-3 (considering OBT)	2.0E-08	3.5E-08	7.0E-08	Used for the assessment of ingestion of seafood assuming that 10% of tritium to be ingested is OBT
C-14	5.8E-07	9.9E-07	1.4E-06	
Mn-54	7.1E-07	1.9E-06	5.4E-06	
Fe-55	3.3E-07	1.7E-06	7.6E-06	
Co-60	3.4E-06	1.7E-05	5.4E-05	
Ni-63	1.5E-07	4.6E-07	1.6E-06	
Se-79	2.9E-06	1.9E-05	4.1E-05	
Sr-90	2.8E-05	4.7E-05	2.3E-04	
Y-90	2.7E-06	1.0E-05	3.1E-05	
Tc-99	6.4E-07	2.3E-06	1.0E-05	
Ru-106	7.0E-06	2.5E-05	8.4E-05	
Cd-113m	2.3E-05	3.9E-05	1.2E-04	
Sb-125	1.1E-06	3.4E-06	1.1E-05	
Te-125m	8.7E-07	3.3E-06	1.3E-05	
I-129	1.1E-04	1.7E-04	1.8E-04	
Cs-134	1.9E-05	1.3E-05	2.6E-05	
Cs-137	1.3E-05	9.6E-06	2.1E-05	
Ce-144	5.2E-06	1.9E-05	6.6E-05	
Pm-147	2.6E-07	9.6E-07	3.6E-06	
Sm-151	9.8E-08	3.3E-07	1.5E-06	
Eu-154	2.0E-06	6.5E-06	2.5E-05	
Eu-155	3.2E-07	1.1E-06	4.3E-06	
U-234	4.9E-05	8.8E-05	3.7E-04	
U-238	4.5E-05	8.0E-05	3.4E-04	
Np-237	1.1E-04	1.4E-04	2.0E-03	
Pu-238	2.3E-04	3.1E-04	4.0E-03	
Pu-239	2.5E-04	3.3E-04	4.2E-03	
Pu-240	2.5E-04	3.3E-04	4.2E-03	
Pu-241	4.8E-06	5.5E-06	5.6E-05	
Am-241	2.0E-04	2.7E-04	3.7E-03	
Cm-244	1.2E-04	1.9E-04	2.9E-03	

Table 5-2-16 Effective dose factor of inhalation (GSR Part 3)

Target Nuclide	Effective dose coefficient (mSv/Bq)			Remarks
	Adult	Child under school age	Infant	
H-3	1.8E-08	3.1E-08	6.4E-08	The conversion factor of tritium vapor is used
C-14	5.8E-06	1.1E-05	1.9E-05	
Mn-54	1.5E-06	3.8E-06	7.5E-06	
Fe-55	7.7E-07	2.2E-06	4.2E-06	
Co-60	3.1E-05	5.9E-05	9.2E-05	
Ni-63	1.3E-06	2.7E-06	4.8E-06	
Se-79	6.8E-06	1.3E-05	2.3E-05	
Sr-90	1.6E-04	2.7E-04	4.2E-04	
Y-90	1.5E-06	4.2E-06	1.3E-05	
Tc-99	1.3E-05	2.4E-05	4.1E-05	
Ru-106	6.6E-05	1.4E-04	2.6E-04	
Cd-113m	1.1E-04	1.8E-04	3.0E-04	
Sb-125	1.2E-05	2.4E-05	4.2E-05	
Te-125m	4.2E-06	7.8E-06	1.7E-05	
I-129	3.6E-05	6.1E-05	7.2E-05	
Cs-134	2.0E-05	4.1E-05	7.0E-05	
Cs-137	3.9E-05	7.0E-05	1.1E-04	
Ce-144	5.3E-05	1.4E-04	3.6E-04	
Pm-147	5.0E-06	1.1E-05	2.1E-05	
Sm-151	4.0E-06	6.7E-06	1.1E-05	
Eu-154	5.3E-05	9.7E-05	1.6E-04	
Eu-155	6.9E-06	1.4E-05	2.6E-05	
U-234	9.4E-03	1.9E-02	3.3E-02	
U-238	8.0E-03	1.6E-02	2.9E-02	
Np-237	5.0E-02	6.0E-02	9.8E-02	
Pu-238	1.1E-01	1.4E-01	2.0E-01	
Pu-239	1.2E-01	1.5E-01	2.1E-01	
Pu-240	1.2E-01	1.5E-01	2.1E-01	
Pu-241	2.3E-03	2.6E-03	2.8E-03	
Am-241	9.6E-02	1.2E-01	1.8E-01	
Cm-244	5.7E-02	8.3E-02	1.5E-01	

Table 5-2-17 Concentration factor for seafood (TRS-422 [13])

Target Nuclide	Concentration factor (Bq/kg)/(Bq/L)			Remarks
	Fish	Invertebrates	Seaweeds	
H-3	1.0E+00	1.0E+00	1.0E+00	
C-14	2.0E+04	2.0E+04	1.0E+04	
Mn-54	1.0E+03	5.0E+04	6.0E+03	
Fe-55	3.0E+04	5.0E+05	2.0E+04	
Co-60	7.0E+02	2.0E+04	6.0E+03	
Ni-63	1.0E+03	2.0E+03	2.0E+03	
Se-79	1.0E+04	1.0E+04	1.0E+03	
Sr-90	3.0E+00	1.0E+01	1.0E+01	
Y-90	—	—	—	Equilibrium state with the parent nuclide Sr-90
Tc-99	8.0E+01	1.0E+03	3.0E+04	
Ru-106	2.0E+00	5.0E+02	2.0E+03	
Cd-113m	5.0E+03	8.0E+04	2.0E+04	
Sb-125	6.0E+02	3.0E+02	2.0E+01	
Te-125m	—	—	—	Equilibrium state with the parent nuclide Sb-125
I-129	9.0E+00	1.0E+01	1.0E+04	
Cs-134	1.0E+02	6.0E+01	5.0E+01	
Cs-137	1.0E+02	6.0E+01	5.0E+01	
Ce-144	5.0E+01	2.0E+03	5.0E+03	
Pm-147	3.0E+02	7.0E+03	3.0E+03	
Sm-151	3.0E+02	7.0E+03	3.0E+03	
Eu-154	3.0E+02	7.0E+03	3.0E+03	
Eu-155	3.0E+02	7.0E+03	3.0E+03	
U-234	1.0E+00	3.0E+01	1.0E+02	
U-238	1.0E+00	3.0E+01	1.0E+02	
Np-237	1.0E+00	4.0E+02	5.0E+01	
Pu-238	1.0E+02	3.0E+03	4.0E+03	
Pu-239	1.0E+02	3.0E+03	4.0E+03	
Pu-240	1.0E+02	3.0E+03	4.0E+03	
Pu-241	1.0E+02	3.0E+03	4.0E+03	
Am-241	1.0E+02	1.0E+03	8.0E+03	
Cm-244	1.0E+02	1.0E+03	5.0E+03	

※For invertebrates, the value of mollusks (excluding cephalopods) was used.

(4) Setting of the representative person subject to the exposure assessment

① Situation around the FDNPS

In the area surrounding the FDNPS, a "Specified Reconstruction and Revitalization Base Area" has been established in which evacuation orders are lifted and residence is made possible in a part of the difficult-to-return area established by the accident, and the return of the general public has begun. However, the situation surrounding the FDNPS has not changed significantly, such as an intermediate storage facilities that are installed surrounding the land side of the FDNPS.

Under these circumstances, the assessment was conducted under the same conditions as in the previous assessment.

② Characteristics of the representative person

As shown in ①, the characteristics of the representative person subject to exposure assessment was as follows, as the same shown in the previous assessment 6-1-2.(4). For each discharge, the exposure time and seafood ingestion were set according to the ratio of the assessment period to the annual period.

・Engage in fishing 120 days (2,880 hours) a year, of which 80 days (1,920 hours) are spent near fishing nets.
・Stay at the beach 500 hours a year and swim for 96 hours.

"External exposure," groups by ages were not set for the external exposure assessment, but were set in three groups by ages (adult, child under school age, infant) for internal exposure to assess.

The time spent at the beach and swimming time used to assess internal exposure from ingestion of water and inhalation intake were set to be the same as those for adults.

The ingestion of seafood was assessed as two types, the average ingestion and the high ingestion of seafood, as shown in Tables 5-2-18 and 5-2-19. The ingestion of seafood for each assessment period was set according to the number of days in the assessment period.

The assessment points related to exposure and the seawater concentration used for the assessment are as follows.

i. External exposure from sea surface and external exposure from hulls

The same as the previous assessment, the area of 10km×10km surrounding the FDNPS shown in Figure 5-2-3 is used as the assessment point, and the seawater concentration used for the assessment is the annual average concentration of seawater (sea surface) within 10km×10km around the FDNPS for each assessment period.

ii. External exposure from seawater during swimming, etc., external exposure from beach sand, internal exposure from ingestion water, and internal exposure from inhalation of seawater spray

The same as the previous assessment, the nearby beach to the north of the FDNPS shown in Figure 5-2-2 is used as the assessment point, and the seawater concentration used for the assessment is the annual average concentration in the seawater (all layers) in front of the beach for each assessment period.

iii. External exposure from fishing nets and internal exposure from ingestion of seafood

The same as the previous assessment, the seawater concentration used for the assessment is the average concentration of seawater (all layers) within 10km×10km area surrounding the FDNPS for each assessment period.

Tables 5-2-18 Ingestion of persons who ingest the average amount of seafood (g/day) (Set based on the National Health and Nutrition Survey in Japan in 2019 (Ministry of Health, Labour and Welfare) [14])

	Fish	Invertebrate	Seaweed
Adult	58	10	11
Child under school age	29	5.1	5.3
Infant	12	2.0	2.1

Table 5-2-19 Ingestion of persons who consume a large amount of seafood (g/day) (Set based on the National Health and Nutrition Survey in Japan in 2019 (Ministry of Health, Labour and Welfare) [14])

	Fish	Invertebrate	Seaweed
Adult	190	62	52
Child under school age	97	31	26
Infant	39	12	10

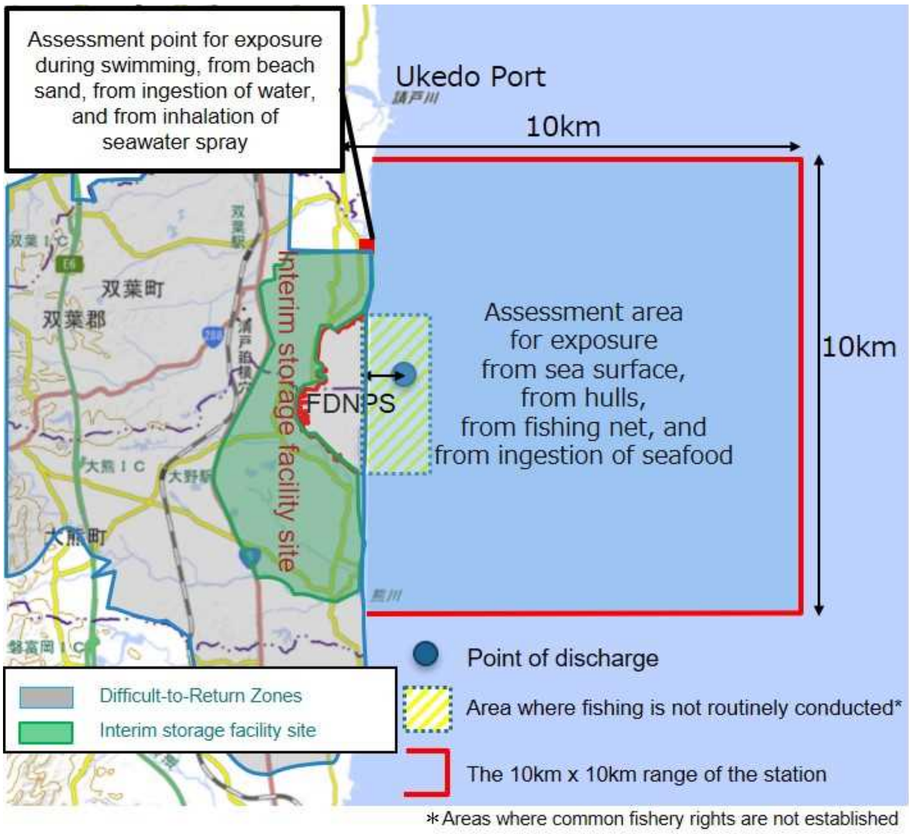


Figure 5-2-2 Point to determine concentrations in seawater used for the assessment of exposures in normal conditions

Source: Geographical Survey Institute (Electronic Map Web) and support for victims of the nuclear accident of the Ministry of Economy, Trade and Industry (Regarding evacuation orders) Prepared by Tokyo Electric Power Company Holdings, Inc. based on the map of the area surrounding Difficult-to-Return Zones (from R2.12.10)
https://maps.gsi.go.jp/#13/37.422730/141.044970/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f1

(5) Dose assessment method

Exposure is calculated by the assessment method set in 5-2. (3).

The calculation results are compared with the dose limit of 1mSv/ year for the general public, and the dose constraint of 0.05mSv/ year (dose targets for domestic nuclear power plants) and with the assessment results in the previous assessment.

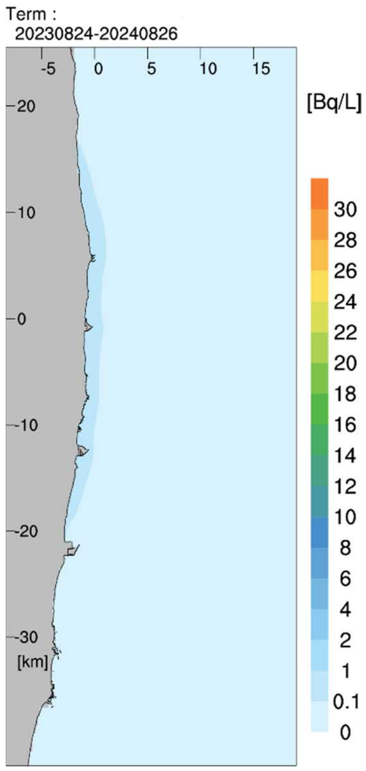
5-3. Assessment result

(1) Dispersion simulation result

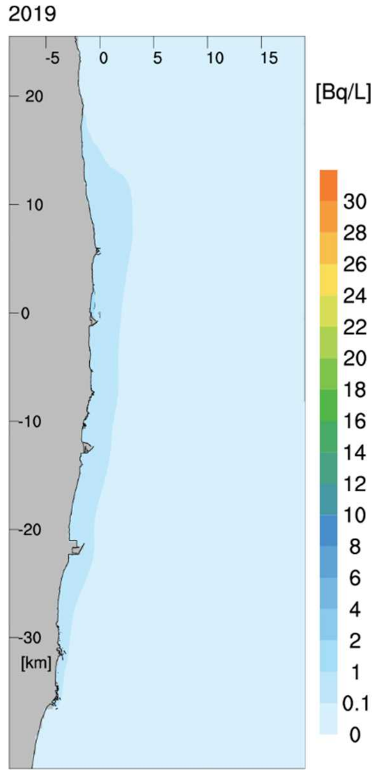
The Tritium was discharged from the seabed about 1km the off the coast of the FDNPS at the discharge rate and discharge period based on the discharged result, and the tritium concentration in the seawater after advection and dispersion was calculated based on actual meteorological and oceanographic data.

Figures 5-3-1, 5-3-2 summarize the calculation results as annual average concentration distribution charts, along with the previous assessment. Figures 5-3-1 shows the average anal concentration of the sea surface in the wide area and 5-3-2 shows the average annual concentration of the sea surface in the vicinity of the FDNPS. In the previous assessment, the concentration range exceeding 1Bq/L was confirmed in the range of about 2 to 3km around the FDNPS. However, that was not confirmed in the calculation result for one year after the discharge commenced, and the concentration range exceeding 0.1Bq/L was also narrower than the calculation result in the previous assessment.

In addition, Figure 5-3-3 shows the comparison of the range in which the annual average concentration exceeds 0.1Bq/L, and Table 5-3-1 shows the comparison of the average concentration within the 10 km × 10 km range around the FDNPS, for the calculation results of dispersion simulations for 2014 to 2020 calculated in the previous assessment and the calculation results for one year after the commencement of discharge. The range over which the annual average concentration for one year after discharge commenced exceeds 0.1Bq/L is narrower than the calculated results over the past seven years. The annual average concentration of 10km×10km range was also about 40% of the concentration in 2014-2020 for the one year after discharge commenced. This is thought to be due to the fact that the amount of tritium discharged for the one year after the discharge commenced was about 1.0E+13 Bq, which is less compared with the upper limit 2.2E+13 Bq of the amount of tritium discharged for the one year used in the previous assessment.

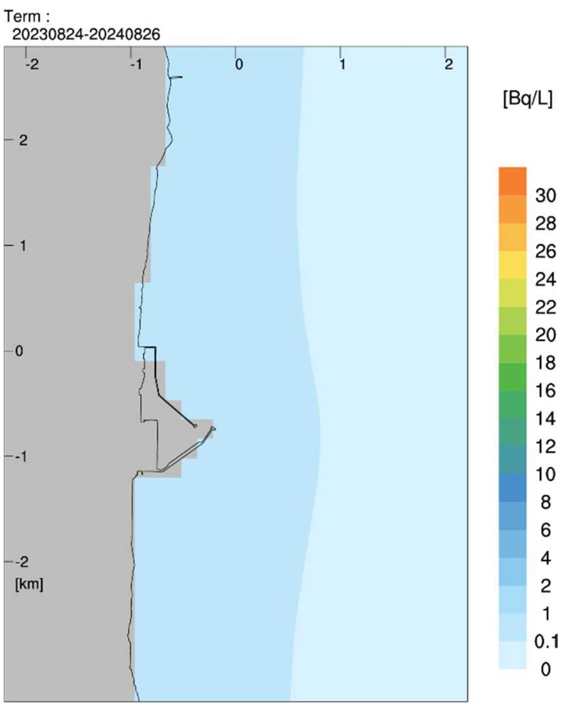


1 year after discharge (discharge of about 1.0E+13 Bq in 8 divided doses)

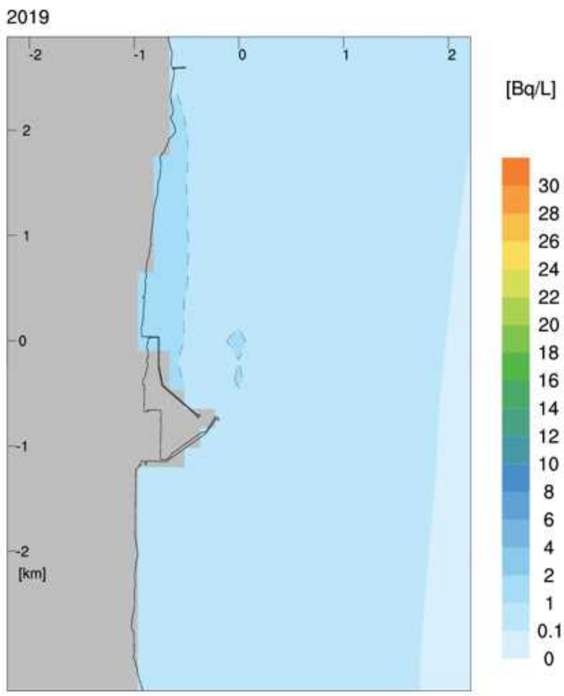


Previous assessment (Discharge tritium 2.2E+13 Bq constantly throughout the year)

Figure 5-3-1 Distribution of tritium annual average concentration on the sea surface



1 year after discharge (discharge of about 1.0E+13 Bq in 8 divided doses)



Previous assessment (Discharge tritium 2.2E+13 Bq constantly throughout the year)

Figure 5-3-2 Distribution of annual average concentration on the sea surface (enlarged figure of neighborhood)

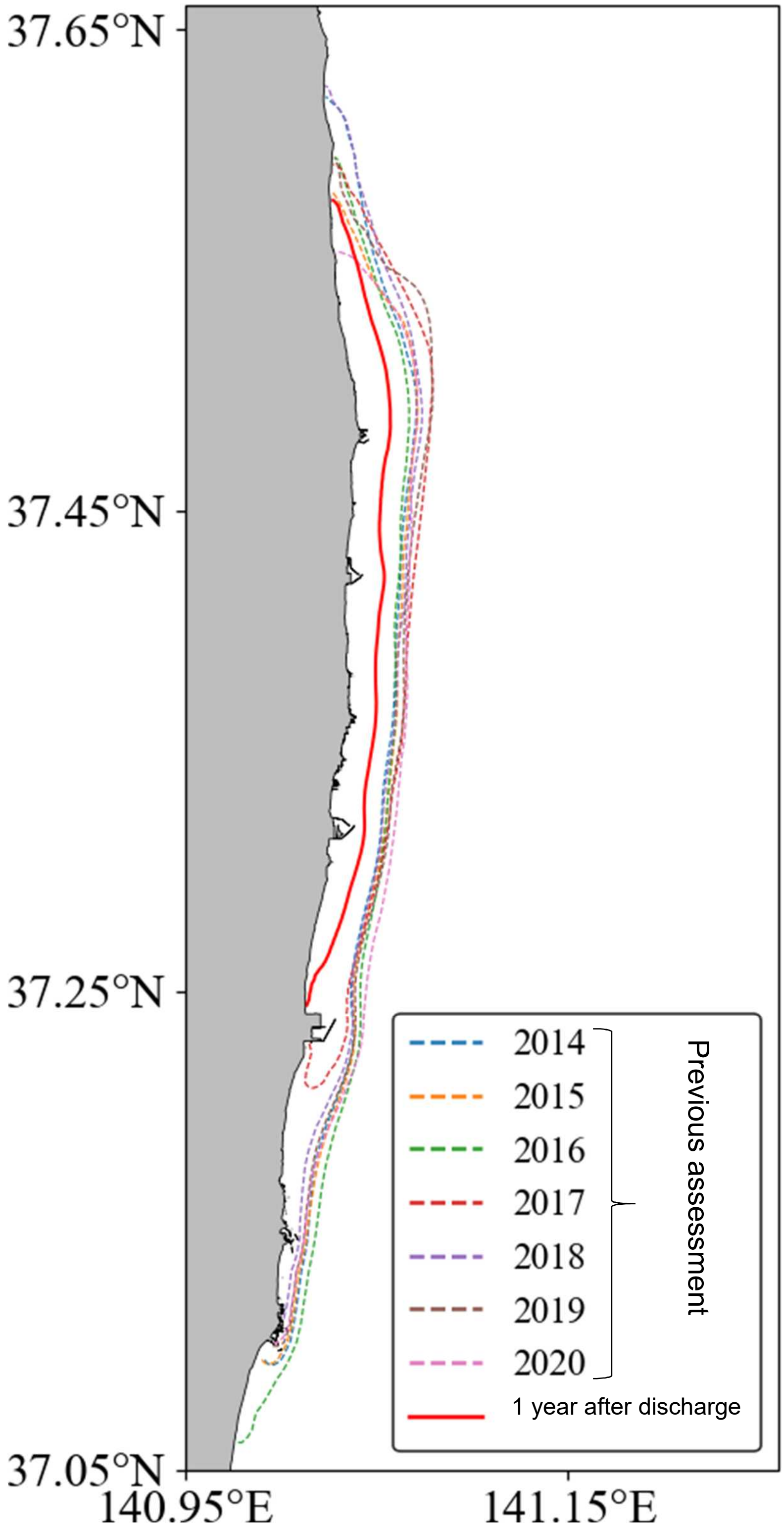


Figure 5-3-3 Comparison with the previous assessment (2014-2020) of the range of increases exceeding 0.1 Bq/L in annual average concentrations based on dispersion simulations

Table 5-3-1 Comparison of tritium concentrations in seawater within the range of 10 km × 10 km around the FDNPS and the previous assessment (2014-2020)

Assessment period		Annual average concentration within the range of 10km×10km around the FDNPS (Bq/L)		
		All layers	Top layer	Bottom layer
Previous assessment	2014	4.8E-02	1.0E-01	5.0E-02
	2015	4.9E-02	9.6E-02	5.3E-02
	2016	4.9E-02	9.6E-02	5.3E-02
	2017	5.8E-02	1.2E-01	6.3E-02
	2018	5.0E-02	1.1E-01	5.4E-02
	2019	5.6E-02	1.2E-01	6.0E-02
	2020	5.4E-02	1.1E-01	6.0E-02
	Average	5.2E-02	1.1E-01	5.6E-02
	Standard deviation	3.8E-03	9.3E-03	4.4E-03
One year after discharge commenced		2.2E-02	4.2E-02	2.4E-02

(2) Concentration used for the assessment in the seawater

Table 5-3-2 shows the tritium concentrations in the seawater (average concentrations during the assessment period) in 10km×10km area around the FDNPS and at the beach assessment point to the north of the FDNPS for assessmentperiod. Periodic concentrations were generally below those of the previous assessment, but were above only at the beach point in FY2024 4th-8 session. This is due to the high amount of tritium discharge in FY2024 4th-8 session and the fact that all assessments were conducted during discharge. However, the tritium concentration levels assessed were low.

Based on these results, the seawater concentrations of each nuclide were calculated from the ratio of tritium to other nuclides discharged during the source terms for each assessment period shown in Tables 5-2-1 to 5-2-8. The seawater concentrations used for the assessment of each nuclide for each assessment period are shown in Tables 5-3-3 to 5-3-10.

Table 5-3-2 Average tritium concentration in the seawater by assessment period

Assessment period	Average concentration within the range of 10km×10km around the FDNPS during the period (Bq/L) over time		Average concentration at the beach assessment point during the period (Bq/L)
	All layers	Surface layer	
FY2023 1st-1 (2023/08/24-2023/10/04)	1.4E-02	2.7E-02	3.7E-01
FY2023 2nd-2 (2023/10/05-2023/11/01)	4.8E-02	9.8E-02	5.6E-01
FY2023 3rd-3 (2023/11/02-2024/02/27)	1.5E-02	2.5E-02	1.2E-01
FY2023 4th-4 (2024/02/28-2024/04/18)	1.7E-02	3.2E-02	2.2E-01
FY2024 1st-5 (2024/04/19-2024/05/16)	3.4E-02	7.1E-02	6.4E-01
FY2024 2nd-6 (2024/05/17-2024/06/27)	1.9E-02	3.2E-02	3.8E-01
FY2024 3rd-7 (2024/06/28-2024/08/06)	2.0E-02	6.1E-02	2.1E-01
FY2024 4th-8 (2024/08/07-2024/08/25)	4.5E-02	6.8E-02	1.4E+00
Previous assessment (2019/01/01-2019/12/31)	5.6E-02	1.2E-01	8.8E-01

Table 5-3-3 Concentration in the seawater used for the assessment (FY2023 1st-1) (2023/08/24-2023/10/04)

Target nuclide	Discharge amount during the period (Bq)	Concentration in the seawater used for the assessment (Bq/L)		
		Within 10km×10km average of all layers	Within 10km×10km average of the top layer	Beach assessment point average of all layers
H-3	1.1E+12	1.4E-02	2.7E-02	3.7E-01
C-14	1.1E+08	1.4E-06	2.8E-06	3.7E-05
Mn-54	2.0E+05	2.6E-09	5.0E-09	6.8E-08
Fe-55	1.1E+08	1.5E-06	2.8E-06	3.9E-05
Co-60	2.7E+06	3.5E-08	6.7E-08	9.1E-07
Ni-63	6.8E+07	8.8E-07	1.7E-06	2.3E-05
Se-79	7.3E+06	9.4E-08	1.8E-07	2.5E-06
Sr-90	3.2E+06	4.1E-08	7.8E-08	1.1E-06
Y-90	3.2E+06	4.1E-08	7.8E-08	1.1E-06
Tc-99	5.3E+06	6.9E-08	1.3E-07	1.8E-06
Cd-113m	2.0E+06	2.5E-08	4.8E-08	6.6E-07
Ru-106	6.6E+05	8.5E-09	1.6E-08	2.2E-07
Sb-125	1.4E+06	1.8E-08	3.5E-08	4.8E-07
Te-125m	5.0E+05	6.4E-09	1.2E-08	1.7E-07
I-129	1.5E+07	2.0E-07	3.8E-07	5.2E-06
Cs-134	2.5E+05	3.3E-09	6.3E-09	8.6E-08
Cs-137	3.6E+06	4.7E-08	9.0E-08	1.2E-06
Ce-144	2.8E+06	3.6E-08	7.0E-08	9.5E-07
Pm-147	2.4E+06	3.1E-08	6.0E-08	8.2E-07
Sm-151	9.3E+04	1.2E-09	2.3E-09	3.1E-08
Eu-154	5.5E+05	7.1E-09	1.3E-08	1.8E-07
Eu-155	1.5E+06	1.9E-08	3.7E-08	5.0E-07
U-234	1.6E+05	2.1E-09	4.1E-09	5.5E-08
U-238	1.6E+05	2.1E-09	4.1E-09	5.5E-08
Np-237	1.6E+05	2.1E-09	4.1E-09	5.5E-08
Pu-238	1.6E+05	2.1E-09	4.1E-09	5.5E-08
Pu-239	1.6E+05	2.1E-09	4.1E-09	5.5E-08
Pu-240	1.6E+05	2.1E-09	4.1E-09	5.5E-08
Pu-241	4.5E+06	5.8E-08	1.1E-07	1.5E-06
Am-241	1.6E+05	2.1E-09	4.1E-09	5.5E-08
Cm-244	1.6E+05	2.1E-09	4.1E-09	5.5E-08
Target exposure assessment		From fishing nets ingestion of seafood	From sea surface from hulls	During swimming from the beach sand Ingestion of seawater inhalation of seawater spray

Table 5-3-4 Concentration in the seawater used for the assessment (FY2023 2nd-2) (2023/10/05-2023/11/01)

Target nuclide	Discharge amount during the period (Bq)	Concentration in the seawater used for the assessment (Bq/L)		
		Within 10km×10km average of all layers	Within 10km×10km average of the top layer	Beach assessment point average of all layers
H-3	1.1E+12	4.8E-02	9.8E-02	5.6E-01
C-14	1.0E+08	4.5E-06	9.3E-06	5.3E-05
Mn-54	1.8E+05	7.8E-09	1.6E-08	9.2E-08
Fe-55	1.1E+08	4.7E-06	9.7E-06	5.5E-05
Co-60	1.9E+06	8.3E-08	1.7E-07	9.8E-07
Ni-63	6.9E+07	3.0E-06	6.3E-06	3.6E-05
Se-79	6.8E+06	3.0E-07	6.1E-07	3.5E-06
Sr-90	2.5E+05	1.1E-08	2.3E-08	1.3E-07
Y-90	2.5E+05	1.1E-08	2.3E-08	1.3E-07
Tc-99	1.5E+06	6.4E-08	1.3E-07	7.5E-07
Cd-113m	1.7E+06	7.3E-08	1.5E-07	8.6E-07
Ru-106	6.7E+05	2.9E-08	6.0E-08	3.4E-07
Sb-125	6.9E+05	3.0E-08	6.2E-08	3.5E-07
Te-125m	2.4E+05	1.1E-08	2.2E-08	1.2E-07
I-129	1.4E+07	6.3E-07	1.3E-06	7.4E-06
Cs-134	2.3E+05	1.0E-08	2.1E-08	1.2E-07
Cs-137	3.5E+06	1.5E-07	3.2E-07	1.8E-06
Ce-144	2.8E+06	1.2E-07	2.5E-07	1.4E-06
Pm-147	2.5E+06	1.1E-07	2.2E-07	1.3E-06
Sm-151	9.4E+04	4.1E-09	8.5E-09	4.8E-08
Eu-154	5.5E+05	2.4E-08	5.0E-08	2.8E-07
Eu-155	1.9E+06	8.3E-08	1.7E-07	9.7E-07
U-234	2.3E+05	1.0E-08	2.1E-08	1.2E-07
U-238	2.3E+05	1.0E-08	2.1E-08	1.2E-07
Np-237	2.3E+05	1.0E-08	2.1E-08	1.2E-07
Pu-238	2.3E+05	1.0E-08	2.1E-08	1.2E-07
Pu-239	2.3E+05	1.0E-08	2.1E-08	1.2E-07
Pu-240	2.3E+05	1.0E-08	2.1E-08	1.2E-07
Pu-241	6.4E+06	2.8E-07	5.7E-07	3.3E-06
Am-241	2.3E+05	1.0E-08	2.1E-08	1.2E-07
Cm-244	2.3E+05	1.0E-08	2.1E-08	1.2E-07
Target exposure assessment		From fishing nets ingestion of seafood	From sea surface from hulls	During swimming from the beach sand ingestion of seawater inhalation of seawater spray

Table 5-3-5 Concentration in the seawater used for the assessment (FY2023 3rd-3) (2023/11/02-2024/02/27)

Target nuclide	Discharge amount during the period (Bq)	Concentration in the seawater used for the assessment (Bq/L)		
		Within 10km×10km average of all layers	Within 10km×10km average of the top layer	Beach assessment point average of all layers
H-3	9.8E+11	1.5E-02	2.5E-02	1.2E-01
C-14	1.1E+08	1.6E-06	2.7E-06	1.3E-05
Mn-54	1.9E+05	3.0E-09	5.0E-09	2.4E-08
Fe-55	1.3E+08	1.9E-06	3.2E-06	1.5E-05
Co-60	2.5E+06	3.9E-08	6.5E-08	3.1E-07
Ni-63	7.0E+07	1.1E-06	1.8E-06	8.6E-06
Se-79	6.9E+06	1.1E-07	1.8E-07	8.6E-07
Sr-90	3.2E+05	4.9E-09	8.2E-09	3.9E-08
Y-90	3.2E+05	4.9E-09	8.2E-09	3.9E-08
Tc-99	1.5E+06	2.3E-08	4.0E-08	1.9E-07
Cd-113m	1.8E+06	2.7E-08	4.6E-08	2.2E-07
Ru-106	7.2E+05	1.1E-08	1.9E-08	8.9E-08
Sb-125	7.3E+05	1.1E-08	1.9E-08	9.0E-08
Te-125m	2.6E+05	3.9E-09	6.6E-09	3.2E-08
I-129	1.5E+07	2.2E-07	3.8E-07	1.8E-06
Cs-134	2.3E+05	3.5E-09	5.9E-09	2.8E-08
Cs-137	2.9E+06	4.5E-08	7.5E-08	3.6E-07
Ce-144	3.1E+06	4.8E-08	8.0E-08	3.8E-07
Pm-147	2.7E+06	4.1E-08	6.8E-08	3.3E-07
Sm-151	1.0E+05	1.6E-09	2.6E-09	1.3E-08
Eu-154	5.9E+05	9.1E-09	1.5E-08	7.3E-08
Eu-155	2.0E+06	3.1E-08	5.3E-08	2.5E-07
U-234	1.8E+05	2.8E-09	4.7E-09	2.3E-08
U-238	1.8E+05	2.8E-09	4.7E-09	2.3E-08
Np-237	1.8E+05	2.8E-09	4.7E-09	2.3E-08
Pu-238	1.8E+05	2.8E-09	4.7E-09	2.3E-08
Pu-239	1.8E+05	2.8E-09	4.7E-09	2.3E-08
Pu-240	1.8E+05	2.8E-09	4.7E-09	2.3E-08
Pu-241	5.0E+06	7.7E-08	1.3E-07	6.2E-07
Am-241	1.8E+05	2.8E-09	4.7E-09	2.3E-08
Cm-244	1.8E+05	2.8E-09	4.7E-09	2.3E-08
Target exposure assessment		From fishing nets ingestion of seafood	From sea surface from hulls	During swimming from the beach sand ingestion of seawater inhalation of seawater spray

Table 5-3-6 Concentration in the seawater used for the assessment (FY2023 4th-4) (2024/02/28-2024/04/18)

Target nuclide	Discharge amount during the period (Bq)	Concentration in the seawater used for the assessment (Bq/L)		
		Within 10km×10km average of all layers	Within 10km×10km average of the top layer	Beach assessment point average of all layers
H-3	1.3E+12	1.7E-02	3.2E-02	2.2E-01
C-14	1.1E+08	1.4E-06	2.6E-06	1.8E-05
Mn-54	1.9E+05	2.3E-09	4.5E-09	3.0E-08
Fe-55	1.1E+08	1.4E-06	2.6E-06	1.8E-05
Co-60	2.6E+06	3.3E-08	6.4E-08	4.3E-07
Ni-63	7.6E+07	9.5E-07	1.8E-06	1.2E-05
Se-79	8.6E+06	1.1E-07	2.1E-07	1.4E-06
Sr-90	2.4E+06	3.0E-08	5.8E-08	3.9E-07
Y-90	2.4E+06	3.0E-08	5.8E-08	3.9E-07
Tc-99	2.6E+07	3.3E-07	6.4E-07	4.3E-06
Cd-113m	1.9E+06	2.4E-08	4.7E-08	3.2E-07
Ru-106	6.9E+05	8.6E-09	1.6E-08	1.1E-07
Sb-125	8.6E+05	1.1E-08	2.1E-08	1.4E-07
Te-125m	3.1E+05	3.9E-09	7.5E-09	5.1E-08
I-129	1.9E+07	2.4E-07	4.7E-07	3.2E-06
Cs-134	2.6E+05	3.3E-09	6.4E-09	4.3E-08
Cs-137	3.9E+06	4.9E-08	9.4E-08	6.3E-07
Ce-144	2.9E+06	3.6E-08	6.9E-08	4.7E-07
Pm-147	2.6E+06	3.2E-08	6.2E-08	4.2E-07
Sm-151	1.0E+05	1.3E-09	2.4E-09	1.6E-08
Eu-154	5.8E+05	7.2E-09	1.4E-08	9.4E-08
Eu-155	1.6E+06	2.0E-08	3.7E-08	2.5E-07
U-234	1.9E+05	2.4E-09	4.7E-09	3.2E-08
U-238	1.9E+05	2.4E-09	4.7E-09	3.2E-08
Np-237	1.9E+05	2.4E-09	4.7E-09	3.2E-08
Pu-238	1.9E+05	2.4E-09	4.7E-09	3.2E-08
Pu-239	1.9E+05	2.4E-09	4.7E-09	3.2E-08
Pu-240	1.9E+05	2.4E-09	4.7E-09	3.2E-08
Pu-241	5.5E+06	6.9E-08	1.3E-07	8.9E-07
Am-241	1.9E+05	2.4E-09	4.7E-09	3.2E-08
Cm-244	1.9E+05	2.4E-09	4.7E-09	3.2E-08
Target exposure assessment		From fishing nets ingestion of seafood	From sea surface from hulls	During swimming from the beach sand ingestion of seawater inhalation of seawater spray

Table 5-3-7 Concentration in the seawater used for the assessment (FY2024 1st-5) (2024/04/19-2024/05/16)

Target nuclide	Discharge amount during the period (Bq)	Concentration in the seawater used for the assessment (Bq/L)		
		Within 10km×10km average of all layers	Within 10km×10km average of the top layer	Beach assessment point average of all layers
H-3	1.5E+12	3.4E-02	7.1E-02	6.4E-01
C-14	1.3E+08	2.8E-06	5.9E-06	5.4E-05
Mn-54	2.3E+05	5.1E-09	1.1E-08	9.7E-08
Fe-55	1.2E+08	2.7E-06	5.6E-06	5.0E-05
Co-60	3.2E+06	7.3E-08	1.5E-07	1.4E-06
Ni-63	7.2E+07	1.6E-06	3.4E-06	3.1E-05
Se-79	8.6E+06	2.0E-07	4.1E-07	3.7E-06
Sr-90	3.1E+06	6.9E-08	1.5E-07	1.3E-06
Y-90	3.1E+06	6.9E-08	1.5E-07	1.3E-06
Tc-99	2.7E+07	6.2E-07	1.3E-06	1.2E-05
Cd-113m	1.9E+06	4.3E-08	8.9E-08	8.1E-07
Ru-106	6.7E+05	1.5E-08	3.2E-08	2.9E-07
Sb-125	7.6E+05	1.7E-08	3.6E-08	3.3E-07
Te-125m	2.8E+05	6.4E-09	1.3E-08	1.2E-07
I-129	1.8E+07	4.1E-07	8.6E-07	7.7E-06
Cs-134	2.5E+05	5.7E-09	1.2E-08	1.1E-07
Cs-137	3.1E+06	6.9E-08	1.5E-07	1.3E-06
Ce-144	3.0E+06	6.7E-08	1.4E-07	1.3E-06
Pm-147	2.7E+06	6.2E-08	1.3E-07	1.2E-06
Sm-151	1.0E+05	2.3E-09	4.8E-09	4.4E-08
Eu-154	6.1E+05	1.4E-08	2.9E-08	2.6E-07
Eu-155	2.4E+06	5.5E-08	1.2E-07	1.0E-06
U-234	1.7E+05	3.9E-09	8.2E-09	7.4E-08
U-238	1.7E+05	3.9E-09	8.2E-09	7.4E-08
Np-237	1.7E+05	3.9E-09	8.2E-09	7.4E-08
Pu-238	1.7E+05	3.9E-09	8.2E-09	7.4E-08
Pu-239	1.7E+05	3.9E-09	8.2E-09	7.4E-08
Pu-240	1.7E+05	3.9E-09	8.2E-09	7.4E-08
Pu-241	4.6E+06	1.0E-07	2.2E-07	2.0E-06
Am-241	1.7E+05	3.9E-09	8.2E-09	7.4E-08
Cm-244	1.7E+05	3.9E-09	8.2E-09	7.4E-08
Target exposure assessment		From fishing nets ingestion of seafood	From sea surface from hulls	During swimming from the beach sand ingestion of seawater inhalation of seawater spray

Table 5-3-8 Concentration in the seawater used for the assessment (FY2024 2nd-6) (2024/05/17-2024/06/27)

Target nuclide	Discharge amount during the period (Bq)	Concentration in the seawater used for the assessment (Bq/L)		
		Within 10km×10km average of all layers	Within 10km×10km average of the top layer	Beach assessment point average of all layers
H-3	1.3E+12	1.9E-02	3.2E-02	3.8E-01
C-14	1.0E+08	1.4E-06	2.5E-06	2.9E-05
Mn-54	1.9E+05	2.6E-09	4.6E-09	5.4E-08
Fe-55	1.3E+08	1.7E-06	3.1E-06	3.6E-05
Co-60	2.4E+06	3.3E-08	5.7E-08	6.8E-07
Ni-63	7.0E+07	9.7E-07	1.7E-06	2.0E-05
Se-79	1.0E+07	1.4E-07	2.5E-07	2.9E-06
Sr-90	2.2E+06	3.1E-08	5.3E-08	6.3E-07
Y-90	2.2E+06	3.1E-08	5.3E-08	6.3E-07
Tc-99	4.3E+06	6.0E-08	1.0E-07	1.2E-06
Cd-113m	2.1E+06	2.8E-08	5.0E-08	5.9E-07
Ru-106	6.8E+05	9.4E-09	1.6E-08	1.9E-07
Sb-125	1.1E+06	1.5E-08	2.7E-08	3.2E-07
Te-125m	4.1E+05	5.7E-09	9.9E-09	1.2E-07
I-129	7.9E+06	1.1E-07	1.9E-07	2.3E-06
Cs-134	2.4E+05	3.3E-09	5.7E-09	6.8E-08
Cs-137	2.4E+06	3.3E-08	5.7E-08	6.8E-07
Ce-144	4.0E+06	5.6E-08	9.7E-08	1.2E-06
Pm-147	2.6E+06	3.6E-08	6.3E-08	7.4E-07
Sm-151	1.0E+05	1.4E-09	2.5E-09	2.9E-08
Eu-154	5.8E+05	8.1E-09	1.4E-08	1.7E-07
Eu-155	1.7E+06	2.3E-08	4.0E-08	4.7E-07
U-234	2.0E+05	2.7E-09	4.8E-09	5.6E-08
U-238	2.0E+05	2.7E-09	4.8E-09	5.6E-08
Np-237	2.0E+05	2.7E-09	4.8E-09	5.6E-08
Pu-238	2.0E+05	2.7E-09	4.8E-09	5.6E-08
Pu-239	2.0E+05	2.7E-09	4.8E-09	5.6E-08
Pu-240	2.0E+05	2.7E-09	4.8E-09	5.6E-08
Pu-241	5.5E+06	7.6E-08	1.3E-07	1.6E-06
Am-241	2.0E+05	2.7E-09	4.8E-09	5.6E-08
Cm-244	2.0E+05	2.7E-09	4.8E-09	5.6E-08
Target exposure assessment		From fishing nets ingestion of seafood	From sea surface from hulls	During swimming from the beach sand ingestion of seawater inhalation of seawater spray

Table 5-3-9 Concentration in the seawater used for the assessment (FY2024 3rd-7) (2024/06/28-2024/08/06))

Target nuclide	Discharge amount during the period (Bq)	Concentration in the seawater used for the assessment (Bq/L)		
		Within 10km×10km average of all layers	Within 10km×10km average of the top layer	Beach assessment point average of all layers
H-3	1.3E+12	2.0E-02	6.1E-02	2.1E-01
C-14	7.8E+07	1.2E-06	3.6E-06	1.2E-05
Mn-54	2.0E+05	3.1E-09	9.4E-09	3.2E-08
Fe-55	1.5E+08	2.2E-06	6.8E-06	2.3E-05
Co-60	3.9E+06	5.9E-08	1.8E-07	6.2E-07
Ni-63	7.1E+07	1.1E-06	3.3E-06	1.1E-05
Se-79	6.9E+06	1.0E-07	3.2E-07	1.1E-06
Sr-90	1.1E+07	1.7E-07	5.0E-07	1.7E-06
Y-90	1.1E+07	1.7E-07	5.0E-07	1.7E-06
Tc-99	6.3E+06	9.4E-08	2.9E-07	9.9E-07
Cd-113m	2.0E+06	3.0E-08	9.0E-08	3.1E-07
Ru-106	6.7E+05	1.0E-08	3.1E-08	1.1E-07
Sb-125	2.0E+06	3.1E-08	9.4E-08	3.2E-07
Te-125m	7.5E+05	1.1E-08	3.5E-08	1.2E-07
I-129	6.1E+06	9.2E-08	2.8E-07	9.6E-07
Cs-134	2.6E+05	3.9E-09	1.2E-08	4.1E-08
Cs-137	2.3E+06	3.4E-08	1.0E-07	3.6E-07
Ce-144	3.0E+06	4.5E-08	1.4E-07	4.7E-07
Pm-147	2.6E+06	3.9E-08	1.2E-07	4.1E-07
Sm-151	1.0E+05	1.5E-09	4.7E-09	1.6E-08
Eu-154	5.8E+05	8.7E-09	2.7E-08	9.1E-08
Eu-155	2.0E+06	3.1E-08	9.4E-08	3.2E-07
U-234	2.2E+05	3.3E-09	1.0E-08	3.5E-08
U-238	2.2E+05	3.3E-09	1.0E-08	3.5E-08
Np-237	2.2E+05	3.3E-09	1.0E-08	3.5E-08
Pu-238	2.2E+05	3.3E-09	1.0E-08	3.5E-08
Pu-239	2.2E+05	3.3E-09	1.0E-08	3.5E-08
Pu-240	2.2E+05	3.3E-09	1.0E-08	3.5E-08
Pu-241	6.1E+06	9.2E-08	2.8E-07	9.6E-07
Am-241	2.2E+05	3.3E-09	1.0E-08	3.5E-08
Cm-244	2.2E+05	3.3E-09	1.0E-08	3.5E-08
Target exposure assessment		From fishing nets ingestion of seafood	From sea surface from hulls	During swimming from the beach sand ingestion of seawater inhalation of seawater spray

Table 5-3-10 Concentration in the seawater used for the assessment (FY2024 4th-8) (2024/08/07-2024/08/25)

Target nuclide	Discharge amount during the period (Bq)	Concentration in the seawater used for the assessment (Bq/L)		
		Within 10km×10km average of all layers	Within 10km×10km average of the top layer	Beach assessment point average of all layers
H-3	1.6E+12	4.5E-02	6.8E-02	1.4E+00
C-14	9.5E+07	2.7E-06	4.1E-06	8.6E-05
Mn-54	2.1E+05	5.9E-09	8.8E-09	1.9E-07
Fe-55	1.3E+08	3.6E-06	5.4E-06	1.2E-04
Co-60	3.5E+06	1.0E-07	1.5E-07	3.2E-06
Ni-63	6.4E+07	1.8E-06	2.7E-06	5.8E-05
Se-79	7.7E+06	2.2E-07	3.3E-07	7.1E-06
Sr-90	9.5E+06	2.7E-07	4.1E-07	8.6E-06
Y-90	9.5E+06	2.7E-07	4.1E-07	8.6E-06
Tc-99	5.8E+06	1.7E-07	2.5E-07	5.3E-06
Cd-113m	1.7E+06	5.0E-08	7.4E-08	1.6E-06
Ru-106	6.1E+05	1.7E-08	2.6E-08	5.5E-07
Sb-125	1.8E+06	5.2E-08	7.8E-08	1.7E-06
Te-125m	6.9E+05	2.0E-08	2.9E-08	6.3E-07
I-129	2.3E+06	6.6E-08	9.8E-08	2.1E-06
Cs-134	2.7E+05	7.7E-09	1.1E-08	2.4E-07
Cs-137	1.7E+06	5.0E-08	7.4E-08	1.6E-06
Ce-144	3.0E+06	8.6E-08	1.3E-07	2.7E-06
Pm-147	2.6E+06	7.5E-08	1.1E-07	2.4E-06
Sm-151	1.0E+05	2.9E-09	4.4E-09	9.4E-08
Eu-154	5.8E+05	1.7E-08	2.5E-08	5.3E-07
Eu-155	1.7E+06	4.8E-08	7.1E-08	1.5E-06
U-234	2.3E+05	6.6E-09	9.8E-09	2.1E-07
U-238	2.3E+05	6.6E-09	9.8E-09	2.1E-07
Np-237	2.3E+05	6.6E-09	9.8E-09	2.1E-07
Pu-238	2.3E+05	6.6E-09	9.8E-09	2.1E-07
Pu-239	2.3E+05	6.6E-09	9.8E-09	2.1E-07
Pu-240	2.3E+05	6.6E-09	9.8E-09	2.1E-07
Pu-241	6.2E+06	1.8E-07	2.7E-07	5.7E-06
Am-241	2.3E+05	6.6E-09	9.8E-09	2.1E-07
Cm-244	2.3E+05	6.6E-09	9.8E-09	2.1E-07
Target exposure assessment		From fishing nets ingestion of seafood	From sea surface from hulls	During swimming from the beach sand ingestion of seawater inhalation of seawater spray

(3) Exposure assessment result

The results of representative person exposure assessments for each assessment period using the seawater concentrations in Tables 5-3-3 to 5-3-10 are shown in Tables 5-3-11 to 5-3-14, and the results of internal exposure assessment by age are shown in Tables 5-3-15 to 5-3-18.

In addition, these results were totaled to form the result of the exposure assessment for one year, and it was compared with the result of the exposure assessment by three source terms in the previous assessment. (Tables 5-3-19 and 5-3-20)

The result of representative person exposure assessments is 0.000002(2E-05) mSv/year, which is well below the dose limit 1mSv/year for the general public as well as the dose target 0.05mSv/year for domestic nuclear power plants equivalent to dose constraints.

And also, for internal exposure assessment result by age, even in infants with a large effective dose coefficient and high internal exposure assessment value, the assessment result of internal exposure is 0.000052(5.2E-05) mSv/year, which is significantly below the dose limit 1mSv/year as well as the dose target value 0.05mSv/year equivalent to the dose limit value.

Comparison with the assessment results of the previous assessment showed roughly the same results. The reason why the results are similar to those of the previous assessment, despite the fact that the amount of ALPS treated water discharged is smaller, is that the detection limits of some undetectable nuclides were higher during the operation stage, and the amount discharged in the assessment increased, resulting in increased exposure to those nuclides. The impact of undetectable nuclides on the assessment results is described in Attachment II.

Table 5-3-11 Results of human exposures assessment (FY2023 1st-1 to 2nd-2)

Assessed case	Source term	FY2023 1st-1 (2023/8/24–10/4)*		FY2023 2nd-2 (2023/10/5–11/1)*	
	Ingestion amount of seafood	Average	Large	Average	Large
External exposure (mSv/year)	Sea surface	2.7E-11		6.0E-11	
	Hull	2.6E-11		6.0E-11	
	During swimming	3.4E-11		3.2E-11	
	Beach sand	5.8E-08		5.4E-08	
	Fishing net	6.9E-09		1.4E-08	
Internal exposure (mSv/year)	Ingestion of water	1.6E-08		1.6E-08	
	Inhalation of spray	2.3E-08		3.1E-08	
	Ingestion of seafood	3.3E-07	1.6E-06	7.0E-07	3.4E-06
Total (mSv/year)		4E-07	2E-06	8E-07	4E-06

*() indicates the assessment period.

Table 5-3-12 Results of human exposures assessment (FY2023 3rd-3 to 4th-4)

Assessed case	Source term	FY2023 3rd-3 (2023/11/2−2024/2/27)*		FY2023 4th-4 (2024/2/28−4/18)*	
	Ingestion amount of seafood	Average	Large	Average	Large
External exposure (mSv/year)	Sea surface	7.9E-11		3.2E-11	
	Hull	7.5E-11		3.2E-11	
	During swimming	3.6E-11		2.0E-11	
	Beach sand	6.1E-08		3.4E-08	
	Fishing net	2.3E-08		8.2E-09	
Internal exposure (mSv/year)	Ingestion of water	1.5E-08		1.2E-08	
	Inhalation of spray	2.5E-08		1.6E-08	
	Ingestion of seafood	1.1E-06	5.5E-06	4.2E-07	2.0E-06
Total (mSv/year)		1E-06	6E-06	5E-07	2E-06

*() indicates the assessment period.

Table 5-3-13 Results of human exposures assessment (FY2024 1st-5 to 2nd-6)

Assessed case	Source term	FY2024 1st-5 (2024/4/19−5/16)*		FY2024 2nd-6 (2024/5/17−6/27)*	
	Ingestion amount of seafood	Average	Large	Average	Large
External exposure (mSv/year)	Sea surface	4.1E-11		2.4E-11	
	Hull	3.8E-11		2.2E-11	
	During swimming	3.5E-11		2.7E-11	
	Beach sand	5.9E-08		4.5E-08	
	Fishing net	9.7E-09		6.8E-09	
Internal exposure (mSv/year)	Ingestion of water	1.9E-08		1.6E-08	
	Inhalation of spray	2.1E-08		2.3E-08	
	Ingestion of seafood	4.2E-07	2.0E-06	3.2E-07	1.6E-06
Total (mSv/year)		5E-07	2E-06	4E-07	2E-06

*() indicates the assessment period.

Table 5-3-14 Results of human exposures assessment (FY2024 3rd-7 to 4th-8)

Assessed case	Source term	FY2024 3rd-7 (2024/6/28−8/6)*		FY2024 4th-8 (2024/8/7−8/25)*	
	Ingestion amount of seafood	Average	Large	Average	Large
External exposure (mSv/year)	Sea surface	5.9E-11		3.4E-10	
	Hull	5.2E-11		3.0E-10	
	During swimming	1.9E-11		2.5E-10	
	Beach sand	3.2E-08		4.2E-07	
	Fishing net	9.7E-09		8.7E-08	
Internal exposure (mSv/year)	Ingestion of water	8.5E-09		1.3E-07	
	Inhalation of spray	1.3E-08		5.6E-07	
	Ingestion of seafood	3.3E-07	1.7E-06	6.7E-07	3.3E-06
Total (mSv/year)		4E-07	2E-06	2E-06	5E-06

*() indicates the assessment period.

Table 5-3-15 Results of internal exposure assessment by age (FY 2023 1st-1, 2nd-2)

Assessed case	Source term	FY2023 1st-1 (2023/8/24−10/4)*		FY2023 2nd-2 (2023/10/5−11/1)*	
	Ingestion amount of seafood	Average	Large	Average	Large
Internal exposure from ingestion of water (mSv/year)	Adult	1.6E-08		1.6E-08	
	Child under school age	2.8E-08		2.8E-08	
	Infant	—		—	
Internal exposure from inhalation of spray (mSv/year)	Adult	2.3E-08		3.1E-08	
	Child under school age	1.2E-08		1.6E-08	
	Infant	6.3E-09		8.2E-09	
Internal exposure from ingestion of seafood (mSv/year)	Adult	3.3E-07	1.6E-06	7.0E-07	3.4E-06
	Child under school age	5.4E-07	2.8E-06	1.1E-06	5.9E-06
	Infant	8.0E-07	4.1E-06	1.7E-06	8.8E-06

*() The evaluation period is indicated.

Table 5-3-16 Results of internal exposure assessment by age (FY 2023 3rd-3, 4th-4)

Assessed case	Source Term	FY2023 3rd-3 (2023/11/2−2024/2/27)*		FY2023 4th-4 (2024/2/28−4/18)*	
	Ingestion amount of seafood	Average	Large	Average	Large
Internal exposure from ingestion of water (mSv/year)	Adult	1.5E-08		1.2E-08	
	Child under school age	2.6E-08		2.0E-08	
	Infant	—		—	
Internal exposure from inhalation of spray (mSv/year)	Adult	2.5E-08		1.6E-08	
	Child under school age	1.3E-08		8.4E-09	
	Infant	6.8E-09		4.4E-09	
Internal exposure from ingestion of seafood (mSv/year)	Adult	1.1E-06	5.5E-06	4.2E-07	2.0E-06
	Child under school age	1.9E-06	9.7E-06	6.5E-07	3.3E-06
	Infant	2.9E-06	1.5E-05	9.3E-07	4.8E-06

*() indicates the assessment period.

Table 5-3-17 Results of internal exposure assessment by age (FY 2024 1st-5, 2nd-6)

Assessed case	Source Term	FY2024 1st-5 (2024/4/19−5/16)*		FY2024 2nd-6 (2024/5/17−6/27)*	
	Ingestion amount of seafood	Average	Large	Average	Large
Internal exposure from ingestion of water (mSv/year)	Adult	1.9E-08		1.6E-08	
	Child under school age	3.2E-08		2.8E-08	
	Infant	—		—	
Internal exposure from inhalation of spray (mSv/year)	Adult	2.1E-08		2.3E-08	
	Child under school age	1.1E-08		1.2E-08	
	Infant	6.1E-09		6.4E-09	
Internal exposure from ingestion of seafood (mSv/year)	Adult	4.2E-07	2.0E-06	3.2E-07	1.6E-06
	Child under school age	6.8E-07	3.4E-06	5.9E-07	3.0E-06
	Infant	9.8E-07	5.0E-06	9.2E-07	4.7E-06

*() indicates the assessment period.

Table 5-3-18 Results of internal exposure assessment by age (FY 2024 3rd-7, 4th-8)

Assessed case	Source term	FY2024 3rd-7 (2024/6/28−8/6)*		FY2024 4th-8 (2024/8/7−8/25)*	
	Ingestion amount of seafood	Average	Large	Average	Large
Internal exposure from ingestion of water (mSv/year)	Adult	8.5E-09		2.7E-08	
	Child under school age	1.5E-08		4.6E-08	
	Infant	—		—	
Internal exposure from inhalation of spray (mSv/year)	Adult	1.3E-08		3.9E-08	
	Child under school age	7.1E-09		2.1E-08	
	Infant	3.7E-09		1.1E-08	
Internal exposure from ingestion of seafood (mSv/year)	Adult	3.3E-07	1.7E-06	2.5E-07	1.3E-06
	Child under school age	6.6E-07	3.4E-06	5.2E-07	2.7E-06
	Infant	1.1E-06	5.6E-06	8.5E-07	4.4E-06

*() indicates the assessment period.

Table 5-3-19 Results of human exposures assessment (Comparison of total value for one year after commencement of discharge and previous assessment)

Assessed case	Source term	Total value for one year after commencement of discharge (2023/8/24−2024/8/25)		Previous assessment of K4 tanks	Previous assessment of J1-C tanks	Previous assessment of J1-G tanks
	Ingestion amount of seafood	Average	Large	Large	Large	Large
External exposure (mSv/year)	Sea surface	3.4E-10		4.6E-10	1.7E-10	3.7E-10
	Hull	3.3E-10		4.9E-10	1.8E-10	3.7E-10
	During swimming	2.5E-10		3.2E-10	1.2E-10	2.5E-10
	Beach sand	4.2E-07		5.4E-07	2.0E-07	4.3E-07
	Fishing net	8.7E-08		1.1E-07	3.9E-08	8.3E-08
Internal exposure (mSv/year)	Ingestion of water	1.3E-07		3.4E-07	3.1E-07	3.1E-07
	Inhalation of spray	1.9E-07		9.2E-08	1.9E-07	3.8E-07
	Ingestion of seafood	3.9E-06	1.9E-05	3.1E-05	5.5E-06	1.1E-05
Total (mSv/year)		5E-06	2E-05	3E-05	6E-06	1E-05

Table 5-3-20 Results of internal exposure assessment by age (Comparison of total value for one year after commencement of discharge and previous assessment)

Assessed case	Source term	Total value for one year after commencement of discharge (2023/8/24−2024/8/25)		Previous assessment of K4 tanks	Previous assessment of J1-C tanks	Previous assessment of J1-G tanks
	Ingestion amount of seafood	Average	Large	Large	Large	Large
Internal exposure from ingestion of water (mSv/year)	Adult	1.3E-07		3.4E-07	3.1E-07	3.1E-07
	Child under school age	2.2E-07		5.8E-07	5.3E-07	5.4E-07
	Infant	—		—	—	—
Internal exposure from inhalation of spray (mSv/year)	Adult	1.9E-07		9.2E-08	1.9E-07	3.8E-07
	Child under school age	1.0E-07		6.0E-08	1.1E-07	2.0E-07
	Infant	5.3E-08		3.9E-08	6.2E-08	1.1E-07
Internal exposure from ingestion of seafood (mSv/year)	Adult	3.9E-06	1.9E-05	3.1E-05	5.5E-06	1.1E-05
	Child under school age	6.7E-06	3.4E-05	3.6E-05	6.8E-06	1.6E-05
	Infant	1.0E-05	5.2E-05	3.2E-05	8.1E-06	2.2E-05

6. Assessment regarding environmental protection

The same as the previous assessment, the assessment for protection of plants and animals in the normal operation is performed according to GSG-10 Annex I.

6-1. Assessment procedure

Assessment is performed according to the procedure shown in Figure 6-1.

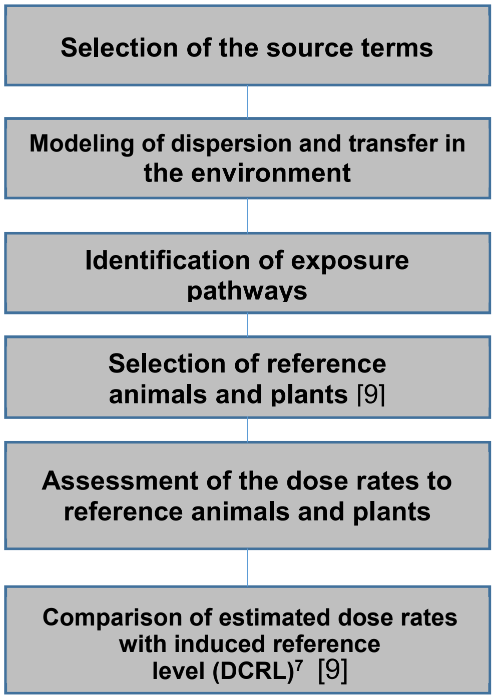


Figure 6-1 Environmental protection assessment procedure (prepared from GSG-10)

[7] Derived consideration reference level (DCRL): Range of the dose rates within a range of one digit specified for each species advocated by ICRP. Dose rate level at which the impact has to be considered if is exceeded.

6-2. Assessment method

(1) Source term

Use the same source term as the one shown in 5-2.(1) Source term.

(2) Modeling of dispersion and transfer after discharge

① Selection of the transfer model

The following items were selected as well as the previous assessment 7-2-2(1).

i. Advection and dispersion by tidal currents, etc.
Selected because advection and dispersion will occur after discharge into the sea.

ii. Advection and dispersion caused by tidal currents, etc. → Transfer to seabed sediment
Selected because ALPS treated water will migrate to the seabed sediment, etc., due to advection and dispersion caused by tidal currents, etc., after discharge into the sea.

iii. Advection and dispersion by tidal currents, etc.→ Intake and concentration by marine plants and animals such as fish selected because transfer to and concentration in fish, etc. will occur after discharge into the sea.

② Assessment of advection and dispersion in the sea area

The same model as that for the human protection assessment is used.

(3) Method for establishing and evaluating exposure routes

The following pathways were selected as well as the Radiation Environmental Impact Assessment Report (Construction stage / Revised version) 7-2-3.

i. Internal exposure from radioactive material ingested or inhaled by plants and animals
ii. External exposure from the surrounding sea water
iii. External exposure from the surrounding seabed sediment

The assessment methods were also the same as those of the previous assessment: Table 6-2-1 shows the internal exposure dose conversion factor for plants and animals to which Cd-113m was added, Table 6-2-2 shows the external exposure dose conversion factor for plants and animals, Table 6-2-3 shows the concentration ratio of plants and animals to seawater, and Table 6-2-4 shows the concentration distribution coefficient of sediments in seawater and seabed.

(4) Selection of reference animals and plants (organisms to be assessed)

The same as the previous assessment 7-2-4, the following were selected as the reference and reference plants listed in ICRP Pub.136 "Dose Coefficients for Non-human Biota Environmentally Exposed to Radiological" (ICRP,2017) [15] based on the conditions in the surrounding seawaters.

- Reference flatfish (Left-eyed and right-eyed flounders and widely inhabit in the sea area around the FDNPS)
- Reference crabs (Ovalipes punctatus and portunus trituberculatus widely inhabit in the sea area around the FDNPS)
- Reference brown seaweeds (Sargassum and Eisenia bicyclis widely inhabit in the sea areas around the FDNPS)

As these animals and plants are widely distributed in the sea area around the FDNPS and are thought to be affected by radioactive materials that have migrated into the seabed sediments, the radioactive material concentration in the seawater used for the assessment is the concentration near the seabed (bottom layer) in 10km×10km surrounding the FDNPS, as well as in the previous assessment.

(5) Methods for dose assessment

Dose assessment involves calculating the annual average absorbed dose rate from the absorbed dose rate for each assessment period, weighted by the number of days in the assessment period.

Dose assessment results are made for each type of reference plant and animal by comparing them with the Derived Consideration Reference Levels (DCRL) shown in ICRP Publication 124 "Protection of the Environment under Different Exposure Situations" [9].

In addition, comparison with the previous assessment will also be made.

Table 6-2-1 Internal exposure conversion factors for marine animals and plants

(ICRP Pub.136, and others are shown in remarks)

	Target nuclide	Internal exposure dose conversion factor ((mGy/day)/(Bq/kg))			Remarks
		Flatfish	Crab	Brown seaweed	
1	H-3	7.9E-08	7.9E-08	7.9E-08	
2	C-14	7.0E-07	7.0E-07	7.0E-07	
3	Mn-54	1.1E-06	1.4E-06	9.4E-07	
4	Fe-55	8.0E-08	8.0E-08	8.0E-08	Calculated from BiotaDC[8]
5	Co-60	3.8E-06	5.0E-06	3.6E-06	
6	Ni-63	2.4E-07	2.4E-07	2.4E-07	
7	Se-79	7.2E-07	7.2E-07	7.2E-07	
8	Sr-90	1.4E-05	1.5E-05	1.4E-05	
9	Y-90	—	—	—	Contained in the parent nuclide Sr-90
10	Tc-99	1.4E-06	1.4E-06	1.4E-06	
11	Ru-106	1.7E-05	1.9E-05	1.7E-05	
12	Cd-113m	2.5E-06	2.5E-06	2.4E-06	Calculated from BiotaDC
13	Sb-125	2.0E-06	2.2E-06	1.9E-06	
14	Te-125m	1.7E-06	1.8E-06	1.6E-06	Calculated from BiotaDC
15	I-129	1.0E-06	1.1E-06	1.0E-06	
16	Cs-134	4.1E-06	4.8E-06	3.8E-06	
17	Cs-137	4.1E-06	4.3E-06	4.1E-06	
18	Ce-144	1.6E-05	1.7E-05	1.6E-05	
19	Pm-147	8.6E-07	8.6E-07	8.5E-07	Calculated by BiotaDC
20	Sm-151	2.8E-07	2.8E-07	2.8E-07	Calculated by BiotaDC
21	Eu-154	5.0E-06	5.8E-06	5.0E-06	
22	Eu-155	1.0E-06	1.0E-06	9.8E-07	
23	U-234	6.7E-05	6.7E-05	6.7E-05	
24	U-238	6.0E-05	6.0E-05	6.0E-05	
25	Np-237	6.7E-05	6.7E-05	6.7E-05	
26	Pu-238	7.7E-05	7.7E-05	7.7E-05	
27	Pu-239	7.2E-05	7.2E-05	7.2E-05	
28	Pu-240	7.2E-05	7.2E-05	7.2E-05	
29	Pu-241	7.4E-08	7.4E-08	7.4E-08	
30	Am-241	7.7E-05	7.7E-05	7.7E-05	
31	Cm-244	8.2E-05	8.2E-05	8.2E-05	

[8] BiotaDC programme of ICRP [18]

Table 6-2-2 External exposure conversion factor to marine animals and plants

(ICRP Pub.136, and others are shown in remarks)

	Target nuclide	External exposure dose conversion factor ((mGy/day)/(Bq/kg))			Remarks
		Flatfish	Crab	Brown seaweed	
1	H-3	1.9E-14	2.4E-16	2.4E-16	
2	C-14	4.3E-10	5.3E-10	5.3E-10	
3	Mn-54	1.1E-05	1.0E-05	1.1E-05	
4	Fe-55	3.3E-10	3.9E-10	1.0E-09	Calculated from BiotaDC
5	Co-60	3.1E-05	3.1E-05	3.4E-05	
6	Ni-63	2.6E-11	4.1E-11	4.1E-11	
7	Se-79	4.8E-10	5.8E-10	6.2E-10	
8	Sr-90	1.2E-06	5.5E-07	1.2E-06	
9	Y-90	—	—	—	Contained in the parent nuclide Sr-90
10	Tc-99	3.1E-09	3.4E-09	3.6E-09	
11	Ru-106	5.3E-06	3.8E-06	5.3E-06	
12	Cd-113m	1.7E-08	1.6E-08	1.4E-07	Calculated by BiotaDC
13	Sb-125	5.5E-06	5.3E-06	5.5E-06	
14	Te-125m	2.9E-07	2.4E-07	4.3E-07	Calculated by BiotaDC
15	I-129	2.2E-07	1.9E-07	2.4E-07	
16	Cs-134	2.0E-05	1.9E-05	2.0E-05	
17	Cs-137	7.2E-06	7.0E-06	7.2E-06	
18	Ce-144	2.6E-06	1.5E-06	2.6E-06	
19	Pm-147	9.9E-10	1.1E-09	1.0E-08	Calculated by BiotaDC
20	Sm-151	7.7E-11	8.4E-11	7.6E-10	Calculated by BiotaDC
21	Eu-154	1.6E-05	1.5E-05	1.6E-05	
22	Eu-155	7.4E-07	7.0E-07	7.4E-07	
23	U-234	4.8E-09	4.1E-09	5.5E-09	
24	U-238	3.1E-09	2.6E-09	3.6E-09	
25	Np-237	3.1E-07	2.9E-07	3.1E-07	
26	Pu-238	4.6E-09	3.8E-09	5.5E-09	
27	Pu-239	2.6E-09	2.3E-09	3.1E-09	
28	Pu-240	4.3E-09	3.6E-09	5.3E-09	
29	Pu-241	1.9E-11	1.9E-11	2.0E-11	
30	Am-241	2.9E-07	2.6E-07	2.9E-07	
31	Cm-244	4.8E-09	3.8E-09	5.5E-09	

Table 6-2-3 Concentration ratio to marine plants and animals

(ICRP Pub.114 [16] and others, shown in remarks)

	Target nuclide	Concentration ratio ((Bq/kg-f.w)/(Bq/L))			Remarks
		Flatfish	Crab	Brown seaweed	
1	H-3	1.0E+00	1.0E+00	3.7E-01	Excerpted from ICRP Pub.114
2	C-14	1.2E+04	1.0E+04	8.0E+03	Excerpted from ICRP Pub.114
3	Mn-54	2.6E+03	4.5E+04	1.1E+04	Excerpted from TRS-479 [17] (fish and crab) Excerpted from ICRP Pub.114 (brown seaweed)
4	Fe-55	3.0E+04	5.0E+05	2.0E+04	Excerpted from concentration coefficient of TRS-422 [13] since No description in ICRP Pub.114, TRS-479.
5	Co-60	1.1E+04	5.5E+03	1.7E+03	Excerpted from TRS-479
6	Ni-63	2.7E+02	6.4E+03	2.0E+03	Excerpted from TRS-479 (crab) Excerpted from ICRP Pub.114 (fish and brown seaweed)
7	Se-79	1.0E+04	1.0E+04	4.3E+02	Excerpted from TRS-479 (brown seaweed) Excerpted from ICRP Pub.114 (fish and crab)
8	Sr-90	4.4E+01	2.3E+02	4.3E+01	Excerpted from TRS-479 (fish and crab) Excerpted from ICRP Pub.114 (brown seaweed)
9	Y-90	—	—	—	Assessed with the parental nuclide Sr-90
10	Tc-99	8.0E+01	1.8E+04	5.3E+04	Excerpted from ICRP Pub.114 (fish) Excerpted from TRS-479 (crab and brown seaweed)
11	Ru-106	2.9E+01	1.6E+03	1.2E+03	Excerpted from TRS-479
12	Cd-113m	2.9E+04	1.3E+05	1.6E+03	Excerpted from TRS-479 (fish and crab) Excerpted from ICRP Pub.114 (brown seaweed)
13	Sb-125	6.0E+02	4.7E+02	1.5E+03	Excerpted from TRS-479 (crab) Excerpted from ICRP Pub.114 (fish and brown seaweed)
14	Te-125m	1.0E+03	1.0E+03	1.0E+04	Excerpted from ICRP Pub.114
15	I-129	9.0E+00	8.8E+03	4.2E+03	Excerpted from ICRP Pub.114 (fish) Excerpted from TRS-479 (crab and brown seaweed)

	Target nuclide	Concentration ratio ((Bq/kg-f.w)/(Bq/L))			Remarks
		Flatfish	Crab	Brown seaweed	
16	Cs-134	1.2E+02	6.3E+01	9.6E+01	Excerpted from TRS-479
17	Cs-137	1.2E+02	6.3E+01	9.6E+01	Excerpted from TRS-479
18	Ce-144	3.9E+02	2.2E+03	2.1E+03	Excerpted from TRS-479
19	Pm-147	7.3E+02	2.4E+04	5.9E+03	Excerpted Eu value of the same family (fish and crab) Excerpted La value of TRS-479 (brown seaweed)
20	Sm-151	7.3E+02	2.4E+04	5.9E+03	Excerpted from Eu value of the same family (fish and crab) Excerpted from La value of TRS-479 (brown seaweed)
21	Eu-154	7.3E+02	2.4E+04	1.4E+03	Excerpted from TRS-479 (brown seaweed) Excerpted by ICRP Pub.114 (fish and crab)
22	Eu-155	7.3E+02	2.4E+04	1.4E+03	Excerpted from TRS-479 (brown seaweed) Excerpted by ICRP Pub.114 (fish and crab)
23	U-234	8.8E+00	3.5E+01	8.3E+01	Excerpted from TRS-479
24	U-238	8.8E+00	3.5E+01	8.3E+01	Excerpted from TRS-479
25	Np-237	2.1E+01	4.3E+02	5.4E+01	Excerpted from TRS-479 (crab) Excerpted from ICRP Pub.114 (fish and brown seaweed)
26	Pu-238	2.5E+03	1.7E+03	4.1E+03	Excerpted from TRS-479
27	Pu-239	2.5E+03	1.7E+03	4.1E+03	Excerpted from TRS-479
28	Pu-240	2.5E+03	1.7E+03	4.1E+03	Excerpted from TRS-479
29	Pu-241	2.5E+03	1.7E+03	4.1E+03	Excerpted from TRS-479
30	Am-241	3.2E+02	9.9E+03	4.3E+02	Excerpted from TRS-479
31	Cm-244	1.9E+02	3.2E+04	1.2E+04	Excerpted from TRS-479 (crab and brown seaweed) Excerpted by ICRP Pub.114 (fish)

Table6-2-4 Concentration distribution coefficient of the seawater and seabed sediment

(Excerpted from TRS-422)

	Target nuclide	Concentration distribution coefficient ((Bq/kg)/ (Bq/L))	Remarks
1	H-3	1.00E+00	
2	C-14	1.00E+03	
3	Mn-54	2.00E+06	
4	Fe-55	3.00E+08	
5	Co-60	3.00E+05	
6	Ni-63	2.00E+04	
7	Se-79	3.00E+03	
8	Sr-90	8.00E+00	
9	Y-90	—	Assessed with parent nuclide Sr-90
10	Tc-99	1.00E+02	
11	Ru-106	4.00E+04	
12	Cd-113m	3.00E+04	
13	Sb-125	2.00E+03	
14	Te-125m	—	Assessed with parent nuclide Sb-125.
15	I-129	7.00E+01	
16	Cs-134	4.00E+03	
17	Cs-137	4.00E+03	
18	Ce-144	3.00E+06	
19	Pm-147	2.00E+06	
20	Sm-151	3.00E+06	
21	Eu-154	2.00E+06	
22	Eu-155	2.00E+06	
23	U-234	1.00E+03	
24	U-238	1.00E+03	
25	Np-237	1.00E+03	
26	Pu-238	1.00E+05	
27	Pu-239	1.00E+05	
28	Pu-240	1.00E+05	
29	Pu-241	1.00E+05	
30	Am-241	2.00E+06	
31	Cm-244	2.00E+06	

6-3. Assessment results

(1) Concentration in the seawater used for the assessment

As with the human protection assessment, concentration in the seawater used for the exposure assessment for each nuclide was calculated by proportion calculation with the calculation result of advection and dispersion of tritium and the annual discharge amount of tritium and each nuclide.

Table 6-3-1 shows the concentration of tritium in the seawater in the bottom layer within 10km×10km around the FDNPS (average concentration during the period) for each assessment period. Periodic concentrations were generally below those of the previous assessment, however only in the 4th-8 in FY2024 of it was exceeded. The reason for this is that, as shown in 5-3(1), all of the assessment periods for the 4th-8th assessment in FY2024 were during discharge, but the tritium concentrations were all low.

Tables 6-3-2 to 9 show this result, and the concentrations in the seawater used for the assessment for each assessment period and each nuclides, calculated from the source terms shown in Tables 5-1-1 to 8.

Table 6-3-1. Average tritium concentration in seawater by assessment period

Assessment period	Average concentration in each period within 10 km×10 km around the FDNPS (Bq/L)
	Bottom layer
FY2023 1st-1 (2023/08/24-2023/10/04)	2.1E-02
FY2023 2nd-2 (2023/10/05-2023/11/01)	3.9E-02
FY2023 3rd-3 (2023/11/02-2024/02/27)	1.2E-02
FY2023 4th-4 (2024/02/28-2024/04/18)	1.7E-02
FY2024 1st-5 (2024/04/19-2024/05/16)	3.2E-02
FY2024 2nd-6 (2024/05/17-2024/06/27)	2.4E-02
FY2024 3rd-7 (2024/06/28-2024/08/06)	3.3E-02
FY2024 4th-8 (2024/08/07-2024/08/25)	7.5E-02
Previous assessment (2019/01/01-2019/12/31)	6.0E-02

Table 6-3-2 Concentration in the seawater used for the assessment (FY2023 1st-1) (2023/08/24 ~ 2023/10/04)

Target nuclide	Period discharge amount (Bq)	Concentration in the seawater used for the assessment (Bq/L)
		Average of the bottom layer (within 10km×10km range)
H-3	1.1E+12	2.1E-02
C-14	1.1E+08	2.1E-06
Mn-54	2.0E+05	3.8E-09
Fe-55	1.1E+08	2.2E-06
Co-60	2.7E+06	5.2E-08
Ni-63	6.8E+07	1.3E-06
Se-79	7.3E+06	1.4E-07
Sr-90	3.2E+06	6.0E-08
Y-90	3.2E+06	6.0E-08
Tc-99	5.3E+06	1.0E-07
Ru-106	2.0E+06	3.7E-08
Cd-113m	6.6E+05	1.3E-08
Sb-125	1.4E+06	2.7E-08
Te-125m	5.0E+05	9.4E-09
I-129	1.5E+07	2.9E-07
Cs-134	2.5E+05	4.8E-09
Cs-137	3.6E+06	6.9E-08
Ce-144	2.8E+06	5.4E-08
Pm-147	2.4E+06	4.6E-08
Sm-151	9.3E+04	1.8E-09
Eu-154	5.5E+05	1.0E-08
Eu-155	1.5E+06	2.8E-08
U-234	1.6E+05	3.1E-09
U-238	1.6E+05	3.1E-09
Np-237	1.6E+05	3.1E-09
Pu-238	1.6E+05	3.1E-09
Pu-239	1.6E+05	3.1E-09
Pu-240	1.6E+05	3.1E-09
Pu-241	4.5E+06	8.6E-08
Am-241	1.6E+05	3.1E-09
Cm-244	1.6E+05	3.1E-09
Target exposure assessment		Environmental protection

Table 6-3-3 Concentration in the seawater used for the assessment (FY2023 2nd-2) (2023/10/05 ~ 2023/11/01)

Target nuclide	Period discharge amount (Bq)	Concentration in the seawater used for the assessment(Bq/L)
		Average of the bottom layer (within 10km×10km range)
H-3	1.1E+12	3.9E-02
C-14	1.0E+08	3.7E-06
Mn-54	1.8E+05	6.4E-09
Fe-55	1.1E+08	3.8E-06
Co-60	1.9E+06	6.8E-08
Ni-63	6.9E+07	2.5E-06
Se-79	6.8E+06	2.4E-07
Sr-90	2.5E+05	9.0E-09
Y-90	2.5E+05	9.0E-09
Tc-99	1.5E+06	5.3E-08
Ru-106	1.7E+06	6.0E-08
Cd-113m	6.7E+05	2.4E-08
Sb-125	6.9E+05	2.5E-08
Te-125m	2.4E+05	8.6E-09
I-129	1.4E+07	5.2E-07
Cs-134	2.3E+05	8.3E-09
Cs-137	3.5E+06	1.3E-07
Ce-144	2.8E+06	1.0E-07
Pm-147	2.5E+06	8.8E-08
Sm-151	9.4E+04	3.4E-09
Eu-154	5.5E+05	2.0E-08
Eu-155	1.9E+06	6.8E-08
U-234	2.3E+05	8.3E-09
U-238	2.3E+05	8.3E-09
Np-237	2.3E+05	8.3E-09
Pu-238	2.3E+05	8.3E-09
Pu-239	2.3E+05	8.3E-09
Pu-240	2.3E+05	8.3E-09
Pu-241	6.4E+06	2.3E-07
Am-241	2.3E+05	8.3E-09
Cm-244	2.3E+05	8.3E-09
Target exposure assessment		Environmental protection

Table 6-3-4 Concentration in the seawater used for the assessment (FY2023 3rd-3) (2023/11/02 ~ 2024/02/27)

Target nuclide	Period discharge amount (Bq)	Concentration in the seawater used for the assessment (Bq/L)
		Average of the bottom layer (within 10km×10km)
H-3	9.8E+11	1.2E-02
C-14	1.1E+08	1.3E-06
Mn-54	1.9E+05	2.4E-09
Fe-55	1.3E+08	1.5E-06
Co-60	2.5E+06	3.1E-08
Ni-63	7.0E+07	8.6E-07
Se-79	6.9E+06	8.5E-08
Sr-90	3.2E+05	3.9E-09
Y-90	3.2E+05	3.9E-09
Tc-99	1.5E+06	1.9E-08
Ru-106	1.8E+06	2.2E-08
Cd-113m	7.2E+05	8.8E-09
Sb-125	7.3E+05	8.9E-09
Te-125m	2.6E+05	3.1E-09
I-129	1.5E+07	1.8E-07
Cs-134	2.3E+05	2.8E-09
Cs-137	2.9E+06	3.6E-08
Ce-144	3.1E+06	3.8E-08
Pm-147	2.7E+06	3.2E-08
Sm-151	1.0E+05	1.2E-09
Eu-154	5.9E+05	7.3E-09
Eu-155	2.0E+06	2.5E-08
U-234	1.8E+05	2.2E-09
U-238	1.8E+05	2.2E-09
Np-237	1.8E+05	2.2E-09
Pu-238	1.8E+05	2.2E-09
Pu-239	1.8E+05	2.2E-09
Pu-240	1.8E+05	2.2E-09
Pu-241	5.0E+06	6.1E-08
Am-241	1.8E+05	2.2E-09
Cm-244	1.8E+05	2.2E-09
Target exposure assessment		Environmental protection

Table 6-3-5 Concentration in the seawater used for the assessment (FY2023 4th-4) (2024/02/28 ~ 2024/04/18)

Target nuclide	Period discharge amount (Bq)	Concentration in the seawater used for the assessment (Bq/L)
		Average of the bottom layer (within 10km×10km)
H-3	1.3E+12	1.7E-02
C-14	1.1E+08	1.4E-06
Mn-54	1.9E+05	2.5E-09
Fe-55	1.1E+08	1.4E-06
Co-60	2.6E+06	3.5E-08
Ni-63	7.6E+07	9.9E-07
Se-79	8.6E+06	1.1E-07
Sr-90	2.4E+06	3.2E-08
Y-90	2.4E+06	3.2E-08
Tc-99	2.6E+07	3.5E-07
Ru-106	1.9E+06	2.6E-08
Cd-113m	6.9E+05	9.0E-09
Sb-125	8.6E+05	1.1E-08
Te-125m	3.1E+05	4.1E-09
I-129	1.9E+07	2.6E-07
Cs-134	2.6E+05	3.5E-09
Cs-137	3.9E+06	5.1E-08
Ce-144	2.9E+06	3.8E-08
Pm-147	2.6E+06	3.4E-08
Sm-151	1.0E+05	1.3E-09
Eu-154	5.8E+05	7.6E-09
Eu-155	1.6E+06	2.0E-08
U-234	1.9E+05	2.6E-09
U-238	1.9E+05	2.6E-09
Np-237	1.9E+05	2.6E-09
Pu-238	1.9E+05	2.6E-09
Pu-239	1.9E+05	2.6E-09
Pu-240	1.9E+05	2.6E-09
Pu-241	5.5E+06	7.2E-08
Am-241	1.9E+05	2.6E-09
Cm-244	1.9E+05	2.6E-09
Target exposure assessment		Environmental protection

Table 6-3-6 Concentration in the seawater used for the assessment (FY2024 1st-5) (2024/04/19 ~ 2024/05/16)

Target nuclide	Period discharge amount (Bq)	Concentration in the seawater used for the assessment (Bq/L)
		Average of the bottom layer (within 10km×10km)
H-3	1.5E+12	3.2E-02
C-14	1.3E+08	2.7E-06
Mn-54	2.3E+05	4.9E-09
Fe-55	1.2E+08	2.5E-06
Co-60	3.2E+06	7.0E-08
Ni-63	7.2E+07	1.6E-06
Se-79	8.6E+06	1.9E-07
Sr-90	3.1E+06	6.6E-08
Y-90	3.1E+06	6.6E-08
Tc-99	2.7E+07	5.9E-07
Ru-106	1.9E+06	4.1E-08
Cd-113m	6.7E+05	1.4E-08
Sb-125	7.6E+05	1.6E-08
Te-125m	2.8E+05	6.1E-09
I-129	1.8E+07	3.9E-07
Cs-134	2.5E+05	5.4E-09
Cs-137	3.1E+06	6.6E-08
Ce-144	3.0E+06	6.5E-08
Pm-147	2.7E+06	5.9E-08
Sm-151	1.0E+05	2.2E-09
Eu-154	6.1E+05	1.3E-08
Eu-155	2.4E+06	5.3E-08
U-234	1.7E+05	3.7E-09
U-238	1.7E+05	3.7E-09
Np-237	1.7E+05	3.7E-09
Pu-238	1.7E+05	3.7E-09
Pu-239	1.7E+05	3.7E-09
Pu-240	1.7E+05	3.7E-09
Pu-241	4.6E+06	1.0E-07
Am-241	1.7E+05	3.7E-09
Cm-244	1.7E+05	3.7E-09
Target exposure assessment		Environmental protection

Table 6-3-7 Concentration in the seawater used for the assessment (FY2024 2nd-6) (2024/05/17 ~ 06/27)

Target nuclide	Period discharge amount (Bq)	Concentration in the seawater used for the assessment (Bq/L)
		Average of the bottom layer (within 10km×10km)
H-3	1.3E+12	2.4E-02
C-14	1.0E+08	1.8E-06
Mn-54	1.9E+05	3.4E-09
Fe-55	1.3E+08	2.2E-06
Co-60	2.4E+06	4.2E-08
Ni-63	7.0E+07	1.3E-06
Se-79	1.0E+07	1.8E-07
Sr-90	2.2E+06	3.9E-08
Y-90	2.2E+06	3.9E-08
Tc-99	4.3E+06	7.7E-08
Ru-106	2.1E+06	3.7E-08
Cd-113m	6.8E+05	1.2E-08
Sb-125	1.1E+06	2.0E-08
Te-125m	4.1E+05	7.3E-09
I-129	7.9E+06	1.4E-07
Cs-134	2.4E+05	4.2E-09
Cs-137	2.4E+06	4.2E-08
Ce-144	4.0E+06	7.2E-08
Pm-147	2.6E+06	4.6E-08
Sm-151	1.0E+05	1.8E-09
Eu-154	5.8E+05	1.0E-08
Eu-155	1.7E+06	3.0E-08
U-234	2.0E+05	3.5E-09
U-238	2.0E+05	3.5E-09
Np-237	2.0E+05	3.5E-09
Pu-238	2.0E+05	3.5E-09
Pu-239	2.0E+05	3.5E-09
Pu-240	2.0E+05	3.5E-09
Pu-241	5.5E+06	9.8E-08
Am-241	2.0E+05	3.5E-09
Cm-244	2.0E+05	3.5E-09
Target exposure assessment		Environmental protection

Table 6-3-8 Concentration in the seawater used for the assessment (FY2024 3rd-7) (2024/06/28 ~ 08/06)

Target nuclide	Period discharge amount (Bq)	Concentration in the seawater used for the assessment (Bq/L)
		Average of the bottom layer (within 10km×10km)
H-3	1.3E+12	3.3E-02
C-14	7.8E+07	1.9E-06
Mn-54	2.0E+05	5.1E-09
Fe-55	1.5E+08	3.7E-06
Co-60	3.9E+06	9.8E-08
Ni-63	7.1E+07	1.8E-06
Se-79	6.9E+06	1.7E-07
Sr-90	1.1E+07	2.8E-07
Y-90	1.1E+07	2.8E-07
Tc-99	6.3E+06	1.6E-07
Ru-106	2.0E+06	4.9E-08
Cd-113m	6.7E+05	1.7E-08
Sb-125	2.0E+06	5.1E-08
Te-125m	7.5E+05	1.9E-08
I-129	6.1E+06	1.5E-07
Cs-134	2.6E+05	6.5E-09
Cs-137	2.3E+06	5.7E-08
Ce-144	3.0E+06	7.5E-08
Pm-147	2.6E+06	6.5E-08
Sm-151	1.0E+05	2.6E-09
Eu-154	5.8E+05	1.5E-08
Eu-155	2.0E+06	5.1E-08
U-234	2.2E+05	5.5E-09
U-238	2.2E+05	5.5E-09
Np-237	2.2E+05	5.5E-09
Pu-238	2.2E+05	5.5E-09
Pu-239	2.2E+05	5.5E-09
Pu-240	2.2E+05	5.5E-09
Pu-241	6.1E+06	1.5E-07
Am-241	2.2E+05	5.5E-09
Cm-244	2.2E+05	5.5E-09
Target exposure assessment		Environmental protection

Table 6-3-9 Concentration in the seawater used for the assessment (FY2024 4th-8) (2024/08/07 ~ 08/25)

Target nuclide	Period discharge amount (Bq)	Concentration in the seawater used for the assessment (Bq/L) Average of the bottom layer (within 10km×10km)
H-3	1.6E+12	7.5E-02
C-14	9.5E+07	4.5E-06
Mn-54	2.1E+05	9.8E-09
Fe-55	1.3E+08	6.0E-06
Co-60	3.5E+06	1.7E-07
Ni-63	6.4E+07	3.1E-06
Se-79	7.7E+06	3.7E-07
Sr-90	9.5E+06	4.5E-07
Y-90	9.5E+06	4.5E-07
Tc-99	5.8E+06	2.8E-07
Ru-106	1.7E+06	8.3E-08
Cd-113m	6.1E+05	2.9E-08
Sb-125	1.8E+06	8.7E-08
Te-125m	6.9E+05	3.3E-08
I-129	2.3E+06	1.1E-07
Cs-134	2.7E+05	1.3E-08
Cs-137	1.7E+06	8.3E-08
Ce-144	3.0E+06	1.4E-07
Pm-147	2.6E+06	1.2E-07
Sm-151	1.0E+05	4.9E-09
Eu-154	5.8E+05	2.8E-08
Eu-155	1.7E+06	7.9E-08
U-234	2.3E+05	1.1E-08
U-238	2.3E+05	1.1E-08
Np-237	2.3E+05	1.1E-08
Pu-238	2.3E+05	1.1E-08
Pu-239	2.3E+05	1.1E-08
Pu-240	2.3E+05	1.1E-08
Pu-241	6.2E+06	3.0E-07
Am-241	2.3E+05	1.1E-08
Cm-244	2.3E+05	1.1E-08
Target exposure assessment		Environmental protection

(2) Exposure assessment results

Table 6-3-10 to 6-3-11 show the results of exposure assessments for reference plants and animals by assessment period. In addition, Table 6-3-12 shows the comparison between the annual average exposure dose calculated from the results for each assessment period and the assessment results of the previous assessment.

The assessment results all showed low dose rates, less than one millionth of the lower limit of the induced reference level. The results were roughly the same as the previous assessment, but the latest results were slightly higher. The reason why the exposure results were higher despite the smaller amount of ALPS treated water discharged compared to the previous assessment is that the detection limits for some undetectable nuclides were higher during the operation stage, resulting in increased exposure from nuclides that were discharged in greater amounts in the assessment. The impact of undetectable nuclides on the assessment results is described in Appendix II.

Table 6-3-10 Assessment result regarding environmental protection (FY2023, 1st-1 to 4th-4)

Assessed Case		Assessment period			
		FY2023 1st-1 (2023/08/24~ 10/04)	FY2023 2nd-2 (2023/10/05~ 11/01)	FY2023 3rd-3 (2023/11/02~ 2024/02/27)	FY2023 4th-4 (2024/02/28~ 04/18)
Exposure (mGy/day)	Flatfish	8E-07	1E-06	6E-07	6E-07
	Crab	8E-07	1E-06	6E-07	6E-07
	Brown seaweed	1E-06	2E-06	7E-07	8E-07
Derived consideration Reference Level (DCRL) Flatfish : 1-10 mGy/day Crab : 10-100mGy/day Brown seaweed : 1-10mGy/day					

Table 6-3-11 Assessment results regarding environmental protection (FY2024, 1st-5 to 4th-8)

Assessed Case		Assessment period			
		FY2024 1st-5 (2024/04/19~ 05/16)	FY2024 2nd-6 (2024/05/17~ 06/27)	FY2024 3rd-7 (2024/06/28~ 08/06)	FY2024 4th-8 (2024/08/07~ 08/25)
Exposure (mGy/ day)	Flatfish	1E-06	8E-07	1E-06	2E-06
	Crab	1E-06	8E-07	1E-06	2E-06
	Brown seaweed	1E-06	1E-06	2E-06	3E-06
Lead Consideration Reference Level (DCRL) Flatfish : 1-10 mGy/day Crab : 10-100mGy/day Brown seaweed : 1-10mGy/day					

Table 6-3-12 Assessment results regarding environmental protection (Comparison of average values for the first year after discharge with the previous assessment)

Assessed case		The first year of discharge (2023/08/24～2024/08/25) (annual average)	Previous assessment K4 tanks	Previous assessment J1-C tanks	Previous assessment J1-G tanks
Exposure (mGy/ day)	Flatfish	9E-07	6E-07	3E-07	7E-07
	Crab	9E-07	7E-07	3E-07	7E-07
	Brown seaweed	1E-06	7E-07	3E-07	8E-07
Derived consideration reference level (DCRL) Flatfish : 1-10 mGy/day Crab : 10-100mGy/day Brown seaweed : 1-10mGy/day					

7. Sea area monitoring results

We have been strengthening and conducting monitoring in the sea area for more than a year since we commenced discharging ALPS treated water into the sea.

This section explains the sea area monitoring results conducted for approximately one year after the commencement of discharge of ALPS treated water into the sea.

For reference, details of the sea area monitoring results are provided in Attachment III.

7-1. Details of strengthened monitoring regarding the discharge of ALPS treated water into the sea

In the previous assessment, we considered the results of the assessment and selected the monitoring locations and nuclides based on the following:

- The results of the dispersion simulation showed that after discharge from the planned discharge point, radioactive materials dispersed quickly in the environment, and at the points used in the Radiological Environmental Impact Assessment (such as the beach about 3 km north of the FDNPS), there were no areas with significantly higher concentrations than the surrounding areas.
- The concentrations of each nuclide in the treated water are below the detection limit, with the exception of the seven major nuclides, tritium, and C-14. This water is diluted 100 times or more before being discharged into the sea and then discharged from the outlet, and is then dispersed in the environment. Even taking into account distribution or concentration in the environment, the concentrations of these nuclides below the detection limit in environmental samples are extremely low, and even if the detection limit were lowered to the feasible extent, it is considered that detection would be difficult.
- Therefore, it is appropriate to screen a wide range of nuclides to be monitored, focusing on those that are particularly easy to observe among the above-mentioned detected nuclides (H-3, Cs-137, and I-129, which tends to accumulate in seaweed), and to conduct detailed analysis if abnormal values are found.

As a result of consideration, In preparation for the commencement of discharge of ALPS treated water into the sea, we have decided to strengthen and expand our sea area monitoring as follows. Specific details of our strengthening and expansion of sea area monitoring are shown in Figures 7-1 and 7-2 and Tables 7-1 and 7-2. All measurements shown here will be conducted as part of the national comprehensive monitoring plan.

- Adding measurement points and objects
  - Considering that we are the entity responsible for discharging the ALPS treated water into the sea, we have decided to focus our monitoring efforts particularly on the area

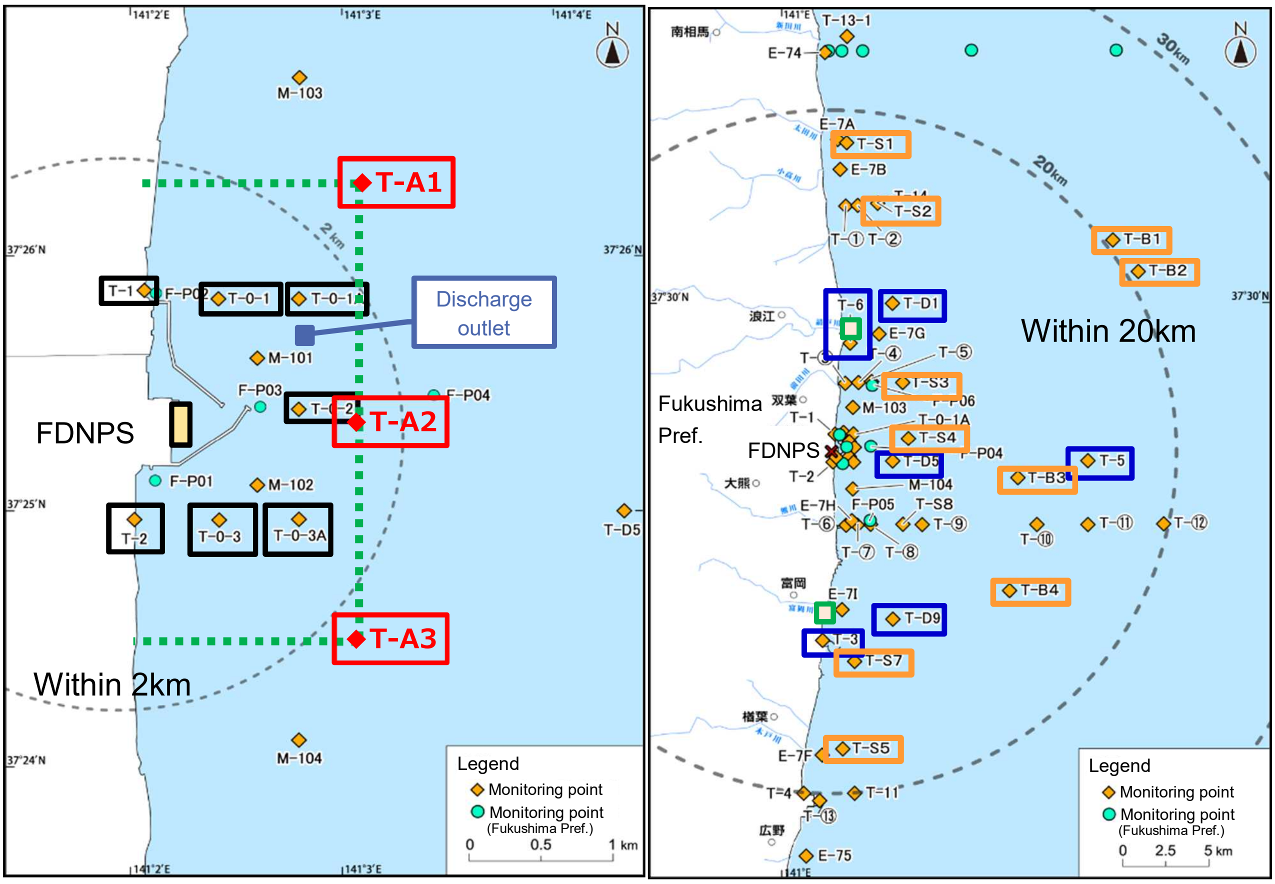
around the discharge outlet, and will increase the number of tritium measurement points in seawater and marine life (fish) by a total of 13 in the vicinity of the FDNPS and along the coast of Fukushima Prefecture (see the red and orange frames in Figure 7-1).

- Regarding seawater monitoring, we will add three new monitoring points on the border of the "area where fishing is not conducted on a daily basis" that was taken into account in this radiological environmental impact assessment on people and the environment, and monitor the seawater there (see red in Figure 7-1).
- In addition, we have decided to conduct monitoring at nine new points "outside the 20km radius off the coast of the FDNPS," where tritium analysis had not been conducted until now and where our dispersion simulations have estimated that the concentration will not exceed the background level in seawater (see the orange frame in Figure 7-2).
- As for fish, currently, cesium, a representative element in measuring the radiological environmental impact[9], is analyzed based on samples taken from 11 locations within a 20km radius off the coast of Fukushima Prefecture (one of which is currently conducting tritium analysis), but to confirm the impact of tritium enrichment, tritium analysis will be conducted on fish taken from a total of 11 locations, including 10 locations where tritium analysis is not currently being conducted (see orange frame in Figure 7-1, right). Tritium analysis will also be conducted on seawater from the same location.
- Seaweed will be collected and analyzed at two new locations outside the port, in addition to the one location within the port where gamma nuclides are currently being analyzed (see the green frame in Figure 7-1). Tritium will be added to the list of nuclides to be measured to check for its concentration, and iodine, which is easily concentrated in seaweed, will also be added to the list of nuclides to be measured.
- However, measurements of nuclides other than tritium and I-129 (Cs-134, Cs-137, strontium-90 (Sr-90), plutonium-238 (Pu-238), and plutonium-239+240 (Pu-239+240)) that will be strengthened and expanded will continue as before[10].

- Increasing frequency
  - As the number of measurement points increases, the frequency of tritium measurements in seawater will be increased at locations where they have been conducted previously (see the blue frame in Figure 7-1, and Table 7-1 for frequency).

[9] This is because it is a nuclide that emits strong gamma rays.
[10] Monitoring will focus on tritium, taking into account the transfer and dispersion processes in the environment, but if any abnormalities are detected during enhanced monitoring, the need for additional monitoring of these nuclides and C-14 will be considered.

- Setting detection limits to align with national targets
    - In order to confirm the dispersion of radioactive materials in seawater and the status of marine life, the detection limits for tritium and I-129 will be set to a level consistent with the national detection limit targets (see the black box in Figure 7-1; see Table 7-1 for detection limits).



<Legend>

【Current Comprehensive Monitoring Plan】
NRA M-○
MOE E-○
Fisheries Agency (seafood)
Fukushima Pref. F-○
TEPCO T-○

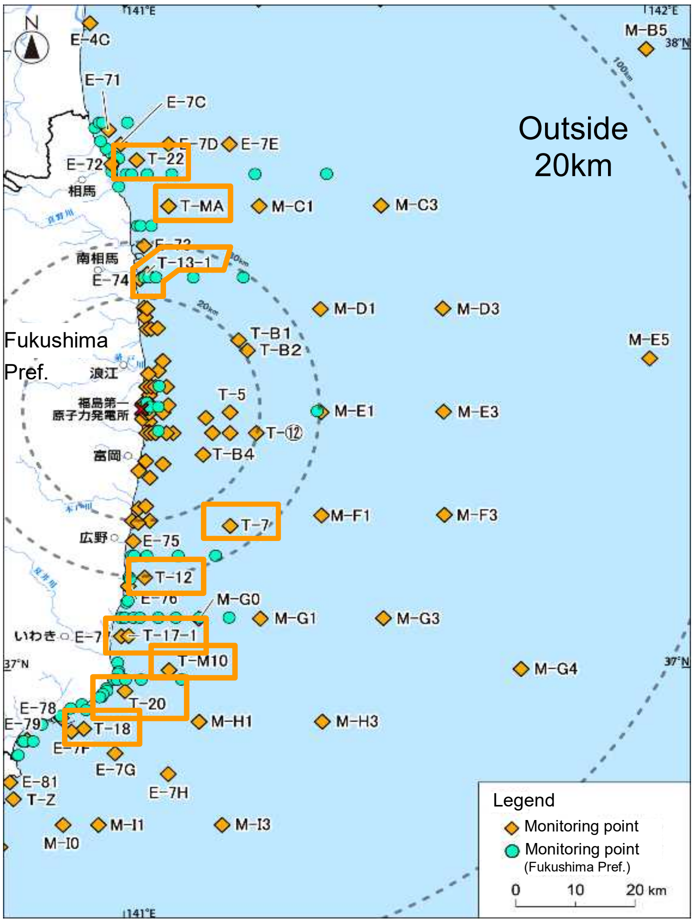
【TEPCO's Strengthening Plan】
: Reviewing of detection limit (seawater)
: Points to newly collect (seawater)
: Points to increase frequency (seawater)
: Added tritium to cesium (seawater, fish)
: Same points as before (seaweed)
: Point to newly collect (seaweed)

: Area where no fishing is conducted on a daily basis*
1.5km east to west
3.5km north to south

*Areas where common fishery rights are not established

Figure 7-1 Sampling points for sea area monitoring that we have strengthened and expanded

(Near the FDNPS/within 20km of the coast)



<Legend>

【Current Comprehensive Monitoring Plan】
NRA M-○
MOE E-○
Fisheries Agency (seafood)
Fukushima Pref. F-○
TEPCO T-○

【TEPCO's Strengthening Plan】
▭ : Added tritium to cesium (seawater)

Figure 7-2 Sampling points for sea area monitoring that we have strengthened and expanded
(Outside 20km of the coast)

Table 7-1 The tritium analysis frequency and the number of sampling points for sea area monitoring conducted by TEPCO near the FDNPS and in coastal waters

Institution	Tritium analysis			
	Frequency	The number of sampling points		
		Seawater	Fish	Seaweed
TEPCO	1 time/week	17 → **20**	–	–
	2 time/month →**1 time/week**	6	–	–
	1 time/month	1 → **20**	1 → **11**	–
	3 time/year	–	–	0 → **2**

Table 7-2 Measurement target samples, nuclides, and detection limits (thick boxes indicate areas that will be strengthened or expanded from the current level)

Targets	Sampling locations	Number of sampled points	Nuclides to be measured	Frequency	Target detection limits
Seawater (surface)	Inside the harbor	10	Cs-134/137	Daily	0.4 Bq/L
			Tritium	1 time/week	3 Bq/L
	Within 2km outside the harbor	2	Cs-134/137	1 time/week	0.001 Bq/L
				Daily	1 → **0.4** Bq/L
		5 → **8**	Cs-134/137	1 time/week	1 → **0.4** Bq/L
		7 → **10**	Tritium	1 time/week	1 → **0.4** Bq/L[*1]
	Within 20km of the coast	6	Cs-134/137	1 time/week	0.001 Bq/L
			Tritium	2 time/month → **1 time/week**[*2]	0.4 → **0.1** Bq/L[*3]
	Within 20km of the coast (Fish collection points)	1	Tritium	1 time/month	0.1 Bq/L
		0 → **10**	**Tritium**	None → **1 time/month**	**0.1 Bq/L**
	Outside 20km of the coast	9	Cs-134/137	1 time/month	0.001 Bq/L
		0 → **9**	**Tritium**	None → **1 time/month**	**0.1 Bq/L**
Fish	Within 20km of the coast	11	Cs-134/137	1 time/month	10 Bq/kg (raw)
			Sr-90 (Only the top 5 samples with high Cs concentration)	Quarterly	0.02 Bq/kg (raw)
		1	Tritium (FWT)	1 time/month	0.1 Bq/L
			Tritium (OBT)		0.5 Bq/L
		0 → **10**	**Tritium (FWT)**[*4]	None → **1 time/month**	**0.1 Bq/L**[*6]
			Tritium (OBT)[*5]		**0.5 Bq/L**
Seaweed	Inside the harbor	1	Cs-134/137	1 time/year → 3 time/year	0.2 Bq/kg (raw)
	Within 2km outside the harbor	0 → **2**	**Cs-134/137**	None → **3 time/year**	**0.2 Bq/kg (raw)**
			I-129		**0.1 Bq/kg (raw)**
			Tritium (FWT)		**0.1 Bq/L**
			Tritium (OBT)		**0.5 Bq/L**

*1：If necessary, detection values are obtained using electrolytic enrichment (an enrichment method that takes advantage of tritium's resistance to electrolysis).

*2：Measurements with a detection limit of 0.1 Bq/L are conducted once a month.

*3：Depending on the installation status of the electrolytic concentration equipment, the limit will be 0.4 Bq/L for the time being.

*4：Tritium exists as water in living tissue and does not remain in the body for long.

*5：Tritium bound to living tissue. It remains in the body longer than free water tritium.

*6：Depending on the installation status of the electrolytic concentration equipment, measurements will be conducted at 0.4 Bq/L for the time being.

7-2. Setting indicators for sea area monitoring (e.g., discharge suspension decision level) and measurements to obtain results quickly

(1) Setting indicators for sea area monitoring (e.g., discharge suspension decision level)

When ALPS treated water is diluted with seawater and discharged into the sea, if monitoring of the surrounding sea area reveals that the discharged water is not being sufficiently dispersed, an indicator for determining whether to "stop discharging" the water as part of the operation of the facility has been set as the "discharge suspension level".

In addition, indicators (investigation level) for taking necessary measures as a preliminary step have been established.

These indicators are shown in Table 7-3.

Table 7-3 Indicators for sea area monitoring

	Discharge suspension level	Investigation level
Near theFDNPS (Within 3km outside the harbor)	700Bq/L	350Bq/L
In front of the FDNPS Within 10km square	30Bq/L	20Bq/L
Actions	Discharge of ALPS treated water stopped More frequent monitoring will be carried out to grasp trends, and weather and ocean conditions will be checked to assess the spread of the material. After checking the equipment and procedures, and the tritium concentration in the sea area, discharge will be resumed.	It will be confirmed that there are no problems with the equipment, operating conditions or operating procedures, and seawater will be sampled again and monitoring will be increased in frequency depending on the results.

(2) Measurements to obtain quick results

Monitoring to set indicators (such as discharge suspension level, etc.) will be carried out will aim for a detection limit of 10 Bq/L in order to quickly grasp the spread of the ALPS-treated water discharged into the sea, and will provide quick results.

The measurement plan to obtain results quickly is shown in Table 7-4 and Figure 7-3.

In order to proceed carefully with the discharge of the ALPS treated water into the sea, measurements were conducted daily at 10 points around the discharge outlet to obtain results quickly from the commencement of discharge on August 24, 2023, until December 25.

In the one year since the commencement of discharge, no measurement results have been confirmed that exceeded the discharge suspension level or the investigation level.

Table 7-4 Monitoring plan for measurements to obtain results quickly

	Around the discharge outlet Total of 4 points*1	**Others 6 points**
During the discharge period and one week after the discharge end date	Quick: daily*2 (Normal: once a week)	Quick: twice a week (Normal: once a week)
During the suspension period (excluding one week from the end of the discharge)	Quick: once a week (Normal: once a week)	Quick: once a month (Normal: once a week)

*1 The selection was made based on three points near the discharge outlet where monitoring is being conducted by the Ministry of the Environment, detection results from our own monitoring, and the direction of ocean currents.
*2 If data are missed for two consecutive days due to bad weather during the discharge period and data is predicted to be missing on the following day (the third day), data will be collected at T-1 and T-2 on the third day.

Quick: Analysis aimed for a detection limit of 10 Bq/L, in order to quickly confirm that the dispersion from the discharge outlet is proceeding as expected
Normal: Analysis aimed at detection limits of 0.4 Bq/L (once a week) and 0.1 Bq/L (once a month) as stipulated in the national comprehensive monitoring plan

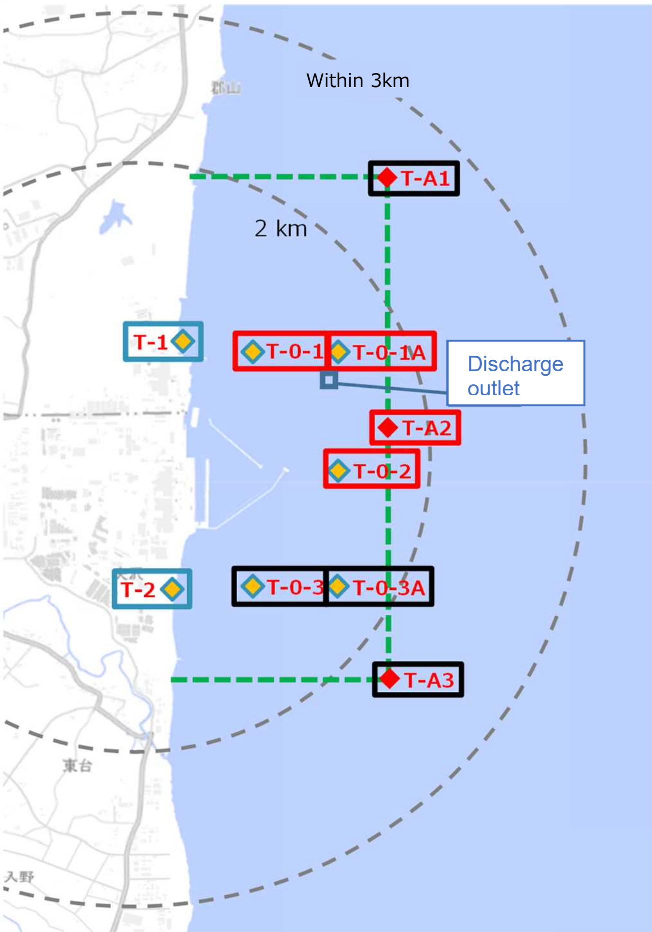


Figure 7-3 Monitoring plan for measurements to obtain results quickly

7-3. Summary of the monitoring result

The strengthened monitoring will begin in April 2022, starting with those areas that are ready. The results of the monitoring are summarized below.

Detailed monitoring results are provided in Appendix III.

(1) Tritium concentration in seawater

The tritium concentration, which rose after the accident, has been on a downward trend, and the detection limit has been reviewed as appropriate.

Figure 7-4 shows the trend in tritium concentration in seawater near the north and south outlets of the FDNPS, which has been implemented since before the accident. By lowering the target detection limit from 1 Bq/L to 0.4 Bq/L from April 2022, it has become possible to grasp lower levels, and it can be seen that the measurement results have returned to the level before the accident both on the north side of the Units 5 and 6 outlets and near the south outlet.

From June 2023, electrolytic concentration equipment has been introduced to continue monitoring in line with the comprehensive monitoring plan's detection limit target of 0.1 Bq/L.

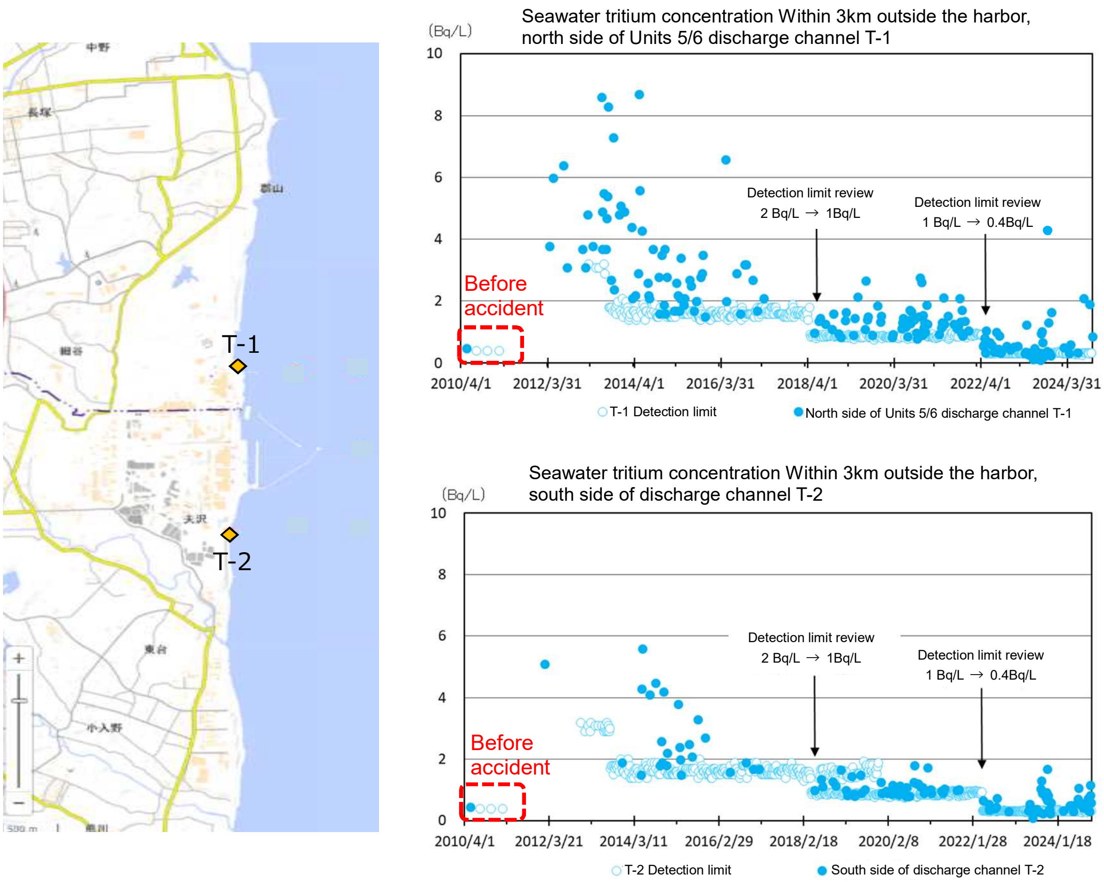


Figure 7-4 Tritium concentration in seawater (Near the north and south outlets of the FDNPS)

Because sea currents along the coast of the FDNPS tend to flow in a north-south direction, the sampling points were grouped according to distance from the FDNPS so that they were roughly symmetrical north and south, and the trends in tritium concentration were compared. The results are shown in Figure 7-5.

Tritium concentrations in seawater were observed to rise during the discharge of ALPS treated water at survey points close to the FDNPS, such as within 3 km of the harbor, but remained well below the indicators set when the discharge commenced. Furthermore, all of these increases were temporary and returned to original levels after the discharge ended.

Furthermore, no increase in concentration was observed away from the FDNPS, within 20 km of the coast and beyond 20 km of the coast, and the discharged ALPS-treated water is dispersed and diluted in the sea, so in areas away from the discharge point, the tritium concentration is roughly the same as that in the sea.

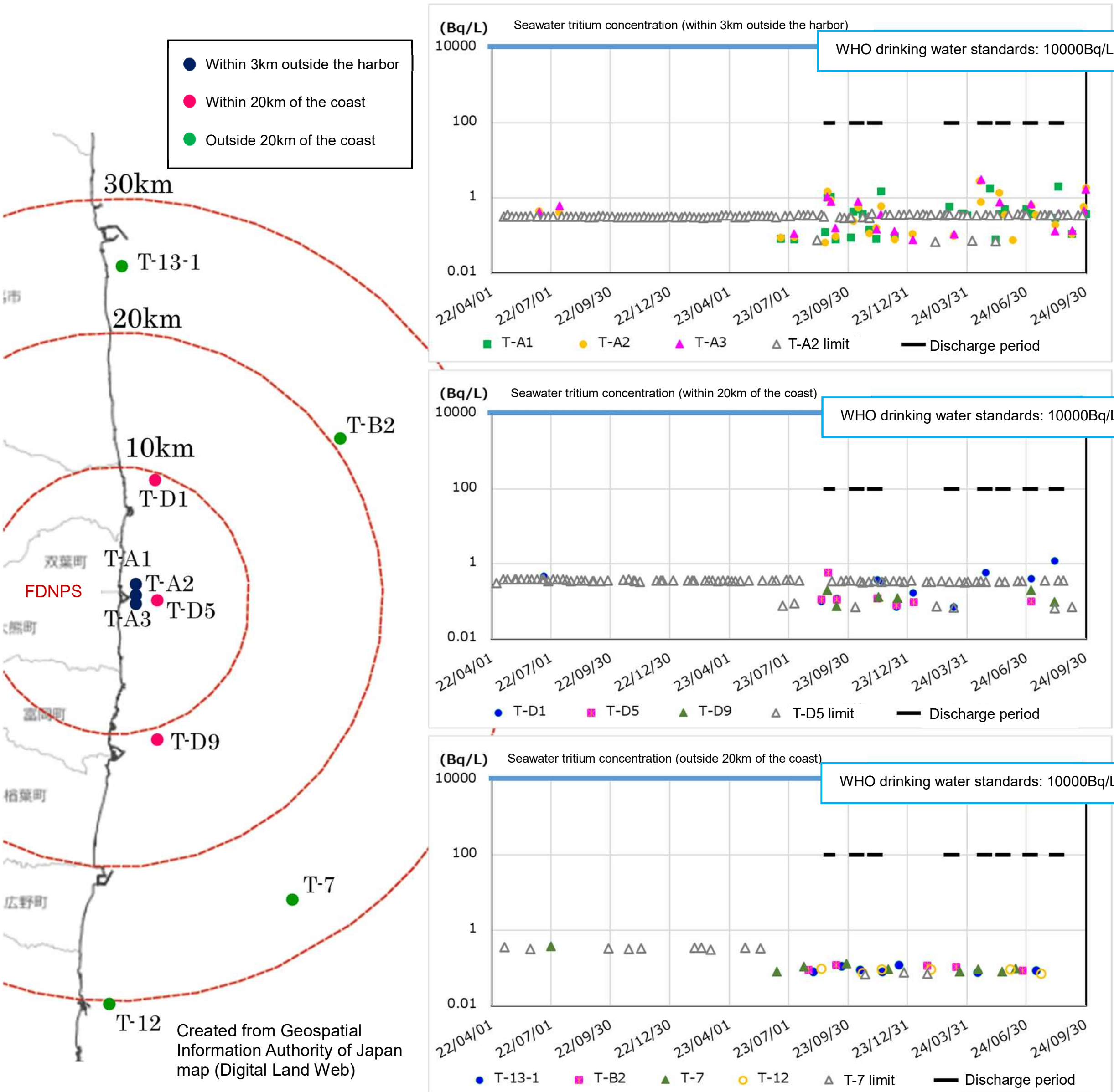


Figure 7-5 Tritium concentration in seawater (Organized by distance)

(2) Tritium concentration in seafood

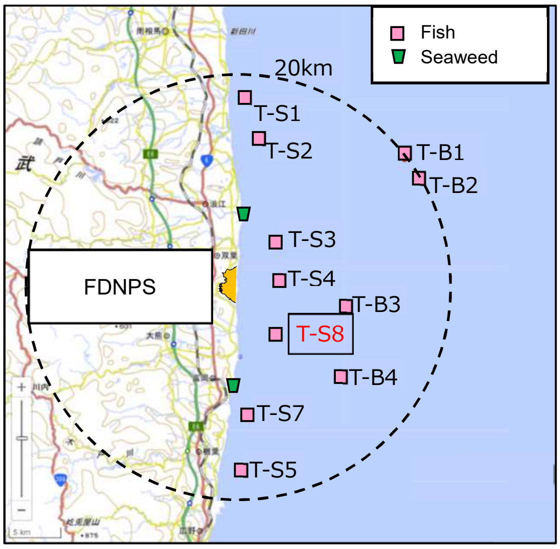
Since 2015, the tritium concentration of fish has been measured at a point 4 km off the coast of Kumagawa (T-S8) south of the FDNPS, mainly for flounder, for tissue free water tritium (TFWT)[11] and organically bound tritium (OBT)[12]. The survey location map is shown in Figure 7-6, and the survey results of the tritium concentration of fish and seawater at the T-S8 point are shown in Figure 7-7. In the measurement results so far, the TFWT concentration is about the same as the tritium concentration in the seawater near the collection point, and no results have been found that show it is concentrated in the bodies of fish. In addition, all OBT, which is difficult to lower the detection limit, has been undetectable.

From fiscal year 2022, the number of sampling points has been increased to 11, but the levels are still the same as those at the previous sampling point (T-S8).

The tritium concentration in the seaweed was approximately the same as that in seawater.

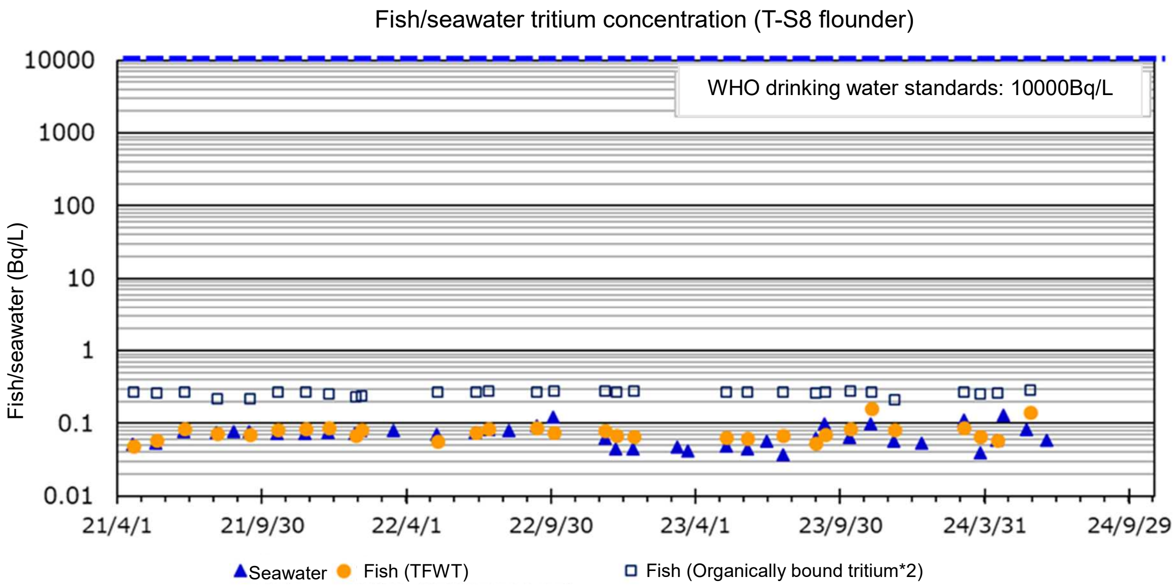
In addition, the I-129 concentration in the seaweed was below the detection limit.

[11] Tritium exists in the form of water in the tissues of plants and animals.
[12] Tritium is bonded to proteins and other organic matter in the bodies of plants and animals, replacing hydrogen.



Created from Geospatial Information Authority of Japan map (Digital Land Web)

Figure 7-6 Fish and seaweed collection points



Note: No organically bound tritium was detected in the fish.

Figure 7-7 Tritium concentrations in fish and seawater (4km offshore Kumagawa (T-S8))

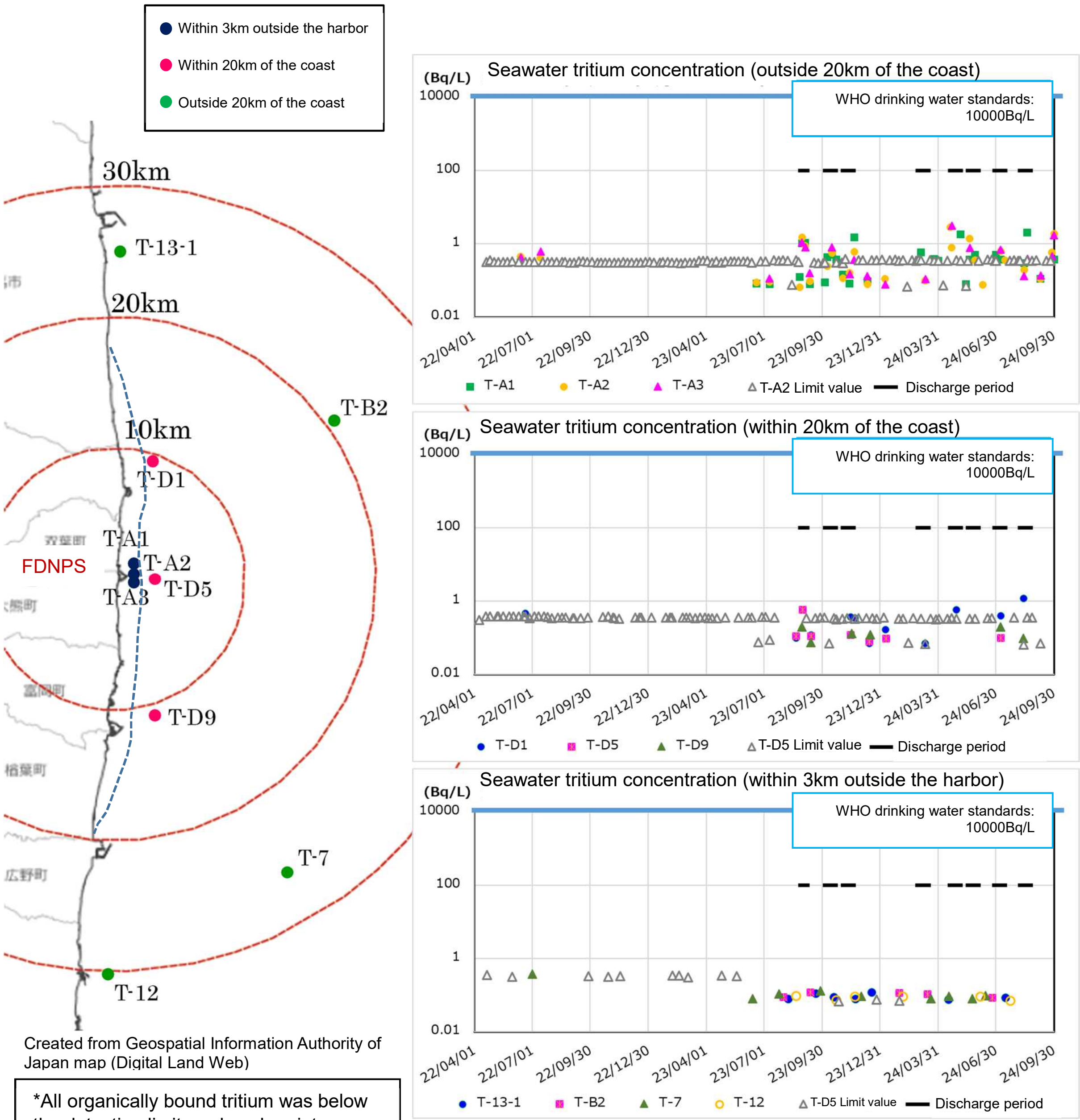
(3) Comparison with dispersion simulation results

In 5-3.(1) Dispersion Simulation Results, the results of the dispersion simulation conducted based on the discharge record and actual meteorological and oceanographic data for one year after the commencement of the discharge are shown. Figure 7-8 shows the range in which the annual average concentration exceeding 0.1 Bq/L in the tritium dispersion simulation results, added to the monitoring results by distance shown in Figure 7-5.

In the dispersion simulation results, the range in which the annual average concentration exceeding 0.1 Bq/L is limited to within a 20 km radius, and no range in which the concentration increases by 1 Bq/L or more was confirmed.

In the monitoring results, no increase in tritium concentration was confirmed outside the 20 km radius. In addition, within the 20 km radius, temporary increases may be observed at some survey points during the ALPS treated water discharge period, but after the end of the discharge, the concentration has decreased to the level before the discharge commenced, and it is considered that the ALPS treated water discharged from the discharge outlet is being dispersed and diluted promptly.

It is considered that the results of sea area monitoring have also confirmed that the diluted ALPS treated water is being dispersed and diluted after the discharge into the sea, as expected from the dispersion simulation results.



*All organically bound tritium was below the detection limit, and each point indicates the detection limit.

------- The range in which the annual average concentration exceeds 0.1 Bq/L in the results of a simulation of tritium dispersion for one year after the commencement of discharge

Figure 7-8 Tritium dispersion simulation results and seawater monitoring results

8. Summary

At the Fukushima Daiichi Nuclear Power Station, the discharge of ALPS treated water into the sea, which commenced on August 24, 2023, has now been one year since the discharge commenced. Using the one-year discharge result and meteorological and oceanographic data for that period, an assessment of human and environmental exposure was conducted.

The results of the dispersion simulation of tritium showed that the annual average concentration increase around the FDNPS was less than 1 Bq/L. In addition, the range of the annual average concentration increase of 0.1 Bq/L was narrower than the seven-year calculation results in the previous assessment. These results are thought to be due to the fact that the amount of tritium discharged in the year after the commencement of discharge was 1.0E+13 Bq, which was smaller than the 2.2E+13 Bq set in the previous assessment. However, seawater monitoring also showed almost no increase in tritium concentration at sampling points far from the FDNPS, and it is thought that the ALPS treated water that was diluted and discharged into the sea is dispersing and diluting in the sea area as expected.

The radiation exposure assessment results for humans, even if they consumed a large amount of seafood, were 2E-05 mSv/year, far below not only the 1mSv/year dose limit for the general public in the ICRP recommendations, but also the 0.05mSv/year that the Nuclear Regulation Authority deemed equivalent to the dose constraint. The results were also comparable to the predicted assessment results in the previous assessment.

The assessment results for environmental protection were also 9E-07 to 1E-06 mGy/day for reference plants and animals set based on the ICRP recommendations, far below the Derived Consideration Reference Level (DCRL) of 1-10mGy/day for flatfish and brown seaweed and 10-100mGy/day for crabs in the ICRP recommendations. The results were also comparable to the predicted assessment results in the previous assessment compiled before the commencement of discharges.

Going forward, we will continue to appropriately reflect the progress of operational considerations, opinions received from various parties, and knowledge gained through cross-checks by third parties, while continuing environmental monitoring and, if necessary, reviewing the assessment and reflecting it in discharge plans, etc.

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Terms

Term	Explanation
Advanced liquid processing system (ALPS)	Water treatment facility which can purify 62 types of radioactive materials other than tritium contained in contaminated water up to a level which meets the standard set by laws. (Multi-Nuclide Removal Facility)
ALPS treated water	Water purified by ALPS, etc. so that the radioactive materials other than tritium surely fall below the regulatory standards for safety. (The sum of the ratios to regulatory concentrations limits of nuclides excluding tritium is less than 1)
Treated water to be purified	Water which is purified by ALPS, etc., but does not meet the regulatory standard for safety (The sum of the ratios to regulatory concentrations limits of nuclides excluding tritium is less than 1)
ALPS treated water, etc.	Generic term for ALPS treated water and treated water to be purified
Strontium-treated water (water before ALPS treatment)	Contaminated water with most of the cesium and strontium removed.
Secondary Treatment	Purifying treated water to be purified in which radioactive materials other than tritium are not purified until the sum of the ratios to regulatory concentrations limits is less than 1 by ALPS, etc.
Groundwater bypass	Measure to reduce the amount of groundwater approaching the reactor building, etc., by pumping groundwater flowing from the mountain side to the sea side from a well far away from the reactor building, etc., and discharging it to the sea after verification that the discharge standard is met.
Subdrain	Measure to perform purification by pumping with the subdrain (well near the building) and discharge the sea after verification that the discharge standard is met, in order to reduce the amount of contaminated water increased by inflow of groundwater into the reactor building, etc.
Regulatory concentration limit	Standard of discharge of radioactive waste into the sea set in "Pronouncement which set the dose limit based on the regulations such as the Regulations on Business of Smelting of Nuclear Source Materials or Nuclear Fuel Materials." If the corresponding radioactive waste contains radioactive materials, the sum of the ratios to regulatory concentrations limits has to be less than 1.
Target discharge control value	Target control value set for each nuclide to be discharge in order to control the amount of radioactive materials discharged by the nuclear power plant per year. For the FDNPS, the target discharge control value of tritium before the accident is set to 22 trillion Bq (2.2E+13 Bq).
WHO Guidelines for Drinking Water Quality	Guidelines for drinking water quality set by the World Health Organization for securing of the safety of drinking water. These guidelines show water quality which do not cause any problem when a person keep drinking the water from the viewpoints of radioactive materials, microorganisms, chemical substances, etc. As radioactive material concentrations, 10Bq/L and 10,000Bq/L are shown for Cs-137 and tritium, respectively.
International Commission on Radiological Protection (ICRP) recommendation	Document that shows the Basic Policy (concept) of radiation protection recommended by ICRP and the basic numerical standards.
International Atomic Energy Agency (IAEA) safety standard document	Document issued by the IAEA which shows the standards for protection of safety such as human health, lives, and assets in using radiation and radioactive materials as activities for securing nuclear safety. It consists of the safety principles, the safety requirements, the safety guidelines, etc., and shows the policy, the standards, etc., to follow. The IAEA safety

Term	Explanation
	standard document is prepared reflecting the comments of all IAEA member countries.
Representative person	Virtual person set as the target of exposure in the exposure assessment of public for consideration of radiation protection. Consider environments, life habits, etc., in which the exposure amounts increase, etc.
Potential exposure	Exposure caused by possible events in operation or events or possible events sequences including accidents of radiation sources or failures and operation mistakes of equipment. It was considered for the future. It is used for consideration of radiation protection.
An area where no fishing is conducted on a daily basis	Area where members of fisheries cooperatives jointly use a certain water area and rights to perform fishing (common fishery rights) are not established. Areas where common fishery rights are not established.
Area sea model	Numerical analysis model of tidal currents developed in Rutgers University in the U.S.
Submersion model	External exposure dose calculation model assuming the state that people are surrounded by radioactive materials (submersion).
Concentration factor	Expedient factor indicating the relationship between the radioactive nuclide concentration in marine organisms (per wet weight) in marine organisms (in principle, edible parts) and the radioactive nuclide concentration in the seawater in the environment where such organisms live, which is used for the assessment model for transfer to organisms.
Dose conversion factor for the effective dose	Conversion factor to assess the human exposure amount from radiation from radioactive materials.
Effective dose factor	Conversion factor to assess the human internal exposure dose from the inhalation amount and ingestion of radioactive nuclides.
Environmental protection	Protecting organisms other than human from adverse effects of ionizing radiation.
Reference plants and animals	Specific types of plants and animals assumed in order to associate radiation exposure from the environment with the dose and impact.
Dose conversion coefficients for plants and animals	Conversion factor for simplified calculations of internal and external exposure doses to organism by radioactive nuclides in the environment.
Derived consideration reference level (DCRL)	Range of the dose rate with a range of one order of magnitude set for each species advocated by ICRP. Dose rate level at which the impact has to be considered if is exceeded. (Derived consideration reference level)
Concentration ratio	Transfer factor from an empirical calculation of the ratio of the (overall) radioactive nuclide concentration in aquatic organisms to the underwater concentration in the environment to be used for radiation exposure to plants and animals from the environment.
Distribution coefficient	Ratio of radioactive materials at which the concentration in the seawater (Bq/L) and the concentration in the seabed sediment (Bq/kg) are in the equilibrium state. It is used for the assessment of transfer of radioactive materials from the seawater to seabed sediment.

Preparation member（As of November 29, 2024）

For preparation of this report, in-house personnel with knowledge on the radiological impact assessment were appointed and external experts were invited as members in three fields, which are especially important for the radiological impact assessment: human radiation protection, environmental protection, and marine dispersion calculation.

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・Secretariat

Gaku Sato	(Tokyo Electric Power Company Holdings, Inc.)
Kunifumi Tanaka	(Tokyo Electric Power Company Holdings, Inc.)

End

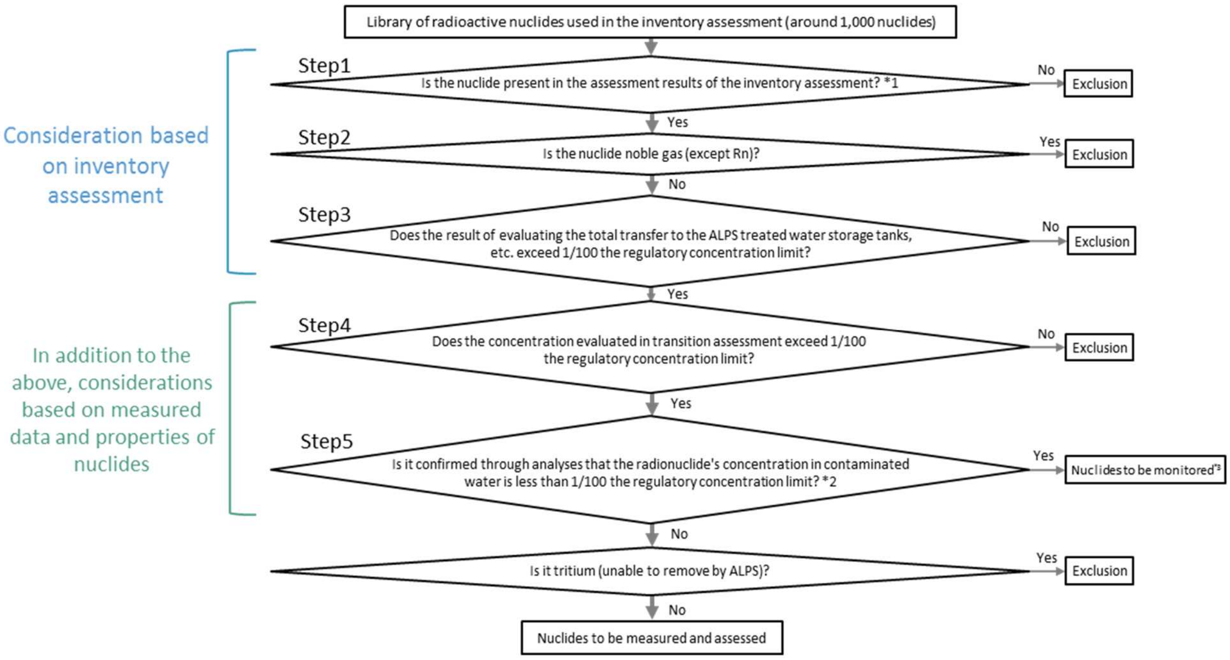
Attachment I: Addition of nuclides to be measured and assessed

I-1. Overview

Before discharging ALPS treated water into the sea, we will confirm whether the ALPS treated water to be discharged satisfies the discharge criteria (the sum of the ratios of the notified concentration limits of radioactive nuclides excluding tritium is less than 1). At the time of preparing the Radiation Environmental Impact Assessment Report (design stage), the target nuclides (nuclides to be measured and assessed) were set at 63 nuclides, consisting of the 62 nuclides to be removed by ALPS plus carbon-14. After that, at the previous assessment, we reviewed the nuclides to be measured and assessed, and selected 29 nuclides that existed in significant concentrations (1/100 or more of the notified concentration limit) in the contaminated water in past analyses according to the flow below (see Figure I-1). (For details, see Attachment I of the previous assessment)

However, since it is possible that the concentrations of radioactive substances in contaminated water may fluctuate in conjunction with the progress of decommissioning, once a year we confirm that six nuclides as nuclides to be monitored that may theoretically be present in contaminated water do not exist at significant levels, even though no significant concentrations have been found during past analysis. (Investigative analysis).

When we conducted our FY2023 investigative analysis in water sampled from the ALPS inlet, the results showed that there is Cd-113m. Thus, we have added Cd-113m to the nuclides to be measured/assessed since the fourth discharge of ALPS treated water in FY2024 (8th time in total).



*1 : The inventory assessment decay period has been set properly in accordance with when the selection results are used (initially set to be 2023 (12 years after the accident))

*2 : The maximum detection value is used for nuclides that have been detected in the past, and the minimum detection limit is used for nuclides that have never been detected

*3 : Nuclides that are continually measured to confirm that there are no significant concentrations in contaminated water

Figure I-1 Process flow for selecting nuclides to be measured and assessed

I-2. Nuclides subject to measurement and evaluation to date

I-2-1. Nuclides subject to measurement and evaluation and nuclides not subject to measurement and evaluation

During the previous assessment, the nuclides subject to measurement and assessment were reviewed, and at the time of the commencement of discharge into the sea of the ALPS treated water, the 29 nuclides in Table I-1 were to be analyzed and measured and assessed in the ALPS treated water prior to discharge into the sea.

On the other hand, of the nuclides subject to ALPS removal, 39 nuclides other than the 29 mentioned above (Table I-2) were excluded from measurement and assessment, but it was decided that these would be voluntarily measured prior to discharge to confirm that they were not present at significant concentrations (1/100 or more of the concentration limit required by notification).

Table I-1 Nuclides to be measured and assessed (29 nuclides)

	Measurement target nuclide (half-life)		Measurement target nuclide (half-life)
1	C-14（5700 years）	16	Ce-144（280 days）
2	Mn-54（310 days）	17	Pm-147（2.6 years）
3	Fe-55（2.7 years）	18	Sm-151（90 years）
4	Co-60（5.3 years）	19	Eu-154（8.6 years）
5	Ni-63（100 years）	20	Eu-155（4.8 years）
6	Se-79（300,000 years）	21	U-234（250,000 years）
7	Sr-90（29 years）	22	U-238（4.5 billion years）
8	Y-90（64 hours）	23	Np-237（2.1 million years）
9	Tc-99（210,000 years）	24	Pu-238（88 years）
10	Ru-106（370 days）	25	Pu-239（24000 years）
11	Sb-125（2.8 years）	26	Pu-240（6600 years）
12	Te-125m（57 days）	27	Pu-241（14 years）
13	I-129（16 million years）	28	Am-241（430 years）
14	Cs-134（2.1 years）	29	Cm-244（18 years）
15	Cs-137（30 yaers）		

Table I-2 Nuclides not subject to measurement and evaluation (39 nuclides)

	Nuclides (half-life)		Nuclides (half-life)
1	Fe-59（45 days）	21	Te-129（70 minutes）
2	Co-58（71 days）	22	Te-129m（34 days）
3	Zn-65（240 days）	23	Cs-135（3 million years）
4	Rb-86（19 days）	24	Cs-136（13 days）
5	Sr-89（51 days）	25	Ba-137m（3 minutes）
6	Y-91（59 days）	26	Ba-140（13 days）
7	Nb-95（35 days）	27	Ce-141（32 days）
8	Ru-103（40 days）	28	Pr-144（17 minutes）
9	Rh-103m（56 minutes）	29	Pr-144m（7 minutes）
10	Rh-106（30 seconds）	30	Pm-146（6 years）
11	Ag-110m（250 days）	31	Pm-148（5 days）
12	Cd-113m（14 years）	32	Pm-148m（41 days）
13	Cd-115m（45 days）	33	Eu-152（13 years）
14	Sn-119m（290 days）	34	Gd-153（240 days）
15	Sn-123（130 days）	35	Tb-160（72 days）
16	Sn-126（100,000 years）	36	Am-242m（150 years）
17	Sb-124（60 days）	37	Am-243（7400 years）
18	Te-123m（120 days）	38	Cm-242（160 days）
19	Te-127（9 hours）	39	Cm-243（29 years）
20	Te-127m（110 days）		

I-2-2. Monitored nuclides

When reviewing the nuclides to be measured and assessed, the six nuclides in Table I-3, which have not been detected in significant concentrations in past analyses of contaminated water and treated water but which theoretically may be present in contaminated water, were designated as nuclides to be monitored for continued confirmation of their significant presence in the contaminated water.

As for the nuclides to be monitored, it was decided that, as part of the investigation and analysis, it would be confirmed once a year that the nuclides to be monitored were not present in significant concentrations in the contaminated water before ALPS treatment, and their presence would be investigated.

In addition, if the investigation and analysis confirmed that nuclides to be monitored were present in significant concentrations, the nuclides selected as targets for measurement and assessment would be reassessed.

Table I-3 Nuclides surveyed and analyzed (6 nuclides)

	Measurement target nuclide (half-life)
1	Cl-36（300,000 years）
2	Nb-93m（16 years）
3	Nb-94（20,000 years）
4	Mo-93（4000 years）
5	Cd-113m（14 years）
6	Ba-133（11 years）

I-3. Results of the survey and analysis in FY2023 (analysis of monitored nuclides)

The results of the survey and analysis of the contaminated water before ALPS treatment in FY2023 are shown in Table I-4.

Of the six monitored nuclides, five (Cl-36, Nb-93m, Nb-94, Mo-93, Ba-133) were below the detection limit, but Cd-113m was detected at more than 1/100 of the notified concentration limit.

As a result, from the fourth discharge in FY2024 (8th discharge overall), Cd-113m has been added to the list of nuclides to be measured and assessed.

Cd-113m is a nuclide targeted for removal by ALPS, and all voluntary measurements conducted before discharges from the first discharge in FY2023 (1st discharge overall) to the third discharge in FY2024 (7th discharge overall) showed no detection.

Table I-4 Nuclides surveyed and analyzed (6 nuclides)

Nuclides	Sampling date	Result (Bq/L)		1/100 of the notification concentration limit (Bq/L)	Note
Cl-36	2024/2/7	<	1.7	9	
Nb-93m	2024/2/7	<	14	70	
Nb-94	2024/2/7	<	0.88	5	
Mo-93	2024/2/7	<	1.9	3	
Cd-113m	2024/2/7		2.9	0.4	Exceeds 1/100 of the notification concentration limit
Ba-133	2024/2/7	<	4.9	5	

Attachment 2: Contribution of undetected nuclides

The eight discharges covered in this report include many nuclides for which all analysis results were undetectable (hereafter referred to as undetectable nuclides) in the measurements and assessments prior to the discharge. As shown in 5-2.(1) "Source term (annual discharge amount by nuclide)," the source term is set by conservatively setting the discharge amount assuming that nuclides below the detection limit are included at the detection limit, so the exposure assessment results include the contribution of undetectable nuclides.

Here, in order to confirm the contribution of undetectable nuclides in the results of the exposure assessment, the exposure assessment results for each nuclide were tabulated separately for detected and undetectable nuclides.

The tabulated results are shown in Tables II-1 to II-4, and the exposure assessment results by nuclide for the assessment results one year after the start of the discharge are shown in Tables II-5 to II-8.

Compared to the previous assessment, the results of the assessment in this report show an increase in exposure from undetectable nuclides, and as a result, the assessment values for some of the exposure assessment results are higher than in the previous assessment.

This difference is due to changes in the detection limits for some nuclides (Fe-55, Ce-144, Eu-155, etc.). The conclusion of the assessment results in this report that the levels are extremely small compared to international standards remains unchanged from the previous assessment.

Table II-1 Contribution of detected and undetected nuclides (human exposure, high seaweed ingestion)

Assessment Case	Source Term	One year after discharge begins	Previous assessment*		
			K4 tanks	J1-C tanks	J1-G tanks
Exposure* (mSv/year)	Detected nuclides	7.8E-06	2.6E-05	4.3E-06	6.9E-06
	Undetectable nuclides	1.2E-05	5.5E-06	1.9E-06	5.4E-06
	Total	2.0E-05	3.2E-05	6.2E-06	1.2E-05
Proportion of undetectable nuclides in the total		61%	17%	31%	44%

* The previous assessment was for 30 nuclides excluding Cd-113m.

Table II-2 Contribution of detected and undetected nuclides (environmental protection, flatfish)

Assessment Case	Source Term	One year after discharge begins	Previous assessment*		
			K4 tanks	J1-C tanks	J1-G tanks
Exposure* (mSv/year)	Detected nuclides	2.8E-07	5.1E-07	1.1E-07	2.4E-07
	Undetectable nuclides	6.2E-07	1.1E-07	1.8E-07	4.8E-07
	Total	9.0E-07	6.2E-07	2.9E-07	7.2E-07
Proportion of undetectable nuclides in the total		69%	18%	61%	66%

* The previous assessment was for 30 nuclides excluding Cd-113m.

Table II-3 Contribution of detected and undetected nuclides (environmental protection, crabs)

Assessment Case	Source Term	One year after discharge begins	Previous assessment*		
			K4 tanks	J1-C tanks	J1-G tanks
Exposure* (mSv/year)	Detected nuclides	2.8E-07	5.1E-07	1.1E-07	2.4E-07
	Undetectable nuclides	6.4E-07	1.5E-07	1.9E-07	4.9E-07
	Total	9.2E-07	6.6E-07	3.0E-07	7.3E-07
Proportion of undetectable nuclides in the total		69%	23%	52%	68%

* The previous assessment was for 30 nuclides excluding Cd-113m.

Table II-4 Contribution of detected and undetected nuclides (environmental protection, seaweed)

Assessment Case	Source Term	One year after discharge begins	Previous assessment*		
			K4 tanks	J1-C tanks	J1-G tanks
Exposure* (mSv/year)	Detected nuclides	3.1E-07	5.5E-07	1.2E-07	2.5E-07
	Undetectable nuclides	8.6E-07	2.0E-07	2.1E-07	5.7E-07
	Total	1.2E-06	7.5E-07	3.3E-07	8.2E-07
Proportion of undetectable nuclides in the total		74%	26%	64%	70%

* The previous assessment was for 30 nuclides excluding Cd-113m.

Table II-5 Breakdown of radiation exposure assessment results by nuclide (human protection, high ingestion of seafood)

Nuclides	Exposure assessment results (mSv/year)	Note
Fe-55	9.9E-06	All nuclides were undetectable
I-129	4.9E-06	
C-14	2.2E-06	
Cd-113m	7.2E-07	All nuclides were undetectable
Se-79	3.7E-07	All nuclides were undetectable
Co-60	3.2E-07	
H-3	2.0E-07	
Pu-240	1.7E-07	All nuclides were undetectable
Pu-239	1.7E-07	All nuclides were undetectable
Am-241	1.5E-07	All nuclides were undetectable
Pu-238	1.5E-07	All nuclides were undetectable
Eu-155	1.5E-07	All nuclides were undetectable
Pu-241	1.0E-07	All nuclides were undetectable
Cm-244	6.8E-08	All nuclides were undetectable
Cs-137	6.3E-08	
Tc-99	5.4E-08	
Ce-144	4.6E-08	All nuclides were undetectable
Ni-63	2.9E-08	All nuclides were undetectable
Eu-154	2.7E-08	All nuclides were undetectable
Ru-106	2.5E-08	All nuclides were undetectable
Np-237	1.8E-08	All nuclides were undetectable
Sb-125	1.6E-08	
Cs-134	1.3E-08	All nuclides were undetectable
Mn-54	8.5E-09	All nuclides were undetectable
Sr-90	2.9E-09	
Pm-147	2.9E-09	All nuclides were undetectable
U-234	2.9E-09	All nuclides were undetectable
U-238	2.6E-09	All nuclides were undetectable
Te-125m	9.2E-10	
Y-90	1.5E-10	
Sm-151	4.2E-11	All nuclides were undetectable
Total	2.0E-05	

Table II-6 Breakdown of radiation exposure assessment results by nuclide (environmental protection, flatfish)

Nuclides	Exposure assessment results (mSv/year)	Note
Co-60	2.6E-07	
Ce-144	2.3E-07	All nuclides were undetectable
Eu-154	1.8E-07	All nuclides were undetectable
Fe-55	1.2E-07	All nuclides were undetectable
Mn-54	4.2E-08	All nuclides were undetectable
Eu-155	2.7E-08	All nuclides were undetectable
C-14	1.7E-08	
Ru-106	3.9E-09	All nuclides were undetectable
H-3	1.9E-09	
Am-241	1.2E-09	All nuclides were undetectable
Se-79	1.1E-09	All nuclides were undetectable
Cd-113m	9.6E-10	All nuclides were undetectable
Cs-137	8.4E-10	
Pu-238	7.5E-10	All nuclides were undetectable
Pu-240	7.0E-10	All nuclides were undetectable
Pu-239	7.0E-10	All nuclides were undetectable
Cs-134	2.0E-10	All nuclides were undetectable
Sb-125	1.5E-10	
Ni-63	8.9E-11	All nuclides were undetectable
Pm-147	8.2E-11	All nuclides were undetectable
Cm-244	8.0E-11	All nuclides were undetectable
Sr-90	4.7E-11	
Pu-241	2.0E-11	All nuclides were undetectable
Tc-99	1.7E-11	
Te-125m	1.5E-11	
Np-237	6.1E-12	All nuclides were undetectable
I-129	3.9E-12	
U-234	2.3E-12	All nuclides were undetectable
U-238	2.1E-12	All nuclides were undetectable
Sm-151	6.2E-13	All nuclides were undetectable
Y-90	0.0E+00	Assessed with parent nuclide Sr-90
Total	9.0E-07	

Table II-7 Breakdown of radiation exposure assessment results by nuclide (environmental protection, crabs)

Nuclides	Exposure assessment results (mSv/year)	Note
Co-60	2.6E-07	
Fe-55	2.4E-07	All nuclides were undetectable
Eu-154	1.7E-07	All nuclides were undetectable
Ce-144	1.4E-07	All nuclides were undetectable
Mn-54	3.9E-08	All nuclides were undetectable
Eu-155	2.6E-08	All nuclides were undetectable
C-14	1.4E-08	
Cm-244	1.0E-08	All nuclides were undetectable
Cd-113m	4.3E-09	All nuclides were undetectable
Am-241	4.0E-09	All nuclides were undetectable
Tc-99	3.9E-09	
Ru-106	3.9E-09	All nuclides were undetectable
I-129	2.3E-09	
Ni-63	2.1E-09	All nuclides were undetectable
H-3	1.9E-09	
Pm-147	1.1E-09	All nuclides were undetectable
Se-79	1.1E-09	All nuclides were undetectable
Cs-137	8.0E-10	
Pu-238	5.1E-10	All nuclides were undetectable
Pu-240	4.8E-10	All nuclides were undetectable
Pu-239	4.8E-10	All nuclides were undetectable
Sr-90	2.6E-10	
Cs-134	1.8E-10	All nuclides were undetectable
Sb-125	1.5E-10	
Np-237	1.1E-10	All nuclides were undetectable
Te-125m	1.6E-11	
Pu-241	1.4E-11	All nuclides were undetectable
Sm-151	1.3E-11	All nuclides were undetectable
U-234	9.2E-12	All nuclides were undetectable
U-238	8.2E-12	All nuclides were undetectable
Y-90	0.0E+00	Assessed with parent nuclide Sr-90
Total	9.2E-07	

Table II-8 Breakdown of radiation exposure assessment results by nuclide (environmental protection, seaweed)

Nuclides	Exposure assessment results (mSv/year)	Note
Fe-55	3.6E-07	All nuclides were undetectable
Co-60	2.8E-07	
Ce-144	2.4E-07	All nuclides were undetectable
Eu-154	1.8E-07	All nuclides were undetectable
Mn-54	4.2E-08	All nuclides were undetectable
Eu-155	2.7E-08	All nuclides were undetectable
Tc-99	1.2E-08	
C-14	1.1E-08	
Ru-106	4.6E-09	All nuclides were undetectable
Cm-244	3.9E-09	All nuclides were undetectable
Am-241	1.3E-09	All nuclides were undetectable
Pu-238	1.2E-09	All nuclides were undetectable
Pu-240	1.2E-09	All nuclides were undetectable
Pu-239	1.2E-09	All nuclides were undetectable
I-129	9.8E-10	
Cs-137	8.3E-10	
Pm-147	7.6E-10	All nuclides were undetectable
H-3	7.1E-10	
Ni-63	6.6E-10	All nuclides were undetectable
Cs-134	1.9E-10	All nuclides were undetectable
Sb-125	1.9E-10	
Te-125m	1.4E-10	
Cd-113m	7.8E-11	All nuclides were undetectable
Se-79	4.7E-11	All nuclides were undetectable
Sr-90	4.6E-11	
Pu-241	3.3E-11	All nuclides were undetectable
U-234	2.2E-11	All nuclides were undetectable
U-238	1.9E-11	All nuclides were undetectable
Np-237	1.5E-11	All nuclides were undetectable
Sm-151	5.4E-12	All nuclides were undetectable
Y-90	0.0E+00	Assessed with parent nuclide Sr-90
Total	1.2E-06	

AttachmentⅢ　Monitoring result regarding the discharge of ALPS treated water into the sea

We have been strengthening and conducting monitoring in the sea area for more than a year before we commenced discharging ALPS treated water into the sea.

In this section, the results of sea area monitoring up to about 1 year after the commencement of discharge of ALPS treated water into the sea are supplemented with the content in the main text chapter 7, and the state of sea area monitoring related to cesium-134, cesium-137, and plutonium, which have been conducted based on the National Comprehensive Monitoring Plan, in order to understand the status of the spread and transfer of radioactive materials discharged into the environment due to accidents in March 2011.

The monitoring plan is presented in the main text 7-1.

Ⅲ-1. Strengthened monitoring result of the discharge of ALPS treated water into the sea

Ⅲ-1-1．Seawater

Trends in tritium concentration since April 2021 are shown in Figure. III-1-1 - III-1-4.

Since the commencement of the discharge of ALPS treated water on August 24, 2023, an increase in tritium concentration has been observed at survey points around the discharge outlet during the discharge period, but all survey points have been below the investigation level and other indicators set at the commencement of the discharge. In addition, based on the results of a dispersion simulation at the time of discharge into the sea in the radiological environmental impact assessment, it is considered to be within the expected range.

＜Within 3km outside the port>(Figure. III-1-1)

Tritium has been monitored since April 18, 2022 by lowering the detection limits so that concentration changes can be monitored. However, no change in tritium concentration was observed until the discharge of ALPS treated water was commenced.

Since the commencement of the discharge of ALPS treated water, increased tritium concentration has been observed at the survey points around the discharge outlet during the discharge period. However, all of these concentrations are below the investigation level and other indicators.

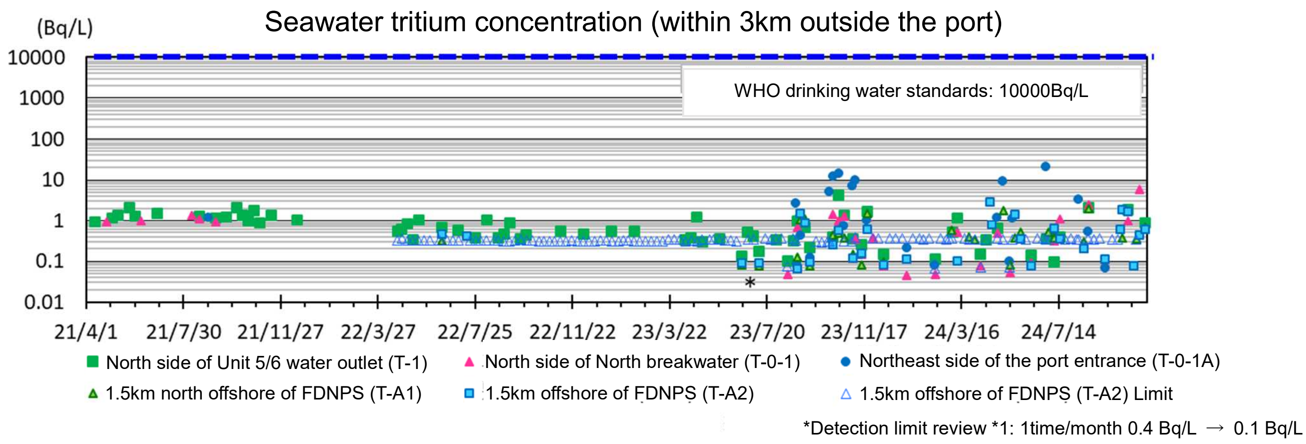
Also at the point of investigation where an increase is observed, the concentration rises temporarily, and after the discharge is completed, the concentration falls to the concentration before the discharge, and it is considered to be within the range assumed from the results of the dispersion simulation at the time of discharge into the sea in the Radiological Environmental Impact Assessment (Construction stage / Revised version).

＜Within 20km of the coast> (Figure. III-1-2 to Figure. III-1-3)

Tritium has been detected at the sampling points within 20km of the coast since the commencement of discharge of ALPS treated water, but both are well below the indicators such as the investigation level. Therefore, it is considered to be within the scope of the assumption based on the results of the dispersion simulation during the discharge into the sea in the radiological environmental impact assessment.

＜Outside 20km of the coast> (Figure. III-1-4)

No changes in tritium concentration have been observed since the commencement of discharge of ALPS treated water.



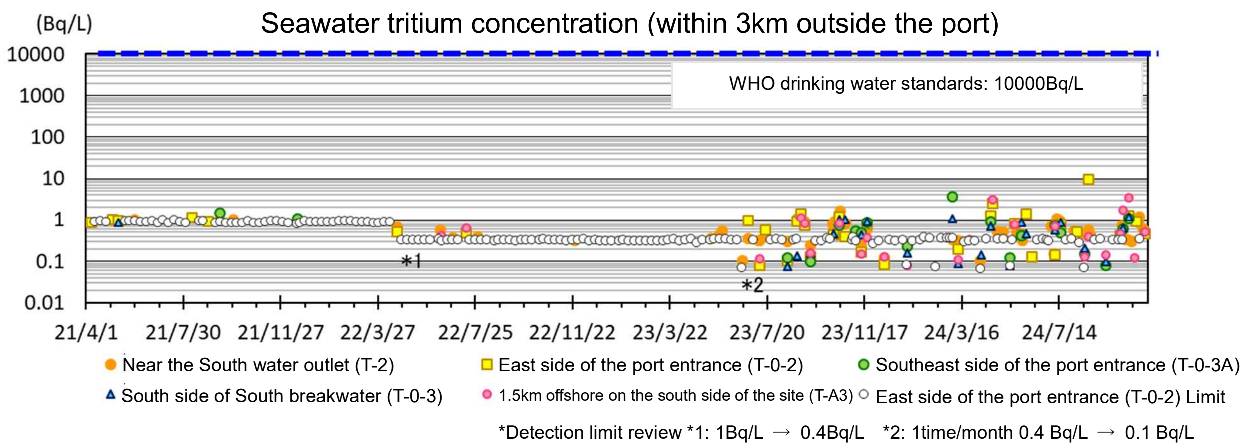


Figure. III-1-1 Tritium concentration within 3km outside the port

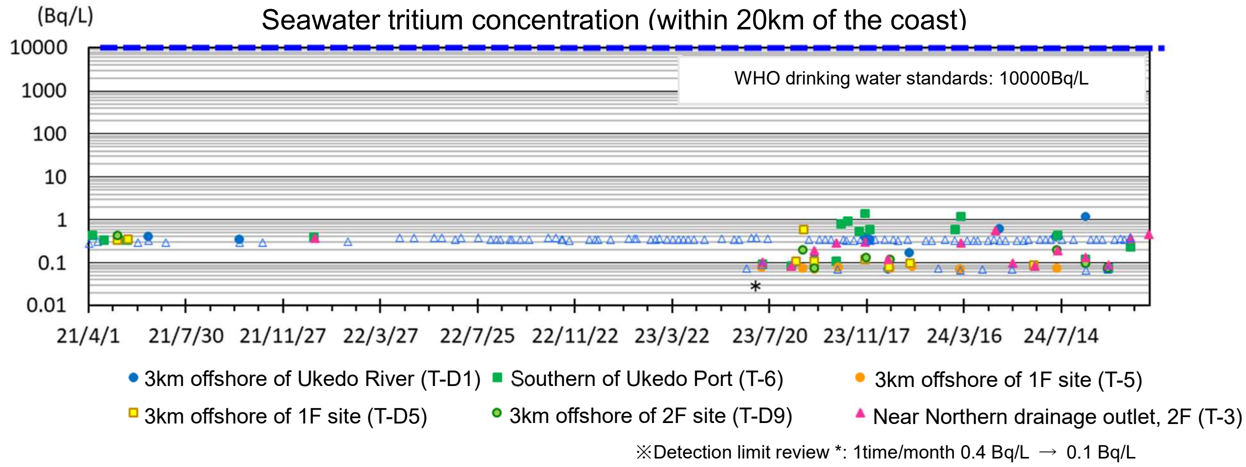


Figure. III-1-2　Tritium concentration within 20km of the coast

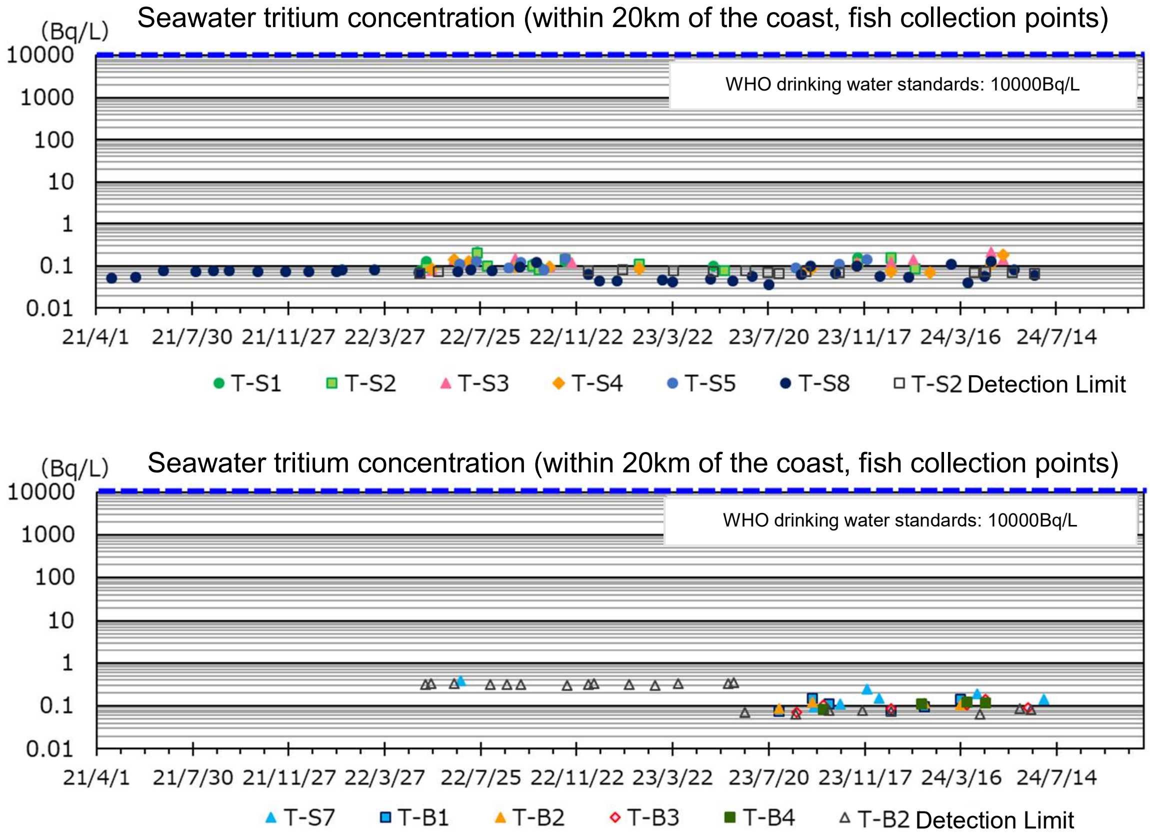
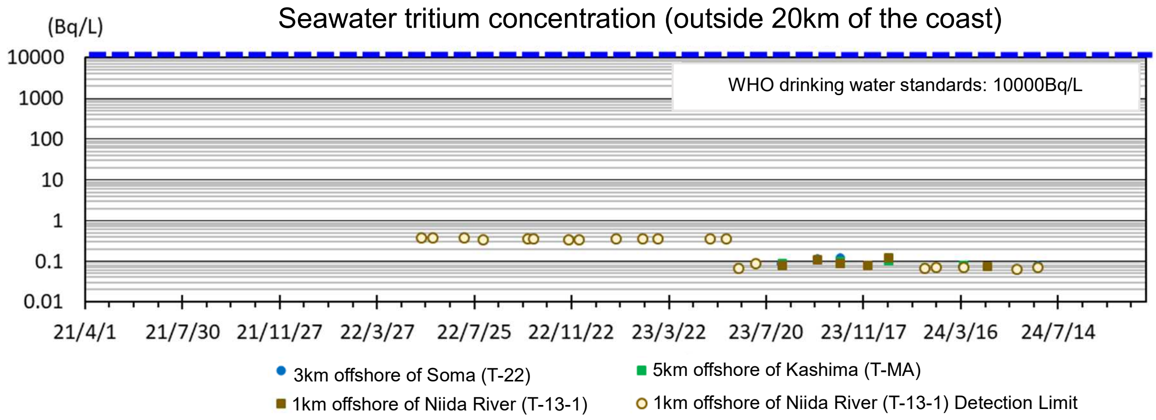


Figure. III-1-3　Tritium concentration within 20km of the coast (fish collection points)



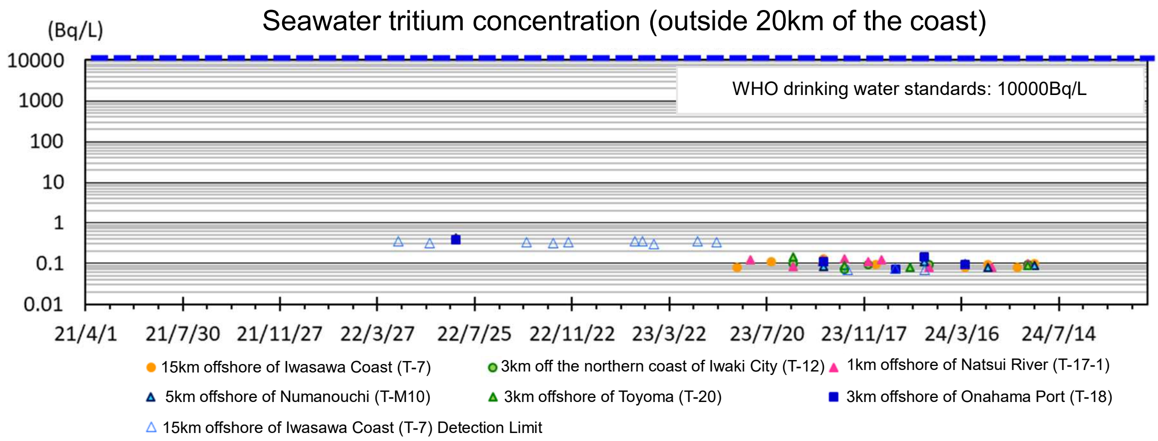


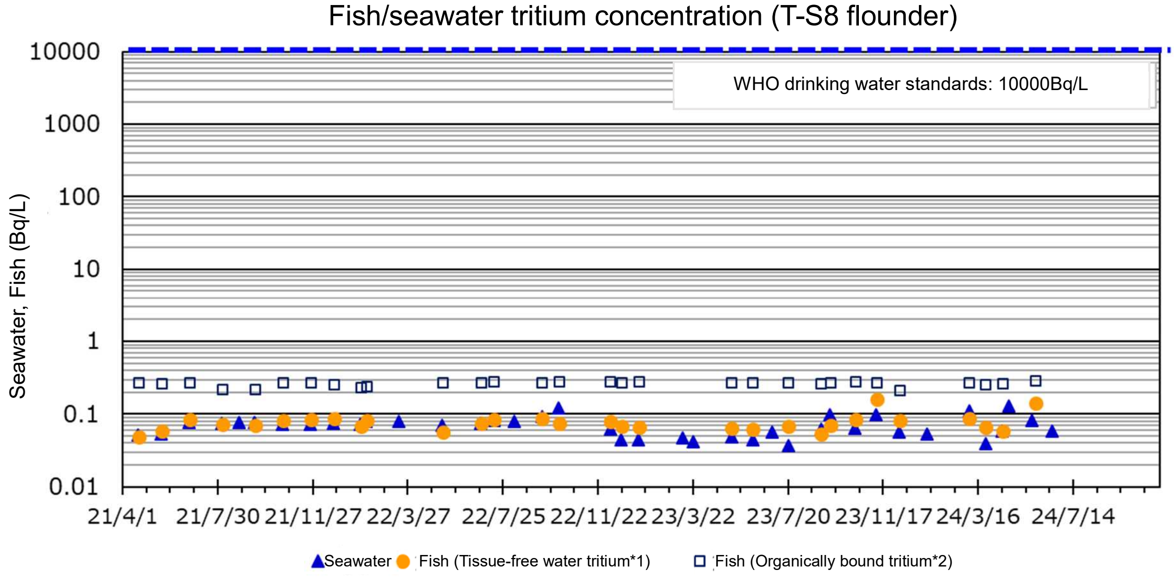
Figure. III-1-4 Tritium concentration outside 20km of the coast

Ⅲ-1-2. Fishes

Trends in tritium concentration in fish since April 2021 are shown in Figure. III-1-5 to III-1-7.

Tritium concentration in fish collected at the sampling point T-S8 were unchanged, and the rest of the sampling points remained at concentrations similar to those in T-S8.

Tissue-free water tritium (TFWT) has remained at the same concentration as seawater concentrations, and no evidence has been found for its concentration in fish. For organically bound tritium (OBT), all were below the limits of detection.



※All organically bound tritium are below the limit of detection, and each point represents the limit of detection.
The limit of detection of organically bound tritium in the integrated monitoring plan is 0.5 Bq/L.

*1 : Tissue-free water tritium is tritium that exists in the form of water in the tissues of plants and animals, and is excreted from the tissues in the same way as water.
*2 : Organically bound tritium is tritium that is organically bound to proteins in the tissues of plants and animals, taken into the tissues, and excreted from the tissues through cellular metabolism.

Figure. III-1-5 Tritium concentration in fish and seawater（T-S8）

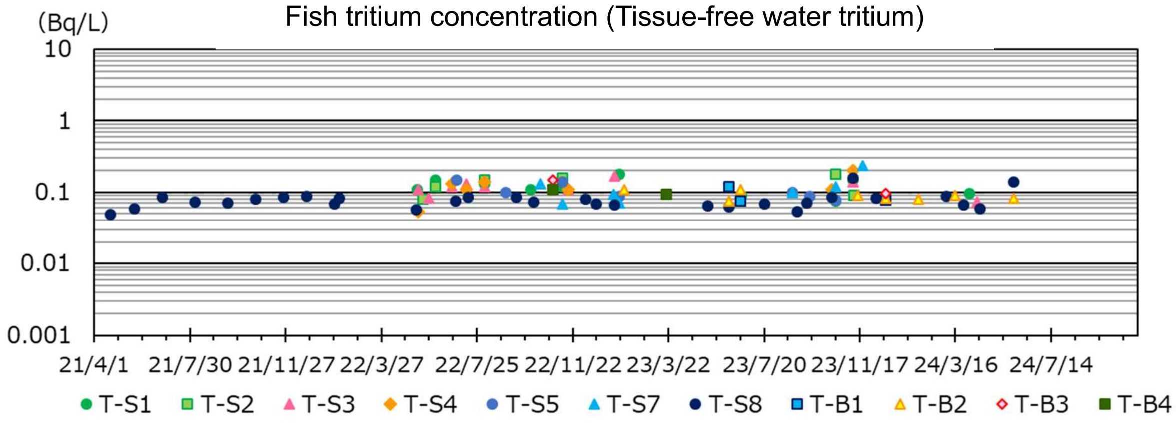
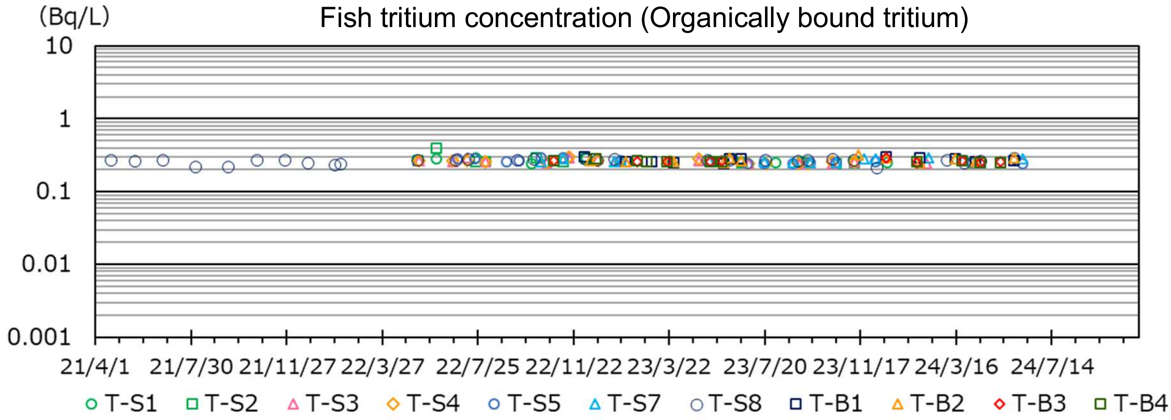


Figure. III-1-6 Tritium concentration in fish (Tissue-free water tritium)



*The fish species is flounder.

*All organically bound tritium was below the detection limit, and each point indicates the detection limit.

Figure. III-1-7 Tritium concentration in fish (organically bound tritium)

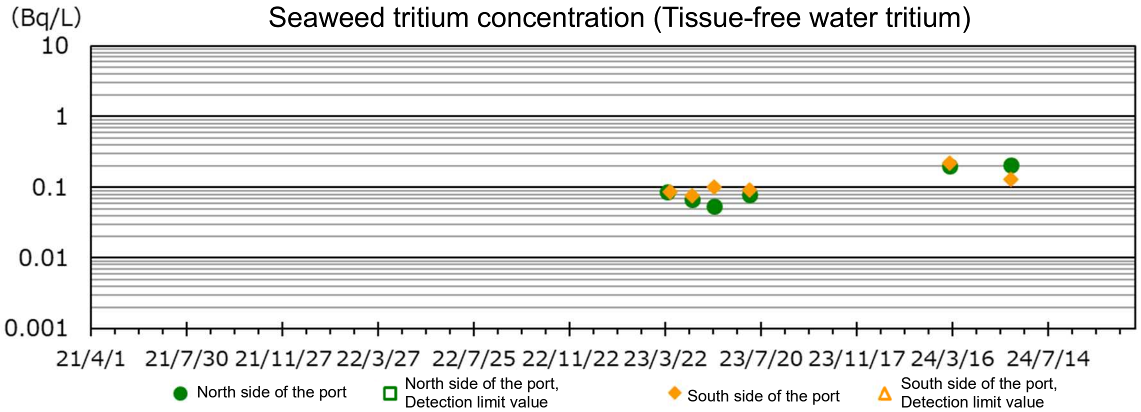
Ⅲ-1-3. Seaweed

Analysis of tritium concentration in seaweed collected from March 2023 to May 2024 are shown in Table III-1-1 and Figureures III-1-8 and III-1-9. The concentration of tissue-free water tritium of seaweed was similar to that of seawater. For organically bound tritium, all were below the limit of detection.

Table. Ⅲ-1-1 Tritium concentration of seaweed

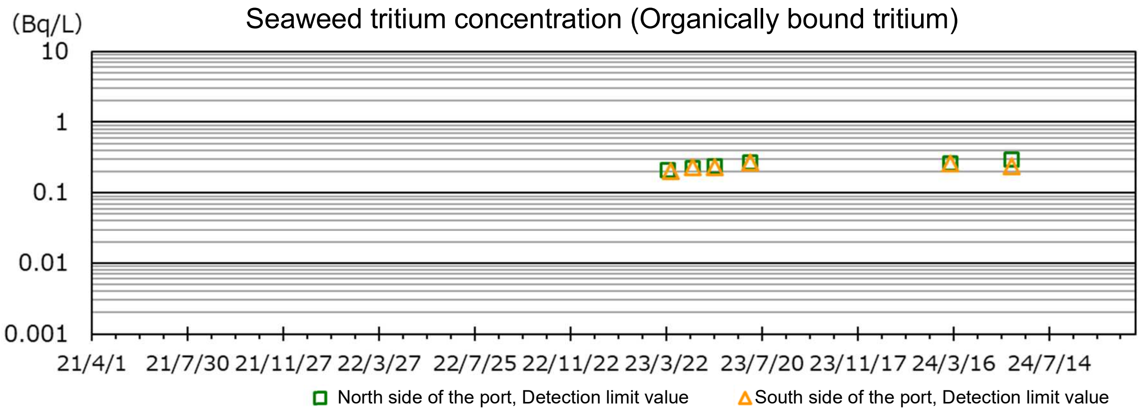
Sampling date	North outside the port			South outside the port		
	Sample name	Tritium		Sample name	Tritium	
		TFWT (Bq/L)	OBT (Bq/L)		TFWT (Bq/L)	OBT (Bq/L)
March 24, 2023	Kelp	0.086	ND (<0.21)	-	-	-
March 28, 2023	-	-	-	Sargassum	0.086	ND (<0.2)
April 24, 2023	Kelp	0.068	ND (<0.22)	Kelp	0.068	ND (<0.23)
May 22, 2023	Kelp	0.055	ND (<0.24)	Kelp	0.055	ND (<0.23)
July 5, 2023	Kelp	0.078	ND (<0.27)	Sargassum	0.078	ND (<0.27)
March 12, 2024	Pachymeniopsis lanceolata	0.20	ND (<0.26)	Eisenia bicyclis	0.20l	ND (<0.26)
May 28, 2024	Sargassum yamadae	0.21	ND (<0.3)	Ulva pertusa	0.21	ND (<0.24)

- : No seaweed available, therefore collection was not possible



*The samples were Kelp, Sargassum, Pachymeniopsis lanceolata, Eisenia bicyclis, Sargassum yamadae, and Ulva pertusa.

Figure. III-1-8 Tritium concentration of seaweed（Tissue-free water tritium）



*The samples were Kelp, Sargassum, Pachymeniopsis lanceolata, Eisenia bicyclis, Sargassum yamadae, and Ulva pertusa.

Figure. III-1-9 Tritium concentration of seaweed（Organically bound tritium）

In addition, the analytical data of iodine-129 concentration in seaweed collected from July 2022 to May 2024 are shown in Tables III-1-2 and Figure III-1-10. All the analytical results were undetectable. The limit of detection was changed from 0.1Bq/kg (raw) to 0.01Bq/kg (raw) from the collection in May 2024.

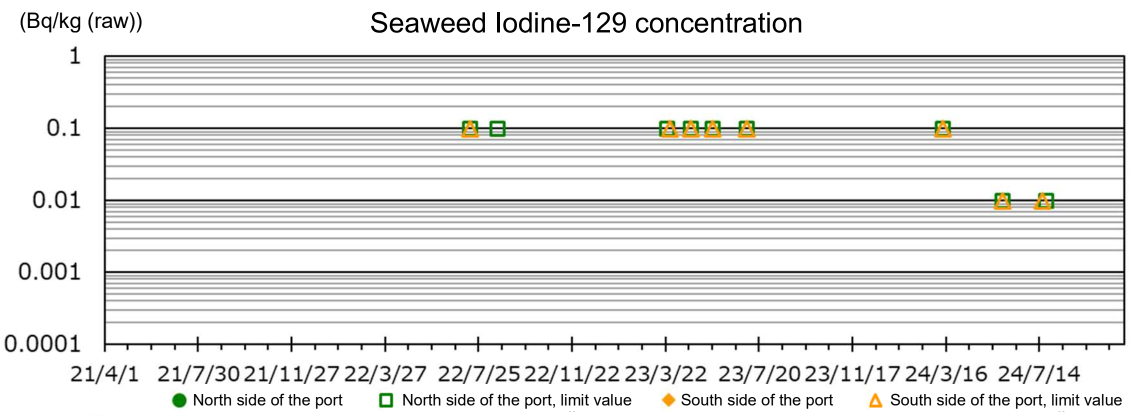
This analytical value is from an inductively coupled plasma-mass spectrometer (ICP-MS) used in a common laboratory. ICP-MS produces ions of an element of interest, which are accelerated to separate the isotopes according to the mass number, and to count the ions of each mass number, which is widely used in mass spectrometry. In radioactivity analysis, a radioactive isotope and a stable isotope are separated, and a trace amount of radioactivity is obtained from the abundance ratio of the radioactive isotope.

The concentration of iodine-129 in seaweed in the surrounding sea area of Japan is very low, and it is below the detectable limit in the analysis by ICP-MS used in common analytical laboratories. We will continue to monitor.

Table III-1-2 Seaweed Iodine-129 concentration

Sampling date	North outside the port		South outside of the port	
	Sample name	Iodine 129 (Bq/kg (raw))	Sample name	Iodine 129 (Bq/kg (raw))
July 14, 2022	Kelp	ND (<0.10)	Sargassum	ND (<0.10)
August 19, 2022	Kelp	ND (<0.10)	-	-
March 24, 2023	Kelp	ND (<0.10)	-	-
March 28, 2023	-	-	Sargassum	ND (<0.10)
April 24, 2023	Kelp	ND (<0.10)	Kelp	ND (<0.10)
May 22, 2023	Kelp	ND (<0.10)	Kelp	ND (<0.10)
July 5, 2023	Kelp	ND (<0.10)	Sargassum	ND (<0.10)
March 12, 2024	Pachymeniopsis lanceolata	ND (<0.10)	Eisenia bicyclis	ND (<0.10)
May 28, 2024	Sargassum yamadae	ND (<0.01)	Ulva pertusa	ND (<0.01)
July 18, 2024	-	-	Ulva pertusa	ND (<0.01)
July 23, 2024	Besa paradoxa	ND (<0.01)	-	-

- : No seaweed available, therefore collection was not possible



*The samples were Kelp, Sargassum, Pachymeniopsis lanceolata, Eisenia bicyclis, Sargassum yamadae, and Ulva pertusa.

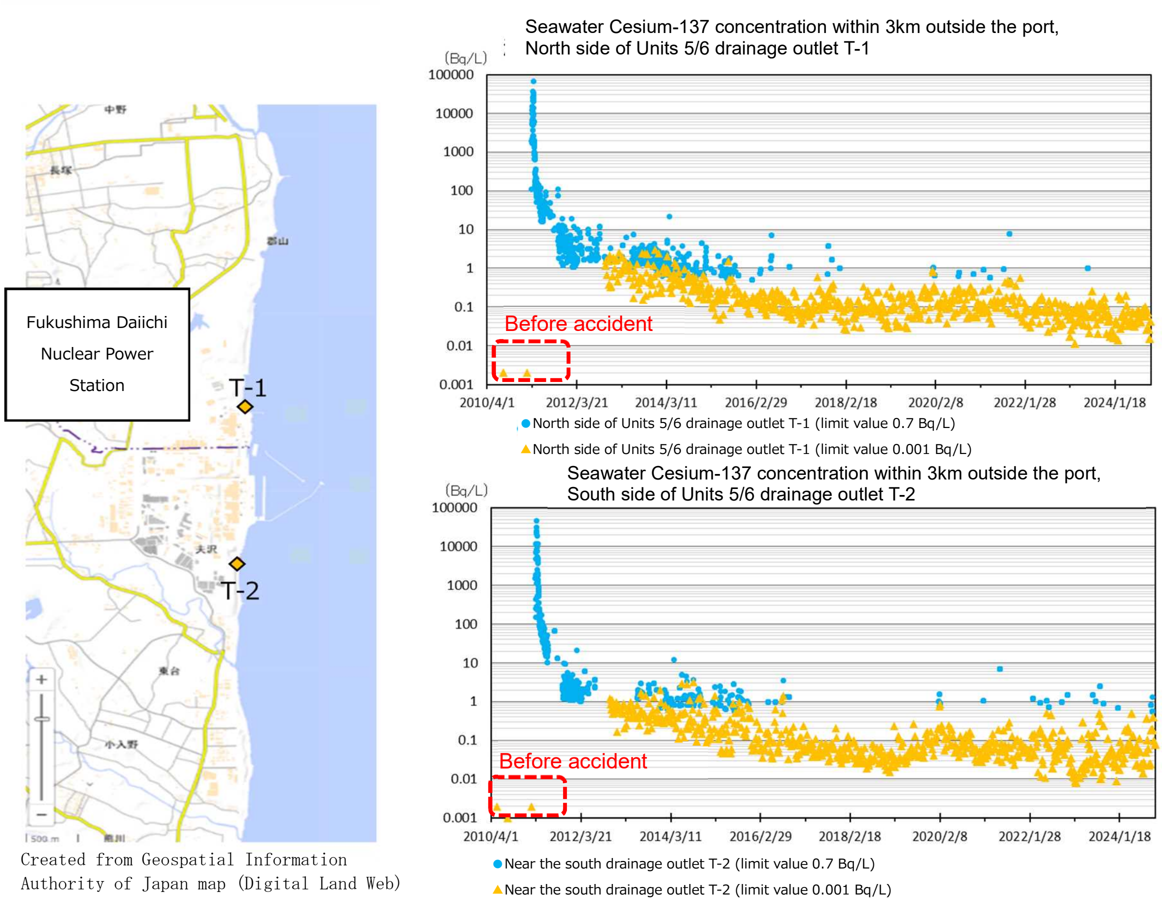
*Analysis was conducted using the target detection limit set in the comprehensive monitoring plan, but from fiscal year 2024, the detection limit was revised to match the results of other institutions (from 0.1 to approximately 0.01 Bq/kg (raw)).

Figure. III-1-10 Iodine-129 concentration in seaweed in the port

Ⅲ-2. Results of continuous monitoring of cesium and other substances since the earthquake

Ⅲ-2-1. Changes in the concentration of cesium-137 in seawater after the accident

Figure III-2-1 shows the changes in cesium-137 concentration in seawater in the vicinity of the north and south of the power station, which is continuously monitored immediately after the Fukushima Daiichi nuclear accident. Cesium-137 concentrations in seawater have been affected by the accident at the FDNPS, exceeding the range of pre-accident measurements, but have declined over the years.



Created from Geospatial Information Authority of Japan map (Digital Land Web)

Figure. III-2-1 Changes in cesium concentration in seawater near the north and south drainage outlets of the power station

Ⅲ-2-2. Status of cesium concentration in seawater

As with the tritium concentration, the coastal current of the power station appeared more frequently in the north-south direction. Therefore, we compared the changes in the concentration of cesium-137 by grouping it according to the distance from the middle of the sampling points so that the north-south of the plant would be almost symmetric.

There has been no change in monitoring results, and there has been a trend toward lower concentrations with increasing distance from the power station.

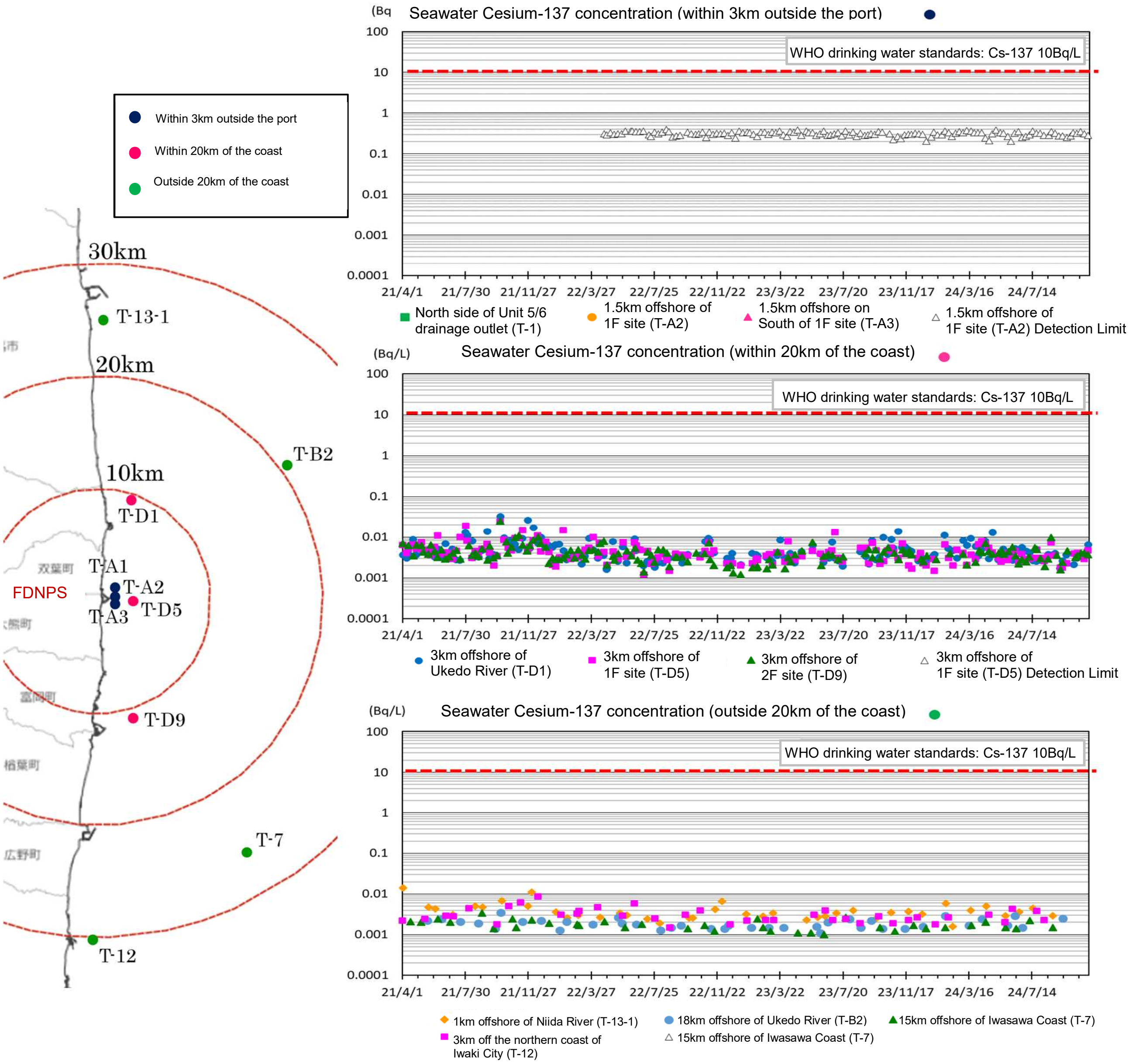


Figure. III-2-2 Changes in cesium concentration in sea water around power station

＜Within 3km outside the port＞ （Figure. III-2-3）

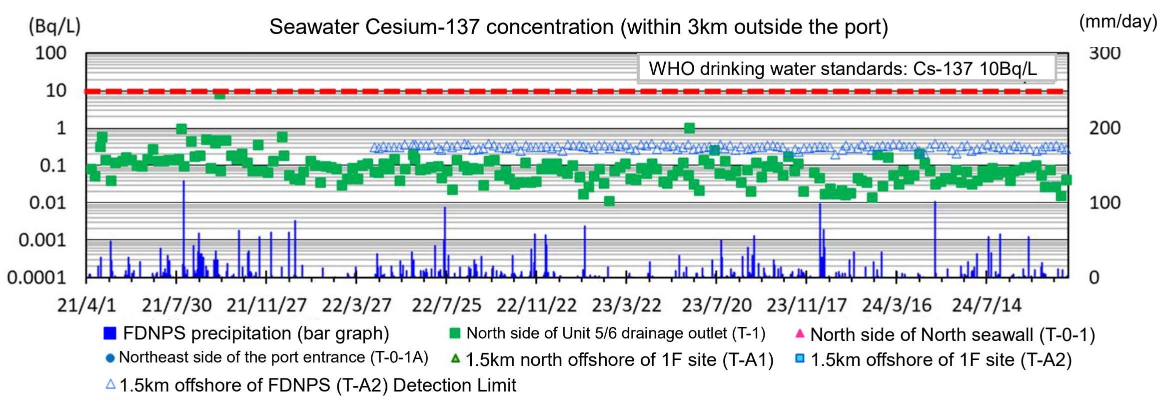
After the commencement of the discharge of ALPS treated water, there is no change in cesium-137 concentration except for a transient increase in cesium concentration, which is considered to be the same effect of rainfall as previous changes in near-power station seawater concentration.

＜Within 20km of the coast＞ （Figure. III-2-4）

There is no change in cesium-137 concentration.

＜Outside 20km of the coast＞ （Figure. III-2-5）

There is no change in cesium-137 concentration.



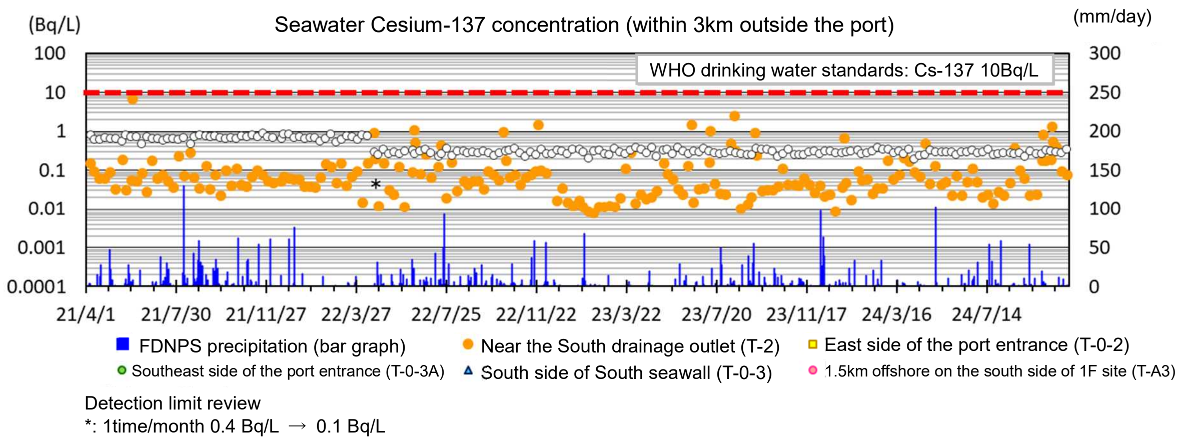


Figure. III-2-3 Trend of cesium concentration in seawater within 3km outside the port

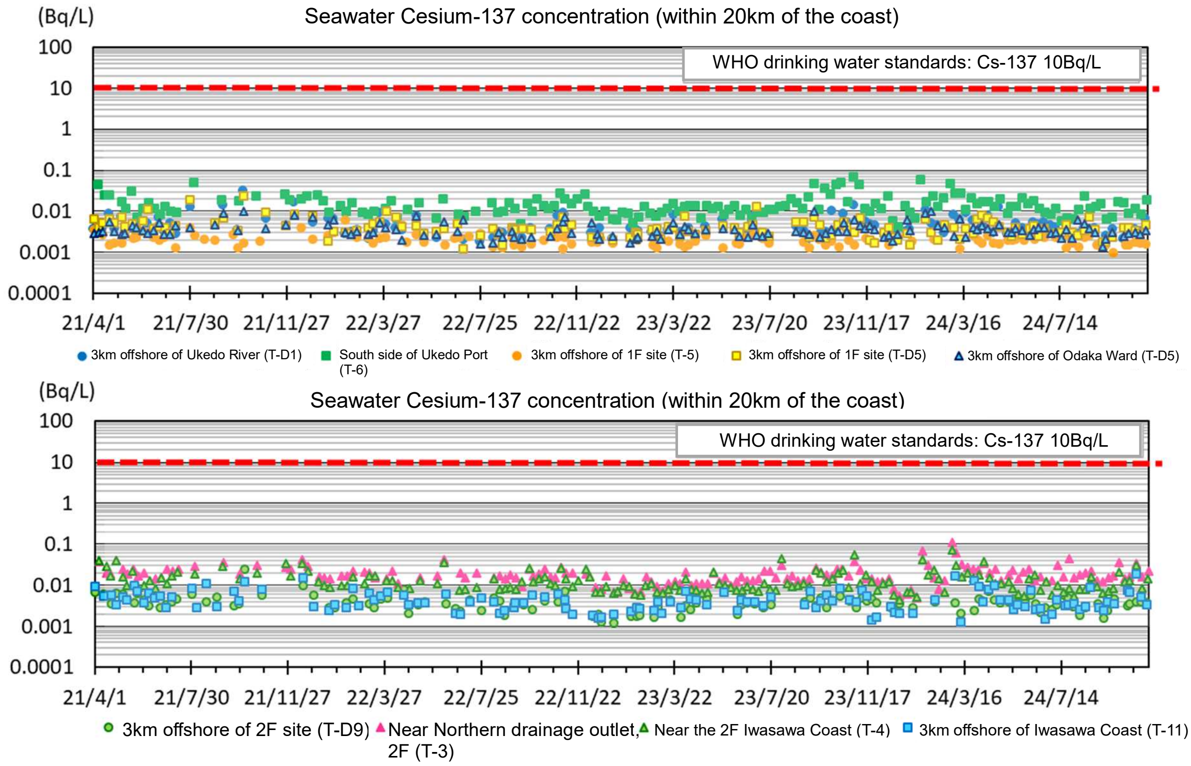


Figure. III-2-4 Changes in seawater cesium concentration within 20km of the coast

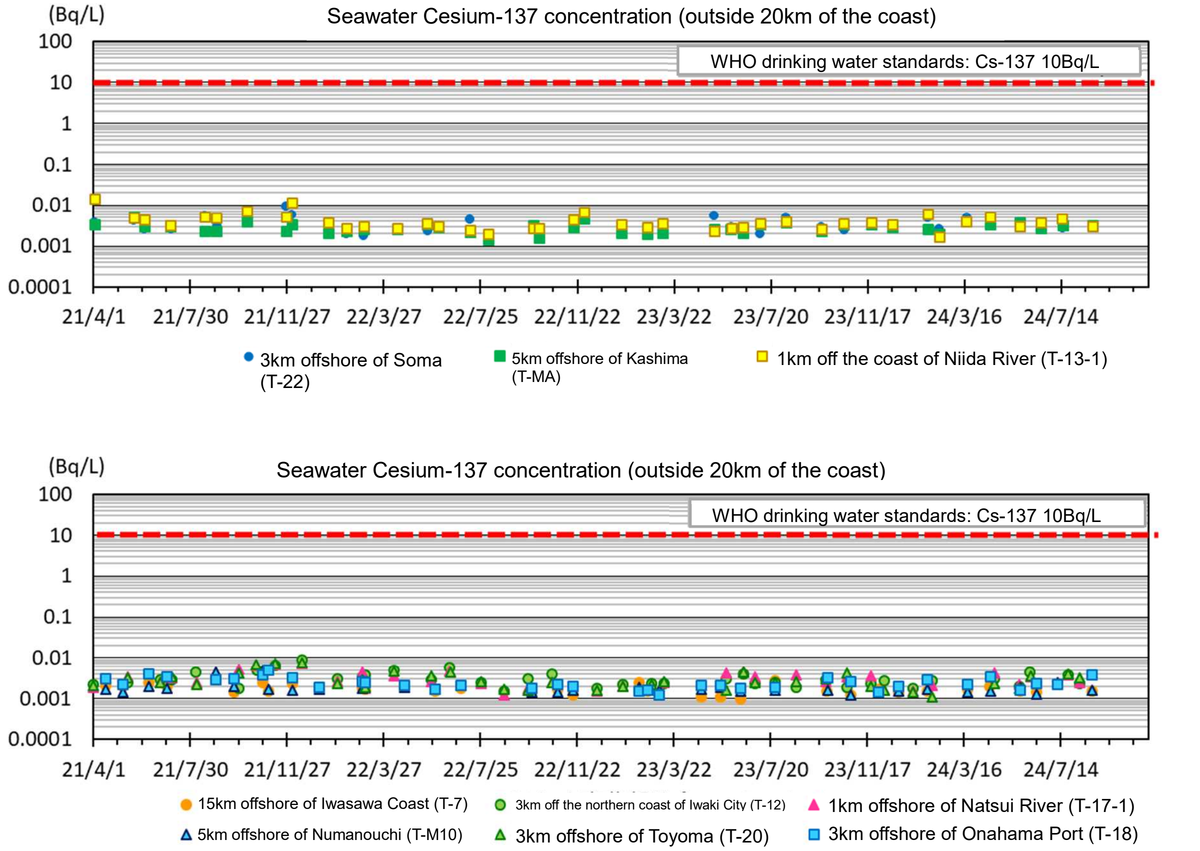


Figure. III-2-5 Changes in cesium concentration in seawater outside 20km of the coast

Ⅲ-2-３．Changes in cesium-134,137 concentration in seafood

Concentrations of cesium-134,137 in fish and shellfish were higher immediately after the accident, which was affected by the accident at the FDNPS. However, the concentration decreased with the passage of the year and month, and was mostly below 10Bq/kg (raw) at present.

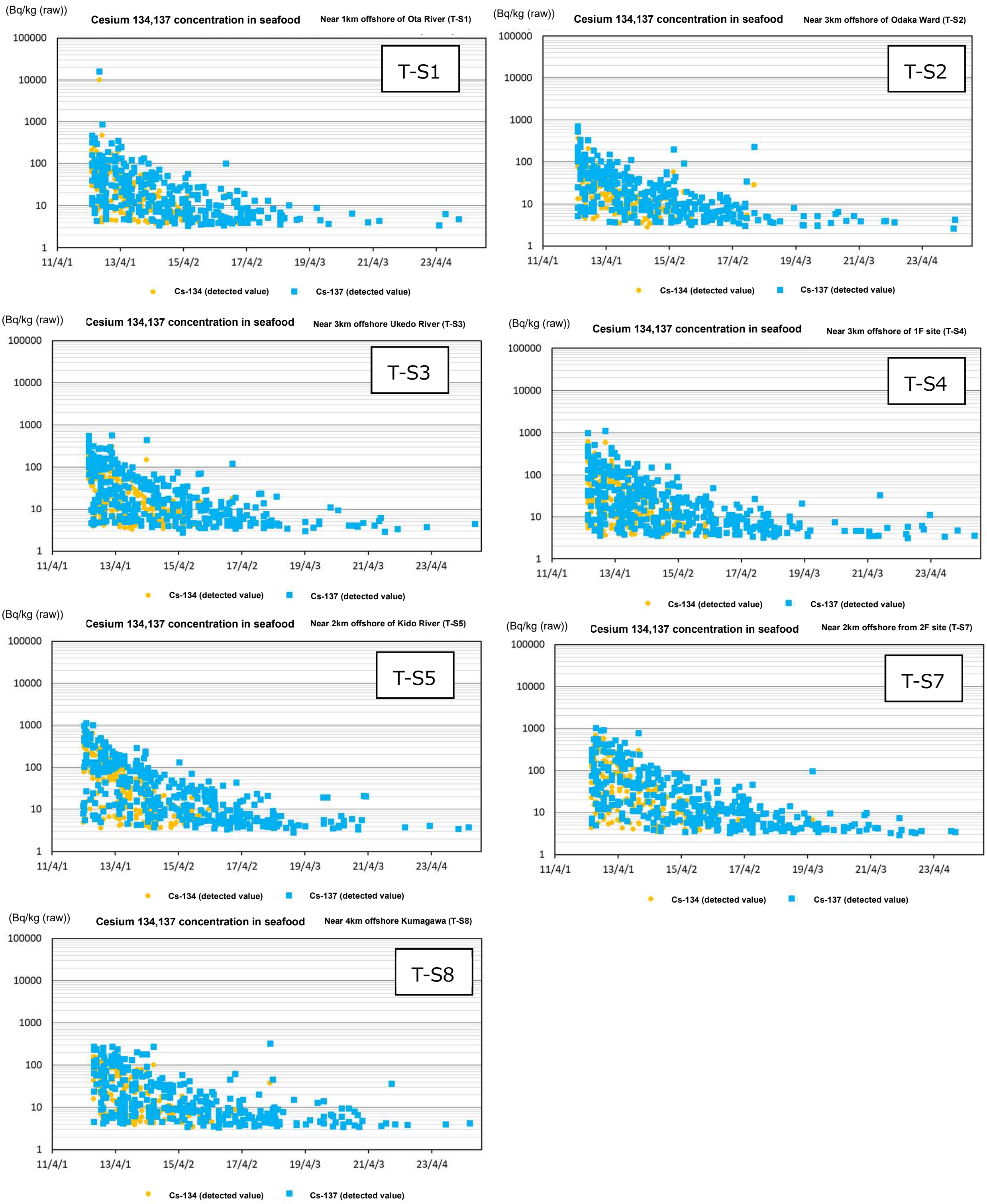


Figure. III-2-6 Changes in cesium concentration in seafood (Gillnet survey points)

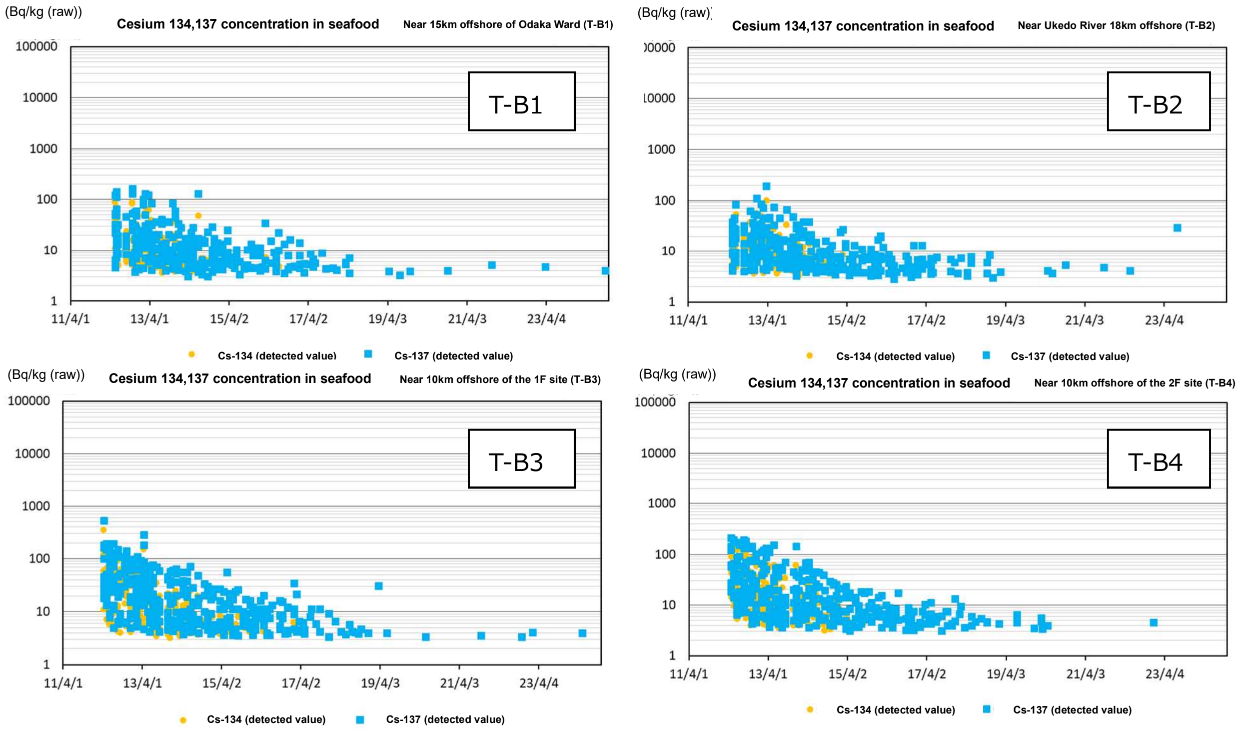


Figure. III-2-7 Changes in cesium concentration in seafood (bottom trawling survey points)

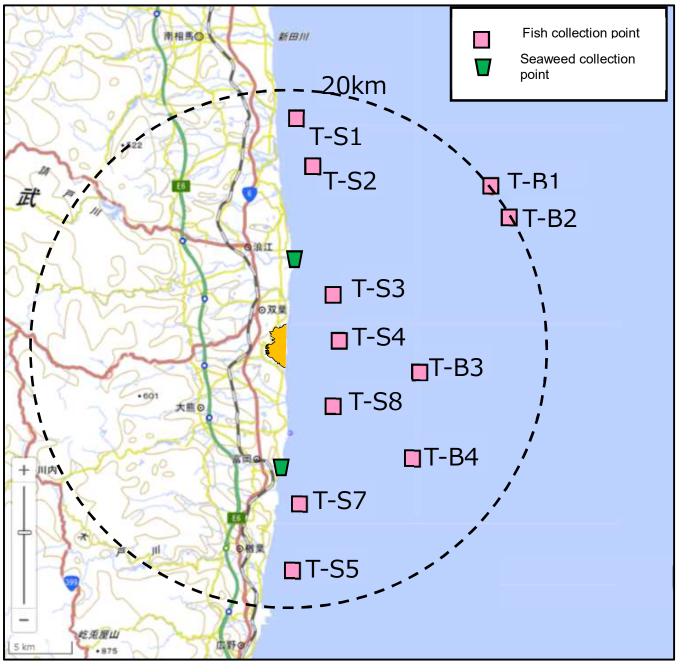


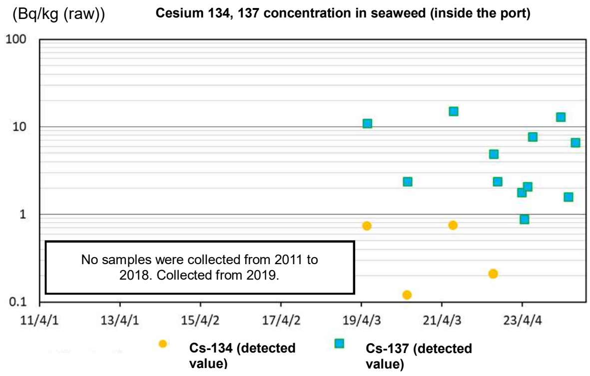
Figure. III-2-8 Seafood monitoring points

Ⅲ-2-４． Changes in cesium 134,137 concentration in seaweed

The concentration of cesium-134,137 in seaweed has been monitored since before the accident. Before the accident at the FDNPS, a survey was conducted outside the port, and it was undetected (0.09 Bq/kg (raw) the detection limit of cesium-137 in FY2010), but after the accident, collections have been resumed in the port from FY2019, and the results have shown that they are about 1 to 10 Bq/kg (raw).

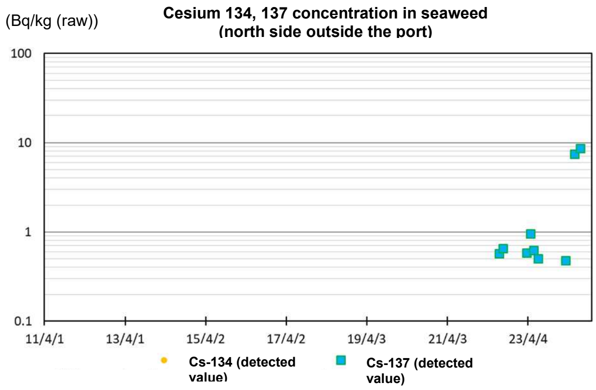
Outside the port, monitoring began in 2022 to strengthen the monitoring of discharges of ALPS treated water into the sea, which is comparable to that within the port.

Inside the port



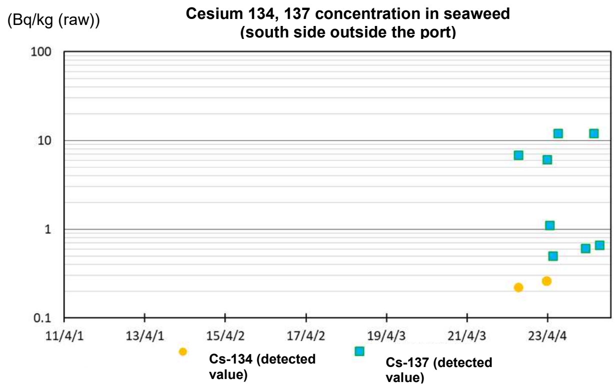
***The sample is Sargassum.**

Northern part of outside the port



***Samples include kelp, Pachymeniopsis lanceolate, Sargassum yamadae, and Besa paradoxa.**

Southern part of outside the port



***Samples are Sargassum, Kelp, Eisenia bicyclis, and Ulva pertusa.**

Figure. Ⅲ-2-9 Changes in cesium concentration in seaweed

Ⅲ-2-5. Changes in plutonium and cesium concentrations in seabed soil

Measurements of plutonium and cesium concentrations in seabed soil have been continued since the accident.

Since there is a report in the literature that information identifying the origin of plutonium can be obtained by grasping the isotope ratios (ratio of number of atoms) of plutonium 239 and plutonium 240 contained in seabed soil, and whether plutonium has an origin other than fallout in atmospheric nuclear tests, the measurement of plutonium isotope ratios in seabed soil was started in FY2022.

（1）Plutonium

Table III-2-1 to III-2-3 shows plutonium concentration in the seabed soil around the power station, and Figure III-2-10, III-2-11 shows the changes. No changes have been observed in plutonium 238, 239 + 240 concentrations in the seabed soil since April 2021.

And, the isotope ratio has obtained the result which is comparable with the result of the power station sea area reported until now.

Continue * from FY2023 onwards and confirm that there are no changes before and after discharge.

*: Measurements are scheduled quarterly for the first 3 years after the commencement of discharge, and twice annually from the fourth year

Table. Ⅲ-2-1 Plutonium concentration in seabed soil on the north side of Units 5/6 drainage outlet (T-1)

Sampling date	North side of Unit 5/6 drainage outlet (T-1)		
	Plutonium 238 concentration (Bq/kg (dry))	Plutonium 239+240 concentration (Bq/kg(dry))	Plutonium 240 / Plutonium 239 Isotope ratio (ratio of number of atoms)
April 4, 2022	ND (<0.011)	0.024	0.240
July 4, 2022	ND (<0.014)	0.040	0.239
October 3, 2022	ND (<0.011)	0.049	0.246
January 2, 2023	ND (<0.011)	0.043	0.244
April 3, 2023	ND (<0.011)	0.071	0.236
July 3, 2023	ND (<0.012)	0.053	0.216
October 9, 2023	ND (<0.016)	0.058	0.246
January 3, 2024	ND (<0.011)	0.041	0.239
April 11, 2024	ND (<0.011)	0.064	0.237

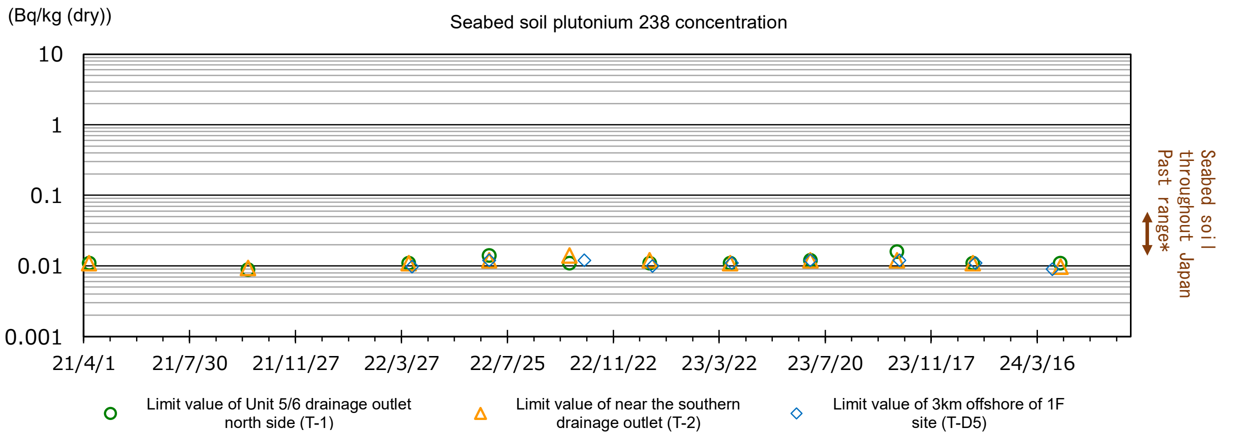
Table. Ⅲ-2-2 Plutonium concentration in seabed soil near the southern drainage outlet (T-2)

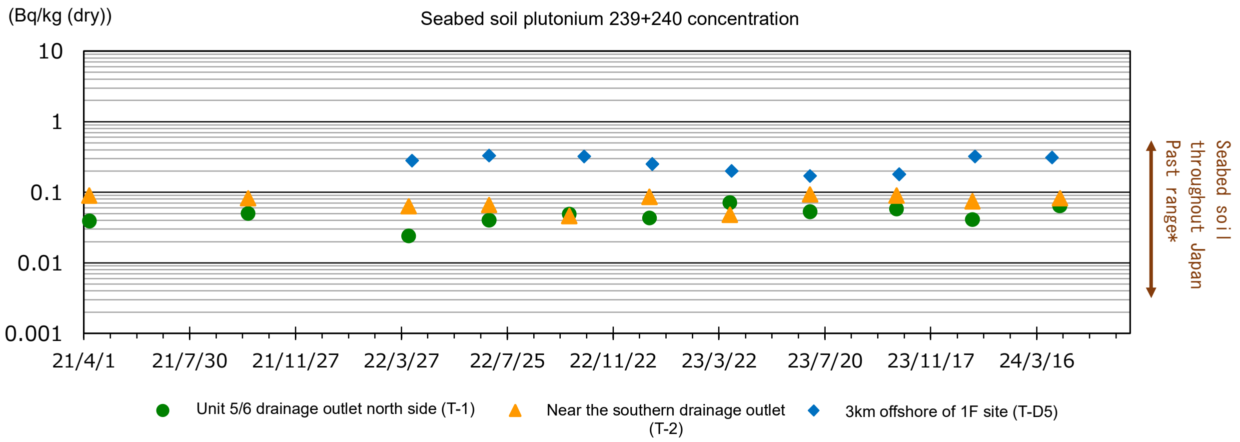
Sampling date	Near the southern drainage outlet (T-2)		
	Plutonium 238 concentration (Bq/kg (dry))	Plutonium 239 + 240 concentration (Bq/kg (dry))	Plutonium 240 / Plutonium 239 Isotope ratio (ratio of number of atoms)
April 4, 2022	ND (<0.011)	0.063	0.240
July 4, 2022	ND (<0.012)	0.066	0.245
October 3, 2022	ND (<0.014)	0.046	0.242
January 2, 2023	ND (<0.012)	0.086	0.243
April 3, 2023	ND (<0.011)	0.048	0.242
July 3, 2023	ND (<0.012)	0.093	0.243
October 9, 2023	ND (<0.012)	0.090	0.232
January 3, 2024	ND (<0.011)	0.074	0.242
April 11, 2024	ND (<0.0093)	0.082	0.242

Table. Ⅲ-2-3 Plutonium concentration in seabed soil 3km offshore of 1F site (T-D5)

Day of harvesting	3km offshore of 1F site (T-D5)		
	Plutonium 238 concentration (Bq/kg (dry))	Plutonium 239 + 240 concentration (Bq/kg (dry))	Plutonium 240 / Plutonium 239 Isotope ratio (ratio of number of atoms)
April 8, 2022	ND (<0.0098)	0.28	0.249
July 4, 2022	ND (<0.012)	0.33	0.247
October 20, 2022	ND (<0.012)	0.32	0.247
January 5, 2023	ND (<0.010)	0.25	0.249
April 5, 2023	ND (<0.011)	0.20	0.243
July 3, 2023	ND (<0.012)	0.17	0.250
October 12, 2023	ND (<0.012)	0.18	0.241
January 6, 2024	ND (<0.011)	0.32	0.248
April 2, 2024	ND (<0.0090)	0.31	0.246

※The sampling points are as shown in Figure 7-1 of the main text.





*: The range of minimum to maximum values of data detected between April 2019 and March 2023 in the following databases

All over Japan (including off Fukushima)	Plutonium-238 concentration: 0.01 Bq/kg (dry)-0.037 Bq/kg (dry)
	Plutonium 239+240 concentration: 0.032 Bq/kg (dry)-4.8 Bq/kg (dry)
Off the coast of Fukushima Prefecture	Plutonium-238 Concentration: 0.01 Bq/kg (dry)-0.022 Bq/kg (dry)
	Plutonium 239+240 concentration: 0.11 Bq/kg (dry)-0.97 Bq/kg (dry)

Source: Japanese Environmental Radioactivity and Radioactive Environmental Radiation Database
https://www.kankyo-hoshano.go.jp/data/database/

Figure. III-2-10 Changes in plutonium concentration in seabed soil

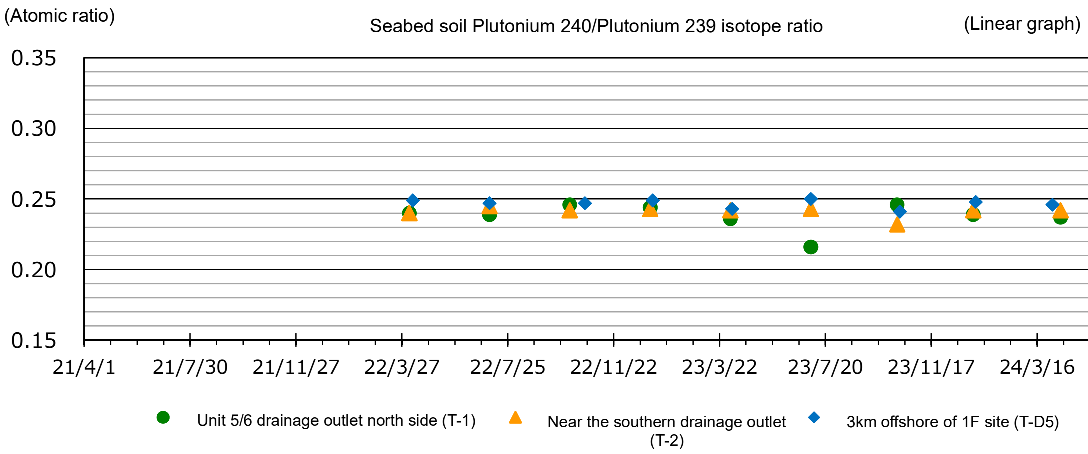
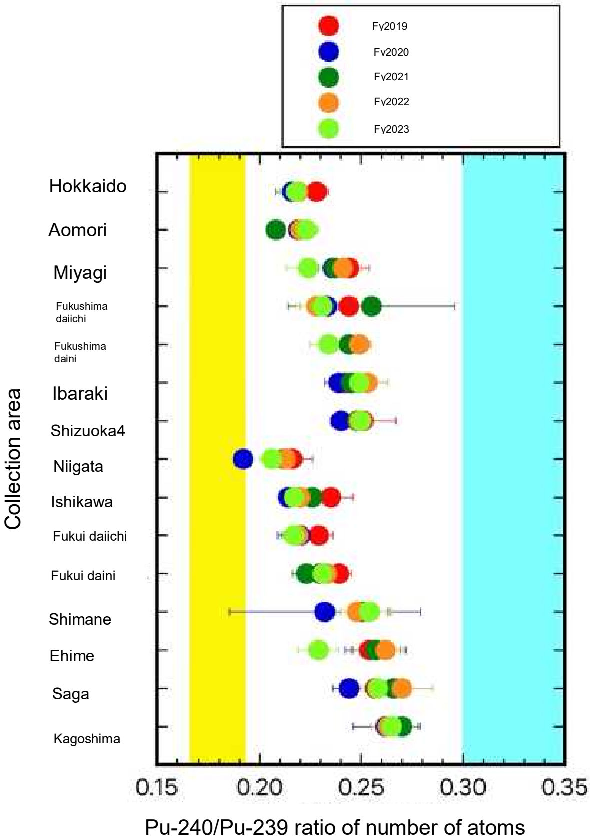


Figure. III-2-11 Changes in isotope ratio of plutonium concentration in seabed soil

Some reference information regarding the plutonium isotope ratios in seabed soil is shown below.



Pu-240/Pu-239 atomic ratio of plutonium contained in seabed soil collected in the sea area of the power station
(Red, blue, dark green, orange, and light green indicate FY 2019, FY 2020, FY 2021, FY2022, FY2023 respectively. Yellow and light blue shading indicate the global fallout ratio and the local fallout ratio originating from the Pacific Nuclear Test Site, respectively.)

Source: Nuclear Regulatory Commission Web site
2023 Expenses for Disaster Prevention Measures at Nuclear Facilities (Radioactivity Survey and Comprehensive Evaluation in the Marine Environment) Project Study Report
https://radioactivity.nra.go.jp/cont/ja/docs/reps/rep2023_NRA.pdf

<Half-life of plutonium isotope>

Plutonium 238: 87.7 years

Plutonium 239: 2.411×10^4 years

Plutonium 240: 6564 years

Plutonium 241: 14.35 years

<Major Origin and Isotope Ratio of Plutonium Isotopes in the North Pacific>

・Large amounts of global radioactive fallout (global fallout) from the Atmospheric Nuclear Tests conducted in 1950s and the early 1960s

Plutonium 240/Plutonium 239 Isotope Ratio (ratio of number of atoms): 0.180±0.014

・Radioactive Fallouts from Atmospheric Nuclear Tests conducted at the U.S. Pacific Nuclear Experiment Station in the Marshall Islands (Bikini and Enewetok Atoll) from 1946 to 1958

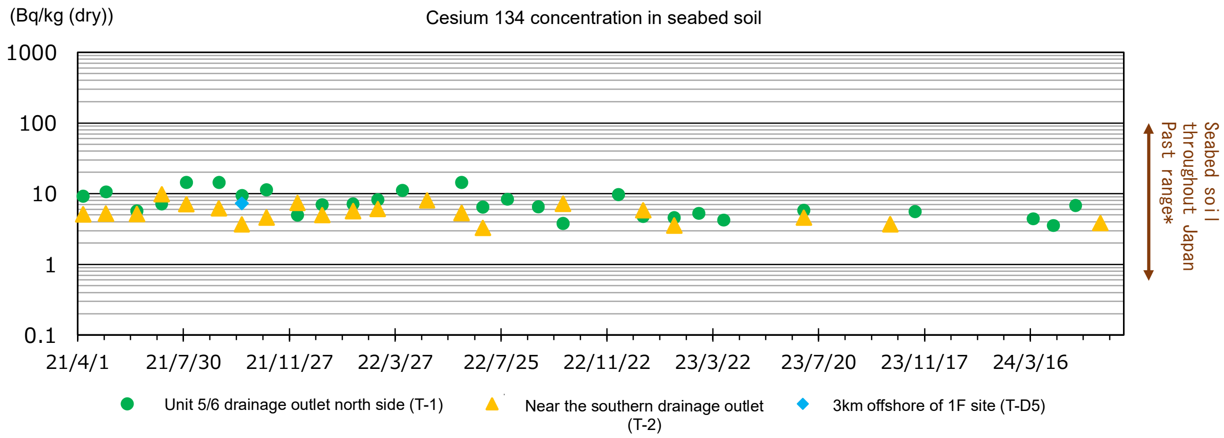
Plutonium 240/Plutonium 239 Isotope Ratio (ratio of number of atoms): 0.30-0.36

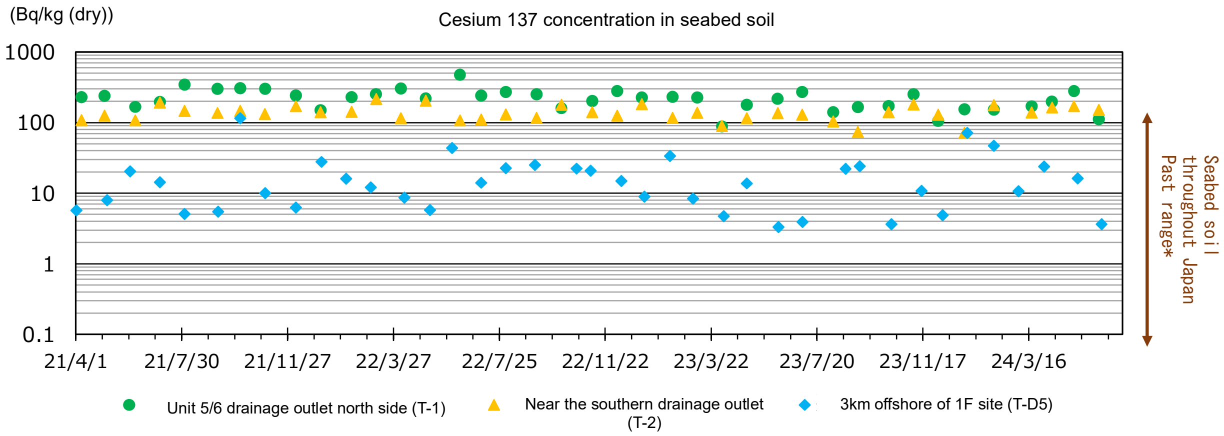
<Plutonium in the seabed soil in the sea area of the power station>

・The plutonium of local fallout origin is also transported to the waters surrounding Japan by the Hokkaido and Kuroshio currents and the Tsushima currents, and it has been found that the global fallout origin and the local fallout origin of the Pacific Nuclear Test Site exist.

（2） Changes in cesium 134,137 concentration in seabed soil

The transition of cesium-134,137 concentration in the seabed soil around the power station is shown in Figure III-2-12. No changes in cesium-134,137 concentrations have been observed since April 2021.





*: Range of minimum to maximum values of data detected between April 2019 and March 2023 in the previous database

All of Japan (including off Fukushima)	Cesium-134 concentration: 0.18 Bq/kg (dry) - 30 Bq/kg (dry)
	Cesium-137 concentration: 0.19 Bq/kg (dry) - 500 Bq/kg (dry)
Off the coast of Fukushima Prefecture	Cesium-134 Concentration: 0.28 Bq/kg (dry) - 30 Bq/kg (dry)
	Cesium-137 concentration: 0.79 Bq/kg (dry) - 500 Bq/kg (dry)

Figure. III-2-12 Changes in cesium concentration in seabed soil

[Reference] measurement method

Table Ref-1 shows the measurement method in our sea area monitoring.

Table Ref-1 Sea area monitoring sites

Measurement item	Measuring device	Measurement method
Tritium concentration	Low background liquid scintillation detector	Nuclear Regulatory Agency-edited Tritium Analysis Method (revised in 2023). [Seawater] Detection limit: 0.4, 10 Bq/L: measured by distillation. Detection limit: 0.1 Bq/L: measured by distillation and electrolytic concentration. [Fish, seaweed] Tissue free water tritium: Water in the sample is recovered by freeze-drying and measured. Organically bound tritium: Organically bound tritium in the dried sample is recovered as water by combustion and measured.
Iodine-129 concentration	Inductively Coupled Plasma Mass Spectrometer	Edited by the Ministry of Education, Culture, Sports, Science and Technology, Rapid Analytical Method for Iodine-129 in Environmental Samples (2004) [Seaweed] Measured by treatment with an alkaline solution.
Gamma nuclide concentration (Cesium-134,137 concentration)	Germanium detector	Gamma Spectrometry with a Germanium Semiconductor Detector (Revised 2020) by the Nuclear Regulatory Agency. [Seawater] Measured by treating with the ammonium phosphomolybdate method and the manganese dioxide coprecipitation method. [Fish] Only the edible portion was measured with a raw sample. [Seaweed] Measured by drying. [Seabed soil] Measured by drying.
Plutonium 238, plutonium 239 + 240 concentration	Silicon semiconductor detector	Plutonium Analysis Method (Revised in 1990), edited by the Ministry of Education, Culture, Sports, Science and Technology [Seabed soil] Measured by ion exchange.
Plutonium 240 / Plutonium 239 Isotope ratio	Inductively Coupled Plasma Mass Spectrometer	Rapid analytical method for plutonium in environmental samples (2002), edited by the Ministry of Education, Culture, Sports, Science and Technology [Seabed soil] Measured by chemical separation.