Attachment 1

# Radiological Impact Assessment Report Regarding the Discharge of ALPS Treated Water into the Sea (Design stage*) [Overview]

TEPCO

November 17, 2021

* The assessment in this report will be revised as appropriate based on progress in discussions around design and operation of plans regarding discharged into the sea, opinions from relevant parties, reviews by IAEA experts, and cross check assessments by third parties.

# About the Assessment

TEPCO

- Following the Japanese Government's Basic Policy on the Handling of ALPS Treated Water, TEPCO developed a methodology to assess the radiological impact on the public and the environment when discharging ALPS treated water into the sea assuming that designs and operations being considered by TEPCO in accordance with internationally recognized methods (as found in the International Atomic Energy Agency (IAEA) Safety Standard documents and International Commission on Radiological Protection (ICRP) recommendations).
- Assessment following this methodology indicated that effects of the discharge of ALPS treated water into the sea on the public and the environment is minimal as calculated doses were significantly less than the dose limits, dose targets, and the values specified by international organizations for each species.
- As going through the necessary procedures to gain the Nuclear Regulation Authority(NRA)'s approval of the implementation plan, TEPCO will revise the assessment based on IAEA experts' reviews and input/review by relevant parties.
- TEPCO will continue to disseminate, in a transparent manner, scientific information regarding the radiological impact on the public and the marine environment to foster understanding and expel concerns for people at home and abroad.

TEPCO will strictly comply with various laws and regulations and the Government of Japan regulatory standards that conform to international recognized technical documents (IAEA safety standards and ICRP recommendations) on the concentrations of tritium and other radioactive materials in the water to be discharged to secure the safety of the public and the environment.

1. **DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT**
2. ASSESSMENT METHODS
3. ASSESSMENT RESULTS
4. REFERENCES

# Discharge method of Preconditions for Assessment

- The ALPS treated water to be discharged is purified until the sum of the ratios of legally required concentrations*(hereinafter “the sum of the ratios”) of 62 radionuclides and Carbon-14, other than tritium, is less than one.
- The concentration of all 64 nuclides are measured and assessed (including measurement and assessment by third parties) before discharge to confirm the water meets the regulatory standard.
- The annual amount of tritium discharged will be less than 22 TBq, the discharge management target for the Fukushima Daiichi Nuclear Power Station (FDNPS) before the Accident.
- In discharge, the ALPS treated water will be diluted by seawater by 100 times or more so that the tritium concentration at the discharge outlet will be less than 1,500 Bq/L. Through this process, “the sum of the ratios” of 62 radionuclides and Carbon 14 other than tritium, will be also diluted to less than 1/100.
- The diluted ALPS treated water will be discharged at the bottom of the sea approx. 1 km off the coast of FDNPS so that the discharged water is less likely to be re-taken in as seawater to dilute the ALPS treated water to be discharged.
- If there is an abnormality with the dilution rate or characteristics of the ALPS treated water, the emergency shut-off valves will be actuated swiftly and the ALPS treated water transfer pumps will be shutdown to stop discharging.

* The sum of the ratios: the sum of the ratios of the concentration of each radionuclide to the legally required concentrations of each when multiple radionuclides are contained in the discharged water. The law stipulates that at Fukushima Daiichi, the sum of the ratios of radionuclides must be less than 1 at the outlet. In discharging ALPS treated water into the sea as planned this time, the water will be treated with ALPS and other equipment for the sum of the ratios of radionuclides other than tritium to be less than one and then diluted by 100 times or more with seawater before discharge until the tritium concentration is 1/40$^{th}$ (1,500 Bq/L) of the legally required concentration of tritium (less than 60,000Bq/L). As a result, the concentrations of radionuclides other than tritium will be far below the legally required concentrations of each.

# Procedures for the radiological impact assessment

TEPCO

The radiological impact was assessed according to the following procedures based on the IAEA safety standards documents*1.

## Impact on the public

| | |
|---|---|
| Selection of the source terms | Define the type and amount of radioactive materials discharged into the sea of treated water |
| Modelling of direct irradiation, dispersion and transfer in the environment | Study how the various radioactive materials discharged into the sea diffuse, transfer, and accumulate |
| Identification of exposure pathways | Study the pathways by which people are exposed to the dispersed and transferred radioactive materials |
| Identification of the representative person for normal operation | Define the person most exposed in the population being assessed from the exposure pathways identified above |
| Assessment of the dose to the representative person | Assess the dose for the representative person |
| Comparison of estimated dose with dose constraints*2 and dose limits | Evaluate after comparing the estimated dose against the station target dose (0.05 mSv/year) and the dose limit for the general public (1mSv/year) |

## Impact on environmental protection (organisms other than humans)

| | |
|---|---|
| Select the source terms | Define the type and amount of radioactive materials discharged in treated water sea discharge |
| Model dispersion and transfer in the environment | Study how the various radioactive materials discharged into the sea disperse, transfer and accumulate |
| Identify exposure pathways | Study the pathways by which marine animals and plants exposed to the dispersed and transferred radioactive materials |
| Select reference animals and plants | Select species to be assessed (Flatfish, crabs, brown seaweed were selected based on ICRP documents) |
| Assess the dose rate for reference animals and plants | Assess dose rates for reference animals and plants |
| Compare estimated dose rates to with derived consideration reference levels | Evaluate after comparing the derived consideration reference level set out for each species |

*1 IAEA GSG-9 "Regulatory Control of Radioactive Discharges to the Environment"
IAEA GSG-10 "Prospective Radiological Environment Impact Assessment for Facilities and Activities"

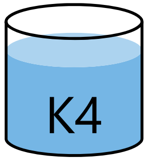
*2 Dose constraint: A value lower than the dose limit, stipulated by the person responsible for radiation work or the radiation facility to optimize safety in physical protection. Because there is no legal dose constraint in Japan, values in this case were compared to the station target dose.

# Selection of source terms (1)
## (type and amount of radioactive material discharged)

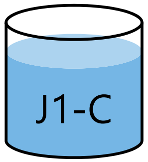
TEPCO

(1) Source term based on the measured value of the 64 radionuclides

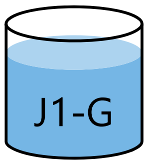
The assessment assumes that the ALPS treated water from the three particular tank groups from which the actual measurements for the 64 nuclides have been gathered is diluted by seawater and then continuously discharged during the discharge period.
Furthermore, radionuclides that have not been detected before are assumed to be included at their detection limit.




(1)-1 K4 tank group
Tritium concentration: approx. 190,000 Bq/L
"The sum of the ratios" of radionuclides other than tritium* : 0.29




(1)-2 J1-C tank group
Tritium concentration: approx. 820, 000 Bq/L
"The sum of the ratios" of radionuclides other than tritium : 0.35




(1)-3 J1-G tank group
Tritium concentration: approx. 270,000 Bq/L
"The sum of the ratios" of radionuclides other than tritium : 0.22

All scenarios assume that

- The amount of tritium in discharged treated water is less than 22 TBq per year
- The tritium concentration of the treated water after dilution is less than 1,500 Bq/L

* The sum of the ratios: the sum of the ratios of the concentration of each radionuclide to the legally required concentrations of each when multiple radionuclides are contained in the discharged water. The law stipulates that at Fukushima Daiichi, "the sum of the ratios" of radionuclides must be less than 1 at the outlet. In discharging ALPS treated water into the sea as planned this time, the water will be treated with ALPS and other equipment for the sum of the ratios of radionuclides other than tritium to be less than one and then diluted by 100 times or more with seawater before discharge until the tritium concentration is 1/40th (1,500 Bq/L) of the legally required concentration of tritium (less than 60,000Bq/L). As a result, the concentrations of radionuclides other than tritium will be far below the legally required concentrations of each.

# Selection of source terms (2)
## （type and amount of radioactive material discharged)

TEPCO

(2) Source terms based on the hypothetical ALPS treated water

This extremely conservative scenario assumes that the hypothetical ALPS treated water with only nuclides that comparatively have a larger effect on exposure dose, which does not actually exist, is continuously discharged throughout the discharge period.

- 8 important radionuclides* in exposure assessments for the public are selected and **control concentrations** are set for each (see next slide).
- To maximize assessed dose in this conservative scenario, the radionuclide (Zn-65) that has the largest impact on exposure dose after the 8 radionuclides is added to the ALPS treated water until “the sum of the ratios” is 1 (the ratio to legally required concentration of Zn-65: 0.68) **
- Since the amount of tritium released is less than 22 TBq/year, and the lower the concentration of tritium is, the more other radioactive materials discharged, the tritium concentration of the treated water to be used in the assessment is set at 100,000 Bq/L, below the observed tritium concentration (approx. 150,000 Bq/L), to conservatively maximize the calculated exposure dose.

(2) The hypothetical ALPS treated water
Tritium concentration: 100, 000 Bq/L
“The sum of the ratios” other than tritium：1.00

* Radionuclides that tend to be more concentrated in marine animals and plants, and whose exposure assessment values tend to be relatively higher when emitted at the same ratio to the legally required concentration. （See next slide）

** Since the top 2 radionuclides (Fe-59, Sn-126) are radionuclides subject to management for animals and plants other than humans, the assessment assumes that these 2 radionuclides existed at the maximum of the control concentration (“the sum of the ratios”: 0.0025) and the nuclide that has the next largest impact, Pm-148m, comprised the remaining 0. 9975 until “the sum of the ratios” equaled 1.

## 【Reference】Selection of radioactive materials important in assessment

TEPCO

- The discharge of ALPS treated water is managed based on the sum of the ratios. However, even if the sum of the ratios is the same, each radionuclide behaves differently in the environment. To further reduce the impact of the ALPS treated water on the environment, new control concentrations* will be set for the 8 nuclides that have a comparatively large impact on exposure (=exceeds 0.001mSv/year)
- Specifically, hypothetical water containing only the said radionuclides at the legally required concentration limit was set up, and exposure assessments were conducted considering the behavior in the environment (mainly enrichment to fish and shellfish) when this water was discharged, and the top eight radionuclides with the highest assessment values (out of 64) were selected. Based on this policy, hypothetical water containing the top eight radionuclides within the operational control limits and with Zn-65, which has the next highest impact and accounts for the rest of the sum of the ratios that does not reach to one, was set up, and the radiation impact assessment for this water was conducted.

**Table E-3 Results of internal exposure assessment when each nuclide is released at the regulatory standard (Adult)**

(8 nuclides that exceed 0.001mSv/year were selected to be managed)

| No. | Nuclide | Regulatory standard [Bq/L] | Internal exposure dose due to ingestion of seafood (mSv/year) | Notes |
|---|---|---|---|---|
| 1 | Sn-126 | 2.0E+02 | 2.6E-02 | subject to management |
| 2 | Sn-123 | 4.0E+02 | 2.3E-02 | subject to management |
| 3 | Sn-119m | 2.0E+03 | 1.9E-02 | subject to management |
| 4 | Fe-59 | 4.0E+02 | 5.6E-03 | subject to management |
| 5 | Cd-115m | 3.0E+02 | 1.4E-03 | subject to management |
| 6 | C-14 | 2.0E+03 | 1.3E-03 | subject to management |
| 7 | Cd-113m | 4.0E+01 | 1.3E-03 | subject to management |
| 8 | Ag-110m | 3.0E+02 | 1.0E-03 | subject to management |
| 9 | Zn-65 | 2.0E+02 | 8.4E-04 | |
| 10 | Mn-54 | 1.0E+03 | 5.2E-04 | |
| 11 | Co-58 | 1.0E+03 | 2.5E-04 | |
| 12 | Co-60 | 2.0E+02 | 2.3E-04 | |
| 13 | Tc-99 | 1.0E+03 | 2.1E-04 | |

※【Definition of discharge limits】

- For nuclides that have been detected before: twice the maximum detected value
- For nuclides that have not been detected before: 1.2 times the detection limit
- The sum of the ratios of these 8 radionuclide is 0.32

⇒ALPS Treated water which contains nuclides at concentrations that exceed the discharge limits will be treated again until the concentrations satisfy the discharge limits, even if the sum of the ratios of the 63 radionuclides is less than 1,

# 【Reference】Table of nuclide concentrations for ②the hypothetical ALPS treated water

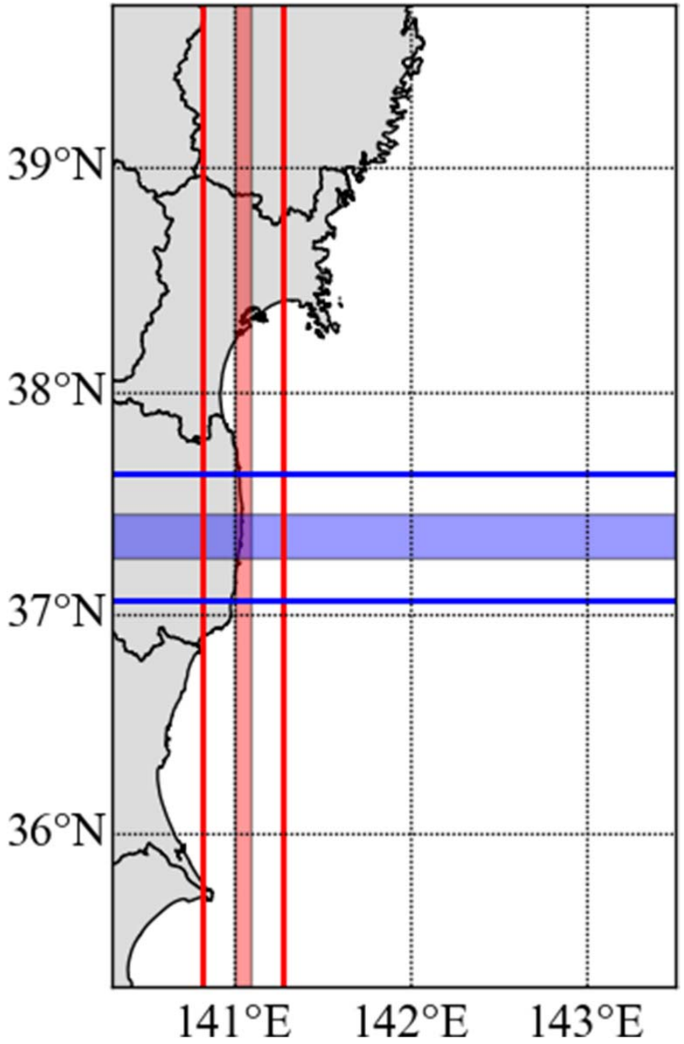
| Target nuclides (half life) | Regulatory standard [Bq/L] | Maximum observed value [Bq/L] | Discharge limits [Bq/L]※ | Ratios of the legally required concentrations | Notes |
|---|---|---|---|---|---|
| Nuclides subject to control | | | | | **Sum of the ratios of 8 radionuclides**<br>0.32 |
| Nuclides that have not been detected | | | | | |
| Fe-59（approx.45 days） | 4.0E+02 | <8.66E-02 | 2.0E-01 | 5.0E-04 | |
| Ag-110m（approx.250 days） | 3.0E+02 | <4.26E-02 | 6.0E-02 | 2.0E-04 | |
| Cd-113m（approx. 15 years） | 4.0E+01 | <8.55E-02 | 2.0E-01 | 5.0E-03 | |
| Cd-115m（45 days） | 3.0E+02 | <2.70E+00 | 4.0E+00 | 1.3E-02 | |
| Sn-119m（approx. 290 days） | 2.0E+03 | <4.24E+01 | 6.0E+01 | 3.0E-02 | |
| Sn-123（approx. 130 days） | 4.0E+02 | <6.59E+00 | 8.0E+00 | 2.0E-02 | |
| Sn-126（approx. 100000 years） | 2.0E+02 | <2.92E-01 | 4.0E-01 | 2.0E-03 | |
| Detected nuclides | | | | | |
| C-14（approx.5700 years） | 2.0E+03 | 2.15E+02 | 5.0E+02 | 2.5E-01 | |
| Other nuclides | | | | | **Ratio of the concentration of Zn-65 to the regulatory standard**<br>1-0.32=0.68<br>**Concentration of Zn-65**<br>200[Bq/L]×0.68=136[Bq/L] |
| Zn-65（approx. 240 days） | 2.0E+02 | - | –<br>（Concentration in assessment is set at 1.4E+02） | 6.8E-01 | |
| **Sum of the ratios of the concentration of 8 radionuclides and Zn-65** | | | | 1 | |

※The discharge limit was set at 1.2 times the detection limit for nuclides that have never been detected and 2 times the maximum of the detection limit rounded up to the significant digit for detected nuclides. Other nuclides are expressed by the concentration for assessment instead of discharge limits.

# Dispersion and transfer in the environment (dispersion calculations in the sea area)

TEPCO

The assessment used a model that was found to be reproducible based on the repeatability calculations for the cesium concentration in seawater after the accident at the Fukushima Daiichi Nuclear Power Station. In addition, the calculations with higher resolutions was conducted so as to simulate the sea area near the power station in detail.




- Applied the Regional Ocean Modeling System (ROMS) to the sea area off the Fukushima coast

- Sea area flow data
  - Data interpolated from JMA short-term meteorological forecast data[1] was used in the sea surface driving force
  - Ocean reanalysis data (JCOPE2[2]) was used as the source for boundary conditions for the open sea and data assimilation*

- Scope of modeling: The resolution of the sea area 35.30-39.71°N, 140.30-143.50°E （490km×270km); 22.5 km north to south and 8.4 km east to west of the Station was increased gradually
  - Resolution (overall): NS approx.925m x EW approx.735m （approx.1km); 30 layers vertically
  - Resolution (immediate vicinity of the station): NS approx.185m x EW approx.147m （approx.200m); 30 layers vertically (sea area with red and blue hatching in the diagram on the left)

- Meteorological and sea condition data
  - Data from 2014 and 2019

*Data assimilation: a method for incorporating actual measurements in numerical simulations. Also known as nudging.


[1] A. Hashimoto, H. Hirakuchi, Y. Toyoda, and K. Nakaya, "Prediction of regional climate change over Japan due to global warming (Part 1) – Evaluation of Numerical Weather Forecasting and Analysis System (NuWFAS) applied to a long-term climate simulation-" CRIEPI Report, 2010.
[2] Y.Miyazawa, R.Zhang, X.Guo, H.Tamura, D.Ambe, J.-S.Lee, A.Okuno, H.Yoshinari, T.Setou, and K.Komatsu,, "Water mass variability in the western North Pacific detected in a 15-year eddy resolving ocean reanalysis," 2009.

# Dispersion and transfer in the environment (calculating concentrations of radioactive materials for the assessment)

TEPCO

- The tritium concentration in the sea area was calculated using the actual annual meteorological/sea conditions data assuming that tritium is discharged evenly throughout the year
- The annual average concentration of tritium was calculated for the 10km by 10km area around the station
- Doses were calculated for the upper layers (external exposure from the sea surface), all layers (external exposure in the sea, internal exposure), and lower layers (exposure of animals and plants)
- The concentrations of the other 63 nuclides were calculated using the calculated tritium concentration and the proportions of each nuclide in the discharged treated water


*Area where common fishery rights are not set

**Area diagram for calculating the radiation material concentration in the sea to be used in the assessment**

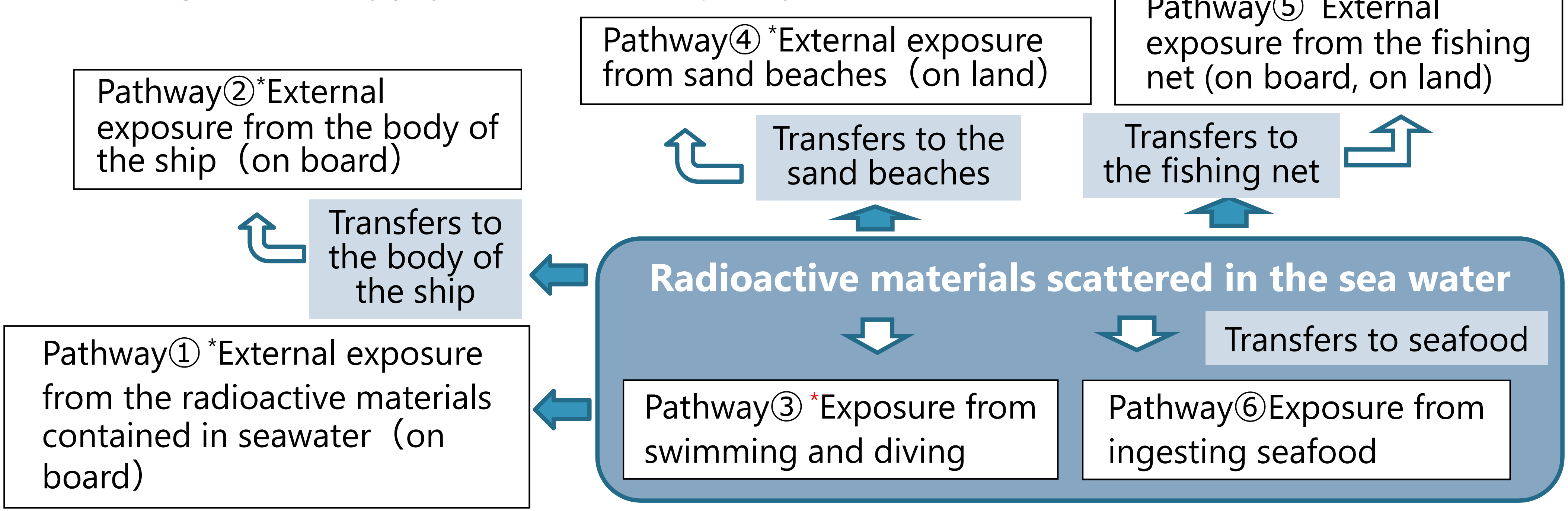
Source: This map was created by Tokyo Electric Power Company Holdings, Inc. based on a map published by the Geographical Survey Institute (Electronic Map Web)
https://maps.gsi.go.jp/#13/37.422730/141.044970/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f1

# Identifying the exposure pathways (assessment model)

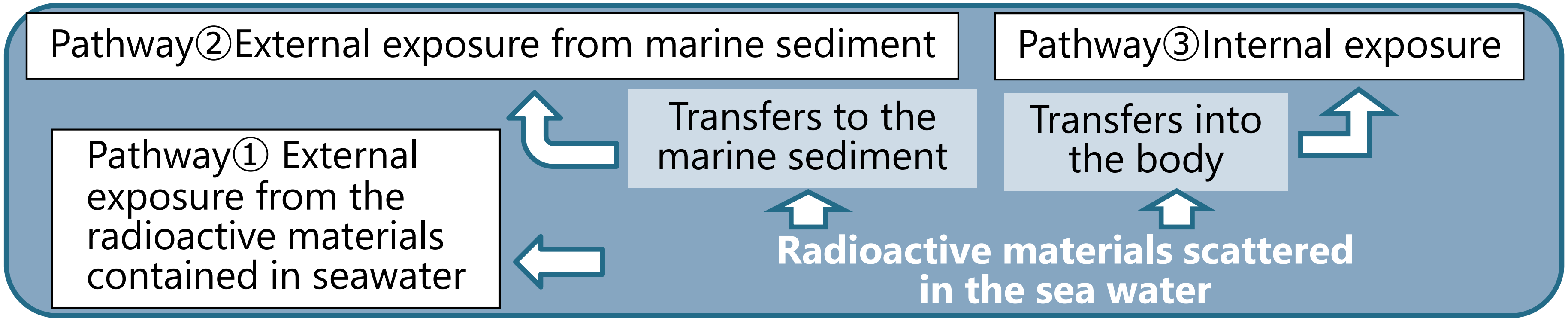
TEPCO

（1） Transfer and exposure pathways (human exposure)

The impact of external exposure is expected to be minimal as the concentration of radioactive materials will be diluted and then discharged. As such, only γ ray levels were assessed. (pathways for *)




（2） Transfer and exposure pathways (plants and animals)



# Setting of the representative person and reference animals/plants

TEPCO

## （1） Representative person (human exposure)

- The lifestyle of the representative person (external exposure) was taken from the "public dose assessment in safety screening for commercial light-water reactor facilities"
  - Works 120 days (2,880 hours) per year in the fishery, of which 80 days (1,920 hours) are spent working near nets
  - Resides by the seashore 500 hours a year and swims 96 hours a year
- The amount of seafood ingested annually (internal exposure) was taken from the latest data on diet. Two scenarios, one for a person who ingests seafood at the national average and the other for a person who ingests a lot of seafood (mean + 2σ * ) were considered

**Table 4-8 Amount of seafood ingested by a person who ingests seafood at the national average (g/day)**

| | Fish | Invertebrate | Seaweed |
|---|---|---|---|
| Adult | 58 | 10 | 11 |
| Toddler | 29 | 5.1 | 5.3 |
| Infant | 12 | 2.0 | 2.1 |

**Table 4-9 Amount of seafood ingested by a person who ingests a lot of seafood (g/day)**

| | Fish | Invertebrate | Seaweed |
|---|---|---|---|
| Adult | 190 | 62 | 52 |
| Toddler | 97 | 31 | 26 |
| Infant | 39 | 12 | 10 |

## （2） Reference animals and plants (environmental protection)

Reference flatfish, reference crab, reference brown seaweed were selected from the marine environment reference organisms indicated in ICRP Pub.136**.

- Flatfish: Flounders widely inhabit in the surrounding sea area, and are important fish for the local fishery industry
- Crab：Many types of crabs (e.g., portunus trituberculatus, ovalipes punctatus) widely inhabit the surrounding sea area
- Brown seaweed：Many types of seaweed including gulfweed and sea oak widely inhabit the surrounding sea area

* Standard deviation
** ICRP Pub.136 "Dose Coefficients for Non-human Biota Environmentally Exposed to Radiation"

# Dose assessment for representative person

TEPCO

External exposure (Pathway ①～⑤)

- Exposure due to radiation from the sea when moving by boat or working in the sea （Pathway ① and ③）

*Amount of exposure ＝Effective dose equivalent coefficient × Concentration of radioactive materials in the seawater*

- Exposure due to radiation from the radioactive materials that have moved to the body of the ship or sand beaches from the seawater （pathways②, ④ and ⑤）

*Amount of exposure ＝ Effective dose equivalent coefficient ×Transfer coefficient× Concentration of radioactive materials in the seawater*

- The effective dose equivalent coefficient that indicates the amount of radiation a person is exposed to from a 1 Bq/L concentration of radioactive material specified in the Handbook on Environmental Impact Assessment for Decommissioning Work*1 was used here
- The transfer coefficient that describes how much radioactive material transfers from the 1Bq/L concentration of radioactive material in the seawater to the body of the ship or sand beaches was mostly taken from the designated application for reprocessing businesses (Japan Nuclear Fuel Limited,1989)*2. The sand beach transfer coefficient specified in the old Nuclear Safety Commission guidelines*3 was used here.

*1 "Survey on Environmental Impact Assessment Technology for Decommissioning of Commercial Reactors - Survey on Environmental Impact Assessment Parameters (FY2006 Survey Commissioned by Ministry of Economy, Trade and Industry) Appendix: Handbook on Environmental Impact Assessment for Decommissioning Work, Central Research Institute of Electric Power Industry

*2 "Application for designation of the Rokkasho Reprocessing Plant as a reprocessing business", Japan Nuclear Fuel Limited

*3 "Dose assessment for the general public in the safety assessment of light water reactor facilities for power generation" , Nuclear Safety Commission

# Dose assessment for representative individuals

TEPCO

## Internal exposure （Pathway⑥）

*Amount of exposure＝ Effective dose coefficient × Ingestion rate*
*Ingestion rate＝ Concentration of radioactive materials in seawater × concentration coefficient × amount of seafood ingested annually*

- The effective dose coefficient specified in the ICRP Publication 72[*1] is used here
- The concentration coefficient specified in IAEA TRS No.422[*2] is used here
- Dilution at the seafood market and attenuation of various radioactive materials from collection to ingestion was not considered
- Fish, invertebrates (excluding squid and octopus) [*3], and seaweed are considered seafood here.

## Assessment standard (sum of external and internal exposure)

- The result was compared with 1mSv/year, the dose limit for the general public
- As the concept of dose constraints[*4] has not been introduced in Japan, the result was compared to the station dose target of 0.05 mSv/year

*1 ICRP Pub.72, "Age-dependent Doses to Members of the Public from Intake of Radionuclides; Part 5 Compilation of Ingestion and Inhalation Doses Coefficients"

*2 IAEA Technical Report Series No.422, "Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment"

*3 Used a dataset in the ICRP Pub.72 named "Invertebrates (excluding squid and octopus)

*4 Dose constraint: A value lower than the dose limit, stipulated by the person responsible for radiation work or the radiation facility to optimize safety in physical protection. There is no legal dose constraint in Japan.

# Dose assessment for reference animals and plants

TEPCO

## Animals and plants

- Animals and plants are evaluated using the dose rate in their habitat
- The reference animals and plants and dose conversion coefficient from the ICRP will be used in the formula below to calculate the dose
- Exposure from the seawater and from the seabed are considered in external exposure.

*Amount of internal exposure* ＝*Internal dose conversion coefficient* × *Radiation material concentration in seawater* × *concentration ratio* （*Pathway*③）

*Amount of external exposure* ＝*0.5×external dose conversion coefficient* × *Radiation material 0concentration in seawater* （*Pathway*①） ＋*0.5*× *external dose conversion coefficient* × *Radiation material concentration in seawater* ×*partition coefficient* （*Pathway*②）

- Internal and external dose conversion coefficients specified in ICRP Pub 136[*1] and BiotaDC[*2] were used here
- The concentration ratio used here is the concentration coefficient specified in ICRP Pub 114[*3] and IAEA TRS-422[*4]
- The partition coefficient specified in IAEA TRS-422（2.3.OCEAN MARGIN *Kd*s）was used here

## Assessment standard

- The results are compared with the Derived Consideration Reference Levels (DCRLs)[*6] published by the ICRP in Pub.124[*5]

*1 ICRP Pub.136, "Dose Coefficients for Non-human Biota Environmentally Exposed to Radiation"

*2 ICRP BiotaDC Program v.1.5.1 (http://biotadc.icrp.org/)

*3 ICRP Pub.114, "Environmental Protection: Transfer Parameters for Reference Animals and Plants"

*4 IAEA Technical Report Series No.422, "Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment"

*5 ICRP Pub.124 "Protection of the Environment under Different Exposure Situations"

*6 DCRL (Derived Consideration Reference Level): a band of dose rates with a single-digit range for each species of organisms, defined by the ICRP. In cases where this dose rate level is exceeded, the effect on the organism should be considered.

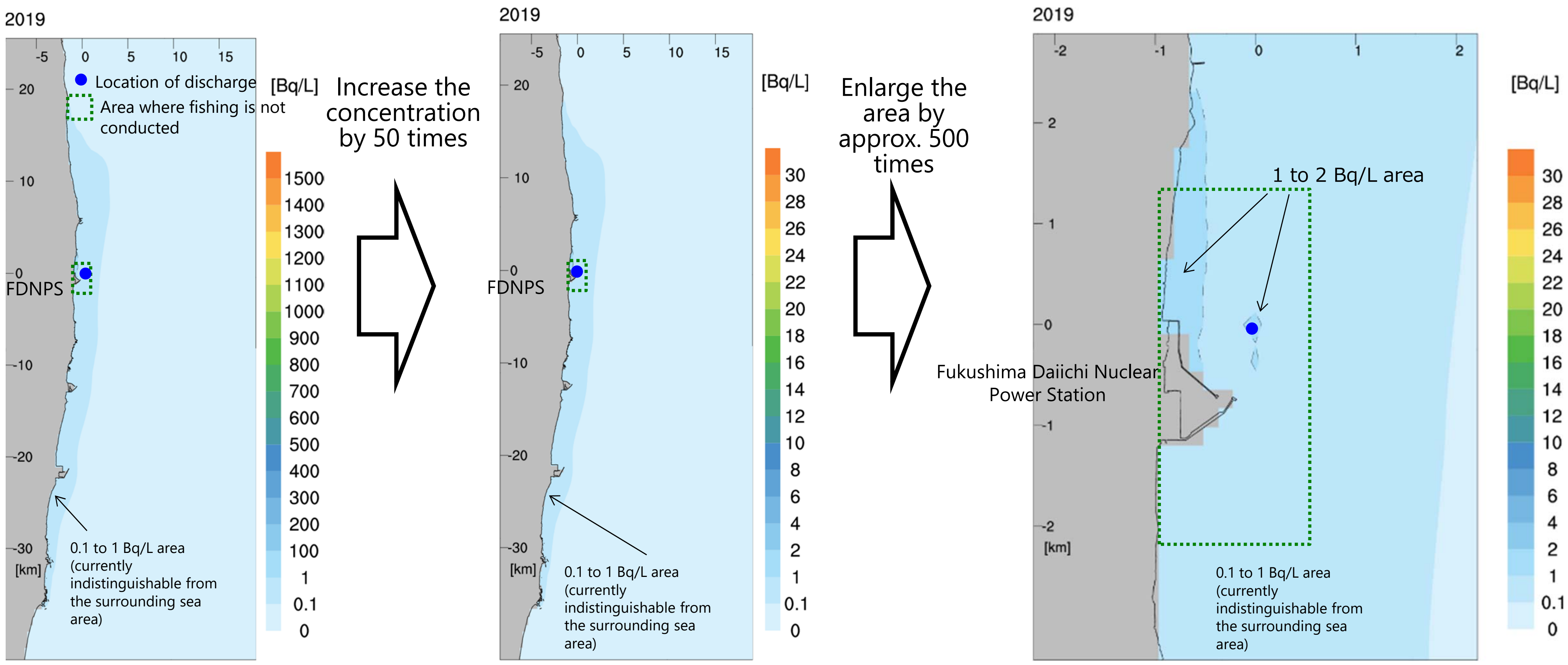
1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT
2. ASSESSMENT METHODS
3. **ASSESSMENT RESULTS**
4. REFERENCES

# Results of dispersion simulation at sea

TEPCO

Assessment using the meteorological and sea conditions data from 2019 found that the area with higher tritium concentrations than the current surrounding area (0.1-1 Bq/L*) (the area inside the dotted line) will be limited to the area 2 to 3 km from the station.

*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

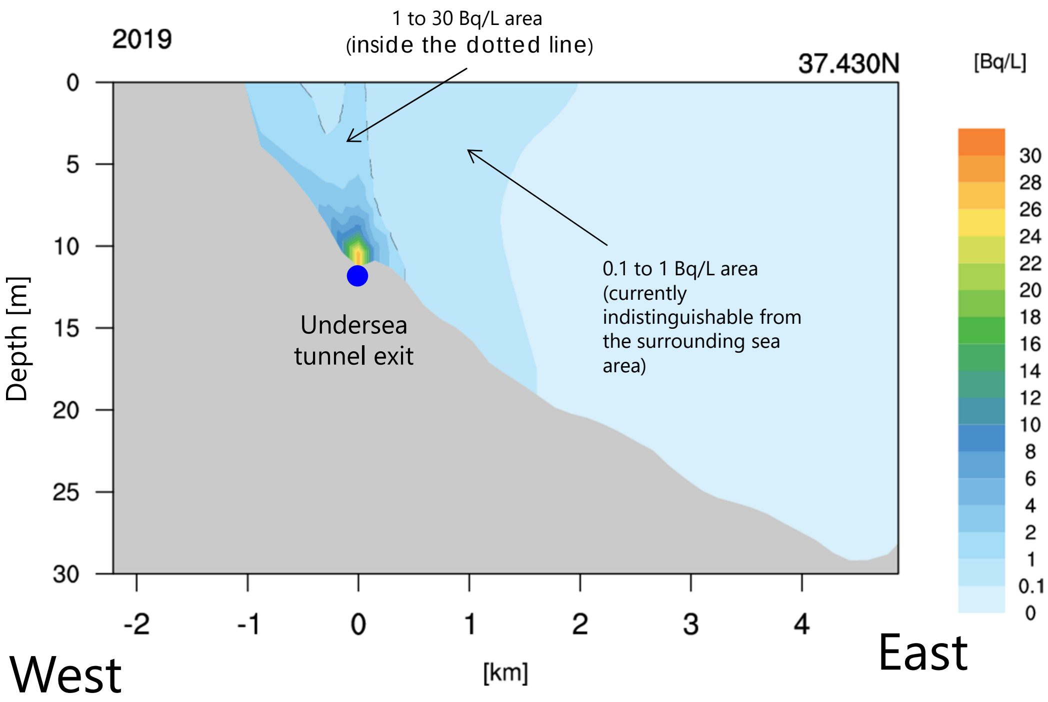



Enlarged view of the area off the coast of Fukushima (Largest value in scale at 30 Bq/L)

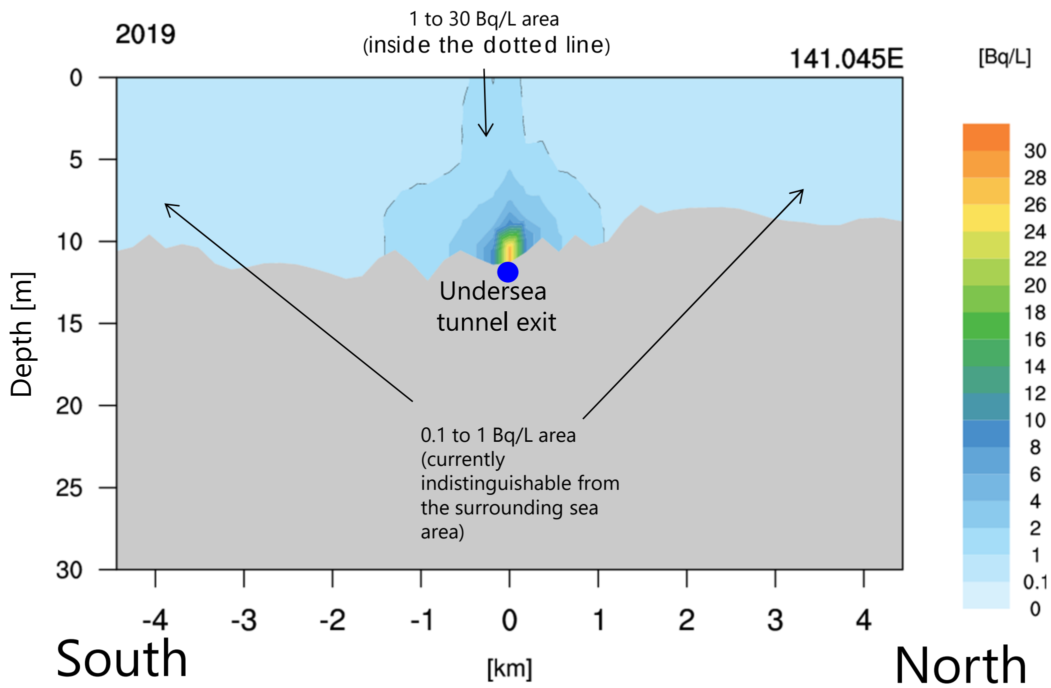
Enlarged view of the area around the station ( Largest value in scale at 30 Bq/L )

# Results of dispersion simulation at sea (area around the tunnel exit)

While some areas directly above the tunnel exit, before dispersion, show concentrations exceeding 30 Bq/L, the concentration swiftly falls in the surrounding area.
Furthermore, the 30 Bq/L measurement observed in the area directly above the tunnel exit is still significantly below the national regulatory standard (60,000 Bq/L) and the **WHO Guidelines for drinking-water quality (10,000 Bq/L).**




Cross-section view of the tunnel exit (East to west)
(Largest value in scale at 30Bq/L)



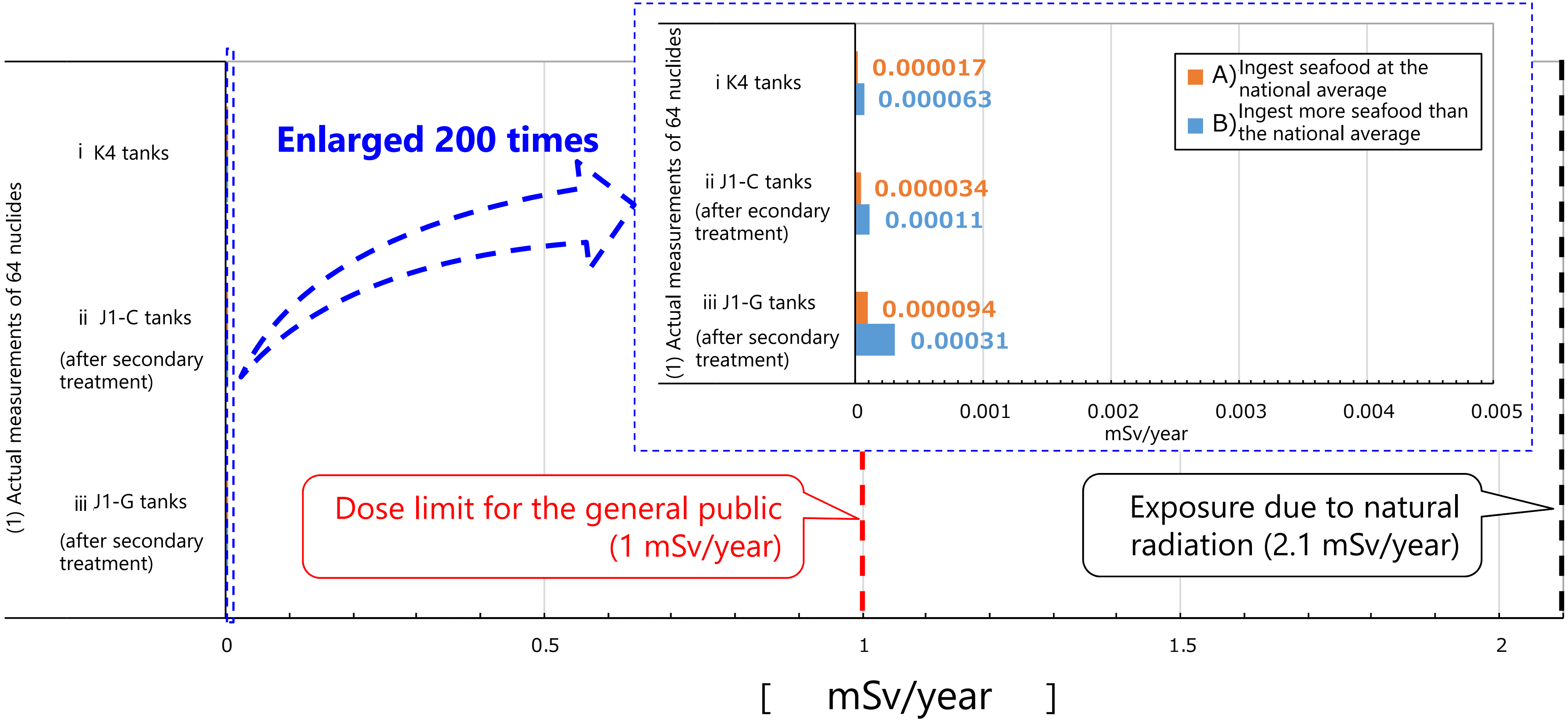

Cross-section view of the tunnel exit (North to south)
(Largest value in scale at 30Bq/L)

*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

# Human exposure assessment results
## (design stage, (1) assessment using actual measurements of 64 nuclides)

TEPCO

- Results of an assessment using (1) actual measurements from 64 nuclides found that the **<u>exposure dose for a person who ingests seafood at the national average (general public) was approx. 1/60,000 to 1/10,000 of the dose limit for the general public (1mSv/year) and approx. 1/120,000 to 1/20,000 of natural radiation exposure (2.1 mSv/year).</u>**




(Note) These are figures for adults only. This assessment assumed that nuclides that had never been detected before existed at the lower limit of detection. These are present results and may be updated according to future discussions and internal and external reviews.

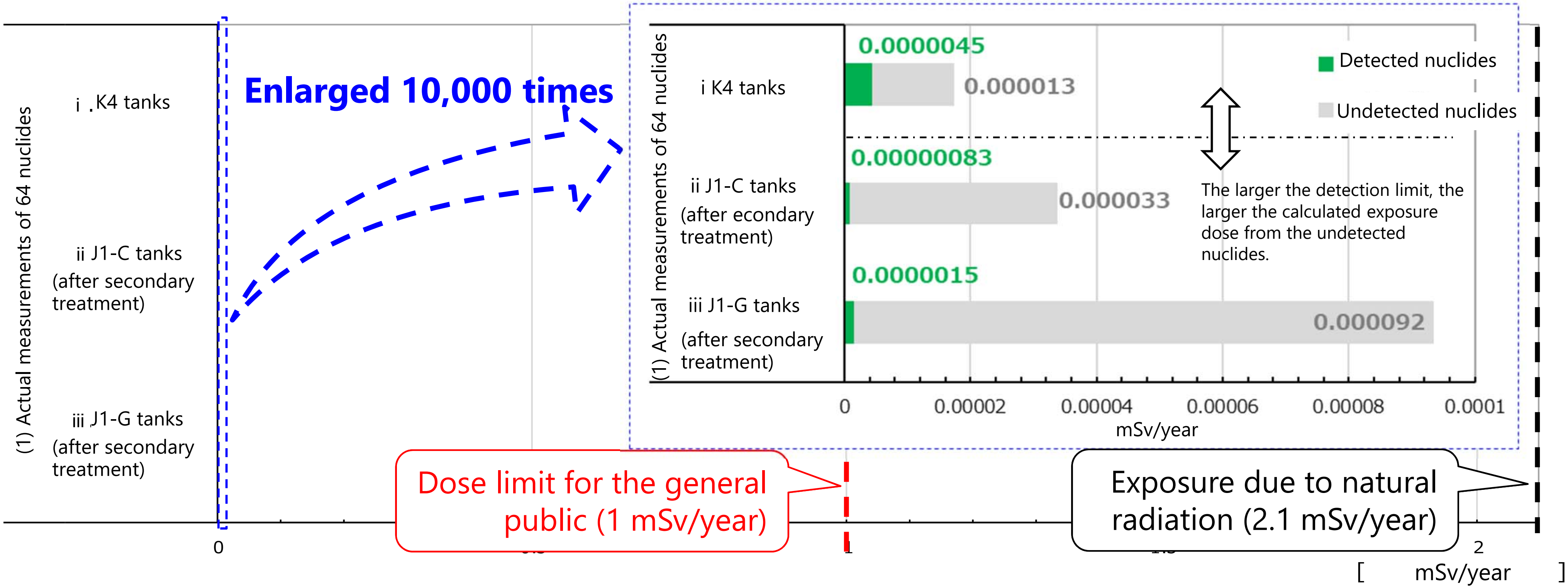
# Insights into undetected nuclides in the assessment results
## (design stage, (1) assessment using actual measurements)

TEPCO

- (1) Assessment based on actual measurements of 64 nuclides assumed that **<u>"undetected nuclides" that had never been detected in analysis before existed in detection limit amounts. Exposure from these undetected nuclides are assumed to comprise the majority of the calculated exposure dose, and the dose from actual measurements is likely to be much lower.</u>**
  - ✓ Going forward, water samples will be measured once a year using a lower detection limit than normal to assess the impact of the undetected nuclides.

i .K4:detailed analysis with lowered detection limits
ii .J1-C, iii .J1-G: detection limits that can be continuously used

Contribution of undetected nuclides in exposure
(when seafood is ingested in amounts at the national average)

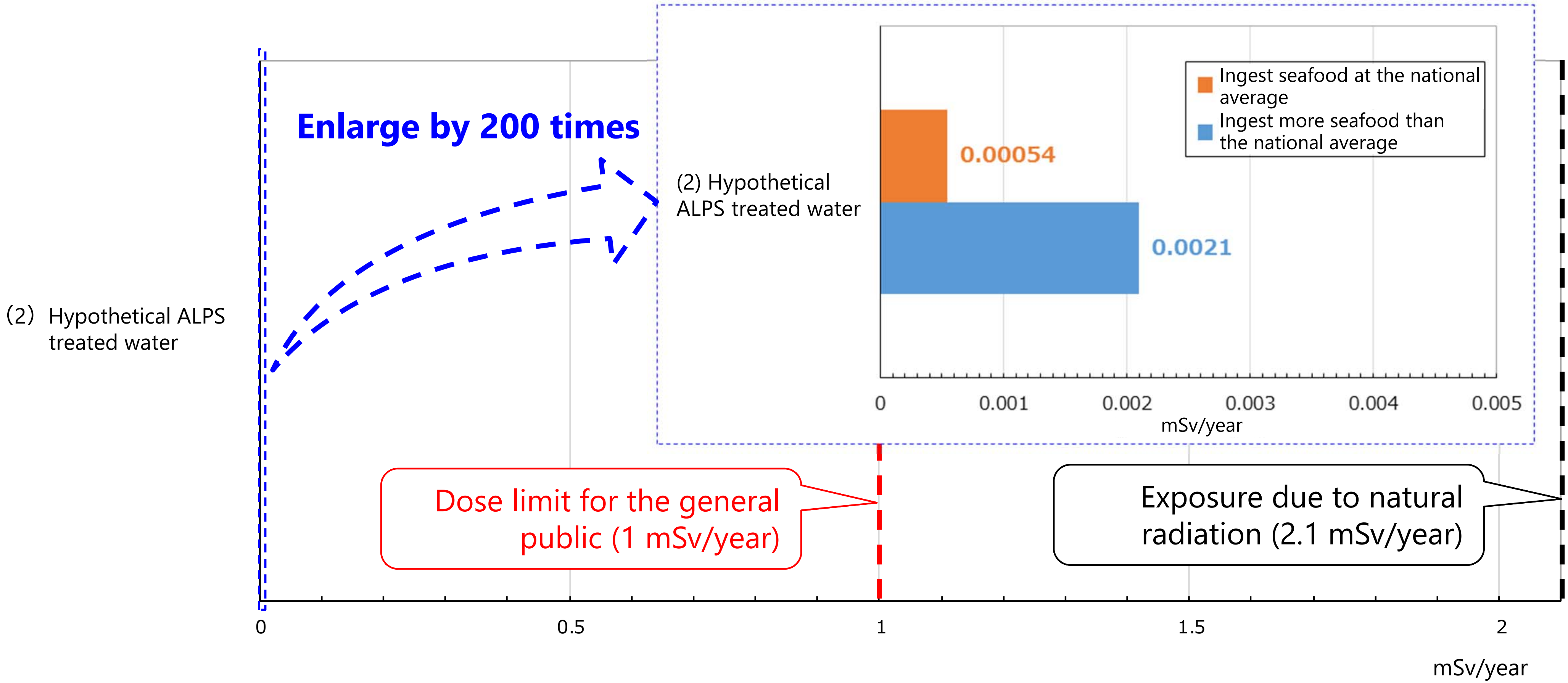



(Note) These are figures for adults only. These are present results and may be updated according to future discussions and internal and external reviews.

# Human exposure assessment results

**(design stage, (2) Assessment using hypothetical ALPS treated water )**

- Even in the most conservative scenario using (2) hypothetical ALPS treated water that only contains nuclides that have a comparatively large impact on exposure, the calculated dose was approximately 1/2,000 to 1/500 of the dose limit for the general public (1mSv/year) and 1/4,000 to 1/1,000 of natural radiation exposure (2.1 mSv/year)

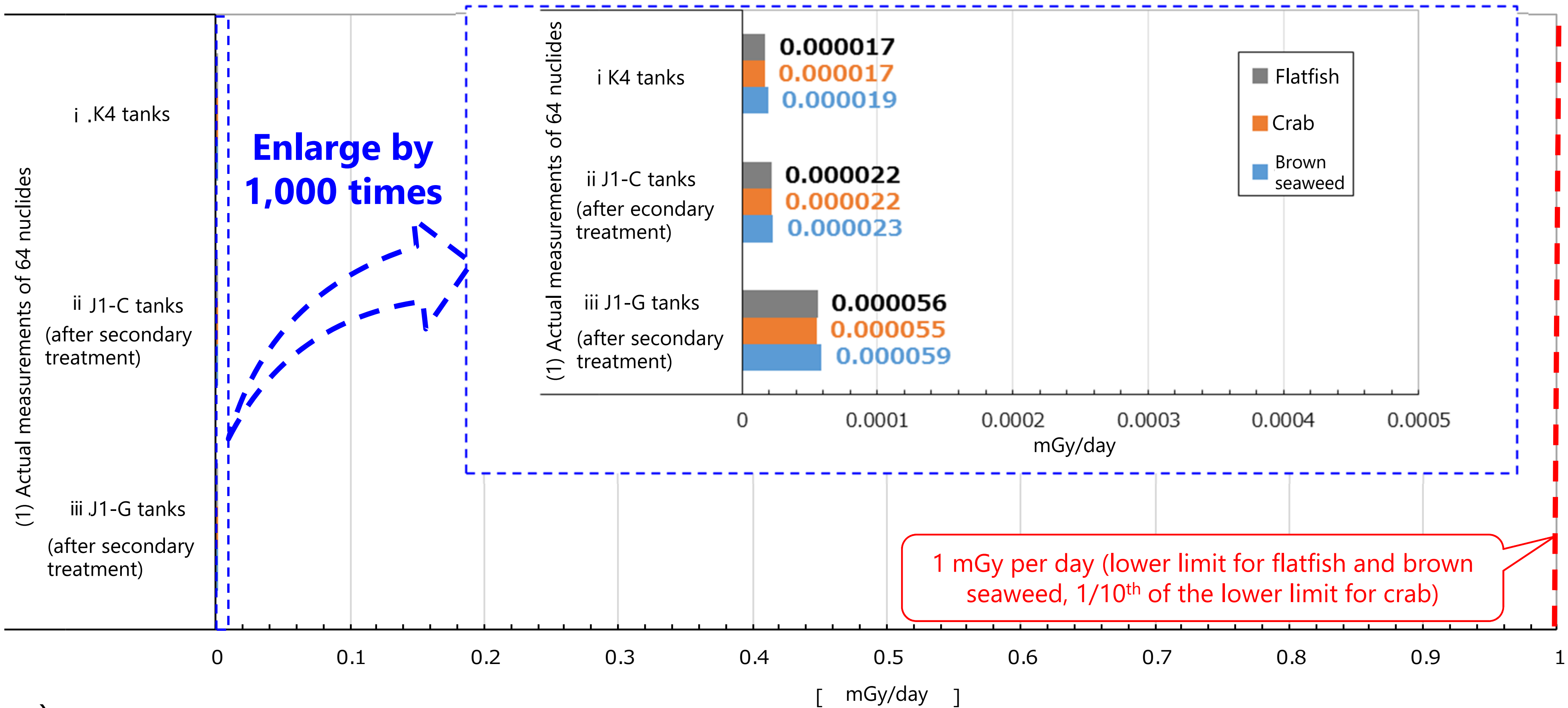



(Note) These are figures for adults only. The results may be updated according to future discussions and internal and external reviews.

# Results of animal and plant exposure assessment
## （design stage, (1) assessment using actual measurements of 64 nuclides ）

TEPCO

- Results from the (1) assessment using actual measurements of 64 nuclides was approximately 1/60,000 to 1/20,000 (1/600,000 to 1/200,000 for crab) of the lower limit of the derived consideration reference level* (DCRL; 1 to 10 mGy /day for flatfish, 10 to 100 mGy/ day for crab, 1 to 10 mGy/day for brown seaweed) which is considered the standard in assessment.




(Note) This assessment assumes that “undetected nuclides” that have never been detected before exist at detection limit amounts.
These are present results and may be updated according to future discussions and internal and external reviews.

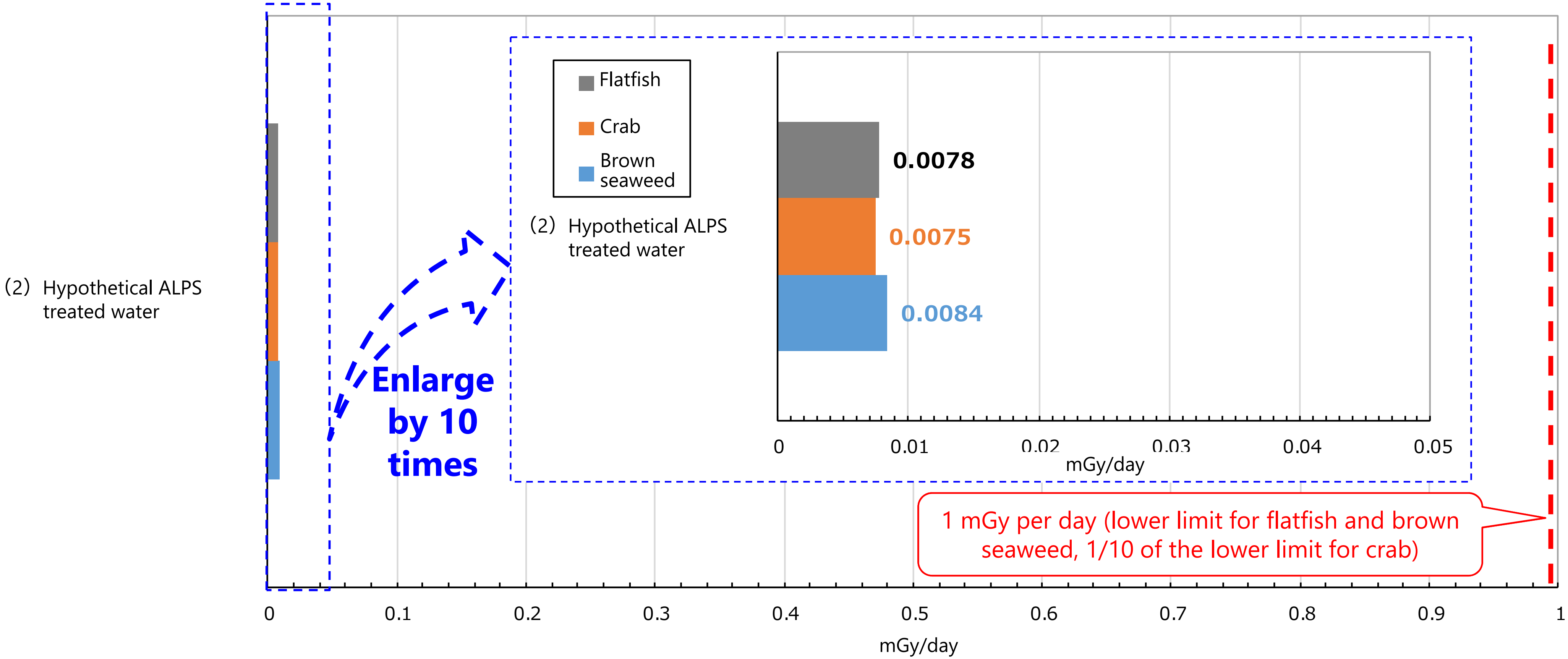
- DCRL (Derived Consideration Reference Level): a band of dose rates with a single-digit range for each species of organisms, defined by the ICRP. In cases where this dose rate level is exceeded, the effect on the organism should be considered.
- **Gy (gray) is a unit of energy absorbed by matter. Sv (sievert) is a unit expressing the impact of radiation on the human body. To be accurate, Sv = corrective coefficient × Gy but for gamma rays and beta rays, Sv and Gy are mostly equivalent.

# Results of animal and plant exposure assessment

**(design stage, (2) Assessment using hypothetical ALPS treated water)**

TEPCO

- Even in the most conservative scenario using (2) hypothetical ALPS treated water that only contains nuclides that have a comparatively large impact on exposure, the calculated dose is approximately 1/130 to 1/120 (1/1,300 to 1/1,200 for crab) of the derived consideration reference level* (1 to10 mGy /day for flatfish, 10 to 100 mGy/ day for crab, 1 to 10 mGy/day for brown seaweed).




(Note) These are present results and may be updated according to future discussions and internal and external reviews.

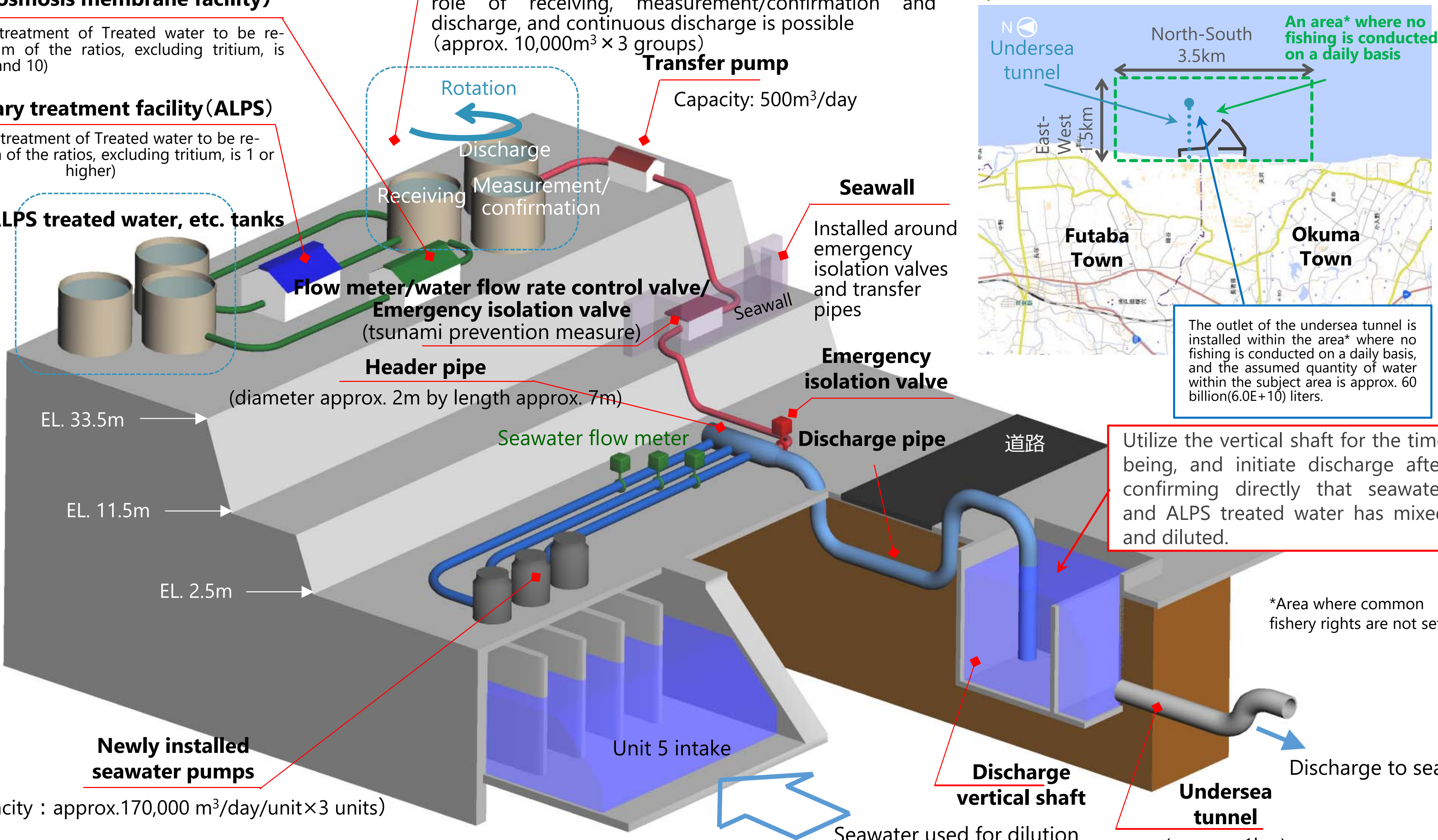
* DCRL (Derived Consideration Reference Level): a band of dose rates with a single-digit range for each species of organisms, defined by the ICRP. In cases where this dose rate level is exceeded, the effect on the organism should be considered.

1. DISCHARGE METHOD OF PRECONDITIONS FOR ASSESSMENT
2. ASSESSMENT METHODS
3. ASSESSMENT RESULTS
4. **REFERENCES**

# 【Reference】Overview of facilities for securing safety

TEPCO

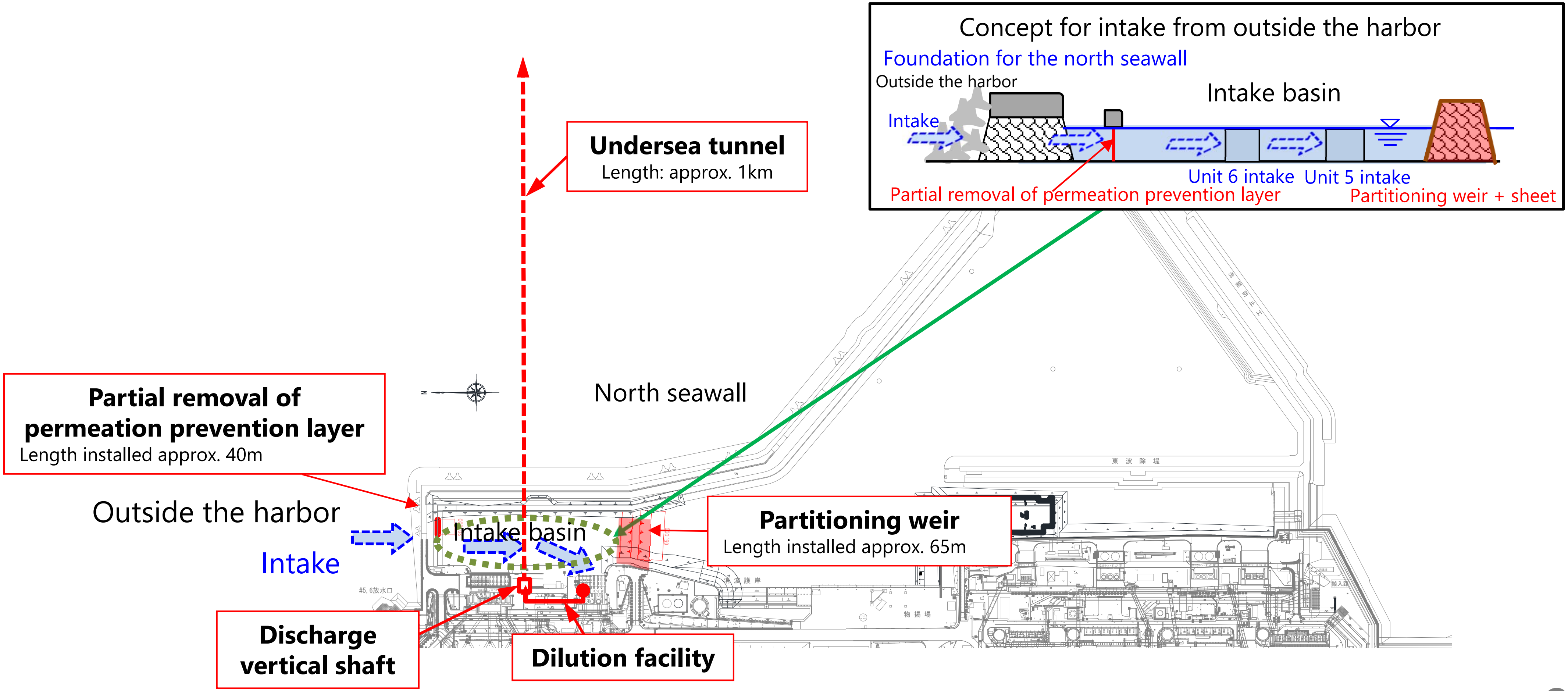
Source: Developed by Tokyo Electric Power Company Holdings, Inc. based on the map developed by the Geospatial Information Authority of Japan (electronic territory web)
https://maps.gsi.go.jp/#13/37.422730/141.044970/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f1



# 【Reference】 Harbor design

TEPCO

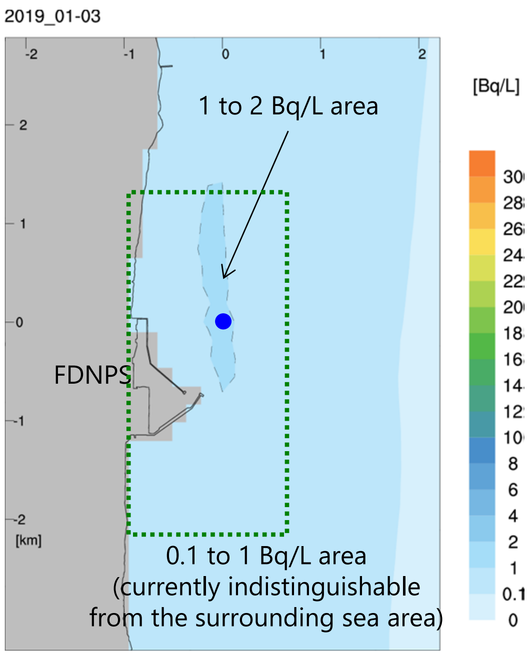
- Modify the north seawall to allow the intake of seawater outside the harbor for use in dilution, and **prevent seawater inside the harbor from mixing directly with the seawater for dilution** by separating from inside the harbor using a partitioning weir.
- The harbor shall be designed to discharge from approx. 1km from the coast to make it **difficult for seawater to recirculate** (unlikely for discharge to go through intake again as seawater for dilution).
- Details for the undersea tunnel shall be reviewed after conducting sea boring survey



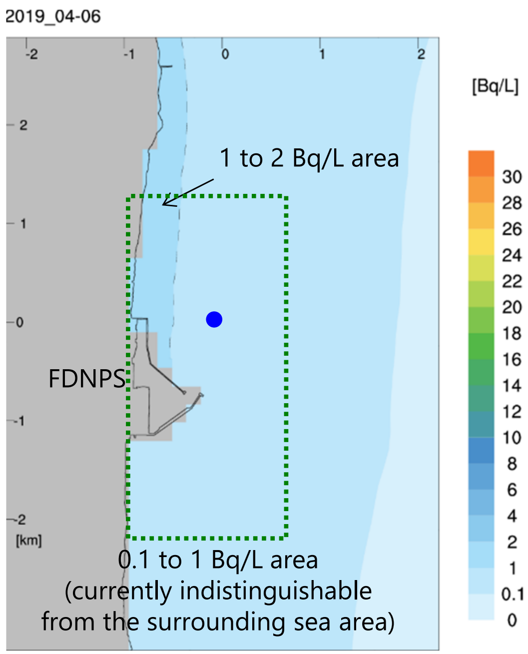
# 【Reference】Results of dispersion simulation at sea (average for each season)

Assessments suggest that the area with higher tritium concentrations than current levels in the surrounding area (0.1-1 Bq/L*) (area in the dotted line) **will be limited to the area around the station** when looking at the average of any season.

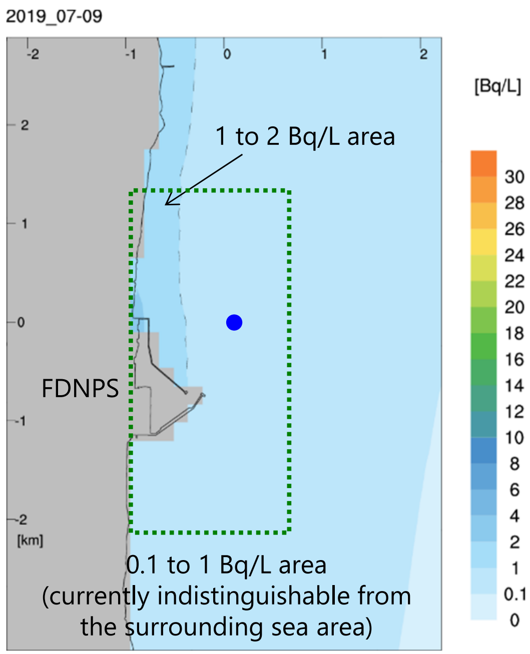
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10, 000 Bq/L)



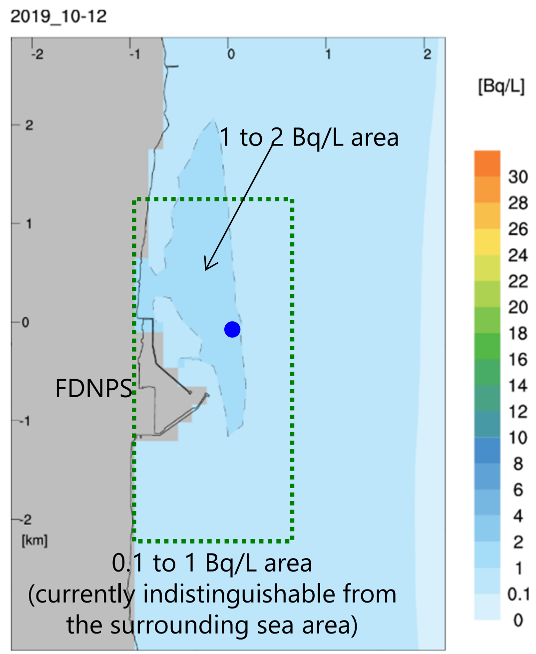

Average of January to March




Average of April to June




Average of July to September



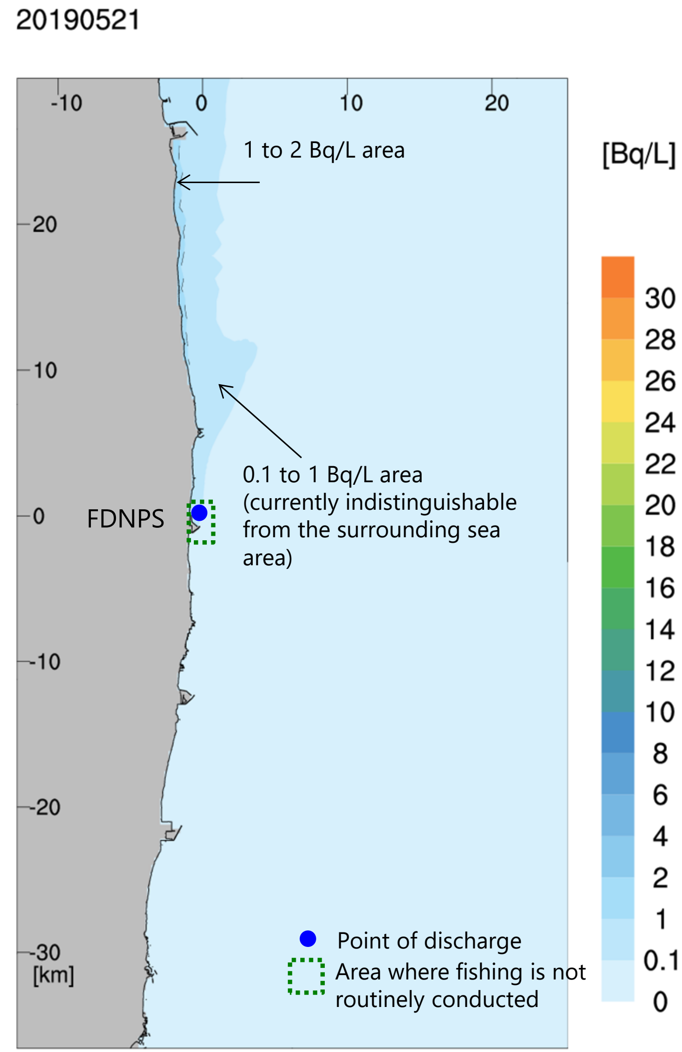

Average of October to December

# 【Reference】Results of dispersion simulation at sea

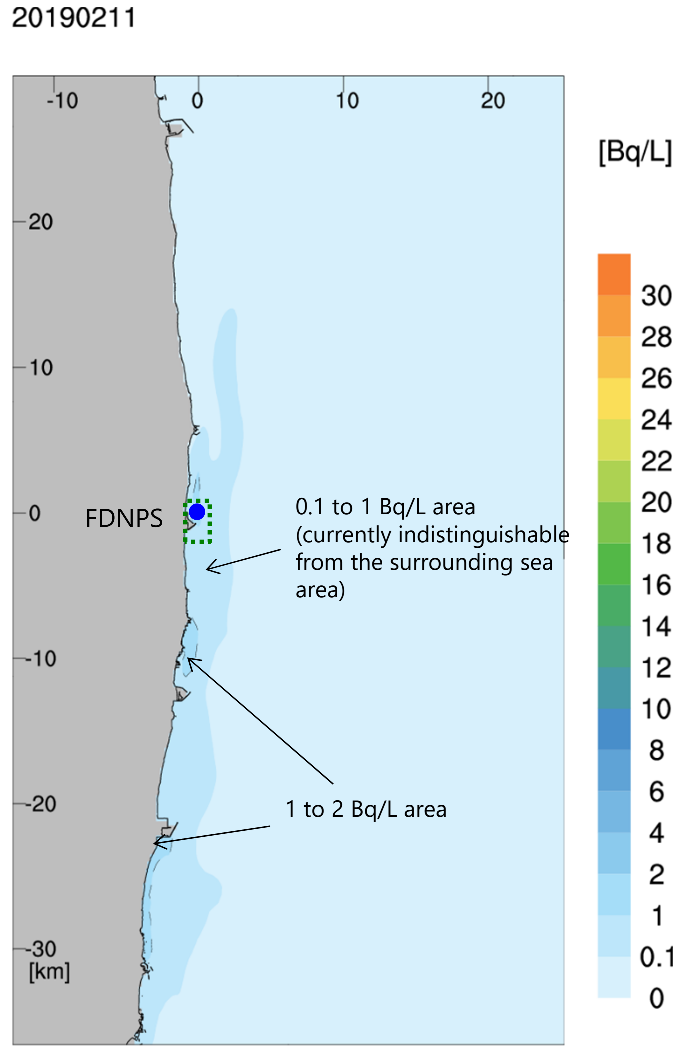
## (Trends in dispersion)

Simulations show that the area with higher tritium concentrations (area that exceeds 1Bq/L) than current levels in the surrounding area (0.1-1 Bq/L*) will be in a 30km range (North-South) of the discharge point even on days when the area spreads out most.

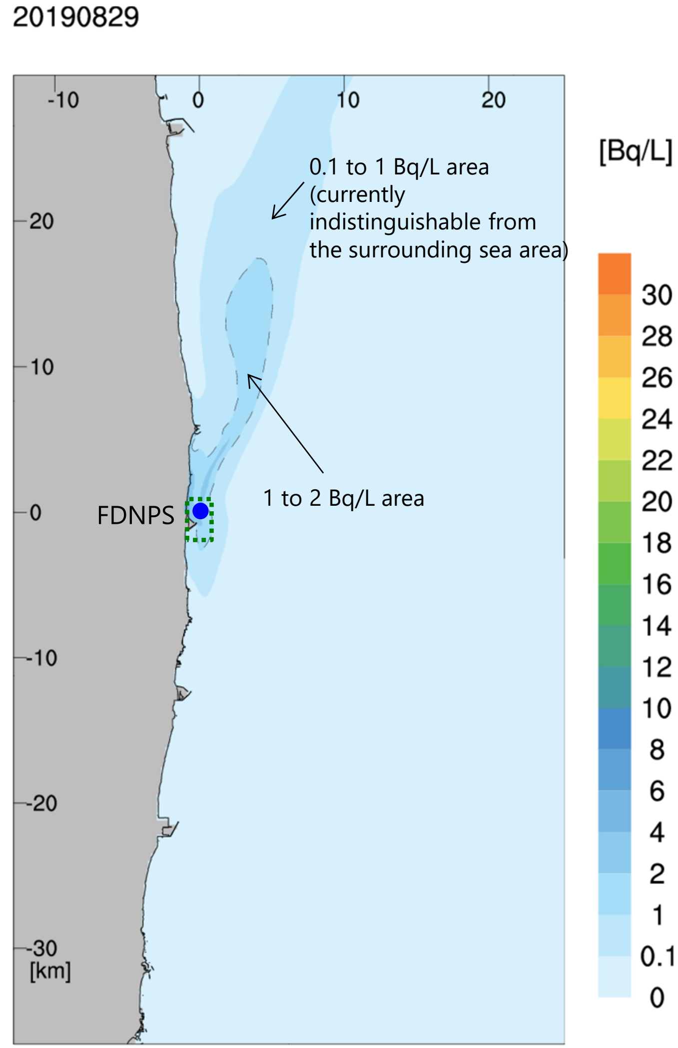
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)




Area at its northernmost configuration (Largest value in scale at 30Bq/L)




Area at its southernmost configuration (Largest value in scale at 30Bq/L)




Area at its easternmost configuration (Largest value in scale at 30Bq/L)

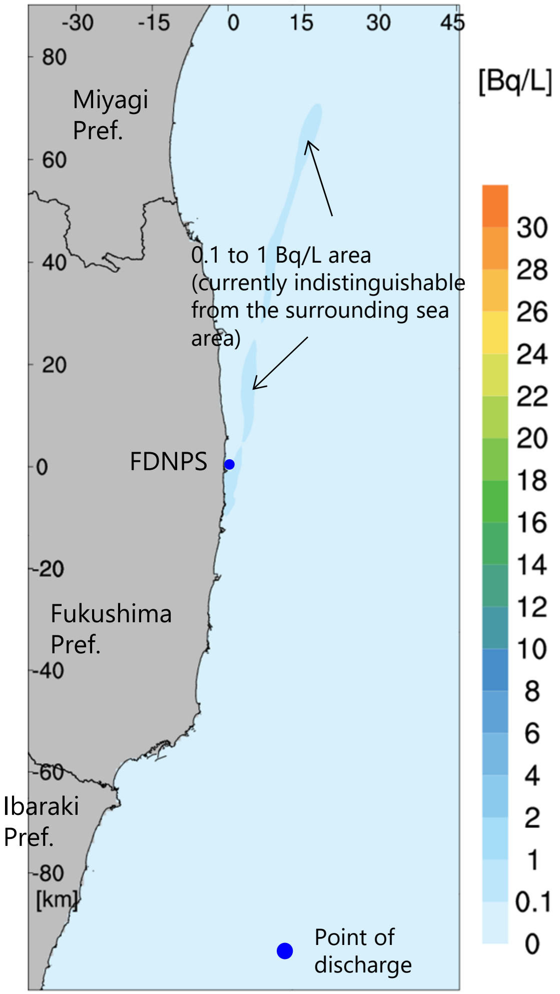
# 【Reference】 Results of dispersion simulation at sea

## (Trends in dispersion)

Simulations show that the area with low tritium concentrations (area that exceeds 0.1 Bq/L), where is indistinguishable from that of the surrounding sea area (0.1 to 1 Bq/L*) by actual measurements, will be as below even on days when the area spreads out most.

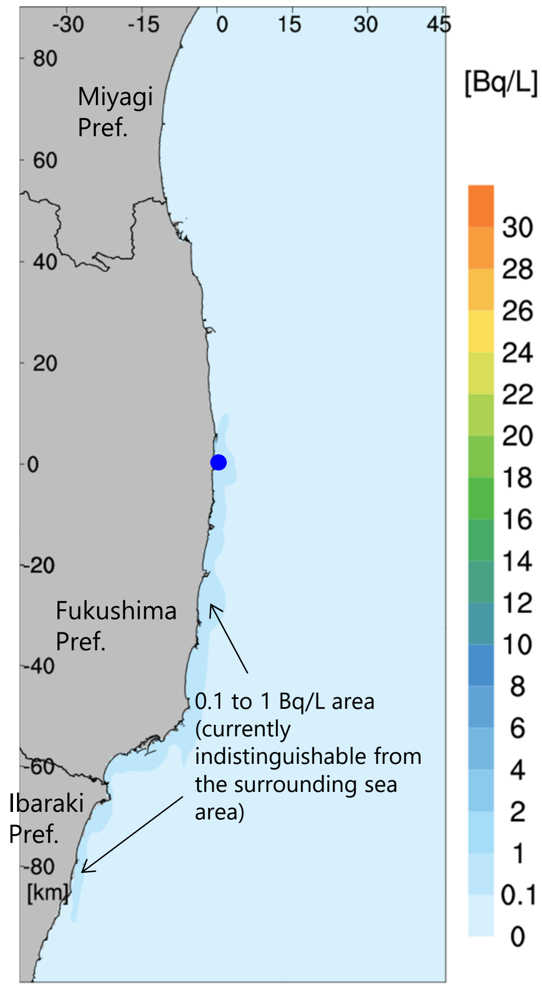
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

20190827



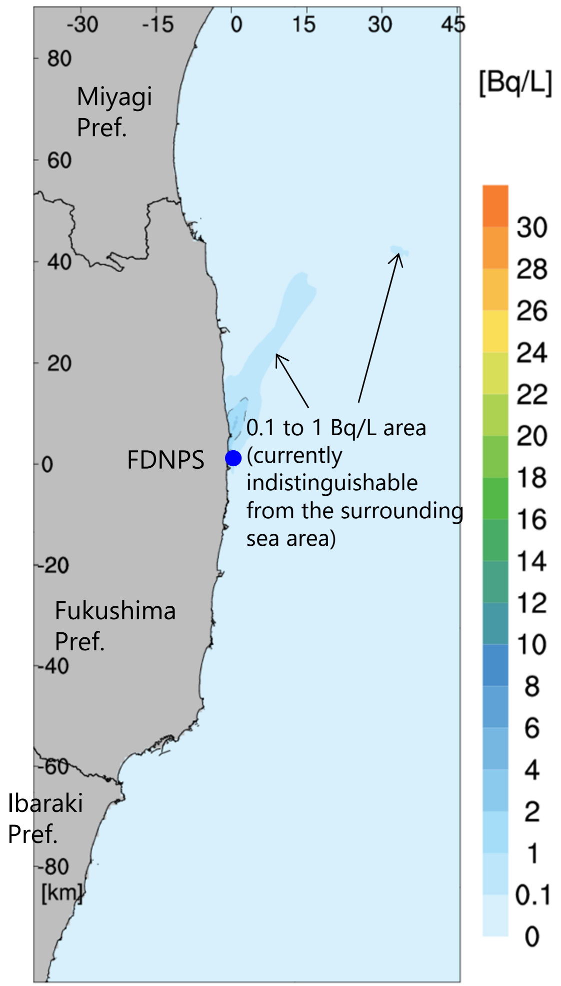

Area at its northernmost configuration
(Largest value in scale at 30Bq/L)

20191027




Area at its southernmost configuration
(Largest value in scale at 30Bq/L)

20190806




Area at its easternmost configuration
(Largest value in scale at 30Bq/L)

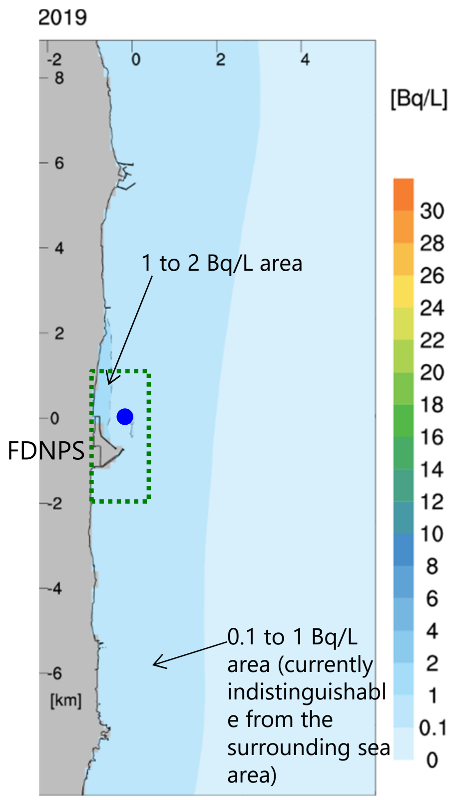
# 【Reference】 Insights of the impact on dispersion according to the discharge point

In addition to the scenario assuming that the ALPS treated water will be discharged according to the plan created by TEPCO, another scenario assuming that the ALPS treated water will be discharged from the Units 5 and 6 discharge port along the coast line was also simulated to see how the radioactive materials would diffuse (potential recirculation due to the proximity of the water intake cannel was not take into account).
The area assessed to have higher tritium concentrations than current levels in the surrounding sea area (0.1-1Bq/L*) (the area inside the dotted line) will be in a 6 to 7 km radius of the station in the scenario where ALPS treated water is discharged along the coast line while the area will be in a **2 to 3 km radius under the current plan that uses an undersea tunnel.**

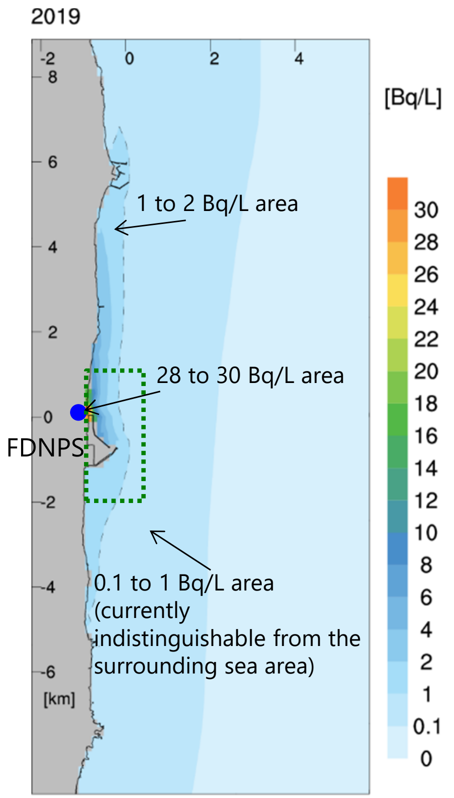
*1/100 thousandth to 1/10 thousandth of the WHO Guidelines for drinking-water quality (10,000 Bq/L)

## Expanded view of the area off the coast of Fukushima prefecture

Current plan



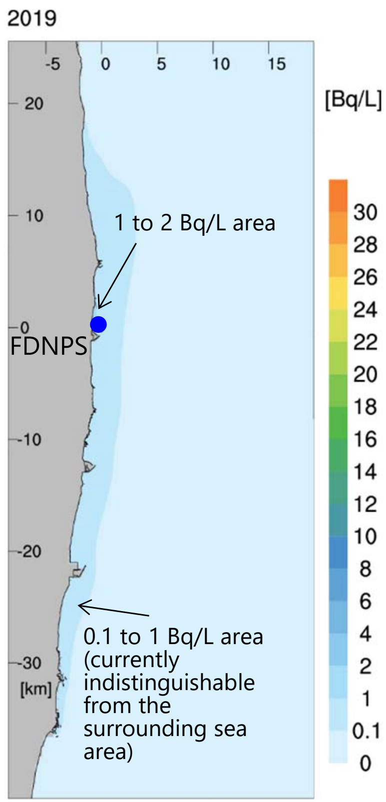

Coast line plan



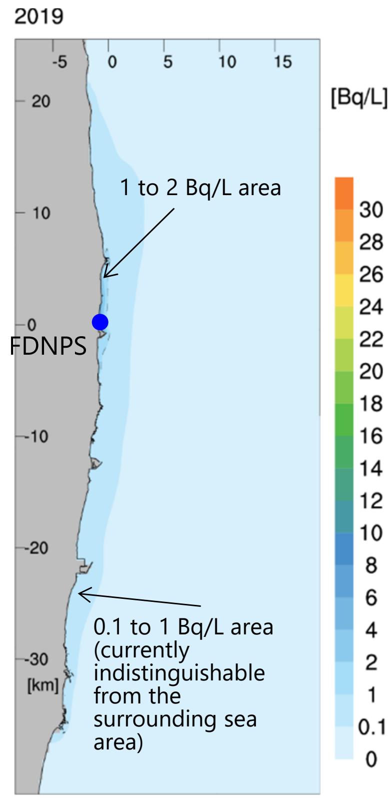

● Point of discharge ⬚ Area where fishing is not routinely conducted

## Wide area map

Current plan




Coast line plan




*The tritium concentration of the light blue area outside of the dotted line is the same as current tritium levels in the surrounding sea area and will be indistinguishable when actual measurements are taken of the water.

# 【Reference】Assumptions in radiological impact assessment on the public and the environment

TEPCO

- Amount of tritium discharged: 22 TBq/year

| Scenario | (1) ⅰ. K4 tanks | (1) ⅱ. J1-C tanks (after secondary treatment) | (1) ⅲ. J1-G tanks (after secondary treatment) | (2) Hypothetical ALPS treated water |
|---|---|---|---|---|
| Tritium concentration [Bq/L] | 190,000 | 820,000 | 270,000 | 100,000※ |
| Amount of ALPS treated water discharged annually [$m^3$/year] | 120,000 | 27,000 | 81,000 | 220,000 |

※Assumed a value lower than actually measured tritium concentrations to increase the impacts of nuclides other than tritium.

- The average concentration in a 10 km X 10 km area around the Fukushima Daiichi Nuclear Power Station was assessed considering advection and dispersion in the seawater.
  - ✓ The Regional Ocean Modeling System (ROMS), an area ocean model, that CRIEPI (Central Research Institute of Electric Power Industry) applied to the sea off the coast of Fukushima, was used in the assessment
  - ✓ The following exposure pathways were evaluated.

| Radiological impact assessment on the public | Radiological impact assessment on the environment |
|---|---|
| ✓External exposure from the sea surface<br>✓External exposure from the body of the ship<br>✓External exposure in work in the sea<br>✓External exposure from sand beaches<br>✓External exposure from the fish nets<br>✓Internal exposure from ingesting seafood | ✓External exposure from the seawater<br>✓External exposure from the sediment at the bottom of the sea<br>✓Internal exposure from ingested radioactive materials |

## 【Reference】Detailed results of the radiological impact assessment on the public

TEPCO

| Conditions | Nuclide composition in source term | (1) Actual measurements of 64 nuclides | | | | | |
|---|---|---|---|---|---|---|---|
| | | i. K4 tanks | | ii. J1-C tanks (after secondary treatment) | | iii. J1-G tanks (after secondary treatment) | |
| | Amount of seafood ingested | A: At the national average | B:More than the average | A: At the national average | B:More than the average | A: At the national average | B:More than the average |
| External exposure (mSv*/year) | Exposure from the sea surface | 6.5E-09 | | 1.7E-08 | | 4.7E-08 | |
| | Exposure from the body of the ship | 5.2E-09 | | 1.3E-08 | | 3.4E-08 | |
| | Exposure in work in the sea | 2.8E-10 | | 7.6E-10 | | 2.0E-09 | |
| | Exposure from sand beaches | 5.0E-07 | | 1.3E-06 | | 3.6E-06 | |
| | Exposure from fishnets | 1.6E-06 | | 4.3E-06 | | 1.2E-05 | |
| Internal exposure (mSv/year) | | 1.5E-05 | 6.1E-05 | 2.8E-05 | 1.1E-04 | 7.9E-05 | 3.0E-04 |
| Total (mSv/year) | | **1.7E-05** | **6.3E-05** | **3.4E-05** | **1.1E-04** | **9.4E-05** | **3.1E-04** |
| Dose limit for the general public : 1mSv/year<br>Dose target for domestic power plants (optimization target) :0.05mSv/year | | | | | | | |

*mSv : millisievert

# 【Reference】 Detailed results of the radiological impact assessment on plants and animals

TEPCO

| Scenario | | （1）Source term based on actual measurements | | |
|---|---|---|---|---|
| | | i. K4 tanks | ii. J1-C tanks | iii. J1-G tanks |
| Exposure (mGy*/day) | Flatfish | 1.7E-05 | 2.2E-05 | 5.6E-05 |
| | Crab | 1.7E-05 | 2.2E-05 | 5.5E-05 |
| | Brown seaweed | 1.9E-05 | 2.3E-05 | 5.9E-05 |
| DCRL<br>Flatfish：1-10 mGy/day Crab：10-100mGy/day Brown seaweed：1-10mGy/day | | | | |

*mGy：milligray

# 【Reference】 Detailed results of the radiological impact assessment
## (②Assessment using hypothetical ALPS treated water)

TEPCO

Results of radiological impact assessment on the public

| Exposure pathway | | Amount of seafood ingested: A: At the national average | Amount of seafood ingested: B:More than the average |
|---|---|---|---|
| External exposure (mSv*/year) | Exposure from the sea surface | 1.8E-07 | |
| | Exposure from the body of the ship | 1.4E-07 | |
| | Exposure during work in the sea | 7.9E-09 | |
| | Exposure from sand beaches | 1.4E-05 | |
| | Exposure from fish nets | 4.5E-05 | |
| Internal exposure（mSv/year） | | 4.8E-04 | 2.0E-03 |
| Total（mSv/year） | | **5.4E-04** | **2.1E-03** |
| Dose limit for the general public：1mSv/year<br>Dose target for domestic power plants (optimization target) :0.05mSv/year | | | |

*mSv： millisievert

Results of radiological impact assessment on the environment

| Reference animal/plant | Exposure（mGy*/day） |
|---|---|
| Flatfish | 7.8E-03 |
| Crab | 7.5E-03 |
| Brown seaweed | 8.4E-03 |
| DCRL<br>Flatfish：1-10 mGy/day Crab：10-100mGy/day Brown seaweed：1-10mGy/day | |

*mGy：milligray