C-2: REIA

Nuclear Regulation Authority, Japan

Additional corroborative calculations of tritium concentrations in seawater simulated in the *radiological impact assessment* using a simple model

- A response to the comment from the IAEA Task Force for Regulatory Review Mission on ALPS Treated Water Handling provided on 24 March 2022 -

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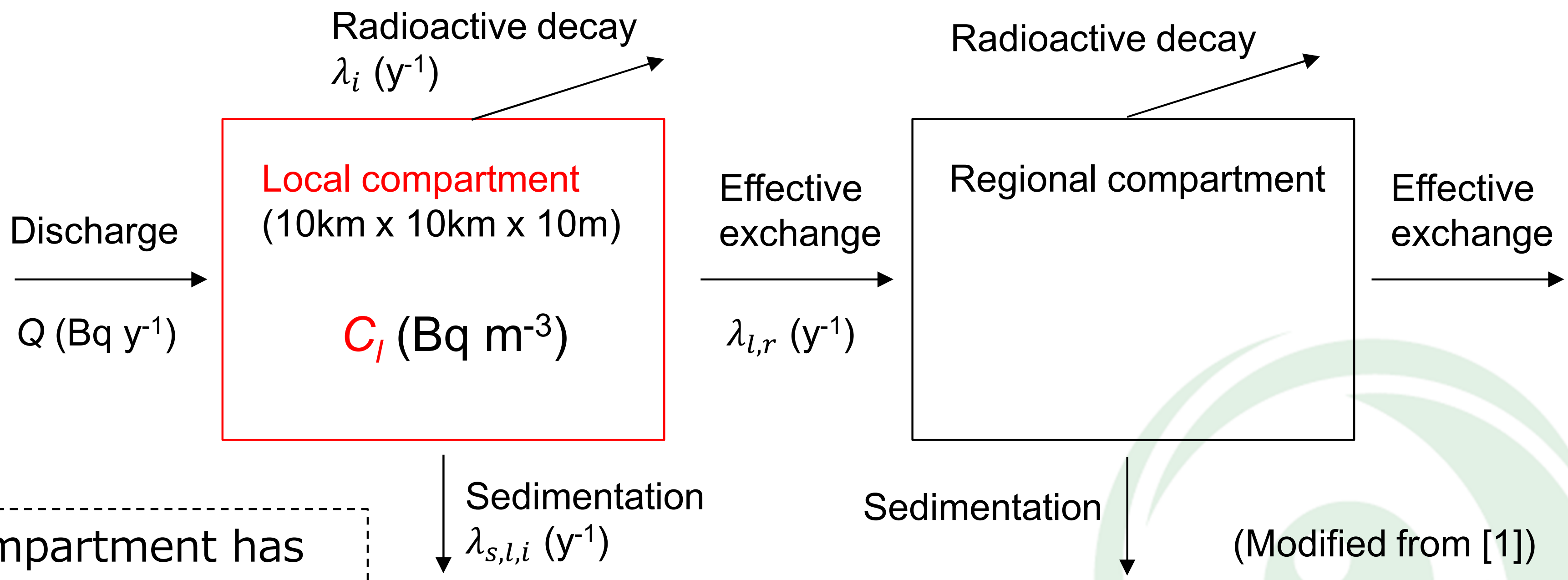
Background

- Radiological impacts of ALPS treated water discharged into the ocean from the Fukushima Daiichi Nuclear Power Station (FDNPS) depend on concentrations of the discharged radionuclides in seawater.
- TEPCO conducted dispersion simulations in the *radiological impact assessment* (RIA) using a regional ocean modeling framework, ROMS, to assess discharged tritium concentrations in seawater.
- The NRA conducted corroborative dispersion simulations and found that ROMS and the same source term derived tritium concentrations in seawater comparable to those reported in the RIA.
- The Task Force noted that consideration should be given to undertaking independent modelling and sensitivity testing to validate that TEPCO's modelling assumptions and outputs are fit for purpose.
- As a response to the Task Force's comment, the NRA conducted additional calculations to check the order of magnitude of tritium concentrations in seawater reported in the RIA using an independent simple compartment model and the same source term.

Methods（1）

- The discharged tritium concentrations in seawater were evaluated using a two-box compartment model adopted in the methodology by UNSCEAR 2016 report for assessing the radiation exposures from discharges of radionuclides to the environment[1].



(Modified from [1])

Local compartment has the same horizontal extent as the assessment area of the RIA.

Methods（2）

- The discharged radionuclide concentrations C_l (Bq L^{-1}) in seawater in the Local compartment were evaluated as follows:

$$C_l = \frac{Q}{\Lambda_{l,i}}\left(1 - e^{-\Lambda_{l,i}\times t}\right) \times {}^{1}/_{1000V_{l'}}$$

where Q and V_l are the discharge rate of 2.2E13 (Bq y^{-1}) and the volume of the Local compartment of 1.0E9 (m^3). The decay constant $\Lambda_{l,i}$ (y^{-1}) is the combination of radioactive decay constant λ_i, sedimentation decay constant $\lambda_{s,l,i}$, and flow rate constant $\lambda_{l,r}$:

$$\Lambda_{l,i} = \lambda_i + \lambda_{s,l,i} + \lambda_{l,r}.$$

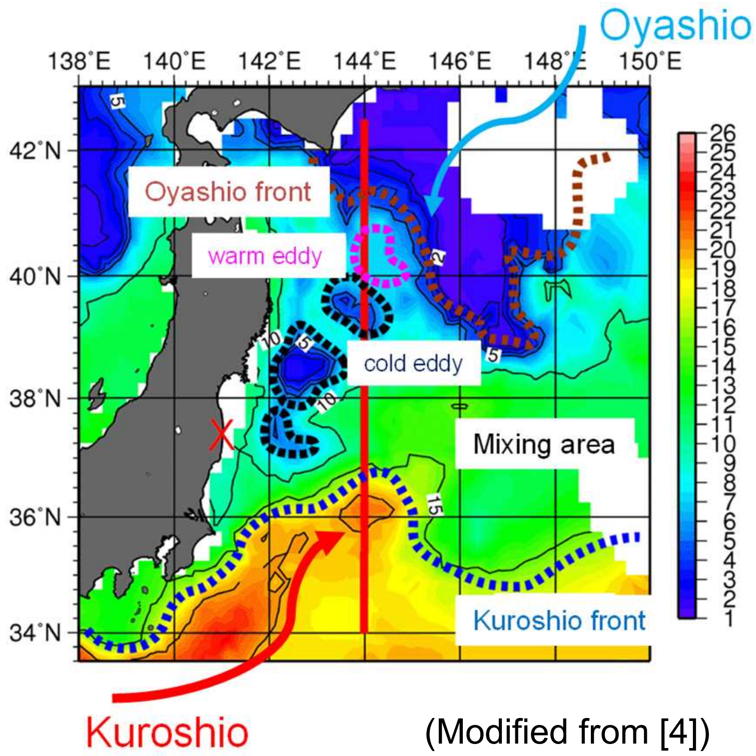
- The values of λ_i and $\lambda_{s,l,i}$ for tritium are 5.5E-2[2] and 1E-5[1][3], respectively.

Methods（3）

- The flow rate constant $\lambda_{l,r}$ is given by $\Delta V_{l,r}/V_l$, where $\Delta V_{l,r}$ is exchange rate from the Local compartment to the Regional compartment and depends on characteristics of the assessment area.

- The $\lambda_{l,r}$ value of 20 (y^{-1}) employed in [1] as a typical value in Europe is not applicable to the Pacific Ocean off Japan under influences of two major ocean currents referred to as Kuroshio and Oyashio.

Seawater temperature at a depth of 100m in July 2002



(Modified from [4])

- The Pacific Ocean off Fukushima is in the mixing area which is perturbed due to influences of two major currents.

- The ocean currents in the Pacific Ocean off Fukushima are much faster than those typical in Europe.

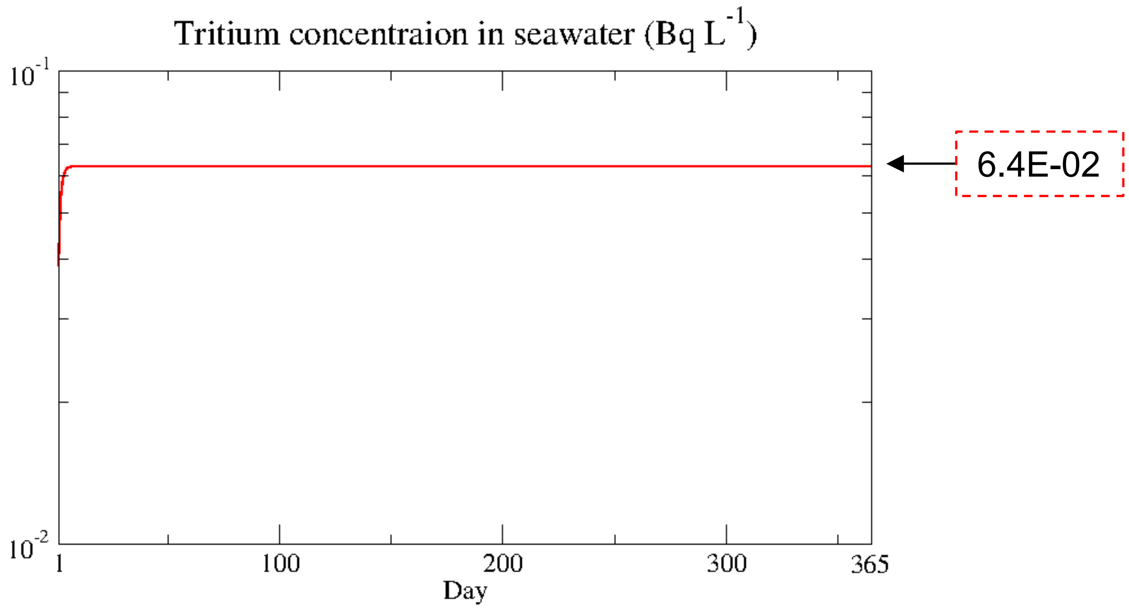
Methods (4)

- Accordingly, the NRA employed the $\lambda_{l,r}$ value of 342 (y^{-1}) derived from current velocities provided by HYCOM GOFS3.1 analysis datasets[5], which are based on observations and have a horizontal resolution of 0.08 degree (~7.1km x 8.9km), and averaged over 5 years from 2015 to 2019 in the beneath of the release point;

$$\lambda_{l,r} = \Delta V_{l,r}/V_l$$
$$= \left(\sum_{t=2015010100}^{2019123121} \sum_{i=1}^{3} \sum_{k=bottom}^{top} u_{k,i(t)} \cdot S_{k,i} \cdot \Delta t \Big/ 5 \right) \Big/ V_l$$
$$= 342$$

where $S_{k,i}$ is a size of the lateral boundary (m^2) and $u_{k,i(t)}$ is the outward current component ($\mathrm{m\ s}^{-1}$) normal to the boundary. Subscript *k* and *i* represent vertical layer and each lateral boundary (east, south, and north), respectively. The time interval of HYCOM datasets Δt is 3600×3 (s).

Results



- The tritium concentration had achieved a steady state in a few days.
- The concentration in the steady state was comparable with annual mean values of concentrations for all layers evaluated using ROMS.

	Concentration (Bq L^{-1})
NRA using a compartment model	6.4E-02
NRA using ROMS	4.4E-02
RIA using ROMS	5.6E-02 (from Table 6-1-17 of the RIA)

Summary

- The tritium concentration at the steady state using a simple compartment model, the same source term, and current datasets based on observations was comparable with that for all the model layers reported in the RIA.

- The order of magnitude of concentrations of the discharged tritium could be controlled mainly by the source term and typical states of ocean currents in the beneath of the release point.

- Finally, it is reasonable to judge that the model results reported in the RIA represent a typical state for the duration of discharge.

References.

[1]UNSCEAR. Sources, effects and risks of ionizing radiation. Annex A: Methodology for estimating public exposures due to radioactive discharges. UNSCEAR 2016 report to the general assembly, with scientific annexes. United Nations Publication Sales No. E.17.IX.1. United Nations, New York, 2017.
[2]ICRP. Radionuclide transformation – energy and intensity of emissions. ICRP Publication 38. Annals of the ICRP 11-13. ICRP Pergamon Press, Oxford, 1983.
[3]IAEA. Sediment distribution coefficients and concentration factors for biota in the marine environment. Technical Report Series No. 422. IAEA, Vienna, 2004.
[4] Japan Meteorological Agency HP (https://www.jma.go.jp/jma/index.html).
[5] Consortium for Data Assimilative Modelling (https://www.hycom.org/).