Nuclear Regulation Authority, Japan

C-2-2 Corroborative calculations of tritium concentrations in seawater simulated in the *radiological impact assessment* using ROMS

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Abstract

- 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, which were multiplied by amount ratios in the source terms to derive concentrations of the other discharged radionuclides in seawater.

- The NRA conducted dispersion simulations using ROMS and the same source term in order to see whether tritium concentrations in seawater reported in the RIA can be replicated.

- The NRA also checked the time trend of the modeled concentrations within the simulated single year to see whether the first-year simulation can represent any following year.

- The NRA also assessed tritium concentrations at the lateral boundaries of the target domain of the simulations to compare them with the background levels in seawater.

What is ROMS?

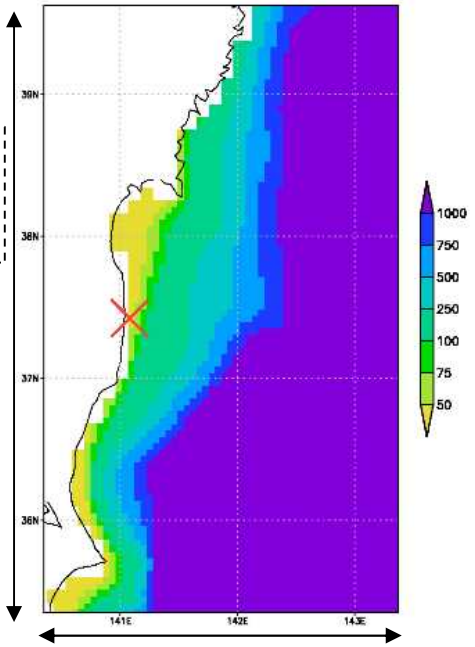
ROMS
(Regional Ocean Modeling System)

- ROMS (https://www.myroms.org/) is an open-source 3D modeling framework of ocean dynamics developed by a scientific community organized mainly by UCLA and Rutgers Univ. It has been broadly applied to various research fields including dynamics, geology, and biology in the ocean.
- ROMS calculates time evolution of variables in the ocean such as current, surface elevation, temperature, and salinity. The modules to calculate advection/diffusion for temperature and salinity enable dispersion simulations of tracers like tritium.
- The governing equations are the primitive equations which are common to ocean modeling frameworks.
- Hydrostatic equilibrium is assumed implying vertical scale much smaller than horizontal scale for motion of seawater.

Methods（1）

- Dispersion simulations like the RIA were conducted applying ROMS to the generally same domain with horizontal resolution not of 200m but of 10km, because the concentrations in seawater used for assessment in the RIA were those averaged over an area of 10km square.

The target domain and bathymetry（m）

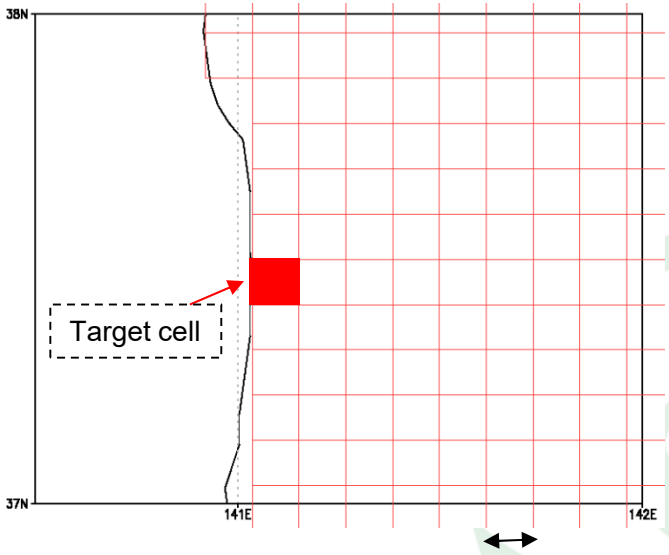


480km wide from south to north

Generally same as that in the RIA（Figure 4－1）.

290km wide from west to east

Model grid cells in the vicinity of the FDNPS



Target cell

Concentrations in seawater at the target cell were compared with those reported in the RIA.

Horizontal resolution of 10km

Methods (2)

Computational conditions

RIA by TEPCO

- Horizontal resolution : 1km for whole of the domain; 200m for the vicinity of the FDNPS.
- Vertical structure : 30 layers.
- Annual amount of discharge : 2.2E13Bq (constant) .
- Target year : 2019.
- Input data for ocean : JAMSTEX reanalysis JCOPE2.
- Input data for atmospheric forcing : Products made from JMA Numerical Weather Prediction.
- Tracer as tritium : passive tracer*.

NRA

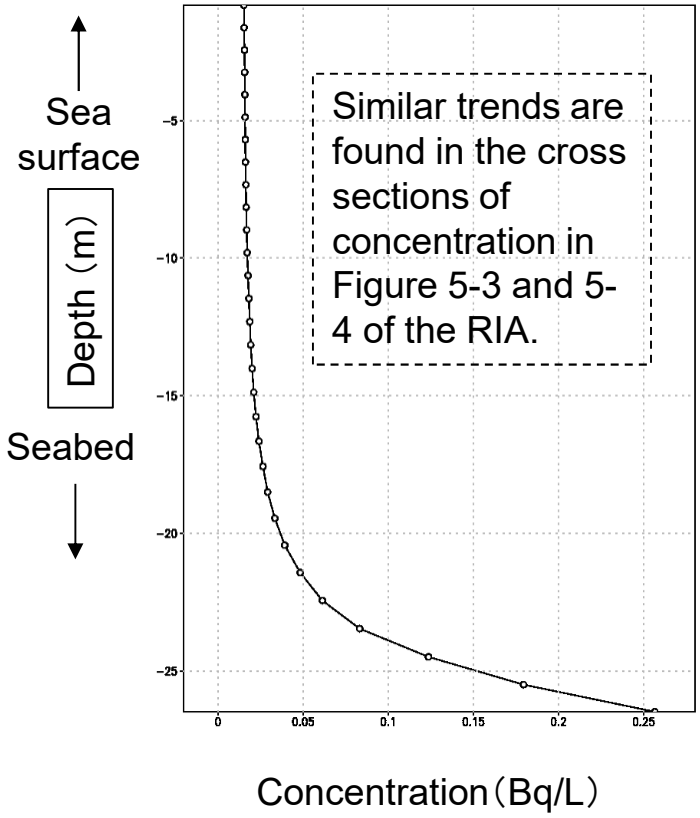
- Horizontal resolution : 10km for whole of the domain.
- Vertical structure : 30 layers.
- Annual amount of discharge : 2.2E13Bq (constant) .
- Target year : 2019.
- Input data for ocean : HYCOM analysis GOFS3.1.
- Input data for atmospheric forcing : JMA Japanese 55-year reanalysis.
- Tracer as tritium : passive tracer*.

- *Passive tracer is a modeled substance which undergoes no removal processes except outflow from the target domain.
- It is conservative to estimate concentrations of radionuclides other than tritium based on those of tritium and the ratios of radioactivity in the source terms neglecting removal processes such as gravity settling of particulate matters and radioactive decay.

Results（1）

Annually averaged tritium concentrations in seawater（Bq/L）

Vertical profile at the target cell



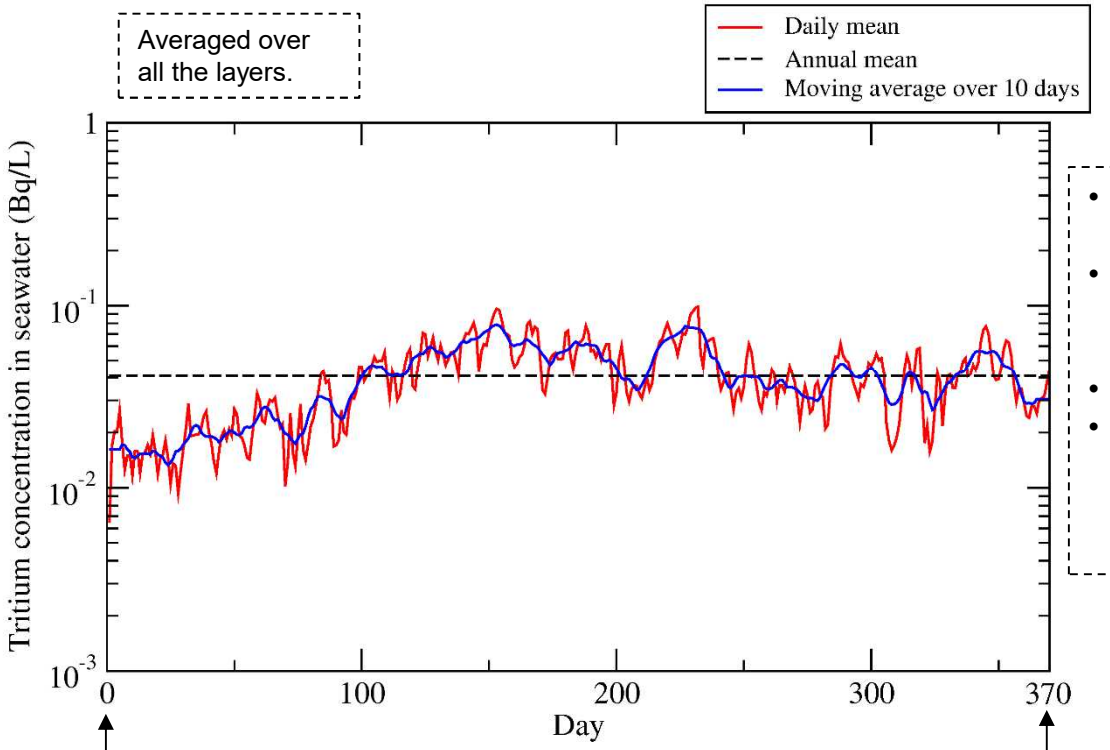
	All layers
RIA	5.6E-02 (from Table 5-5 of the RIA)
NRA	4.4E-02

- The annually averaged tritium concentration for all the model layers was comparable with the RIA.
- Vertical mixing was not active due to the model assumption of hydrostatic equilibrium.
- However, discharged ALPS treated water could activate vertical mixing by promoting local turbulence.

Results（2）

Time series of tritium concentrations in seawater（Bq/L）

Averaged over all the layers.



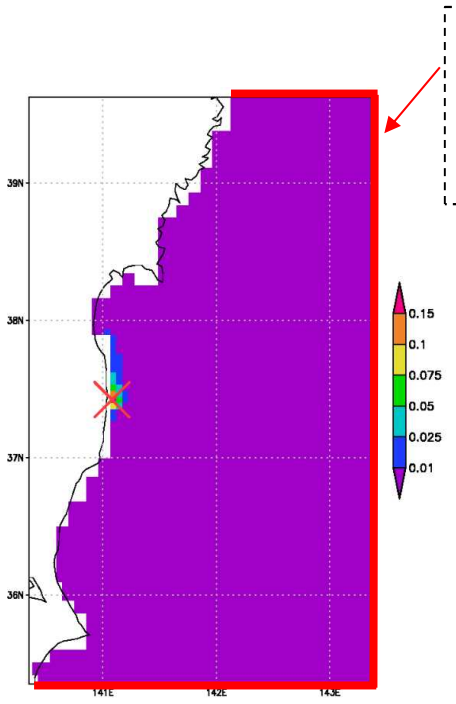
- A monotonous increase was found only in the first few days.
- It is not clear whether the cause of the gentle ascending trend in the first 100 days was accumulation or seasonality.
- After that, there was no ascending trend.
- If the year of 2019 is not an anomaly year, it is reasonable to judge that the model results for a single year of 2019 represent a typical state for whole of the duration of discharge.

Start of the model run on Dec. 27, 2018, with the initial condition of zero.

End of the model run on Jan. 01, 2020.

Results（3）

The maximum value of hourly averaged tritium concentrations in seawater（Bq/L）at the lateral boundaries of the target domain



- North side：3.4E-4
- East side：1.0E-3
- South side：1.8E-3

（For reference）
Background tritium level in seawater
- ・Reference value of UNSCEAR：1E-1[a]
- ・Observed values in Pacific Ocean and Indian Ocean（1996-1997）：4E-2～4E-1[b]
- ・Observed values in the coastal areas of Aomori Prefecture in Japan（2001-2005）：～2.4E-1[c]

[a]UNSCEAR, 2016. Sources, effects, and risks of ionizing radiation. Annex C: Biological effects of selected internal emitters – Tritium.
[b]Kakiuchi et al.,1999. Tritium concentration in ocean. J. Radioanal. Nucl. Chem., 239 (3), 523-526.
[c]海洋生物環境研究所, 2017. 平成28年度原子力施設等防災対策等委託費（海洋環境における放射能調査及び総合評価）事業調査報告書.

Summary

- The annually averaged tritium concentration for all the model layers was comparable with the RIA.
- Vertical mixing of tritium was not active due to the model assumption of hydrostatic equilibrium. In fact, however, the discharged ALPS treated water could activate vertical mixing by promoting local turbulence.
- It is reasonable to judge that the model results for a single year of 2019 represent a typical state for the whole of the duration of discharge.
- The maximum values of hourly averaged tritium concentrations in seawater at the lateral boundaries of the target domain of the simulations were smaller than the background levels reported in literatures by more than an order of magnitude.