IAEA Review of Safety Related Aspects of Handling ALPS Treated Water at TEPCO's Fukushima Daiichi Nuclear Power Station

Additional Measures for Independent Sampling and Analysis Related to Discharges of ALPS Treated Water

– Additional Measures February 2025: Marine Environmental Monitoring

IAEA
International Atomic Energy Agency

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Published by the International Atomic Energy Agency in September 2025

1. INTRODUCTION

The main objective of Additional Measures for Independent Sampling and Analysis Related to Discharges of ALPS (Advanced Liquid Processing System) Treated Water (hereafter referred to as "Additional Measures") is to further increase transparency by facilitating the wider participation of stakeholder countries, through the IAEA's Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA[1]) network [1] member laboratories, in independent sampling and analysis related to discharges of ALPS treated water under the framework of the IAEA.

The IAEA and Japan concurred in September 2024 to implement the Additional Measures, under the framework of the IAEA. The Agency confirms that this agreement builds upon its existing sampling and monitoring activities in compliance with the IAEA statutory functions.

Therefore, the Additional Measures outlined herein are intended to be a key component of the ongoing IAEA programme and will be executed under the authority of the IAEA. The scope of the Additional Measures encompasses the following activities:

a) **Source Monitoring (Post-ALPS Treatment, Pre-Dilution)**: This involves independent sampling and analysis of ALPS treated water sourced from the measurement and confirmation facility, specifically the tanks where the water is stored, homogenized, and tested prior to release.

b) **Monitoring at Discharge Vertical Shaft/Seawater Pipe Header (Post-Dilution)**: This comprises independent sampling and analysis of the diluted ALPS treated water.

c) **Marine Environmental Monitoring (Post-Discharge)**: This includes independent sampling and analysis of seawater and fish.

In February 2025, the IAEA carried out an Additional Measures mission through sampling of seawater and fish undertaken near TEPCO's Fukushima Daiichi Nuclear Power Station (FDNPS). The IAEA Director General joined this mission to Japan to participate in the seawater sampling to promote transparency and build trust in the international community. This report presents the results of subsequent analyses for radionuclide activity concentrations conducted by laboratories in Japan, by the IAEA in Monaco and by member laboratories of the ALMERA Network in China, the Republic of Korea and Switzerland. Additionally, it includes the results of an intercomparison of these measurement results which was carried out by the IAEA according to international best practice for proficiency testing [2].

[1] ALMERA is a network currently comprising more than 200 member laboratories globally. It provides a platform for maintaining and developing capability on the determination of radionuclides in air, water, soil, sediment and vegetation that can be used for both routine and environmental emergency monitoring in the IAEA Member States.

2. PARTICIPATING LABORATORIES

The participating laboratories – 4 from Japan; three from the ALMERA network and the IAEA – are presented in Table 1.

TABLE 1. PARTICIPATING LABORATORIES

Identifier	Participant	Seawater	Fish
IAEA	IAEA Marine Environment Laboratories, Monaco	✓	✓
JCAC	Japan Chemical Analysis Center, Chiba, Japan	✓	×
KANSO	KANSO TECHNOS Co. Ltd., Osaka, Japan	✓	×
KEEA	Kyushu Environmental Evaluation Association, Fukuoka, Japan	✓	×
KINS	Korea Institute of Nuclear Safety, Daejeon, Republic of Korea	✓	✓
MERI	Marine Ecology Research Institute, Chiba, Japan	✓	✓
SPIEZ	Spiez Laboratory (Labor Spiez), Switzerland	✓	✓
TIO	Third Institute of Oceanography, Ministry of Natural Resources, Xiamen, China	✓	✓

3. SAMPLE COLLECTION AND PRETREATMENT

3.1. SEAWATER SAMPLES

Surface seawater samples were collected on 19 February 2025 by boat from monitoring location M-101 as defined in Japan's Comprehensive Radiation Monitoring Plan [3]. M-101 is located at latitude and longitude 37.427 and 141.043 respectively and is located approximately 500 m from FDNPS.

Each participating laboratory was provided with a seawater sample comprised of:

- For analysis for ^{90}Sr and ^{137}Cs, 60 L of seawater in three 20 L cubitainers, acidified to pH 1–2 with concentrated HNO_3.
- For analysis for ^{3}H, 2L of seawater in a 2L plastic bottle.

To take the samples, two 110 L plastic mixing containers were first filled with seawater. The 20 L and 2 L sample containers were filled, one at a time, using a 3 L plastic graduated beaker with a handle from the mixing containers. The experts from the ALMERA member laboratories took the opportunity to fill the containers that would subsequently be shipped to their laboratories for analysis if they wished. In all other cases the sample containers were filled by Japanese contractors. The two 110 L containers were refilled as necessary to facilitate provision of the required sample volume to all participating laboratories. For each sample, recipient laboratory was recorded.

Concentrated HNO_3 was added to the 20 L cubitainers after unloading from the boat. The samples were then checked, boxed and shipped to all participating laboratories.

FIG. 1. Hands-on sampling by IAEA Director General Grossi and an expert from China.

FIG. 2 Experts from ALMERA member laboratories in China, the Republic of Korea and Switzerland and the IAEA Director General Grossi with samples for ^{3}H analysis.

3.2. FISH SAMPLES

A batch of fish, olive flounder (*Paralichthys olivaceus*) was collected from the fish market at Numanouchi Port (Fukushima) on 20 February 2025. The fish species had been caught earlier the same day in the vicinity of FDNPS.

The fish were prepared by fileting, homogenising the muscle tissue and then splitting into separate samples at MERI (Chiba). A sample of mass of approximately 2.4 kg was provided to MERI, the participating Japanese laboratory. Samples of mass of approximately 1.2 kg were frozen and shipped to the IAEA Marine Environment Laboratories in Monaco and the three participating ALMERA laboratories for analysis.

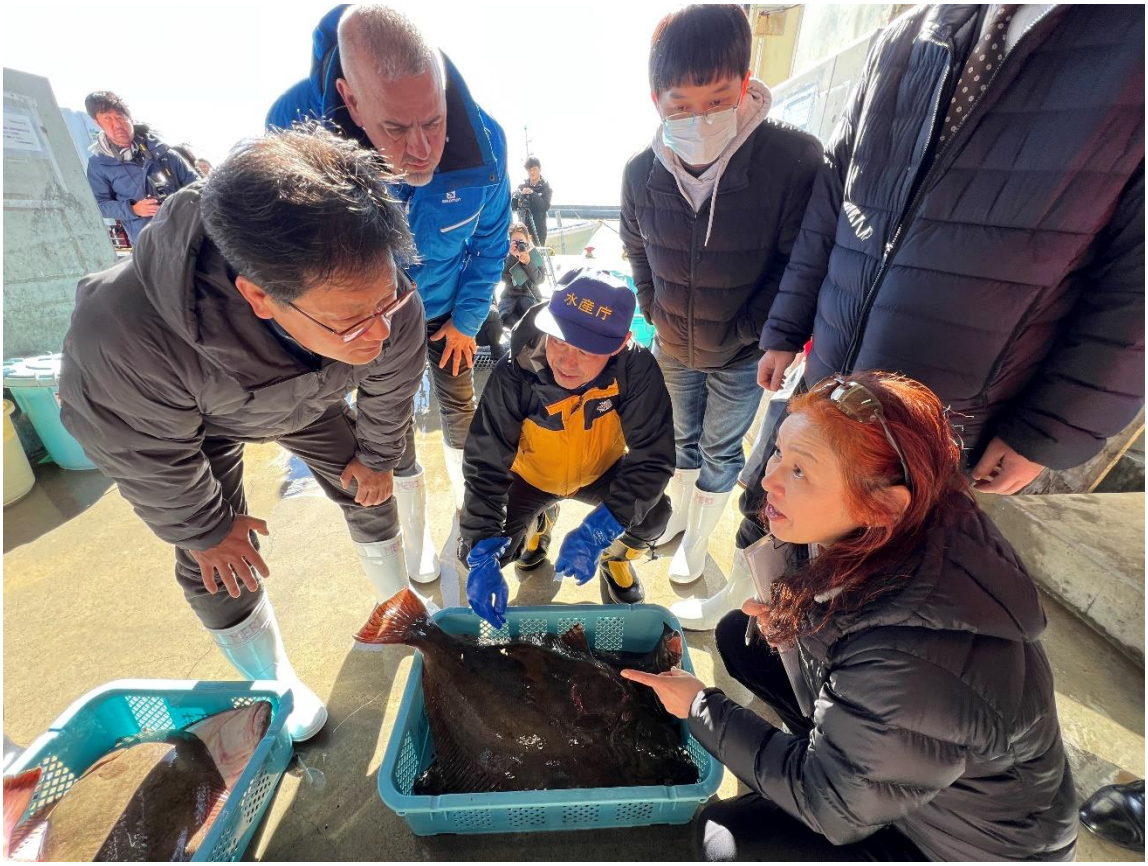

FIG. 3 Experts from ALMERA member laboratories discuss samples with staff of the Fisheries Agency of Japan.

4. ANALYSES

Participating laboratories were requested to analyse the seawater samples for activity concentrations of ^{3}H, ^{90}Sr and ^{137}Cs using an appropriate analytical method. The fish samples were to be analysed for ^{137}Cs by gamma-ray spectrometry in each participating laboratory.

Reporting forms and target detection limits were provided by the IAEA. Participating laboratories were requested to submit a single measurement result for each sample and radionuclide analysed, comprised of an activity concentration, standard combined uncertainty (k=1) and detection limit. They were asked to report activity concentrations for a reference time of 19 February 2025 12:00 UTC for the seawater sample and 20 February 2025 12:00 UTC for the fish sample.

5. STATISTICAL EVALUATION OF THE RESULTS

The IAEA compiled and evaluated the results submitted by all participating laboratories. For each sample and radionuclide combination, a comparison reference value x_{ref} was determined as a power-moderated mean of the combined results [4]:

$$x_{ref} = \sum_{i=1}^{N} w_i x_i$$

where x_i is the value reported by the laboratory i, N is the number of results reported and w_i is a normalized weighting factor.

A ζ (zeta) score was then calculated for each laboratory as follows.

$$\zeta = \frac{d_i}{u(d_i)}$$

where $d_i = x_i - x_{ref}$, the difference between the value reported by the laboratory x_i and the reference value x_{ref}, and $u(d_i)$ is the standard uncertainty associated with d_i, taking the correlation between individual results and the reference value into account.

Following the current ISO standard for statistical methods for use in proficiency testing [5], for zeta scores between -3 and 3, the corresponding result was evaluated as agreeing with the reference value at a 99.7% confidence level and for zeta scores greater than 3 or less than -3 the reported result was evaluated as not agreeing at a 99.7% confidence level.

6. RESULTS

The results submitted by the participating laboratories and associated consensus reference values are presented in Tables 2 and 4 and Figures 4 - 7. The uncertainties quoted are combined standard uncertainties, i.e. with a coverage factor of $k = 1$. Tables 3 and 5 contain the zeta scores.

TABLE 2. ACTIVITY CONCENTRATIONS (Bq L^{-1}) IN SEAWATER SAMPLES

Nuclide	IAEA	JCAC	KANSO	KEEA	KINS	MERI	SPIEZ	TIO	Reference
^{3}H	0.049 ± 0.011	0.054 ± 0.01	-	0.047 ± 0.008	< 0.082	0.058 ± 0.012	<1.2	0.119 ± 0.017	0.064 ± 0.013
^{90}Sr	0.000889 ± 0.000033	0.00089 ± 0.00013	0.00081 ± 0.00018	0.00079 ± 0.00016	0.000606 ± 0.000132	-	0.00091 ± 0.00023	0.000789 ± 0.000084	0.000848 ± 0.000033
^{137}Cs	0.00871 ± 0.00054	0.00642 ± 0.00042	-	0.00581 ± 0.00036	0.00788 ± 0.00042	0.0081 ± 0.00065	0.00536 ± 0.00042	0.00734 ± 0.00041	0.00705 ± 0.00048

TABLE 3. ZETA SCORES FOR ACTIVITY CONCENTRATION OF RADIONUCLIDES IN SEAWATER SAMPLES

Nuclide	IAEA	JCAC	KANSO	KEEA	KINS	MERI	SPIEZ	TIO
^{3}H	-0.97	-0.66	-	-1.17	DL	-0.36	DL	2.94
^{90}Sr	1.41	0.34	-0.23	-0.37	-1.91	-	0.28	-0.75
^{137}Cs	2.51	-1.08	-	-2.22	1.40	1.43	-2.87	0.49

Note: DL: As a value less than the detection limit was submitted, no evaluation was performed.

TABLE 4. ACTIVITY CONCENTRATIONS (Bq kg^{-1}) IN FISH SAMPLES

Nuclide	IAEA	KINS	MERI	SPIEZ	TIO	Reference
^{137}Cs	0.247 ± 0.031	0.283 ± 0.029	0.240 ± 0.024	0.21 ± 0.04	0.252 ± 0.028	0.249 ± 0.014

TABLE 5. ZETA SCORES FOR ACTIVITY CONCENTRATION OF RADIONUCLIDES IN FISH SAMPLES

Nuclide	IAEA	KINS	MERI	SPIEZ	TIO
^{137}Cs	-0.06	1.32	-0.41	-1.05	0.13

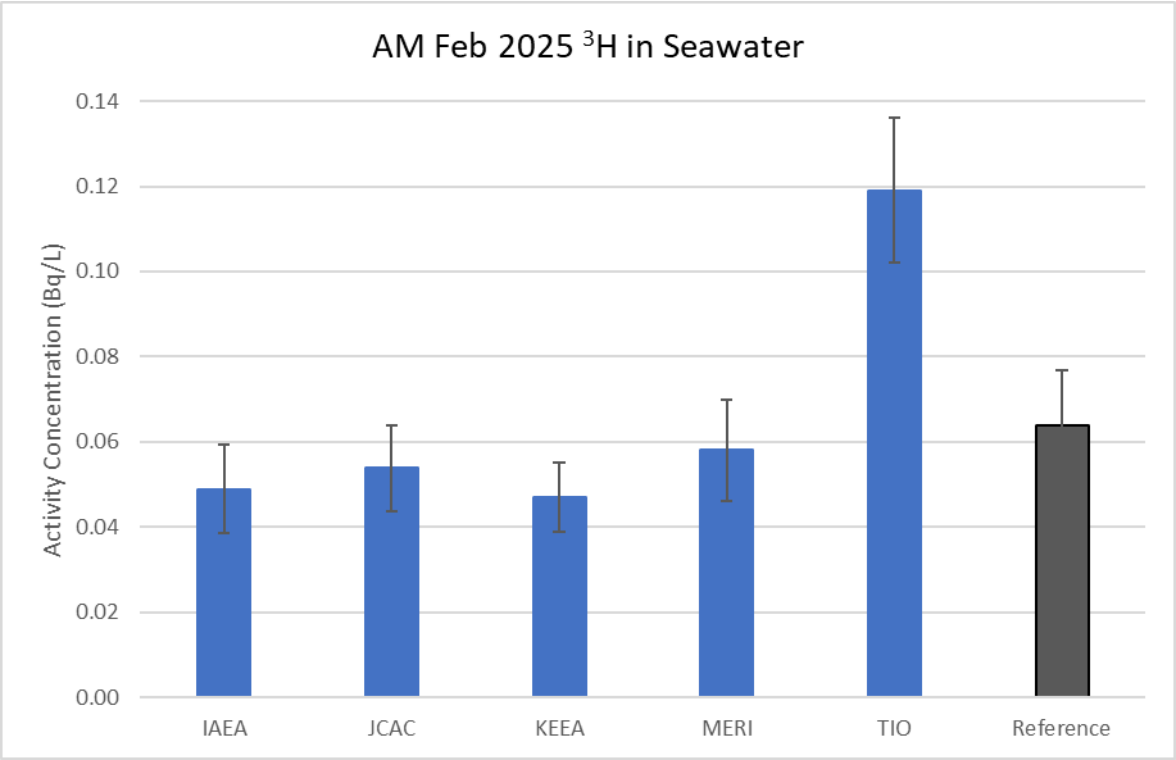

FIG. 4. Activity concentrations of ^{3}H in seawater samples.

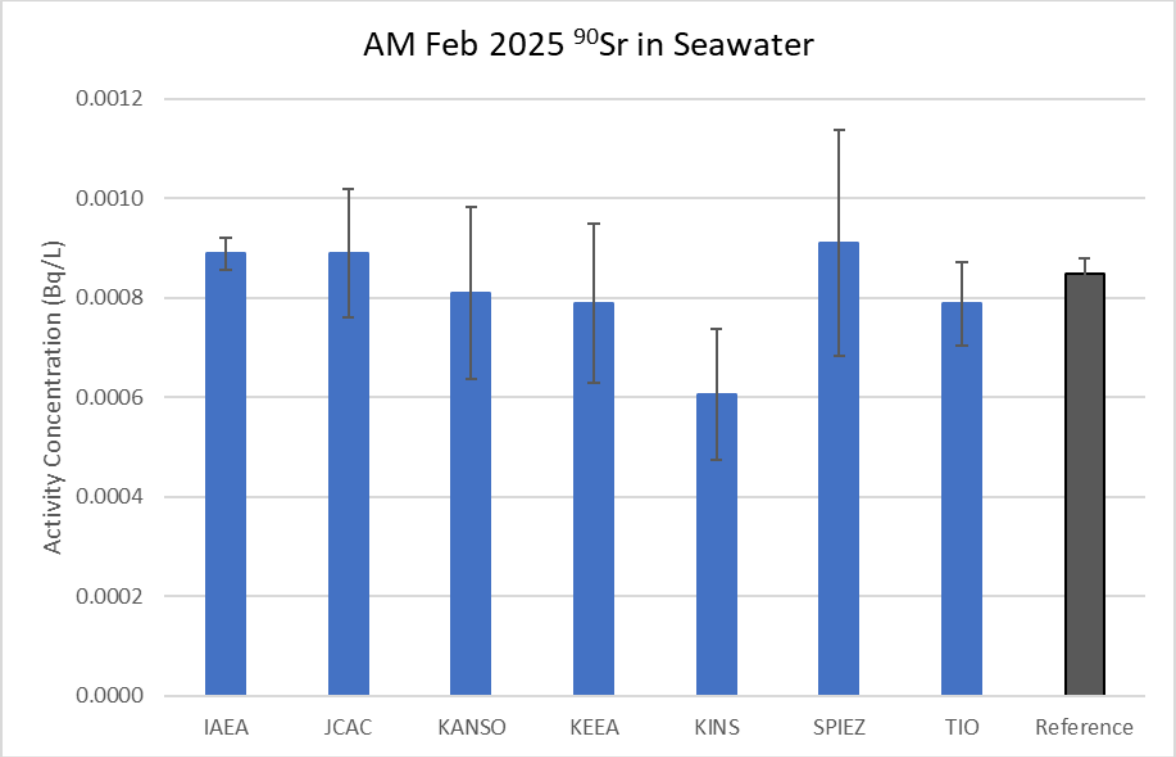

FIG. 5. Activity concentrations of ^{90}Sr in seawater samples.

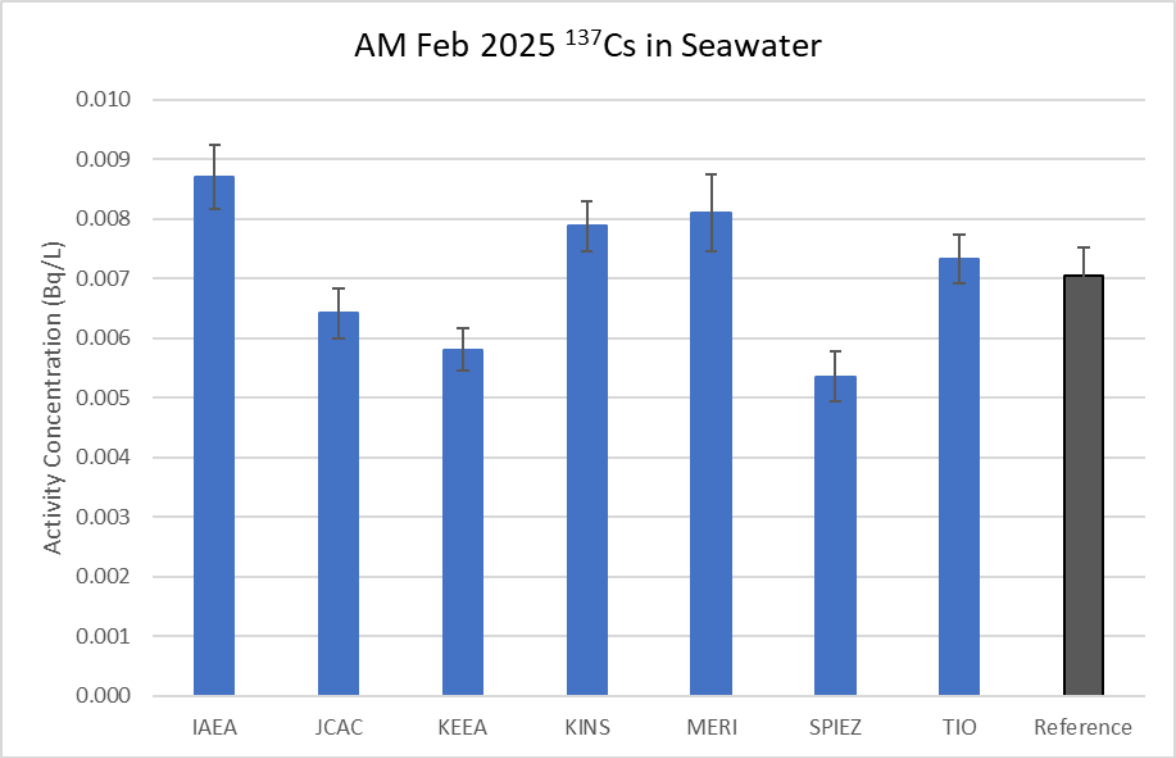

FIG. 6. Activity concentrations of ^{137}Cs in seawater samples.

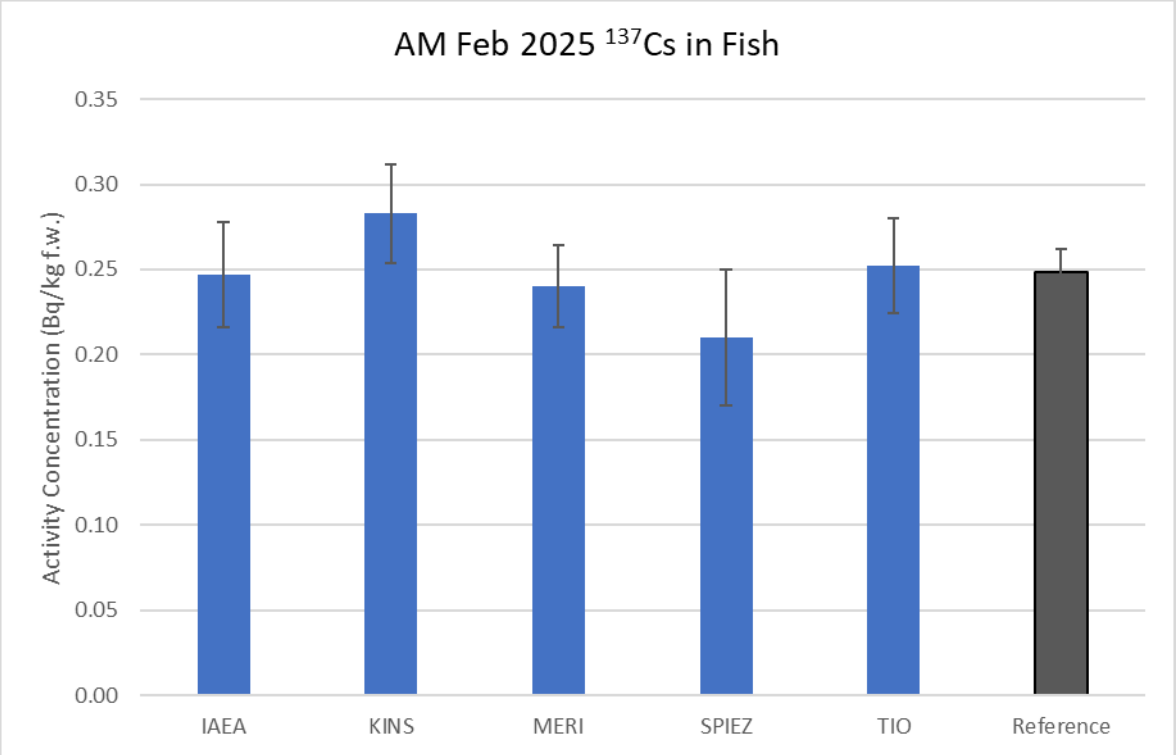

FIG. 7. Activity concentrations of ^{137}Cs in fish samples.

7. CONCLUSION

The results of Additional Measures February 2025: Marine Environmental Monitoring demonstrate that the measurement results reported by all participating laboratories are in statistical agreement with the corresponding consensus reference values derived from their intercomparison.

The measured radionuclide activity concentrations reported by the laboratories in both the seawater and fish samples are low – ^{3}H levels in seawater were around 0.05-0.12 Bq/L, and ^{137}Cs in fish was around 0.2-0.3 Bq/kg. This has been independently verified in Additional Measures February 2025 across multiple international laboratories (from Japan, China, the Republic of Korea, Switzerland, and the IAEA). These activity concentrations are far below levels that would cause concern for human health or marine ecosystems. They are consistent with the applicable international safety standards as well as with the conclusions of the IAEA Comprehensive Report on the Safety Review of the ALPS-Treated Water at the Fukushima Daiichi Nuclear Power Station [6] that was released in July 2023 stating that the IAEA found that the discharges as planned would have a negligible radiological impact to people and the environment.

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