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Determination of the low-level tritium (TFWT & OBT) in fish after ALPS treated water release

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International Atomic Energy Agency (IAEA)

- The IAEA is an international organization to promote the peaceful use of nuclear energy.
- The IAEA is headquartered at the UN office at the Vienna, Austria.
- About 180 member states and over 3000 staff are working.
- Three missions;

  - Peaceful Uses: Nuclear power plants and nuclear science

  - Safeguard: To verify for military purpose

  - Nuclear Safety: Promoting high standard for safety.

Nuclear Science and Application

- Rays of Hope Forum in 2025 (Cancer, Food, Microplastic)
- Cancer Care for All: More than 90 countries have requested to support.
- Atoms4Food: Joint work between FAO and IAEA.
- NUTEC Plastics: 104 member states use nuclear technologies to monitor microplastic. 52 member states are collaborating with the IAEA on upcycling efforts. Only 9% of plastic was recycled.

NUTEC Plastics

- Radiation to create bio-based plastic which is offering a sustainable alternative to conventional petroleum-based plastic.
- Radiation technology to transform plastic waste into durable, stronger and higher value products.
- Nuclear technology to improve recycling (examples)

  - Wood-plastic composites for sustainable construction (Indonesia & Philippines)

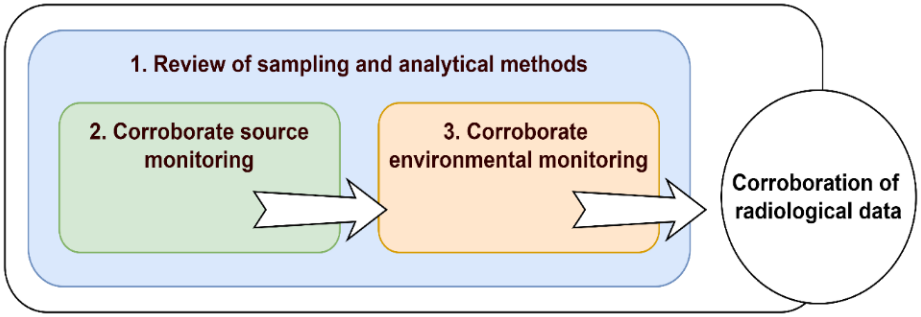
  - Plastic waste converted to fuel (Malaysia)

  - Railroad sleeper from recycled plastic (Argentina)

IAEA review of activities related to the discharge of ALPS treated water

Assessment of Radiation Protection and Safety	• Review TEPCO's implementation plan and supporting documentation. • Focus on technical considerations such as source characterization, safety related aspects of the approach, occupational radiation exposure, and the radiological environmental impact assessment.
Regulatory Activities and Process	• Review NRA actions and processes relevant to the project. • Focus on safety objectives, regulatory requirements, regulatory assessment, and regulatory inspections.
Independent Sampling, Data Corroboration, and Analysis	• Independent sampling and analysis to corroborate data from Japan. • Perform analysis of ALPS treated water and environmental samples. • Corroborate monitoring results for occupational exposure.

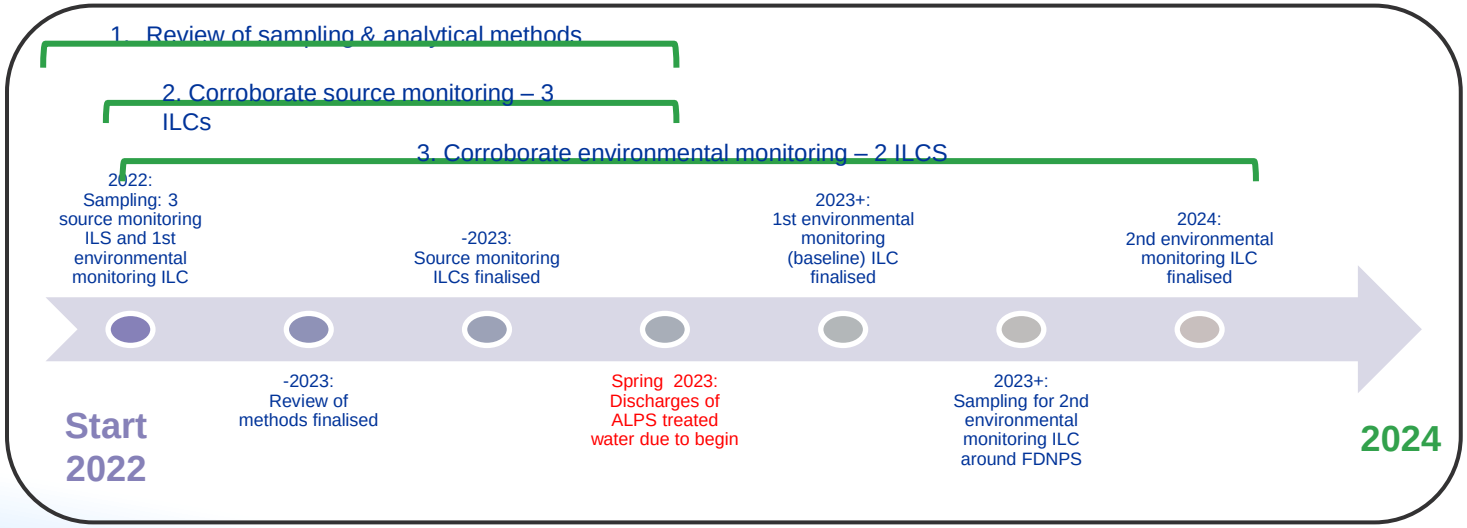
IAEA corroboration of source & environmental monitoring related to discharges of ALPS



Through **independent verification**, ensure that the radiological basis of planning for the discharge of ALPS treated water is sound

Provide **confidence in the accuracy of data** resulting from source & environmental monitoring undertaken by TEPCO/Government of Japan

Enhance transparency for all interested parties



Corroborate environmental monitoring

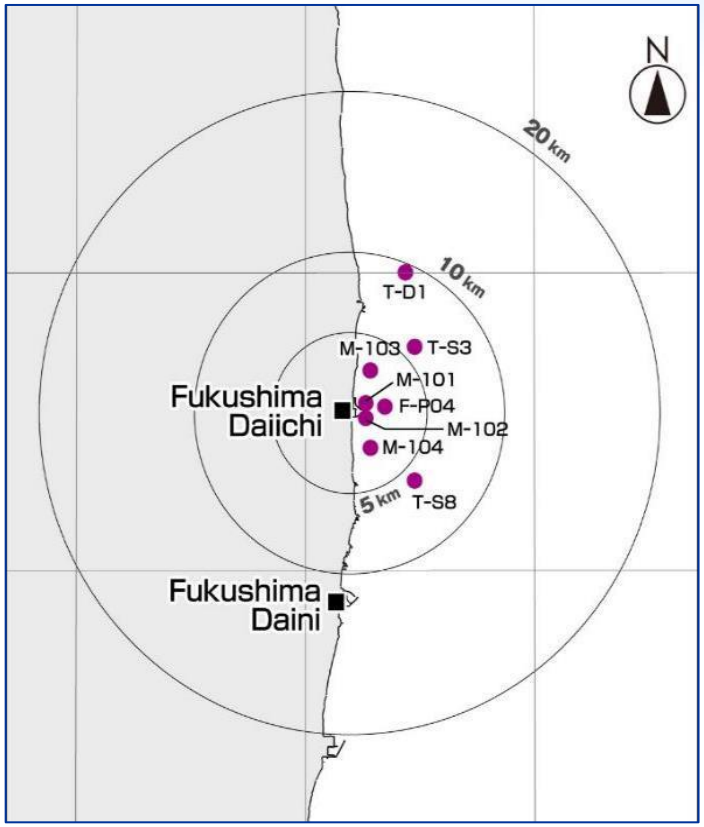
ILCs baseline & after start of discharges:

Seawater, sediment, fish, seaweed Joint sampling, split samples

Statistical comparison of results

Participating laboratories:

- IAEA (Monaco, Vienna)
- Japanese laboratories performing ALPS-related monitoring
- Selected IAEA ALMERA laboratories (5-7 countries)



Background

- The IAEA initiated to establish the two different methods for the environmental OBT measurements before ALPS treated water release.
- IHL of the IAEA applied the low-level OBT in fish samples.
- Our goals are to increase the accuracy of OBT measurement and to reduce the OBT analytical uncertainties.

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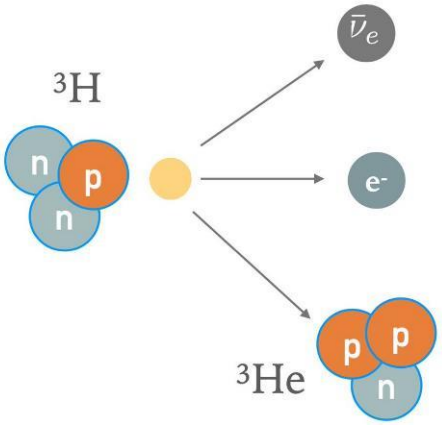
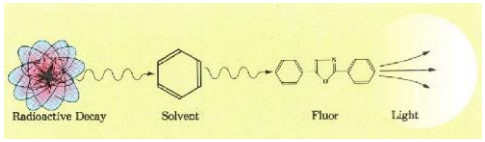
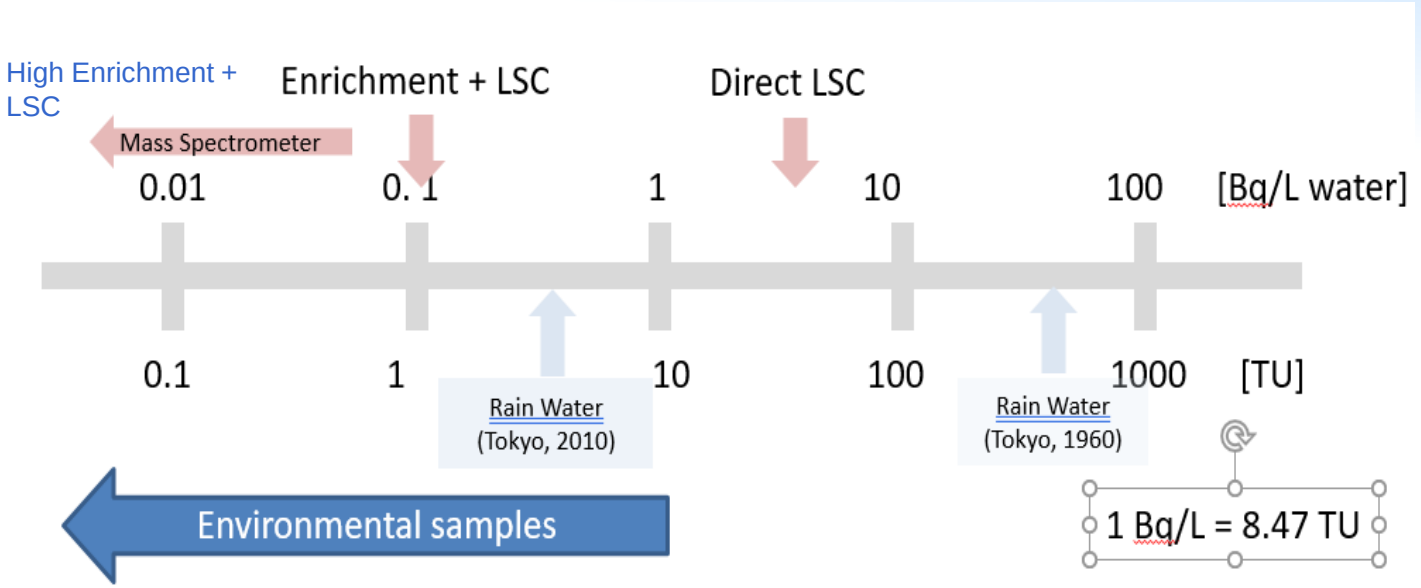
Environnemental ^{3}H analysais

- Decay Counting: Liquid Scintillation Counter (on enriched sample)
- Atom Counting by ^{3}He ingrowth: Mass spectrometer



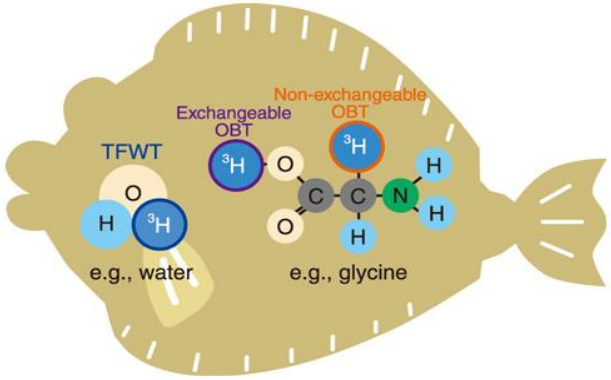


IHL Low Level Tritium Facility



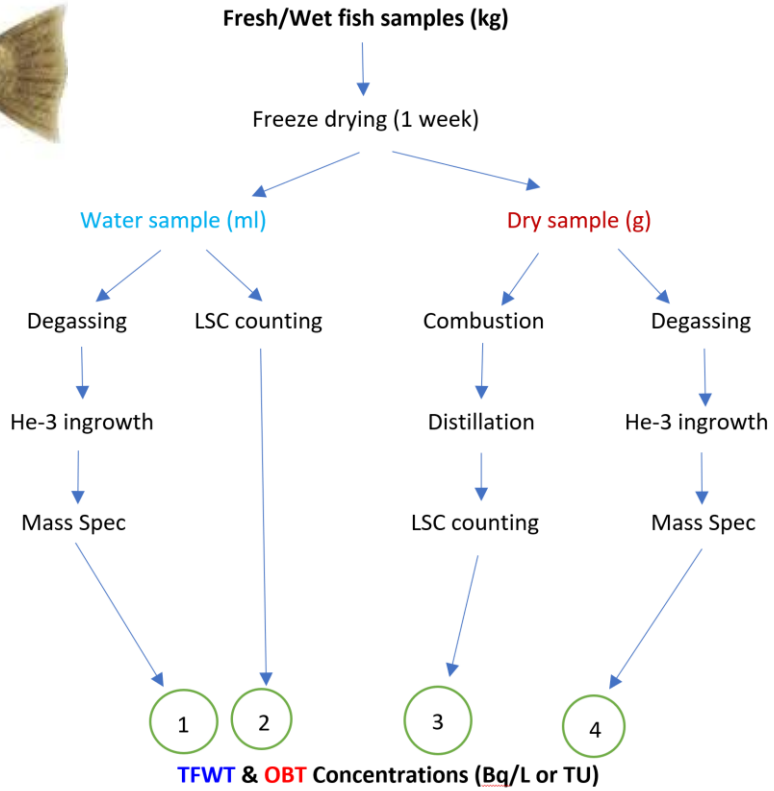
Tritium target concentrations

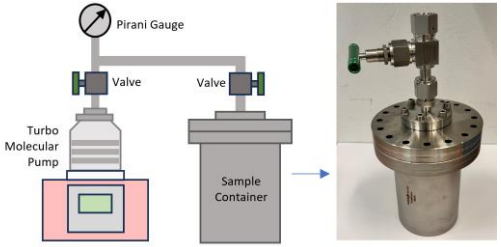
- Seawater & TFWT = 0.1 Bq/L
- OBT in fish = 0.5 Bq/L c.w.



^{3}H in fish analysis

OBT (Bq/L)	
^{3}He ingrowth	Parr combustion
0.54 ± 0.04*	0.70 ± 0.22
0.28 ± 0.02*	<0.66



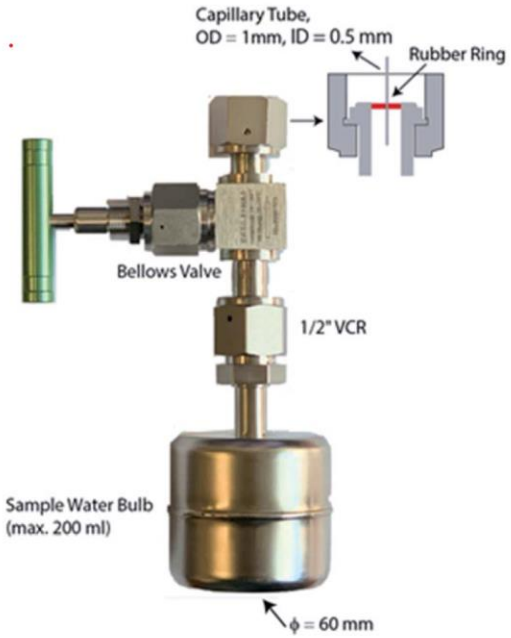


Freeze-drying

- Each unit was applied for one fish sample

- Operating time (6 days): main drying under 0.1 mbar (100 hrs.) and final drying under 0.01 mbar (44 hrs.).
- Pressure Increase Test (PIT) used to validate the sample dry completely (less than 5%).
- Check a weight change in oven (65°C).

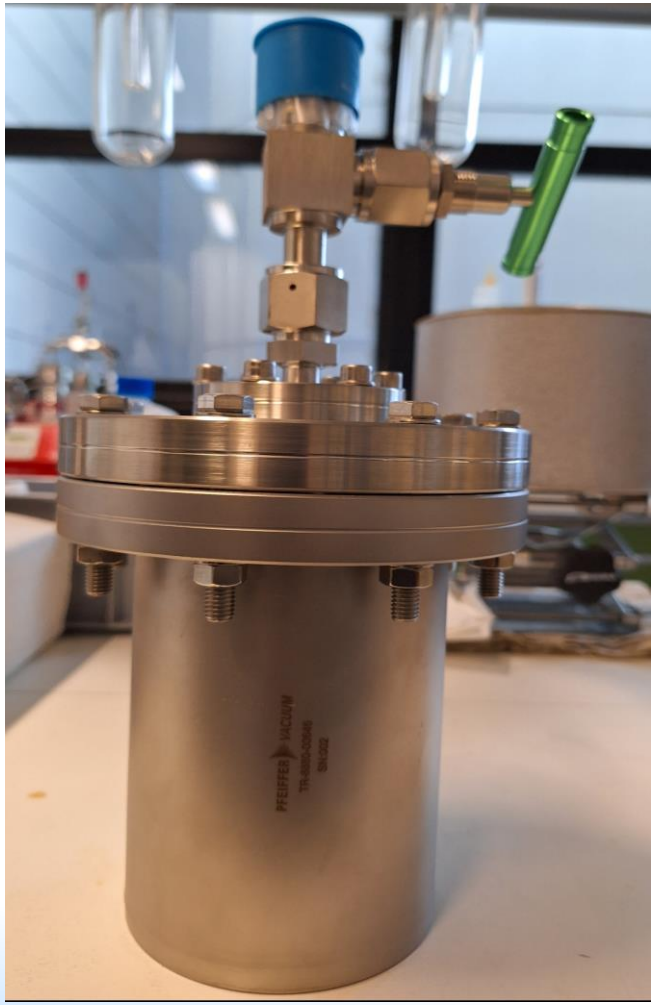
Water sample container



Water sample container for ^{3}He ingrowth analysis at the IAEA.

- About 100 mL of water sample.
- 1~2 months of ^{3}He ingrowth after degassing process.

OBT sample container



- Made entirely of metal with dimensions of 10 cm in diameter and 16 cm in height (volume 1.26L).

- Approximately 90g dry sample applied.

TFWT using ^{3}He ingrowth

- ^{3}He ingrowth method was designed and built in the Isotope Hydrology Laboratory (IHL) of the IAEA.
- The system was achieved to 100 mL of water samples with 2-3 months of storage time for 0.5 to 10 TU samples.
- The developed system was applying for analysis of organically bound tritium (OBT) with fish samples.

OBT using ^{3}He ingrowth

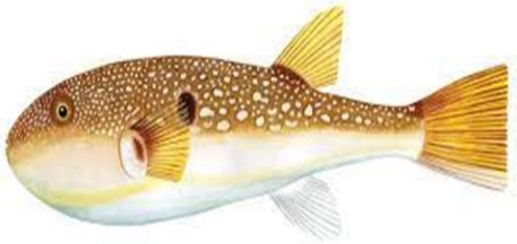
- Non-destructive method.
- Long waiting time to determine the OBT results.
- Lower detection limit can be achievable.
- Currently only limited labs are available.
- The results were compared by the conventional LSC method following Parr combustion.

ILC for the ALPS project (1)

TABLE 10. ACTIVITY CONCENTRATIONS OF ^{3}H (OBT, TFWT) IN FISH SAMPLES

Nuclide	Sample number: Species	IAEA	CAN	KANSO	KEEA	KINS	MERI
^{3}H (OBT, (Bq kg^{-1} f.w.)	T23FA0001: Olive flounder	0.0155 ± 0.0021	<0.064	<0.043	<0.028	<0.32	–
	T23FA0002: Redwing searobin	0.0175 ± 0.0023	<0.064	<0.043	<0.030	<0.32	–
	T23FA0003: Pufferfish	0.0119 ± 0.0019	<0.15	<0.062	<0.030	<0.33	–
	T23FA0004: Silver croaker	0.0145 ± 0.0026	<0.16	<0.049	<0.033	<0.4	–
	T23FA0005: Crimson sea bream	0.0090 ± 0.0020	<0.15	<0.044	<0.029	<0.35	–
	T23FA0006: Japanese jack mackerel	0.0163 ± 0.0028	<0.18	<0.054	<0.035	<0.43	–
^{3}H (TFWT, Bq L^{-1})	T23FA0001: Olive flounder	0.067 ± 0.011	<0.12	<0.30	<0.20	<2.8	<0.32
	T23FA0002: Redwing searobin	0.076 ± 0.013	<0.11	<0.30	<0.21	<2.8	<0.33
	T23FA0003: Pufferfish	0.077 ± 0.013	<0.096	<0.33	<0.21	<2.8	<0.33
	T23FA0004: Silver croaker	0.072 ± 0.011	<0.055	<0.33	<0.21	<2.8	<0.31
	T23FA0005: Crimson sea bream	0.0690 ± 0.0090	<0.11	<0.31	<0.21	<2.7	<0.31
	T23FA0006: Japanese jack mackerel	0.055 ± 0.011	<0.053	<0.31	<0.21	<2.8	<0.31

- ^{3}He ingrowth method can reach to the ultra low-level tritium concentrations!



ILC for the ALPS project (2)

TABLE 13. ACTIVITY CONCENTRATIONS OF ^{3}H (OBT, TFWT) AND ^{14}C IN FISH SAMPLES

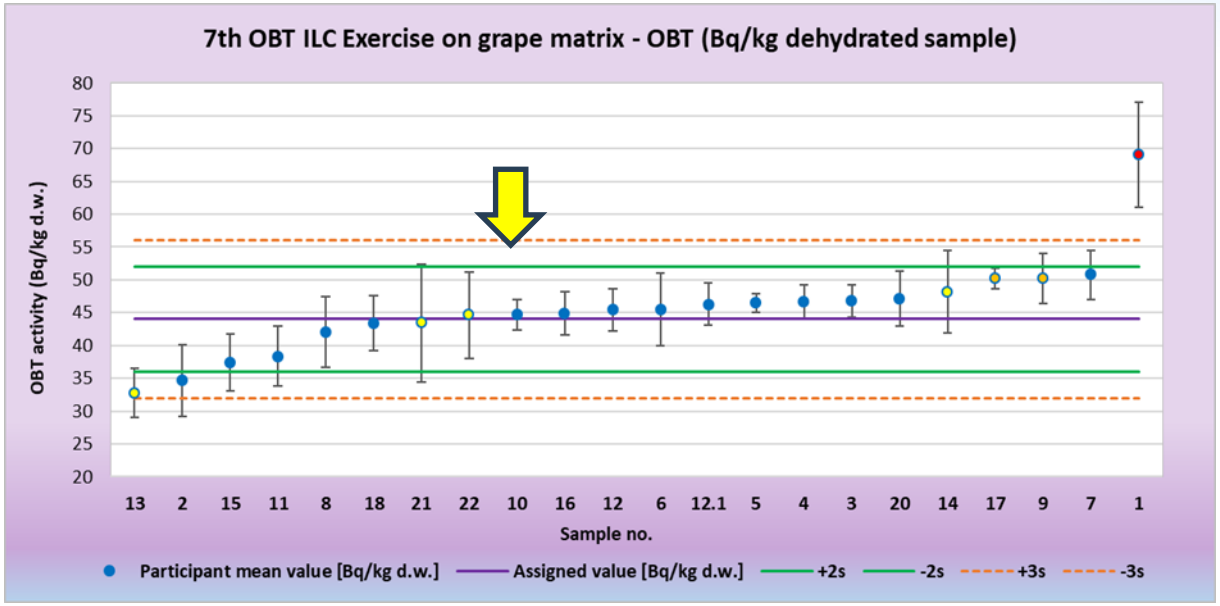
Nuclide	Sample	IAEA	CAN	JCAC	KAKEN	KINS	TPT	Reference value
^{3}H (OBT, (Bq kg^{-1} f.w.)	E-SF3: Olive flounder	0.0462 ± 0.0044	<0.067	0.066 ± 0.016	–	<0.37	–	–
	T-S2: Olive flounder	0.0251 ± 0.0031	<0.066	–	<0.035	<0.37	–	–
	T-S7: Olive flounder	0.0188 ± 0.0025	<0.073	–	–	<0.37	<0.032	–
^{3}H (TFWT, Bq L^{-1})	E-SF3: Olive flounder	1.218 ± 0.041	1.24 ± 0.08	1.17 ± 0.059	–	<1.8	–	–
	T-S2: Olive flounder	0.086 ± 0.016	<0.11	–	0.092 ± 0.026	<1.8	–	–
	T-S7: Olive flounder	0.14 ± 0.015	0.14 ± 0.04	–	–	<1.8	0.12 ± 0.021	–
^{14}C (Bq kg^{-1} f.w)	E-SF3: Olive flounder	22.7 ± 4.6	25.69 ± 0.53	22.7 ± 0.35	–	21.64 ± 0.71	–	23.31 ± 0.99

7th OBT ILC Exercise

- Organized by the SNN-Cernavoda NPP (Romania) in 2024
- 11 countries with 22 participating labs
- Dried grape sample

Figure 3. Dispached samples.

7th OBT ILC Exercise (1)



- Evaluated 21 datasets.
- Robust value was 44±4 Bq/kg dry
- The accepted values ranged from 32.7 Bq/kg dry to 50.8 Bq/kg-dry.

7th OBT ILC Exercise (2)

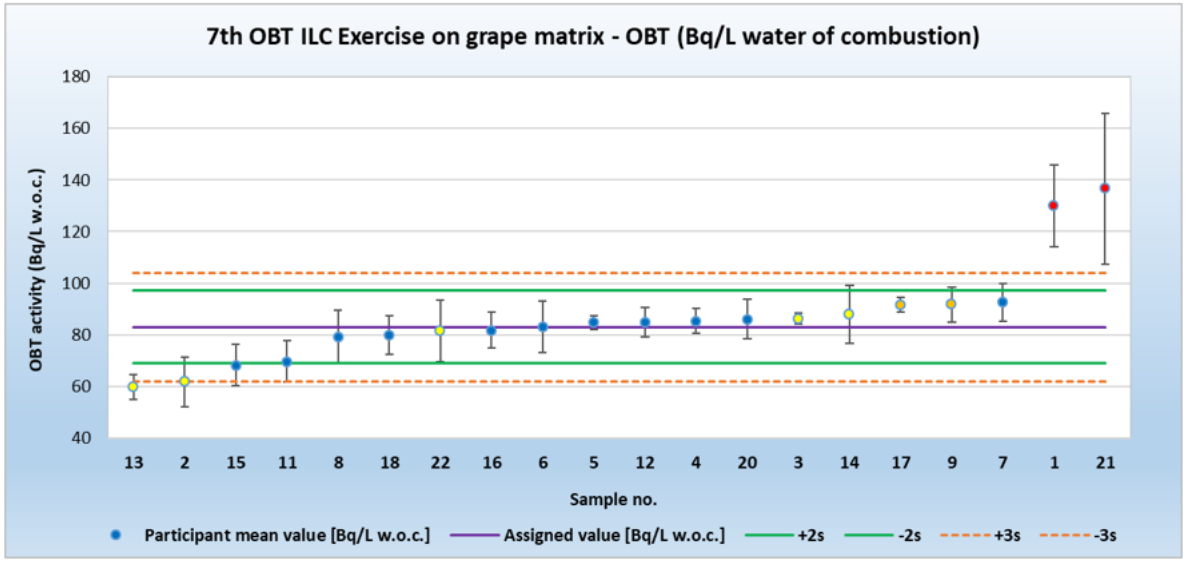


Figure 4. Submitted OBT results – activity concentrations (Bq /L water of combustion).

- IHL's value was not reported to the organizer.
- IHL's value was 83.3 Bq/L water of combustion.
- Assigned value was 83.0 Bq/L.
- The accepted values ranged from 59.7 Bq/L to 92.6 Bq/L.

Conclusion

- ^{3}He ingrowth system is ongoing to improve by IHL of the IAEA to measure low-level tritium in fish samples.
- The method is intended to quantify the OBT in dried sample (<100g) as low as 0.01 Bq with an ^{3}He ingrowth time of less than 2 months.
- Through the 7th OBT exercise, IHL's OBT measurements were consolidated/validated.
- The IAEA is going to continuously corroborate of the environmental monitoring related to discharges of ALPS.

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Thanks for your attention!

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