

Verification of analytical values of tritium in fish in sea area monitoring for the sea
discharge of the water treated by the Advanced Liquid Processing System, etc. of
Fukushima Daiichi Nuclear Power Station
(Report)



December 21, 2022

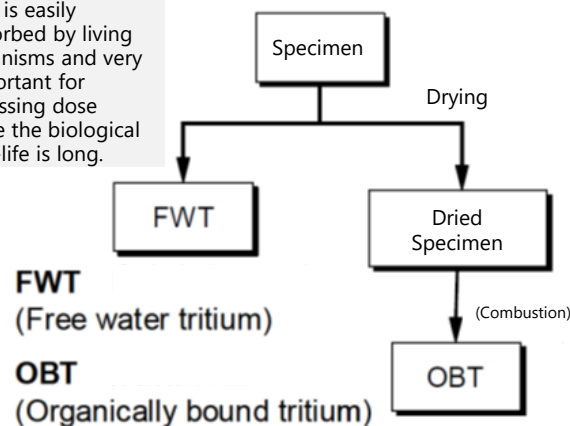
Tokyo Electric Power Company Holdings, Inc.
Fukushima Daiichi Decontamination and
Decommissioning Engineering Company

1. Background

- As a result of adding additional measurement locations and targets to the sea area monitoring plan regarding the discharge of ALPS treated water, which was announced on March 24 of this year, the number of locations from which specimens for analyzing the concentration of tritium in fish will be sampled has increased from one to 11. (The KEEA will continue to analyze tritium concentrations from the one location stipulated in the original sea area monitoring plan)
- According to the monitoring plan, the results from each agency engaged in monitoring shall be compared to confirm validity, and accordingly, since TEPCO and Kaken Co., Ltd. (hereinafter referred to as, "Kaken") have analyzed tritium concentrations in fish for the first time, the analysis was conducted based on official methods (Radioactivity Measurement Methods Series) and the results were compared with the results from the KEEA, which has already produced a substantial amount of analysis results.
- After commencing the analysis of tritium concentrations in fish from 11 locations in May of this year, we confirmed that the concentrations of free water tritium (hereinafter referred to as, "FWT") analyzed by TEPCO, and the concentrations of organically bound tritium (hereinafter referred to as, "OBT" ※Refer to the diagram below) analyzed by both TEPCO and Kaken were higher than tritium concentrations in the surrounding sea water. The analysis results from TEPCO and Kaken differed from those from the KEEA, which were approximately the same as they have always been.
- Therefore, TEPCO and Kaken have temporarily suspended analysis since August when the aforementioned analysis results from TEPCO and Kaken were compared with those from the KEEA, and the cooperation of experts apart from these three parties was elicited to perform an investigation into the cause of the discrepancies in analysis methods.

Measuring tritium in organic substances

OBT is easily absorbed by living organisms and very important for assessing dose since the biological half-life is long.



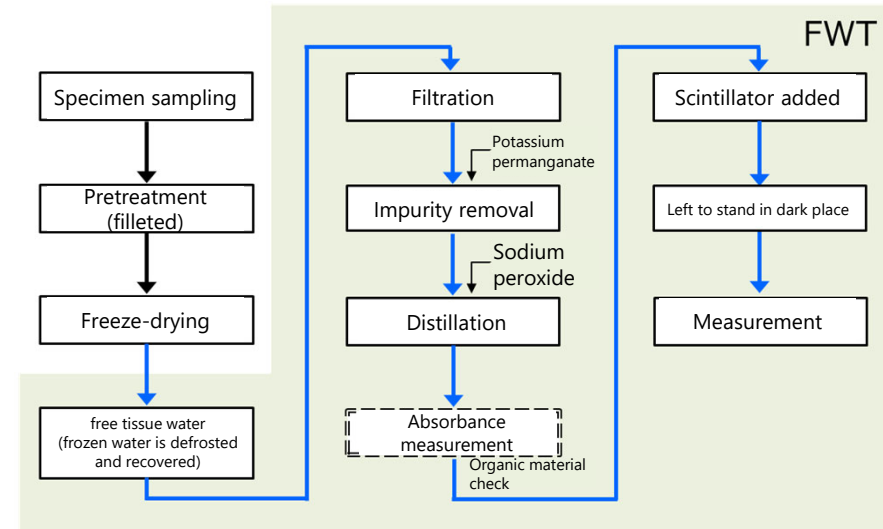
- When measuring tritium concentrations in fish, two types are measured, FWT and OBT.
- FWT refers to the concentration of tritium in the water inside the fish, so the water in the fish is evaporated, recovered and then measured.
- OBT is tritium that exists as part of hydrogen atoms in fish tissue (protein tissue, such as muscles, etc.), so the water generated during the burning of this tissue is recovered and measured. Since impurities that could impact measurements migrate into the specimens during combustion, they must be removed from the recovered water.
- Fish tritium measurement is very difficult and there are only a few analysis agencies that are capable of performing this measurement.

2. Fish tritium analysis method

- When measuring tritium concentrations in fish, two types are measured, FWT and OBT.

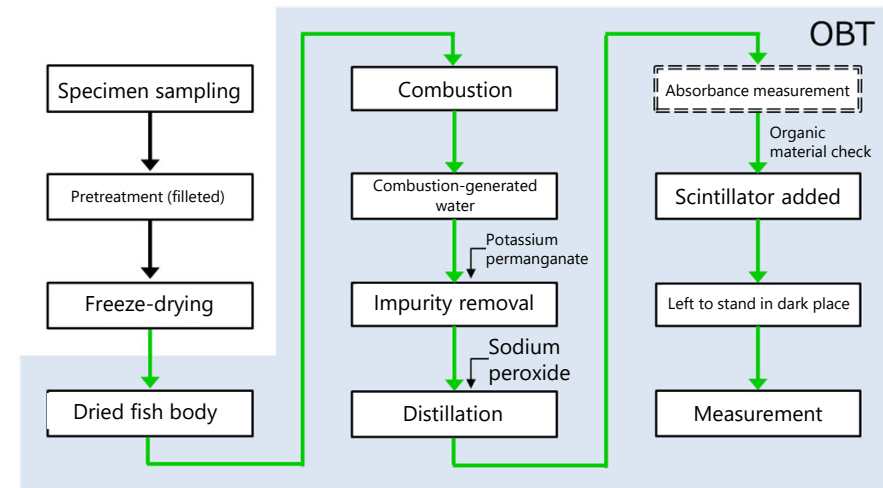
<FWT analysis method>

- After the parts of the specimen that are subject to analysis are harvested, they are frozen in a freezer and then the frozen specimens are freeze-dried after which water (free tissue water) is extracted and an analysis specimen is prepared.
- After this, an oxidant is added to the remaining organic material in the free tissue water (analysis specimen) to dissolve it, the water is distilled, and the specimen is measured using a liquid scintillation counter.



<OBT analysis method>

- Dry tissue that remains after freeze-drying is burned, and the vapor (combustion-generated water) generated is recovered and prepared as an analysis specimen.
- After this, an oxidant is added to the organic material that remains in the combustion-generated water (analysis specimen) to dissolve it (remove impurities), the water is distilled, and the specimen is measured using a liquid scintillation counter.



3. Factors that affect fish tritium analysis

- There are many more factors that affect fish tritium analysis compared to sea water tritium analysis.
- In addition to factor analysis, analysis methods employed by the KEEA and Kaken were directly observed, and the analysis methods of all three parties, including TEPCO, were compared. Experts apart from the three parties were also asked for their opinion during the process of factor identification in the course of the investigation.
- As a result, we identified "the impact of measurement equipment," "the impact of impurities (organic material)," and "the impact of chemical reactions," as factors that affect analysis results.

① The impact of measurement equipment

- Since the performance and installation environments of measurement devices differ, the differences in equipment may have an impact on analysis results.

② The impact of impurities (organic material)

- The concentration of tritium in fish is the same as the concentration in the seawater, and if the fish analysis contains even a few impurities, the concentration of tritium cannot be measured accurately. As a result of differences in pretreatment processes, it is possible that impurities are not being adequately removed. (Deliberation of pretreatment processes)

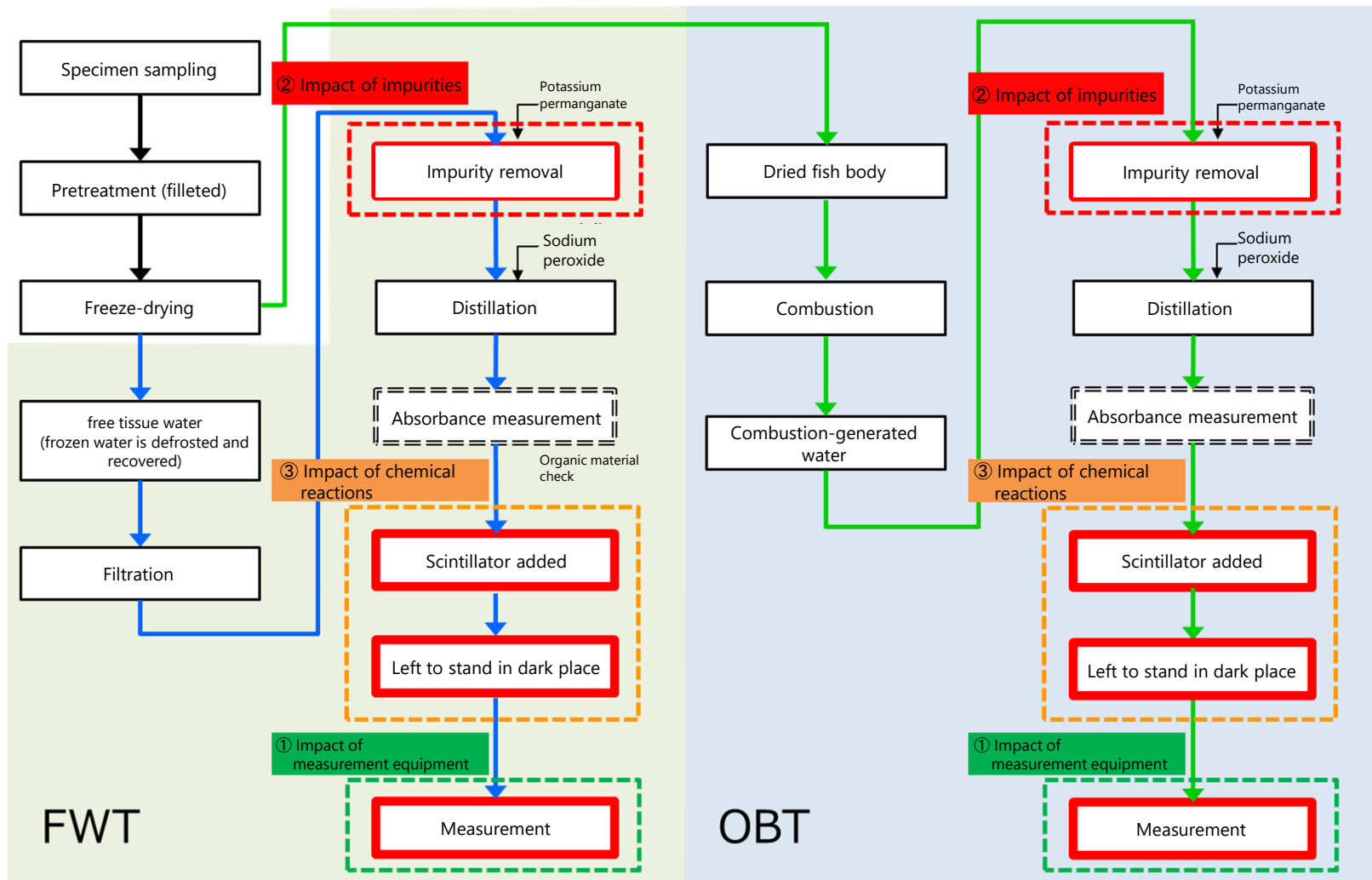
③ The impact of chemical reactions

- Since tritium cannot be directly measured, the radiation must be converted into light that can be measured. However, due to the differences in the way the specimen is left to stand, it is possible that the specimen may remain luminescent due to chemical reactions that have yet to conclude. (Deliberation of measurement stages)

3. Factors that affect fish tritium analysis

■ Factors identified this time

- ① The impact of measurement equipment
- ② The impact of impurities (organic material)
- ③ The impact of chemical reactions



4. Verification method

- The following examination of the impact of measurement equipment, impurities (organic material) and chemical reactions was conducted while listening to the opinions of experts apart from the three parties.
- The same examination was conducted at TEPCO and Kaken.

① The impact of measurement equipment

- The same piece of equipment (LSC-LB-8) located at TEPCO (1F on-site analysis facility), off-site facilities, and Kaken was used to measure an empty measurement vessel (no specimen) at the same time on the same day and under the same conditions in order to check for any impact from differences in measurement equipment.

② The impact of impurities (organic material)

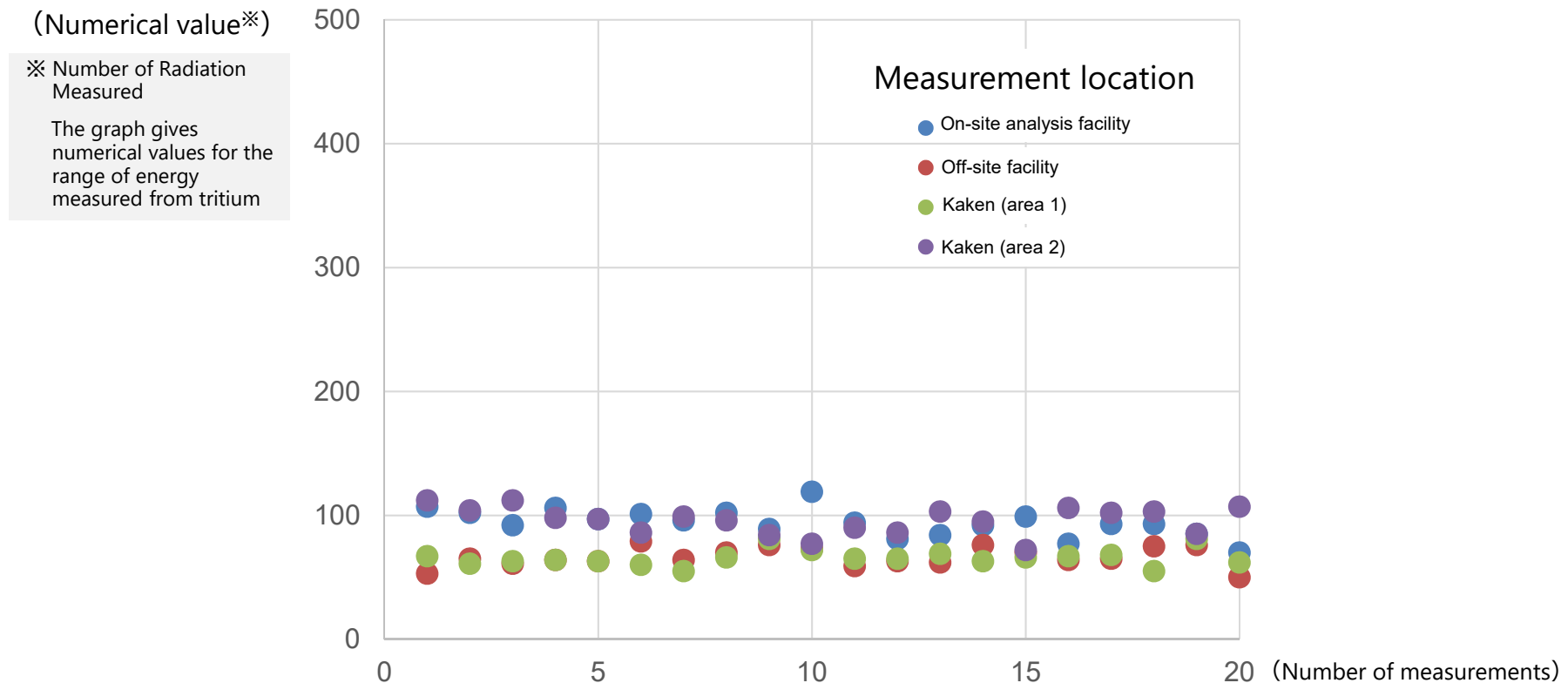
- TEPCO (1F on-site analysis facility) and Kaken performed analysis using the pretreatment process of the KEEA (impurity removal). Results after the pretreatment process conducted at each analysis facility were compared to check for any impact from impurities (organic material).

③ The impact of chemical reactions

- TEPCO (1F on-site analysis facility) and Kaken took chronological measurements of measured specimens in which OBT had already been detected to check changes over time and checked for any impact from chemical reactions.

5. Results from verification of measurement equipment

- The same piece of equipment (LSC-LB-8) located at TEPCO (1F on-site analysis facility), off-site facilities, and Kaken was used to measure an empty measurement vessel (no specimen) at the same time on the same day and under the same conditions.
- There was no significant difference in the data from each of the four facilities that repeatedly conducted the same test.
- Therefore, it was determined that there is no impact from any difference in measurement equipment.



6. Results from investigation into impurities (organic material)

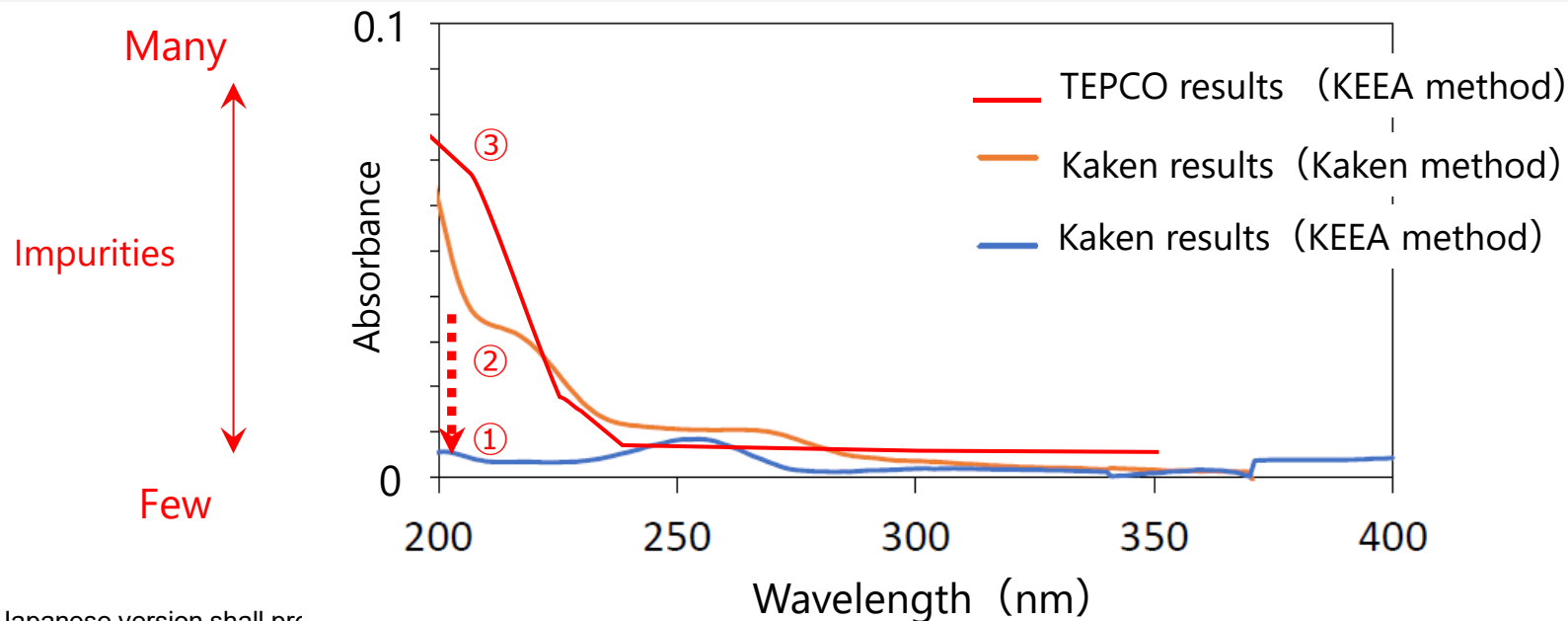
- Impurities (organic material) are removed based on official methods (Radioactivity Measurement Methods Series). The official methods stipulate the type and amount of reagent that must be added in order to remove [impurities], however it is also noted to, "adjust the amount of reagent added appropriately in accordance with the amount of organic material in the specimen," so the party taking the measurements must ascertain the appropriate amount of additive to be used in accordance with the attributes of the fish to be measured, etc.
- When a check was performed to see if the impurities had been removed as noted on the next page, it was discovered that impurities were better removed using the method employed by the KEEA compared to the methods employed by TEPCO and Kaken. When the methods were compared, it was found that the KEEA took more time to remove impurities and added more reagent. Through this discovery we learned that the method employed by TEPCO and Kaken did not allow enough time for the chemical reaction to completely remove impurities.

Comparison of official analysis methods employed by KEEA/Kaken/TEPCO (1F on-site analysis facility)

Analysis agency	KEEA	Kaken	TEPCO (1F on-site analysis facility)	Official method*
Impurity removal method				
Reagent	Potassium permanganate (Approx. 1g added)	Potassium permanganate (Approx. 1g added)	Potassium permanganate (Approx. 0.3g added)	Potassium permanganate (Approx. 0.5g added per approx. 70ml of analysis specimen)
Temp.	100°C	100°C	60°C	100°C
Time	7 hours/day for 4 days	8 hours	More than 6 hours	More than 4 hours

6. Results from investigation into impurities (organic material)

- In order to examine any impact from the differences in impurity removal methods, TEPCO and Kaken both removed impurities using the same method employed by the KEEA and then measured/compared absorbance (the lower the value, the fewer the impurities), which is the standard for determining if there are residual impurities.
- Kaken found that by using the KEEA method absorbance near the 200nm range decreased greatly compared with the conventional method thereby confirming that the removal of impurities (decrease in residuals) is being promoted. (②→① in the graph below)
- When this method was tested during the analysis of fish specimens, Kaken found that it was able to eliminate the impact of chemical luminescence caused by impurities and that OBT fell below detectable levels. It also confirmed that the impurity dissolution method employed by KEEA is effective for preventing chemical luminescence originating from residual impurities.
- However, when TEPCO employed the method used by the KEEA, it was unable to satisfactorily decrease absorbance and was not able to obtain the anticipated improvement in results. (③ in the graph below)



7. Results from investigation into chemical reactions

- After dissolving impurities and distilling the water, a luminescent liquid (liquid scintillator) was added and measurements were taken.
- According to official methodology (Radioactivity Measurement Methods Series) it is recommended that the specimen be left to stand for approximately a whole day to one week after addition of the liquid scintillator.
- A comparison of the time that each party left the specimens stand after addition of the additive showed that the KEEA and Kaken left the specimens data for one week, while TEPCO left it stand for more than three days, which is based on its experience with analyzing seawater, etc.
- Since TEPCO was not leaving the specimens stand as long as other analysis agencies, it is possible that it was not allowing enough time to eliminate chemical reactions.

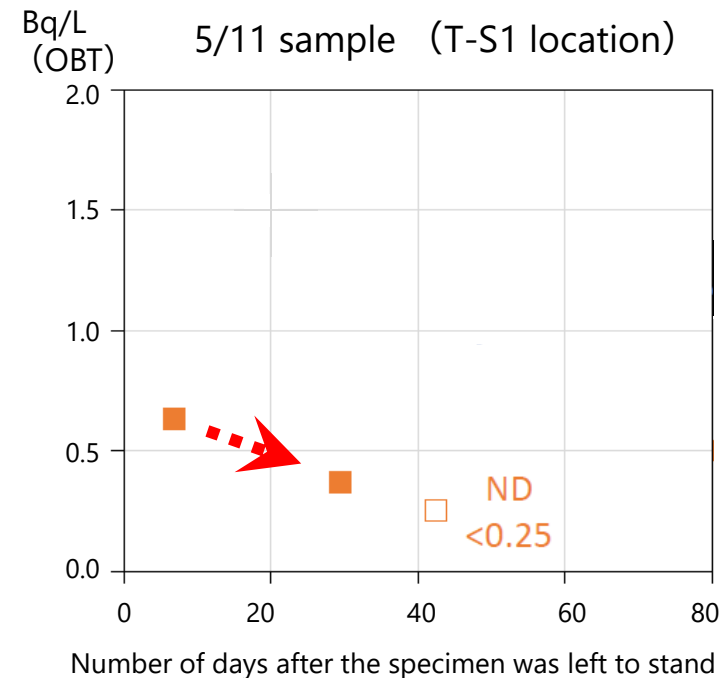
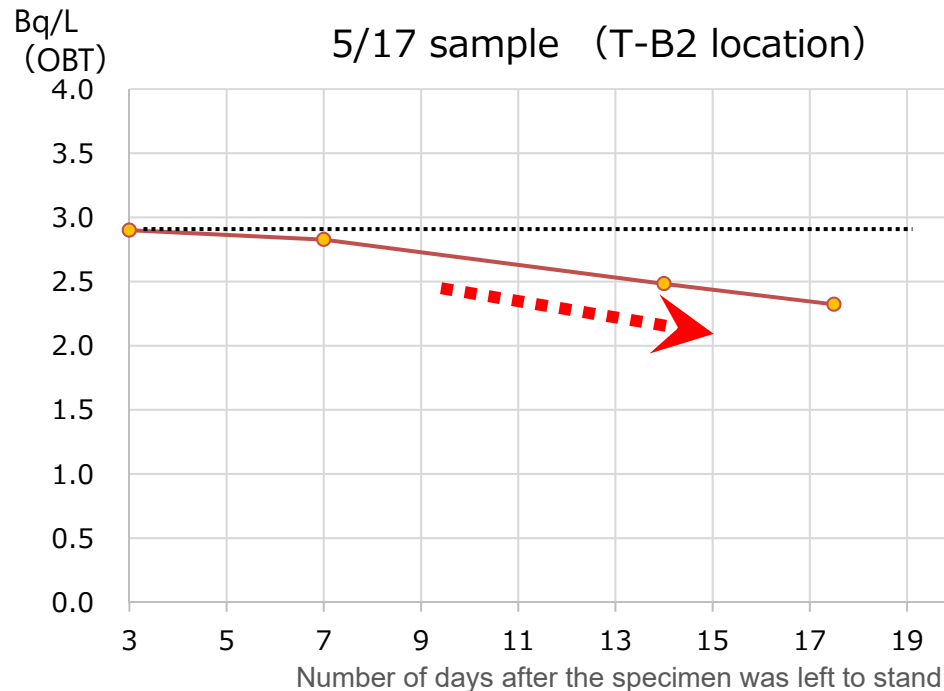
Comparison of official analysis methods employed by KEEA/Kaken/TEPCO (1F on-site analysis facility)

<i>Analysis agency</i>	KEEA	Kaken	TEPCO (1F on-site analysis facility)	Official method*
Measurement equipment	LSC-LB-5, LB-7 (Made by Nippon RayTech Co., Ltd.)	LSC-LB-7, LB-8 (Made by Nippon RayTech Co., Ltd.)	LSC-LB-7, LB-8 (Made by Nippon RayTech Co., Ltd.)	Liquid scintillation counter
Liquid scintillator	Ultima Gold uLLT	Ultima Gold LLT	Ultima Gold LLT	Emulsification scintillator (Commercial products such as Scintisol and Ultima Gold LLT, etc.)
Amount of time left to stand after liquid scintillator is added to the specimen	One week	One week	More than three days	A whole day and approximately one week and after specimen adjustment
Environment in which the specimen is left to stand	20°C (Air-conditioning temperature) Dark location	15°C Inside measurement equipment (dark location)	15°C Inside measurement equipment (dark location)	Inside of the measurement equipment or in an incubator set to approximately 16° C

*Radioactivity Measurement Method Series 9 Tritium Analysis Methods (2002 Revision) MEXT
The Japanese version shall prevail.

7. Results from investigation into chemical reactions

- When Kaken and TEPCO used a specimen in which OBT had been detected to perform chronological measurements, it was confirmed that analysis values decreased because chemical reactions were allowed to conclude.
- Therefore it was determined that chemical reactions that occur in conjunction with the addition of the liquid scintillator had not been allowed to run their course, and that measurements had been taken without allowing the specimen to stand for a sufficient amount of time.
- When using the aforementioned specimens, it is true that chemical luminescence from residual impurities had a great impact, but this was compounded by the impact of chemical luminescence from ongoing chemical reactions.



8. Kaken initiatives

- Based on the investigation results, Kaken determined that the method employed by the KEEA is scientifically-based and logical, and will now employ the method for removing impurities used by the KEEA during OBT analysis (pretreatment). When this method was tested during the analysis of fish specimens, Kaken found that it was able to eliminate the impact of chemical luminescence caused by impurities, and that OBT fell below detectable levels.
- Kaken created new analysis procedures based on the method employed by the KEEA and when analysis of fish tritium recommenced on October 24, OBT results showed that tritium concentrations were below detectable levels.

Kaken analysis method (After revision)

<i>Analysis agency</i>	Kaken (After revision)	KEEA
Impurity removal method		
Reagent	Potassium permanganate (Approx. 1g added)	Potassium permanganate (Approx. 1g added)
Temperature	100°C	100°C
Time	More than 28 hours	7 hours/day for four days
Method for confirming residual impurities		
Absorbance	<0.1(near 200nm)	<0.1(near 200nm)
Conductivity rate	<10μS/cm	<10μS/cm
pH	Neutral	Neutral

9. TEPCO initiatives

- TEPCO's analysis results differed from those by the KEEA and Kaken, and determined that OBT measurements showed higher values than the actual amount of OBT.
- Since extremely small concentrations of tritium are being measured during fish tritium analysis this time, we are being very careful not to contaminate specimens. However, since analysis is being conducted within TEPCO's controlled area, we will continue to closely examine our methods for removing impurities as well as investigate the possibilities that specimens are being contaminated by tritium from the surrounding environment.
 - The KEEA impurity removal method will be used in an analysis area within the on-site analysis facility that is assumed to result in minimal tritium contamination, and the specimen will be left to stand for the same amount of time that the KEEA employs after which test analysis of fish specimens will be conducted. (Action 1)
 - After these tests have been concluded, the measurement results will be compared with fish specimens on trial by TEPCO and Kaken, and the skills of analysis personnel shall also be reviewed. (Action 2)
- Kaken will analyze specimens from the TEPCO's five locations while the investigation is ongoing.



Using the impurity (organic material) removal device
The Japanese version shall prevail.

[Schedule for recommencing analysis by TEPCO]

- Action 1: To be implemented in December
- Action 2: To commence as soon as preparations have been completed after the completion of action 1

Reference

References: Table of Contents

Data on surveys and tests are posted on the following pages.

- A. Confirmation of detail for analysis method
Factor analysis, facility layout, and analysis procedures
- B. Checking the impact of the measurement equipment
Spectral investigation
- C. Checking the impact of impurities
Absorbance investigation
- D. Checking the impact of chemical reaction
Survey on temporal changes

Reference

- Changes in tritium concentration in seawater at fish sampling sites
- Changes in tritium concentration in the surrounding sea area
- Atmospheric tritium concentration of 1F on-site analytical facility

A-1. Possibilities listed in the identification of factors affecting the analytical values

Equipment dependent factors and stationary time of specimen: data collection and investigation consideration

Residual organic matter, transfer during distillation, etc.: it was determined that stricter reaction conditions and purification check can work.

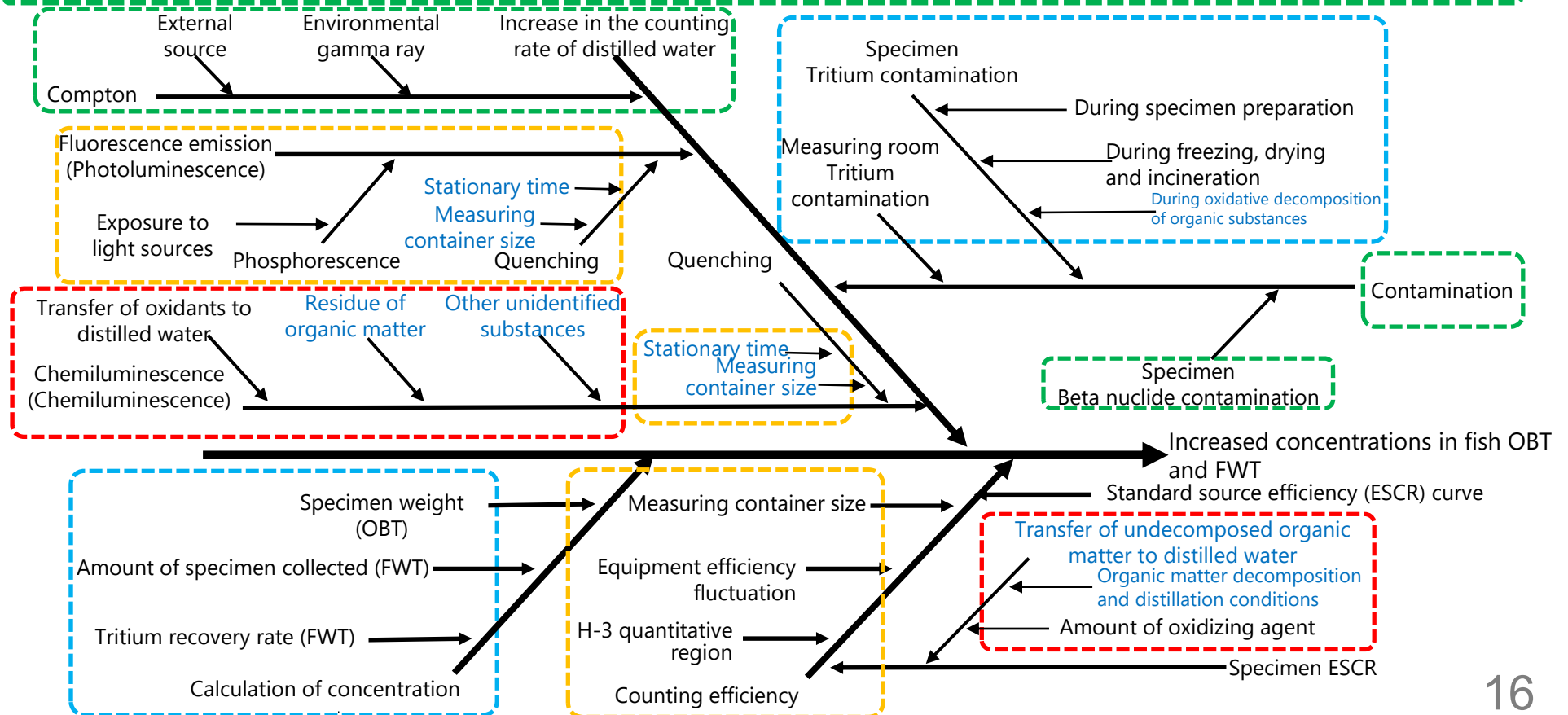
[1] Miscalculation, [2] Possibility of atmospheric tritium contamination: Excluded due to the following reasons, but the survey on contamination will continue in the work environment of 1F on-site analysis facility.

-> [1] No miscalculation is confirmed with verification

[2] Simultaneous contamination at TEPCO and Kaken, and inconsistent detection values of FWT and OBT.

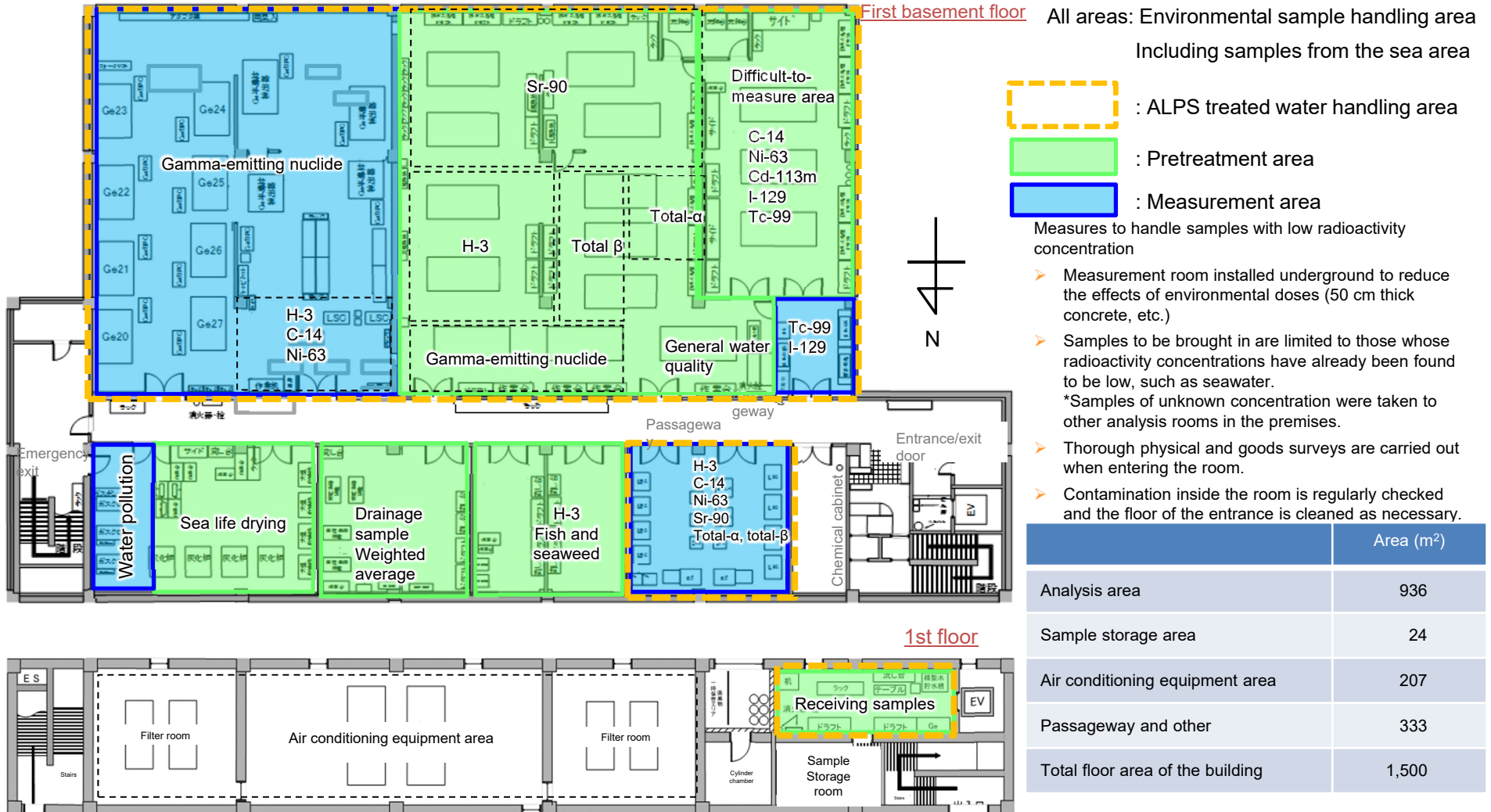
Impact from external β -nuclide contamination and atmospheric dose:

> Surface contamination of materials brought in and working environment dose are excluded because they are always checked.



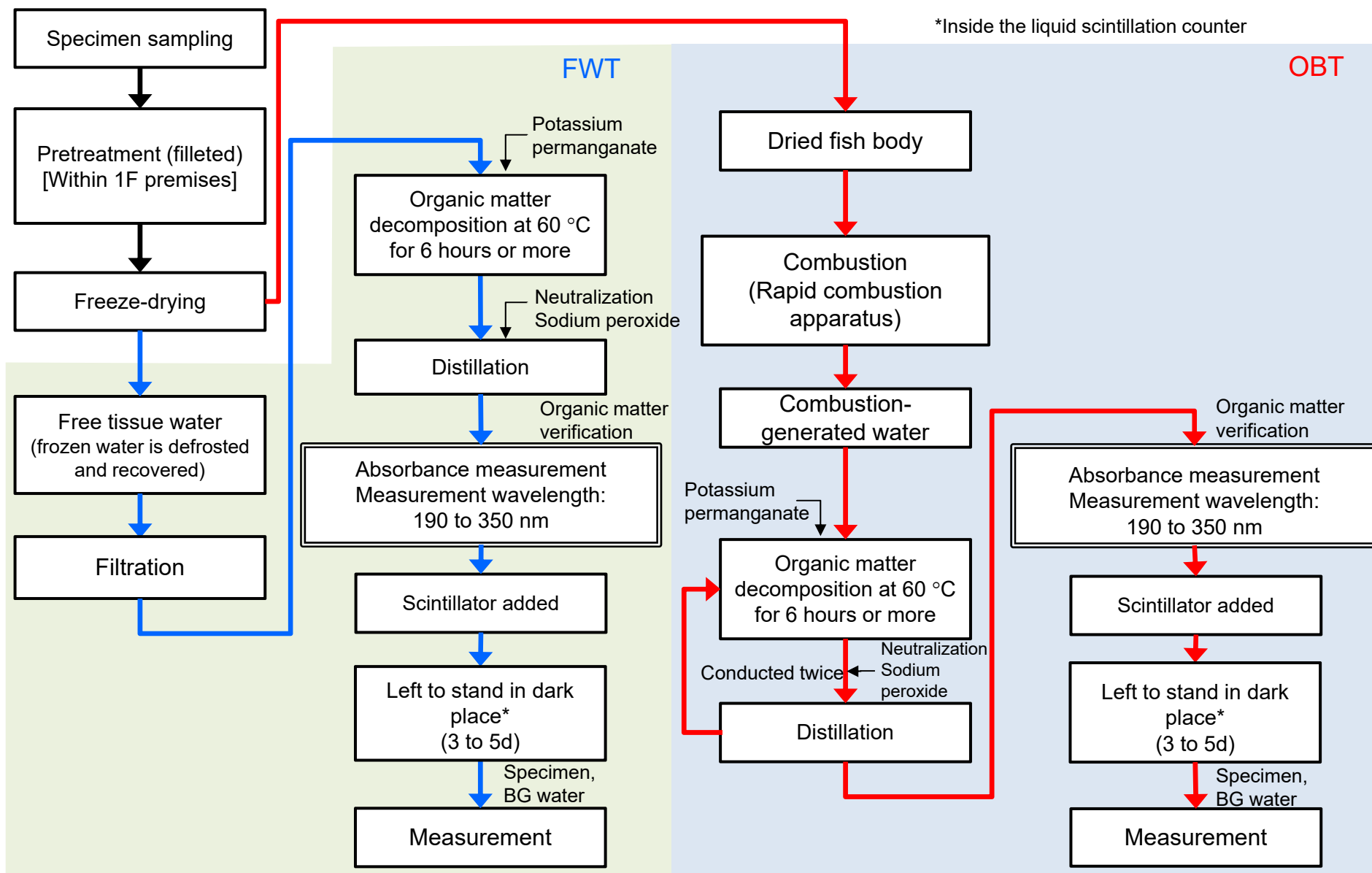
A-2. Layout of 1F onsite analytical facility

- Although the design is based on the assumption that samples with low concentrations will be handled, subdrain purified water, groundwater bypass water, and ALPS treated water contain tritium at levels of $1\text{E}+2$ to $1\text{E}+6$ Bq/L (tritium in fish: $1\text{E}-2$ to $1\text{E}-1$ Bq/L).
- The sample water mentioned above is not treated on the north side of the underground passage.

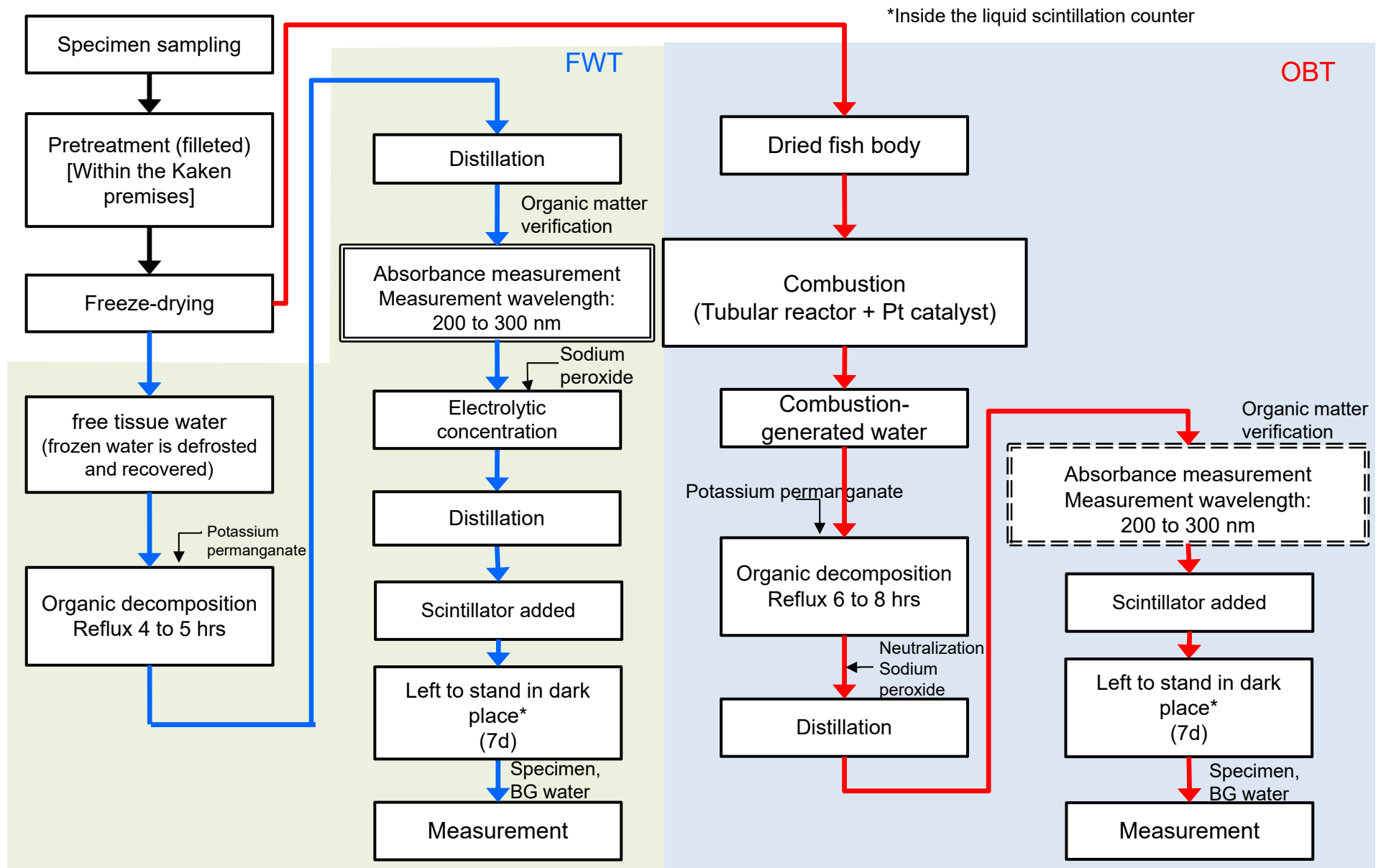


The Japanese version shall prevail.

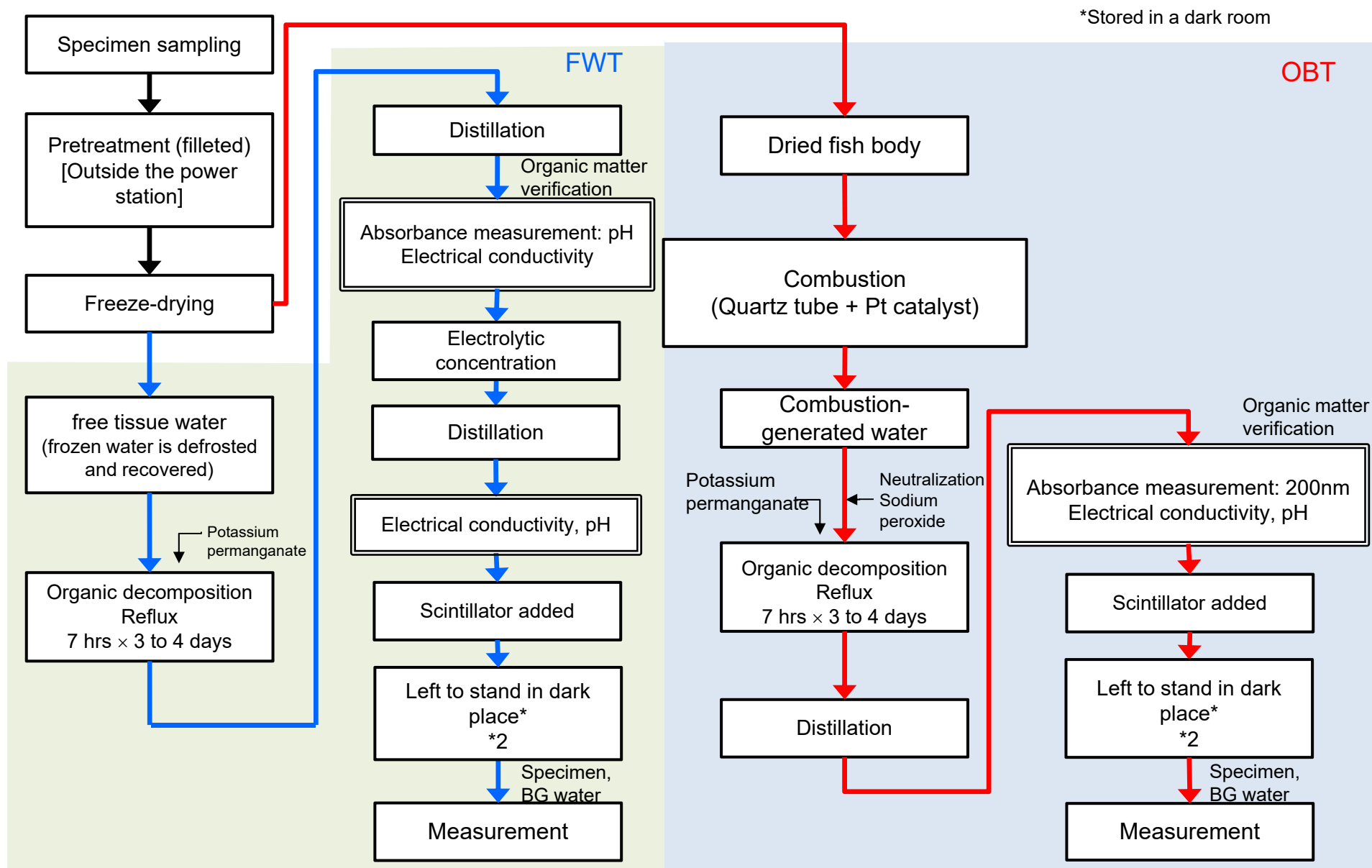
A-3. Analysis procedure at 1F on-site analysis facility



A-4. Analysis procedure at Kaken



A-5. Analysis procedure at Kyushu Environmental Evaluation Association



A-6. Conditions for organic matter decomposition

- Kyushu Environmental Evaluation Association: using reflux condensers: 1 g of KMnO_4 added, 100 °C _ 7 hours/day × 4 days
- 1F on-site analysis facility: using hermetically sealed eggplant-shaped flasks: 0.3 g of KMnO_4 added, 60 °C _ 6 hours or more
- Kaken: Using reflux condensers: 1 g of KMnO_4 added, 100 °C _ 8 hours

(Reference) Official Method *: For 70 mL specimen, 0.5 g of KMnO_4 added, 100 °C _ 4 hours or more.



Kyushu Environmental
Evaluation Association



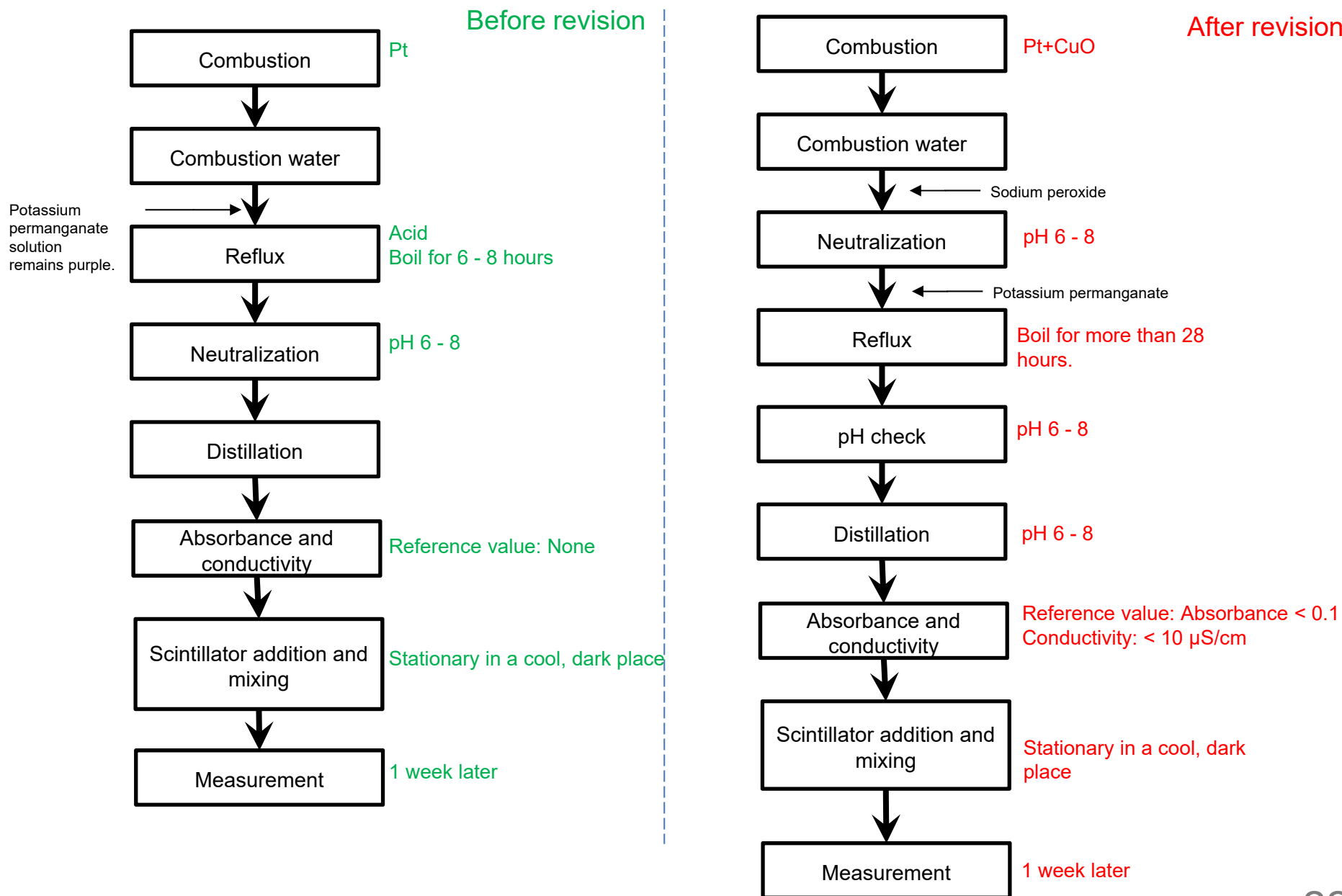
1F on-site analytical facility



Kaken

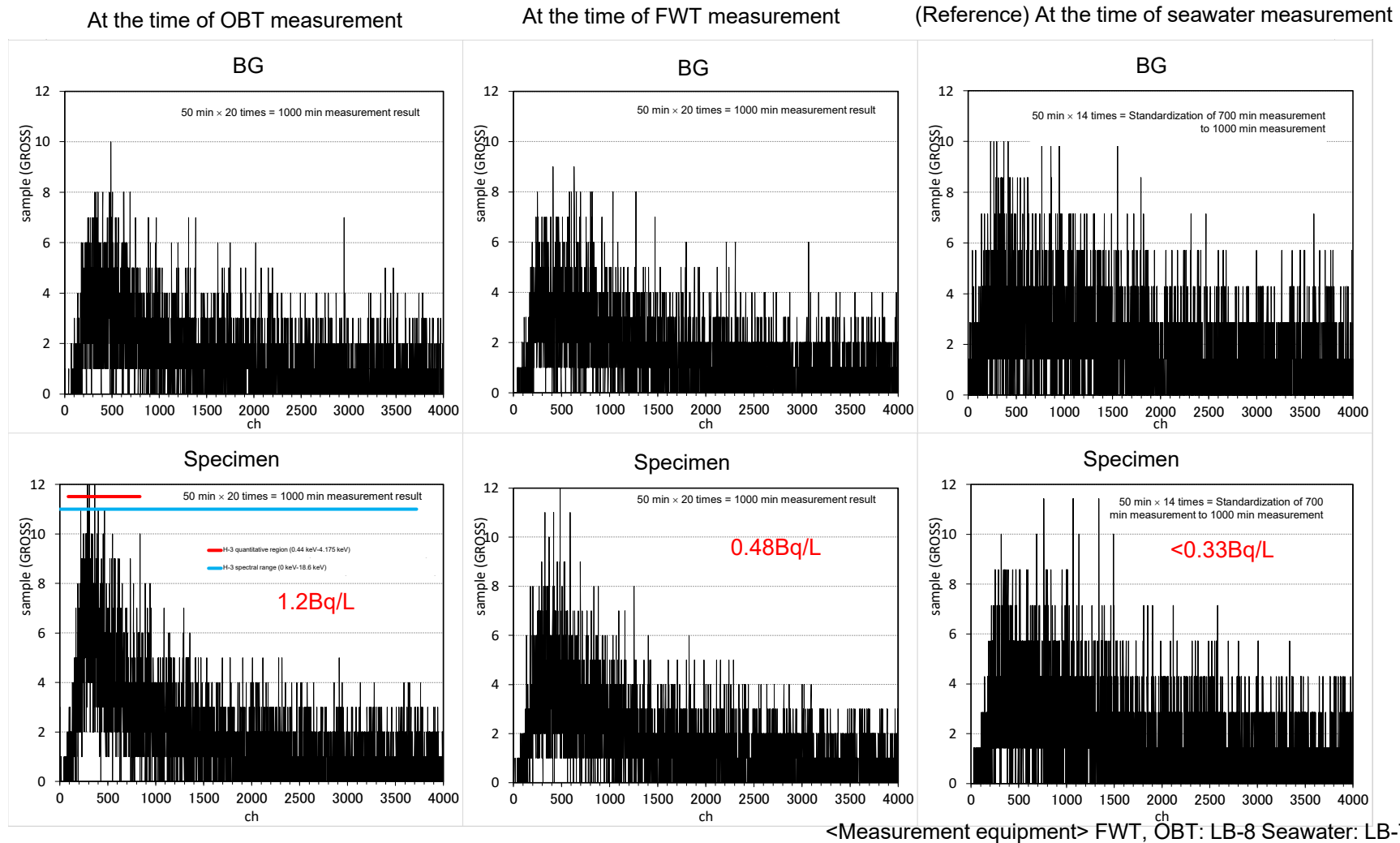
*Radioactivity Determination Series 9 Tritium Analysis Method (revised in 2002): Ministry of Education, Culture, Sports, Science and Technology

A-7. Outline of OBT analysis procedure at Kaken



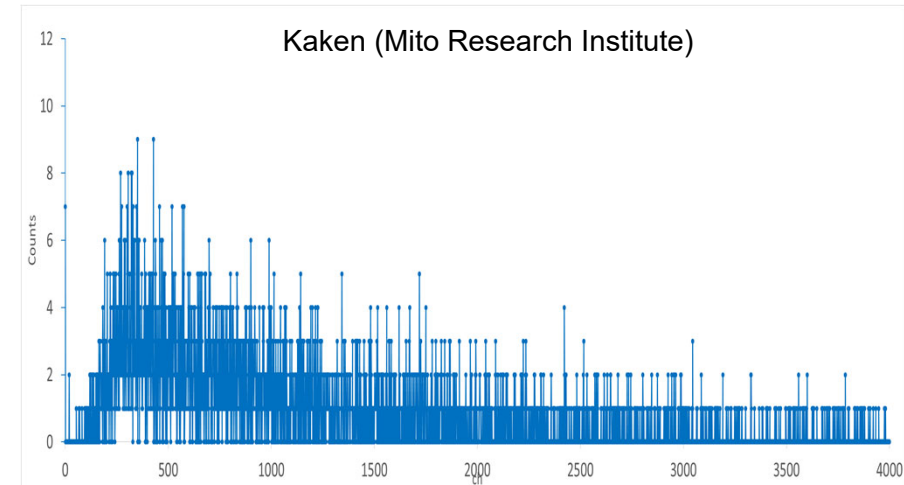
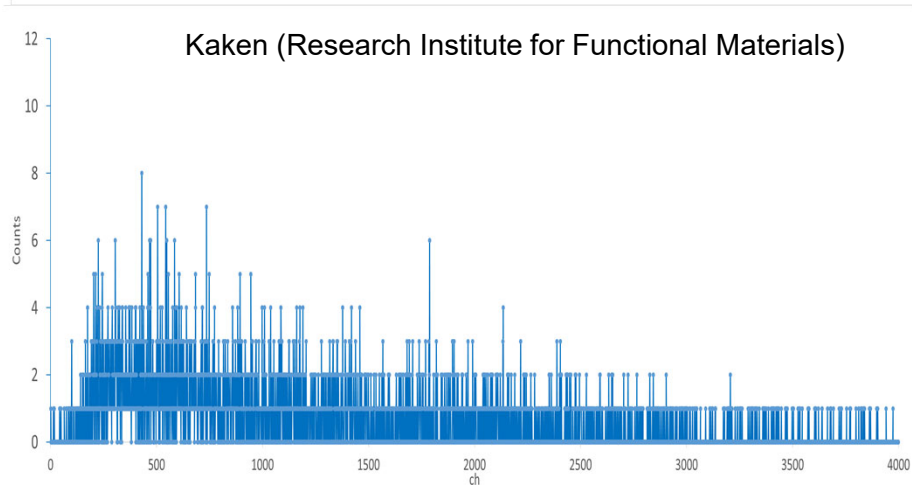
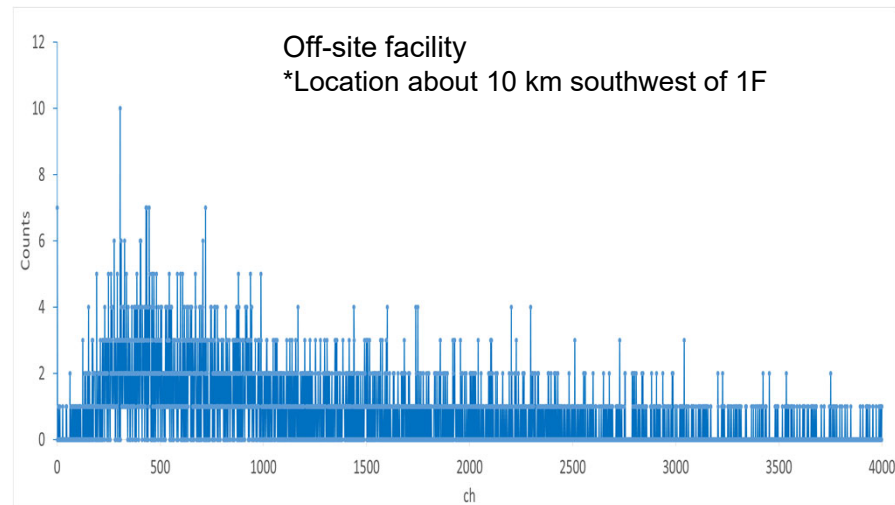
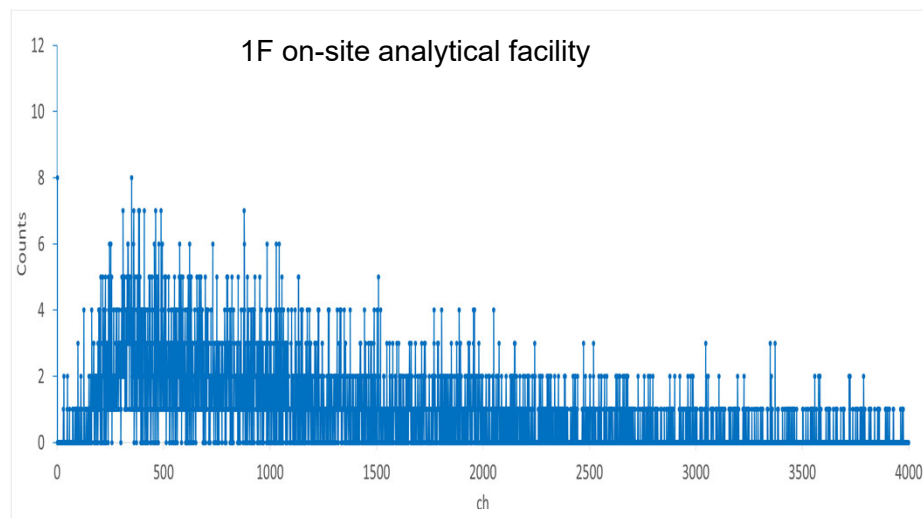
B-1. Spectra during fish specimen measurement (1F on-site analysis facility)

- For the fish specimens collected on May 17, significant peaks were observed in both OBT and FWT in the H-3 quantitative region.
- Although there was a possibility of a peak in the BG spectrum as well, the results of measuring BG using the LSC of another institution (see next slide) confirmed that the difference in measuring equipment did not affect the analysis results.



B-2. BG spectra at each facility

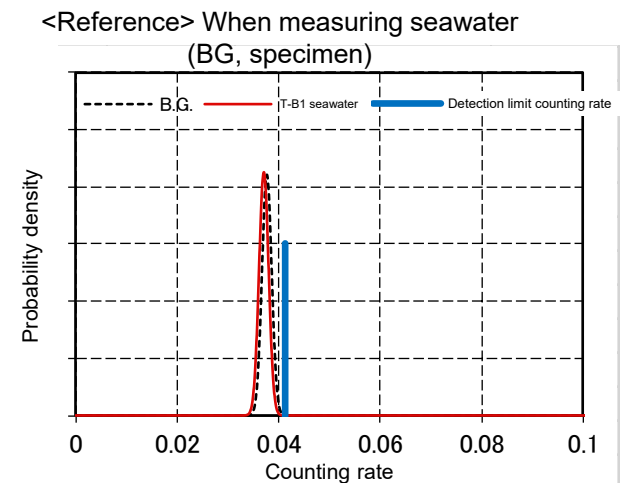
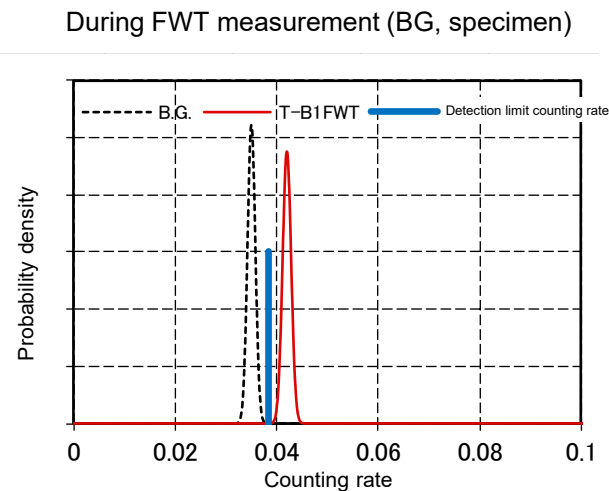
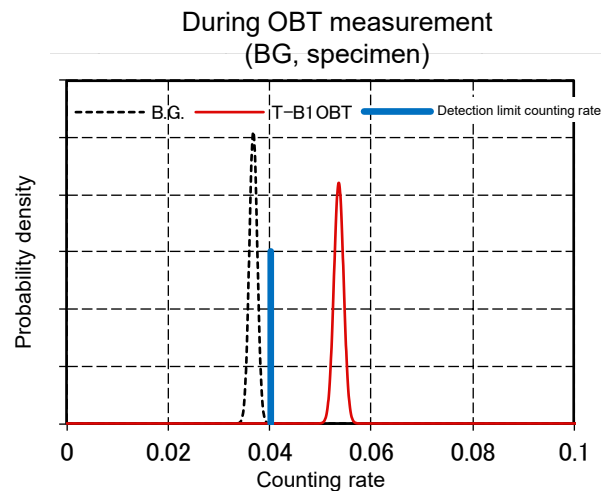
*Accumulation spectrum of 6 to 25 repeats at each facility (excluding 1 to 5 repeats)



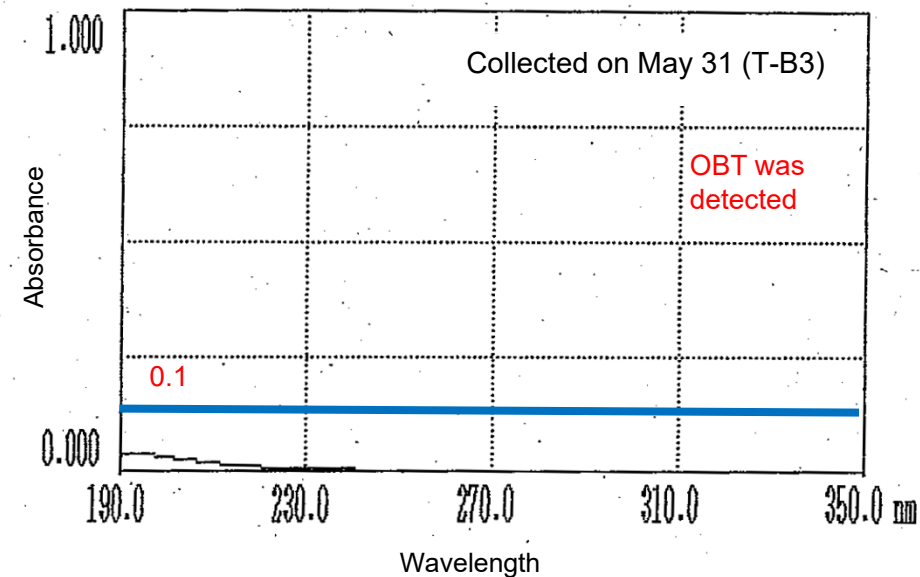
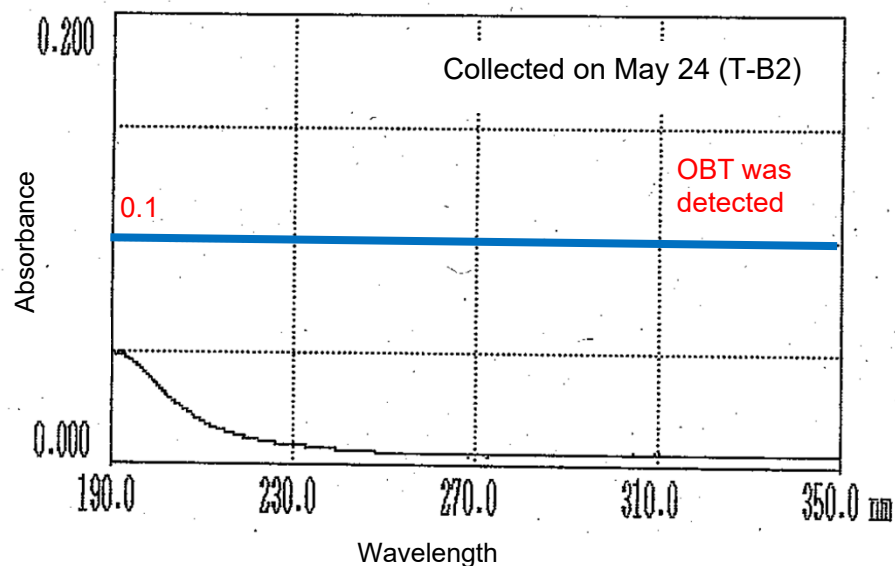
*Container: 100 mL polyvial bottle (empty container), measurement time: 50 minutes \times 20 cycles, measurement conditions: gain "0.005 keV/ch" and energy range "20 keV"
Number of channels "4000 channels," ionizer "on (0.5 min)," waiting time "none," chemiluminescence correction "none"

B-3. Evaluation of normal distribution of spectra during measurement of fish specimens (1F on-site analysis facility)

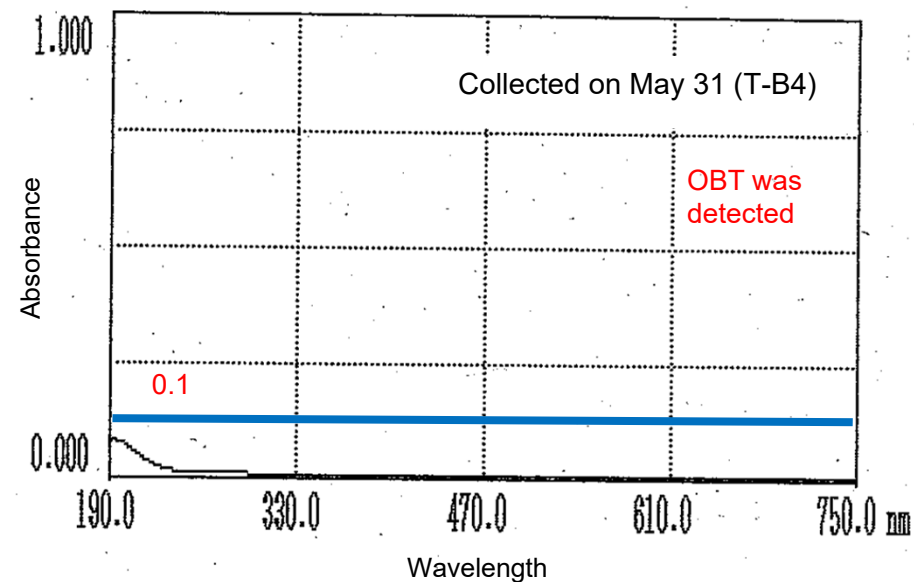
- Statistic processing was conducted for the measurement results on slide 23.
- The standard deviation calculated from the count is not very large and the distribution is relatively sharp.
- It was confirmed that the detection is not due to a spread in standard deviation, but that the counting rate of the specimen itself is increased by some factor.
- Impurities in the specimen were estimated as a factor.



C-1. Absorbance data (1F on-site analytical facility)

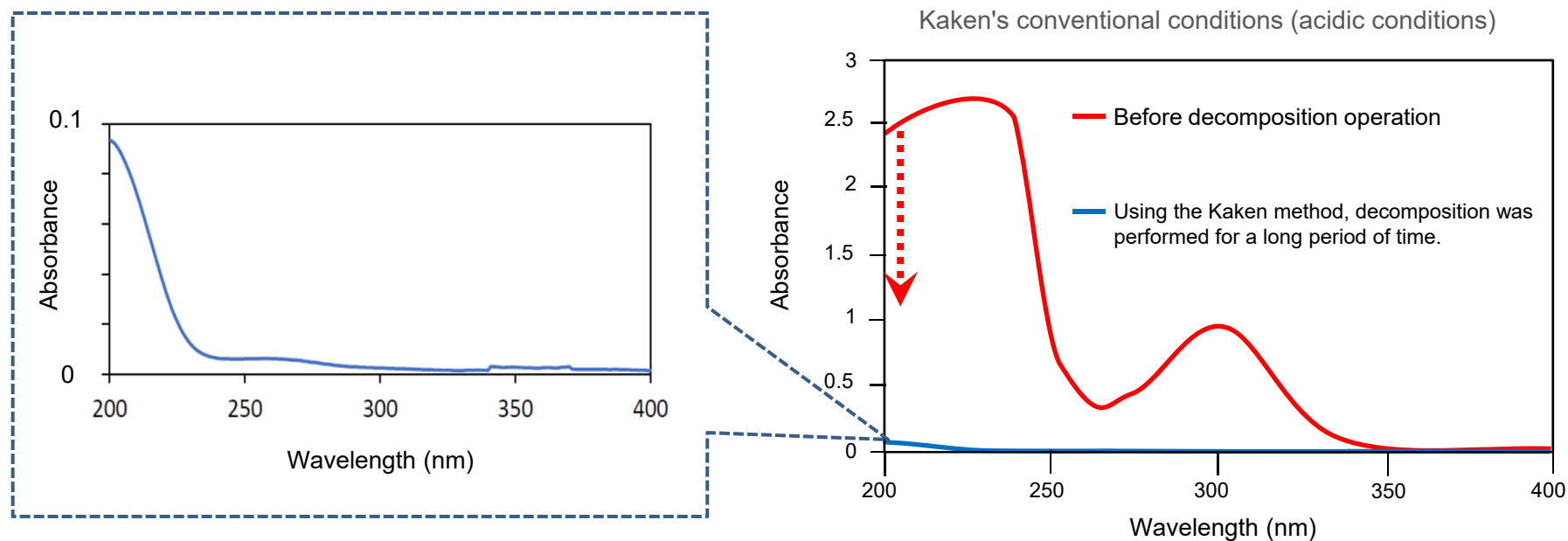


- The absorbance of the actual specimen was checked, and it was < 0.1 at around 200 nm.
- OBT was detected, although KEEA's determination criteria for completion of organic decomposition were satisfied.
- If there is a clear ultraviolet absorption peak even when the absorbance is < 0.1 , it is determined to be necessary to perform the process of eliminating impurities again.



C-2. Absorbance data (Kaken Co., Ltd.)

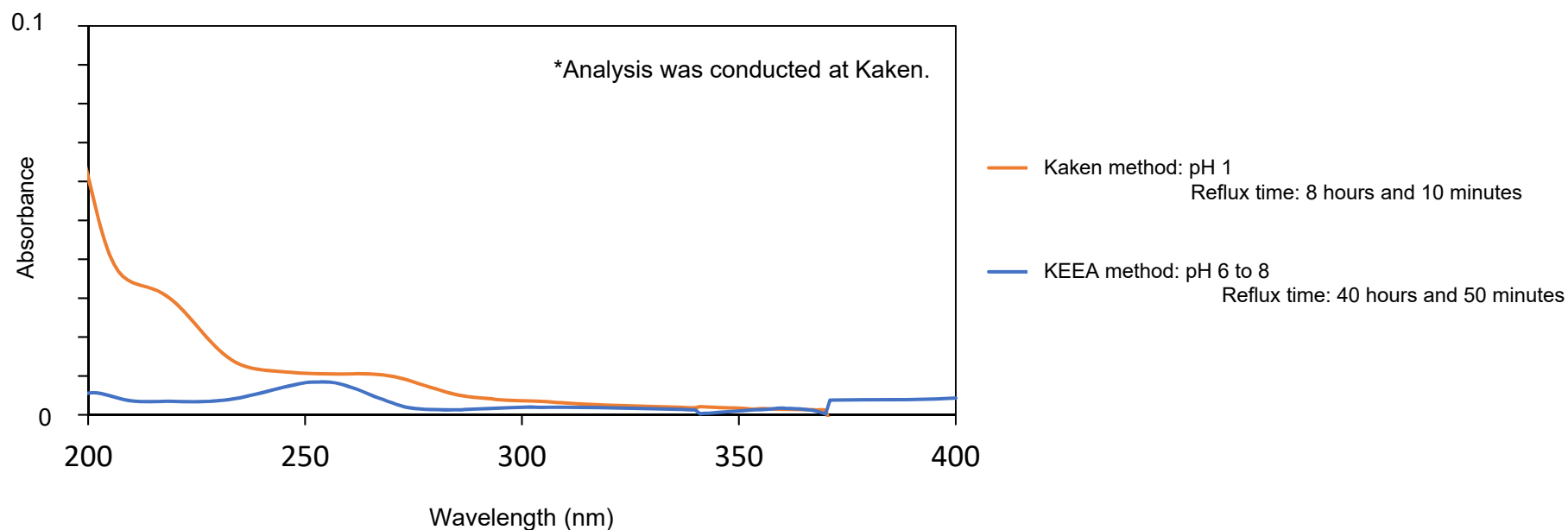
- Decomposition of organic substances was carried out using the Kaken method, which took longer than usual.
- Ultraviolet absorption peak was observed at around 200 nm.
The effect of prolonging the time for decomposing organic matter is small.
- OBT was detected in this specimen.
Even if the absorbance is < 0.1 , when there is a clear ultraviolet absorption peak, reprocessing is required.



Resolving time: 42 hours and 50 minutes in total (normal: 6 to 8 hours)

C-3. Absorbance data (Kaken Co., Ltd.)

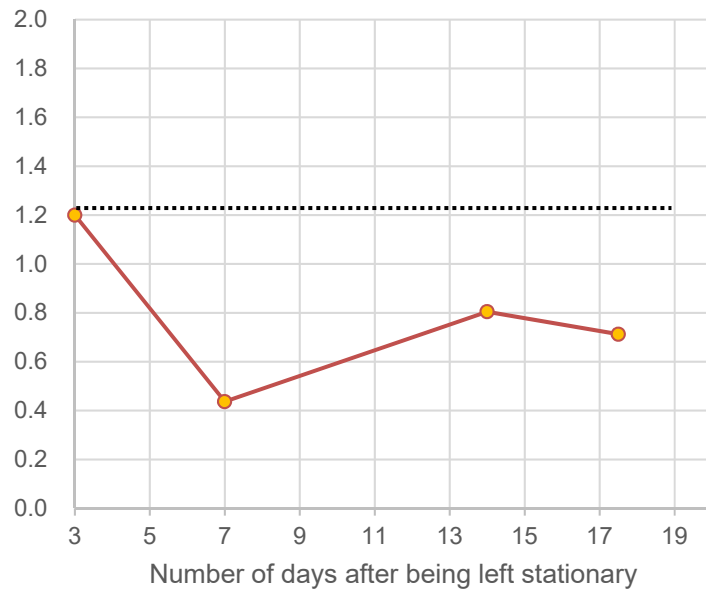
- The absorbance obtained using the Kaken method was compared with the absorbance obtained using the KEEA method.
- Absorbance criteria: < 0.1 (200 nm)
Kaken method: 0.056, KEEA method: < 0.01
- Conductivity criteria: 10 $\mu\text{S}/\text{cm}$
Kaken method: 9.57 $\mu\text{S}/\text{cm}$, KEEA method: 6.21 $\mu\text{S}/\text{cm}$
- In both methods, OBT was not detected, and it was confirmed that the absorbance decreased with the length of the reflux time. Therefore, it was determined that sufficient reflux operation (decomposition of organic matter) was effective in reducing the absorbance.



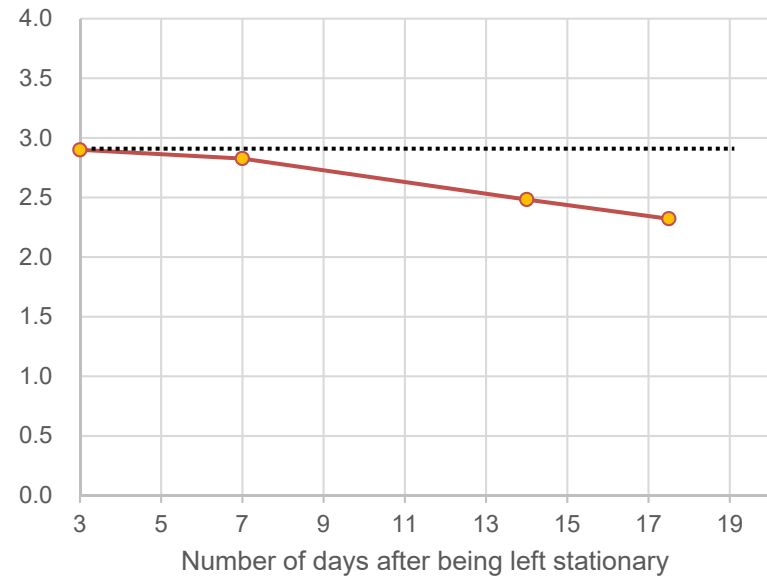
D-1. Elapsed data (1F on-site analytical facility)

- Measurement over time was carried out on the measured specimen containers in which OBT had been detected at the 1F on-site analysis facility.
- Some specimens show a decrease in concentration over time, while others do not.
- Since the chemiluminescence (measured concentration) decayed (decreased) over time, it is presumed that the activity of organic substances decayed due to the deactivation over time.
- On the other hand, as for the specimen (slide 30) that showed no decay over time, it was assumed that this was not due to the effect of chemiluminescence. (It is assumed that it was caused by pretreatment conditions and the analytical environment.)

Bq/L(OBT) May 17 sample (T-B1 location) Bq/L(OBT)

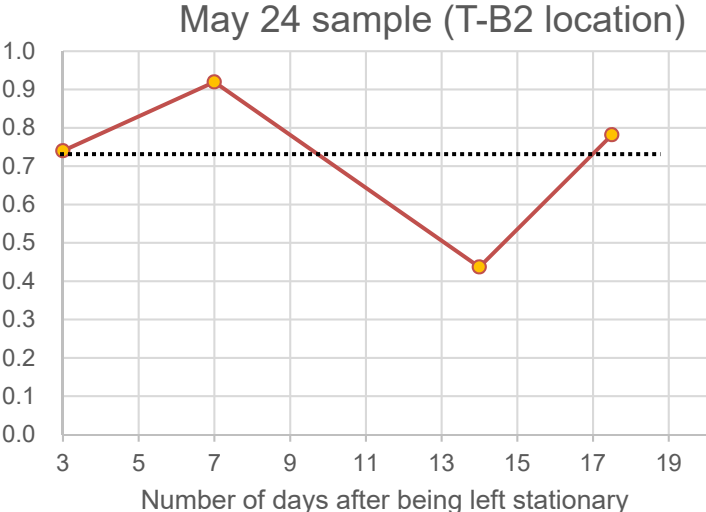


May 17 sample (T-B2 location)

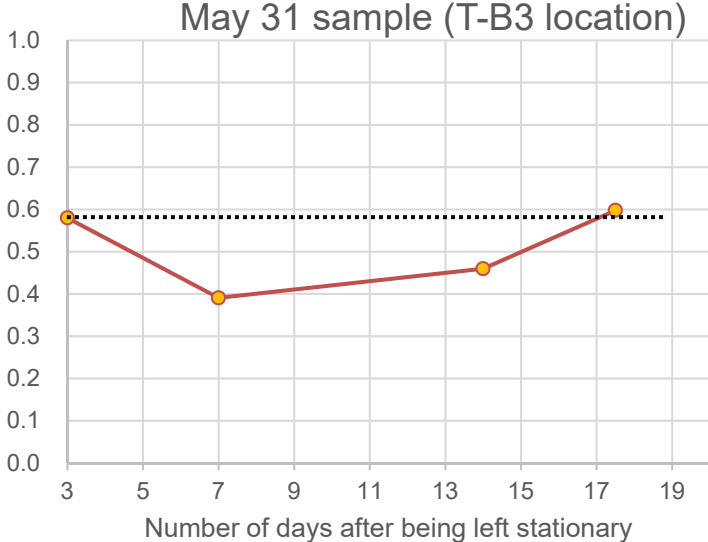


D-2. Elapsed data (1F on-site analytical facility)

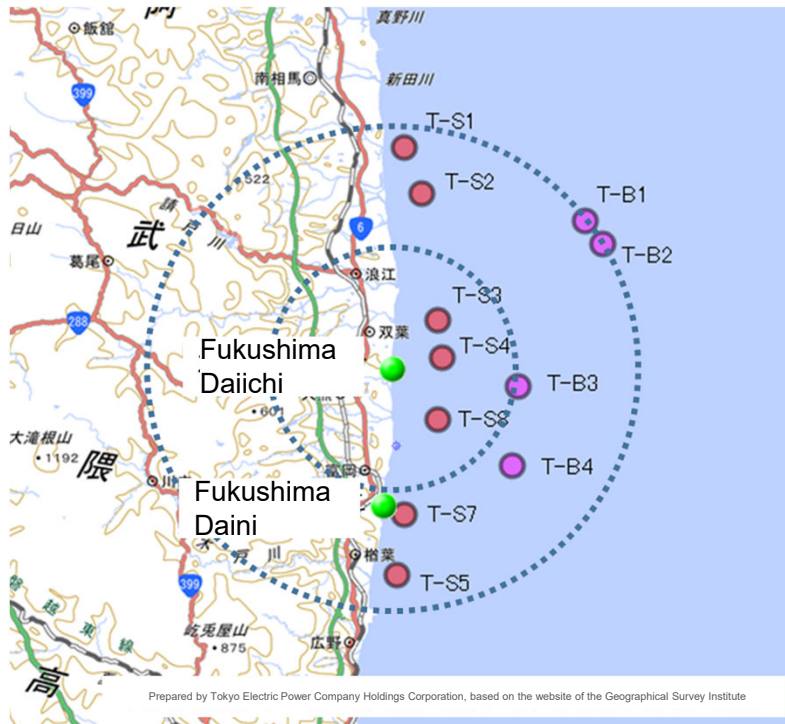
Bq/L(OBT)



Bq/L(OBT)

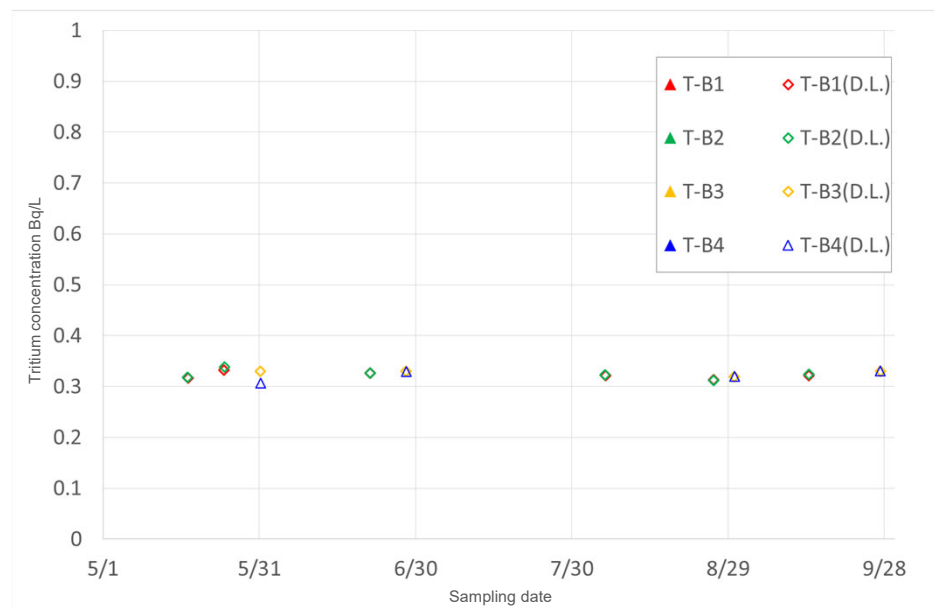
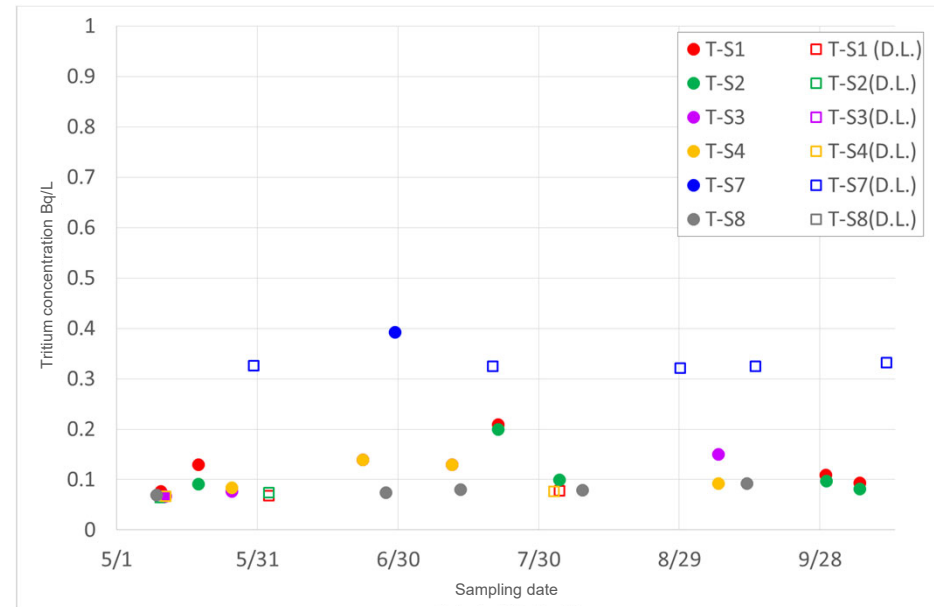


[Reference] Change in tritium concentration at fish sampling sites (surface seawater)

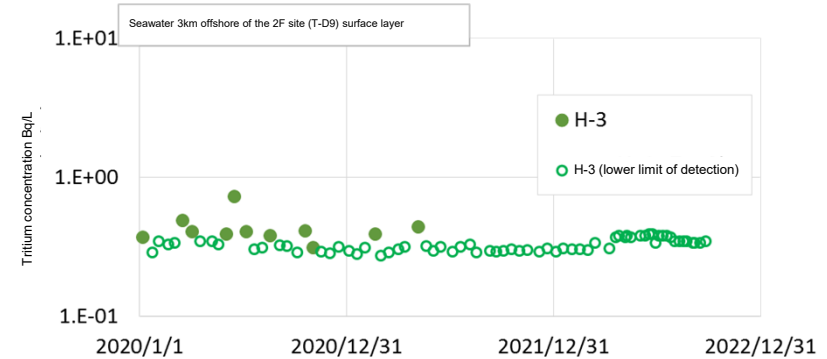
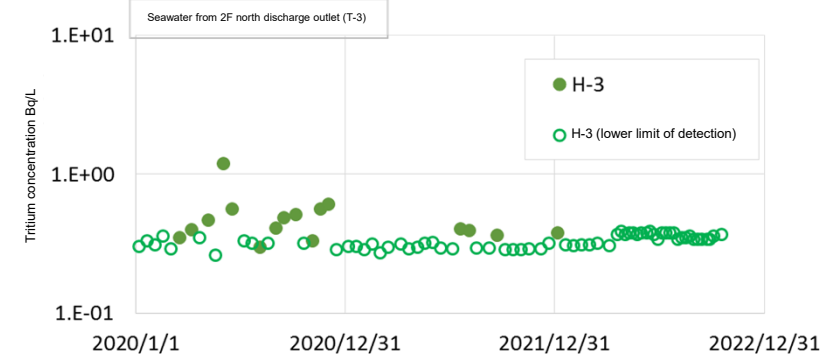
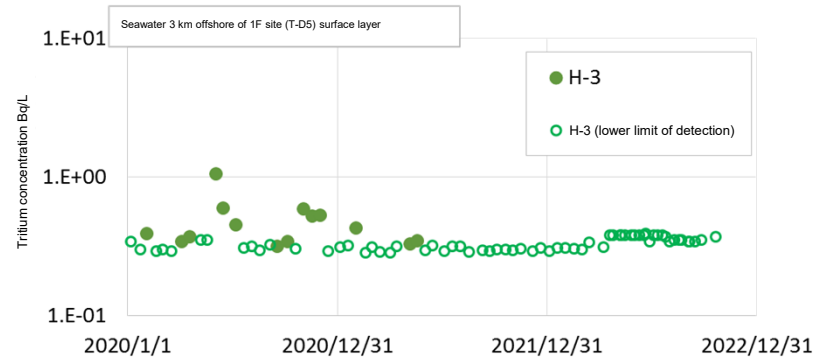
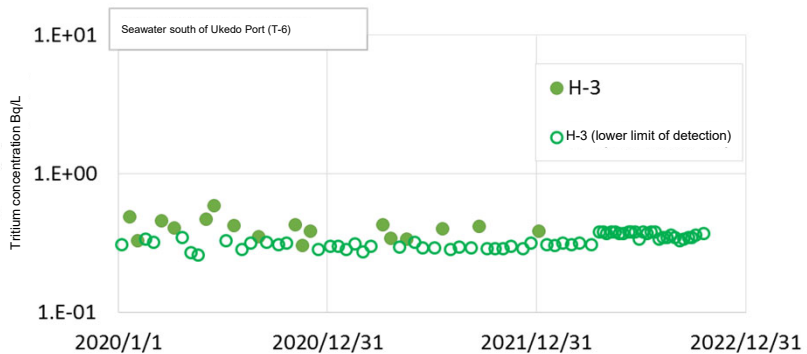
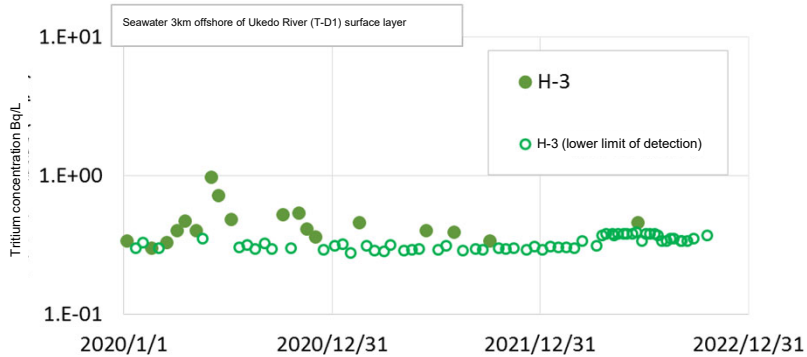
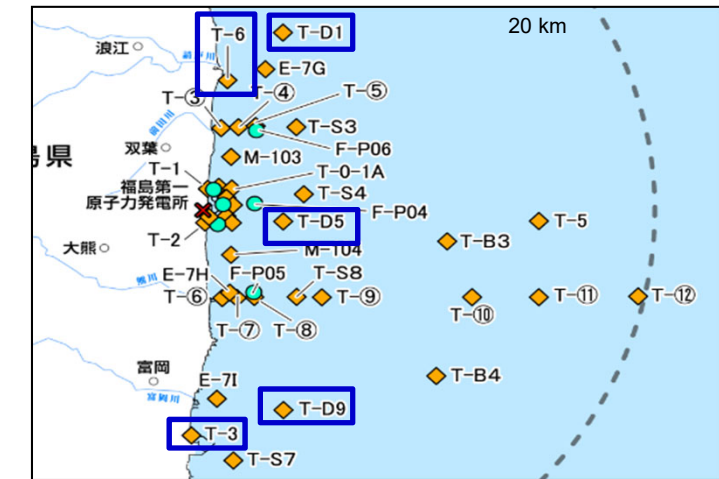


Fish sampling survey location map

- Measurement of tritium concentration at fish sampling sites started simultaneously with enhanced monitoring.
- The lower limit of measurement differs depending on the presence or absence of electrolytic concentration.
- No more than 0.5 Bq/L was observed.



[Reference] Changes in tritium concentrations at sites other than monitoring sites



There were no changes in the surrounding sea area, and no environmental changes affecting tritium concentrations in fish were observed.

[Reference] Atmospheric tritium concentration of 1F on-site analytical facility

- Measured tritium in condensed water using dehumidifier
- Tritium in the 1F on-site analysis facility is higher than KEEA: ND (0.4 Bq/L) to 1 Bq/L, Kaken: about 0.7 Bq/L.

No.	Collection area		Details of analysis work for tritium in fish	Measured result (Bq/L)	Remarks
[1]	Pretreatment area	Agricultural, Livestock and Seafood Pretreatment Office	<ul style="list-style-type: none"> • Fish handling work • Lyophilization • Organic decomposition 	3.6	Collection date: Oct. 8–Oct. 9 Preprocessing: Oct. 11 Measured: Oct. 12
[2]		Soil sample pretreatment room	<ul style="list-style-type: none"> • Combustion 	3.3	Collection date: Oct. 7–Oct. 8 Preprocessing: Oct. 8 Measured: Oct. 9
[3]		Sample analysis room 1	<ul style="list-style-type: none"> • Distillation (FWT and OBT) • Absorbance measurement 	2.9	Collection date: Oct. 9–Oct. 10 Preprocessing: Oct. 11 Measured: Oct. 12
[4]		Sample analysis room 2	<ul style="list-style-type: none"> • Filtration 	4.3	Collection date: Oct. 5–Oct. 7 Preprocessing: Oct. 8 Measured: Oct. 9
[5]	Measurement area	Measurement Room 1	(no work)	5.3	Collection date: Oct. 10–Oct. 11 Preprocessing: Oct. 11 Measured: Oct. 12
[6]		Measurement Room 2	<ul style="list-style-type: none"> • Stationary in a cool, dark place • LSC measurement 	2.8	Collection date: Oct. 11–Oct. 12 Preprocessing: Oct. 12 Measured: Oct. 13
Reference	Surrounding environment		-	-	Okuma Town: to 4.2 Bq/L - Water Futaba Town: to 2.5 Bq/L -Water

[Reference] Atmospheric tritium concentration of 1F on-site analytical facility (sample collection area)



: ALPS treated water handling area
 : Pretreatment area
 : Measurement area

The Japanese version shall prevail.

[Reference] Data from all three parties

- Originally, analysis results from TEPCO (1F on-site analysis facility) and Kaken showed higher concentrations of tritium than in the surrounding seawater. (Chart 1 in red)
- Analysis results from the KEEA were approximately the same as they have always been (OBT concentrations were below detectable levels). (Chart 2)
- After employing the same methodology as the KEEA, OBT levels measured by Kaken also dropped to below detectable levels. (chart 3)

Chart 1 Data confirmed after the start of the analysis by TEPCO and Kaken

Sampling location	Sampling date	Fish type	Concentrations in surrounding sea water (Bq/L)	Free water tritium (Bq/L)	Organically bound tritium (Bq/L)	Analysis location
T-B1	May 17	Flounder	ND(0.33)	0.48	1.2	TEPCO
T-B1	June 21	Flounder	ND(0.33)	ND(0.23)	0.40	TEPCO
T-B2	May 17	Slime flounder	ND(0.32)	0.58	2.9	TEPCO
T-B2	May 24	Flounder	ND(0.34)	0.45	0.74	TEPCO
T-B2	June 21	Marbled sole	ND(0.33)	ND(0.23)	—※1	TEPCO
T-B3	May 31	Flounder	ND(0.33)	0.45	0.58	TEPCO
T-B4	May 31	Flounder	ND(0.33)	0.42	0.87	TEPCO
T-S1	May 11	Flounder	0.077	0.11	0.63	Kaken
T-S2	May 11	Flounder	ND(0.065)	ND	0.96	Kaken
T-S3	May 12	Flounder	0.067	0.11	0.94	Kaken
T-S4	May 12	Flounder	ND(0.067)	0.053	0.52	Kaken
T-S7	May 31	Flounder	ND(0.33)	0.36	0.68	TEPCO

※ KEEA analysis results were the same as always showing that the concentration of tritium in fish was the same, or lower, as the surrounding seawater

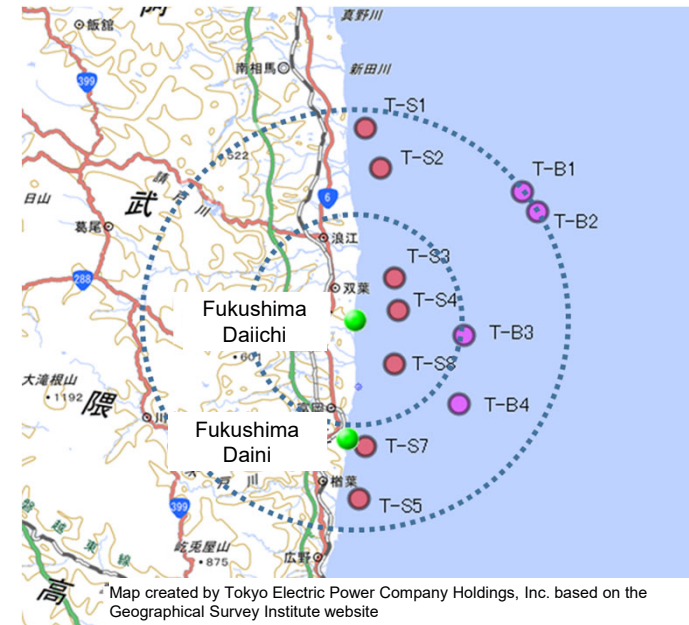
※1 No measurements could be performed due to a lack of specimens

Chart 2 KEEA data

Sampling location	Sampling date	Fish type	Concentrations in surrounding sea water (Bq/L)	Free water tritium (Bq/L)	Organically bound tritium (Bq/L)	Analysis location
T-S8	May 10	Flounder	0.070	0.057	ND(0.27)	KEEA
T-S8	June 28	Flounder	0.075	0.075	ND(0.27)	KEEA

Chart 3 Kaken data (After recommending analysis)

Sampling location	Sampling date	Fish type	Concentrations in surrounding sea water (Bq/L)	Free water tritium (Bq/L)	Organically bound tritium (Bq/L)	Analysis location
T-S1	June 3	Flounder	ND(0.068)	0.15	Analysis underway	Kaken
T-S2	June 3	Flounder	ND(0.074)	0.12	ND(0.39)	Kaken
T-S3	June 23	Flounder	0.14	0.12	Analysis underway	Kaken
T-S4	June 23	Flounder	0.14	0.13	ND(0.27)	Kaken
			0.11	0.15	ND(0.28)	Kaken



Fish sampling point map

-
- Disclosure of analytical values assessed excessively
 - Validity of other analytical values

[Reference] Disclosure of analytical values assessed excessively

[Preparation of analysis procedure]

- Since this is the first time that TEPCO has been engaged in the analysis of tritium in fish, in December 2020, the company formulated an analytical method based on the one presented in the Radioactivity Determination Series beginning in FY 2020 (official method: "Radioactivity Determination Series 9 Tritium Analysis Method, revised in 2002" by the Ministry of Education, Culture, Sports, Science and Technology) taking into account the situation at 1F on-site analytical facilities.
- Then, the tritium source ($2.6 \text{ Bq} \doteq 1.23 \text{ Bq/L}$) was injected into the edible part of the fish, and the result of analysis according to the established analysis method was confirmed to be the expected analytical value (about 1.35 Bq/L), and the validity was verified. After that, we created the Procedure Manual to ensure the competence of the analysts through six test-analyses using fish specimens without the addition of radiation sources.
- Like TEPCO, Kaken also prepared an analytical procedure based on the official method.

[Implementation of analysis based on procedures and disclosure]

- Since May of this year, TEPCO and Kaken have started analysis of tritium in fish conducted by the analysts who conducted the tests in accordance with the established analytical procedures.
- After the analysis, it was confirmed that the analysis was performed in accordance with the analysis procedure, and it was determined that there were no issues with quality control.
- Next, through a comparison, we confirmed that the analytical values obtained by TEPCO were not significantly different from the analytical values obtained by Kaken. We determined both analytical values to be definite values, and proceeded with the following disclosure procedures.
- Analytical values have been released sequentially since August 1 under the framework of the "Full Disclosure of Radiation Data," which discloses all the radiation data measured at the Fukushima Daiichi NPS.

[Understanding the problem]

- On August 16, it was confirmed that the concentration of tritium in this analyzed value was higher than that of tritium in the surrounding seawater. Based on this finding, we thought that there might have been some problem with the analysis, and on August 18, we started to investigate the cause of this problem by annotating the publicly available data*.

* "As a result of comparing to the past monitoring data, a discrepancy was found, and the circumstances are under investigation," was added to the remarks.

[Reference] Disclosure of analytical values assessed excessively

[Investigation of the cause]

- As a result of comparing the analytical procedures of TEPCO and Kaken with those of KEEA, which has an extensive track record of analyses of tritium in fish, it was found that there were insufficiencies in the removal of impurities necessary to measure a small amount of tritium and in the length of the stationary time. For these reasons, the pseudoluminescence could not be sufficiently reduced, and the resulting analytical value was high.
- When determining the analytical values, we confirmed the correctness of the procedure and compared them with the analytical values of Kaken, but did not compare them with tritium concentrations in surrounding seawater or with past trends (the analytical values of KEEA).
- As a background factor, the amount of tritium added to the fish (1.23 Bq/L) when preparing the analysis procedure was slightly higher than the environmental sample level (< 1 Bq/L), so there was a lack of awareness of the factors that affect the accuracy of the analysis at the environmental sample level.
- We are currently continuing to investigate the possibility that the cause is attributable to environmental factors at the 1F onsite analysis facility.

[Measures to prevent recurrence]

- In determining analytical values, in addition to confirming accuracy in the procedures, we will clarify the rules to ensure that comparisons with similar points (including analytical values of the other institutions) and previous trends will be carried out to determine values.
- When conducting a new analyses, in addition to preparing analysis procedures in accordance with official methods, etc., we will prepare analysis procedures in a variety of ways, such as referring to the analysis procedures of other organizations that have a track record of analysis, receiving expert reviews, and carefully verifying the analysis procedures according to the subject of analysis.

[Reference] Validity of other analytical values

- Unlike other analytical specimens, tritium analysis of fish specimens is performed at extremely low concentrations. Furthermore, unlike other specimens, the analysis process involves complicated processes such as combustion work.
- The on-site analytical facility for tritium analysis of seawater has acquired the ISO/IEC _ 17025 certification. We also participate in the skills tests* provided by the IAEA every year and have received favorable results.
- As for γ -ray emitting nuclides, we have acquired the ISO/IEC _ 17025 certification for cesium analysis, and we believe there are no issues with the analytical values.
- For other analyses, we have introduced a proven analytical method that has been developed at JAEA to confirm the radioactivity concentration of plant waste and research facility waste. Each analysis method has been introduced by conducting verification tests using standard sources, etc., as well as examining sites.
- Based on these, we believe that the analytical values other than those for tritium in fish specimen are valid.



*Proficiency Test: An IAEA test that uses specimens with added radiation sources

Certified for:

Radionuclides in public waters, wastewater, soil, ash and sludge
(including Cs134/Cs137 and H-3)

The Japanese version shall prevail.