

Fukushima Daiichi Nuclear Power Station Status of Progress of the Marine Organisms Rearing Test



April 27, 2023

Tokyo Electric Power Company Holdings, Inc

1. Report on the marine organisms rearing test (as of April 2023) (1/5)



State of marine organisms

- No flounders have died or have experience abnormalities since February 11, in both series of tanks of normal seawater and tanks of ALPS treated water diluted with seawater. Current survival rate※¹ continues to be high at over 90% (Survival rate for tanks of normal seawater: 99%; Survival rate for tanks of ALPS treated water diluted with seawater: 99%)(as of April 22).
- Since this test began on October 25, the survival rate for abalone has been approximately 80% (Survival rate for tanks of normal seawater: 81%; Survival rate for tanks of ALPS treated water diluted with seawater: 75%)(as of April 22).
 - Experts have advised us that the cause of death of abalones since the testing began is injures during transport or daily cleaning, not from disease due to the facts that the internal organs had not bloated and portions of the mantle had been damaged. It is therefore assumed that injures can be attributed to the high population density of abalone in captivity and contact during tank cleaning, so improvements were made.
 - As abalones continued to die after improvements were made, experts were again consulted and further advice pertaining to abalone growth was received. Based on this advice, we have increased the amount of food and frequency of feeding to abalone, and also implemented countermeasures to ensure that the food gets spread out throughout the entire tank.

Size of flounder at the start of the test: Weight $36\pm 12\text{g}$; length: $15.9\pm 1.8\text{cm}$

Size of abalone at the start of the test: Weight $27\pm 4\text{g}$; shell length: $5.8\pm 0.3\text{cm}$

Tank series	Classification	Number of marine organisms in each tank (as of April 20, 2023)		
		Flounder	Abalone	Seaweed
Series 1	Normal seawater (around 0.1~1 Bq/L)	120	126	-
Series 2	Normal seawater (around 0.1~1 Bq/L)	125	130	-
Series 3	Less than 1500Bq/L※ ²	148	136	-
Series 4	Less than 1500Bq/L※ ²	149	123	-
Series 5	Around 30Bq/L※ ³	10	-	-

※¹ Survival rate has been calculated after excluding the number of specimens removed for investigations or other testing.

※² Measurement as of the end of March: approx. 1235Bq/L (no large change from the last measurement taken)

※³ Measurement as of the end of March: approx. 34Bq/L (no large change from the last measurement taken)

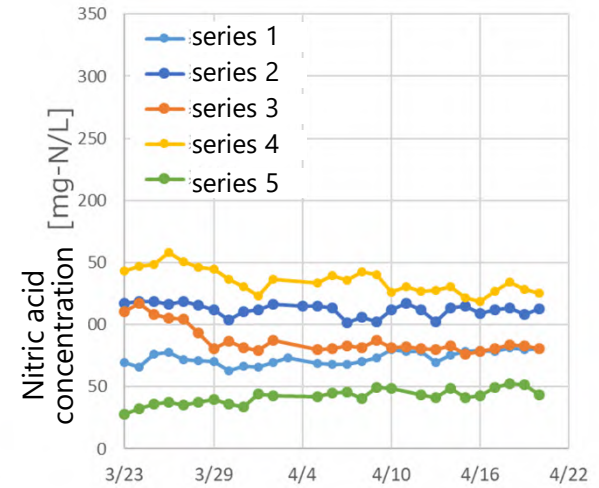
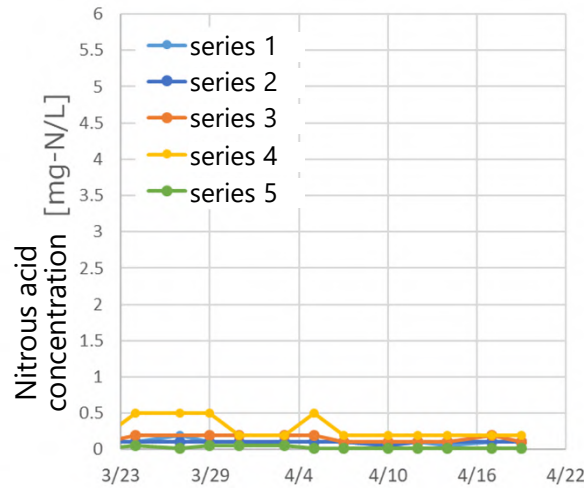
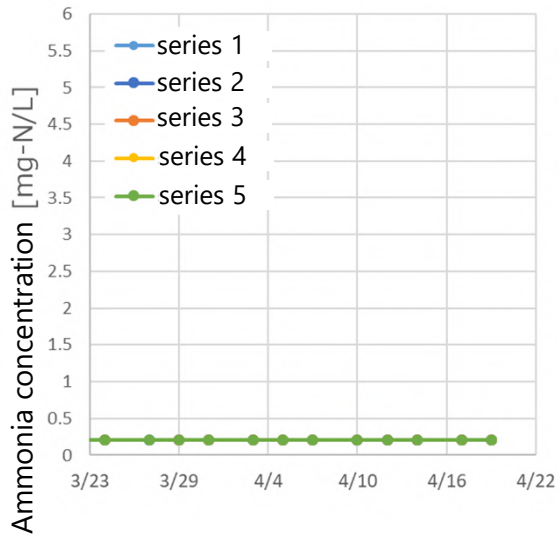
1. Report on the marine organisms rearing test (as of April 2023) (2/5)



Water quality in the rearing tanks

- While there have been some fluctuations in figures, water quality has been kept generally in the range suited to rearing marine organisms.

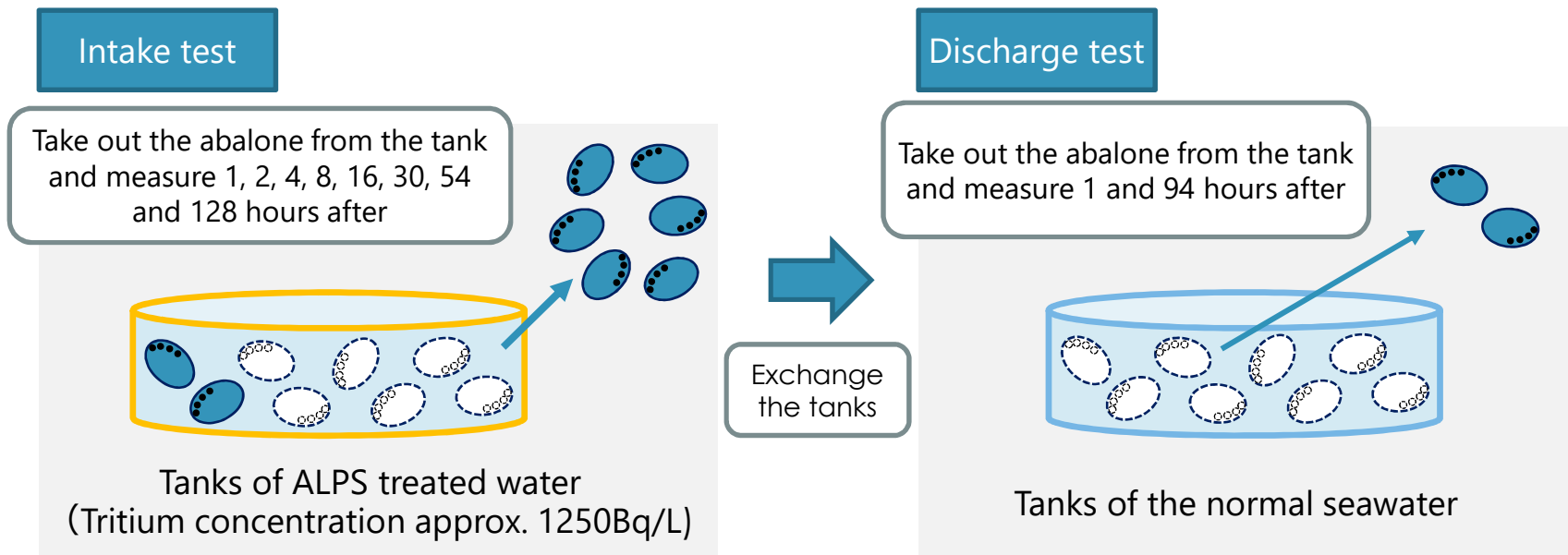
Item	Minimum to maximum in series 1 through 5 (March 23, 2023 to April 20, 2023)	Explanation for the measurement values
Water temperature (°C)	17.2~18.7	Kept around 18.0°C
Ammonia (mg-N/L)	0.2	Generally kept below 0.5mg-N/L, in a range that doesn't impact most marine organisms
Nitrous acid (mg-N/L)	0.01~0.5	Generally kept below 0.5mg-N/L, in a range that doesn't impact most marine organisms
Nitric acid (mg-N/L)	28~158	Since heaters were installed and carbon sources were re-added on March 8 to 10, a gradual increase has been changed to flat to decreasing



1. Report on the marine organisms rearing test (as of April 2023) (3/5)

Measurement of tritium concentrations in abalone (tritium concentration of less than 1500Bq/L)

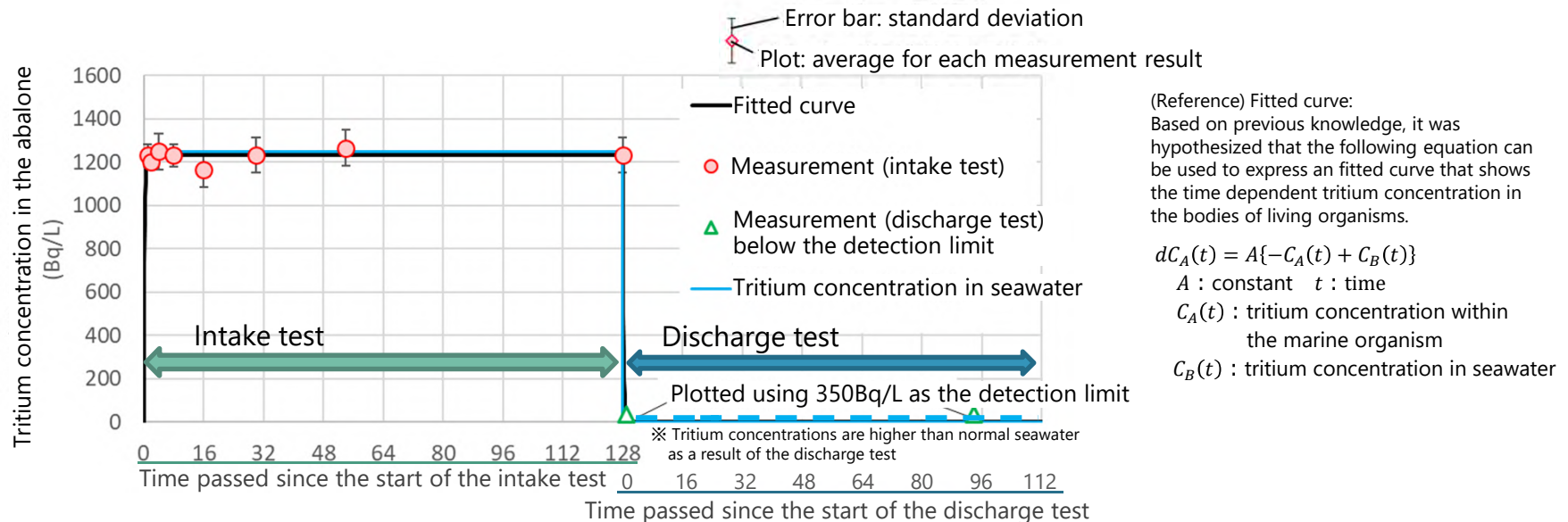
- We have obtained the tritium concentration measurement results for abalone reared in ALPS treated water diluted with seawater (less than 1,500Bq/L) since October 26, 2022.
 - The number of abalones used for measurements: 48 for intake test, 12 for discharge test
- In order to demonstrate that the tritium concentration in the abalones does not exceed the tritium concentration of the environment where they are living after a certain period of time during which the abalones ingest the tritium, an *intake test* was conducted by measuring the tritium concentration of the abalones 1, 2, 4, 8, 16, 30, 54 and 128 hours after the abalones were put in the tanks of ALPS treated water.
- Subsequently, in order to demonstrate that the tritium concentration in the abalones decreases as the abalones excrete the tritium after moving the abalones from tanks of ALPS treated water to the tanks of normal seawater, a *discharge test* was conducted by measuring the tritium concentration of the abalones 1 and 94 hours after the abalones were moved.



1. Report on the marine organisms rearing test (as of April 2023) (4/5)

Results and insights of tritium concentrations in abalone (tritium concentration of less than 1500Bq/L)

- In both tests, changes were seen in tritium concentrations over time. The relationship between the fitted curve from this data drawn based on the comparison with the fitted curve drawn based on previous knowledge, and the measurement values is as follows:



- Referring the data from the graph above, we have been able to observe the following, which are consistent with previous knowledge and tritium concentration measurements for flounders (tritium concentration: less than 1500Bq/L).

【Intake test】

- The tritium concentration in the organisms does not exceed the tritium concentration in the environment where the organisms are living (for this test, this means that the tritium concentration in the organisms does not exceed the tritium concentration in ALPS treated water diluted with seawater)
- Tritium concentrations reach equilibrium after a certain period of time

【Discharge test】

- The tritium concentration in the abalones decreases over time when the abalones, the tritium concentration has reached equilibrium in higher than that of normal seawater, are returned to normal seawater.

1. Report on the marine organisms rearing test (as of April 2023) (5/5)

Rearing schedule

- Seaweed: The date of starting the rearing test will be announced as soon as it is determined.

Schedule going forward

- Measurements of tritium concentration in flounder reared in ALPS treated water diluted with seawater (30Bq/L) from November to December 2022 【additional rearing test】

【Reference】

Fukushima Daiichi Nuclear Power Station Start of Marine Organisms Rearing Tests
(September 29, 2022 Excerpts from documents)

What We Hope to Prove with the Rearing Test (1/2)

- ① In order to alleviate people's concerns and to cultivate peace of mind, we will rear marine organisms in tanks of seawater containing ALPS treated water and compare them with organism reared in normal seawater and report the results carefully in an easy-to-understand manner.

To be confirmed in the test

- Marine organisms rearing tests will be conducted both in seawater and in ALPS treated water diluted with seawater. The marine organisms in these two environments will be compared via rearing data to confirm there are no significant differences between the two populations.

Information disclosure policy

- For ①, we will provide a live stream of the rearing tank and write about how the rearing test is going on in the observation diary on our website and on Japanese Twitter. The rearing environment (e.g., water quality, temperature of the water), state of organisms (e.g., changes in the number of organisms), analysis results (e.g., comparisons of the tritium concentration in the live organisms and in seawater) of the marine organisms reared in ALPS treated water diluted with seawater and organisms reared in normal seawater will be summarized and disclosed every month.
- In addition to having people from the local community and parties concerned visit the test site, we will also have biology experts check on the test as it is ongoing.



◀ Live stream of the seawater rearing test (for illustration purposes only)

- The normal seawater is in the blue tanks and the ALPS treated water diluted with seawater is in the yellow tanks.
- The layout of the tanks will be changed as needed based on feedback from relevant parties to ensure optimal visibility.

【Reference】

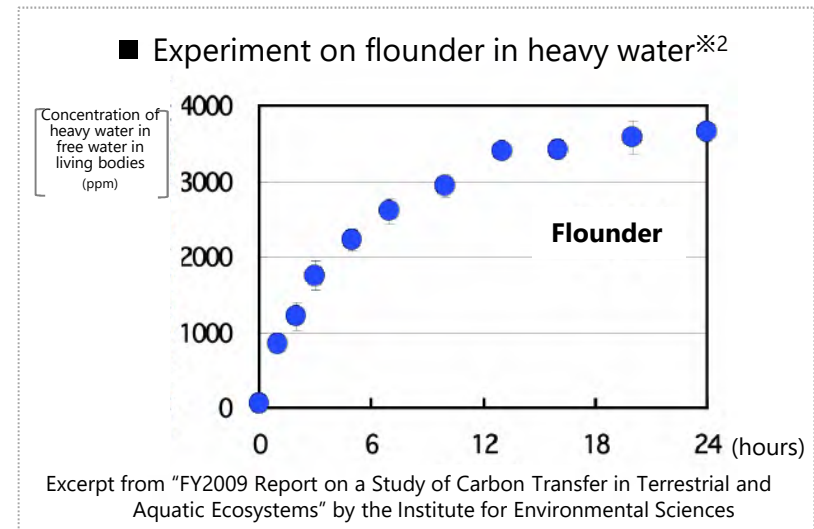
Fukushima Daiichi Nuclear Power Station Start of Marine Organisms Rearing Tests
(September 29, 2022 Excerpts from documents)

What We Hope to Prove with the Rearing Test (2/2)

- ② Based on the results of many studies domestic and abroad on the behavior of tritium, data for this test will first be gathered for 6 months to show that "tritium is not concentrated in the living bodies and that the concentration of tritium in living bodies does not exceed that of the rearing environment" as demonstrated in past tests results.

Results of experiments domestic and abroad

- The tritium concentration in a living bodies does not exceed that of the environment which it was reared in.
- The tritium concentration reached an equilibrium after a certain period of time.
 - ※1 Tritium in living bodies is either free water tritium (FWT) or organically bound tritium (OBT). Studies have been conducted domestically and abroad for both.
 - ※2 This experiment was conducted using heavy hydrogen (H-2) which has the same properties as tritium (H3) (The heavy hydrogen concentration in seawater is about 4000 ppm.)
 - Free water tritium (FWT): Tritium that exists in the form of water in living bodies
 - Organically bound tritium (OBT): Tritium that is organically bound with carbon and other molecules in living bodies



To be confirmed in the rearing test

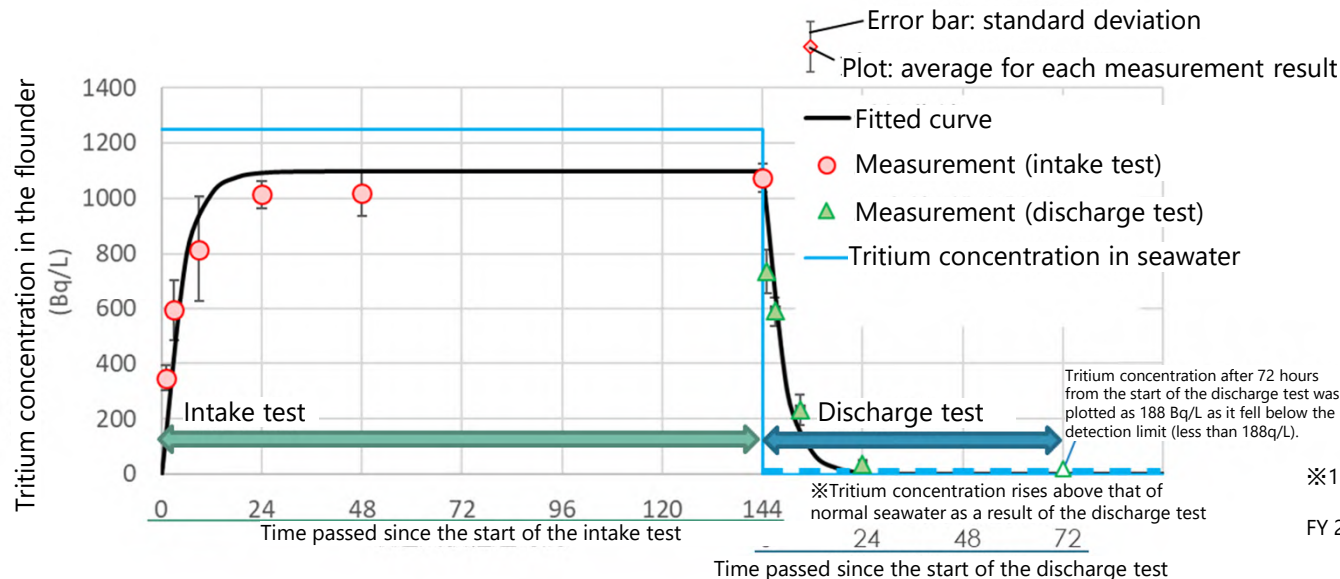
- The tritium levels in the flounder, abalone and seaweed reared in the ALPS treated water diluted with seawater (tritium concentration of approx. 1500 Bq/L) will be analyzed and assessed* to confirm that tritium levels will reach equilibrium after a certain amount of time, and that the tritium concentration at equilibrium doesn't exceed that of the rearing environment.
 - It will also be confirmed that the tritium levels of marine organisms that have reached the tritium equilibrium will fall once they are moved to seawater only tanks .
- ※3 OBT data will be collected over 6 months and assessed for conformity with past data to confirm that OBT levels do not exceed that of the rearing environment.

[Reference] Report on the marine organisms rearing test (as of December 2022) (Excerpts)

110th meeting of the Secretariat of the Team for Countermeasures for Decommissioning, Contaminated Water and Treated Water Fukushima Daiichi Nuclear Power Station Start of Marine Organisms Rearing Tests (December 22, 2022 Excerpts from documents)

Results of tritium concentrations in flounder (tritium concentration of less than 1500Bq/L) and insights

- Tritium concentrations changed with time in both intake and discharge tests. The relationship between the measurement values and the fitted curve for the data drawn based on the approach to fitted curve developed based on past data is as follows.



※ In graphing the measurements, points below the detection limit and suspected adulteration were removed

(Reference) On the fitted curve: Based on previous findings, the changes in tritium concentration within marine organisms were represented by the following formula.

$$dC_A(t) = A\{-C_A(t) + C_B(t)\}$$

A : constant t : time
 $C_A(t)$: tritium concentration within the marine organism
 $C_B(t)$: tritium concentration in seawater

※1 Similar analysis results have been reported in the following literature in the past.
 FY 2009 Experimental Study on Carbon Transfer in Land and Aquatic Ecosystems, Research Institute of Environmental Science and Technology

- Referring the data from graph above, the following results are confirmed same as previous findings. ※¹
 - [Intake test]**
 - The tritium concentration in living bodies does not exceed that of the environment which it was reared in (i.e., does not exceed the tritium concentration in ALPS treated water diluted with seawater in this test).
 - The tritium concentration reaches an equilibrium after a certain period of time.
 - [Discharge test]**
 - The tritium concentration in the flounder will be reduced as time passes after the flounder, which has reached equilibrium in higher tritium concentrations than that of normal seawater, is returned to normal seawater.