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Establishment of OBT/TFWT dataset in seafood in Zhejiang province, China

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Objectives: This work aims to establish a dataset of ratios between tissue free water tritium (TFWT) and organically bound tritium (OBT) (containing both exchangeable and non-exchangeable OBT) in different types of seafood from Zhejiang province, China, thus to provide references for rapid screening of potential contamination of tritium in biological samples.

Methods: Five types of seafood (fish, prawn, mussel, crab and kelp) were collected from Jiaxing, Ningbo, Zhoushan, Taizhou and Wenzhou city in Zhejiang Province in 2022, and measured for TFWT and OBT using tube furnace combustion system and liquid scintillation counting.

Results: The observed activity concentrations of TFWT and OBT in this study were within the range of 1.01-10.09 Bq/L and 0.51-7.61 Bq/L, respectively. No significant difference in OBT/TFWT ratio was observed among different types of seafood ($p > 0.05$), among the geographic distribution of the five cities ($p > 0.05$), nor among the area of coastline, fishing ground and island ($p > 0.05$). Additionally, there was no significant difference in the OBT/TFWT ratio between seafood from area with and without nuclear power plant operation ($p > 0.05$). The mean OBT/TFWT ratio of fish, prawn, mussel, crab and kelp was 0.37 ± 0.19, 0.48 ± 0.27, 0.63 ± 0.33, 0.82 ± 0.50, and 0.64 ± 0.37, respectively. The mean and range of OBT/TFWT ratios were 0.59 ± 0.37 and 0.15-2.09 in all seafood collected from the five cities in Zhejiang Province, respectively.

Conclusions: Our results indicate that tritium in seafood from coastal cities in Zhejiang Province is at the background level, and the operation of nuclear power plants in the province has no notable impact on the radioactivity levels of tritium in local marine biota. This study filled the gap in OBT/TFWT ratios in seafood, which provides new dataset for rapid detection of tritium contamination in nuclear emergencies.

KEYWORDS

seafood, OBT, TFWT, ratio, dataset

1 Introduction

Tritium is a radioactive isotope of hydrogen, though not as ubiquitous as regular hydrogen, it can be found in trace amounts in the environment. Naturally occurring tritium is mainly produced by the nuclear reaction of cosmic neutrons with nitrogen-14 in the upper atmosphere (Ifayefunmi et al., 2021; Ferreira et al., 2023). In addition, tritium can also be produced from human activities such as nuclear accidents, nuclear reactor operation and spent fuel reprocessing. Anthropogenic tritium sources contribute more to the environment compared with its natural production, and the operation of nuclear facilities is currently the main source of anthropogenic tritium (Feng et al., 2017; Nie et al., 2021). As tritium is a low-energy (E_{max}=18.6 keV) beta emitter, it is less likely to cause external exposure to humans. However, tritium can still pose internal radiation exposure, if ingested, inhaled, or absorbed into the body (Jaeschke and Bradshaw, 2013; Matsumoto et al., 2021).

Since the Fukushima nuclear accident in 2011, large quantities of radionuclides have been released into the ocean, including tritium (Aoyama et al., 2016; Querfeld et al., 2019). Most radionuclides were transported to the Pacific Ocean, where they were taken up by marine organisms through absorption or the food chain, posing potential risks to human health through seafood consumption (Madigan et al., 2012; Zhao et al., 2021). On August 24, 2023, Japan declared its intention to discharge radioactive contaminated water from the Fukushima nuclear power plant, which was strongly opposed by the public. Given that seafood is a significant component of the diet for residents in Zhejiang Province, monitoring the levels of tritium in seafood is particularly important for ensuring radiological safety and public health.

After spreading into the environment, tritium enters various hydrosphere and biosphere cycles in the form of tritiated water (HTO) due to its extremely high mobility (Ferreira et al., 2023). In organisms, such as plants and marine animals that are exposed to HTO, tritium can undergo various transformations, finally convert into tissue free water tritium (TFWT) and organically bound tritium (OBT) (Eyrolle et al., 2018). The risk of OBT ingestion is higher due to its longer residence time in organisms compared with TFWT, as OBT may even cause genetic damage due to internal exposure, thus has a more severe adverse effects on the human body (Baumgaertner et al., 2009; Jaeschke et al., 2011). Due to the fact that OBT is more difficult to be measured than TFWT, the OBT/TFWT ratio is often used to predict OBT activity concentrations by measuring TFWT in the food chain (Nayak et al., 2021). In addition, the radioactivity levels and ratios of TFWT and OBT in living organisms are considered to be indicators to study the effects of anthropogenic tritium release on ecological status (Feng and Zhuo, 2022). At present, there are few studies on OBT/TFWT ratios in seafood, as the majority of reported OBT/TFWT ratios were targeted for terrestrial vegetation (Akata et al., 2015; Kristof et al., 2017; Renard et al., 2017).

In this study, OBT/TFWT ratios in different seafood were systematically analyzed. We determined activity concentrations of TFWT and OBT in five types of seafood primarily consumed by local residents in five coastal cities in Zhejiang Province to obtain a database of OBT/TFWT ratio and study the radioecological effects of anthropogenic tritium release.

2 Material and methods

2.1 Apparatus and reagents

2.1.1 Experimental apparatus

Apparatus used in this study include vacuum freeze dryer (LABCONCO, 4 L-105°C), moisture analyzer (CYS, Shenzhen Fenxi Instrument Manufacturing Co., Ltd.), grinder (NB-YMY-48A, North and South Instrument Co., Ltd.), element analyzer (Flash Smart, Thermo scientific), tube furnace oxidation system (Pyrolyser-6 Trio, Raddec International Ltd.), Liquid Scintillation Counter (LB7, ALOKA), distillation unit, conductivity meter (DDS-11A, Shanghai INESA Scientific Instrument Co., Ltd.).

2.1.2 Experimental reagents

Reagents used in this study include potassium permanganate (AR, Hangzhou Xiaoshan Chemical Reagent Factory), Pt-Al_2O_3 (containing 0.3% Pt, Raddec International Ltd), liquid scintillation cocktail (Ultima Gold LLT, PerkinElmer), artificial zeolite (particle size 4 mm, Shanghai Yi Hui Biotechnology Co., Ltd.), tritium standard solution (1022 Bq/g, Chinese Academy of Quantitative Sciences).

2.2 Sample collection and pretreatment

In 2022, five monitoring areas were set up in Zhejiang Province, including Jiaxing, Ningbo, Zhoushan, Taizhou and Wenzhou (Figure 1), which included 9 samples from Jiaxing area reported by previously published work (Ma et al., 2024). Each monitoring area extended from the land to the sea, and was divided into I, II and III zones (I zones < 30 km, encompassing the coastline, II zones 30 ~ 100 km, including the island region, III zones > 100 km, encompassing the fishing ground). The coastline monitoring system covered Qinshan Nuclear Power Plant (power output of 6.564 GW) and Sanmen Nuclear Power Plant (power output of 2.50 GW). Five types of dead seafood including fish, prawn, mussel, crab and kelp (more than 3 kg per sample) were purchased from local fishing vessels at five monitoring sites (see Table 1). The weight of samples collected in this work and the corresponding annual consumption rate each food species in Zhejiang province are shown in Supplementary Table S1.

After cleaning the collected sample with water and draining the edible part at room temperature, about 1 kg of fresh sample were crushed and mixed with an electric grinder. 1.5-3 g of the processed sample were measured with a moisture meter to obtain moisture content. The remaining sample was frozen at -5 °C in a freezer and then dried with a vacuum freeze dryer (vacuum pressure is 0.599 mbar). TFWT was extracted after freeze-drying the sample for about 4-5 days. Thereafter, the sample was ground into powder, hydrogen content was determined by an elemental analyzer, and the remainder was canned for OBT analysis.

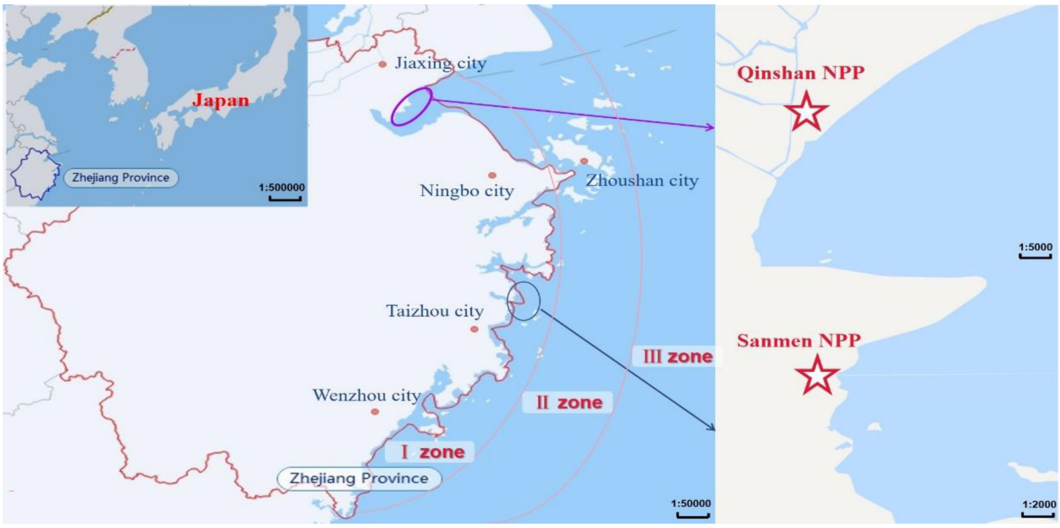

FIGURE 1
Sampling sites of seafood in Zhejiang Province.

2.3 Sample oxidation combustion

In this study, a tubular furnace system was used to collect OBT (containing both exchangeable and non-exchangeable OBT), which has been proved effective in many literatures (Hou, 2005; Warwick et al., 2010; Nayak et al., 2020; Nayak et al., 2021). The tubular combustion furnace was equipped with six working tubes, which were divided into three areas: sample area, intermediate area and catalyst area. The general experimental procedure is described as follows. 6-8g of dry sample was weighed into each of the six sample boats and placed in the sample area of the furnace. When the catalytic zone of the furnace reached 800°C, a pre-weighted tritium

TABLE 1 Sample collection information.

Location	Zone	N	Sample types					Date
			Fish	Prawn	Mussel	Crab	Kelp	
Jiaxing	I	4	Mugil cephalus	Penaeus orientalis	–	Portunus trituberculatus	Unidentified	2022.4.20
	I	5	Pseudobrama simoni	Penaeus orientalis	Sinonovacula constricta	Unidentified	Unidentified	2022.4.20
Ningbo	I	3	–	Penaeus orientalis	Sinonovacula constricta	Portunus trituberculatus	–	2022.6.19
	II	5	Pneumatophorus japonicus	Penaeus orientalis	Elliptio complanata	Portunus trituberculatus	Seaweed	2022.6.19
Zhoushan	II	5	Pangasius hypophthalmus	Penaeus orientalis	Elliptio complanata	Portunus trituberculatus	Laminaria japonica	2022.9.29
	III	5	Ditrema temmincki Bleeker	Penaeus orientalis	Elliptio complanata	Portunus trituberculatus	Laminaria japonica	2022.9.29
Taizhou	I	4	Mugil cephalus	Penaeus orientalis	Sinonovacula constricta	Scylla	–	2022.10.27
	II	5	Miichthys miiuy	Penaeus orientalis	Elliptio complanata	Portunus trituberculatus	Unidentified	2022.10.27
	III	5	Trichiurus lepturus	Penaeus orientalis	Elliptio complanata	Portunus trituberculatus	Unidentified	2022.10.27
Wenzhou	II	5	Lateolabrax japonicus	Penaeus orientalis	Ostreidae	Portunus trituberculatus	Laminaria japonica	2022.6.16
	III	5	Pneumatophorus japonicus	Penaeus orientalis	Sinonovacula constricta	Portunus trituberculatus	Laminaria japonica	2022.6.16

bubbler was connected to the tube furnace oxidation system. The OBT fraction was collected into the bubbler (The bubbler was placed in a cold trap at -110°C), which was weighed again to quantify the mass of OBT fraction (Chen et al., 2022). After weighing, the tritium water from six tritium bubblers were combined together for azeotropic distillation.

2.4 Sample treatment

2.4.1 OBT sample treatment

The obtained OBT fraction (more than 15 mL) from the oxidation combustion was placed in a round-bottomed flask, potassium permanganate was added with a ratio of 0.1 g potassium permanganate to 30 mL of sample. After adding an appropriate amount of zeolite, azeotropic distillation was carried out. The distilled liquid was collected in a condenser. The tritium background sample and the standard sample were prepared using a background water (commercial pure water, used after secondary distillation) and a tritium standard solution, respectively, according to the same method as for a sample (Ministry of Ecology and Environment of the People's Republic of China, 2020).

2.4.2 TFWT sample treatment

The TFWT sample was treated according to our previously developed method (Ren et al., 2023). In general, the TFWT fraction was extracted with a disposable syringe after the freeze-drying, filtered into a beaker with a 0.22 µm filter membrane.

2.5 OBT and TFWT measurements

OBT and TFWT samples with conductivity ≤5 µS/cm were selected for measurement by a liquid scintillation counter (ALOKA). OBT samples were prepared in a 20 mL polyethylene vial at the ratio of 8 mL water to 12 mL Ultima Gold LLT. TFWT samples were prepared in 100 mL polyethylene vial by the ratio of 40 mL water to 60 mL Ultima Gold LLT. OBT samples were counted for 1000 min and TFWT samples were counted for 500 min. The standard was measured to calculate the detection efficiency with the following Equation 1.

$$E = \frac{N_s - N_b}{60 \times D} \quad (1)$$

Where: E is the detection efficiency of the instrument, N_s and N_b are the counting rates of standard and background, respectively; D is the activity of tritium added to the standard, Bq.

The Equation 2 is used to calculate the radioactivity concentrations of OBT and TFWT in each purified fraction, expressed in Bq/L.

$$A_1 = \frac{N_x - N_b}{60 \times V \times E_H} \times 1000 \quad (2)$$

Where: A_1 is the radioactivity concentration of OBT or TFWT, Bq/L; N_x and N_b are the counting rates of OBT or TFWT sample and tritium background, respectively, min^{-1}; V is the volume of OBT or TFWT sample contained in the counting vial, mL; E_H is the detection efficiency of the instrument for OBT or TFWT, %.

Thereby, radioactivity concentrations of OBT and TFWT in the original samples can be calculated according to Equations 3, 4:

$$A_{TFWT} = \frac{(N_{x_1} - N_{b_1}) \times w}{60 \times m_{H_1} \times E_{H_1}} \times 1000 \quad (3)$$

Where: A_{TFWT} is the radioactivity concentration of TFWT, Bq/kg·fresh weight (Bq/kg f.w.); N_{x_1} and N_{b_1} are the counting rates of TFWT sample and background, respectively; w is the moisture content of seafood. m_{H_1} is the mass of the water sample measured for tritium, g; E_{H_1} is the detection efficiency of the instrument for TFWT, %.

$$A_{OBT} = \frac{(N_{x_2} - N_{b_2}) \times m_{OBT} \times (1 - w)}{60 \times m_{H_2} \times E_{H_2} \times Y_H \times M} \times 1000 \quad (4)$$

Where: A_{OBT} is the radioactivity concentration of OBT, Bq/kg·f.w.; N_{x_2} and N_{b_2} are the counting rates of OBT sample and background, respectively; w is the moisture content of seafood. m_{OBT} is the amount of water produced during sample oxidation combustion, g; m_{H_2} is the mass of the water sample measured for tritium, g. Y_H is the recovery of tissue water in organisms by the oxidation combustion device (The combustion recovery was calculated as the weight of water generated in the actual combustion divided by the weight of water according to theoretical calculation based on hydrogen content), %; and M is the mass of the dry sample, g; E_{H_2} is the detection efficiency of the instrument for OBT, %.

2.6 Data analysis

The relevant data of OBT and TFWT were analyzed using SPSS Statistics Data 25 software. When the data met the condition of homogeneity of variance, One-Way ANOVA was selected for analysis, otherwise, Kruskal-Walls H(K) test was used for analysis. Significant difference was defined if the statistics test indicated p -value< 0.05.

3.Results and discussion

3.1 Choice of radioactivity unit

OBT and TFWT radioactivity in biological samples can be expressed in terms of Bq/L or Bq/kg·f.w. Expression in the unit of Bq/L allows for comparison of the ratio of tritium to hydrogen in different matrix parts and even different compartments. Bq/kg·f.w. assesses the relative contribution of tritium to the global transfer of tritium through the food chain to humans (Le Goff et al., 2014). In this study, the average OBT/TFWT ratio for the investigated seafood was 0.59 ± 0.37 when Bq/L was used as the unit for OBT and TFWT. When using Bq/kg·f.w. as the unit, the average OBT/TFWT ratio in seafood was 0.14 ± 0.21. The OBT/TFWT ratio with tritium concentration expressed in Bq/L was significantly higher (p< 0.001) than that in Bq/kg f.w., as shown in Figure 2A. Our study revealed that the moisture content of seafood was the decisive factor for the difference between the two ratios. As can be seen from the linear regression analysis (Figure 2B) that there is a negative correlation between the OBT/TFWT ratio (with tritium in Bq/k.g., f.w.) versus moisture content (R = 0.507, N = 51, p<0.001). The slope (R-value) of the regression line is -0.514 ± 0.479. As OBT/TFWT ratio (Bq/kg·f.w.) is greatly affected by the moisture content, therefore, the tritium radioactivity concentration of all seafood in this study was expressed as Bq/L to calculate the OBT/TFWT ratio.

If the unit Bq/kg·f.w. is used, the conversion between the two needs to take into account the hydrogen content and moisture content of the seafood, as shown in Equation 5, which is transformed from Equations 2-4. Apparently, the OBT/TFWT ratio (Bq/kg·f.w.) is negatively correlated to moisture content, and positively correlated to hydrogen content.

$$\left(\frac{OBT}{TFWT}\right)\left(expressed \ \ in \frac{Bq}{kg} f.w.\right) = 9 \ C_H \times \left(\frac{1}{w} - 1\right) \times \left(\frac{OBT}{TFWT}\right)\left(expressed \ \ in \frac{Bq}{L}\right) \quad (5)$$

Where, C_H is the hydrogen content in the dry seafood, expressed in g/g.

3.2 Radioactivity of OBT and TFWT in five types of seafood

The activity concentrations of OBT and TFWT in seafood collected from Jiaxing, Ningbo, Zhoushan, Taizhou and Wenzhou city of Zhejiang Province are shown in Figure 3. The radioactivity levels of OBT and TFWT were at the same order of magnitude among the five cities, with the activity concentrations of OBT ranging from 0.51 to 7.61 Bq/L and the activity concentrations of TFWT ranging from 1.01 to 10.09 Bq/L. Our results of OBT and TFWT concentrations obtained in this work are comparable to the values reported by Thompson et al (Thompson et al., 2015). and Kim et al (Kim et al., 2018). The tritium levels in the sea area of Zhejiang Province are considered at the background level.

3.3 OBT/TFWT ratio in five types of seafood

The mean and range of OBT/TFWT ratios obtained for seafood investigated in this work are 0.59 ± 0.37 and 0.15-2.09, respectively. The detailed results are summarized in Table 2, some of which cite previously published articles (Ma et al., 2024), showing a range of values similar to those reported in the literature (see Table 3). Although the reactor type, capacity and sample collection area of nuclear power plants in different studies were different, the OBT/TFWT ratio was still at the same level, which may be related to the similar tritium biological uptake process among different species. It also indicated that OBT and TFWT in seafood were relatively stable when nuclear power plants were in normal operation. The mean OBT/TFWT ratio of fish, prawn, mussel, crab and kelp obtained in this work was 0.37 ± 0.19, 0.48 ± 0.27, 0.63 ± 0.33, 0.82 ± 0.50, and 0.64 ± 0.37, respectively. There was no significant difference in OBT/TFWT ratio among these five types of seafood (p = 0.436). The lack of differentiation is likely due to the unclear food chain of the samples we have collected. Moving forward, we plan to gather seafood with well-defined food chains for more comprehensive study and analysis. Since the tritium content of environmental samples is relatively low, the corresponding count rate is close to that of background samples, the uncertainty of the sample count rate using the liquid scintillation counter was relatively high, causing large data fluctuations (Huang et al., 2014).

Since the biological half-life of TFWT is less than that of OBT, it is reasonable to believe that once exposed to high concentrations of tritium water, the concentration of TFWT in organisms will rise rapidly, resulting in a relatively low OBT/TFWT value. With the increase of OBT in organisms and the excretion of TFWT, the OBT/TFWT value will increase in the following period of time. Until the tritium level reaches equilibrium between the organism and the environment, the OBT/TFWT value will gradually decrease and stay at a relatively stable level (Baglan et al., 2011). In this study, the OBT/TFWT values of different types of seafood represent background levels.

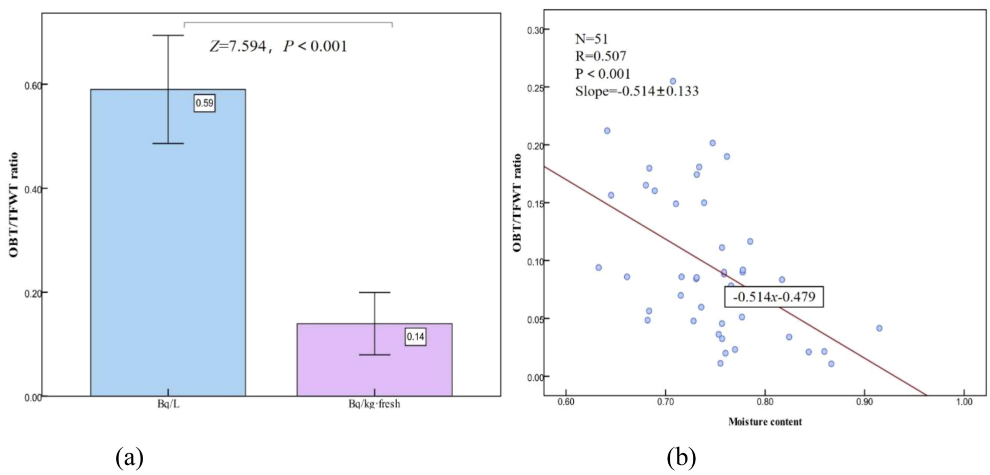

FIGURE 2
(A) Difference in OBT/TFWT ratio of different units **(B)** Correlation between water content and OBT/TFWT ratio (Bq/kg·f.w.).

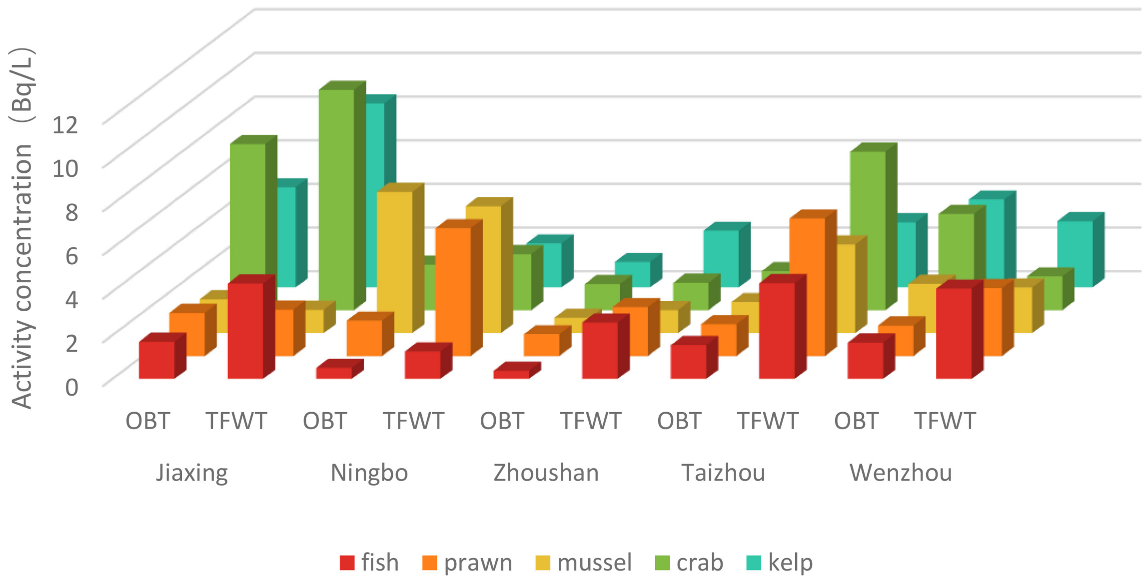

FIGURE 3
OBT and TFWT activity concentrations in five types of seafood collected from five cities in Zhejiang Province.

The dataset of OBT/TFWT ratio established in this study provides a new basis for rapid estimation of the activity concentration of OBT in seafood. The activity concentration of TFWT in seafood can be detected by simple sample processing. With the OBT/TFWT ratio provided in this study, the corresponding OBT concentration can be swiftly estimated.

3.4 Differences in OBT/TFWT ratios in seafood from five cities

The mean ± standard deviation of OBT/TFWT ratio in seafood from Jiaxing, Ningbo, Zhoushan, Taizhou and Wenzhou city was 0.68 ± 0.26, 0.75 ± 0.30, 0.55 ± 0.33, 0.36 ± 0.23, 0.74 ± 0.55, respectively. No statistically significant difference was found in the OBT/TFWT ratio among seafood collected in the five cities (p =0.054). The relevant statistical analysis chart is shown in Supplementary Figure S1.

3.5 Differences in OBT/TFWT ratios in seafood from I, II and III zones

The mean ± standard deviation of the OBT/TFWT ratio in seafood collected from I, II and III zones was 0.60 ± 0.29, 0.62 ± 0.51, 0.54 ± 0.33, respectively. No statistically significant difference was observed for OBT/TFWT ratios among these three zones (by Kruskal-Walls H(K) test at p =0.796). The relevant statistical analysis chart is shown in Supplementary Figure S2.

3.6 Differences in OBT/TFWT ratios between seafood from areas with and without nuclear power plant operation

The operation of nuclear power plants may discharge a certain amount of tritium into the surrounding environment (NRC, 2005), leading to potential increase of tritium concentration in the local

TABLE 2 OBT/TFWT ratio in seafood of Zhejiang Province.

Location	OBT/TFWT ratio, mean ± sd					Range	Mean
	Fish	Prawn	Mussel	Crab	Kelp		
Jiaxing	0.38 ± 0.14	0.92 ± 0.13	0.88	0.68 ± 0.16	0.66 ± 0.37	0.15-2.09	0.59 ± 0.37
Ningbo	0.40	0.47 ± 0.36	1.05 ± 0.10	0.82 ± 0.13	0.89		
Zhoushan	0.14 ± 0.01	0.43 ± 0.04	0.63 ± 0.27	0.95	0.62 ± 0.47		
Taizhou	0.44 ± 0.16	0.27 ± 0.11	0.33 ± 0.13	0.54 ± 0.44	0.17		
Wenzhou	0.46 ± 0.34	0.45 ± 0.14	0.56 ± 0.39	1.25 ± 1.19	0.97 ± 0.01		
Range	0.15-0.70	0.19-1.01	0.18-1.12	0.19-2.09	0.17-0.98		
Mean	0.37 ± 0.19	0.48 ± 0.27	0.63 ± 0.33	0.82 ± 0.50	0.64 ± 0.37		

TABLE 3 OBT/TFWT ratios in biota from different places.

Location	Reactor capacity	Reactor type	Distance from the reactor	Sample type	OBT/TFWT	
					Range	Mean
Tarapur (Baburajan et al., 2020)	1,720 MW	BWR、PHWR	1-10 km	seaweed	0.96-39	–
				marine animals	0.69-16	3.6
south-west of China (Meng et al., 2021)	–	–	–	plants	0.80-2.72	–
Indian (Nayak et al., 2021)	880 MW	PHWR	2.3-20 km	wild plants	0.38-1.64	0.82 ± 0.27
vicinity of Krško NPP (Kristof et al., 2017)	2000 MW	PHWR	0.2-1 km	corn and apples	0.5-1.1	–
East Asia (Feng and Zhuo, 2022)	–	–	–	Fish, cereal, fruit, vegetation, egg, meat	0.4-5.1	–
Lake Nipissing (Kim et al., 2019)	–	–	–	freshwater fish	1.4-2.8	–
This study	9.054 GW	PWR、HWR(CANDU type)、AP1000	<30 km	Fish, prawn, mussel, crab, kelp	0.19-0.88	0.50 ± 0.27

BWR refers to Boiling Water Reactor, PHWR refers to Pressurized Heavy Water Reactor, PWR refers to Pressurized Water Reactor, HWR refers to Heavy Water Reactor.

seafood. Herein, we compared OBT/TFWT ratios in seafood collected around nuclear power plants, namely Qinshan Nuclear Power Plant (QNPP) and Sanmen Nuclear Power Plant (SNPP), with those from the areas (Jiaxing, Ningbo, Zhoushan, Taizhou and Wenzhou city) without nuclear power plant operation. The average OBT/TFWT ratio in seafood collected around nuclear power plants was 0.50 ± 0.27, while the average OBT/TFWT ratio in seafood collected from the areas without nuclear power plant operation was 0.61 ± 0.39. There is no significant difference in OBT/TFWT ratios in seafood between the two types of area (p = 0.422), the relevant statistical analysis chart is shown in Supplementary Figure S3, which indicates that the operation of QNPP and SNPP has no notable impact on the radioactivity levels of tritium in marine creatures, thus not imposing health risks to local residents via seafood consumption.

4 Conclusion

In this study, the OBT/TFWT ratio was systematically analyzed by studying various influencing factors of OBT and TFWT in seafood, including species, region and operation of nuclear power plant. According to our current study, the mean of OBT/TFWT ratios for all seafood investigated in this work was 0.59 ± 0.37, which can be used to estimate the accumulation of OBT in seafood. The results show that the activity concentrations of OBT and TFWT in seafood from coastal cities in Zhejiang Province are at safe levels, and no excessive tritium has been discharged into the sea during the operation of nuclear power plants.

The OBT/TFWT ratios of seafood obtained in our study filled the gap of tritium background level in Chinese seafood, providing reference for study of tritium pollution in marine environment and biota. In addition, the OBT/TFWT ratio in seafood can be used as a reference value, which makes it possible to quickly screen potential tritium contamination in various samples. This approach can be applied to various emergency situations, providing a novel method for rapid detection of OBT and countermeasures. The OBT/TFWT ratios of seafood in this work were derived from the analysis of five types of seafood commonly consumed by residents in Zhejiang Province. However, further analysis is necessary to enrich the dataset with a wider variety of seafood types and reduce method uncertainty to improve data accuracy, allowing us to refine and calibrate the existing OBT/TFWT ratios. Given the prolonged impact of the operation of nuclear power plants on the surrounding environment, continuous monitoring on the radioactivity levels of tritium in seafood around coastal cities and nuclear facilities is essential to help us understand the evolving situation and take appropriate measures to safeguard public health and environmental integrity.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the study involving animals in accordance with the local legislation and institutional requirements because only commercially available samples were used.

Author contributions

XYG: Writing – original draft. WZH: Data curation, Writing – original draft. YYC: Writing – review & editing. XXM: Investigation, Writing – review & editing. LZ: Investigation, Writing – review & editing. PW: Funding acquisition, Writing – review & editing. HR: Supervision, Writing – review & editing.

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Conflict of interest

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2024.1398933/full#supplementary-material

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