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IAEA Analytical Quality in Nuclear Applications Series No. 67

Interlaboratory Comparisons 2017–2020: Determination of Radionuclides in Sea Water, Sediment and Fish

Marine Monitoring: Confidence Building and Data Quality Assurance

IAEA
International Atomic Energy Agency

INTERLABORATORY COMPARISONS 2017–2020: DETERMINATION OF RADIONUCLIDES IN SEA WATER, SEDIMENT AND FISH

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MARINE MONITORING: CONFIDENCE BUILDING AND DATA QUALITY ASSURANCE

INTERNATIONAL ATOMIC ENERGY AGENCY
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Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 26007 22529
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
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For further information on this publication, please contact:

IAEA Environment Laboratories, Monaco
Marine Environmental Studies Laboratory
International Atomic Energy Agency
4a Quai Antoine 1er, 98000
Principality of Monaco

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FOREWORD

The IAEA's Radiometrics Laboratory has been providing quality support products and services for the past 50 years. These include the organization of proficiency tests and interlaboratory comparisons, and the production of certified reference materials, including a wide range of marine sample matrices and radionuclide levels.

As part of these activities, a series of interlaboratory comparisons was organized at the request of the Japanese Nuclear Regulation Authority to assist the Government of Japan in its objectives of making its Sea Area Monitoring Action Plan comprehensive, credible and transparent. The objective of these interlaboratory comparisons was to test the performance of participating Japanese laboratories in the analysis of radionuclides in seawater, marine sediment and fish samples, to ensure the high quality of data and prove the comparability of the results. As part of this series of interlaboratory comparisons, four sampling missions to collect seawater, sediment and fish samples were organized between 2017 and 2020 in the proximity of the Fukushima Daiichi nuclear power plant.

The IAEA wishes to thank all the participants and laboratories who took part in this series of interlaboratory comparisons. The IAEA is also grateful to the Government of Monaco for its support. The IAEA officers responsible for this publication were P. McGinnity and I. Osvath of the IAEA Environment Laboratories.

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1. INTRODUCTION

1.1. BACKGROUND

The IAEA Environment Laboratories in Monaco, through the project Marine Monitoring: Confidence Building and Data Quality Assurance, are assisting the Government of Japan in ensuring that its regularly updated Sea Area Monitoring Plan [1] is comprehensive, credible and transparent. This Plan defines the framework for the ongoing monitoring of radionuclides released to the marine environment as a result of the accident at the Fukushima Daiichi Nuclear Power Station in 2011.

The project was initiated in 2014 as a follow-up activity to the advisory points on marine monitoring included in a report by the IAEA International Peer Review Mission on Mid- and Long-Term Roadmap Towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1-4 [2], which in late 2013 reviewed Japan's efforts to plan and implement the decommissioning of the plant.

A series of interlaboratory comparisons (ILCs) and proficiency tests (PTs) have since been organized to test the sampling and analytical performance of Japanese laboratories monitoring radionuclides in seawater, sediment and fish as part of the Sea Area Monitoring Plan. PTs and ILCs are standard methods for participating laboratories to assess the quality of their measurement results in comparison with those of other participating laboratories, and to identify any potentially needed improvements. PTs involve evaluation of performance against pre-established criteria whereas ILCs involve organization, performance and evaluation of measurements on the same or similar items by two or more laboratories in accordance with predetermined conditions [3].

During the initial phase of the project 2014–2016, six ILCs and three PTs were organized. The results have been published in IAEA reports [4,5,6,7].

During the second phase of the project, 2017–2021, four ILCs and four PTs have been organized. This publication reports on the ILCs that have been carried out during the second phase.

1.2. OBJECTIVE

This publication reports four ILCs that have been carried out annually between 2017 and 2020, as part of the IAEA project Marine Monitoring: Confidence Building and Data Quality Assurance.

1.3. SCOPE

This publication reports all aspects of the four ILCs that have been carried out annually between 2017 and 2020, as part of the Marine Monitoring: Confidence Building and Data Quality Assurance including: the ILC design; participating laboratories; the methods employed for the sampling of seawater, sediment and fish, for sample preparation and for distribution of the samples between participating laboratories; the methods used by each participating laboratory to determine activity concentrations of radionuclides in the samples; the methodology employed for the statistical evaluation of the results; the results and conclusions.

1.4. STRUCTURE

This publication contains descriptions of the ILC design and participating laboratories (Section 2); the methods employed for the sampling of seawater, sediment and fish, for sample preparation and for distribution of the samples between participating laboratories (Section 3 with detailed descriptions of the distribution of seawater samples in Appendix I), the methods used by each participating laboratory to determine activity concentrations of radionuclides in the samples (Section 4) and the methodology employed for the statistical evaluation of the results (section 5). The results of the ILCs are presented in Section 6 and conclusions in Section 7. The results of the ILCs are also presented in charts in Appendix II.

2. DESIGN AND PARTICIPATING LABORATORIES

2.1. DESIGN

Each ILC comprised sampling of seawater and sediment at offshore locations close to the Fukushima Daiichi Nuclear Power Station and different species of fish from fish markets at nearby ports. Sample collection was undertaken according to normal practice for radiation monitoring carried out under the Sea Area Monitoring Plan [1]. These samples were split, ensuring homogeneity, and sub-samples provided to participating laboratories for analysis. All sample collection and preparation activities were undertaken in the presence of IAEA observers and Japanese authorities involved in the Sea Area Monitoring Plan[1,2]. The results of the analyses were submitted to the IAEA which carried out a compilation and a statistical evaluation to assess agreement. The compiled data and the results of the statistical evaluation were shared with all participating laboratories to allow them to assess the quality of their measurement results in comparison with those of the other laboratories, and to identify any potentially needed improvements.

2.2. PARTICIPATING LABORATORIES

The laboratories participating in analyses for ILCs 2017–2020 were mainly Japanese laboratories involved in the Sea Area Monitoring Plan [1] and the IAEA Environment Laboratories in Monaco. For ILC 2019, two laboratories from Switzerland and Canada, both member laboratories of the IAEA ALMERA Network (Analytical Laboratories for the Measurement of Environmental Radioactivity) also participated[3]. A full list of participating laboratories is presented in Table 1. The participation of each laboratory in specific analyses for each ILC is presented in Tables 2–5.

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[1] For ILC 2019, representatives from two member laboratories of the IAEA ALMERA Network (Analytical Laboratories for the Measurement of Environmental Radioactivity), from Switzerland and Canada, also observed.

[2] For ILC 2020, it was impossible for IAEA observers to travel to Japan due to COVID-19 related restrictions and, instead, IAEA-designated independent Japanese experts joined representatives from Japanese authorities involved in the Sea Area Monitoring Plan as observers. These experts were selected from Japanese member laboratories of the ALMERA Network not involved in the Sea Area Monitoring Plan and are all internationally recognized in their respective areas of scientific expertise. The experts helped to ensure the integrity of sample collection, identification, tracking and pre-treatment and were required to provide written reports and photos to the IAEA.

[3] More information on the ALMERA Network is available from the following IAEA website: https://nucleus.iaea.org/sites/ReferenceMaterials/Pages/ALMERA.aspx.

TABLE 1. LABORATORIES PARTICIPATING IN ILCS 2017–2020

Identifier	**Laboratory**	**Years**
FOCP	Federal Office for Civil Protection, Switzerland	2019
FP	Fukushima Prefectural Centre for Environmental Creation, Fukushima, Japan	All
FRA	Japan Fisheries Research and Education Agency, Yokohama, Japan	2018
GSL	Chikyu Kagaku Kenkyusho Inc. (Geo-Science Laboratory), Nagoya, Japan	2017–2019
HC	Radiation Protection Bureau Health Canada, Canada	2019
IAEA	IAEA Environment Laboratories, Monaco	All
JCAC	Japan Chemical Analysis Center, Chiba, Japan	All
JFFIC	Japan Frozen Foods Inspection Corporation, Japan	2017
JFRL	Japan Food Research Laboratories, Tama, Japan	2020
KANSO	The General Environmental Technos Co. Ltd. (KANSO Ltd.), Japan	All
KEEA	Kyushu Environmental Evaluation Association, Fukuoka, Japan	2018–2020
MERI	Marine Ecology Research Institute, Onjuku, Japan	All
SKC	Seikan Kensa Center Inc., Fujieda, Japan	2020
TPT	Tokyo Power Technology Ltd., Fukushima, Japan	All
TRK	Tohoku Ryokka Kankyohozen Co. Ltd., Tagajo, Japan	2018

TABLE 2. PARTICIPATION OF EACH LABORATORY IN SPECIFIC ANALYSES IN ILC 2017

Sample type	Nuclide	IAEA	FP	GSL	JCAC	JFFIC	KANSO	MERI	TPT
Seawater	^{3}H	Y	Y	Y	Y				
	^{90}Sr	Y			Y		Y		
	^{134}Cs	Y			Y		Y		
	^{137}Cs	Y			Y		Y		
Sediment	^{134}Cs	Y	Y		Y				Y
	^{137}Cs	Y	Y		Y				Y
	^{238}Pu	Y	Y		Y				
	^{239,240}Pu	Y	Y		Y				
Fish	^{134}Cs	Y			Y	Y		Y	
	^{137}Cs	Y			Y	Y		Y	

TABLE 3. PARTICIPATION OF EACH LABORATORY IN SPECIFIC ANALYSES IN ILC 2018

Sample type	Nuclide	IAEA	FP	FRA	GSL	JCAC	KANSO	KEEA	MERI	TPT	TRK
Seawater	^{3}H	Y			Y	Y	Y		Y		
	^{90}Sr	Y	Y			Y	Y			Y^{a}	
	^{134}Cs	Y	Y			Y	Y			Y^{a}	
	^{137}Cs	Y	Y			Y	Y			Y^{a}	
Sediment	^{134}Cs	Y	Y			Y				Y	
	^{137}Cs	Y	Y			Y				Y	
	^{238}Pu	Y	Y			Y		Y			
	^{239,240}Pu	Y	Y			Y		Y			
Fish	^{134}Cs	Y		Y					Y		Y
	^{137}Cs	Y		Y					Y		Y

[a] Sampling location T-D1 only.

TABLE 4. PARTICIPATION OF EACH LABORATORY IN SPECIFIC ANALYSES IN ILC 2019

Sample type	Nuclide	IAEA	FOCP	FP	GSL	HC	JCAC	KANSO	KEEA	MERI	TPT
Seawater	^{3}H	Y	Y		Y	Y	Y	Y		Y	
	^{90}Sr	Y	Y	Y		Y	Y	Y			Y^{a}
	^{134}Cs	Y	Y	Y		Y	Y	Y			Y^{a}
	^{137}Cs	Y	Y	Y		Y	Y	Y			Y^{a}
Sediment	^{134}Cs	Y	Y	Y		Y	Y				Y
	^{137}Cs	Y	Y	Y		Y	Y				Y
	^{238}Pu	Y	Y	Y		Y	Y		Y		
	^{239,240}Pu	Y	Y	Y		Y	Y		Y		
Fish	^{134}Cs	Y	Y			Y		Y	Y	Y	
	^{137}Cs	Y	Y			Y		Y	Y	Y	

[a] Sampling location T-D1 only.

TABLE 5. PARTICIPATION OF EACH LABORATORY IN SPECIFIC ANALYSES IN ILC 2020

Sample type	Nuclide	IAEA	FP	JCAC	JFRL	KANSO	KEEA	MERI	SKC	TPT
Seawater	^{3}H	Y	Y^{a}	Y		Y	Y	Y		Y^{b}
	^{90}Sr	Y	Y	Y		Y				Y^{b}
	^{134}Cs	Y	Y	Y		Y		Y		Y^{b}
	^{137}Cs	Y	Y	Y		Y		Y		Y^{b}
Sediment	^{134}Cs	Y	Y	Y						Y
	^{137}Cs	Y	Y	Y						Y
	^{238}Pu	Y	Y	Y			Y			
	^{239,240}Pu	Y	Y	Y			Y			
Fish	^{134}Cs	Y			Y			Y	Y	
	^{137}Cs	Y			Y			Y	Y	

[a] FP were unable to report results for ^{3}H due to a technical malfunction.
[b] Sampling location T-D1 only.

3. COLLECTION AND PREPARATION OF SEAWATER, SEDIMENT AND FISH SAMPLES

3.1. SEAWATER AND SEDIMENT SAMPLING LOCATIONS

For all ILCs 2017–2020, surface seawater samples were collected at five sampling locations (M-101, M-102, M-103, M-104, and T-D1) and sediment samples at three locations (F-P04, T-S3, and T-S8) offshore the Fukushima Daiichi Nuclear Power Station. The sampling locations are shown in Figure 1 and their coordinates are provided in Table 6.

3.2. SEAWATER

For each ILC, seawater samples were collected from each seawater sampling location for subsequent analysis for ^{90}Sr, ^{134}Cs and ^{137}Cs and, separately, for ^{3}H.

For each ILC, seawater samples were collected using the procedures described below. Sampling was undertaken on 16 and 17 October 2017 for ILC 2017, on 9 and 10 October 2018 for ILC 2018, between 3 and 5 June 2019 for ILC 2019 and between 4 and 6 November 2020 for ILC 2020.

For ^{90}Sr, ^{134}Cs and ^{137}Cs, the basic collection and distribution methods at each sampling location were:

- A 400 L plastic container with four valves was first filled with seawater.
- Separate 20 L cubitainers were filled simultaneously from each of the four valves.
- Each sample was acidified to pH 1–2 with concentrated HCl.
- Three 20 L samples were normally provided to each participating laboratory.

For ^{3}H, the basic sample collection and distribution methods were:

- From the same 400 L plastic container from which the samples to be analysed for ^{90}Sr, ^{134}Cs and ^{137}Cs were taken, separate 2 L containers were filled from each of the four valves.
- One 2 L sample was provided to each participating laboratory.

The exact sampling procedure and distribution matrix, meant to ensure the homogenisation of the samples, depended on the number of participating laboratories which was different for each ILC. A detailed description for each ILC is provided in Appendix I.

3.3. SEDIMENT

Sediment samples were collected from each sediment sampling location for subsequent analysis for ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu.

For each ILC, sediment samples were collected using a grab sampler. Sampling was undertaken on 16 and 17 October 2017 for ILC 2017, on 9 October 2018 for ILC 2018, on 3 and 4 June 2019 for ILC 2019 and between 4 and 6 November 2020 for ILC 2020.

The samples were subsequently oven-dried at 105 °C on large stainless-steel trays, crushed using stainless-steel spatulae, and sieved through a 2-mm mesh sieve at the KANSO laboratory. No grinding was required prior to the initial sieving due to the sandy nature of the sediments. The fraction with grain size <2 mm was ground using a rotary ball mill, sieved to ≤250 µm, then placed in a plastic bag and mixed thoroughly to ensure homogeneity. An incremental division method was used for sample splitting. Each sample was split into two aliquots using a splitter; one aliquot was archived and the second one was further split until the required sample weight for each participating laboratory was attained. The samples were then bottled in 500 mL plastic bottles.

The precise mass provided depended on the total weight of the different particle fractions of the sample after grinding and sieving. As the project progressed, it was realized that none of the participating laboratories were using the whole mass of samples provided for analyses. Therefore, the mass provided was reduced for more recent ILCs.

For ILC 2017, approximately 350 g of homogeneous dried sediment from each sampling location was provided to each participating laboratory. For ILC 2018, approximately 400 g was provided to each laboratory participating in analyses for all radionuclides (^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu). For those analysing only for either Cs or Pu isotopes, approximately 200 g was provided. For ILCs 2019 and 2020, approximately 300 g or 150 g was provided to each participating laboratory analysing, respectively, for all radionuclides (^{134}Cs, ^{137}Cs, ^{238}Pu, ^{239,240}Pu) and for either Cs or Pu isotopes.

For all ILCs, all samples were first shipped to the IAEA Environment Laboratories in Monaco where their ^{137}Cs homogeneity was checked using γ-ray spectrometry with high purity germanium (HPGe) detectors. They were then shipped from Monaco to each participating laboratory.

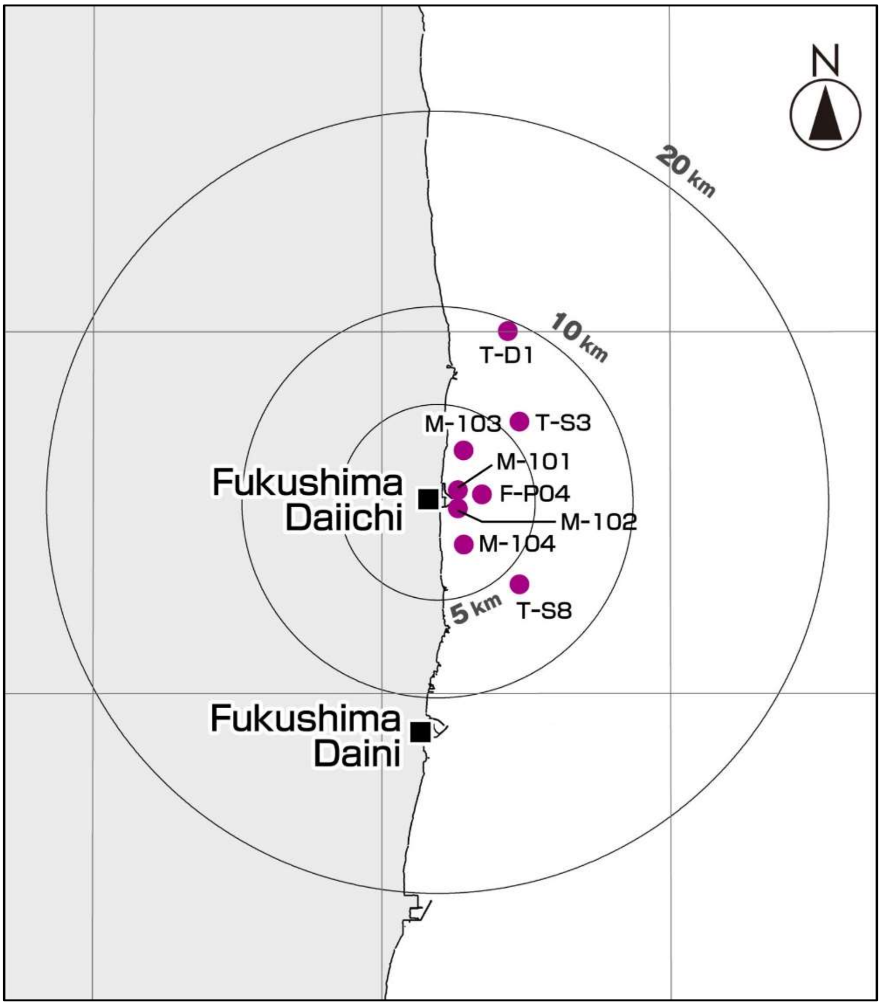

FIG. 1. Surface seawater and sediment sampling locations offshore the Fukushima Daiichi Nuclear Power Station.

TABLE 6. COORDINATES OF THE SURFACE SEAWATER AND SEDIMENT SAMPLING LOCATIONS

Sampling location	Latitude (N)	Longitude (E)
M-101 (seawater)	37°25′36″	141°02′36″
M-102 (seawater)	37°25′06″	141°02′36″
M-103 (seawater)	37°26′42″	141°02′48″
M-104 (seawater)	37°24′06″	141°02′48″
T-D1 (seawater)	37°30′00″	141°04′20″
F-P04 (sediment)	37°25′27″	141°03′26″
T-S3 (sediment)	37°27′30″	141°04′44″
T-S8 (sediment)	37°23′00″	141°04′44″

3.4. FISH

For all ILCs 2017–2020, fish samples of a range of species were collected from fish markets at ports in Fukushima Prefecture for subsequent analysis for ^{134}Cs and ^{137}Cs. The fish were caught by bottom trawling or gill net at locations in the vicinity of the Fukushima Daiichi Nuclear Power Station. Six batches of freshly landed fish, each comprising one species, were sampled for each ILC. Details of the specific fish species sampled for each ILC are provided below.

The samples were transported at freezing temperature to MERI (Onjuku) where they were prepared by homogenizing the muscle tissue. Normally a single homogenized sample for each batch of fish sampled was distributed among participating laboratories in a round robin fashion. The samples were first analyzed by all participating Japanese laboratories before being frozen and shipped to the IAEA Environment Laboratories in Monaco for analysis. For ILC 2019, due to the participation of the two laboratories from the ALMERA Network, HC and FOCP, the amount of fish collected was increased and three sub-samples of each batch were prepared after homogenization at MERI. The first set of sub-samples was distributed as normal as described above. The second and third set of sub-samples prepared were shipped to the two laboratories from the ALMERA Network, HC and FOCP.

All measurements were performed using γ-ray spectrometry with HPGe detectors (see section 4.3 for more details). The measurement times were normally one hour per sample for Japanese participating laboratories and approximately 24 hours for IAEA (and the two laboratories from the ALMERA Network in ILC 2019). All measurements conducted by Japanese participating laboratories comply with procedures set out in a testing manual for radioactive substances in food for emergencies published by the Ministry of Health, Labour and Welfare (MHLW) which require a measurement time of one hour. As IAEA was the final recipient of the fish samples in each ILC, it was possible to measure the fish samples for a longer time, thus resulting in smaller counting uncertainties.

The methodology was modified for ILC 2020. Two sets of measurement results for the fish samples were requested from each participating laboratory, one set for measurement times per sample of one hour, thus continuing to comply with MHLW procedures, and a second set for measurement times per sample of 24 hours. The latter were intended to facilitate effective intercomparison of the results from each laboratory by reducing detection limits and counting uncertainties, particularly for ^{134}Cs.

3.4.1. ILC 2017

For ILC 2017, two batches of olive flounder (*Paralichthys olivaceus*), two batches of ocellate spot skate (*Okamejei kenojei*), one batch of sea robin (*Lepidotrigla microptera*) and one batch of yellow-striped flounder (*Pseudopleuronectes herzensteini*), were collected from the fish landing port of Numanouchi on 16 October 2017. The fish were caught at the locations and depths shown in Table 7.

The fish were homogenised at MERI on 24 October 2017. The resulting six samples were first analysed for ^{134}Cs and ^{137}Cs at MERI on the same date. Subsequently, they were analysed for the same radionuclides on 25 October 2017 at JCAC and on 26 October 2017 at JFFIC. The samples were then frozen and shipped to IAEA in Monaco in December 2017. After defrosting, the fish samples were measured at IAEA in April 2018.

3.4.2. ILC 2018

In ILC 2018, one batch of crimson sea bream (*Evynnis tumifrons*), marbled sole (*Pseudopleuronectes yokohamæ*), ocellate spot skate (*Okamejei kenojei*), olive flounder (*Paralichthys olivaceus*), redwing sea robin (*Lepidotrigla microptera*) and shotted halibut (*Eopsetta grigorjewi*), were collected from the port of Hisanohama on 5 October 2018. The fish were caught at the locations and depths shown in Table 8.

The fish were homogenised at MERI (Onjuku) on 17 October 2018. The resulting six samples were first analysed for ^{134}Cs and ^{137}Cs at MERI on the same date. Subsequently, they were analysed for the same radionuclides at FRA (Yokohama) on 18 October 2018 and at TRK (Tagajo) on 19 October 2018. The samples were then frozen and shipped to IAEA in Monaco on 14 November 2018 where they were analysed later the same month.

3.4.3. ILC 2019

For ILC 2019, one batch of whitespotted conger (*Conger myriaster*), willowy flounder (*Tanakius kitaharae*), olive flounder (*Paralichthys olivaceus*), slime flounder (*Microstomus achne*), shotted halibut (*Eopsetta grigorjewi*) and stone flounder (*Kareius bicoloratus*), were collected from the port of Numanouchi on 6 June 2019. The fish were caught at the locations and depths shown in Table 9.

Each batch of fish was homogenized and then split into three separate sub-samples at MERI (Onjuku) on 11 June 2019. The first set of sub-samples was analysed for ^{134}Cs and ^{137}Cs at MERI on the same date. Subsequently, these sub-samples were shipped to KEEA (Fukuoka) on 13 June 2019 and to KANSO (Katano) on 14 June 2019 for the same analyses. They were then frozen and shipped to IAEA in Monaco where they were analysed in September and October 2019.

The second and third set of sub-samples prepared at MERI were shipped to the two laboratories from the ALMERA Network, HC and FOCP, in June 2019 where they were analysed in July and August 2019.

3.4.4. ILC 2020

For ILC 2020, one batch of olive flounder (*Paralichthys olivaceus*), stone founder (*Kareius flounder*), crimson sea bream (*Evynnis tumifrons*), redwing sea robin (*Lepidotrigla microptera*), whitespotted conger (*Conger myriaster*) and shotted halibut (*Eopsetta grigorjewi*), were collected from the port of Numanouchi on 16 November 2020. The fish species were caught at the locations and depths shown in Table 10 on 15 and 16 November 2020.

Each batch of fish was homogenized and then split into two separate sub-samples at MERI (Onjuku) on 20 November 2020. One set of sub-samples, each of mass approximately 2.4 kg, was analysed for ^{134}Cs and ^{137}Cs by the three participating Japanese laboratories. The fish were analysed at MERI between 20 November and 1 December 2020, at JFRL (Tama) between 23 November and 3 December 2020 and at SKC (Fujieda) between 23 November and 1 December 2020.

The second set of sub-samples, each of mass 1.2 kg, was frozen and shipped to IAEA in Monaco in February 2021. They were analysed during the same month.

TABLE 7. ILC 2017: COORDINATES AND DEPTHS OF THE CATCH LOCATIONS

Sample: Species	Latitude (N)	Longitude (E)	Depth (m)
17FA0001: Sea robin	36°53′00″	141°01′00″	71
17FA0002: Yellow-striped flounder	36°56′00″	141°02′00″	123
17FA0003: Olive flounder	36°55′00″	141°00′00″	69
17FA0004: Olive flounder	36°56′00″	141°02′00″	65
17FA0005: Ocellate spot skate	36°55′00″	141°00′00″	60
17FA0006: Ocellate spot skate	36°51′00″	140°55′00″	60

TABLE 8. ILC 2018: COORDINATES AND DEPTHS OF THE CATCH LOCATIONS

Sample: Species	Latitude (N)	Longitude (E)	Depth (m)
18FA0001: Ocellate spot skate	37°14′35″	141°07′36″	63
18FA0002: Redwing sea robin	37°14′35″	141°07′36″	63
18FA0003: Crimson sea bream	37°14′35″	141°07′36″	63
18FA0004: Marbled sole	37°11′04″	141°08′24″	61
18FA0005: Olive flounder	37°11′04″	141°08′24″	61
18FA0006: Shotted halibut	37°19′11″	141°12′14″	90

TABLE 9. ILC 2019: COORDINATES AND DEPTHS OF THE CATCH LOCATIONS

Sample: Species	Latitude (N)	Longitude (E)	Depth (m)
19FA0001: Whitespotted conger	37°10′38″	141°10′20″	124
19FA0002: Willowy flounder	37°10′38″	141°10′20″	124
19FA0003: Olive flounder	37°10′38″	141°10′20″	124
19FA0004: Slime flounder	37°04′30″	141°04′16″	76
19FA0005: Shotted halibut	37°10′38″	141°10′20″	124
	37°04′30″	141°04′16″	76
19FA0006: Stone flounder	36°05′23″	140°04′57″	29
	37°00′50″	140°59′51″	14

TABLE 10. ILC 2020: COORDINATES AND DEPTHS OF THE CATCH LOCATIONS

Sample: Species	Latitude (N)	Longitude (E)	Depth (m)
20FA0001: Olive flounder	36°55′54″	140°55′52″	21
20FA0002: Stone flounder	37°01′51″	140°59′15″	11
20FA0003: Crimson sea bream	36°54′41″	140°59′44″	66
20FA0004: Redwing sea robin	37°04′43″	141°06′16″	87
20FA0005: Whitespotted conger	37°04′43″	141°06′16″	87
20FA0006: Shotted halibut	37°04′43″	141°06′16″	87

4. RADIONUCLIDE DETERMINATION

4.1. METHODOLOGIES FOR SEAWATER

Radionuclides in seawater were determined by a total of ten participating laboratories for ILCs 2017–2020: FP, GSL, JCAC, KANSO, KEEA, MERI and TPT, all participating on behalf of the Japan Nuclear Regulation Authority; IAEA; and, for ILC 2019, FOCP and HC, member laboratories of the IAEA ALMERA Network (see Tables 1–5). The methodologies used at each laboratory for relevant analyses are described in this section.

4.1.1. Federal Office for Civil Protection (FOCP, Switzerland)

4.1.1.1. ^{3}H analysis

Liquid scintillation counting after distillation of the sample at 60 °C and mixing of a 10 ml aliquot with scintillation cocktail.

4.1.1.2. ^{90}Sr analysis

Low level gas proportional counting following acid leaching, pre-concentration by oxalate precipitation and extraction chromatography using a SR-Spec resin.

4.1.1.3. ^{134}Cs and ^{137}Cs analysis

Analysis by gamma-ray spectrometry of a pre-concentrated sample (by sub-boiling) in a 1 L Marinelli beaker.

4.1.2. Fukushima Prefectural Centre for Environmental Creation (FP)

4.1.2.1. ^{3}H analysis

Tritium was determined by low-background liquid scintillation counting after distillation.

4.1.2.2. ^{90}Sr analysis

A cation exchange resin column was used for pre-concentration of strontium from each seawater sample, followed by precipitation of carbonates and an additional cation exchange resin column for separation of calcium. ^{90}Y was removed by scavenging and, once the sample reached secular equilibrium, was measured using a low background β counter.

4.1.2.3. ^{134}Cs and ^{137}Cs analysis

Chemical separation of caesium by ammonium molybdophosphate (AMP) and manganese dioxide (MnO_2), followed by γ-ray spectrometry with a HPGe detector.

4.1.3. Chikyu Kagaku Kenkyusho Inc. (Geo-Science Laboratory, GSL)

4.1.3.1. ^{3}H analysis

Low-background liquid scintillation counting after distillation and electrolytic enrichment.

4.1.4. Radiation Protection Bureau Health Canada (HC)

4.1.4.1. ^{3}H analysis

Liquid scintillation counting after distillation of the sample.

4.1.4.2. ^{90}Sr analysis

A stable yttrium carrier (1 mg) was added to 40 L of each seawater sample. An iron hydroxide/lanthanum hydroxide precipitation was performed, followed by a second fluoride precipitation to concentrate yttrium and to remove seawater ions. The fluoride precipitate was redissolved and the yttrium fraction was isolated using Eichrom DGA resin. The yttrium fraction (20 mL) was collected in an LSC vial and counted for 6 hours by Cerenkov counting. The yttrium carrier recovery was determined by ICP-MS.

4.1.4.3. ^{134}Cs and ^{137}Cs analysis

Stable caesium (1 mg) was added to each seawater sample as a yield tracer. The seawater was then passed through a 5 g (wet weight) KNiFC-PAN (potassium nickel hexacyanoferrate (II)-polyacrylonitrile) resin. After sample elution, the KNiFC-PAN resin was transferred to a 20 mL glass LSC vial and dried overnight (1 g dry weight) in preparation for analysis by gamma-ray spectrometry using a Canberra broad energy HPGe detector. The retention of stable Cs on the KNiFC-PAN resin was determined by ICP-MS. A blank resin sample was prepared using deionized water. An efficiency standard was prepared by spiking resin with ^{134}Cs and ^{137}Cs.

4.1.5. IAEA Environment Laboratories (IAEA)

4.1.5.1. ^{3}H analysis

The samples were measured by liquid scintillation counting after double vacuum distillation (at 35°C) and electrolytic enrichment followed by a second distillation (at atmospheric pressure for ILCs 2017–2019 and under vacuum for ILC 2020). An ultra-low level liquid scintillation counter was used for the counting of an aliquot of the enriched and distilled sample mixed with a scintillation cocktail.

4.1.5.2. ^{90}Sr analysis

Liquid-liquid extraction with di-(2-ethylhexyl)phosphoric acid (HDEHP) was used for the separation of yttrium from seawater samples, while caesium was precipitated from the same sample by using ammonium molybdophosphate (AMP). The ^{90}Sr activity concentration was calculated based on the measurement of ^{90}Y (yttrium oxalate source) β activity using a proportional counter with an efficiency of up to 44%.

4.1.5.3. ^{134}Cs and ^{137}Cs analysis

Caesium was separated with AMP, followed by γ-ray spectrometry using a HPGe detector.

4.1.6. Japan Chemical Analysis Center (JCAC)

4.1.6.1. ^{3}H analysis

The seawater samples were distilled, followed by electrolytic enrichment (500 mL reduced to 55 mL). 50 mL of the purified sample was mixed with 50 mL of liquid scintillation fluid and measured with a liquid scintillation counter.

4.1.6.2. ^{90}Sr analysis

A cation exchange resin column was used for pre-concentration of strontium from each seawater sample, followed by precipitation of carbonates and an additional cation exchange resin column for separation of calcium. ^{90}Y was removed by scavenging and, once the sample reached secular equilibrium, ^{90}Y was co-precipitated with iron hydroxide and then was measured using a low background β counter.

4.1.6.3. ^{134}Cs and ^{137}Cs analysis

Chemical separation of radiocaesium was undertaken using AMP and followed by γ-ray spectrometry using a HPGe detector.

4.1.7. The General Environmental Technos Co. Ltd. (KANSO)

4.1.7.1. ^{3}H analysis

The samples were first purified by distillation in glass. Then 1 L of the resultant material was electrolytically concentrated using a solid polymer electrolytic film. 50 mL of the purified sample was mixed with 50 mL of Ultima Gold LLT scintillant and then counted for 1000 minutes using a liquid scintillation counter.

4.1.7.2. ^{90}Sr analysis

An ion exchange resin was used for pre-concentration of strontium in each seawater sample, followed by precipitation of carbonates and barium chromate. After secular equilibrium was attained, 90Y was separated using a ferric hydroxide co-precipitation technique and measured by a gas-flow counter.

4.1.7.3. ^{134}Cs and ^{137}Cs analysis

Chemical separation of radiocaesium was undertaken using AMP and followed by γ-ray spectrometry with a HPGe detector.

4.1.8. Kyushu Environmental Evaluation Association (KEEA)

4.1.8.1. ^{3}H analysis

Each seawater sample was distilled and electrically enriched about 50 times. The enriched sample was neutralised and distilled. 10 mL of the enriched sample was mixed with 10 mL of scintillation cocktail in a 20mL low diffusion polyethylene vial and counted for 1100 min using a low background liquid scintillation counter.

4.1.9. Marine Ecology Research Institute (MERI)

4.1.9.1. ^{3}H analysis

Each seawater sample was first purified by distillation. Then ^{3}H was concentrated by electrolysis (a sample volume of 500 mL was reduced to 50 mL). This enriched sample was further purified by distillation. 50 mL of the distillate was mixed with 50 mL of Ultima Gold uLLT scintillation cocktail to prepare a sample for measurement, then measured using a low background liquid scintillation counter.

4.1.9.2. ^{134}Cs and ^{137}Cs analysis

Chemical separation of radiocaesium was undertaken using AMP and followed by γ-ray spectrometry using a HPGe detector.

4.1.10. Tokyo Power Technology Ltd. (TPT)

4.1.10.1. ^{3}H analysis

Each seawater sample was first purified by distillation. The distilled seawater was then mixed with a scintillation cocktail to prepare a sample for measurement using a low background liquid scintillation counter.

4.1.10.2. ^{90}Sr analysis

Strontium was first separated from seawater by alkaline precipitation with sodium carbonate (Na_2CO_3), further separated using cation exchange chromatography and then reprecipitated as strontium carbonate ($SrCO_3$). After attaining secular equilibrium between ^{90}Y and ^{90}Sr, ^{90}Y was separated using an iron hydroxide coprecipitation method and measured with a gas flow counter.

4.1.10.3. ^{134}Cs and ^{137}Cs analysis

Caesium was separated with AMP, followed by γ-ray spectrometry using a HPGe detector.

4.2. METHODOLOGIES FOR SEDIMENT

Radionuclides in sediment were determined by a total of seven participating laboratories for ILCs 2017–2020: FP, JCAC, KEEA and TPT, participating on behalf of the Japan Nuclear Regulation Authority; IAEA; and, for ILC 2019, FOCP and HC, member laboratories of the IAEA ALMERA Network (see Tables 1–5). The methodologies used at each laboratory for relevant analyses are described in this section.

4.2.1. Federal Office for Civil Protection (FOCP, Switzerland)

4.2.1.1. ^{134}Cs and ^{137}Cs analysis

γ-ray spectrometry using a HPGe detector.

4.2.1.2. *^{238}Pu and ^{239,240}Pu analysis*

Each sample underwent total dissolution by melting with Lithium borate and pre-concentration with extraction-chromatography (TEVA-column). $^{239,\,240}$Pu was determined by ICP-MS and ^{238}Pu by alpha-ray spectrometry using the ^{238}Pu /$^{239,\,240}$Pu ratio.

4.2.2. Fukushima Prefectural Centre for Environmental Creation (FP)

4.2.2.1. *^{134}Cs and ^{137}Cs analysis*

γ-ray spectrometry using a HPGe detector.

4.2.2.2. *^{238}Pu and ^{239,240}Pu analysis*

α-particle spectrometry with a Si detector after leaching, radiochemical separation and purification of plutonium by using an anion exchange resin column followed by electrodeposition from the purified solution.

4.2.3. Radiation Protection Bureau Health Canada (HC)

4.2.3.1. *^{134}Cs and ^{137}Cs analysis*

γ-ray spectrometry using a HPGe detector.

4.2.3.2. *^{238}Pu and ^{239,240}Pu analysis*

After addition of a ^{242}Pu yield tracer, each sediment sample (approx. 0.5 g each) in triplicate were twice extracted in nitric acid (12 mL) in a microwave digestion system (CEM MARS 6). Post digestion, the triplicate samples were combined (1.5-1.6 g). The plutonium fraction was isolated using an Eichrom TEVA column. Cerium fluoride microprecipitation was used to prepare the plutonium fraction for counting. Samples were counted for 7 days by alpha-ray spectrometry.

4.2.4. IAEA Environment Laboratories (IAEA)

4.2.4.1. *^{134}Cs and ^{137}Cs analysis*

γ-ray spectrometry using a p-type coaxial HPGe detector.

4.2.4.2. *^{238}Pu and ^{239,240}Pu analysis*

Classical digestion followed by ion exchange, electrodeposition and counting by α-particle spectrometry. An aliquot of 5 g of sediment sample was ashed and spiked with a ^{242}Pu tracer. The sample was totally dissolved by using concentrated acids. After $Fe(OH)_3$ precipitation and plutonium oxidation state adjustment, double ion exchange (DOWEX 1×4) was used for Pu purification. Plutonium was electrodeposited from Na_2SO_4/H_2SO_4 electrolyte solution on stainless-steel discs and counted by α-particle spectrometry.

4.2.5. Japan Chemical Analysis Center (JCAC)

4.2.5.1. *^{134}Cs and ^{137}Cs analysis*

Direct counting on a p-type coaxial HPGe detector with a relative efficiency 31%.

4.2.5.2. ^{238}Pu and ^{239,240}Pu analysis

Plutonium isotopes were measured with a Si semiconductor detector after leaching, radiochemical separation and purification of plutonium by using an anion exchange resin column followed by electrodeposition from the purified solution.

4.2.6. Kyushu Environmental Evaluation Association (KEEA)

4.2.6.1. ^{238}Pu and ^{239,240}Pu analysis

Dried sediment samples were first heated to 450 °C. Then a ^{242}Pu isotope dilution tracer was added to each sample, and the plutonium recovered from the sediment with a 10 M HNO_3/0.1 M HF leach, followed by an 8M HNO_3 leach. This material had the plutonium oxidation stated adjusted with sodium nitrate (III) ($NaNO_2$). Plutonium was then separated and purified using Dowex 1×8 (100-200 mesh) anion exchange resin. Plutonium was electrodeposited onto stainless-steel plate and measured by silicon semiconductor detector.

4.2.7. Tokyo Power Technology Ltd. (TPT)

4.2.7.1. ^{134}Cs and ^{137}Cs analysis

γ-ray spectrometry using a p-type coaxial HPGe detector.

4.3. METHODOLOGIES FOR FISH

Radionuclides in fish were determined by a total of 12 participating laboratories for ILCs 2017–2020: FRA, JCAC, JFFIC, JFRL, KANSO, KEEA, MERI, TRK and SKC, participating on behalf of the Japan Fisheries Agency; IAEA; and, for ILC 2019, FOCP and HC, member laboratories of the IAEA ALMERA Network (see Tables 1–5). The methodologies used at each laboratory for relevant analyses are described in this section.

4.3.1. Federal Office for Civil Protection (FOCP, Switzerland)

4.3.1.1. ^{134}Cs and ^{137}Cs analysis

Direct counting on n-type coaxial HPGe detectors with relative efficiencies of 25% and 30%. The samples were prepared in 1 L Marinelli beakers and measured for approximately 24 hours.

4.3.2. Japan Fisheries Research and Education Agency (FRA)

4.3.2.1. ^{134}Cs and ^{137}Cs analysis

Direct counting on p-type coaxial HPGe detectors with relative efficiencies between 29% and 33%. The samples were prepared in 2 L Marinelli beakers and measured for one hour.

4.3.3. Radiation Protection Bureau Health Canada (HC)

4.3.3.1. ^{134}Cs and ^{137}Cs analysis

Sub-samples of approximately 150 g were measured on a p-type coaxial HPGe detector with relative efficiency of 46%. Counting times ranged between approximately two and seven days.

4.3.4. IAEA Environment Laboratories (IAEA)

4.3.4.1. ^{134}Cs and ^{137}Cs analysis

Direct counting by a coaxial HPGe detector with relative efficiencies of 35% and 48%. The mass of each sample was approximately 1 kg (wet mass) and the samples were measured for approximately 24 hours. For ILC 2020, two spectra were saved for each sample, one after measuring for one hour and a second after 24 hours.

4.3.5. Japan Chemical Analysis Center (JCAC)

4.3.5.1. ^{134}Cs and ^{137}Cs analysis

Direct counting on p-type coaxial HPGe detectors with relative efficiencies between 29% and 33%. The samples were prepared in 2 L Marinelli beakers and measured for one hour.

4.3.6. Japan Frozen Foods Inspection Corporation (JFFIC)

4.3.6.1. ^{134}Cs and ^{137}Cs analysis

Direct counting by p-type coaxial HPGe detectors with relative efficiencies between 22% and 32% for the determination of 134Cs and 137Cs in fish. The samples were prepared in 2 L Marinelli beakers and measured for one hour.

4.3.7. Japan Food Research Laboratories (JFRL)

4.3.7.1. ^{134}Cs and ^{137}Cs analysis

Direct counting by p-type coaxial HPGe detectors with relative efficiencies between 38% and 39%. The samples were prepared in 2 L Marinelli beakers and measured for 24 hours. JFRL participated in ILC 2020; thus, two spectra were saved for each sample, one after measuring for one hour and a second after 24 hours.

4.3.8. The General Environmental Technos Co. Ltd. (KANSO)

4.3.8.1. ^{134}Cs and ^{137}Cs analysis

Direct counting on p-type coaxial HPGe detectors with relative efficiencies between 29% and 33%. The samples were prepared in 2 L Marinelli beakers and measured for one hour.

4.3.9. Kyushu Environmental Evaluation Association (KEEA)

4.3.9.1. ^{134}Cs and ^{137}Cs analysis

Direct counting by p-type coaxial HPGe detectors, each relative efficiency 46%. The samples were prepared in 2 L Marinelli beakers and measured for one hour.

4.3.10. Marine Ecology Research Institute (MERI)

4.3.10.1. ^{134}Cs and ^{137}Cs analysis

Direct counting by p-type coaxial HPGe detectors with relative efficiencies between 28% and 46%. The samples were prepared in 2 L Marinelli beakers and measured for one hour (ILCs

2017–2019). For ILC 2020, two spectra were saved for each sample, one after measuring for one hour and a second after 24 hours.

4.3.11. Tohoku Ryokka Kankyohozen Co. Ltd. (TRK)

4.3.11.1. ^{134}Cs and ^{137}Cs analysis

Direct counting by p-type coaxial HPGe detectors with relative efficiencies between 30% and 35%. The samples were prepared in 2 L Marinelli beakers and measured for one hour.

4.3.12. Seikan Kensa Center Inc. (SKC)

4.3.12.1. ^{134}Cs and ^{137}Cs analysis

Direct counting by a p-type coaxial HPGe detector with relative efficiency of 45%. The samples were prepared in 2 L Marinelli beakers and measured for 24 hours. SKC participated in ILC 2020; thus, two spectra were saved for each sample, one after measuring for one hour and a second after 24 hours.

5. STATISTICAL EVALUATION OF THE RESULTS

The IAEA collected and evaluated the results reported by all ILC participants. The method used for the statistical evaluation depended on the number of results received for each sampling location, sample type and radionuclide.

If two or three measurement results above the detection limit were received, then one or three zeta tests [8] were performed. The zeta $\zeta_{i,j}$ test is defined as:

$$\zeta_{i,j} = \left| \frac{x_i - x_j}{\sqrt{u_i^2 + u_j^2}} \right| \tag{1}$$

where:

x_i is the value of laboratory i (Bq $unit^{-1}$);
x_j is the value of laboratory j (Bq $unit^{-1}$);
u_i is the standard uncertainty for the value of laboratory i (Bq $unit^{-1}$);
u_j is the standard uncertainty for the value of laboratory j (Bq $unit^{-1}$); and
$unit$ is the unit of volume of mass, L or kg, as appropriate for the particular sample type.

If two results were received, $\zeta_{1,2}$ was calculated, while for three received results $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$ were calculated.

If the value of the zeta test exceeded 2.58, the results were evaluated as being significantly different (at a 99% confidence level).

If the data set contained four or more results, the statistical evaluation consisted of a method for calculating a comparison reference value as a power-moderated mean of the combined results [9]. After calculating a reference value, a relative degree of equivalence (DoE) was calculated for each submitted result and if this relative DoE was significantly different from zero, the corresponding result was evaluated as being discrepant. The relative DoE (%) was calculated according to:

$$\text{DoE (\%)} = \frac{x_{\text{lab}} - x_{\text{ref}}}{x_{\text{ref}}} 100 \tag{2}$$

where:

x_{lab} is the individual laboratory result; and
x_{ref} is the reference value calculated as the power-moderated mean of the combined results.

The standard uncertainty of the relative DoE, u_{DoE}, was calculated according to reference [8]. If the absolute value of the relative DoE exceeded 2.58 times u_{DoE}, the corresponding result was evaluated as being discrepant (at a 99% confidence level), as the relative DoE in this case would be significantly different from zero.

6. RESULTS

6.1. GENERAL

The results of ILCs 2017–2020 are presented in this section. Related charts are presented in Appendix II.

The results for seawater are presented in Tables 11–19 and Figures 2–17.

Table 11 contains the results reported by the participating laboratories (FP, GSL, JCAC, KANSO and IAEA) for the activity concentrations of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in seawater samples for ILC 2017. Figures 2–5 show the activity concentrations of these radionuclides in the seawater samples. Tables 12 and 13 contain zeta scores for the activity concentrations of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in the seawater samples.

Table 14 contains the results reported by the participating laboratories (FP, GSL, JCAC, KANSO, MERI, TPT and IAEA) for the activity concentrations of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in seawater samples for ILC 2018. Figures 6–9 show the activity concentrations of these radionuclides in the seawater samples. Table 15 contains the relative degrees of equivalence for the activity concentrations of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in the seawater samples.

Table 16 contains the results reported by the participating laboratories (FOCP, FP, GSL, HC, JCAC, KANSO, MERI, TPT and IAEA) for the activity concentrations of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in seawater samples for ILC 2019. Figures 10–13 show the activity concentrations of these radionuclides in the seawater samples. Table 17 contains the relative degrees of equivalence for the activity concentrations of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in the seawater samples.

Table 18 contains the results reported by the participating laboratories (FP, JCAC, KANSO, KEEA, MERI, TPT and IAEA) for the activity concentrations of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in seawater samples for ILC 2020. Figures 14–17 show the activity concentrations of these radionuclides in the seawater samples. Table 19 contains the relative degrees of equivalence for the activity concentrations of ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in the seawater samples.

The results for sediment are presented in Tables 20–27 and Figures 18–33.

Table 20 contains the results reported by the four participating laboratories (FP, JCAC, TPT and IAEA) for the activity concentrations of ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in sediment samples for ILC 2017. Figures 18–21 show the activity concentrations of these radionuclides in the sediment samples. Table 21 contains the relative degrees of equivalence for the activity concentrations of ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in the sediment samples.

Table 22 contains the results reported by the four participating laboratories (FP, JCAC, KEEA, TPT and IAEA) for the activity concentrations of ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in sediment samples for ILC 2018. Figures 22–25 show the activity concentrations of these radionuclides in the sediment samples. Table 23 contains the relative degrees of equivalence for the activity concentrations of ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in the sediment samples.

Table 24 contains the results reported by the seven participating laboratories (FOCP, FP, HC, JCAC, KEEA, TPT and IAEA) for the activity concentrations of ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in sediment samples for ILC 2019. Figures 26–29 show the activity concentrations of these radionuclides in the sediment samples. Table 25 contains the relative degrees of equivalence for the activity concentrations of ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in the sediment samples.

Table 26 contains the results reported by the five participating laboratories (FP, JCAC, KEEA, TPT and IAEA) for the activity concentrations of ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in sediment samples for ILC 2020. Figures 30–33 show the activity concentrations of these radionuclides in the sediment samples. Table 27 contains the relative degrees of equivalence for the activity concentrations of ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in the sediment samples.

The results for fish are presented in Tables 28–35 and Figures 34–42.

Table 28 contains the results reported by the four participating laboratories (JCAC, JFFIC, MERI and IAEA) for the activity concentrations of ^{134}Cs and ^{137}Cs in the samples for ILC 2017. Figures 34 and 35 show the activity concentrations of these radionuclides in the fish samples. Table 29 contains the relative degrees of equivalence for the activity concentrations of ^{134}Cs and ^{137}Cs in the fish samples.

Table 30 contains the results reported by the four participating laboratories (FRA, MERI, TRK and IAEA) for the activity concentrations of radionuclides in the samples for ILC 2018. Figures 36 and 37 show the activity concentrations of these radionuclides in the fish samples. Table 31 contains the relative degrees of equivalence for the activity concentrations of ^{134}Cs and ^{137}Cs in the fish samples.

Table 32 contains the results reported by the six participating laboratories (FOCP, HC, KANSO, KEEA, MERI and IAEA) for the activity concentrations of radionuclides in the samples for ILC 2019. Figures 38 and 39 show the activity concentrations of these radionuclides in the fish samples. Table 33 contains the relative degrees of equivalence for the activity concentrations of ^{134}Cs and ^{137}Cs in the fish samples.

Table 34 contains the results reported by the four participating laboratories (JFRL, MERI, SKC and IAEA) for the activity concentrations of radionuclides in the samples for ILC 2020. Figures 40–42 show the activity concentrations of these radionuclides in the fish samples. Table 35 contains the relative degrees of equivalence for the activity concentrations of ^{134}Cs and ^{137}Cs in the fish samples.

6.1.1. Uncertainties and confidence intervals

In this report, the numerical result of an activity concentration measurement is stated in the format $x \pm y$, where the number following the symbol ± is the numerical value of the combined standard uncertainty, i.e. with a coverage factor of $k = 1$.

Relative degrees of equivalence are also quoted in the format $x \pm y$. In this case, the number following the symbol ± is the 99% confidence interval.

6.1.2. Reference times

For ILC 2017, all activity concentrations for seawater, sediment and fish were reported at a reference time of 16 October 2017 12:00 UTC.

For ILC 2018, all activity concentrations for seawater and sediment were reported at a reference time of 9 October 2018 12:00 UTC. All activity concentrations for fish were reported at a reference time of 5 October 2018 12:00 UTC.

For ILC 2019, all activity concentrations for seawater and sediment were reported at a reference time of 9 June 2019 12:00 UTC. All activity concentrations for fish were reported at a reference time of 5 June 2019 12:00 UTC.

For ILC 2020, all activity concentrations for seawater and sediment were reported at a reference time of 4 November 2020 12:00 UTC. All activity concentrations for fish were reported at a reference time of 16 November 2020 12:00 UTC.

6.2. SEAWATER

TABLE 11. ILC 2017: ACTIVITY CONCENTRATIONS (mBq L^{-1}) IN SEAWATER

Nuclide	Sample	IAEA	FP	GSL	JCAC	KANSO
^{3}H	M-101	<63	<250	91 ± 15	92 ± 20	–
	M-102	102 ± 22	<250	132 ± 15	65 ± 16	–
	M-103	128 ± 23	<250	88 ± 15	55 ± 16	–
	M-104	82 ± 21	<250	126 ± 15	80 ± 16	–
	T-D1	53 ± 21	<250	98 ± 15	97 ± 17	–
^{90}Sr	M-101	0.720 ± 0.046	–	–	0.96 ± 0.12	1.10 ± 0.20
	M-102	0.874 ± 0.052	–	–	1.00 ± 0.12	0.84 ± 0.15
	M-103	0.889 ± 0.056	–	–	0.71 ± 0.11	0.91 ± 0.16
	M-104	1.192 ± 0.068	–	–	1.12 ± 0.13	1.60 ± 0.20
	T-D1	0.806 ± 0.048	–	–	0.96 ± 0.12	0.99 ± 0.16
^{134}Cs	M-101	1.020 ± 0.056	–	–	1.92 ± 0.31	0.95 ± 0.15
	M-102	1.390 ± 0.069	–	–	1.37 ± 0.25	1.10 ± 0.15
	M-103	0.967 ± 0.056	–	–	0.98 ± 0.27	0.86 ± 0.16
	M-104	2.45 ± 0.13	–	–	2.45 ± 0.29	2.20 ± 0.20
	T-D1	0.565 ± 0.035	–	–	0.88 ± 0.19	<0.47
^{137}Cs	M-101	9.37 ± 0.38	–	–	15.7 ± 0.89	8.9 ± 0.34
	M-102	10.73 ± 0.40	–	–	12.1 ± 0.71	10.0± 0.37
	M-103	8.73 ± 0.40	–	–	9.57 ± 0.58	8.3 ± 0.32
	M-104	19.68 ± 0.91	–	–	21.7 ± 1.2	19.0 ± 0.65
	T-D1	5.09 ± 0.18	–	–	5.44 ± 0.33	4.7 ± 0.20

TABLE 12. ILC 2017: ZETA SCORES FOR ^{3}H IN SEAWATER SAMPLES

Nuclide	Sample	$\zeta_{IAEA,GSL}$	$\zeta_{IAEA,JCAC}$	$\zeta_{GSL,JCAC}$
^{3}H	M-101	–	–	-0.03
	M-102	-1.14	1.40	**3.11**
	M-103	1.48	**2.68**	1.55
	M-104	-1.71	0.08	2.10
	T-D1	-1.78	-1.69	0.04

Note: All values submitted by FP were less than the detection limit, therefore no evaluation was possible.

TABLE 13. ILC 2017: ZETA SCORES FOR ^{90}Sr, ^{134}Cs AND ^{137}Cs IN SEAWATER SAMPLES

Nuclide	Sample	$\zeta_{IAEA,JCAC}$	$\zeta_{IAEA,KANSO}$	$\zeta_{JCAC,KANSO}$
^{90}Sr	M-101	-1.90	-2.16	-0.65
	M-102	-0.96	0.22	0.83
	M-103	1.43	-0.12	-1.01
	M-104	0.49	-1.93	-2.01
	T-D1	-1.20	-1.10	-0.15
^{134}Cs	M-101	**-2.86**	0.43	**2.82**
	M-102	0.08	1.76	0.93
	M-103	-0.03	0.63	0.37
	M-104	0.00	1.06	0.71
	T-D1	-1.65	–	–
^{137}Cs	M-101	**-6.55**	0.92	**7.14**
	M-102	-1.69	1.35	**2.62**
	M-103	-1.20	0.85	1.92
	M-104	-1.34	0.61	1.98
	T-D1	-0.94	1.44	1.92

TABLE 14. ILC 2018: A CTIVITY CONCENTRATIONS (mBq L^{-1}) IN SEAWATER

Nuclide	Sample	IAEA	FP	GSL	JCAC	KANSO	MERI	TPT	Reference value
^{3}H	M-101	124 ± 19	–	147 ± 15	123 ± 20	160 ± 14	170 ± 24	–	145 ± 9
	M-102	138 ± 20	–	133 ± 14	164 ± 22	160 ± 15	174 ± 23	–	151 ± 8
	M-103	50 ± 13	–	94 ± 14	<55	94 ± 12	88 ± 22	–	81 ± 12
	M-104	65 ± 14	–	74 ± 13	<56	63 ± 12	128 ± 23	–	80 ± 15
	T-D1	44 ± 13	–	99 ± 13	59 ± 19	80 ± 12	101 ± 22	–	76 ± 12
^{90}Sr	M-101	1.95 ± 0.11	2.3 ± 0.29	–	1.81 ± 0.17	2.2 ± 0.23	–	–	2.01 ± 0.11
	M-102	1.410 ± 0.080	1.7 ± 0.26	–	1.34 ± 0.15	1.6 ± 0.19	–	–	1.45 ± 0.08
	M-103	0.762 ± 0.047	1.3 ± 0.22	–	0.79 ± 0.12	1.0 ± 0.17	–	–	0.92 ± 0.12
	M-104	0.908 ± 0.055	1.0 ± 0.20	–	0.74 ± 0.12	0.91 ± 0.17	–	–	0.88 ± 0.06
	T-D1	0.730 ± 0.053	0.9 ± 0.20	–	0.92 ± 0.13	1.1 ± 0.17	–	<5	0.88 ± 0.08
^{134}Cs	M-101	4.38 ± 0.18	4 ± 0.7	–	4.4 ± 0.4	4.2 ± 0.26	–	–	4.3 ± 0.2
	M-102	3.01 ± 0.14	3 ± 0.7	–	3.3 ± 0.3	2.6 ± 0.21	–	–	2.9 ± 0.2
	M-103	0.360 ± 0.047	<2.1	–	<0.74	<0.48	–	–	–
	M-104	0.742 ± 0.073	<2.1	–	1.4 ± 0.3	0.59 ± 0.15	–	–	–
	T-D1	0.34 ± 0.11	<2.1	–	<0.68	<0.48	–	<0.9	–
^{137}Cs	M-101	45.9 ± 2.0	48 ± 3.0	–	49.0 ± 3.0	44 ± 1.5	–	–	46.0 ± 1.2
	M-102	31.8 ± 1.5	34 ± 2.1	–	34.1 ± 1.8	30 ± 1.1	–	–	32.2 ± 1.1
	M-103	5.25 ± 0.34	6 ± 0.7	–	6.8 ± 0.4	5.2 ± 0.22	–	–	5.8 ± 0.4
	M-104	8.82 ± 0.79	8 ± 0.8	–	9.2 ± 0.6	7.9 ± 0.31	–	–	8.4 ± 0.4
	T-D1	4.54 ± 0.28	7 ± 0.7	–	5.3 ± 0.4	4.2 ± 0.20	–	4.7 ± 0.4	5.1 ± 0.5

TABLE 15. ILC 2018: RELATIVE DEGREES OF EQUIVALENCE (%) IN SEAWATER SAMPLES

Nuclide	Sample	IAEA	FP	GSL	JCAC	KANSO	MERI	TPT
^{3}H	M-101	-15 ± 31	–	1 ± 25	-15 ± 34	10 ± 24	17 ± 40	–
	M-102	-9 ± 31	–	-12 ± 21	8 ± 34	6 ± 22	15 ± 36	–
	M-103	-38 ± 45	–	16 ± 48	DL	16 ± 45	9 ± 66	–
	M-104	-19 ± 55	–	-7 ± 55	DL	-21 ± 54	61 ± 74	–
	T-D1	-42 ± 49	–	31 ± 51	-22 ± 64	6 ± 49	33 ± 73	–
^{90}Sr	M-101	-3 ± 15	15 ± 35	–	-10 ± 20	10 ± 26	–	–
	M-102	-4 ± 14	17 ± 43	–	-8 ± 24	10 ± 31	–	–
	M-103	-18 ± 34	41 ± 59	–	-14 ± 40	8 ± 48	–	–
	M-104	3 ± 15	13 ± 55	–	-16 ± 30	3 ± 43	–	–
	T-D1	-17 ± 25	2 ± 54	–	4 ± 36	25 ± 44	–	DL
^{134}Cs	M-101	1.8 ± 8.9	-7 ± 40	–	2 ± 22	-2 ± 13	–	–
	M-102	2 ± 14	2 ± 58	–	12 ± 24	-12 ± 18	–	–
	M-103	Note 1	DL	–	DL	DL	–	–
	M-104	Note 2	DL	–	Note 2	Note 2	–	–
	T-D1	Note 1	DL	–	DL	DL	–	DL
^{137}Cs	M-101	-0.2 ± 9.6	4 ± 16	–	6 ± 16	-4.4 ± 7.3	–	–
	M-102	-1 ± 12	6 ± 16	–	6 ± 14	-6.7 ± 9.5	–	–
	M-103	-9 ± 21	4 ± 31	–	18 ± 22	-10 ± 19	–	–
	M-104	5 ± 22	-5 ± 23	–	10 ± 17	-6 ± 11	–	–
	T-D1	-10 ± 27	**38 ± 38**	–	5 ± 29	-17 ± 26	–	-7 ± 29

Note 1: No evaluation was possible as only one value above the detection limit was submitted.

Note 2: Values of -2.13, 0.92 and 2.4 for $\zeta_{1,4}$, $\zeta_{1,5}$ and $\zeta_{4,5}$, respectively.

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

$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FP, number 3 refers to GSL, number 4 refers to JCAC, number 5 refers to KANSO, number 6 refers to MERI and number 7 refers to TPT.

TABLE 16. ILC 2019: ACTIVITY CONCENTRATIONS (mBq L^{-1}) IN SEAWATER

Nuclide	Sample	IAEA	FOCP	FP	GSL	HC	JCAC	KANSO	MERI	TPT	Reference value
^{3}H	M-101	<99	<2050	–	81 ± 15	<451	63 ± 12	78 ± 13	115 ± 21	–	81 ± 11
	M-102	<99	<2050	–	89 ± 15	<451	64 ± 12	76 ± 14	112 ± 23	–	82 ± 10
	M-103	<99	<2050	–	79 ± 15	<451	76 ± 13	72 ± 13	134 ± 25	–	87 ± 14
	M-104	<99	<2050	–	82 ± 15	<451	78 ± 13	69 ± 13	136 ± 21	–	89 ± 15
	T-D1	<99	<2050	–	57 ± 14	<451	79 ± 13	84 ± 13	96 ± 21	–	78 ± 8
^{90}Sr	M-101	1.061 ± 0.062	1.26 ± 0.21	0.96 ± 0.20	–	0.77 ± 0.23	0.94 ± 0.14	1.19 ± 0.17	–	–	1.04 ± 0.06
	M-102	1.020 ± 0.060	1.33 ± 0.21	1.03 ± 0.21	–	2.86 ± 0.24	1.22 ± 0.16	1.13 ± 0.19	–	–	1.42 ± 0.29
	M-103	0.893 ± 0.052	1.54 ± 0.26	0.77 ± 0.19	–	1.75 ± 0.21	1.06 ± 0.15	1.02 ± 0.18	–	–	1.15 ± 0.16
	M-104	0.766 ± 0.047	1.13 ± 0.26	1.03 ± 0.21	–	0.63 ± 0.21	1.00 ± 0.14	0.90 ± 0.16	–	–	0.86 ± 0.07
	T-D1	0.986 ± 0.057	1.74 ± 0.26	0.73 ± 0.19	–	2.06 ± 0.21	1.12 ± 0.15	0.74 ± 0.16	–	1.744 ± 0.080	1.29 ± 0.21
^{134}Cs	M-101	1.04 ± 0.13	<9.2	<2.1	–	1.08 ± 0.24	1.54 ± 0.31	1.06 ± 0.26	–	–	1.12 ± 0.11
	M-102	0.754 ± 0.068	<9.0	<2.0	–	0.84 ± 0.18	<0.93	0.79 ± 0.24	–	–	–
	M-103	0.709 ± 0.069	<9.7	<1.9	–	0.75 ± 0.18	<0.93	<0.72	–	–	–
	M-104	0.350 ± 0.064	<6.2	<2.3	–	0.421 ± 0.090	<0.91	<0.75	–	–	–
	T-D1	0.246 ± 0.035	<5.5	<2.3	–	0.281 ± 0.076	<0.88	<0.72	–	<0.96	–
^{137}Cs	M-101	14.7 ± 1.4	15.4 ± 1.5	16.7 ± 1.2	–	16.0 ± 3.3	20.5 ± 1.2	15.58 ± 0.59	–	–	16.5 ± 1.0
	M-102	11.2 ± 1.0	15.0 ± 1.8	13.12 ± 0.93	–	12.2 ± 2.5	12.20 ± 0.72	11.28 ± 0.45	–	–	12.1 ± 0.5
	M-103	10.32 ± 0.91	12.9 ± 1.6	11.79 ± 0.82	–	10.7 ± 2.2	11.58 ± 0.62	10.09 ± 0.41	–	–	11.0 ± 0.5
	M-104	5.69 ± 0.61	8.1 ± 0.93	7.37 ± 0.72	–	6.5 ± 1.4	6.36 ± 0.41	7.63 ± 0.34	–	–	6.9 ± 0.4
	T-D1	3.82 ± 0.38	4.54 ± 0.72	3.08 ± 0.52	–	4.10 ± 0.82	4.31 ± 0.31	3.54 ± 0.23	–	3.78 ± 0.38	3.81 ± 0.17

TABLE 17. ILC 2019: RELATIVE DEGREES OF EQUIVALENCE (%) IN SEAWATER SAMPLES

Nuclide	Sample	IAEA	FOCP	FP	GSL	HC	JCAC	KANSO	MERI	TPT
^{3}H	M-101	DL	DL	–	0 ± 47	DL	-23 ± 41	-5 ± 43	41 ± 61	–
	M-102	DL	DL	–	9 ± 45	DL	-22 ± 38	-7 ± 42	37 ± 66	–
	M-103	DL	DL	–	-9 ± 50	DL	-12 ± 47	-17 ± 47	54 ± 69	–
	M-104	DL	DL	–	-8 ± 51	DL	-13 ± 49	-22 ± 49	52 ± 62	–
	T-D1	DL	DL	–	-26 ± 40	DL	2 ± 38	9 ± 39	24 ± 63	–
^{90}Sr	M-101	2 ± 14	21 ± 49	-8 ± 47	–	-26 ± 54	-10 ± 31	14 ± 39	–	–
	M-102	-28 ± 53	-6 ± 61	-27 ± 61	–	**101 ± 63**	-14 ± 57	-21 ± 59	–	–
	M-103	-22 ± 36	34 ± 60	-33 ± 49	–	**52 ± 52**	-8 ± 44	-11 ± 47	–	–
	M-104	-11 ± 21	31 ± 74	19 ± 59	–	-27 ± 59	16 ± 38	4 ± 44	–	–
	T-D1	-24 ± 42	35 ± 60	-44 ± 51	–	**59 ± 54**	-14 ± 48	-43 ± 48	–	35 ± 43
^{134}Cs	M-101	-7 ± 26	DL	DL	–	-4 ± 49	37 ± 65	-6 ± 52	–	–
	M-102	Note 1	DL	DL	–	Note 1	DL	Note 1	–	–
	M-103	Note 2	DL	DL	–	Note 2	DL	DL	–	–
	M-104	Note 3	DL	DL	–	Note 3	DL	DL	–	–
	T-D1	Note 4	DL	DL	–	Note 4	DL	DL	–	DL
^{137}Cs	M-101	-11 ± 23	-7 ± 24	1 ± 20	–	-3 ± 50	**24 ± 20**	-6 ± 16	–	–
	M-102	-8 ± 20	23 ± 36	8 ± 19	–	1 ± 51	1 ± 16	-7 ± 13	–	–
	M-103	-6 ± 20	17 ± 35	7 ± 19	–	-3 ± 49	5 ± 15	-8 ± 12	–	–
	M-104	-18 ± 23	17 ± 33	6 ± 27	–	-7 ± 48	-8 ± 18	10 ± 17	–	–
	T-D1	0 ± 24	19 ± 47	-19 ± 33	–	8 ± 54	13 ± 20	-7 ± 16	–	-1 ± 25

Note 1: Values of -0.44, -0.13 and 0.17 for $\zeta_{1,5}$, $\zeta_{1,7}$ and $\zeta_{5,7}$, respectively.

Note 2: Value of -0.24 for $\zeta_{1,5}$.

Note 3: Value of -0.65 for $\zeta_{1,5}$.

Note 4: Value of -0.42 for $\zeta_{1,5}$.

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

$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FOCP, number 3 refers to FP, number 4 refers to GSL, number 5 refers to HC, number 6 refers to JCAC, number 7 refers to KANSO, number 8 refers to MERI and number 9 refers to TPT.

TABLE 18. ILC 2020: ACTIVITY CONCENTRATIONS (mBq L^{-1}) IN SEAWATER

Nuclide	Sample	IAEA	FP	JCAC	KANSO	KEEA	MERI	TPT	Reference value
^{3}H	M-101	114 ± 14	–	126 ± 17	120 ± 14	108 ± 8	108 ± 20	–	114 ± 6
	M-102	90 ± 13	–	81 ± 15	63 ± 13	81 ± 8	100 ± 20	–	81 ± 6
	M-103	50 ± 11	–	58 ± 14	56 ± 13	67 ± 8	87 ± 20	–	61 ± 6
	M-104	63 ± 11	–	94 ± 16	63 ± 13	69 ± 8	81 ± 20	–	71 ± 6
	T-D1	70 ± 12	–	107 ± 16	48 ± 13	75 ± 8	108 ± 20	<340	80 ± 12
^{90}Sr	M-101	1.166 ± 0.067	1.12 ± 0.22	0.98 ± 0.14	0.93 ± 0.17	–	–	–	1.08 ± 0.06
	M-102	0.67 ± 0.041	<0.5	0.82 ± 0.13	0.75 ± 0.17	–	–	–	–
	M-103	0.889 ± 0.052	0.63 ± 0.19	0.63 ± 0.11	0.69 ± 0.16	–	–	–	0.74 ± 0.08
	M-104	0.633 ± 0.040	<0.5	0.76 ± 0.13	0.98 ± 0.18	–	–	–	–
	T-D1	0.708 ± 0.043	0.71 ± 0.20	0.94 ± 0.13	0.77 ± 0.17	–	–	1.46 ± 0.21	0.90 ± 0.14
^{134}Cs	M-101	1.037 ± 0.086	<2.0	<0.98	1.00 ± 0.24	–	<0.9	–	–
	M-102	<0.24	<2.2	<0.91	<0.7	–	<0.8	–	–
	M-103	0.301 ± 0.054	<1.7	<0.97	<0.7	–	<0.8	–	–
	M-104	0.201 ± 0.029	<2.0	<0.94	<0.7	–	<0.8	–	–
	T-D1	<0.26	<2.2	<0.96	<0.7	–	<0.9	<0.9	–
^{137}Cs	M-101	20.2 ± 1.2	19.96 ± 0.84	22.5 ± 1.2	20 ± 0.72	–	24.4 ± 1.8	–	21.1 ± 0.9
	M-102	4.57 ± 0.23	4.65 ± 0.54	4.91 ± 0.34	4.3 ± 0.24	–	5.7 ± 0.5	–	4.7 ± 0. 3
	M-103	6.52 ± 0.39	7.64 ± 0.62	6.72 ± 0.42	6.8 ± 0.32	–	8.6 ± 0.7	–	7.1 ± 0.4
	M-104	4.55 ± 0.22	4.26 ± 0.60	5.05 ± 0.35	4.1 ± 0.23	–	4.8 ± 0.4	–	4.5 ± 0.2
	T-D1	3.2 ± 0.18	3.73 ± 0.52	3.69 ± 0.28	2.9 ± 0.20	–	3.1 ± 0.3	4.50 ± 0.37	3.5 ± 0.3

TABLE 19. ILC 2020: RELATIVE DEGREES OF EQUIVALENCE (%) IN SEAWATER SAMPLES

Nuclide	Sample	IAEA	FP	JCAC	KANSO	KEEA	MERI	TPT
^{3}H	M-101	0 ± 28	–	11 ± 35	5 ± 29	-5 ± 16	-5 ± 43	–
	M-102	10 ± 35	–	-1 ± 43	-23 ± 38	0 ± 23	23 ± 60	–
	M-103	-19 ± 41	–	-6 ± 53	-9 ± 51	9 ± 31	42 ± 80	–
	M-104	-12 ± 36	–	32 ± 51	-12 ± 43	-3 ± 26	13 ± 68	–
	T-D1	-13 ± 47	–	34 ± 54	-40 ± 49	-6 ± 41	36 ± 65	DL
^{90}Sr	M-101	8 ± 14	3 ± 48	-10 ± 30	-14 ± 36	–	–	–
	M-102	Note 1	DL	Note 1	Note 1	–	–	–
	M-103	20 ± 27	-15 ± 60	-16 ± 37	-7 ± 49	–	–	–
	M-104	Note 2	DL	Note 2	Note 2	–	–	–
	T-D1	-21 ± 40	-21 ± 60	4 ± 49	-14 ± 54	–	–	**63 ± 63**
^{134}Cs	M-101	Note 3	DL	DL	Note 3	–	DL	–
	M-102	DL	DL	DL	DL	–	DL	–
	M-103	Note 4	DL	DL	DL	–	DL	–
	M-104	Note 4	DL	DL	DL	–	DL	–
	T-D1	DL	DL	DL	DL	–	DL	DL
^{137}Cs	M-101	-4 ± 16	-6 ± 13	6 ± 16	-5 ± 12	–	15 ± 22	–
	M-102	-4 ± 15	-2 ± 28	3 ± 19	-9 ± 16	–	20 ± 26	–
	M-103	-9 ± 17	7 ± 23	-6 ± 18	-5 ± 16	–	20 ± 25	–
	M-104	0 ± 13	-6 ± 33	11 ± 19	-10 ± 14	–	6 ± 22	–
	T-D1	-8 ± 21	7 ± 38	6 ± 25	-16 ± 21	–	-11 ± 26	**30 ± 29**

Note 1: Values of -1.09, -0.46 and 0.32 for $\zeta_{1,3}$, $\zeta_{1,4}$ and $\zeta_{3,4}$, respectively.
Note 2: Values of -0.94, -1.97 and -1.02 for $\zeta_{1,3}$, $\zeta_{1,4}$ and $\zeta_{3,4}$, respectively.
Note 3: Value of 0.15 for $\zeta_{1,4}$.
Note 4: No evaluation was possible as only one value above the detection limit was submitted.
DL: As a value less than the detection limit was submitted, no evaluation was performed.
$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FP, number 3 refers to JCAC, number 4 refers to KANSO, number 5 refers to KEEA, number 6 refers to MERI and number 7 refers to TPT.

6.3. SEDIMENT

TABLE 20. ILC 2017: ACTIVITY CONCENTRATIONS (Bq kg^{-1}-dry) IN SEDIMENT

Nuclide	Sample	IAEA	FP	JCAC	TPT	Reference value
^{134}Cs	F-P04	5.77 ± 0.13	5.42 ± 0.40	5.93 ± 0.51	–	–
	T-S3	1.850 ± 0.064	1.90 ± 0.26	2.54 ± 0.33	1.90 ± 0.16	1.98 ± 0.14
	T-S8	9.24 ± 0.17	9.46 ± 0.60	8.75 ± 0.62	8.98 ± 0.42	9.16 ± 0.17
^{137}Cs	F-P04	45.37 ± 0.70	47.0 ± 2.7	46.4 ± 2.4	–	–
	T-S3	14.38 ± 0.24	14.25 ± 0.91	15.5 ± 0.86	14.3 ± 0.49	14.47 ± 0.25
	T-S8	74.1 ± 1.2	80.3 ± 4.5	71.4 ± 3.64	74.1 ± 2.29	74.3 ± 1.4
^{238}Pu	F-P04	0.0081 ± 0.0026	0.0064 ± 0.0015	0.0025 ± 0.0015	–	–
	T-S3	0.0065 ± 0.0025	0.0055 ± 0.0011	0.0052 ± 0.0022	–	–
	T-S8	0.0070 ± 0.0017	0.0082 ± 0.0014	0.0056 ± 0.0019	–	–
^{239,240}Pu	F-P04	0.374 ± 0.019	0.403 ± 0.019	0.353 ± 0.016	–	–
	T-S3	0.387 ± 0.019	0.387 ± 0.017	0.403 ± 0.018	–	–
	T-S8	0.568 ± 0.018	0.618 ± 0.024	0.575 ± 0.023	–	–

TABLE 21. ILC 2017: RELATIVE DEGREES OF EQUIVALENCE (%) IN SEDIMENT SAMPLES

Nuclide	Sample	IAEA	FP	JCAC	TPT
^{134}Cs	F-P04	Note 1	Note 1	Note 1	–
	T-S3	–6 ± 19	–4 ± 32	29 ± 41	–4 ± 23
	T-S8	0.9 ± 4.2	3 ± 16	–4 ± 16	–2 ± 11
^{137}Cs	F-P04	Note 2	Note 2	Note 2	–
	T-S3	–0.6 ± 4.2	–2 ± 16	7 ± 15	–1.2 ± 7.9
	T-S8	–0.4 ± 4.4	8 ± 15	–4 ± 12	-0.3 ± 7.5
^{238}Pu	F-P04	Note 3	Note 3	Note 3	–
	T-S3	Note 4	Note 4	Note 4	–
	T-S8	Note 5	Note 5	Note 5	–
^{239,240}Pu	F-P04	Note 6	Note 6	Note 6	–
	T-S3	Note 7	Note 7	Note 7	–
	T-S8	Note 8	Note 8	Note 8	–

Note 1: Values of 0.85, -0.30 and -0.80 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
Note 2: Values of -0.58, -0.41 and 0.17 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
Note 3: Values of 0.57, 1.91 and 1.86 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
Note 4: Values of 0.36, 0.39 and 0.12 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
Note 5: Values of -0.55, 0.56 and 1.12 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
Note 6: Values of -1.10, 0.85 and 2.01 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
Note 7: Values of 0.00, -0.62 and -0.65 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
Note 8: Values of -1.69, -0.24 and 1.29 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FP, number 3 refers to JCAC and number 4 refers to TPT.

TABLE 22. ILC 2018: ACTIVITY CONCENTRATIONS (Bq kg^{-1}-dry) IN SEDIMENT

Nuclide	Sample	IAEA	FP	JCAC	KEEA	TPT	Reference value
^{134}Cs	F-P04	2.74 ± 0.19	4.1 ± 0.4	3.2 ± 0.4	–	3.9 ± 0.3	3.5 ± 0.4
	T-S3	1.04 ± 0.12	0.95 ± 0.30	1.1 ± 0.3	–	1.10 ± 0.13	1.1 ± 0.1
	T-S8	2.42 ± 0.14	2.2 ± 0.3	2.6 ± 0.4	–	2.47 ± 0.23	2.4 ± 0. 2
^{137}Cs	F-P04	29.7 ± 1.4	41.2 ± 2.3	35.2 ± 1.8	–	32.2 ± 1.1	34.4 ± 2.5
	T-S3	10.7 ± 0.5	10.7 ± 0.7	10.8 ± 0.6	–	12.1 ± 0.4	11.1 ± 0.4
	T-S8	26.2 ± 1.2	26.6 ± 1.5	27.7 ± 1.5	–	27.2 ± 1.0	26.9 ± 0.7
^{238}Pu	F-P04	0.0030 ± 0.0024	0.0047 ± 0.0011	<0.012	<0.012	–	–
	T-S3	0.0038 ± 0.0013	0.0035 ± 0.0011	0.01 ± 0.003	<0.012	–	–
	T-S8	0.0085 ± 0.0030	0.0070 ± 0.0016	<0.013	<0.011	–	–
$^{239,240}Pu$	F-P04	0.398 ± 0.022	0.376 ± 0.018	0.374 ± 0.024	0.39 ± 0.03	–	0.38 ± 0.02
	T-S3	0.382 ± 0.019	0.378 ± 0.020	0.384 ± 0.024	0.38 ± 0.03	–	0.38 ± 0.02
	T-S8	0.556 ± 0.026	0.564 ± 0.028	0.550 ± 0.030	0.52 ± 0.04	–	0.55 ± 0.02

TABLE 23. ILC 2018: RELATIVE DEGREES OF EQUIVALENCE (%) IN SEDIMENT SAMPLES

Nuclide	Sample	IAEA	FP	JCAC	KEEA	TPT
^{134}Cs	F-P04	-21 ± 26	19 ± 33	-7 ± 33	–	13 ± 29
	T-S3	-2 ± 25	-10 ± 67	4 ± 67	–	4 ± 27
	T-S8	0 ± 13	-9 ± 29	8 ± 39	–	2 ± 22
^{137}Cs	F-P04	-14 ± 20	20 ± 23	2 ± 21	–	-6 ± 20
	T-S3	-4 ± 12	-4 ± 16	-3 ± 14	–	9 ± 11
	T-S8	-2.6 ± 10	-1 ± 13	3 ± 13	–	0.9 ± 7.5
^{238}Pu	F-P04	Note 1	Note 1	DL	DL	–
	T-S3	Note 2	Note 2	Note 2	DL	–
	T-S8	Note 3	Note 3	DL	DL	–
^{239,240}Pu	F-P04	4 ± 13	-2 ± 11	-3 ± 15	2 ± 18	–
	T-S3	0 ± 12	-1 ± 12	1 ± 15	0 ± 19	–
	T-S8	1 ± 11	2 ± 12	0 ± 13	-6 ± 17	–

Note 1: Value of -0.67 for $\zeta_{1,2}$.
Note 2: Values of 0.15, -1.92 and 2.03 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.
Note 3: Value of 0.44 for $\zeta_{1,2}$.
DL: As a value less than the detection limit was submitted, no evaluation was performed.
$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FP, number 3 refers to JCAC, number 4 refers to KEEA and number 5 refers to TPT.

TABLE 24. ILC 2019: ACTIVITY CONCENTRATIONS (Bq kg^{-1}-dry) IN SEDIMENT

Nuclide	Sample	IAEA	FOCP	FP	HC	JCAC	KEEA	TPT	Reference value
^{134}Cs	F-P04	2.20 ± 0.12	2.50 ± 0.14	2.58 ± 0.38	1.99 ± 0.13	1.30 ± 0.38	–	2.03 ± 0.25	2.13 ± 0.17
	T-S3	0.468 ± 0.049	0.690 ± 0.055	<0.84	0.517 ± 0.051	0.87± 0.29	–	<0.63	0.59 ± 0.08
	T-S8	2.43 ± 0.14	2.41 ± 0.16	2.30 ± 0.32	2.16 ± 0.14	2.40 ± 0.38	–	3.02 ± 0.26	2.43 ± 0.15
^{137}Cs	F-P04	27.9 ± 1.2	33.4 ± 2.0	28.0 ± 1.3	29.1 ± 1.2	29.0 ± 1.5	–	27.60 ± 0.93	28.9 ± 0.8
	T-S3	7.44 ± 0.33	8.88 ± 0.54	7.50 ± 0.43	7.75 ± 0.33	7.80 ± 0.49	–	7.60 ± 0.38	7.75 ± 0.19
	T-S8	31.7 ± 1.4	30.9 ± 1.9	32.9 ± 1.5	30.2 ± 1.3	30.0 ± 1.6	–	31.8 ± 1.1	31.3 ± 0.6
^{238}Pu	F-P04	0.0078 ± 0.0022	<0.010	0.0072 ± 0.0015	<0.46	0.0059 ± 0.0015	<0.0082	–	–
	T-S3	0.0065 ± 0.0027	0.0120 ± 0.0035	0.0051 ± 0.0013	<0.46	0.0041 ± 0.0016	<0.0071	–	0.0062 ± 0.0016
	T-S8	0.0086 ± 0.0022	0.0140 ± 0.0055	0.0103 ± 0.0018	<0.26	0.0081 ± 0.0018	<0.013	–	0.0094 ± 0.0012
^{239,240}Pu	F-P04	0.422 ± 0.027	0.404 ± 0.006	0.399 ± 0.020	0.356 ± 0.067	0.412 ± 0.013	0.397 ± 0.029	–	0.405 ± 0.007
	T-S3	0.385 ± 0.025	0.394 ± 0.006	0.387 ± 0.019	0.403 ± 0.053	0.392 ± 0.013	0.359 ± 0.026	–	0.390 ± 0.006
	T-S8	0.568 ± 0.026	0.525 ± 0.008	0.559 ± 0.028	0.499 ± 0.065	0.550 ± 0.017	0.549 ± 0.048	–	0.537 ± 0.009

TABLE 25. ILC 2019: RELATIVE DEGREES OF EQUIVALENCE (%) IN SEDIMENT SAMPLES

Nuclide	Sample	IAEA	FOCP	FP	HC	JCAC	KEEA	TPT
^{134}Cs	F-P04	3 ± 24	17 ± 25	21 ± 46	-6 ± 24	-39 ± 46	–	-5 ± 32
	T-S3	-20 ± 36	18 ± 37	DL	-12 ± 37	49 ± 121	–	DL
	T-S8	0 ± 17	-1 ± 18	-5 ± 32	-11 ± 17	-1 ± 39	–	24 ± 27
^{137}Cs	F-P04	-3 ± 11	16 ± 18	-3 ± 12	1 ± 11	1 ± 14	–	-4.3 ± 9.3
	T-S3	-4 ± 11	15 ± 18	-3 ± 14	0 ± 11	1 ± 16	–	-2 ± 12
	T-S8	1 ± 10	-1 ± 15	5 ± 12	-3.7 ± 9.8	-4 ± 13	–	1.5 ± 7.6
^{238}Pu	F-P04	Note 1	DL	Note 1	DL	Note 1	DL	–
	T-S3	5 ± 106	93 ± 136	-18 ± 71	DL	-34 ± 77	DL	–
	T-S8	-9 ± 53	48 ± 142	9 ± 44	DL	-14 ± 44	DL	–
^{239,240}Pu	F-P04	4 ± 17	-0.2 ± 3.8	-1 ± 12	-12 ± 43	1.7 ± 7.8	-2 ± 18	–
	T-S3	-1 ± 16	1.0 ± 3.5	-1 ± 12	3 ± 35	0.4 ± 7.9	-8 ± 17	–
	T-S8	6 ± 12	-2.3 ± 3.7	4 ± 13	-7 ± 31	2.4 ± 7.6	2 ± 23	–

Note 1: Values of 0.22, 0.71 and 0.63 for $\zeta_{1,3}$, $\zeta_{1,5}$ and $\zeta_{3,5}$, respectively.

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

$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FOCP, number 3 refers to FP, number 4 refers to HC, number 5 refers to JCAC, number 6 refers to KEEA and number 7 refers to TPT.

TABLE 26. ILC 2020: ACTIVITY CONCENTRATIONS (Bq kg^{-1}-dry) IN SEDIMENT

Nuclide	Sample	IAEA	FP	JCAC	KEEA	TPT	Reference value
^{134}Cs	F-P04	2.5 ± 0.22	1.97 ± 0.41	2.90 ± 0.32	–	2.81 ± 0.29	2.57 ± 0.20
	T-S3	1.93 ± 0.12	2.25 ± 0.33	2.48 ± 0.27	–	1.83 ± 0.31	2.09 ± 0.15
	T-S8	3.48 ± 0.18	4.08 ± 0.43	3.49 ± 0.31	–	3.70 ± 0.44	3.61 ± 0.15
^{137}Cs	F-P04	55.7 ± 1.8	54.3 ± 3.1	58.4 ± 3.0	–	56.8 ± 1.8	56.3 ± 1.1
	T-S3	41.8 ± 1.4	46.7 ± 2.6	46.6 ± 2.4	–	46.3 ± 1.5	45.1 ± 1.3
	T-S8	75.7 ± 2.5	75.1 ± 4.2	75.8 ± 3.8	–	83.7 ± 2.5	77.9 ± 2.2
^{238}Pu	F-P04	0.0086 ± 0.0020	<0.010	0.0047 ± 0.0012	0.005 ± 0.001	–	–
	T-S3	0.0051 ± 0.0024	<0.014	0.0037 ± 0.0011	0.005 ± 0.002	–	–
	T-S8	0.0066 ± 0.0021	<0.011	0.0084 ± 0.0016	0.009 ± 0.002	–	–
^{239,240}Pu	F-P04	0.414 ± 0.020	0.389 ± 0.032	0.379 ± 0.012	0.410 ± 0.020	–	0.396 ± 0.010
	T-S3	0.393 ± 0.020	0.372 ± 0.035	0.384 ± 0.012	0.391 ± 0.019	–	0.386 ± 0.009
	T-S8	0.556 ± 0.023	0.549 ± 0.040	0.529 ± 0.015	0.530 ± 0.023	–	0.538 ± 0.011

TABLE 27. ILC 2020: RELATIVE DEGREES OF EQUIVALENCE (%) IN SEDIMENT SAMPLES

Nuclide	Sample	IAEA	FP	JCAC	KEEA	TPT
^{134}Cs	F-P04	-3 ± 24	-24 ± 38	13 ± 31	–	9 ± 28
	T-S3	-8 ± 19	8 ± 38	19 ± 31	–	-12 ± 35
	T-S8	-3 ± 11	13 ± 28	-3 ± 20	–	3 ± 29
^{137}Cs	F-P04	-1.1 ± 7.0	-4 ± 13	4 ± 13	–	0.9 ± 6.7
	T-S3	-7.3 ± 8.9	4 ± 14	3 ± 13	–	2.7 ± 9.1
	T-S8	-2.8 ± 8.9	-4 ± 13	-3 ± 12	–	7.4 ± 9.0
^{238}Pu	F-P04	Note 1	DL	Note 1	Note 1	–
	T-S3	Note 2	DL	Note 2	Note 2	–
	T-S8	Note 3	DL	Note 3	Note 3	–
^{239,240}Pu	F-P04	5 ± 12	-2 ± 19	-4.2 ± 7.1	4 ± 12	–
	T-S3	2 ± 12	-4 ± 22	-0.6 ± 6.8	1 ± 11	–
	T-S8	3.3 ± 9.2	2 ± 18	-1.7 ± 6.1	-1.5 ± 9.6	–

Note 1: Values of 1.68, 1.61 and -0.20 for $\zeta_{1,3}$, $\zeta_{1,4}$ and $\zeta_{3,4}$, respectively.

Note 2: Values of 0.54, 0.03 and -0.57 for $\zeta_{1,3}$, $\zeta_{1,4}$ and $\zeta_{3,4}$, respectively.

Note 3: Values of -0.69, -0.84 and -0.24 for $\zeta_{1,3}$, $\zeta_{1,4}$ and $\zeta_{3,4}$, respectively.

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

$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FP, number 3 refers to JCAC, number 4 refers to KEEA and number 5 refers to TPT.

6.4. FISH

TABLE 28. ILC 2017: ACTIVITY CONCENTRATIONS (Bq kg^{-1}-wet) IN FISH

Nuclide	Sample number: Species	IAEA	JCAC	JFFIC	MERI	Reference value
^{134}Cs	17FA0001: Sea robin	0.218 ± 0.027	<0.49	<0.57	0.49 ± 0.14	—
	17FA0002: Yellow-striped flounder	0.243 ± 0.026	<0.50	<0.49	<0.48	—
	17FA0003: Olive flounder	<0.079	<0.51	<0.54	<0.32	—
	17FA0004: Olive flounder	<0.062	<0.58	<0.51	<0.32	—
	17FA0005: Ocellate spot skate	0.551 ± 0.032	<0.51	<0.57	0.42 ± 0.11	—
	17FA0006: Ocellate spot skate	0.523 ± 0.026	0.49 ± 0.17	<0.52	0.66 ± 0.11	—
^{137}Cs	17FA0001: Sea Robin	1.639 ± 0.054	1.58 ± 0.23	1.75 ± 0.26	1.61 ± 0.21	1.64 ± 0.06
	17FA0002: Yellow-striped flounder	1.543 ± 0.063	1.63 ± 0.25	1.82 ± 0.24	1.83 ± 0.23	1.62 ± 0.07
	17FA0003: Olive flounder	0.586 ± 0.033	0.84 ± 0.18	0.60 ± 0.19	0.56 ± 0.13	0.60 ± 0.05
	17FA0004: Olive flounder	0.591 ± 0.027	<0.46	<0.58	0.65 ± 0.11	—
	17FA0005: Ocellate spot skate	4.05 ± 0.11	3.90 ± 0.37	4.11 ± 0.37	4.23 ± 0.34	4.07 ± 0.11
	17FA0006: Ocellate spot skate	3.967 ± 0.099	4.42 ± 0.40	3.75 ± 0.33	4.02 ± 0.26	3.99 ± 0.12

TABLE 29. ILC 2017: RELATIVE DEGREES OF EQUIVALENCE (%) IN FISH SAMPLES

Nuclide	Sample: Species	IAEA	JCAC	JFFIC	MERI
^{134}Cs	17FA0001: Sea robin	Note 1	DL	DL	Note 1
	17FA0002: Yellow-striped flounder	Note 2	DL	DL	DL
	17FA0003: Olive flounder	DL	DL	DL	DL
	17FA0004: Olive flounder	DL	DL	DL	DL
	17FA0005: Ocellate spot skate	Note 3	DL	DL	Note 3
	17FA0006: Ocellate spot skate	Note 4	Note 4	DL	Note 4
^{137}Cs	17FA0001: Sea robin	0.0 ± 7.2	–4 ± 33	7 ± 37	–2 ± 30
	17FA0002: Yellow-striped flounder	–4.9 ± 9.4	0 ± 36	12 ± 34	13 ± 33
	17FA0003: Olive flounder	–3 ± 18	40 ± 72	–1 ± 76	–8 ± 48
	17FA0004: Olive flounder	Note 5	DL	DL	Note 5
	17FA0005: Ocellate spot skate	-0.3 ± 5.9	–4 ± 21	1 ± 21	4 ± 19
	17FA0006: Ocellate spot skate	–0.7 ± 6.7	11 ± 24	–6 ± 20	1 ± 15

Note 1: Value of -1.94 for $\zeta_{1,4}$.

Note 2: No evaluation was possible as only one value above the detection limit was submitted.

Note 3: Value of 1.17 for $\zeta_{1,4}$.

Note 4: Values of 0.17, -1.26 and -0.83 for $\zeta_{1,2}$, $\zeta_{1,4}$ and $\zeta_{2,4}$, respectively.

Note 5: Value of -0.57 for $\zeta_{1,4}$.

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

$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to JCAC, number 3 refers to JFFIC and number 4 refers to MERI.

TABLE 30. ILC 2018: ACTIVITY CONCENTRATIONS (Bq kg^{-1}-wet) IN FISH

Nuclide	Sample number: Species	IAEA	FRA	MERI	TRK	Reference value
^{134}Cs	18FA0001: Ocellate spot skate	0.241 ± 0.041	<0.47	<0.31	<0.37	—
	18FA0002: Redwing sea robin	0.114 ± 0.036	<0.39	<0.28	<0.40	—
	18FA0003: Crimson sea bream	<0.076	<0.46	<0.55	<0.40	–
	18FA0004: Marbled sole	0.104 ± 0.034	<0.47	<0.34	<0.37	—
	18FA0005: Olive flounder	0.049 ± 0.017	<0.48	<0.42	<0.42	–
	18FA0006: Shotted halibut	0.116 ± 0.025	<0.38	<0.49	<0.45	—
^{137}Cs	18FA0001: Ocellate spot skate	2.64 ± 0.16	2.88 ± 0.29	2.69 ± 0.21	2.66 ± 0.23	2.70 ± 0.11
	18FA0002: Redwing sea robin	1.31 ± 0.09	1.45 ± 0.20	1.39 ± 0.16	1.39 ± 0.19	1.37 ± 0.07
	18FA0003: Crimson sea bream	0.53 ± 0.11	0.63 ± 0.18	0.57 ± 0.16	<0.47	–
	18FA0004: Marbled sole	1.57 ± 0.10	1.43 ± 0.22	1.62 ± 0.17	1.66 ± 0.19	1.58 ± 0.09
	18FA0005: Olive flounder	0.514 ± 0.046	0.51 ± 0.17	<0.48	0.47 ± 0.14	–
	18FA0006: Shotted halibut	1.16 ± 0.70	1.33 ± 0.18	1.54 ± 0.25	1.12 ± 0.19	1.23 ± 0.08

TABLE 31. ILC 2018: RELATIVE DEGREES OF EQUIVALENCE (%) IN FISH SAMPLES

Nuclide	Sample: Species	IAEA	FRA	MERI	TRK
^{134}Cs	18FA001: Ocellate spot skate	Note 1	DL	DL	DL
	18FA002: Redwing sea robin	Note 1	DL	DL	DL
	18FA003: Crimson sea bream	DL	DL	DL	DL
	18FA004: Marbled sole	Note 1	DL	DL	DL
	18FA005: Olive flounder	Note 1	DL	DL	DL
	18FA006: Shotted halibut	Note 1	DL	DL	DL
^{137}Cs	18FA001: Ocellate spot skate	-2 ± 14	7 ± 24	0 ± 18	-1 ± 19
	18FA002: Redwing sea robin	-4 ± 15	6 ± 33	2 ± 26	2 ± 31
	18FA003: Crimson sea bream	Note 2	Note 2	Note 2	DL
	18FA004: Marbled sole	0 ± 16	-9 ± 33	3 ± 24	5 ± 28
	18FA005: Olive flounder	Note 3	Note 3	DL	Note 3
	18FA006: Shotted halibut	-6 ± 16	8 ± 34	25 ± 48	-9 ± 36

Note 1: No evaluation was possible as only one value above the detection limit was submitted.

Note 2: Values of -0.47, -0.17, and 0.26 for $\zeta_{1,2}$, $\zeta_{1,3}$ and $\zeta_{2,3}$, respectively.

Note 3: Values of 0.01, 0.29 and 0.18 for $\zeta_{1,2}$, $\zeta_{1,4}$ and $\zeta_{2,4}$, respectively.

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

$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FRA, number 3 refers to MERI and number 4 refers to TRK.

TABLE 32. ILC 2019: ACTIVITY CONCENTRATIONS (Bq kg^{-1}-wet) IN FISH

Nuclide	Sample number: Species	IAEA	FOCP	HC	KANSO	KEEA	MERI	Reference value
^{134}Cs	19FA0001: Whitespotted conger	<0.079	<0.17	<0.10	<0.33	<0.32	<0.39	–
	19FA0002: Willowy flounder	0.065 ± 0.020	<0.17	<0.09	<0.37	<0.35	<0.56	–
	19FA0003: Olive Flounder	<0.098	<0.13	<0.09	<0.30	<0.29	<0.43	–
	19FA0004: Slime Flounder	0.059 ± 0.014	<0.17	<0.08	<0.35	<0.33	<0.29	–
	19FA0005: Shotted Halibut	<0.092	<0.17	<0.08	<0.32	<0.26	<0.29	–
	19FA0006: Stone flounder	0.071 ± 0.013	<0.14	0.072 ± 0.017	<0.40	<0.32	<0.30	–
^{137}Cs	19FA0001: Whitespotted conger	0.337 ± 0.033	0.31 ± 0.035	0.270 ± 0.029	<0.32	0.42 ± 0.10	<0.49	0.32 ± 0.03
	19FA0002: Willowy flounder	0.782 ± 0.055	0.76 ± 0.055	0.699 ± 0.039	0.94 ± 0.15	0.99 ± 0.15	0.98 ± 0.20	0.80 ± 0.05
	19FA0003: Olive Flounder	0.482 ± 0.042	0.53 ± 0.040	0.273 ± 0.021	0.40 ± 0.12	0.86 ± 0.14	0.66 ± 0.15	0.52 ± 0.09
	19FA0004: Slime Flounder	0.938 ± 0.053	0.91 ± 0.065	0.832 ± 0.048	0.48 ± 0.13	0.91 ± 0.14	0.96 ± 0.14	0.85 ± 0.07
	19FA0005: Shotted Halibut	0.565 ± 0.039	0.58 ± 0.045	0.474 ± 0.033	0.65 ± 0.14	0.54 ± 0.13	0.45 ± 0.12	0.53 ± 0.03
	19FA0006: Stone flounder	0.931 ± 0.048	0.89 ± 0.065	0.814 ± 0.039	0.99 ± 0.15	1.16 ± 0.16	0.86 ± 0.12	0.90 ± 0.04

TABLE 33. ILC 2019: RELATIVE DEGREES OF EQUIVALENCE (%) IN FISH SAMPLES

Nuclide	Sample: Species	IAEA	FOCP	HC	KANSO	KEEA	MERI
^{134}Cs	19FA0001: Whitespotted conger	DL	DL	DL	DL	DL	DL
	19FA0002: Willowy flounder	Note 1	DL	DL	DL	DL	DL
	19FA0003: Olive Flounder	DL	DL	DL	DL	DL	DL
	19FA0004: Slime Flounder	Note 1	DL	DL	DL	DL	DL
	19FA0005: Shotted Halibut	DL	DL	DL	DL	DL	DL
	19FA0006: Stone flounder	Note 2	DL	Note 2	DL	DL	DL
^{137}Cs	19FA0001: Whitespotted conger	7 ± 27	-2 ± 29	-14 ± 26	DL	33 ± 74	DL
	19FA0002: Willowy flounder	-2 ± 20	-5 ± 20	-12 ± 17	18 ± 45	24 ± 46	23 ± 63
	19FA0003: Olive Flounder	-7 ± 44	3 ± 44	**-47 ± 42**	-22 ± 65	67 ± 72	28 ± 73
	19FA0004: Slime Flounder	11 ± 25	8 ± 27	-2 ± 24	**-44 ± 39**	8 ± 41	13 ± 41
	19FA0005: Shotted Halibut	6 ± 18	9 ± 21	-11 ± 16	21 ± 64	1 ± 60	-15 ± 55
	19FA0006: Stone flounder	3 ± 15	-1 ± 19	-10 ± 14	10 ± 41	29 ± 45	-5 ± 33

Note 1: No evaluation was possible as only one value above the detection limit was submitted.

Note 2: Value of -0.03 for $\zeta_{1,3}$.

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

$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to FOCP, number 3 refers to HC, number 4 refers to KANSO, number 5 refers to KEEA and number 6 refers to MERI.

TABLE 34. ILC 2020: ACTIVITY CONCENTRATIONS (Bq kg^{-1}-wet) IN FISH

Nuclide	Sample number: Species	IAEA	JFRL	MERI	SKC	Reference value
^{134}Cs (1h)	20FA0001: Olive flounder	<0.79	<0.33	<0.28	<0.42	–
	20FA0002: Stone flounder	<0.77	<0.36	<0.30	<0.40	–
	20FA0003: Crimson sea bream	<0.76	<0.39	<0.30	<0.41	–
	20FA0004: Redwing sea robin	<0.63	<0.42	<0.27	<0.41	–
	20FA0005: Whitespotted conger	<0.72	<0.37	<0.25	<0.38	–
	20FA0006: Shotted halibut	<0.82	<0.35	<0.30	<0.43	–
^{134}Cs (24h)	20FA0001: Olive flounder	<0.12	<0.064	<0.056	<0.072	–
	20FA0002: Stone flounder	<0.14	<0.064	0.055 ± 0.012	<0.065	–
	20FA0003: Crimson sea bream	<0.12	<0.059	<0.049	<0.071	–
	20FA0004: Redwing sea robin	<0.13	<0.064	<0.046	<0.067	–
	20FA0005: Whitespotted conger	<0.11	<0.059	<0.047	<0.062	–
	20FA0006: Shotted halibut	<0.14	0.066 ± 0.019	0.066 ± 0.014	<0.074	–
^{137}Cs (1h)	20FA0001: Olive flounder	0.76 ± 0.18	0.99 ± 0.16	0.99 ± 0.14	0.82 ± 0.14	0.90 ± 0.08
	20FA0002: Stone flounder	<0.98	1.10 ± 0.16	1.04 ± 0.14	1.06 ± 0.15	–
	20FA0003: Crimson sea bream	0.77 ± 0.16	0.78 ± 0.16	0.85 ± 0.12	0.47 ± 0.16	0.73 ± 0.09
	20FA0004: Redwing sea robin	0.53 ± 0.18	0.74 ± 0.15	0.74 ± 0.13	0.57 ± 0.15	0.66 ± 0.08
	20FA0005: Whitespotted conger	<0.66	0.37 ± 0.12	0.545 ± 0.092	0.49 ± 0.13	–
	20FA0006: Shotted halibut	0.69 ± 0.20	0.97 ± 0.15	0.90 ± 0.13	1.19 ± 0.15	0.95 ± 0.10
^{137}Cs (24h)	20FA0001: Olive flounder	0.886 ± 0.052	0.943 ± 0.041	0.905 ± 0.035	0.904 ± 0.029	0.910 ± 0.019
	20FA0002: Stone flounder	1.054 ± 0.075	1.029 ± 0.043	0.983 ± 0.037	1.020 ± 0.030	1.016 ± 0.020
	20FA0003: Crimson sea bream	0.749 ± 0.046	0.772 ± 0.037	0.751 ± 0.031	0.751 ± 0.027	0.755 ± 0.017
	20FA0004: Redwing sea robin	0.674 ± 0.061	0.734 ± 0.036	0.758 ± 0.031	0.763 ± 0.027	0.743 ± 0.019
	20FA0005: Whitespotted conger	0.386 ± 0.031	0.415 ± 0.028	0.439 ± 0.022	0.418 ± 0.023	0.415 ± 0.037
	20FA0006: Shotted halibut	1.060 ± 0.069	0.942 ± 0.041	0.924 ± 0.036	0.937 ± 0.029	0.951 ± 0.026

TABLE 35. ILC 2020: RELATIVE DEGREES OF EQUIVALENCE (%) IN FISH SAMPLES

Nuclide	Sample: Species	IAEA	JFRL	MERI	SKC
^{134}Cs (1h)	20FA0001: Olive flounder	DL	DL	DL	DL
	20FA0002: Stone flounder	DL	DL	DL	DL
	20FA0003: Crimson sea bream	DL	DL	DL	DL
	20FA0004: Redwing sea robin	DL	DL	DL	DL
	20FA0005: Whitespotted conger	DL	DL	DL	DL
	20FA0006: Shotted halibut	DL	DL	DL	DL
^{134}Cs (24h)	20FA0001: Olive flounder	DL	DL	DL	DL
	20FA0002: Stone flounder	DL	DL	Note 1	DL
	20FA0003: Crimson sea bream	DL	DL	DL	DL
	20FA0004: Redwing sea robin	DL	DL	DL	DL
	20FA0005: Whitespotted conger	DL	DL	DL	DL
	20FA0006: Shotted halibut	DL	Note 2	Note 2	DL
^{137}Cs (1h)	20FA0001: Olive flounder	-15 ± 45	10 ± 40	11 ± 33	-9 ± 33
	20FA0002: Stone flounder	DL	Note 3	Note 3	Note 3
	20FA0003: Crimson sea bream	5 ± 52	8 ± 51	18 ± 41	-35 ± 50
	20FA0004: Redwing sea robin	-19 ± 60	12 ± 50	13 ± 42	-13 ± 50
	20FA0005: Whitespotted conger	DL	Note 4	Note 4	Note 4
	20FA0006: Shotted halibut	-27 ± 49	2 ± 40	-5 ± 35	25 ± 39
^{137}Cs (24h)	20FA0001: Olive flounder	-3 ± 14	4 ± 11	-0.5 ± 8.5	-0.7 ± 6.9
	20FA0002: Stone flounder	4 ± 18	1.3 ± 9.4	-3.2 ± 8.0	0.4 ± 6.4
	20FA0003: Crimson sea bream	-1 ± 14	2 ± 12	-0.6 ± 9.0	-0.6 ± 7.8
	20FA0004: Redwing sea robin	-9 ± 20	-1 ± 12	2 ± 9.5	2.6 ± 8.3
	20FA0005: Whitespotted conger	-7 ± 27	0 ± 26	6 ± 25	1 ± 25
	20FA0006: Shotted halibut	11 ± 18	-1 ± 11	-2.9 ± 9.3	-1.5 ± 8.2

Note 1: No evaluation was possible as only one value above the detection limit was submitted.

Note 2: Value of 0.21 for $\zeta_{2,3}$.

Note 3: Values of -0.47, -0.17, and 0.26 for $\zeta_{2,3}$, $\zeta_{2,4}$ and $\zeta_{3,4}$, respectively.

Note 4: Values of 0.01, 0.29 and 0.18 for $\zeta_{2,3}$, $\zeta_{2,4}$ and $\zeta_{3,4}$, respectively.

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

$\zeta_{i,j}$ indexes: number 1 refers to IAEA, number 2 refers to JFRL, number 3 refers to MERI and number 4 refers to SKC.

7. CONCLUSION

For each ILC, a detailed data analysis was performed on the activity concentrations reported for ^{3}H, ^{90}Sr, ^{134}Cs and ^{137}Cs in five seawater samples, for ^{134}Cs, ^{137}Cs, ^{238}Pu and ^{239,240}Pu in three sediment samples and for ^{134}Cs and ^{137}Cs in six fish samples. All samples were collected offshore Fukushima Daiichi Nuclear Power Station between 2017 and 2020 and shared between participating laboratories.

From these analyses it can be concluded that the majority of results for each ILC are not significantly different from each other. A global analysis of the results from all four ILCs demonstrated that 597 out of the 613 statistical tests applied to the data, i.e. over 97% were passed with a high level of confidence (99%).

For ILC 2017, an analysis of all results demonstrated that 115 out of the 122 statistical tests applied to the data, i.e. over 94% were passed with a high level of confidence (99%). The only exceptions were four zeta scores that were just marginally higher than the critical limit of 2.58:

$\zeta = 2.68$ for the ^{3}H activity concentration in seawater from M-103 between IAEA and JCAC.
$\zeta = 2.82$ for the ^{134}Cs activity concentration in seawater from M-101 between KANSO and JCAC.
$\zeta = 2.86$ for the ^{134}Cs activity concentration in seawater from M-101 between IAEA and JCAC.
$\zeta = 2.62$ for the ^{137}Cs activity concentration in seawater from M-102 between KANSO and JCAC.

and three zeta scores that were clearly higher than the critical value:

$\zeta = 3.11$ for the ^{3}H activity concentration in seawater from M-102 between GSL and JCAC.
$\zeta = 6.55$ for the ^{137}Cs activity concentration in seawater from M-101 between IAEA and JCAC.
$\zeta = 7.14$ for the ^{137}Cs activity concentration in seawater from M-101 between KANSO and JCAC.

For ILC 2018, an analysis of all results identified just one discrepant value from the 138 statistical tests applied to the data, i.e. over 99% were passed with a high level of confidence (99%). The only exception was one case where a relative DoE was significantly different from zero:

DoE (%) = 38 ± 38 for the ^{137}Cs activity concentration in the seawater sample from T-D1 submitted by FP.

For ILC 2019, an analysis of all results demonstrated that there were just six discrepant values, two received from Japanese laboratories, from the 190 statistical tests applied to the data. That is, over 96% of the results reported were passed with a high level of confidence (99%). The exceptions were the following cases where the relative DoE was significantly different from zero.

DoE (%) = 101 ± 63 for the ^{90}Sr activity concentration in the seawater sample from M-102 submitted by HC.
DoE (%) = 52 ± 52 for the ^{90}Sr activity concentration in the seawater sample from M-103 submitted by HC.

DoE (%) = 59 ± 54 for the ^{90}Sr activity concentration in the seawater sample from T-D1 submitted by HC.
DoE (%) = 24 ± 20 for the ^{137}Cs activity concentration in the seawater sample from M-101 submitted by JCAC.
DoE (%) = -47 ± 42 for the ^{137}Cs activity concentration in fish sample FA190003 submitted by HC.
DoE (%) = -44 ± 39 for the ^{137}Cs activity concentration in fish sample FA190004 submitted by KANSO.

For ILC 2020, an analysis of all results demonstrated that there were just two discrepant values from the 163 statistical tests applied to the data, i.e. over 98% were passed with a high level of confidence (99%). The exceptions were the following cases where the relative DoE was significantly different from zero:

DoE (%) = 63 ± 63 for the ^{90}Sr activity concentration in the seawater sample from T-D1 submitted by TPT.
DoE (%) = 30 ± 29 for the ^{137}Cs activity concentration in the seawater sample from T-D1 submitted by TPT.

Given the small number of cases where discrepant or significantly different results were reported (less than 3%), on the basis of these ILCs it can be said with confidence that the participating Japanese laboratories continue to report reliable and comparable results for the tested radionuclides in seawater, sediment and fish samples prepared and analysed according to each laboratory’s regularly used methods.

Following these ILCs, the IAEA can confidently report that Japan's sample collection procedures follow the appropriate methodological standards required to obtain representative samples. The results obtained demonstrate a continued high level of accuracy and competence on the part of the Japanese laboratories involved in the analyses of radionuclides in marine samples for the Sea Area Monitoring Plan.

APPENDIX I. SEAWATER SAMPLE DISTRIBUTION

As described in section 3.2, seawater samples were collected from each seawater sampling location (M-101, M-102, M-103, M-104 and T-D1) for subsequent analysis for ^{90}Sr, ^{134}Cs and ^{137}Cs and, separately, for ^{3}H.

For ^{90}Sr, ^{134}Cs and ^{137}Cs, the basic collection and distribution methods at each sampling location were:

- A 400 L plastic container with four valves was first filled with seawater.
- Separate 20 L cubitainers were filled simultaneously from each of the four valves.
- Each sample was acidified to pH 1–2 with concentrated HCl.
- Three 20 L samples were normally provided to each participating laboratory.

For ^{3}H, the basic sample collection and distribution methods were:

- From the same 400 L plastic container from which the samples to be analysed for ^{90}Sr, ^{134}Cs and ^{137}Cs were taken, separate 2 L containers were filled from each of the four valves.
- One 2 L sample was provided to each participating laboratory.

I.1. ILC 2017

For ILC 2017, seawater samples were collected on 16 and 17 October 2017 from each sampling location.

Three laboratories planned to participate in the analyses for ^{90}Sr, ^{134}Cs and ^{137}Cs. The sub-sampling of seawater from the four valves of the 400 L plastic container and the distribution matrix is shown in Table 36.

For ^{3}H, four laboratories planned to participate. In this case one 2 L bottle was filled from each one of the four valves of the 400 L plastic container.

I.2. ILC 2018

For ILC 2018, seawater samples were collected on 9 and10 October 2018 from each sampling location.

I.2.1. Sampling locations M-101, M-102, M-103 and M-104

Four laboratories planned to participate in the analyses for ^{90}Sr, ^{134}Cs and ^{137}Cs from sampling locations M-101, M-102, M-103 and M-104. The sub-sampling of seawater from the four valves of the 400 L plastic container and the distribution matrix is shown in Table 37.

For ^{3}H, six laboratories planned to participate. The sub-sampling of seawater from the 400 L plastic container and the distribution matrix is shown in Table 38.

I.2.2. Sampling location T-D1

Five laboratories planned to participate in the analyses for ^{90}Sr, ^{134}Cs and ^{137}Cs from sampling location T-D1. Two separate fills of the 400 L container were required to facilitate provision of the required sample volume to all participants. (This container cannot be filled to full capacity on board the sampling vessel.). Otherwise the sub-sampling method was essentially the same as described above for locations M-101, M-102, M-103 and M-104. The distribution method is shown in Table 39.

For ^{3}H, the laboratories participating in the analysis of the sample collected at T-D1 were the same as for the other sampling locations. Therefore, the sub-sampling and distribution methods were identical to those described above.

I.3. ILC 2019

For ILC 2019, seawater samples were collected between 3 and 5 June 2019 from each sampling location.

I.3.1. Samples M-101, M-102, M-103 and M-104

Six laboratories planned to participate in the analyses for ^{90}Sr, ^{134}Cs and ^{137}Cs from sampling locations M-101, M-102, M-103 and M-104. The sub-sampling of seawater from the four valves of the 400 L plastic container and the distribution matrix is shown in Table 40.

For ^{3}H, eight laboratories planned to participate. The sub-sampling of seawater from the 400 L plastic container and the distribution matrix is shown in Table 41.

I.3.2. Sample T-D1

Seven laboratories planned to participate in the analyses for ^{90}Sr, ^{134}Cs and ^{137}Cs from sampling location T-D1. Two separate fills of the 400 L container were required to facilitate provision of the required sample volume to all participants. Otherwise the sub-sampling method was essentially the same as described above for locations M-101, M-102, M-103 and M-104. The distribution method is shown in Table 42.

For ^{3}H, the laboratories participating in the analysis of the sample collected at T-D1 were the same as for the other sampling locations. Therefore, the sub-sampling and distribution methods were identical to those described above.

I.4. ILC 2020

For ILC 2020, seawater samples were collected between 4 and 6 November 2020 from each sampling location for subsequent analysis for ^{90}Sr, ^{134}Cs and ^{137}Cs and, separately, for ^{3}H.

I.4.1. Samples M-101, M-102, M-103 and M-104

Four laboratories planned to participate in the analyses for ^{90}Sr from sampling locations M-101, M-102, M-103 and M-104. For ^{134}Cs and ^{137}Cs, five laboratories planned to participate. Two separate fills of the 400 L container were required to facilitate provision of the required sample volume to all participants. The sub-sampling of seawater from the four valves of the 400 L plastic container and the distribution matrix is shown in Table 43.

For ^{3}H, six laboratories planned to participate. The sub-sampling of seawater from the 400 L plastic container and the distribution matrix is shown in Table 44.

I.4.2. Sample T-D1

Five laboratories planned to participate in the analyses for ^{90}Sr from sampling location T-D1. For ^{134}Cs and ^{137}Cs, six laboratories planned to participate. The collection method was essentially the same as described above for locations M-101, M-102, M-103 and M-104. The distribution method is shown in Table 45.

For ^{3}H, seven laboratories planned to participate in the analyses. The sub-sampling of seawater from the 400 L plastic container and the distribution matrix is shown in Table 46.

TABLE 36. ILC 2017: SAMPLE DISTRIBUTION BETWEEN THREE LABORATORIES (^{90}Sr, ^{134}Cs AND ^{137}Cs)

Valve number	1	2	3	4
Seawater sample codes	1-1 1-2 1-3	2-1 2-2 2-3	3-1 3-2 3-3	Not used
Distribution pattern of the participating laboratories coded A, B, and C	A 1-1 2-2 3-3	B 2-1 3-2 1-3	C 3-1 1-2 2-3	–

TABLE 37. ILC 2018: SAMPLE DISTRIBUTION BETWEEN FOUR LABORATORIES (^{90}Sr, ^{134}Cs AND ^{137}Cs)

Valve number	1	2	3	4
Seawater sample codes	1-1	2-1	3-1	4-1
	1-2	2-2	3-2	4-2
	1-3	2-3	3-3	4-3
Distribution pattern of the participating laboratories coded A, B, C and D	A	B	C	D
	1-1	2-1	3-1	4-1
	2-2	3-2	4-2	1-2
	3-3	4-3	1-3	2-3

TABLE 38. ILC 2018: SAMPLE DISTRIBUTION BETWEEN SIX LABORATORIES (^{3}H)

<table>
<tr><td>Valve number</td><td colspan="3">1</td><td colspan="3">2</td><td colspan="3">3</td><td colspan="3">4</td></tr>
<tr><td rowspan="2">Seawater sample codes</td><td colspan="3">1-1</td><td colspan="3">2-1</td><td colspan="3">3-1</td><td colspan="3" rowspan="2">Not used</td></tr>
<tr><td colspan="3">1-2</td><td colspan="3">2-2</td><td colspan="3">3-2</td></tr>
<tr><td rowspan="2">Distribution pattern of the participating laboratories coded A, B, C, D, E and F</td><td colspan="2">A</td><td colspan="2">B</td><td colspan="2">C</td><td colspan="2">D</td><td colspan="2">E</td><td colspan="2">F</td></tr>
<tr><td colspan="2">1-1</td><td colspan="2">2-1</td><td colspan="2">3-1</td><td colspan="2">1-2</td><td colspan="2">2-2</td><td colspan="2">3-2</td></tr>
</table>

TABLE 39. ILC 2018: SAMPLE DISTRIBUTION BETWEEN FIVE LABORATORIES (^{90}Sr, ^{134}Cs AND ^{137}Cs)

<table>
<tr><td>Valve number</td><td colspan="5">1</td><td colspan="5">2</td><td colspan="5">3</td><td colspan="5">4</td></tr>
<tr><td rowspan="4">Seawater sample codes</td><td colspan="5">1-1</td><td colspan="5">2-1</td><td colspan="5">3-1</td><td colspan="5">4-1</td></tr>
<tr><td colspan="5">1-2</td><td colspan="5">2-2</td><td colspan="5">3-2</td><td colspan="5">4-2</td></tr>
<tr><td colspan="5">1-3</td><td colspan="5">2-3</td><td colspan="5">3-3</td><td colspan="5">4-3</td></tr>
<tr><td colspan="5">1-4</td><td colspan="5">2-4</td><td colspan="5">3-4</td><td colspan="5">Not used</td></tr>
<tr><td rowspan="4">Distribution pattern of the participating laboratories coded A, B, C, D and E</td><td colspan="4">A</td><td colspan="4">B</td><td colspan="4">C</td><td colspan="4">D</td><td colspan="4">E</td></tr>
<tr><td colspan="4">1-1</td><td colspan="4">2-1</td><td colspan="4">3-1</td><td colspan="4">4-1</td><td colspan="4">1-2</td></tr>
<tr><td colspan="4">2-2</td><td colspan="4">3-2</td><td colspan="4">4-2</td><td colspan="4">1-3</td><td colspan="4">2-3</td></tr>
<tr><td colspan="4">3-3</td><td colspan="4">4-3</td><td colspan="4">1-4</td><td colspan="4">2-4</td><td colspan="4">3-4</td></tr>
</table>

TABLE 40. ILC 2019: SAMPLE DISTRIBUTION BETWEEN SIX LABORATORIES (^{90}Sr, ^{134}Cs AND ^{137}Cs)

Valve number	1	2	3	4
Seawater sample codes	1-1-1	1-2-1	1-3-1	1-4-1
	1-1-2	1-2-2	Not used	
	2-1-1	2-2-1	2-3-1	2-4-1
	2-1-2	2-2-2	Not used	
	3-1-1	3-2-1	3-3-1	3-4-1
	3-1-2	3-2-2	Not used	

Distribution pattern of the participating laboratories coded A, B, C, D, E and F	A	B	C	D	E	F
	1-1-1	1-2-1	1-3-1	1-4-1	1-1-2	1-2-2
	2-1-1	2-2-1	2-3-1	2-4-1	2-1-2	2-2-2
	3-1-1	3-2-1	3-3-1	3-4-1	3-1-2	3-2-2

TABLE 41. ILC 2019: SAMPLE DISTRIBUTION BETWEEN EIGHT LABORATORIES (^{3}H)

Valve number	1	2	3	4
Seawater sample codes	1-1-1	1-2-1	1-3-1	1-4-1
	1-1-2	1-2-2	1-3-2	1-4-2

Distribution pattern of the participating laboratories coded A, B, C, D, E, F, G and H	A	B	C	D	E	F	G	H
	1-1-1	1-2-1	1-3-1	1-4-1	1-1-2	1-2-2	1-3-2	1-4-2

TABLE 42. ILC 2019: SAMPLE DISTRIBUTION BETWEEN SEVEN LABORATORIES (^{90}Sr, ^{134}Cs AND ^{137}Cs)

Valve number	1	2	3	4
Seawater sample codes	1-1-1	1-2-1	1-3-1	1-4-1
	1-1-2	1-2-2	1-3-2	Not used
	2-1-1	2-2-1	2-3-1	2-4-1
	2-1-2	2-2-2	2-3-2	Not used
	3-1-1	3-2-1	3-3-1	3-4-1
	3-1-2	3-2-2	3-3-2	Not used

Distribution pattern of the participating laboratories coded A, B, C, D, E, F and G	A	B	C	D	E	F	G
	1-1-1	1-2-1	1-3-1	1-4-1	1-1-2	1-2-2	1-3-2
	2-1-1	2-2-1	2-3-1	2-4-1	2-1-2	2-2-2	2-3-2
	3-1-1	3-2-1	3-3-1	3-4-1	3-1-2	3-2-2	3-3-2

TABLE 43. ILC 2020: SAMPLE DISTRIBUTION BETWEEN FOUR LABORATORIES (^{90}Sr, ^{134}Cs AND ^{137}Cs) AND BETWEEN FIVE LABORATORIES (^{134}Cs AND ^{137}Cs ONLY)

Valve number	1	2	3	4
Seawater sample codes	1-1-1	1-2-1	1-3-1	1-4-1
	1-1-2	Not used	Not used	Not used
	2-1-1	2-2-1	2-3-1	2-4-1
	2-1-2	2-2-2	2-3-2	2-4-2

Distribution pattern of the participating laboratories coded A, B, C, D and E	A	B	C	D	E
	1-1-1	1-2-1	1-3-1	1-4-1	1-1-2
	2-1-1	2-2-1	2-3-1	2-4-1	-
	2-1-2	2-2-2	2-3-2	2-4-2	-

TABLE 44. ILC 2020: SAMPLE DISTRIBUTION BETWEEN SIX LABORATORIES (^3H)

<table>
<tr><td>Valve number</td><td colspan="3">1</td><td colspan="3">2</td><td colspan="3">3</td><td colspan="3">4</td></tr>
<tr><td rowspan="2">Seawater sample codes</td><td colspan="3">1-1-1</td><td colspan="3">1-2-1</td><td colspan="3">1-3-1</td><td colspan="3">1-4-1</td></tr>
<tr><td colspan="3">1-1-2</td><td colspan="3">1-2-2</td><td colspan="3">Not used</td><td colspan="3">Not used</td></tr>
<tr><td rowspan="2">Distribution pattern of the participating laboratories coded A, B, C, D, E and F</td><td colspan="2">A</td><td colspan="2">B</td><td colspan="2">C</td><td colspan="2">D</td><td colspan="2">E</td><td colspan="2">F</td></tr>
<tr><td colspan="2">1-1-1</td><td colspan="2">1-2-1</td><td colspan="2">1-3-1</td><td colspan="2">1-4-1</td><td colspan="2">1-1-2</td><td colspan="2">1-2-2</td></tr>
</table>

TABLE 45. ILC 2020: SAMPLE DISTRIBUTION BETWEEN FIVE LABORATORIES (^{90}Sr, ^{134}Cs AND ^{137}Cs) AND BETWEEN SIX LABORATORIES (^{134}Cs AND ^{137}Cs ONLY)

<table>
<tr><td>Valve number</td><td colspan="3">1</td><td colspan="3">2</td><td colspan="3">3</td><td colspan="3">4</td></tr>
<tr><td rowspan="6">Seawater sample codes</td><td colspan="3">1-1-1</td><td colspan="3">1-2-1</td><td colspan="3">1-3-1</td><td colspan="3">1-4-1</td></tr>
<tr><td colspan="3">1-1-2</td><td colspan="3">1-2-2</td><td colspan="3">Not used</td><td colspan="3">Not used</td></tr>
<tr><td colspan="3">2-1-1</td><td colspan="3">2-2-1</td><td colspan="3">2-3-1</td><td colspan="3">2-4-1</td></tr>
<tr><td colspan="3">2-1-2</td><td colspan="3">Not used</td><td colspan="3">Not used</td><td colspan="3">Not used</td></tr>
<tr><td colspan="3">2-1-3</td><td colspan="3">2-2-3</td><td colspan="3">2-3-3</td><td colspan="3">2-4-3</td></tr>
<tr><td colspan="3">2-1-4</td><td colspan="3">Not used</td><td colspan="3">Not used</td><td colspan="3">Not used</td></tr>
<tr><td rowspan="4">Distribution pattern of the participating laboratories coded A, B, C, D, E and F</td><td colspan="2">A</td><td colspan="2">B</td><td colspan="2">C</td><td colspan="2">D</td><td colspan="2">E</td><td colspan="2">F</td></tr>
<tr><td colspan="2">1-1-1</td><td colspan="2">1-2-1</td><td colspan="2">1-3-1</td><td colspan="2">1-4-1</td><td colspan="2">1-1-2</td><td colspan="2">1-2-2</td></tr>
<tr><td colspan="2">2-1-1</td><td colspan="2">2-2-1</td><td colspan="2">2-3-1</td><td colspan="2">2-4-1</td><td colspan="2">-</td><td colspan="2">2-1-2</td></tr>
<tr><td colspan="2">2-1-3</td><td colspan="2">2-2-3</td><td colspan="2">2-3-3</td><td colspan="2">2-4-3</td><td colspan="2">-</td><td colspan="2">2-1-4</td></tr>
</table>

TABLE 46. ILC 2020: SAMPLE DISTRIBUTION BETWEEN SEVEN LABORATORIES (^3H)

<table>
<tr><td>Valve number</td><td colspan="7">1</td><td colspan="7">2</td><td colspan="7">3</td><td colspan="7">4</td></tr>
<tr><td rowspan="2">Seawater sample codes</td><td colspan="7">1-1-1</td><td colspan="7">1-2-1</td><td colspan="7">1-3-1</td><td colspan="7">1-4-1</td></tr>
<tr><td colspan="7">1-1-2</td><td colspan="7">1-2-2</td><td colspan="7">1-3-2</td><td colspan="7">Not used</td></tr>
<tr><td rowspan="2">Distribution pattern of the participating laboratories coded A, B, C, D, E, F and G</td><td colspan="4">A</td><td colspan="4">B</td><td colspan="4">C</td><td colspan="4">D</td><td colspan="4">E</td><td colspan="4">F</td><td colspan="4">G</td></tr>
<tr><td colspan="4">1-1-1</td><td colspan="4">1-2-1</td><td colspan="4">1-3-1</td><td colspan="4">1-4-1</td><td colspan="4">1-1-2</td><td colspan="4">1-2-2</td><td colspan="4">1-3-2</td></tr>
</table>

APPENDIX II: CHARTS

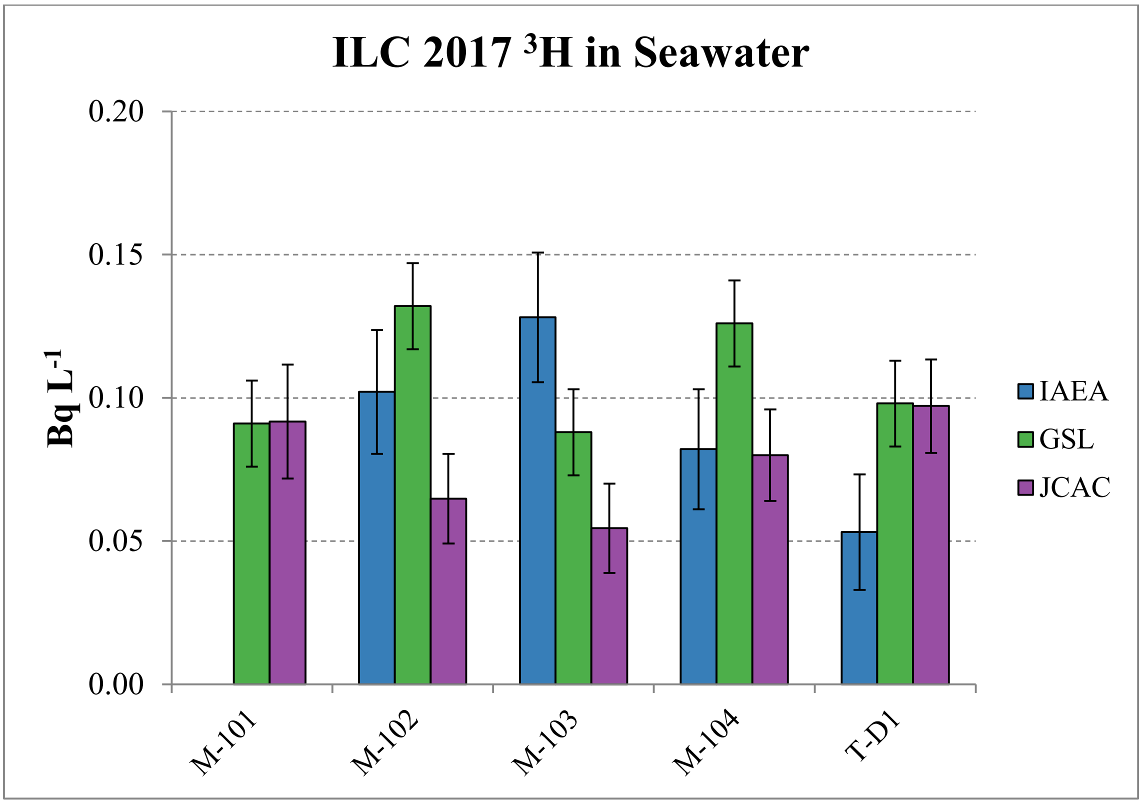

FIG. 2. Activity concentrations of ^{3}H in seawater samples from ILC 2017.

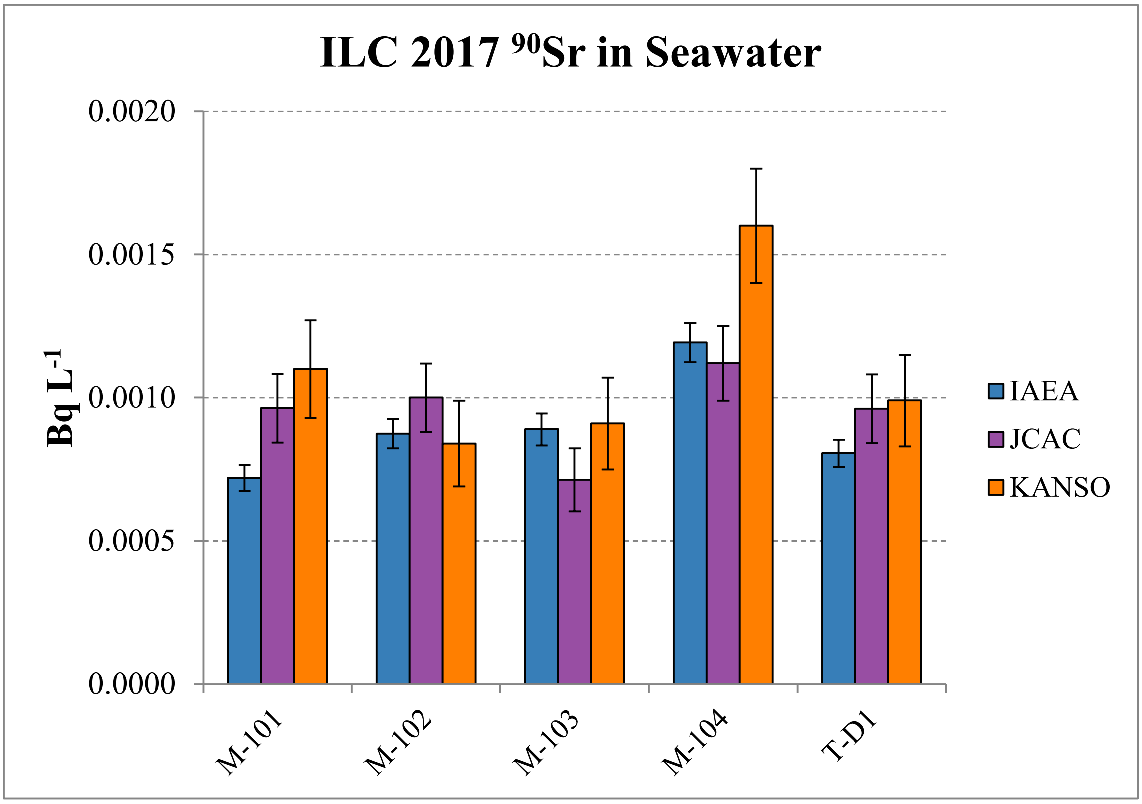

FIG. 3. Activity concentrations of ^{90}Sr in seawater samples from ILC 2017.

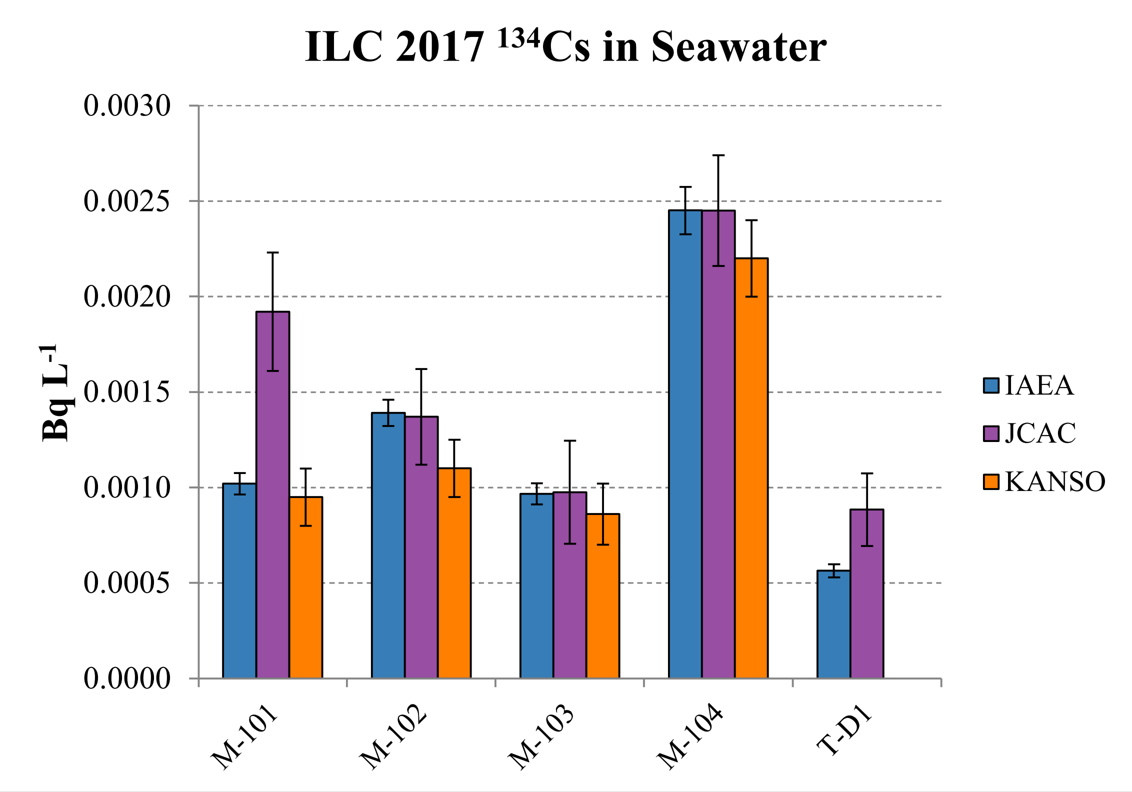

FIG. 4. Activity concentrations of ^{134}Cs in seawater samples from ILC 2017.

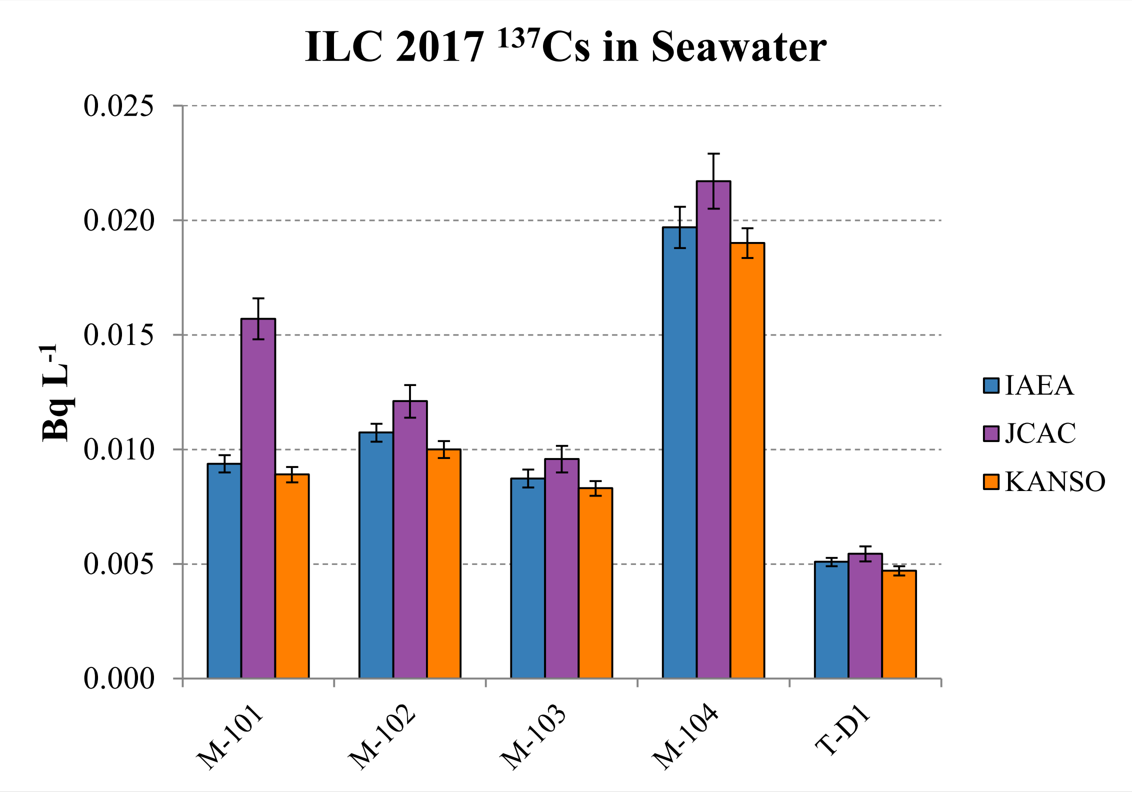

FIG. 5. Activity concentrations of ^{137}Cs in seawater samples from ILC 2017.

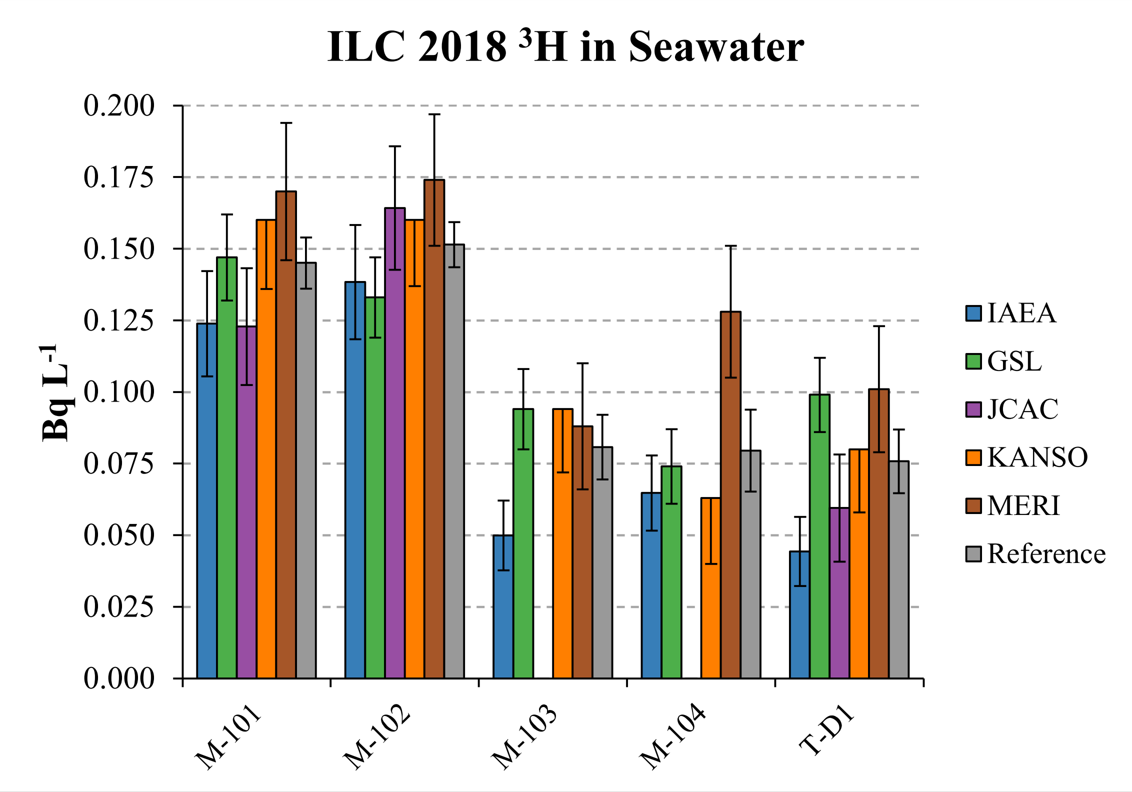

FIG. 6. Activity concentrations of ^{3}H in seawater samples from ILC 2018.

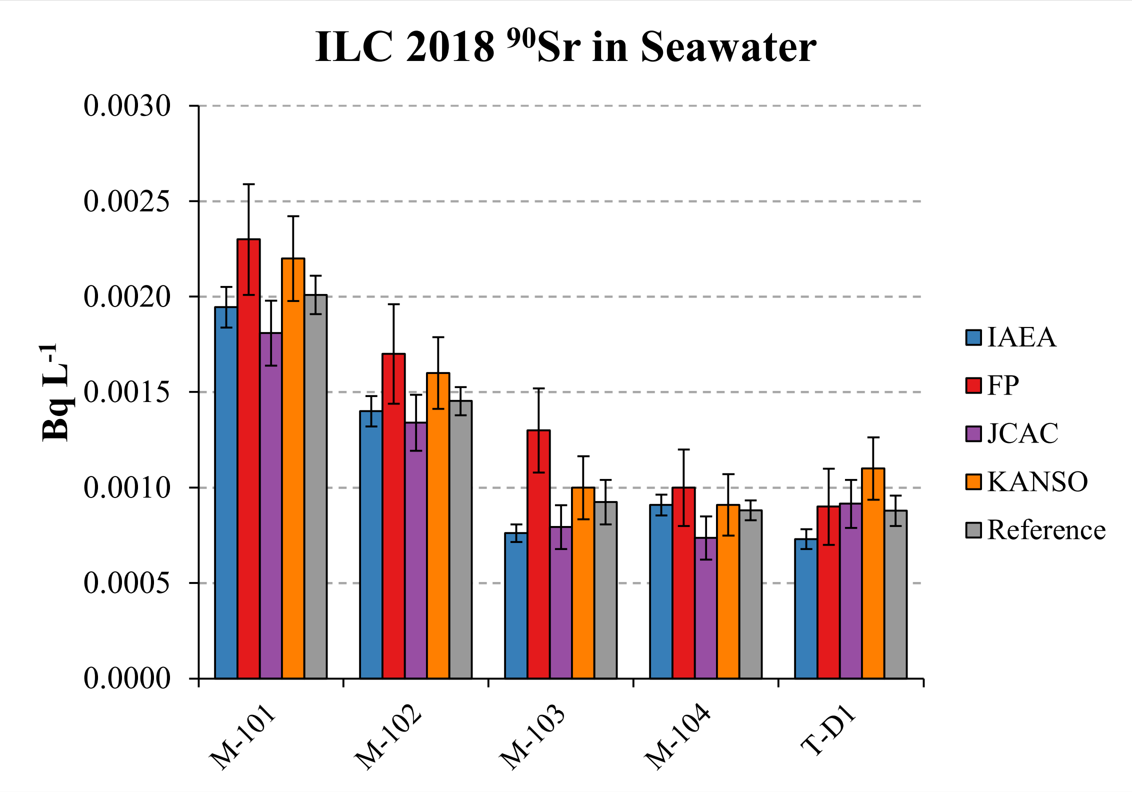

FIG. 7. Activity concentrations of ^{90}Sr in seawater samples from ILC 2018.

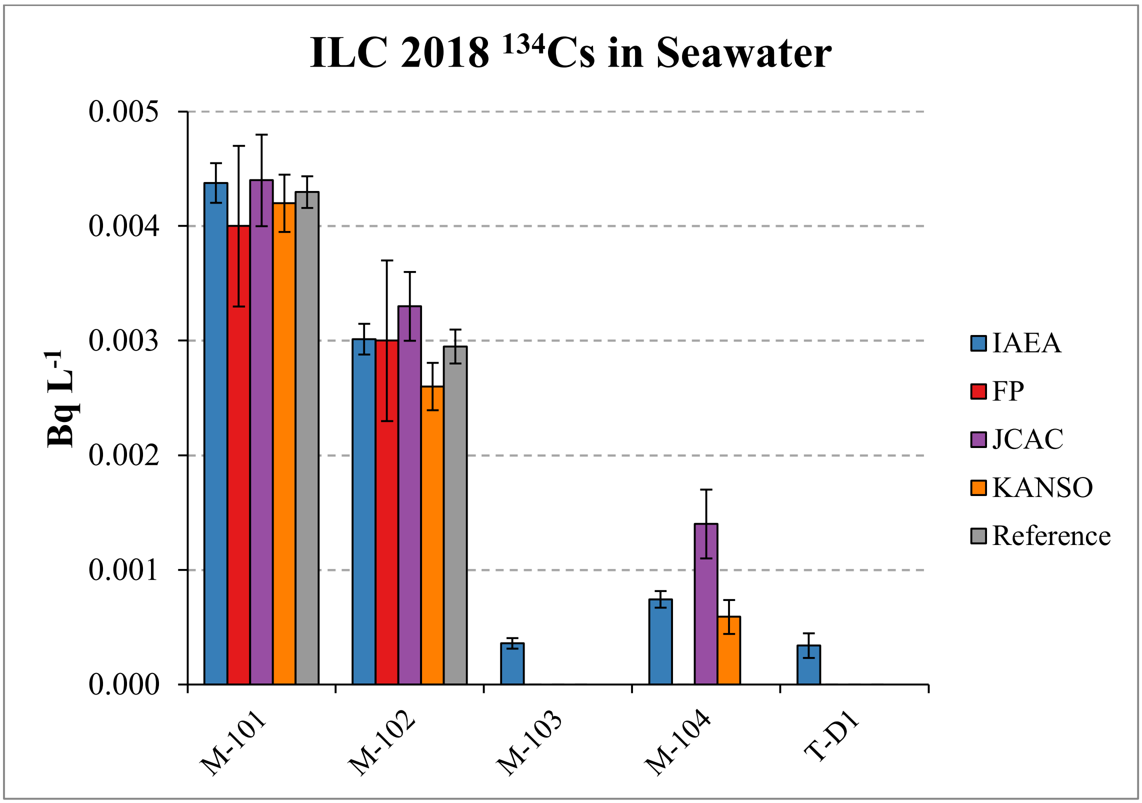

FIG. 8. Activity concentrations of ^{134}*Cs in seawater samples from ILC 2018.*

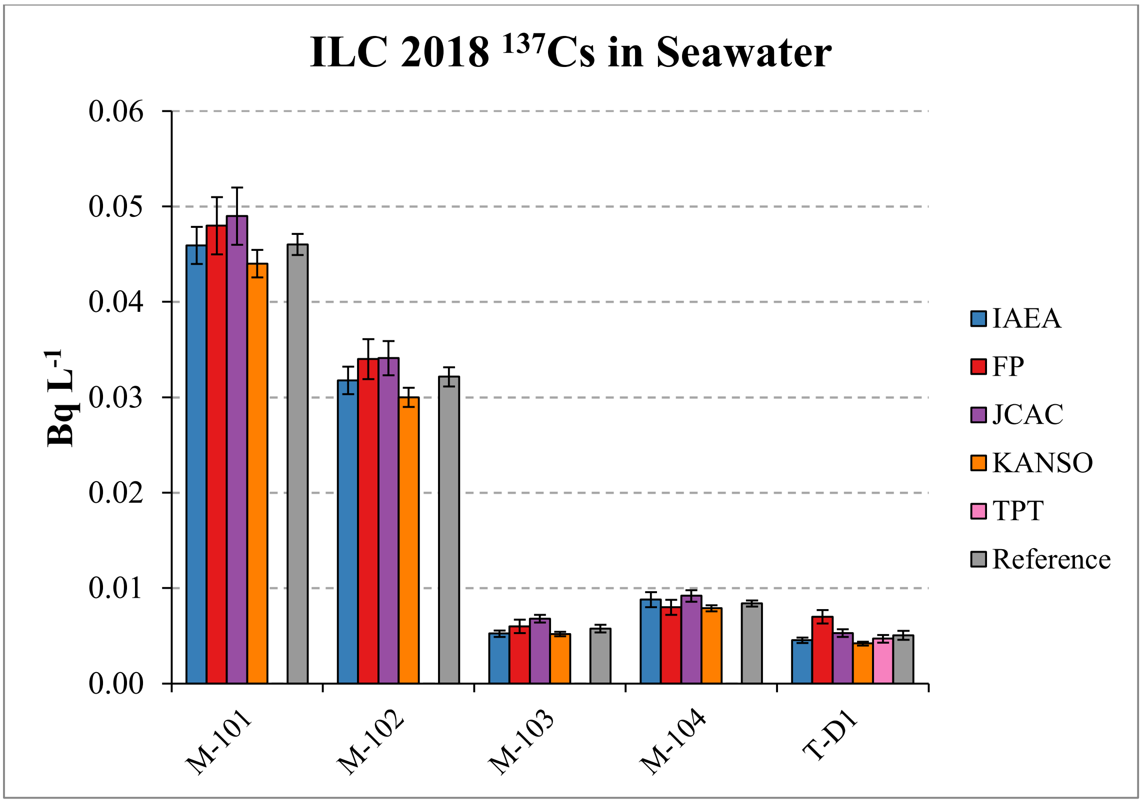

FIG. 9 Activity concentrations of ^{137}*Cs in seawater samples from ILC 2018.*

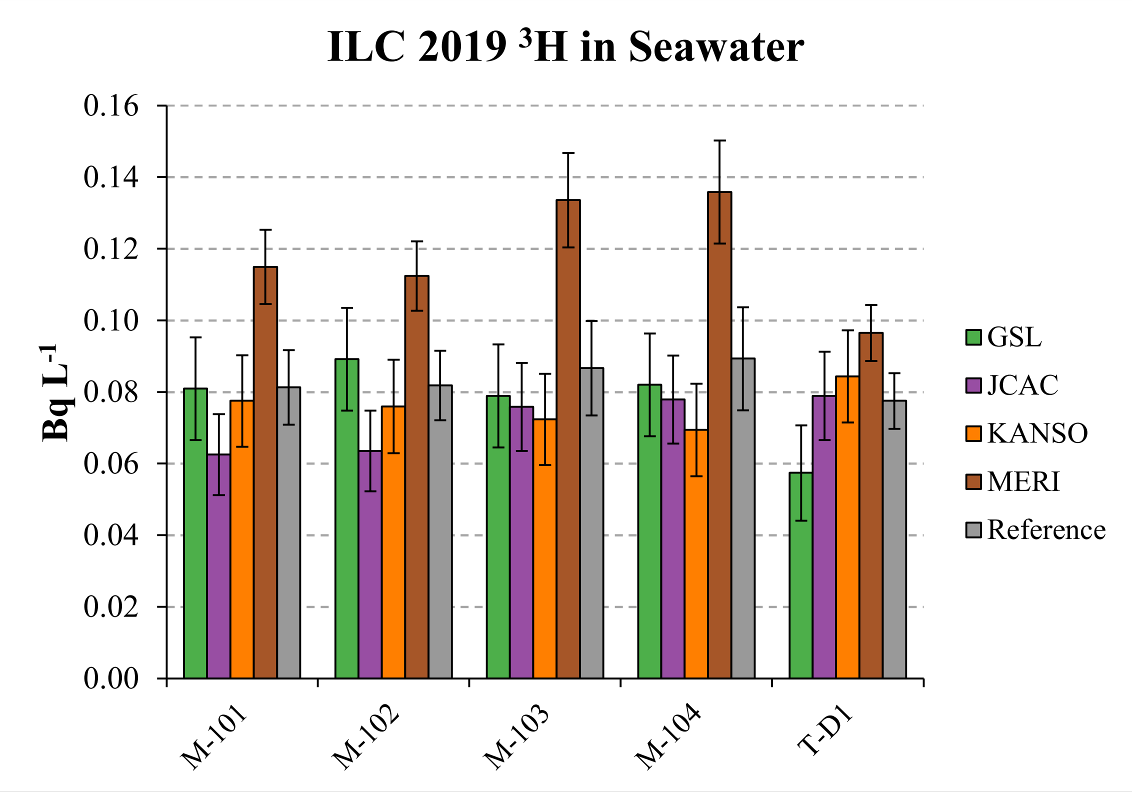

FIG. 10. Activity concentrations of ^{3}H in seawater samples from ILC 2019.

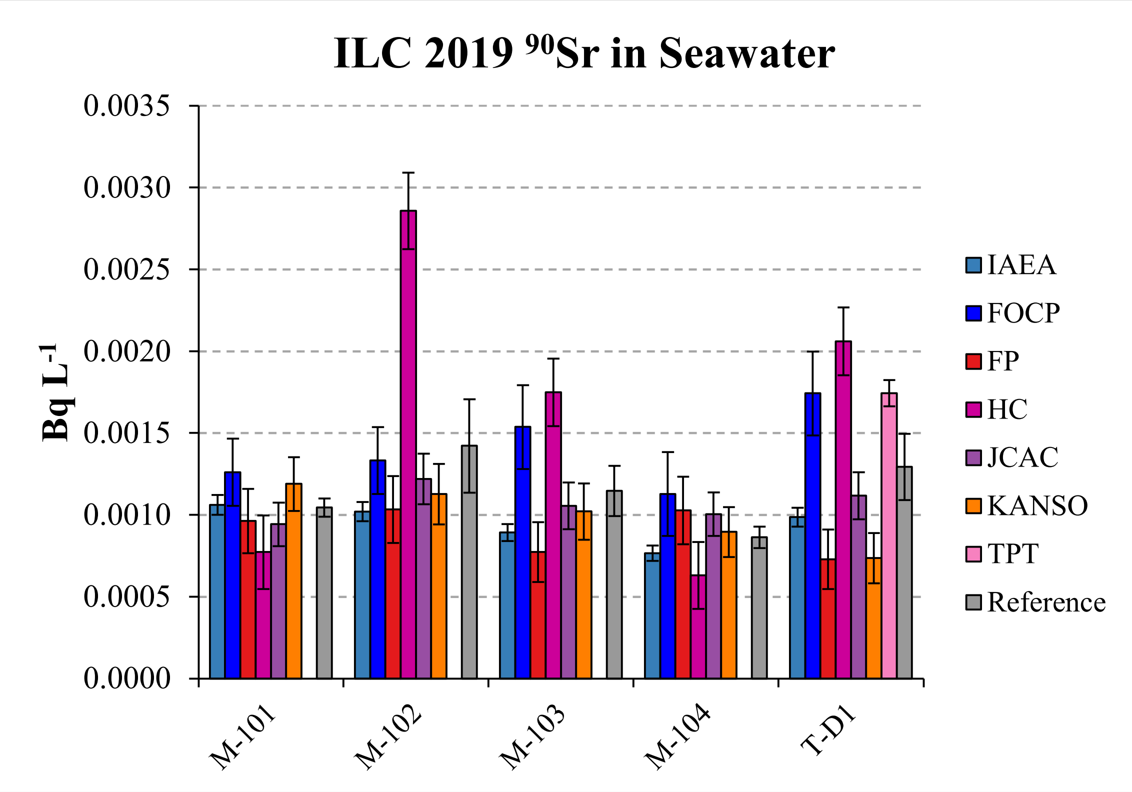

FIG. 11. Activity concentrations of ^{90}Sr in seawater samples from ILC 2019.

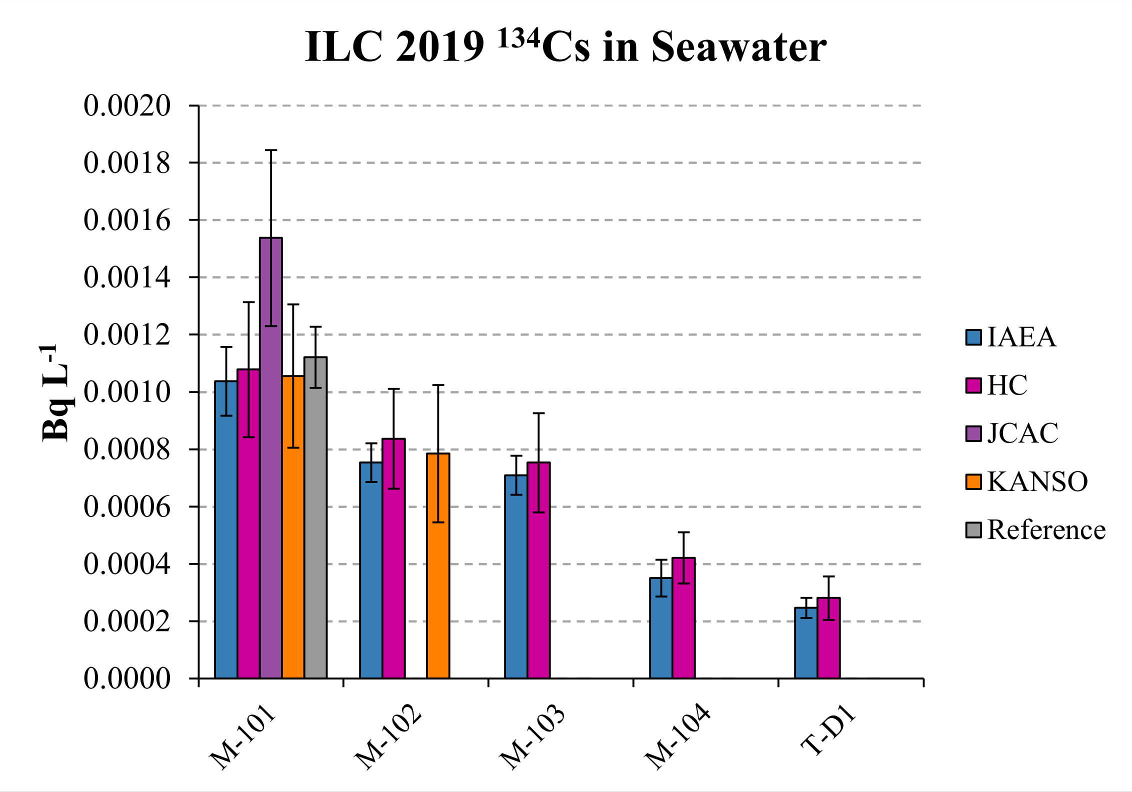

FIG. 12. Activity concentrations of ^{134}Cs in seawater samples from ILC 2019.

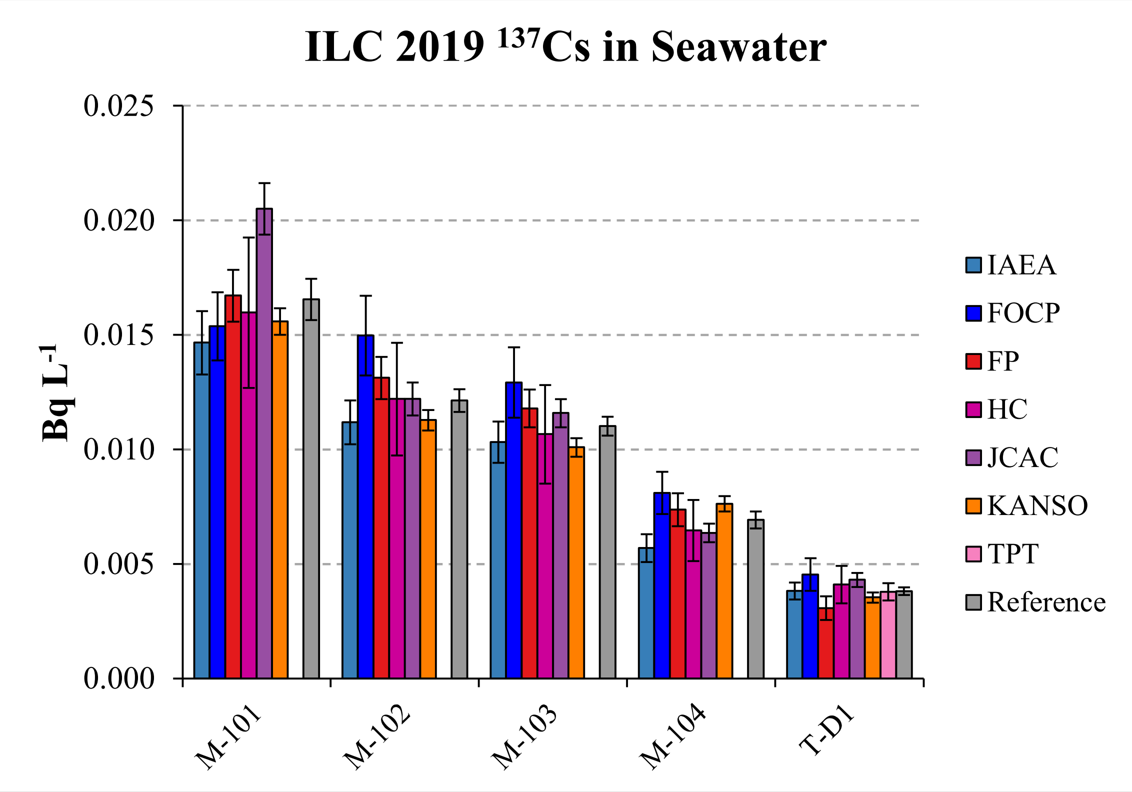

FIG. 13. Activity concentrations of ^{137}Cs in seawater samples from ILC 2019.

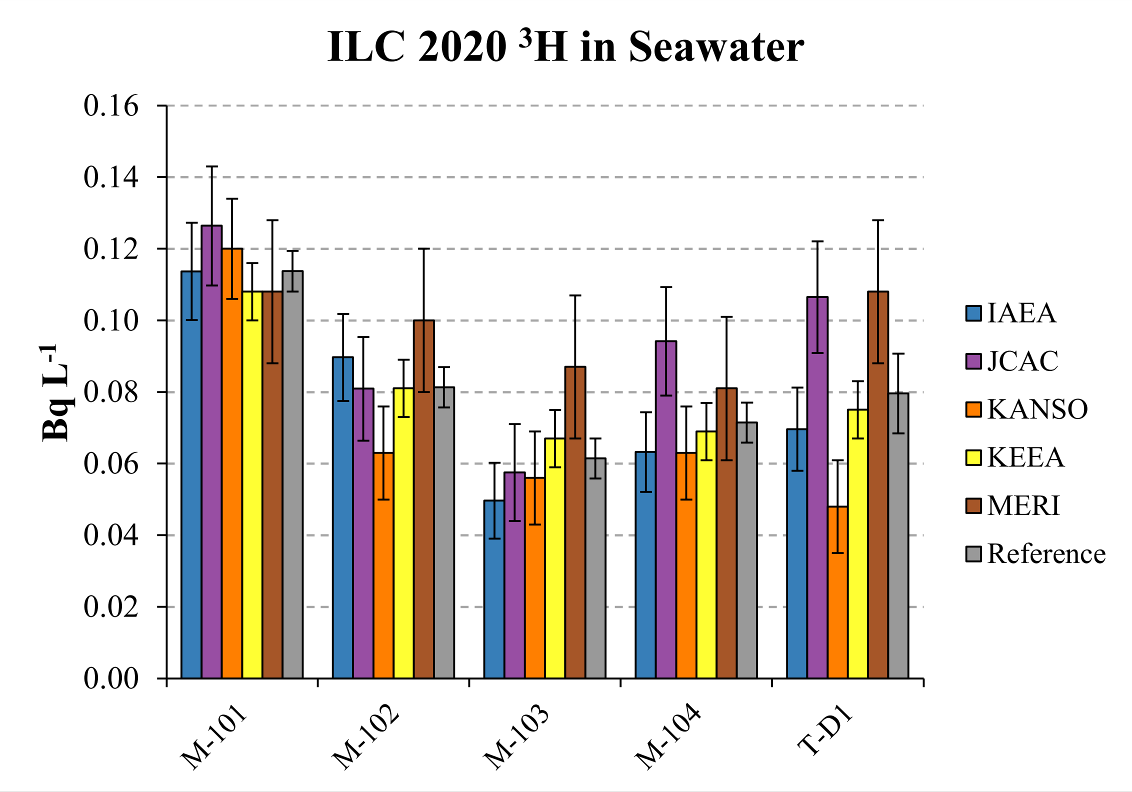

FIG. 14. Activity concentrations of ^{3}H in seawater samples from ILC 2020.

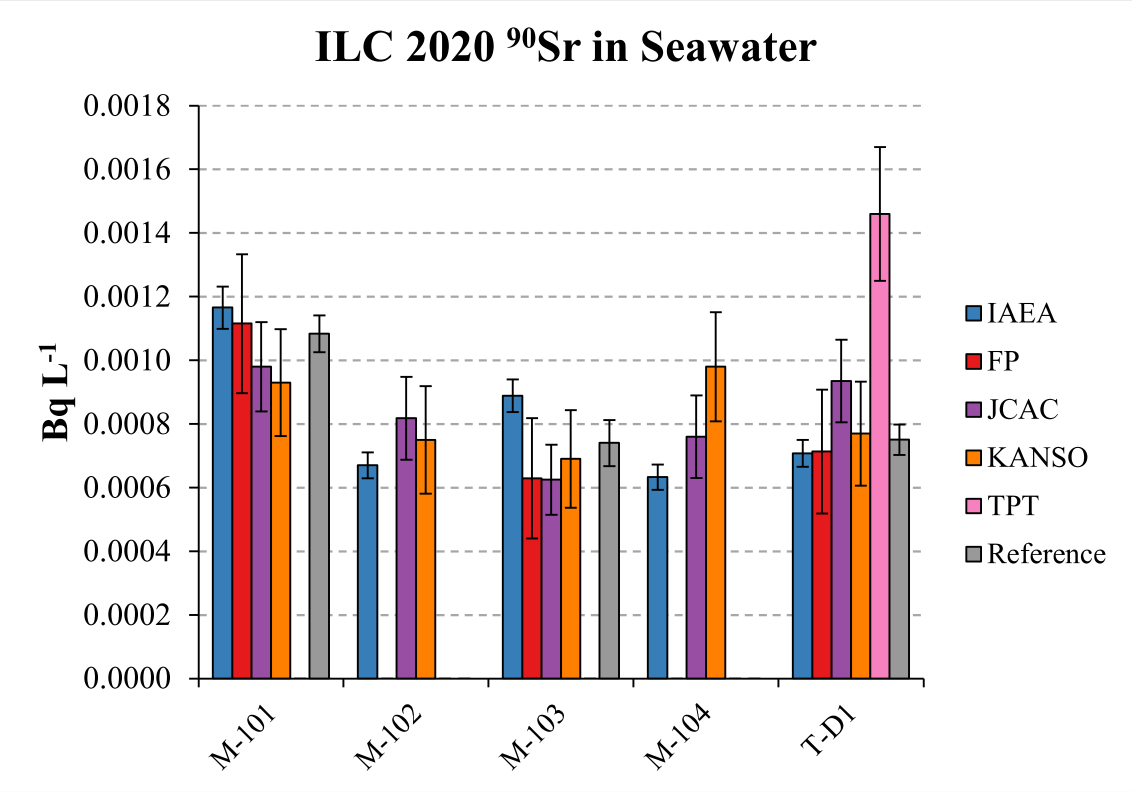

FIG. 15. Activity concentrations of ^{90}Sr in seawater samples from ILC 2020.

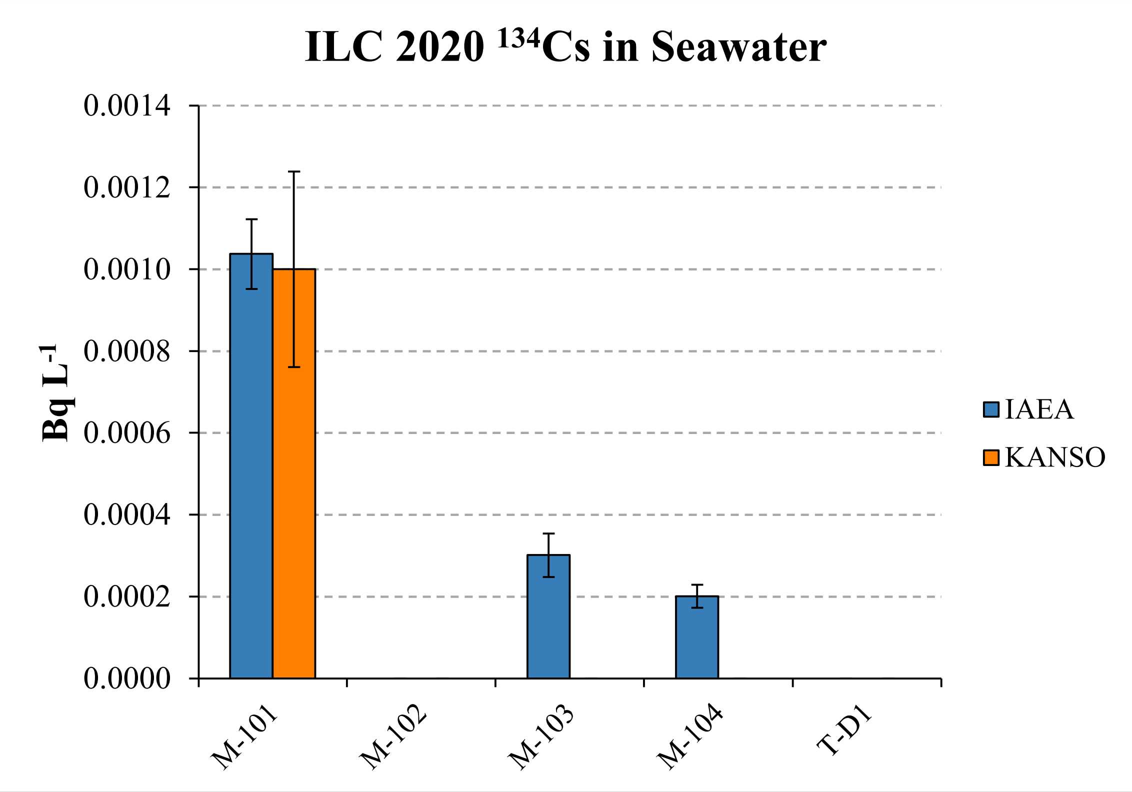

FIG. 16. Activity concentrations of ^{134}*Cs in seawater samples from ILC 2020.*

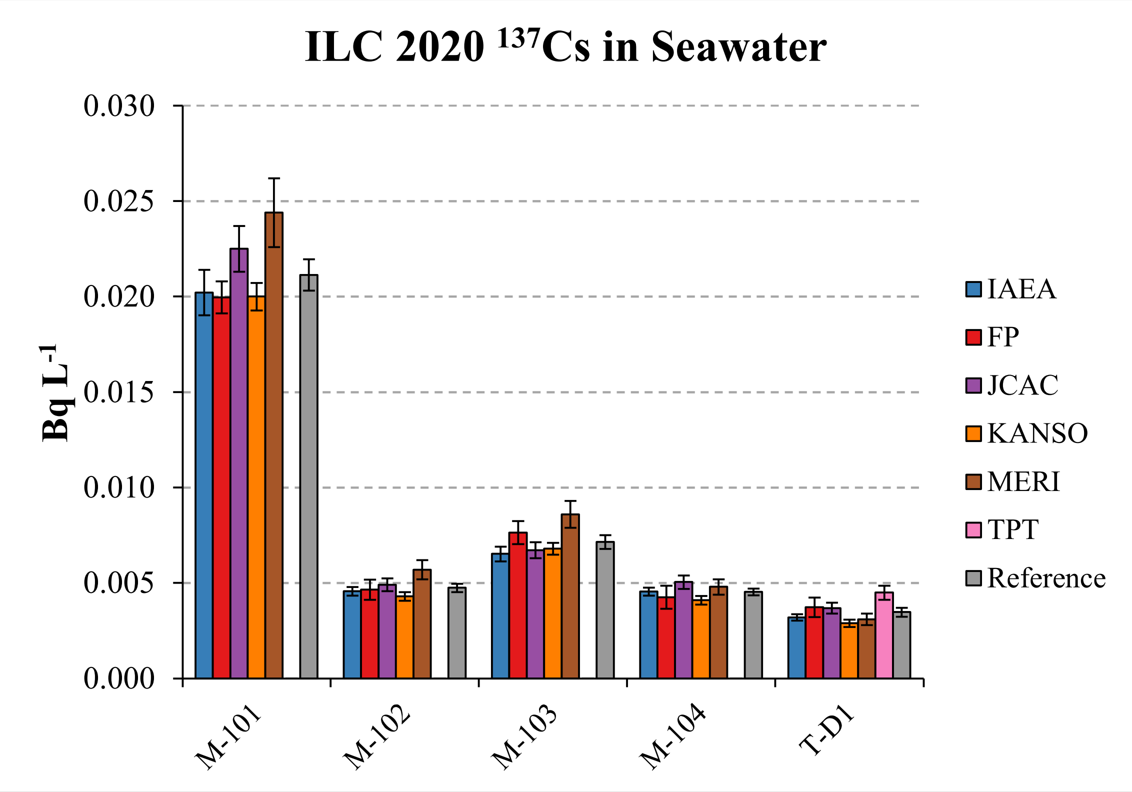

FIG. 17. Activity concentrations of ^{137}*Cs in seawater samples from ILC 2020.*

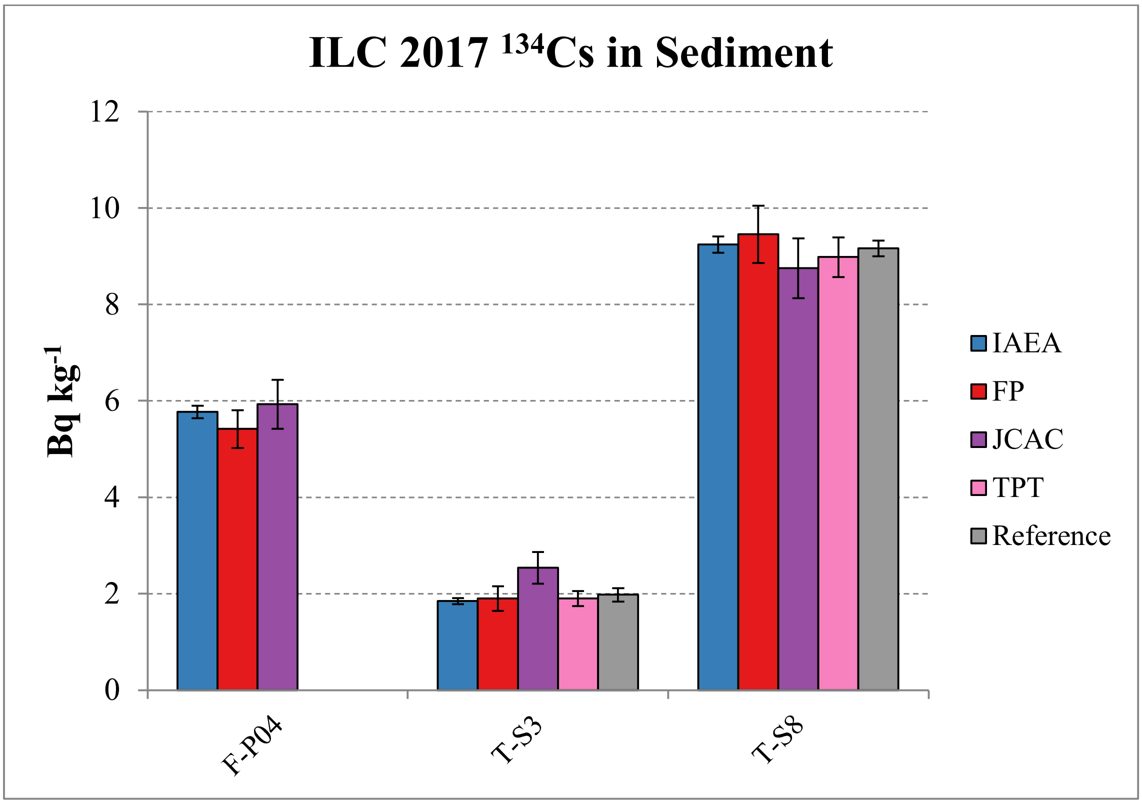

FIG. 18. Activity concentrations of ^{134}Cs in sediment samples from ILC 2017.

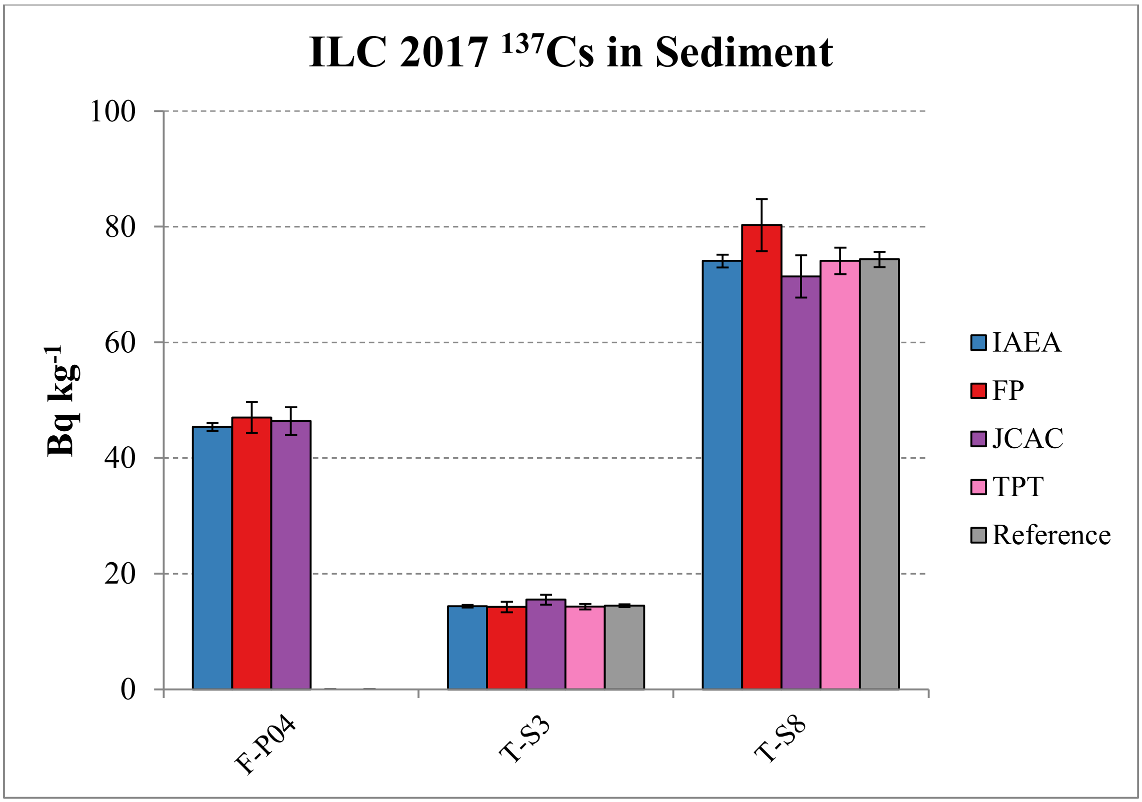

FIG. 19. Activity concentrations of ^{137}Cs in sediment samples from ILC 2017.

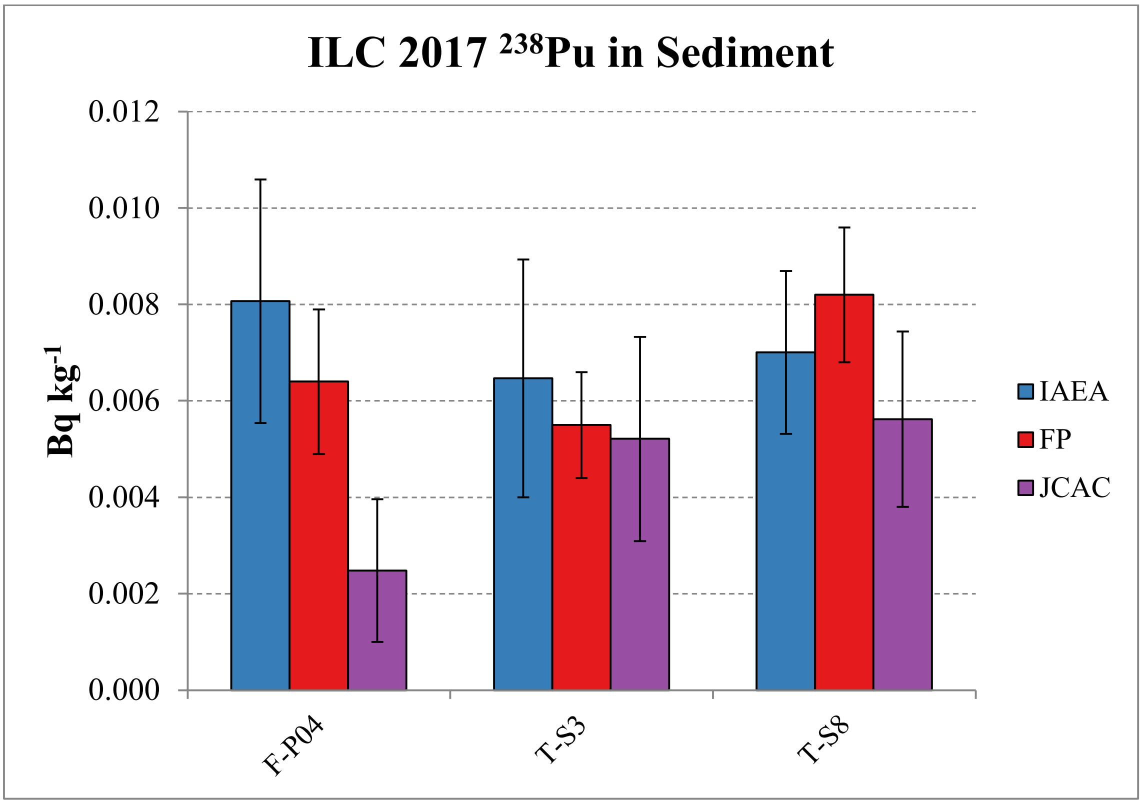

FIG. 20. Activity concentrations of ^{238}*Pu in sediment samples from ILC 2017.*

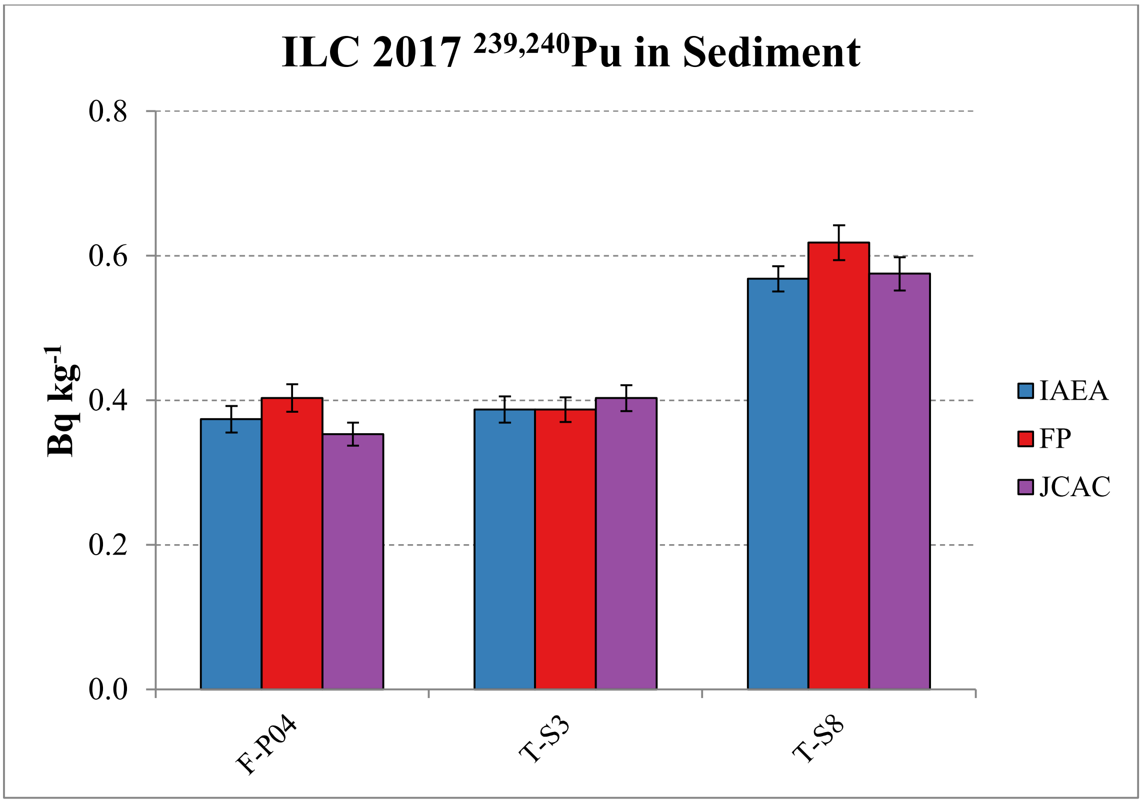

FIG. 21. Activity concentrations of ^{239,240}*Pu in sediment samples from ILC 2017.*

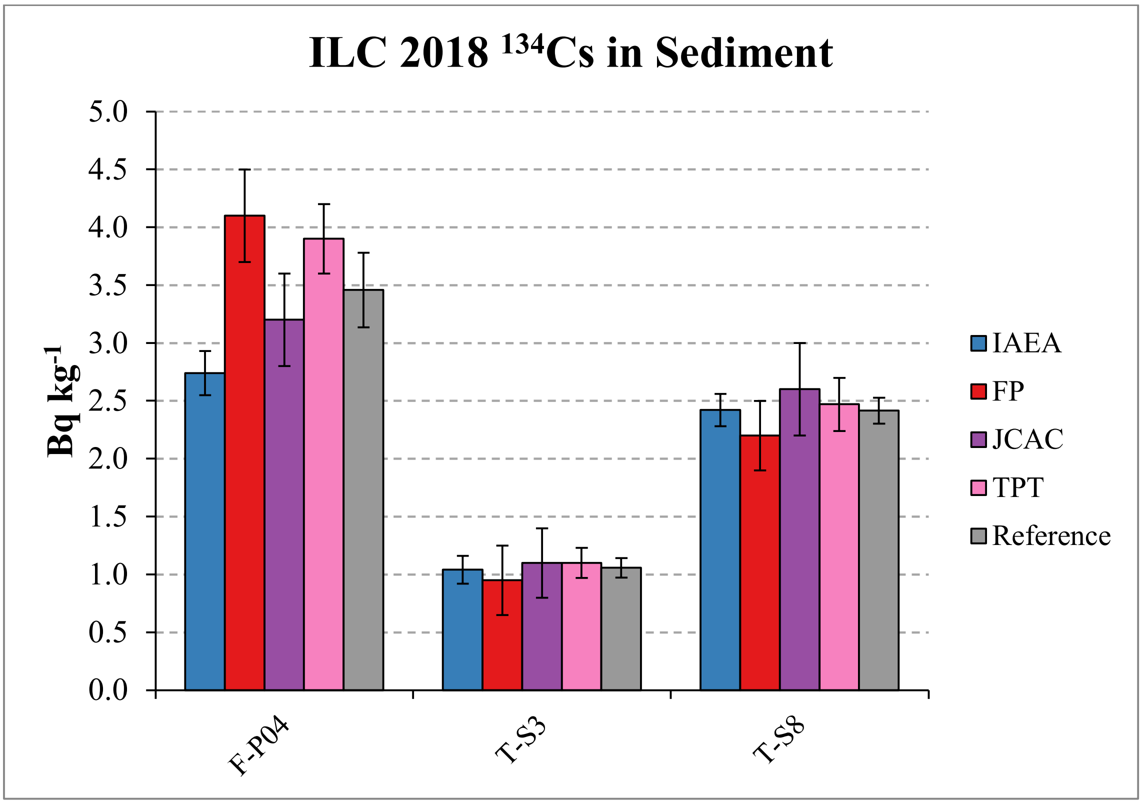

FIG. 22. Activity concentrations of ^{134}Cs in sediment samples from ILC 2018.

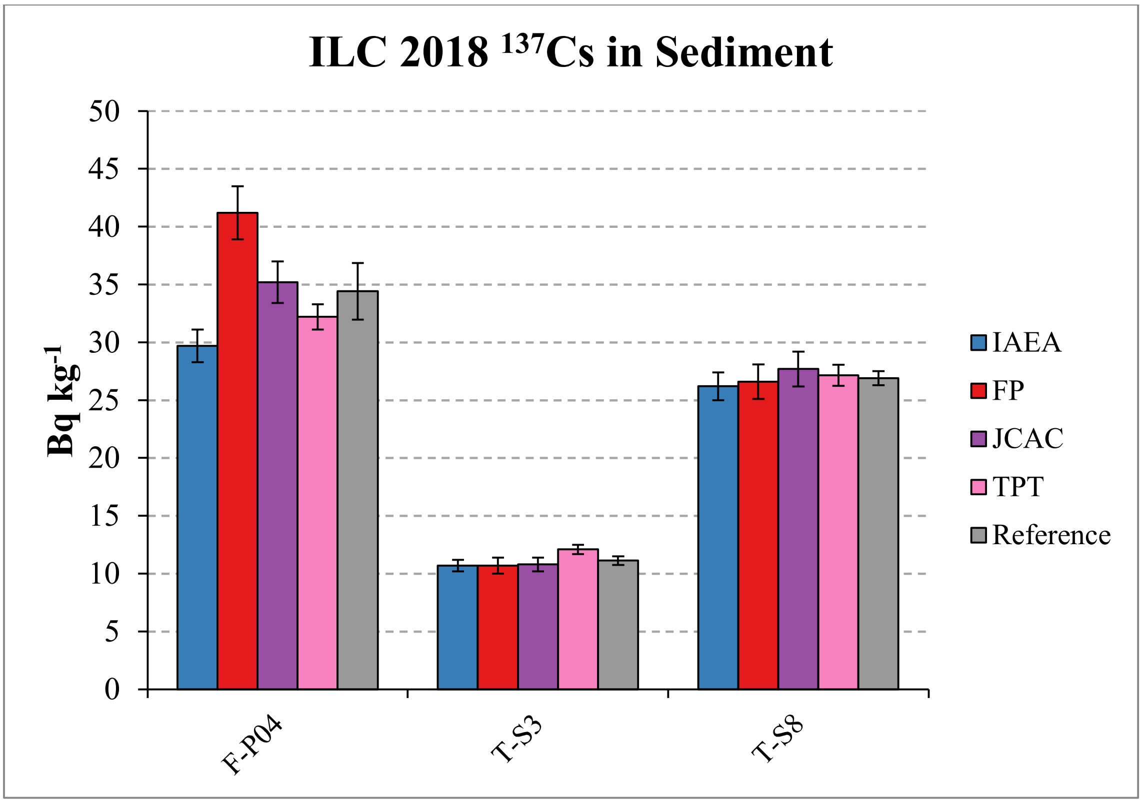

FIG. 23. Activity concentrations of ^{137}Cs in sediment samples from ILC 2018.

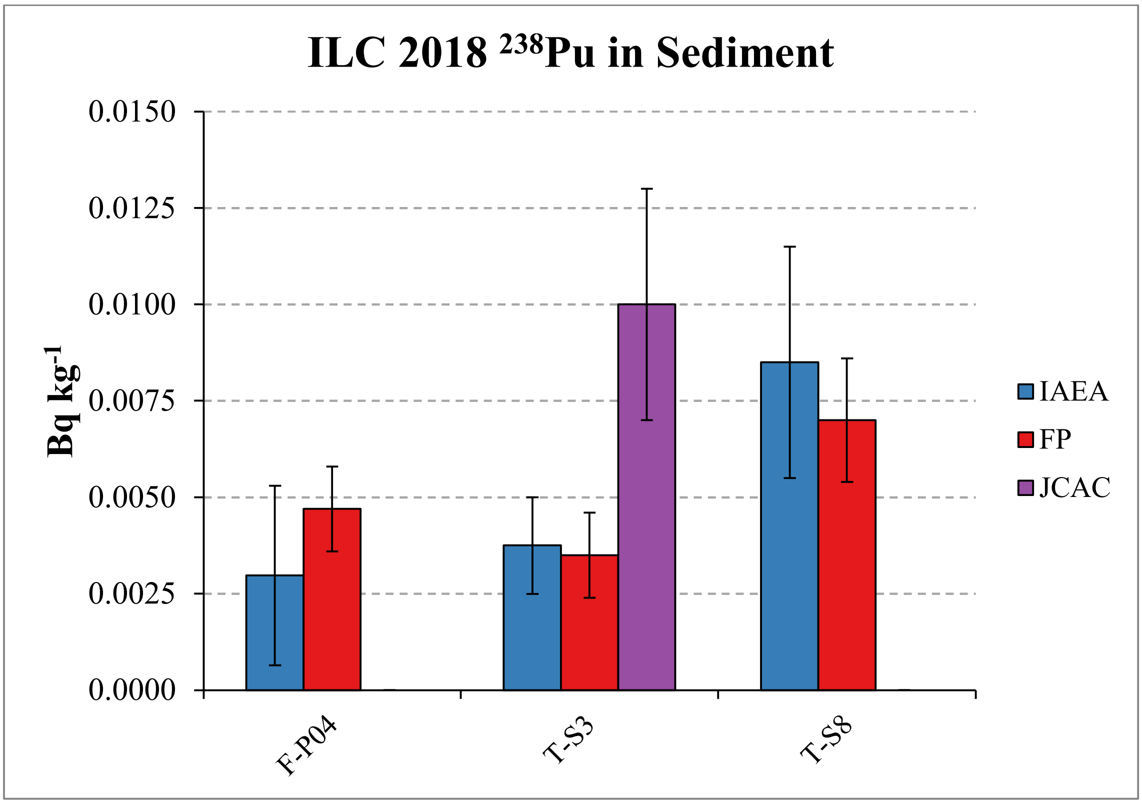

FIG. 24. Activity concentrations of ^{238}Pu in sediment samples from ILC 2018.

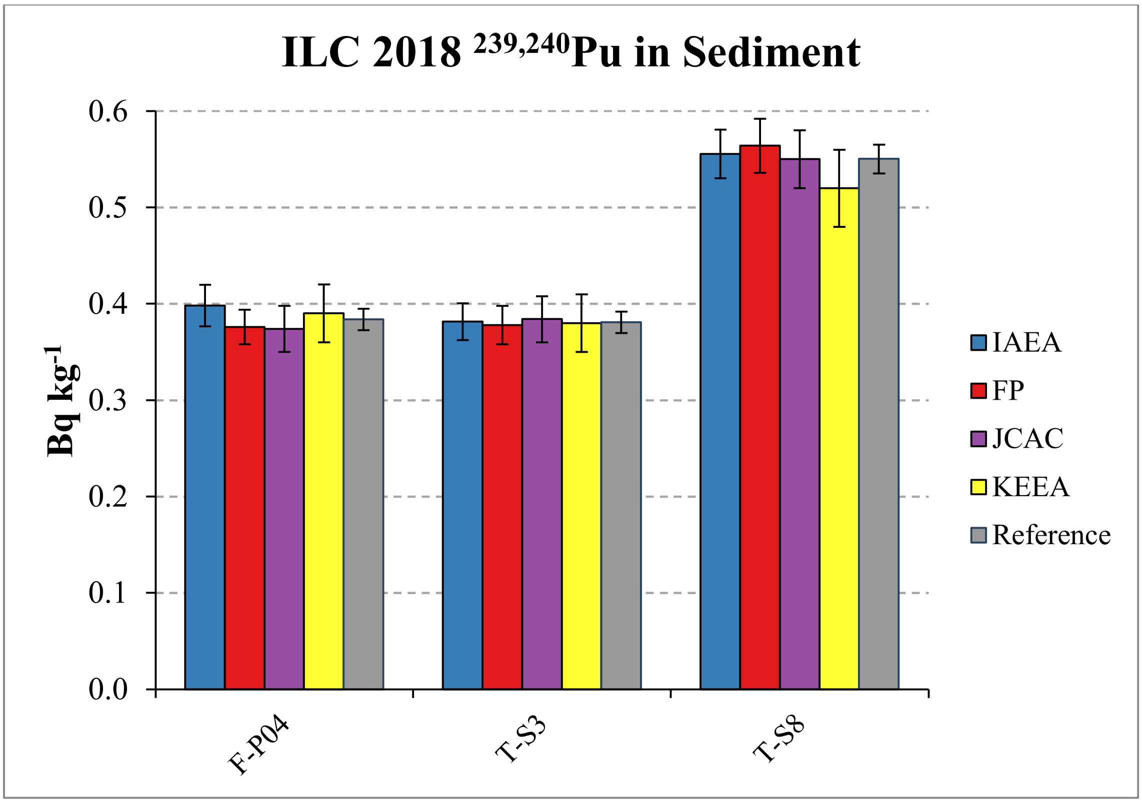

FIG. 25. Activity concentrations of ^{239,240}Pu in sediment samples from ILC 2018.

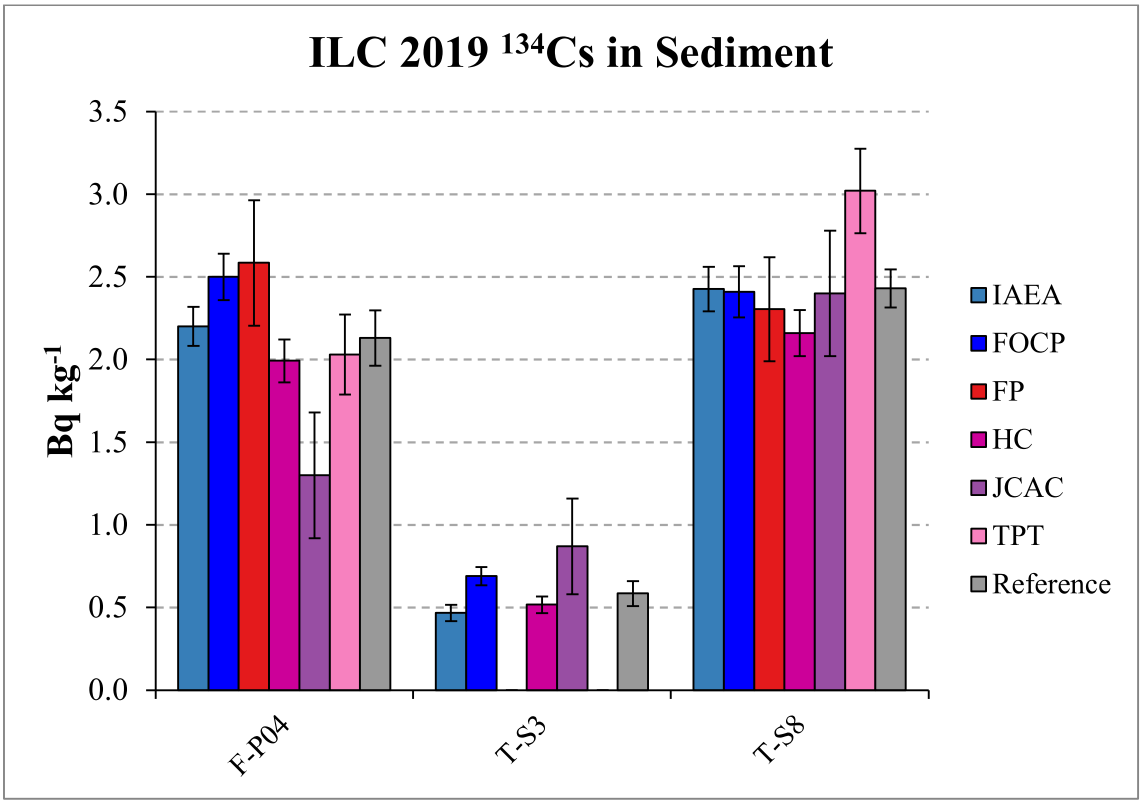

FIG. 26. Activity concentrations of ^{134}Cs in sediment samples from ILC 2019.

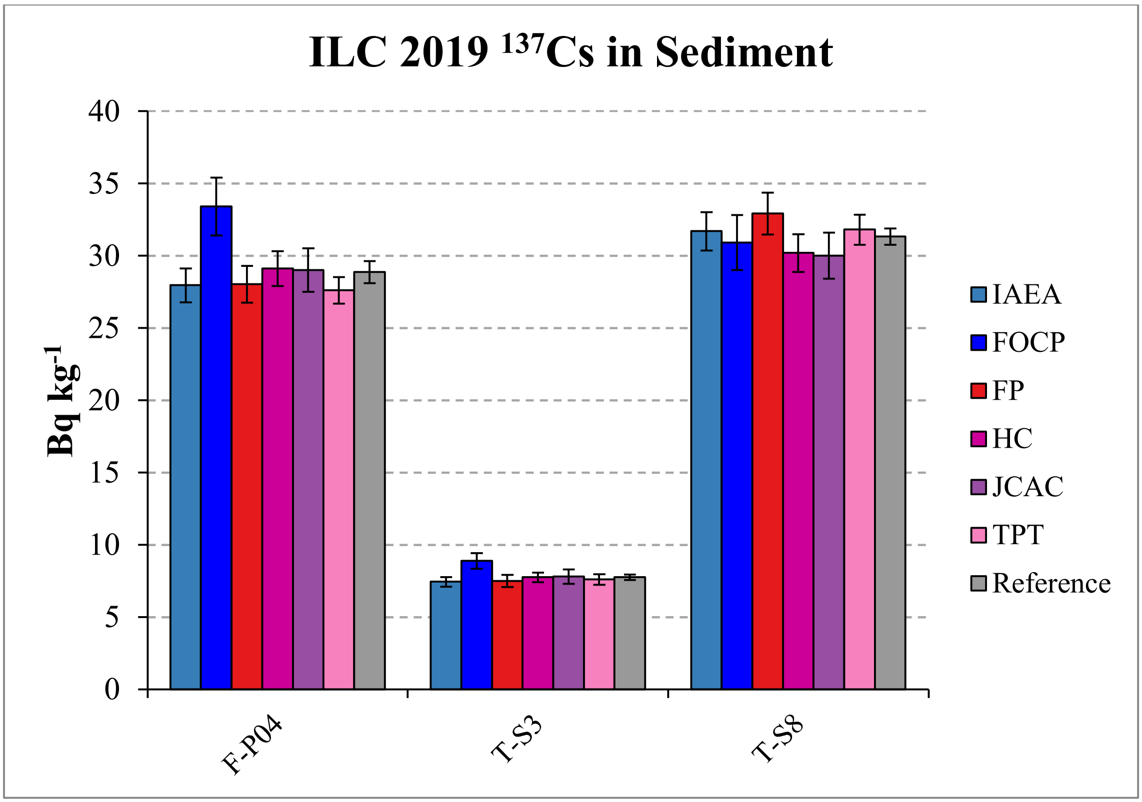

FIG. 27. Activity concentrations of ^{137}Cs in sediment samples from ILC 2019.

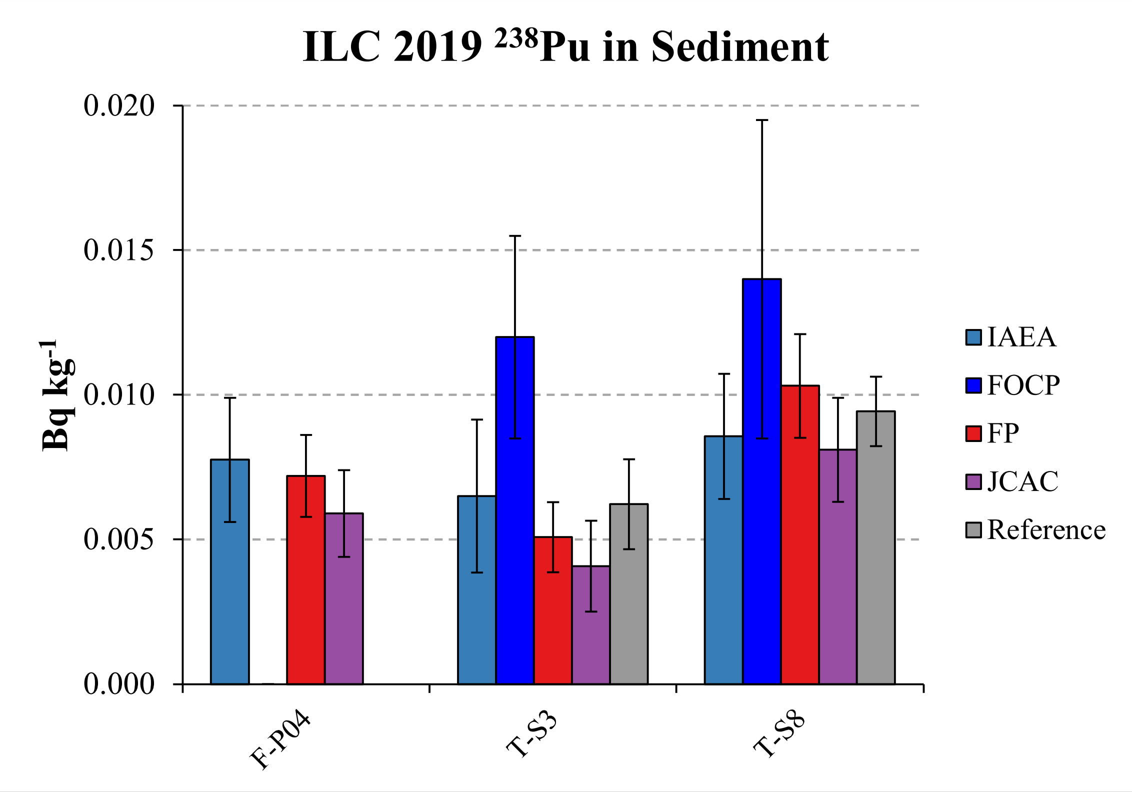

FIG. 28. Activity concentrations of ^{238}Pu in sediment samples from ILC 2019.

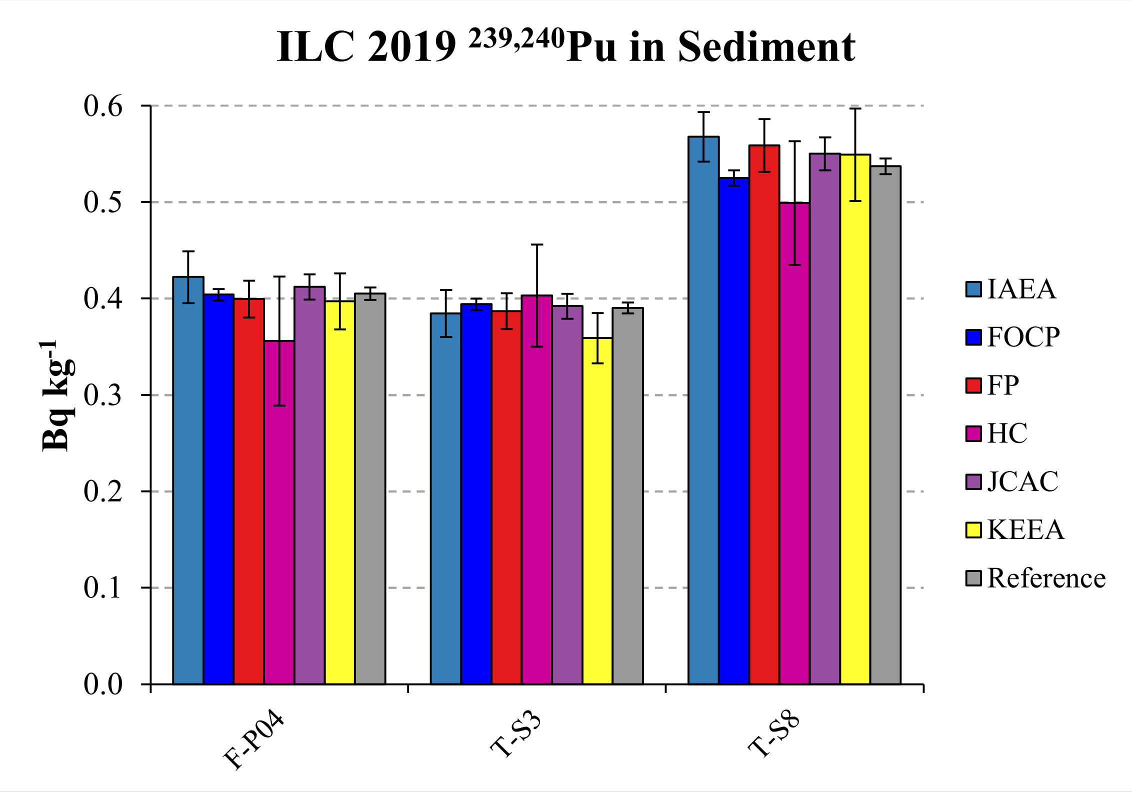

FIG. 29. Activity concentrations of ^{239,240}Pu in sediment samples from ILC 2019.

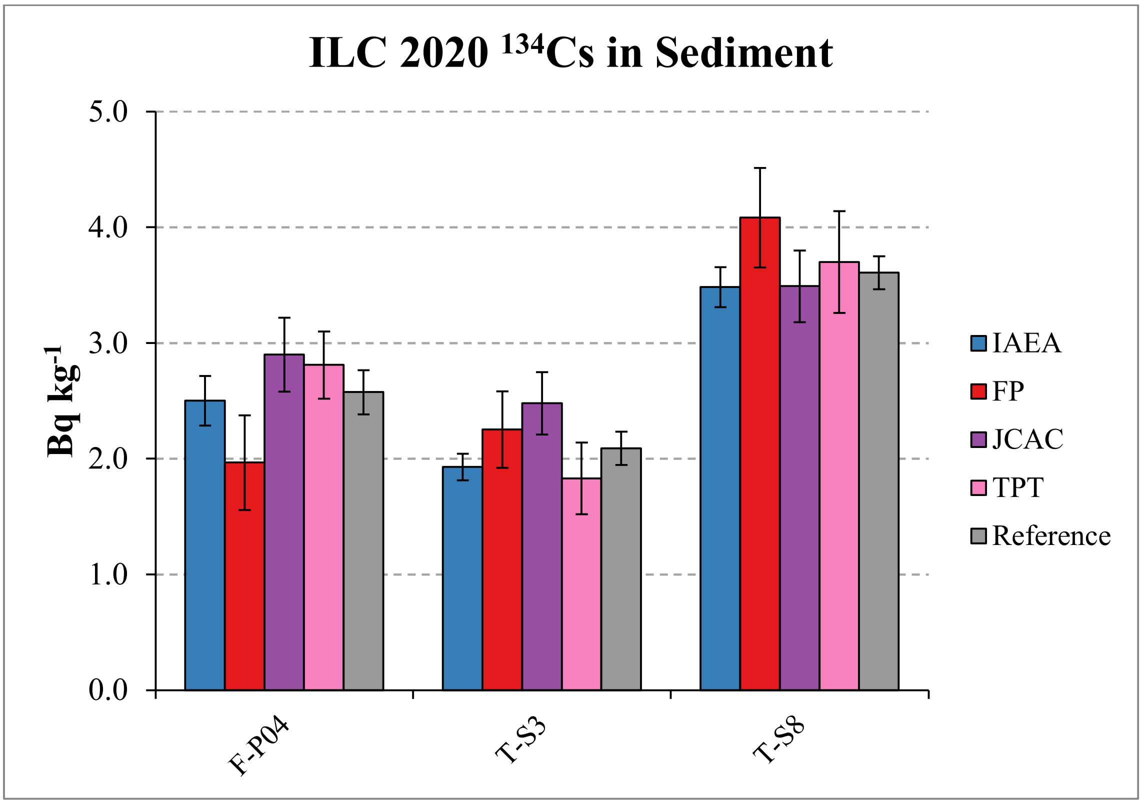

FIG. 30. Activity concentrations of ^{134}Cs in sediment samples from ILC 2020.

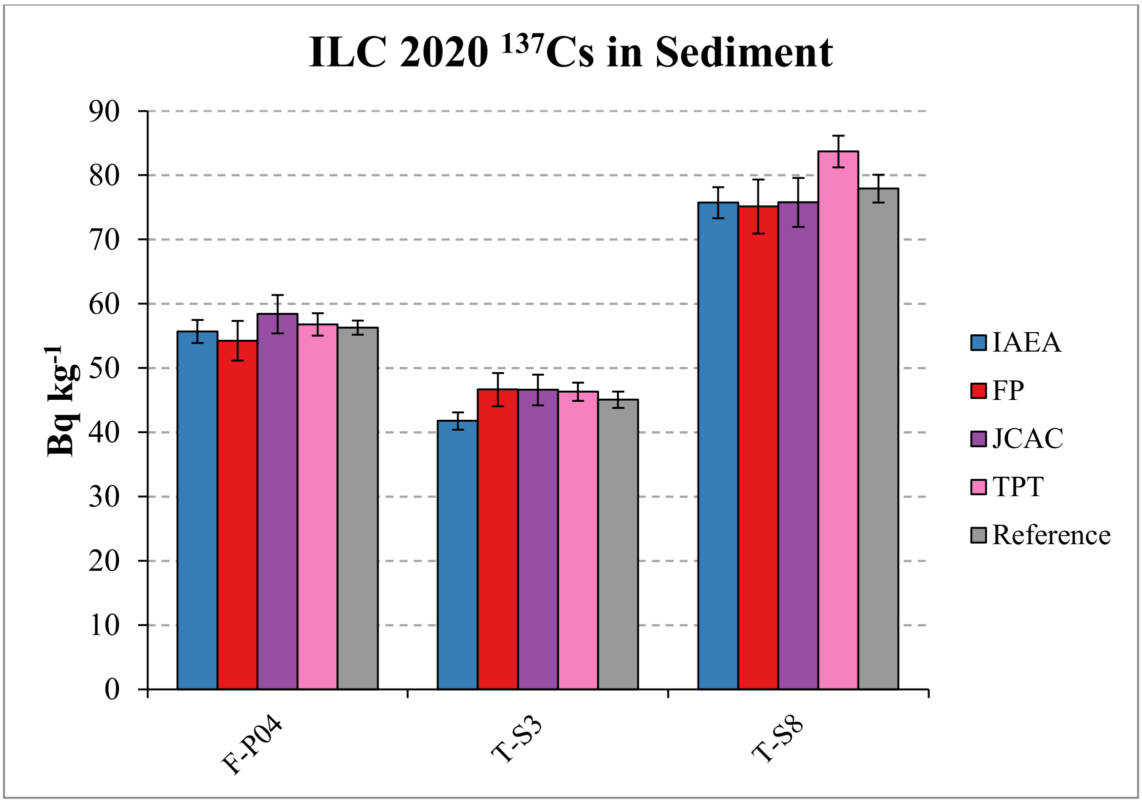

FIG. 31. Activity concentrations of ^{137}Cs in sediment samples from ILC 2020.

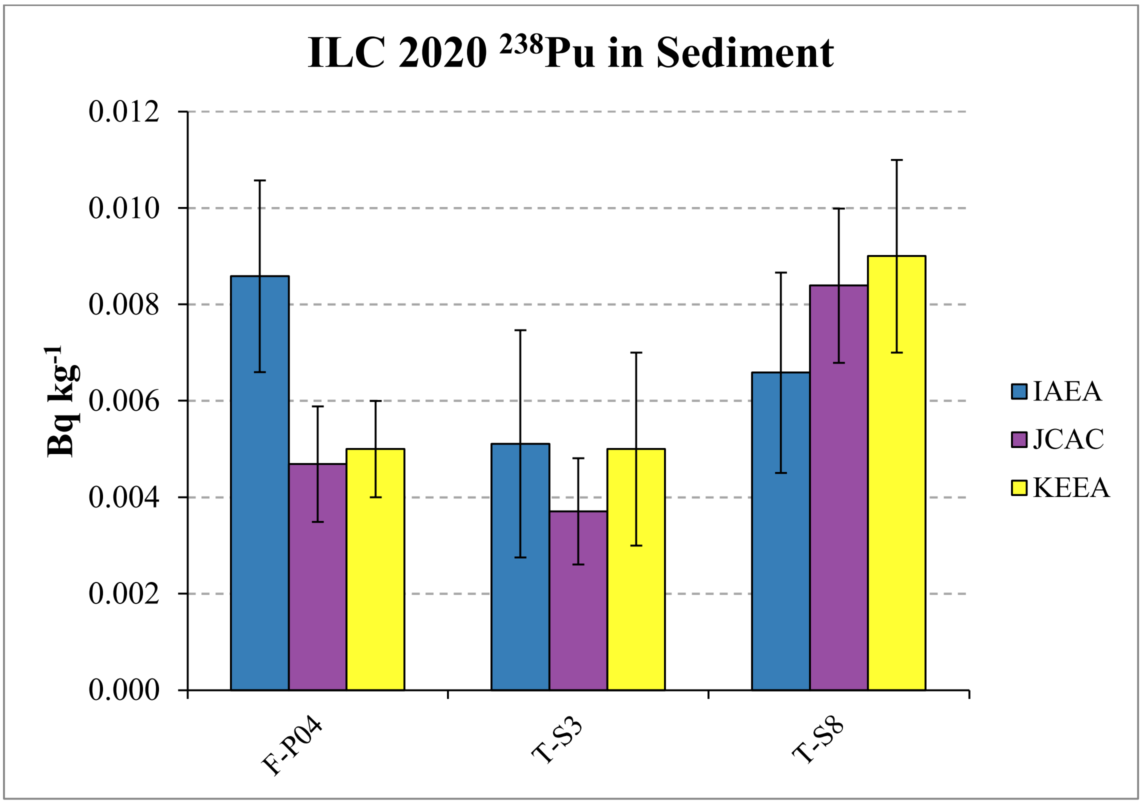

FIG. 32. Activity concentrations of ^{238}Pu in sediment samples from ILC 2020.

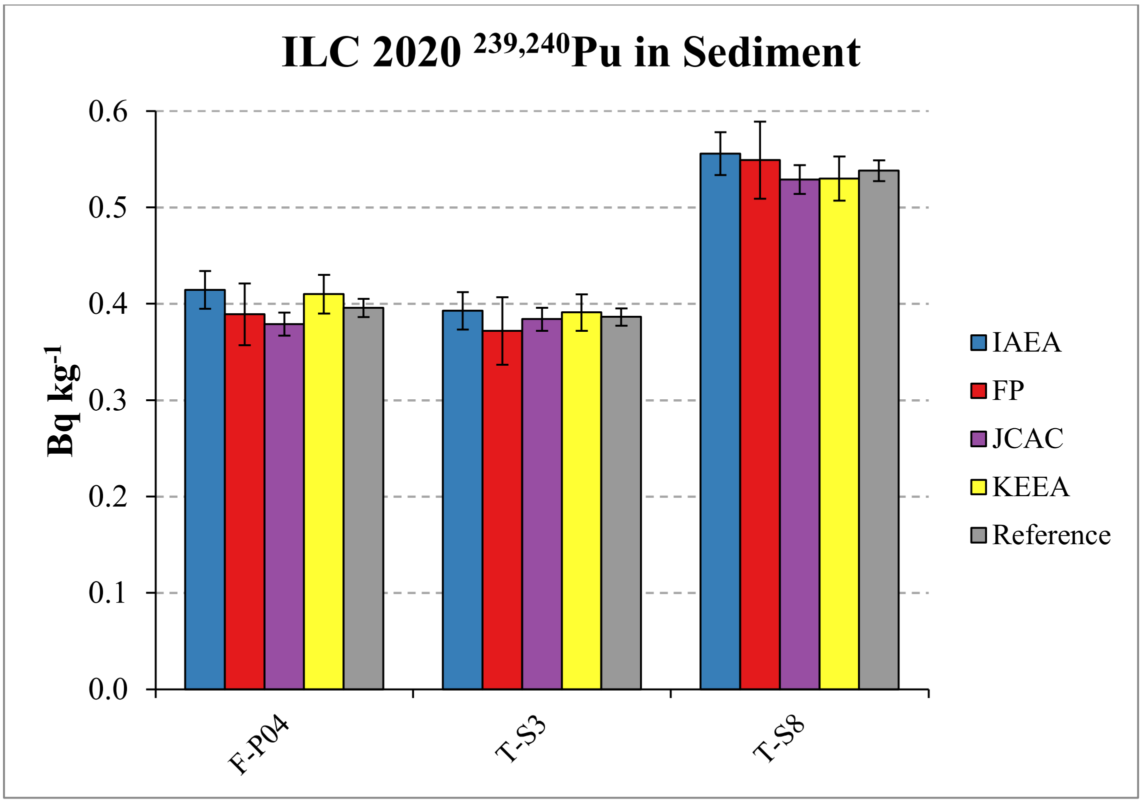

FIG. 33. Activity concentrations of ^{239,240}Pu in sediment samples from ILC 2020.

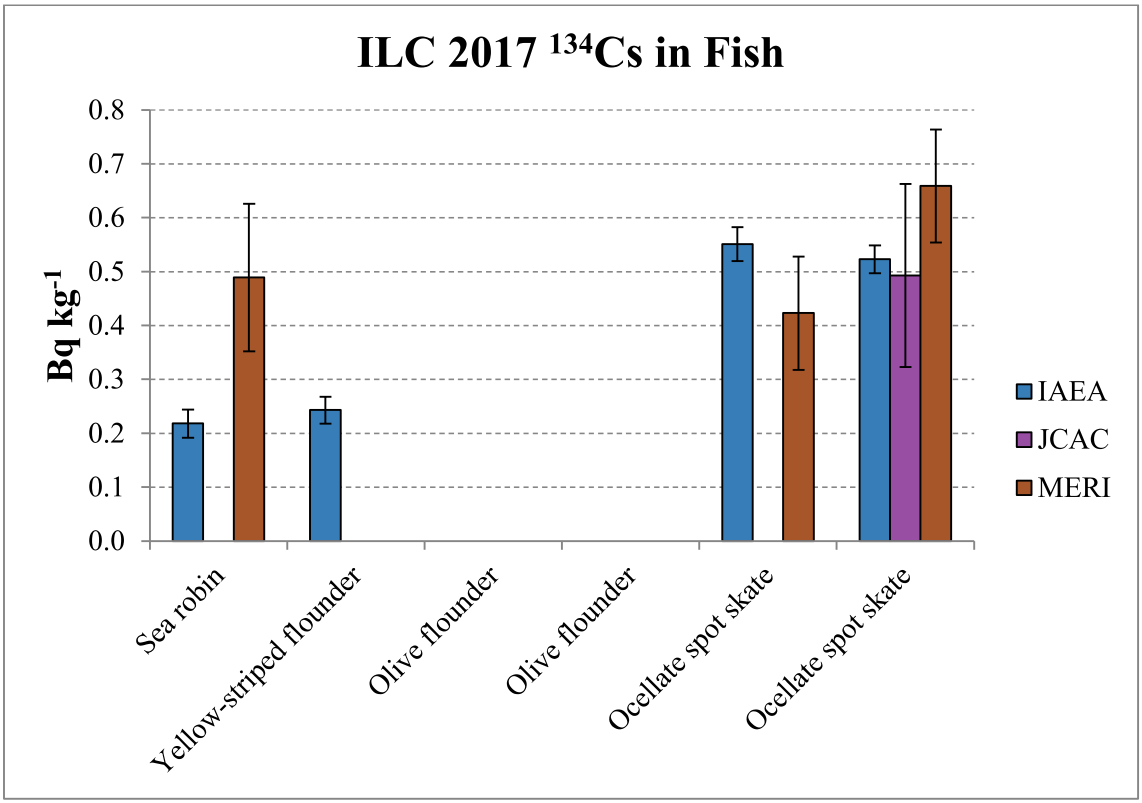

FIG. 34. Activity concentrations of ^{134}Cs in fish samples from ILC 2017.

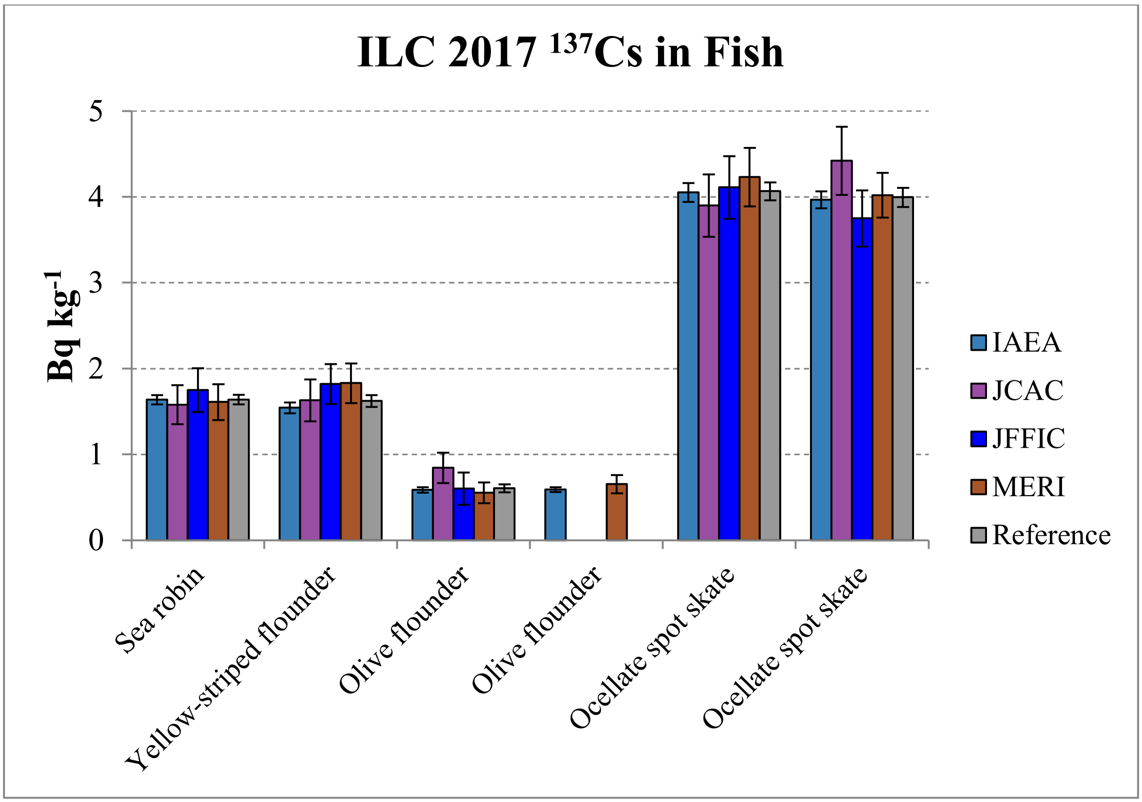

FIG. 35. Activity concentrations of ^{137}Cs in fish samples from ILC 2017.

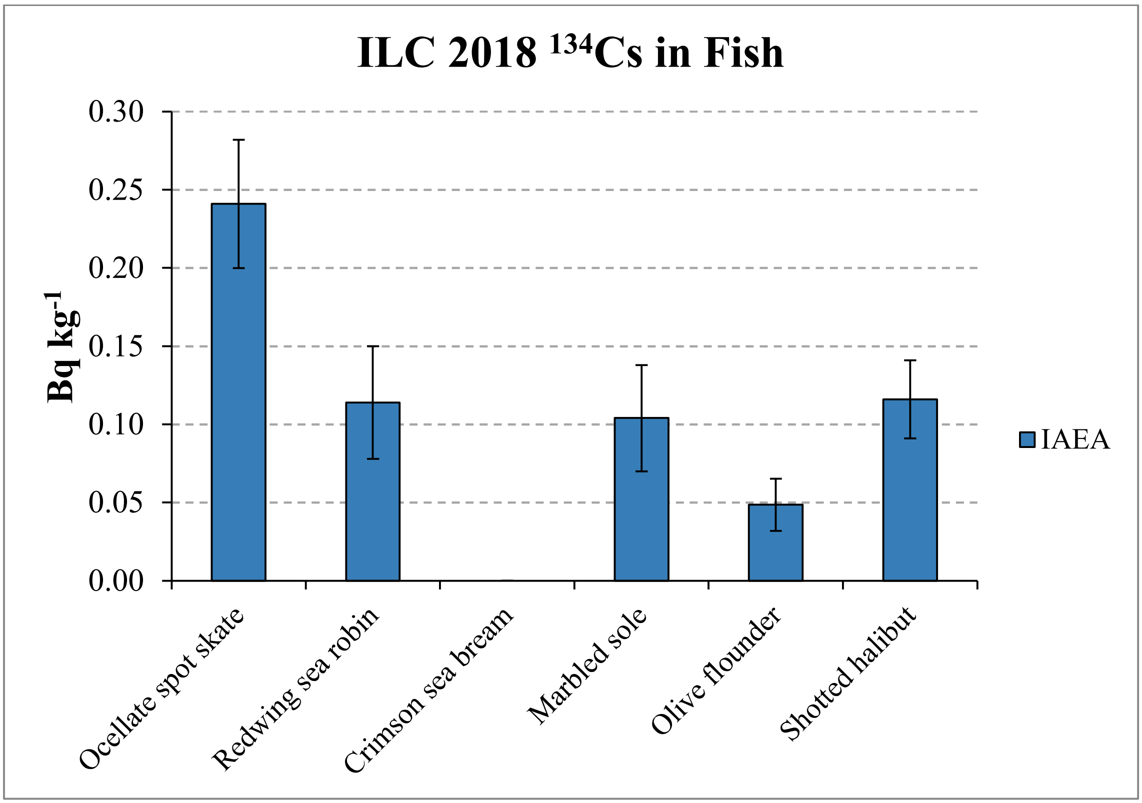

FIG. 36. *Activity concentrations of* ^{134}*Cs in fish samples from ILC 2018.*

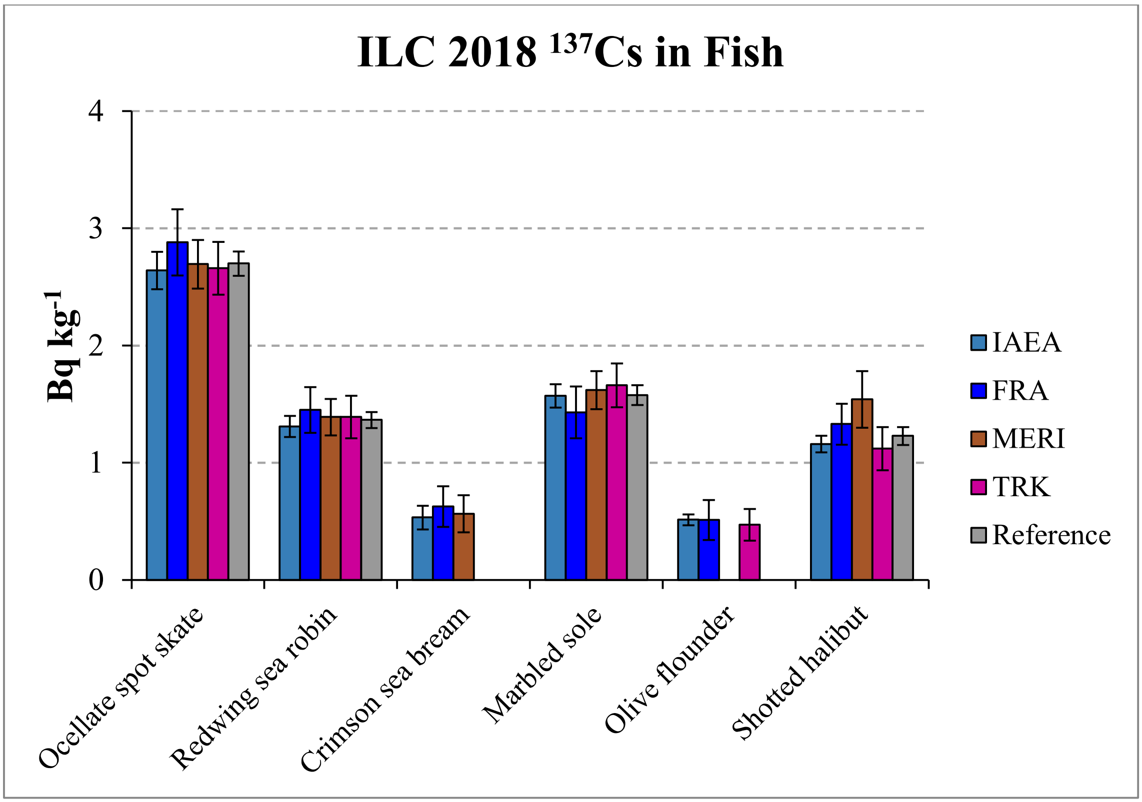

FIG. 37. *Activity concentrations of* ^{137}*Cs in fish samples from ILC 2018.*

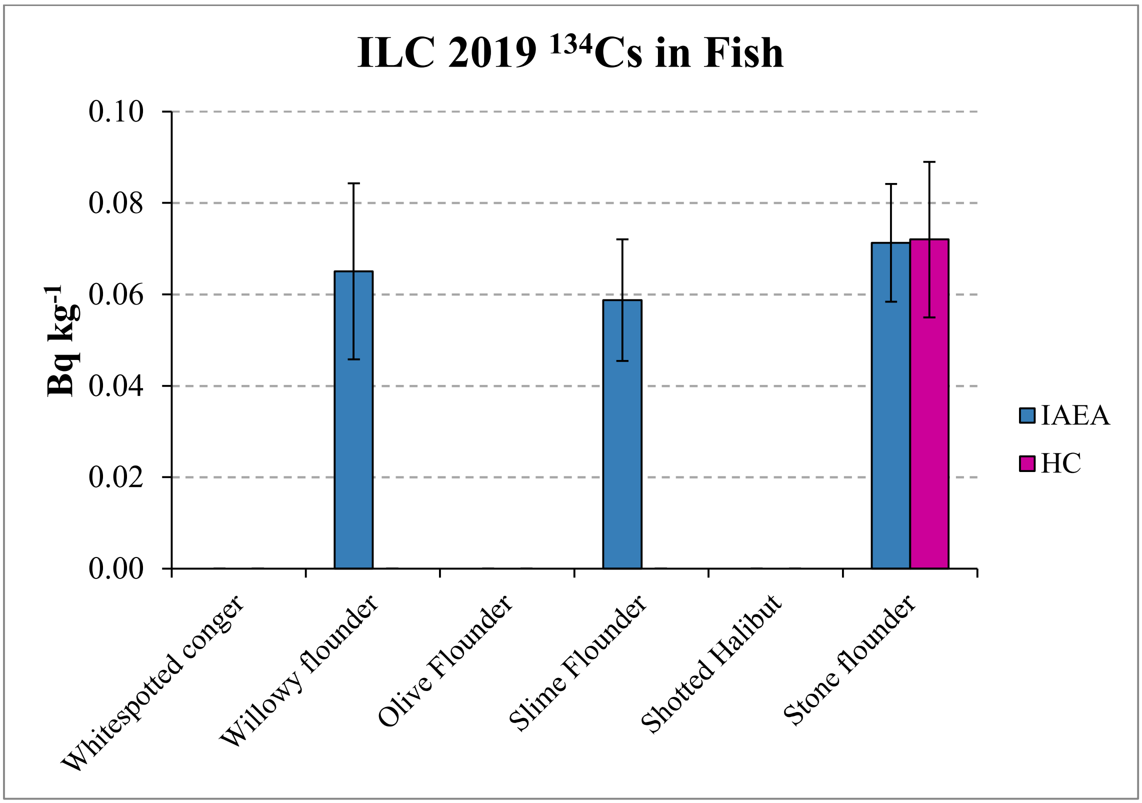

FIG. 38. Activity concentrations of ^{134}Cs in fish samples from ILC 2019.

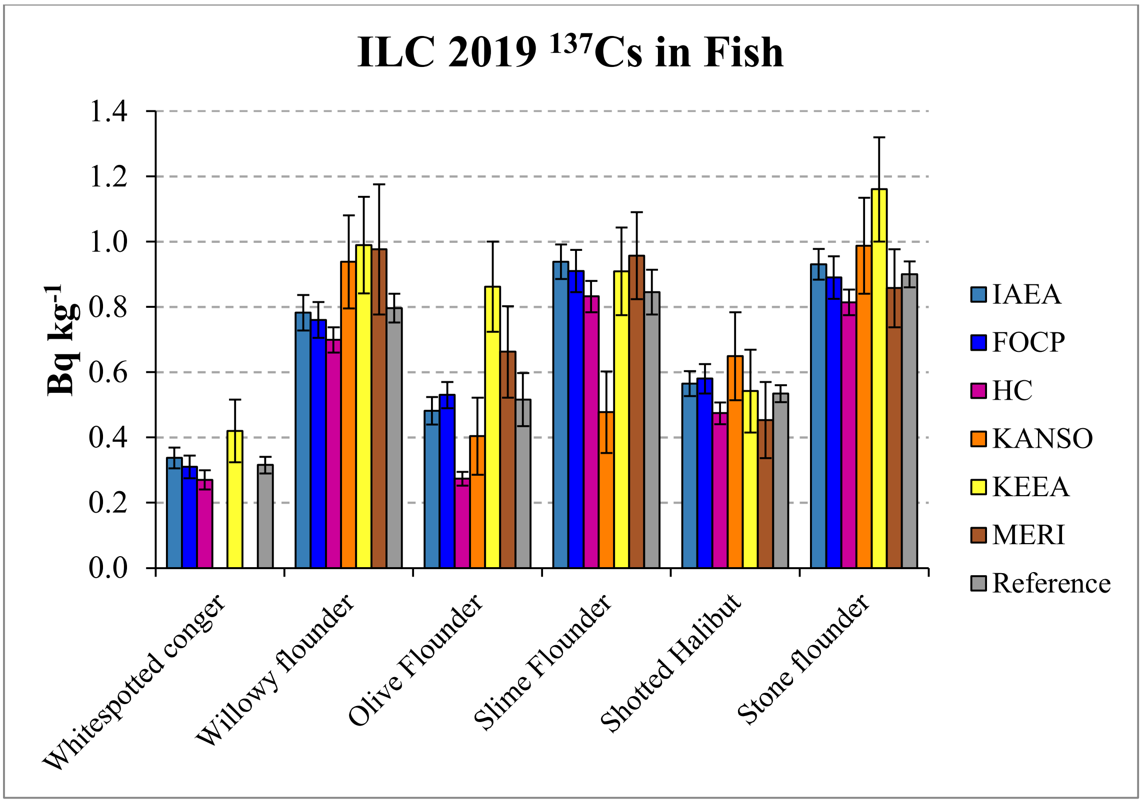

FIG. 39. Activity concentrations of ^{137}Cs in fish samples from ILC 2019.

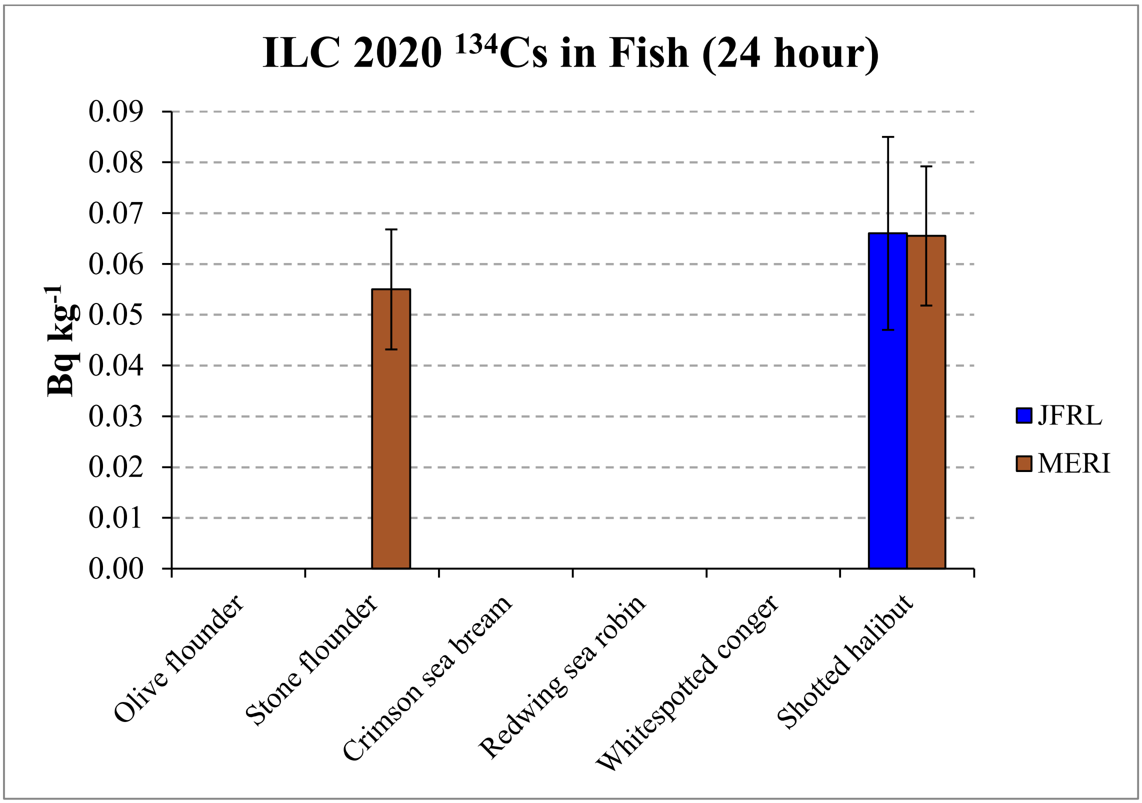

FIG. 40. Activity concentrations of ^{134}Cs in fish samples (24 hour measurement time) from ILC 2020.

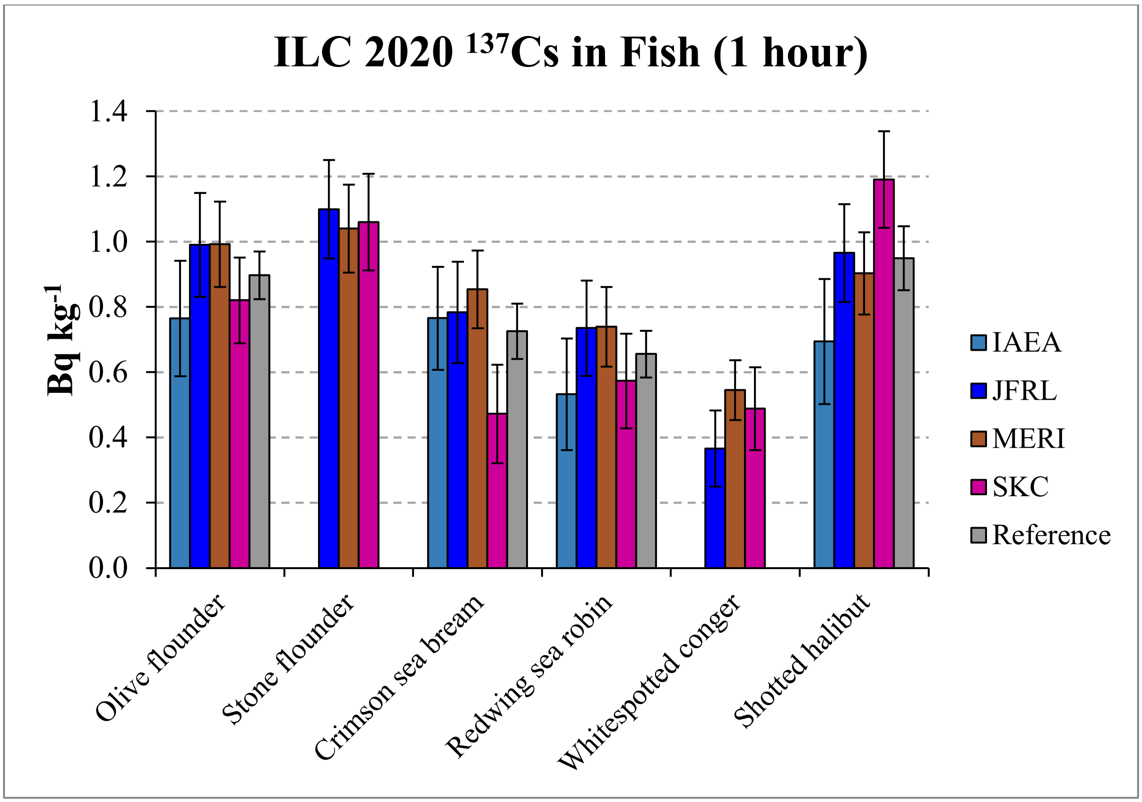

FIG. 41. Activity concentrations of ^{137}Cs in fish samples (one hour measurement time) from ILC 2020.

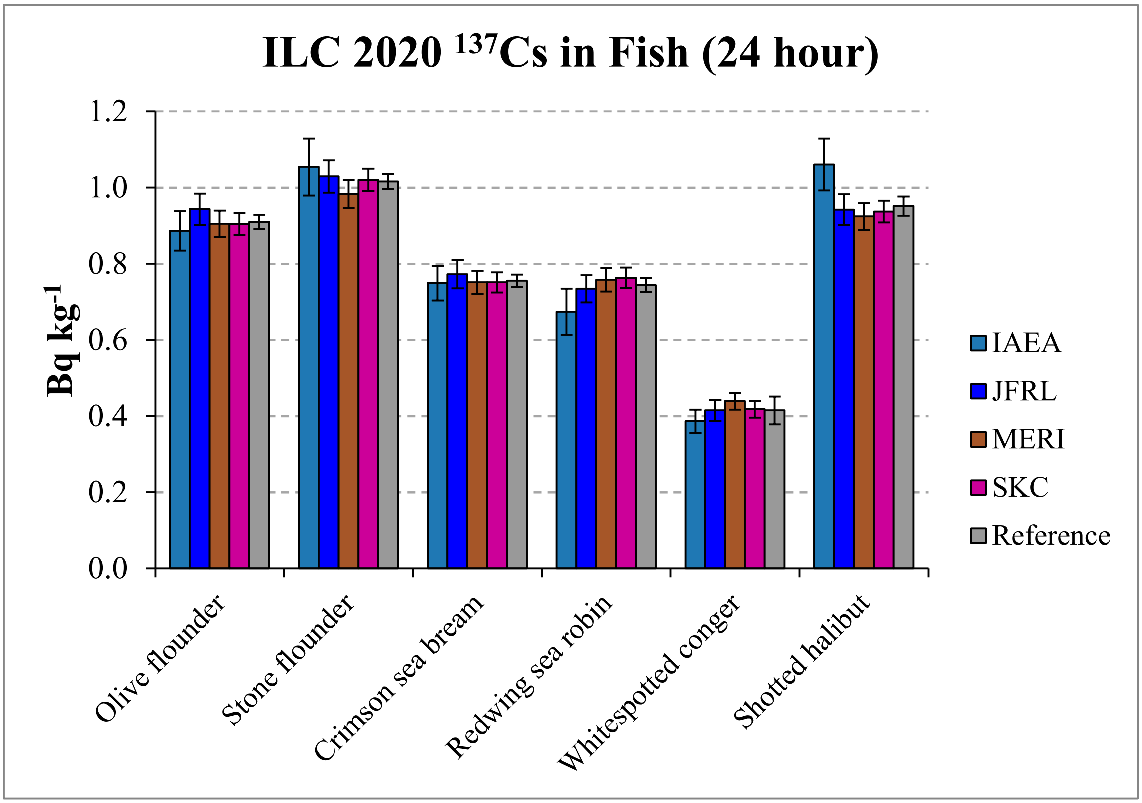

FIG. 42. Activity concentrations of ^{137}Cs in fish samples (24 hour measurement time) from ILC 2020.

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CONTRIBUTORS TO DRAFTING AND REVIEW

Bartocci, J.	International Atomic Energy Agency
Blinova, O.	International Atomic Energy Agency
Fujak, M.	International Atomic Energy Agency
Le Normand, J.	International Atomic Energy Agency
Levy, I.	International Atomic Energy Agency
McGinnity, P.	International Atomic Energy Agency
Osvath, I.	International Atomic Energy Agency
Pham, M. K.	International Atomic Energy Agency
Rozmaric, M.	International Atomic Energy Agency
Sam, A.	International Atomic Energy Agency

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