Analysis of temporal variations of Cs-137 discharge inventory from the port of Fukushima Daiichi Nuclear Power Plant over 9 years after the accident

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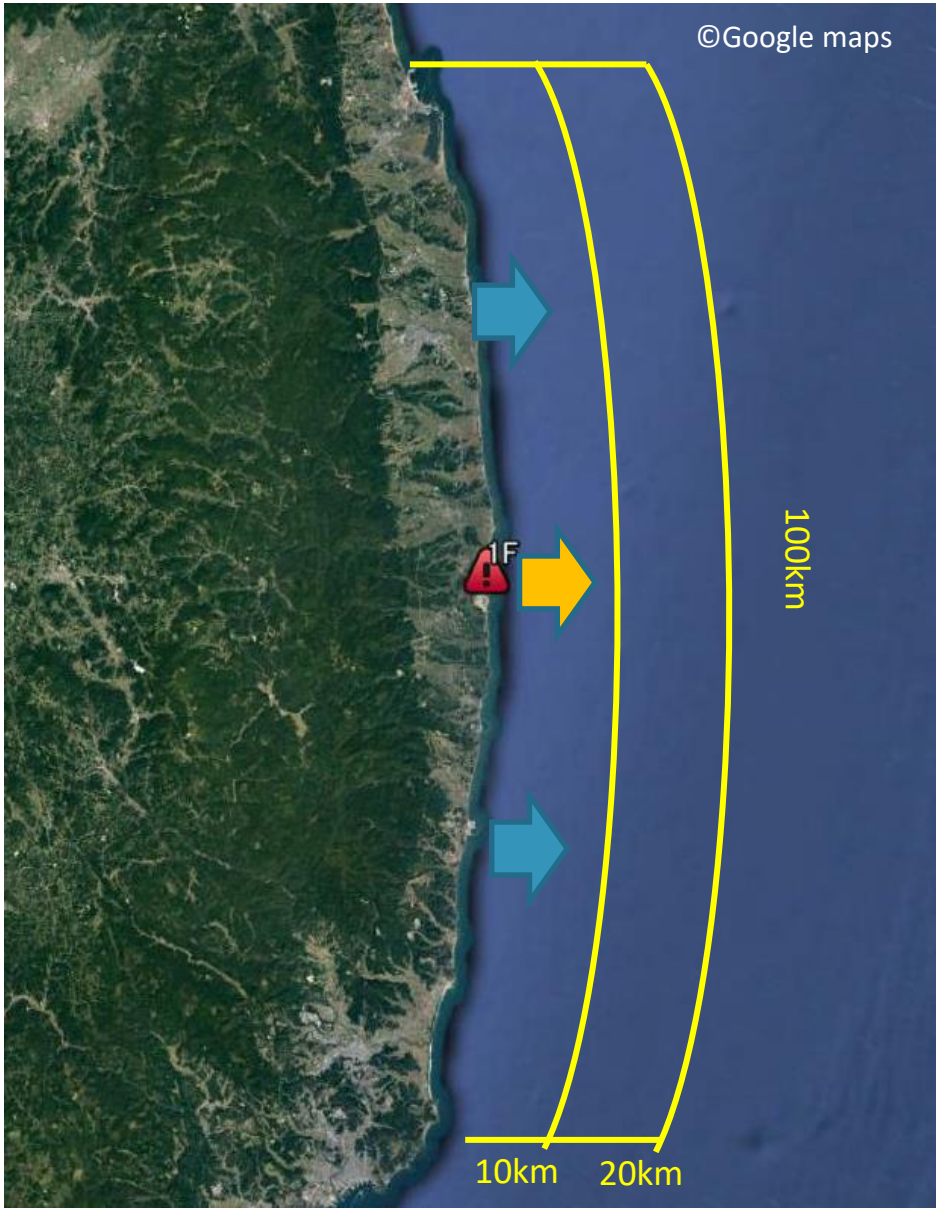
Summary

Just after Fukushima Daiichi Nuclear Power Plant (1F) accident occurred in March 2011, the direct discharges of highly-contaminated water from reactor Unit 2 and 3 into the 1F port followed. After the suppressions of the direct discharges, Kanda (Biogeosci. 10, 6107–6113, 2013) suggested that relatively small amounts of run-off of a radionuclide (Cs-137) from 1F port into Fukushima coastal region has continued based on his estimation method. However, Kanda's estimation period was limited up to September 2012. Therefore, we expand the estimation period of the discharged inventory up to very recently, March 2020 with significant accuracy improvements by the present authors. As a result, we find that totally, in the period over 9 years, the discharged inventory has gradually diminished together with various characteristic fluctuations. In this presentation, we analyze the observed diminishing trends with temporal fluctuations and discuss their relationships with various suppression measures and constructions toward decommissioning of 1F. Furthermore, we estimate the annual discharged amount of Cs-137 and evaluate its impacts on the coastal area in terms of seawater concentrations.

Introduction



Seashore around Fukushima Daiich Nuclear Power Plants (1F)

Our Aim

Evaluate input sources of Cs-137 to seashore around 1F

How does 1F port discharge contributes to the seashore inventory ?

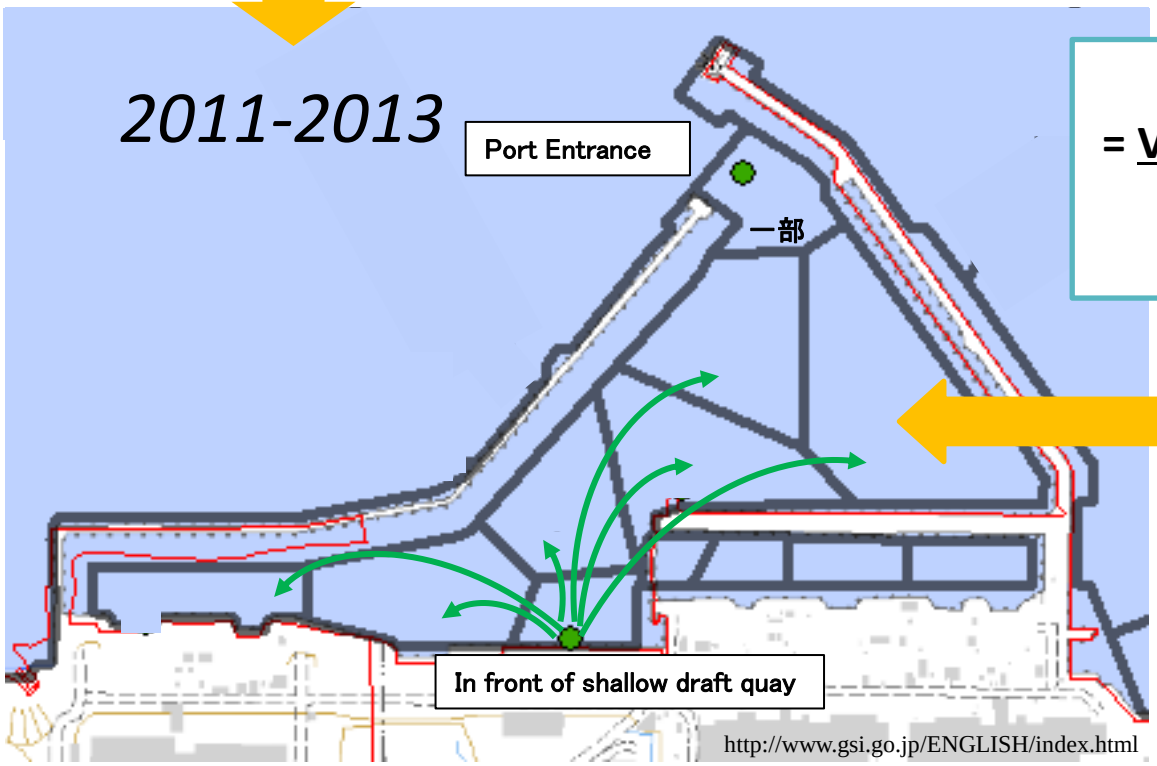
Estimate the discharge from 1F port using monitoring data inside 1F

2011 Apr. - 2018 Jun.
7-years discharge Inventory

Estimation scheme for the discharge inventory from 1F port (I)

Monitoring inside 1F port is limited from 2011 to 2013 (only two points)

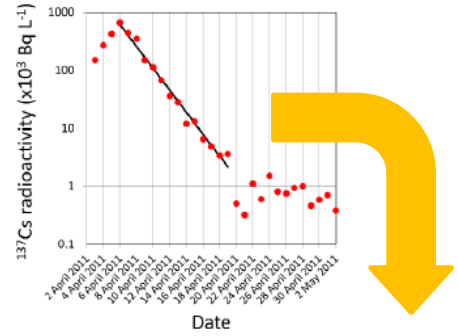
1F port inventory is estimated by using data only at the two points



1F port inventory of Cs-137
= V (L) X Cs-137 concentration (Bq/L)

V(L) : 1F port volume 1640893m^3

Decay after the initial direct discharge



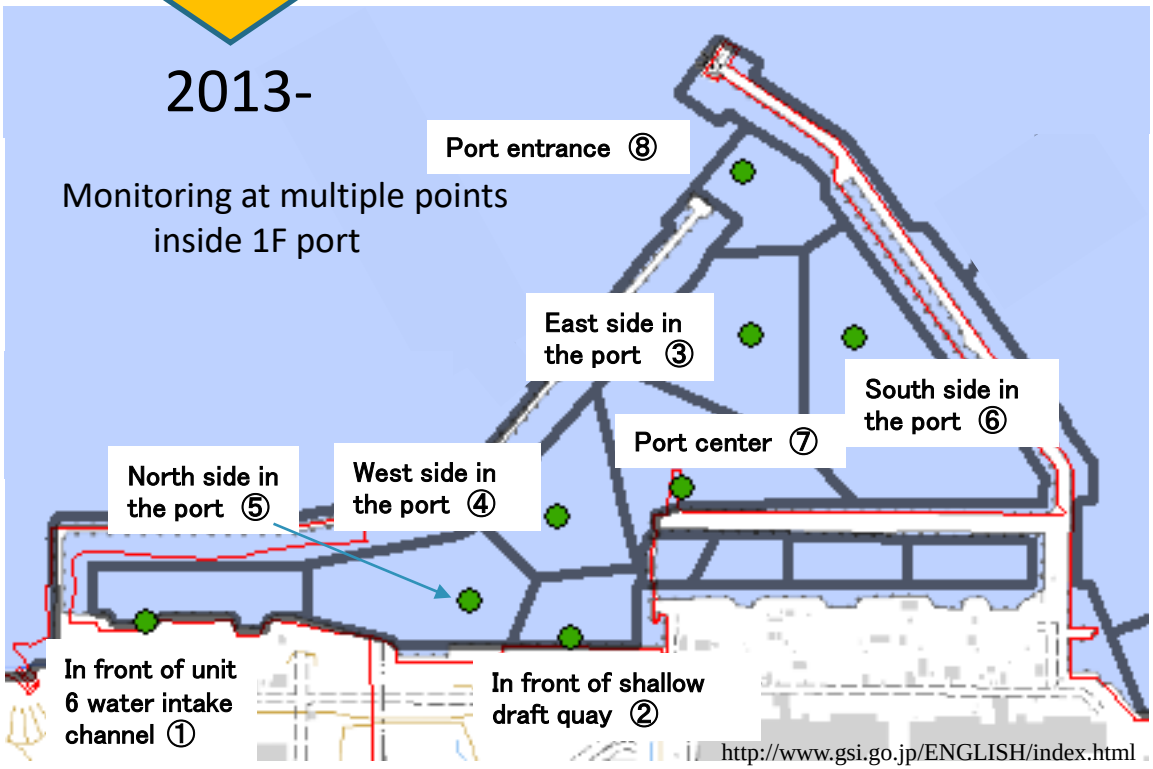
1F port discharge inventory (Bq/day) = 1F port inventory of Cs-137(Bq)X 0.44(/day)

J. Kanda, "Continuing ^{137}Cs release to the sea from the Fukushima Daiichi Nuclear Power Plant through 2012 ", Biogeosciences, 10, 6107–6113, 2013

Estimation method for discharge inventory from 1F port (Ⅱ)

Using Voronoi tessellation scheme for the monitoring system renewal

Inventory is estimated in each Voronoi polygonal column



※The number of monitoring points has increased to 8 since 2013

Monitoring Point	Depth (m)	Area(m^2)
①	5.85	15853.91
②	8.60	11381.35
③	8.61	31688.56
④	8.86	22240.60
⑤	8.32	27554.57
⑥	8.74	53516.06
⑦	4.21	30630.35
⑧	9.75	15816.25

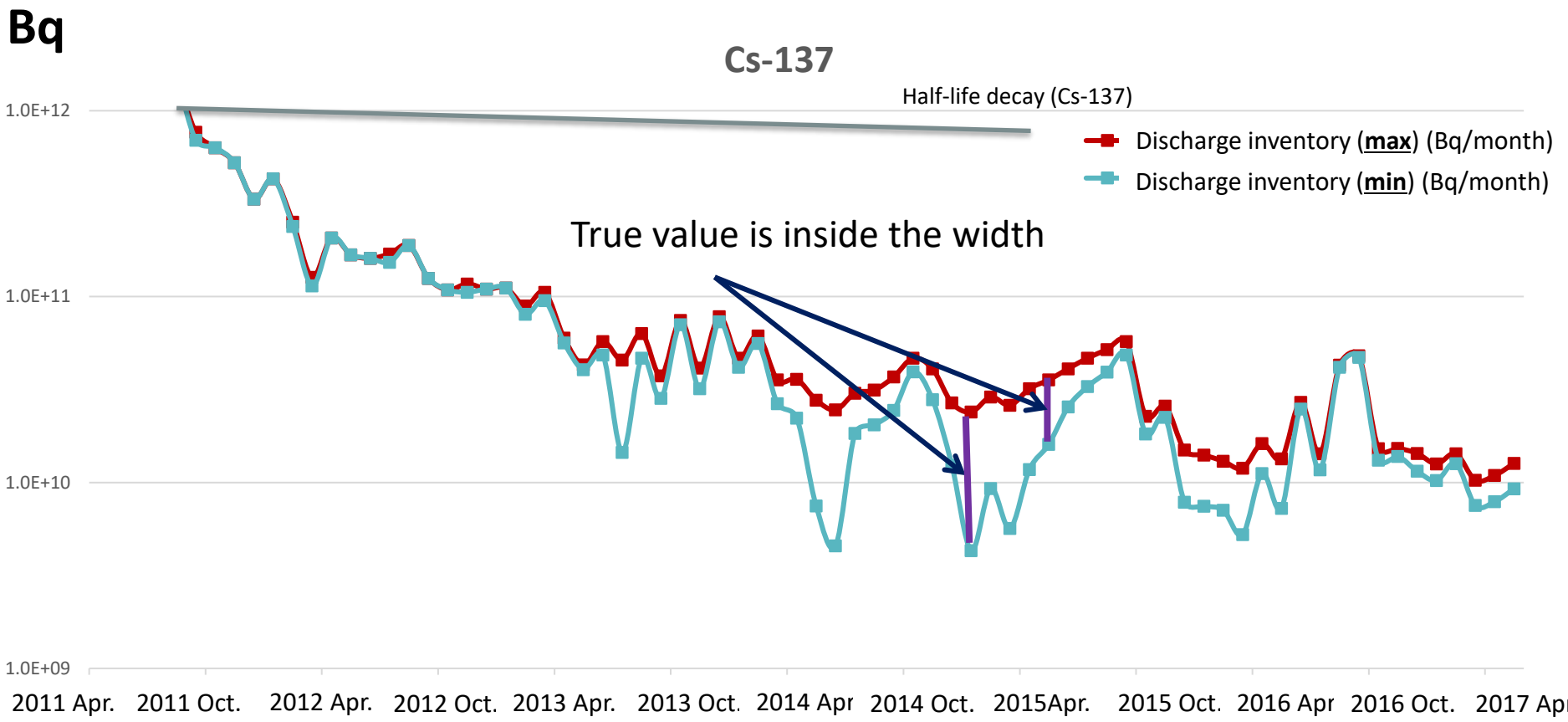
1F port volume：1640893m^3

The inventory estimation accuracy is improved

1F port Inventory(Bq)= $\sum_{i=①}^{⑧}$(each polygonal column volume (L) X concentration (Bq/L))

M. Machida, S. Yamada, A. Iwata, S. Otosaka, T. Kobayashi, M. Watababe, H. Funasaka & T. Morita, “Seven-year temporal variation of Caesium-137 discharge inventory from the port of Fukushima Daiichi Nuclear Power Plant: continuous monthly estimation of Caesium-137 discharge in the period from April 2011 to June 2018”, Journal of Nuclear Science and Technology (2020)

Monthly Cs-137 discharge inventory from 1F port (min~max) by using Voronoi scheme



When less than detection limit is measured

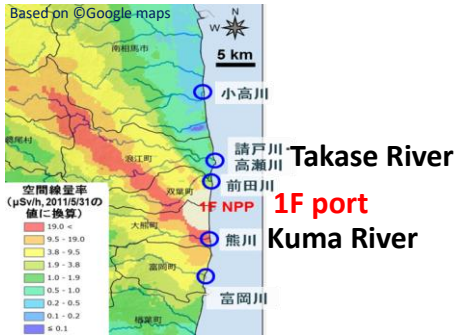
detection limit value is inputted in the estimation equation ⇒ max

zero is inputted in the estimation equation ⇒ min

True is inside

Comparison of discharge inventory between Voronoi tessellation and Kanda scheme

	Voronoi tessellation scheme		Kanda scheme
	Total discharge inventory (/year) min–max		Total discharge inventory (/year) min–max
2011	1.9E+15 ～ 1.9E+15	**2011**	2.3E+15 ～ 2.3E+15
2012	2.1E+12 ～ 2.2E+12	**2012**	2.9E+12 ～ 2.9E+12
2013	7.0E+11 ～ 8.1E+11	**2013**	1.4E+12 ～ 1.4E+12
2014	3.0E+11 ～ 4.5E+11	**2014**	7.1E+11 ～ 7.4E+11
2015	2.4E+11 ～ 4.1E+11	**2015**	3.2E+11 ～ 6.4E+11
2016	2.0E+11 ～ 2.5E+11	**2016**	2.4E+11 ～ 2.8E+11
2017	1.3E+11 ～ 1.6E+11	**2017**	1.9E+11 ～ 2.4E+11



※ **2015 annual discharge inventory:**

Takase River > 1F port > Kuma River

JAEA・Sector of Fukushima R&D

Conclusion

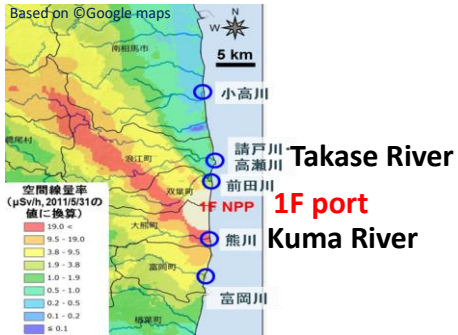
- The Cs-137 discharge inventory from 1F port was estimated by two schemes(Kanda's one and Voronoi tessellation one) from Apri. 2011 to June 2018.

J. Kanda, "Continuing ^{137}Cs release to the sea from the Fukushima Daiichi Nuclear Power Plant through 2012 ", Biogeosciences, 10, 6107–6113, 2013

M. Machida, S. Yamada, A. Iwata, S. Otosaka, T. Kobayashi, M. Watababe, H. Funasaka & T. Morita, "Seven-year temporal variation of Caesium-137 discharge inventory from the port of Fukushima Daiichi Nuclear Power Plant: continuous monthly estimation of Caesium-137 discharge in the period from April 2011 to June 2018", Journal of Nuclear Science and Technology (2020)

- The Cs-137 discharge inventory from 1F port has decreased more rapidly compared to Cs-137 half-life decay.

- The annual Cs-137 discharge inventory from 1F port at 2015 is lower than a river (Takase+Ukedo river).



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