Current state of the marine environment in the Pacific Ocean

1. Radioactivity in seawater and marine soil by Japanese monitoring in 2012
2. Simulation of marine dispersion in the Pacific Ocean

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1. Radioactivity in seawater and marine soil by Japanese monitoring in 2012

Sea Area Monitoring Plan in FY2012

Basic concept of the revision of the monitoring plan is to ascertain

(1) concentration levels mainly for ceasium-134,137 in seawater by enhancing the analysis accuracy,

(2) the spatial distribution and chronological movement of radioactive materials in marine soil and characteristics of marine soil,

(3) the chronological changes in radioactivity concentrations in fishery products with regard to marine organisms.

Furthermore, the monitoring content will be enhanced and strengthened by taking into account not only the routes of radioactive materials discharged into the sea from TEPCO's Fukushima Dai-ichi NPP but also those of radioactive materials flowing into the sea from the land area via rivers.

When conducting the sea area monitoring, attention will also be paid to the viewpoints of helping the understanding of the movement of radioactive materials from the environment to marine organisms and the bioconcentration process.

http://radioactivity.mext.go.jp/en/contents/5000/4854/view.html

Five sea areas

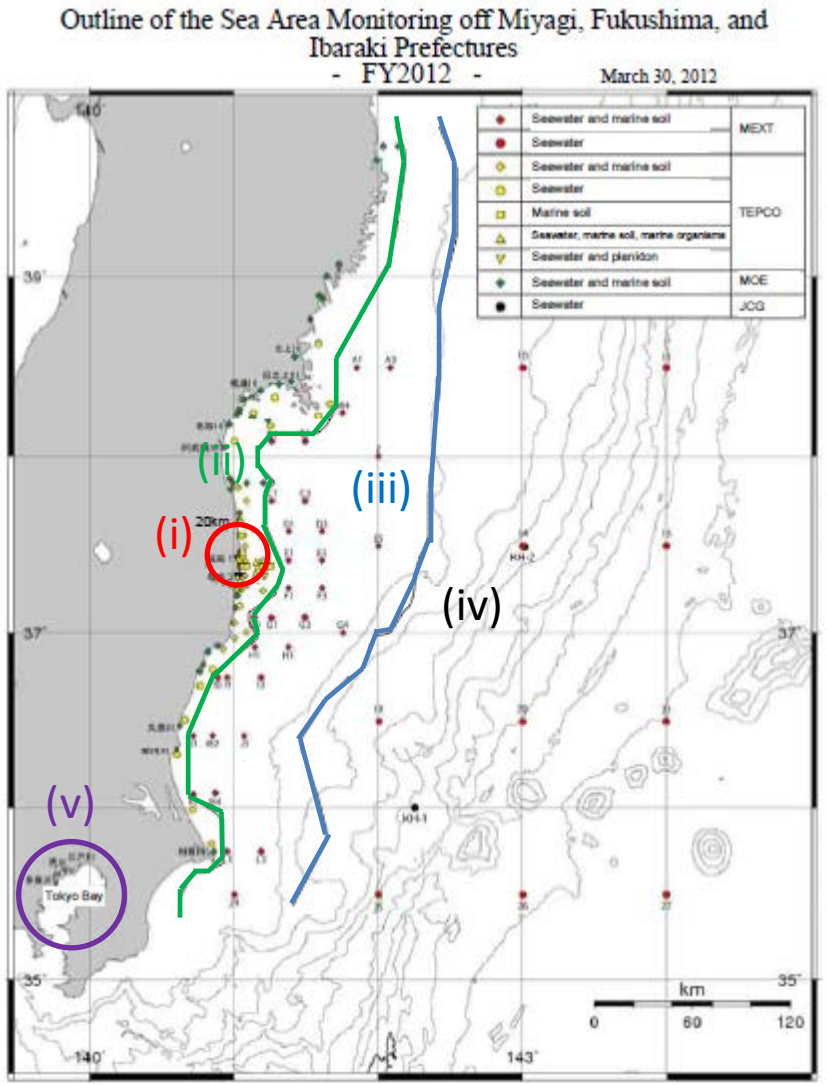
(i) Sea area close to TEPCO's Fukushima Dai-ichi NPP: The area near the 1F-NPP requiring close watch

(ii) Coastal area: The area within about 30 km from the coastline of Aomori (only partially), Iwate to Miyagi, Fukushima and Ibaraki prefectures (including river outlets)

(iii) Off-shore area: The area within about 30 to 90 km from the coastline

(iv) Outer sea area: The area within about 90 to 280 km and 280 km or farther from the coastline

(v) Tokyo Bay: The closed sea area where radioactive materials are highly likely to flow in from rivers and be deposited in particular



http://radioactivity.mext.go.jp/en/contents/5000/4854/view.html

Seawater

- In area(i), high frequency (dairy) monitoring with the aim of checking any new leakage of radioactive materials from the NPP with detection limit(DL) at 1 Bq/L. TEPCO will be in charge of this monitoring.
- In areas (ii)-(v), monitoring by lowering detection limits according to sea areas for the purpose of scientifically ascertaining long-term effects with DL at 1 mBq/L. Mainly MEXT will be in charge of this monitoring.
- Main objective nuclides are Cs-134,137, but sometimes H-3, Sr-89,90, I-131, Pu-238,239,240 etc. will be analyzed.

* http://radioactivity.mext.go.jp/en/contents/5000/4854/view.html

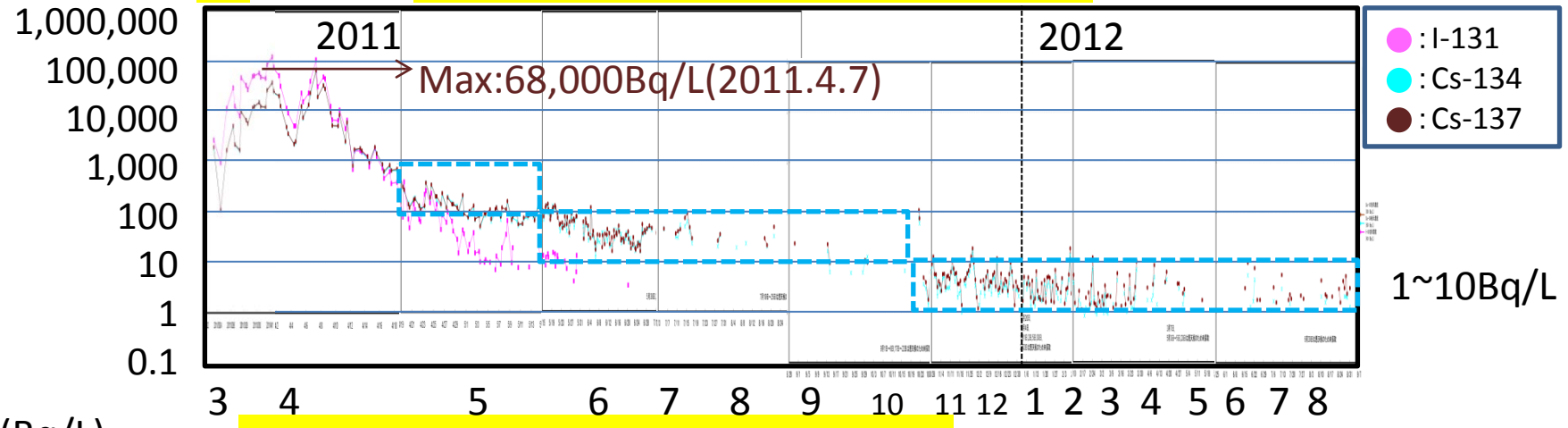
Marine soil

- Measuring points will be determined by taking into consideration river outlets and fishing grounds in order to understand the flow and movement of radioactive materials into the sea via rivers.
- In area(i) and part of (ii), monthly measurement for I-131 and Cs-134,137 are conducted with DL at 10 Bq/kg.
- The other areas except (iv), lower frequency measurement are conducted with DL at 1 Bq/kg .

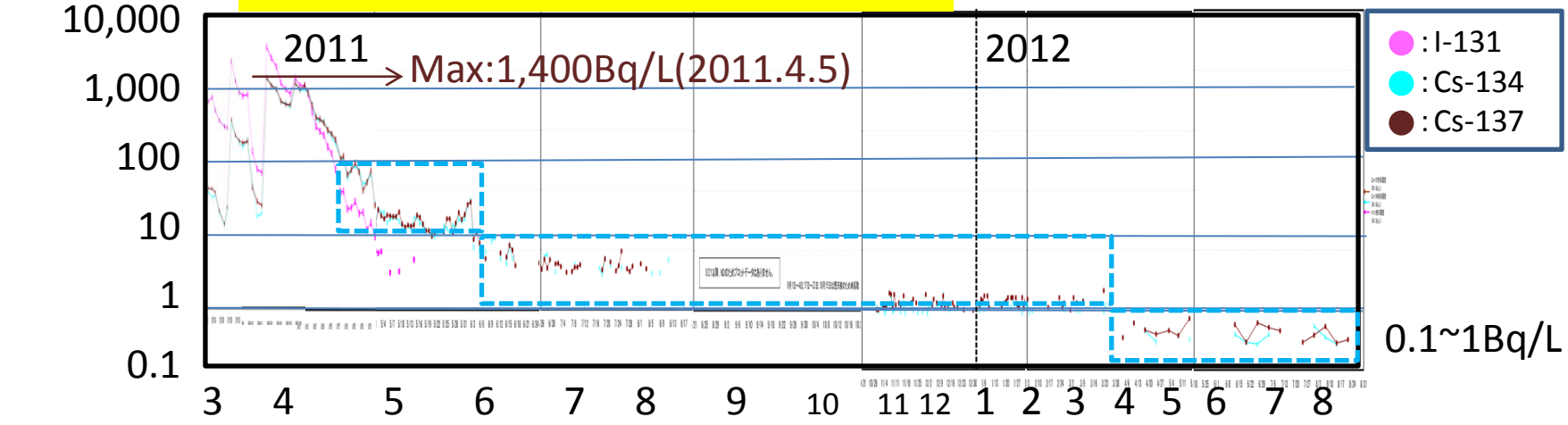
* http://radioactivity.mext.go.jp/en/contents/5000/4854/view.html

Seawater in area (i)*

(Bq/L) Northern Side of the Water Discharge Canal of 5 and 6



(Bq/L) Iwasawa coast (15km south of 1F-NPP)



BG level for ^{137}Cs before the accident=0.001~0.002 Bq/L

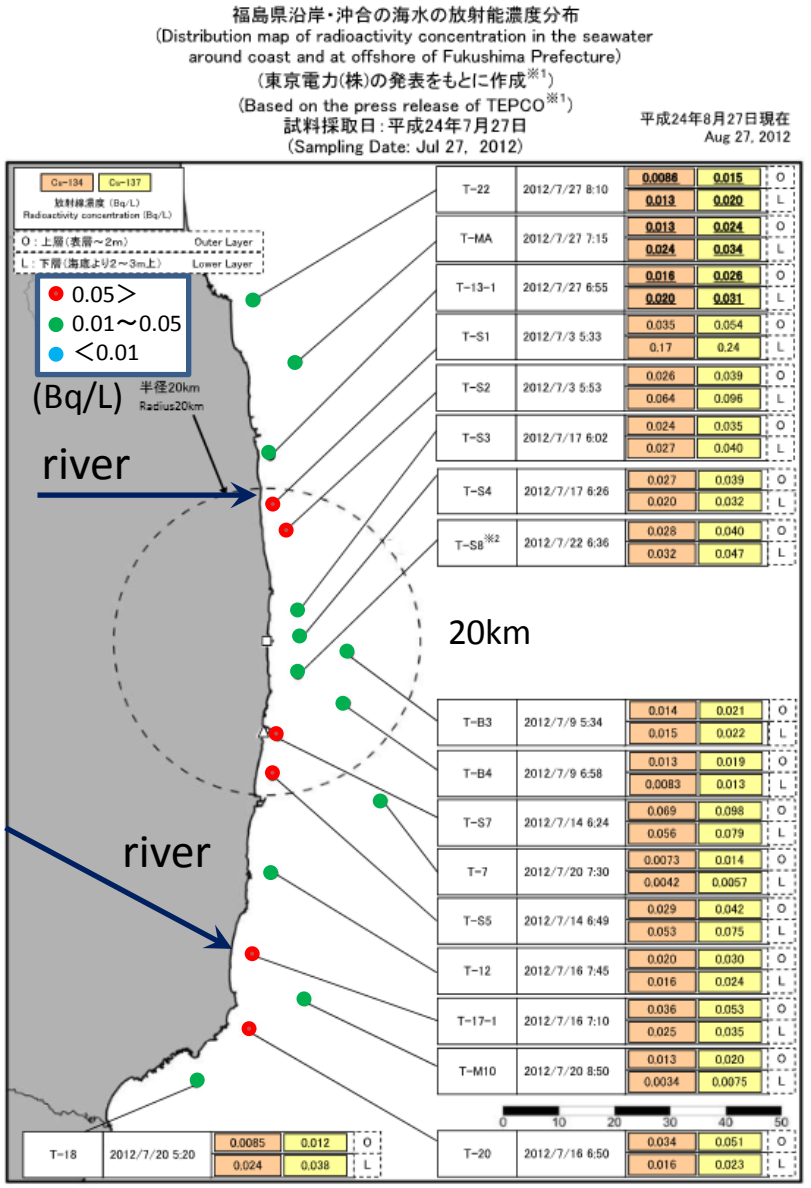
* http://www.tepco.co.jp/en/nu/fukushima-np/f1/index9-e.html

Seawater in area (ii)

(Bq/L)

2012	Cs-134	Cs-137
Miyagi (27,June)	ND~0.022	0.0017~0.032
Fukushima (27, July)	0.0034~0.069	0.0057~0.098
Ibaraki (6-9, August)	ND(<1.1)	ND(<1.1)

In Fukushima prefecture,
North ＜ South
But less than 0.1 Bq/L



http://radioactivity.mext.go.jp/ja/contents/7000/6107/24/229_m_0831.pdf
http://radioactivity.mext.go.jp/ja/contents/7000/6069/24/229_F_0727_0827.pdf
http://radioactivity.mext.go.jp/ja/contents/6000/5979/24/229_3_120815.pdf

Seawater in area (iii)

(Bq/L)

15-28, May, 2012	Cs-134	Cs-137
Miyagi	~0.018	~0.029
Fukushima	~0.041	~0.060
Ibaraki	~0.055	~0.087

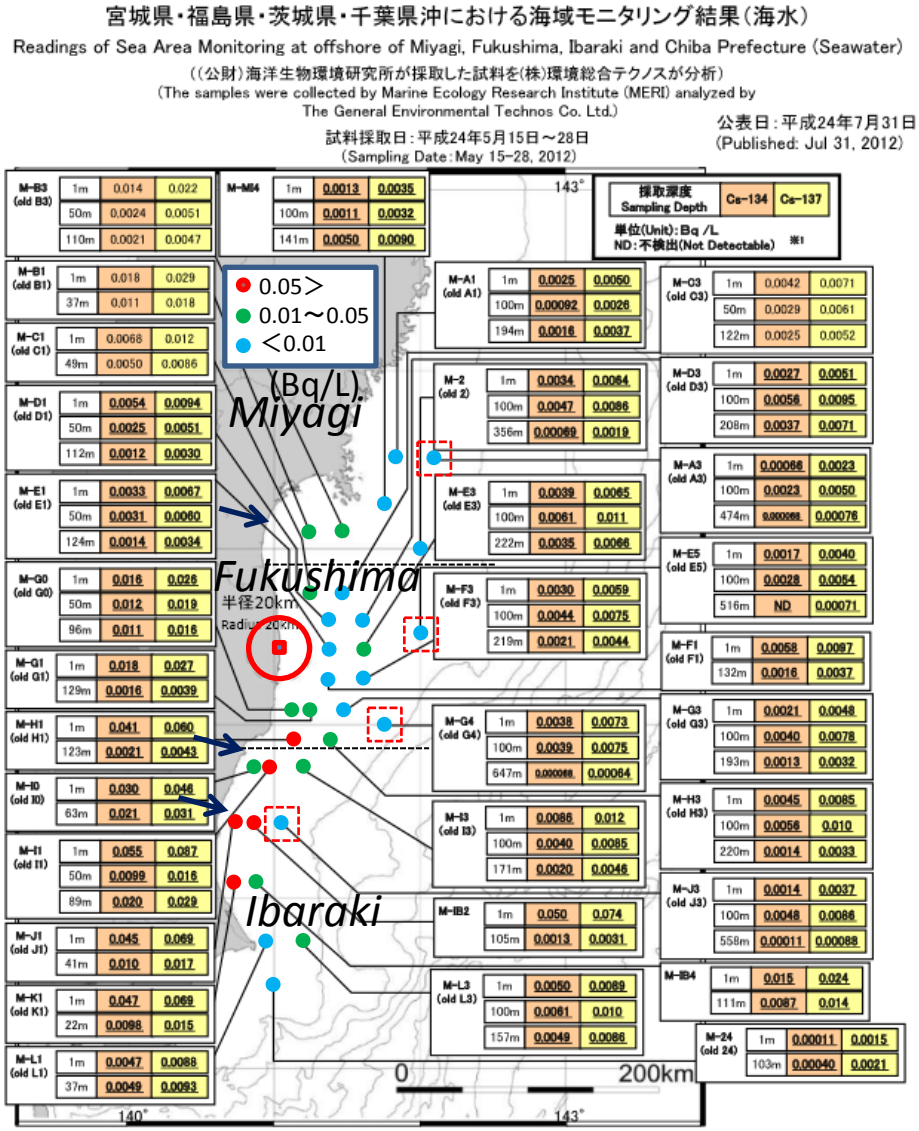
In 3 prefectures,
North ＜ South
Less than 0.1 Bq/L

Deep sea

(Bq/L)

15-28, May, 2012	Cs-134	Cs-137
Miyagi(474m)	0.000068	0.00076
Fukushima (516m, 647m)	ND ~0.000068	0.00064 ~0.00071
Ibaraki(558m)	0.00011	0.00088

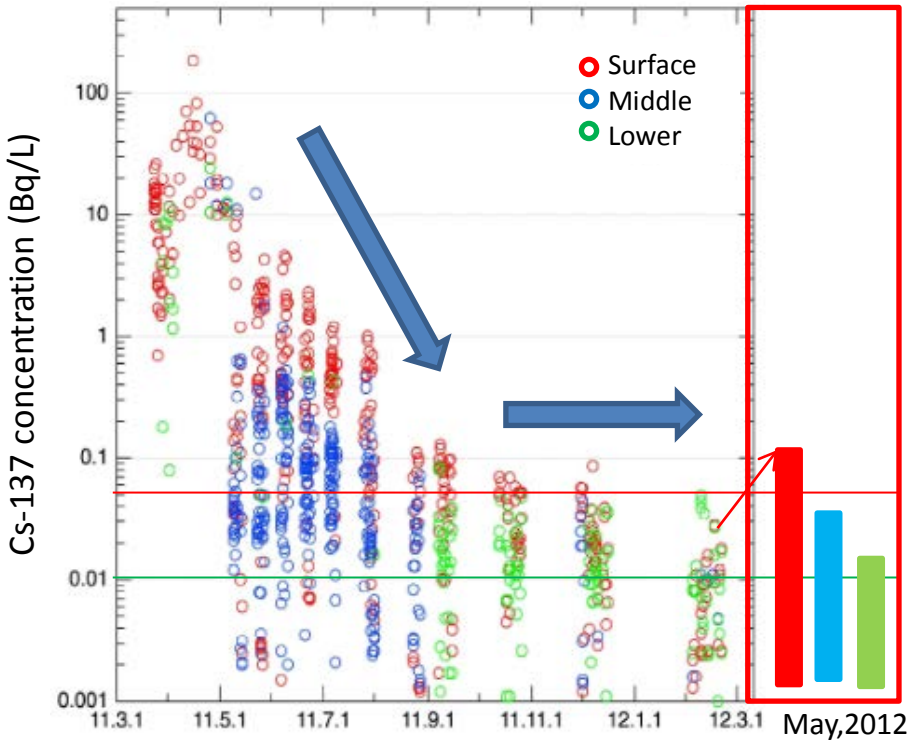
Cs-137=BG level
Cs-134=1/10 of Cs-137

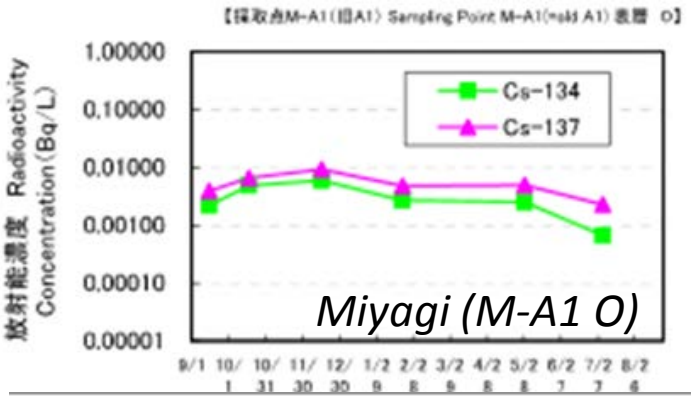


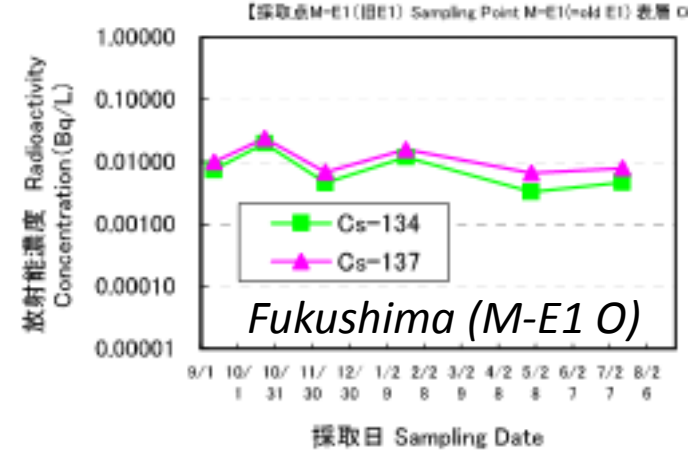
http://radioactivity.mext.go.jp/ja/contents/6000/5876/24/229_mhic_0731.pdf

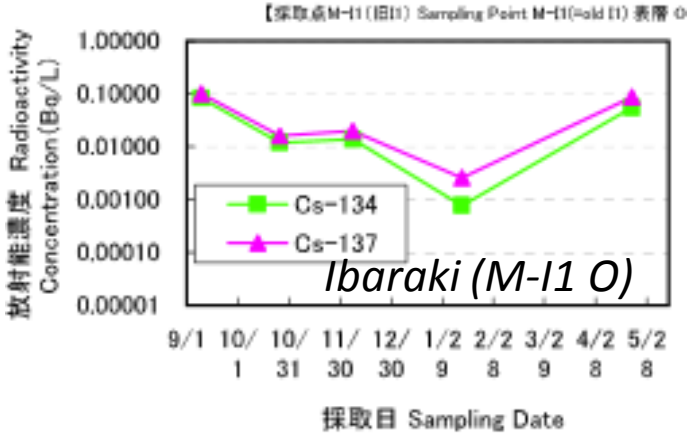
Trend of seawater in area (iii)

Concentration of Cs-137 had been decreasing till last September. But since then,
unchanged in Miyagi and Fukushima,
Fluctuated in Ibaraki, depending on desorption from marine soil? Inflow from river? Release from NPP?







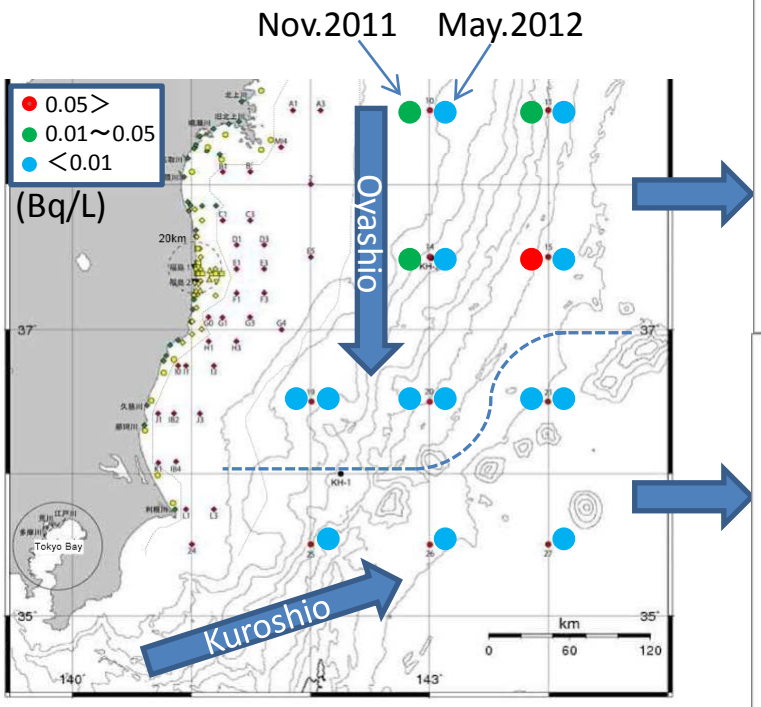


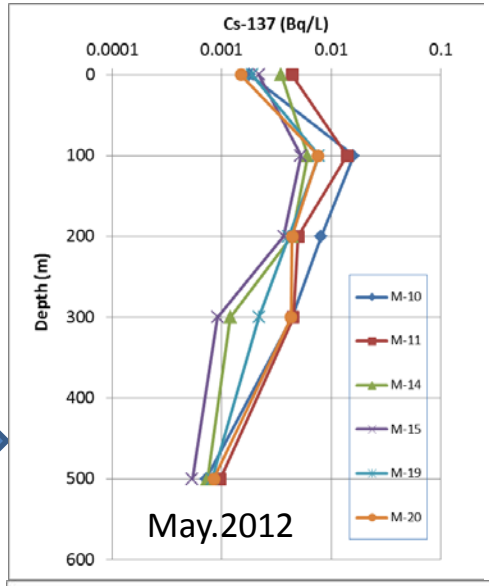
http://www.mext.go.jp/b_menu/shingi/chousa/gijyutu/019/shiryo/__icsFiles/afieldfile/2012/08/07/1324368_6_1.pdf (in Japanese)

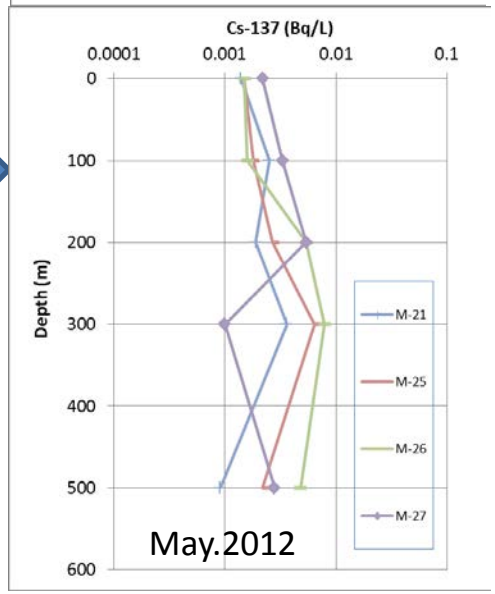
http://radioactivity.mext.go.jp/ja/contents/6000/5876/24/229_mhic_0731.pdf

Seawater in area (iv)

- 90-280km







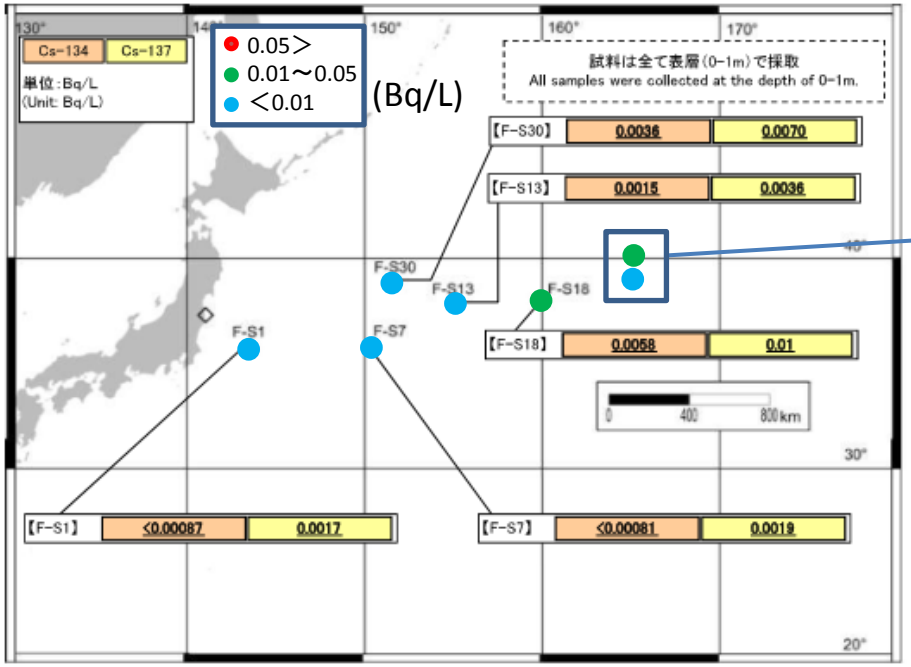
Oyashio region
Maximum: 100m depth

Kuroshio region
Maximum: unclear

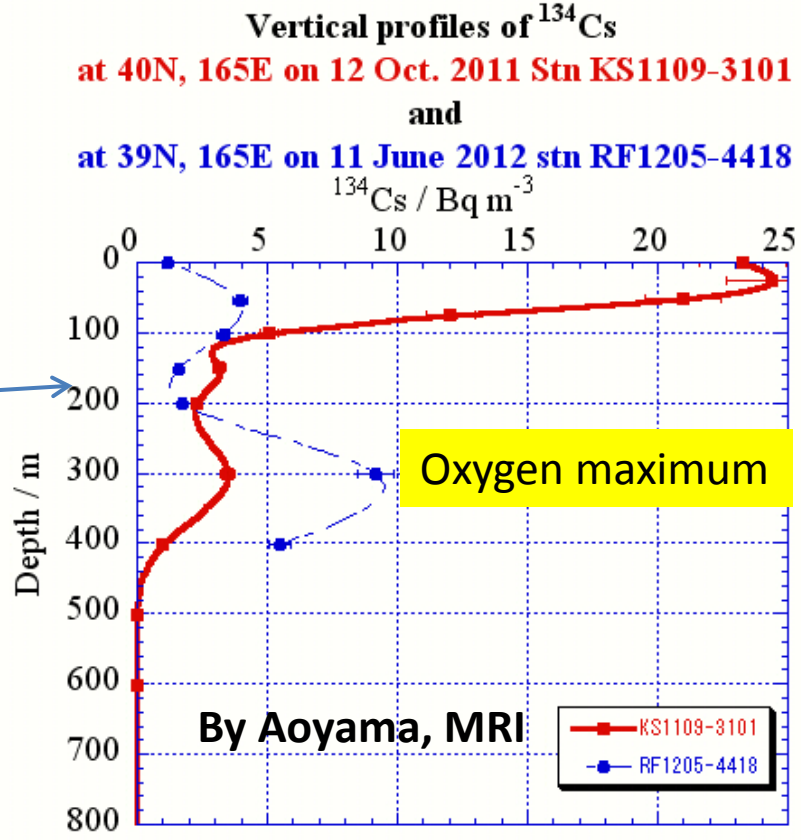
http://radioactivity.mext.go.jp/ja/contents/4000/3806/24/1330_012414.pdf
http://radioactivity.mext.go.jp/ja/contents/7000/6124/24/229_mfic_0903.pdf

Seawater in area (iv)

- 280km~



In May 2012:Less than 0.01 Bq/L



Surface seawater
Oct 2011: 0.025 Bq/L
June 2012: 0.001Bq/L

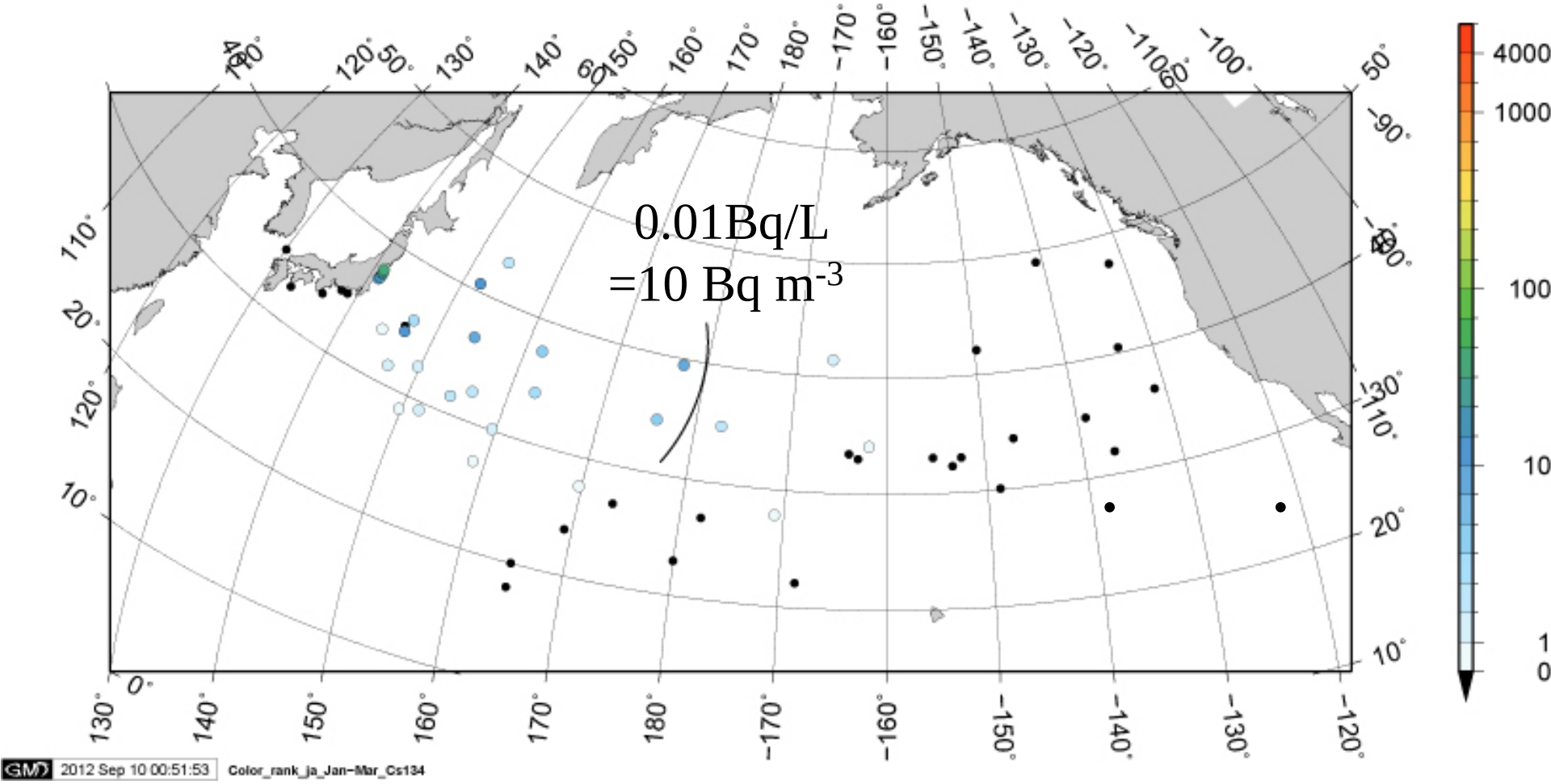
http://radioactivity.mext.go.jp/ja/contents/6000/5889/24/229_g_0802.pdf

http://www.mri-jma.go.jp/Topics/hotyouhi/houtyouhi_sea.html (in Japanese)

^{134}Cs in surface water in Jan. – Mar. 2012

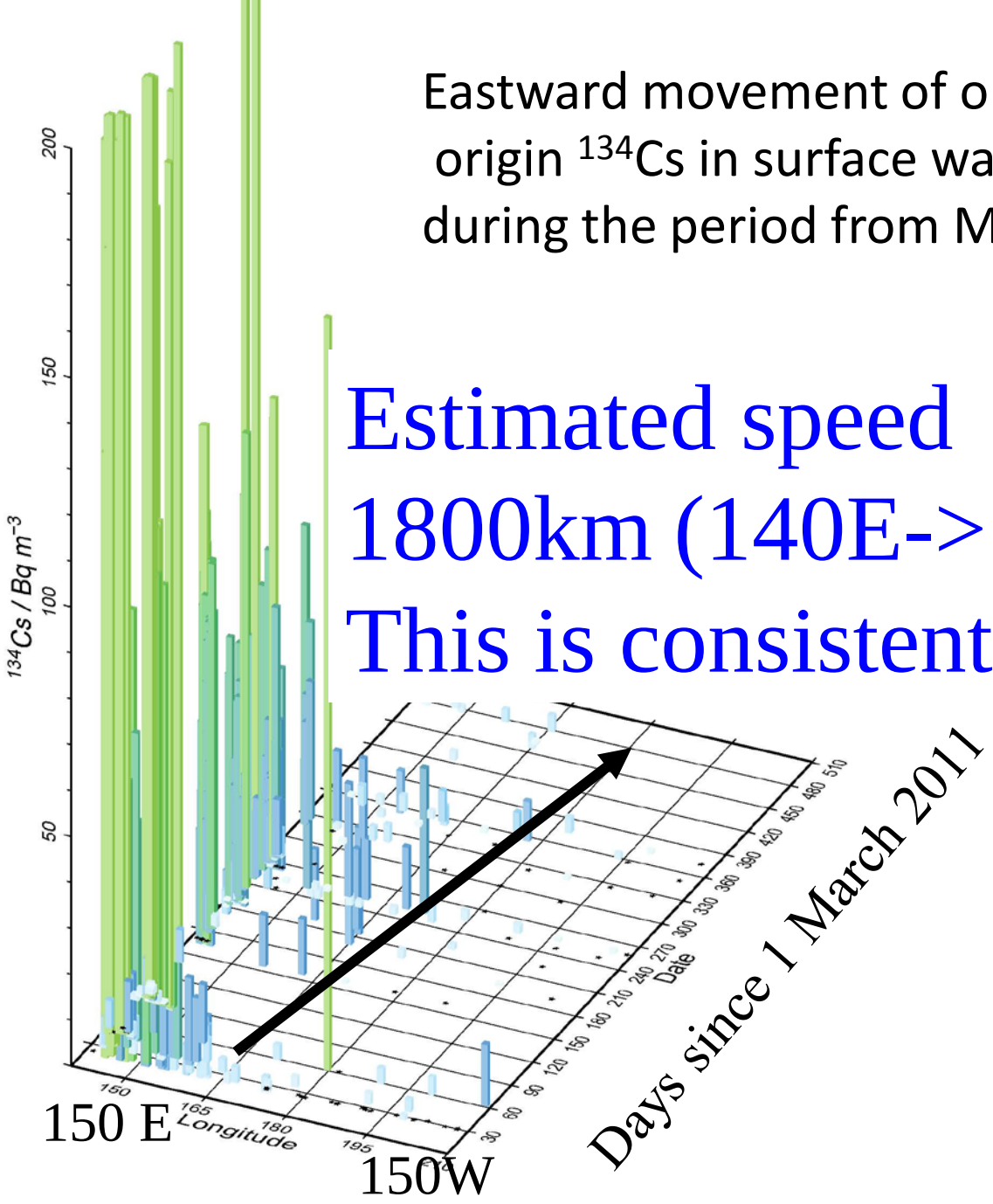
Data sources: MEXT monitoring, Aoyama this study

Solid circle with color: observed data unit: Bq m^{-3}



Aoyama, unpublished

Eastward movement of observed Fukushima origin ^{134}Cs in surface water during the period from March 2011 to July 2012



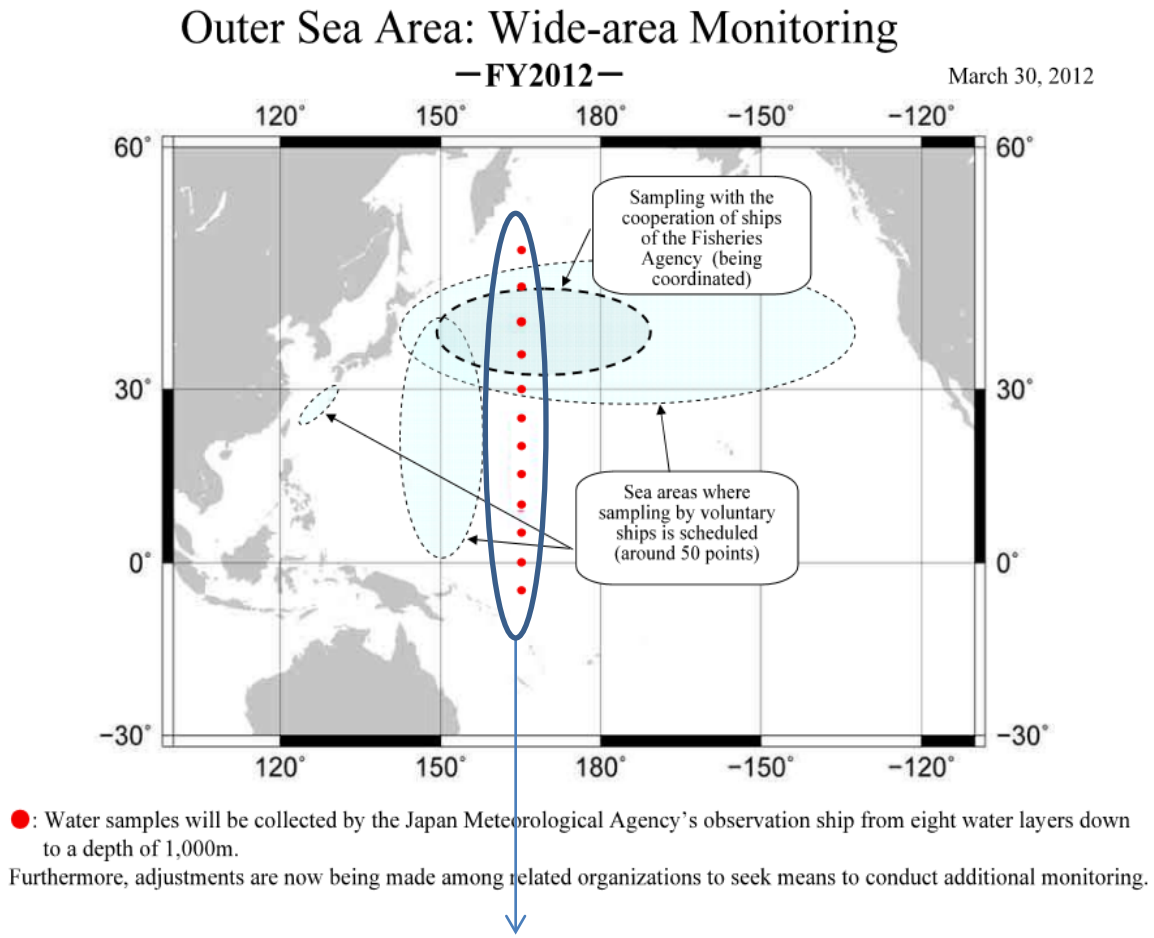
Estimated speed : 8 cm s^{-1}

1800km (140E->160E) 270 days

This is consistent with 4-16 cm s^{-1}

Aoyama, unpublished

More data in area (iv) in near future

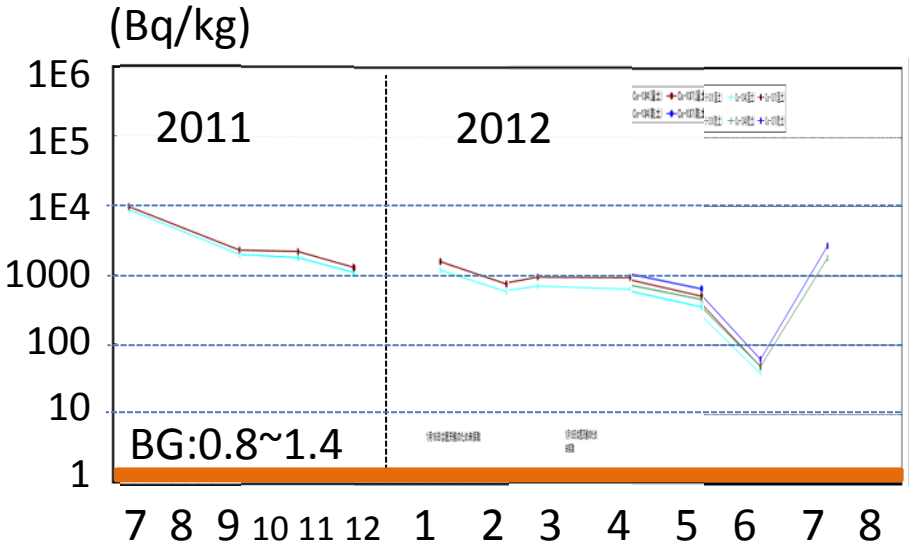


Seawater samples collected during June 2012 by MRI are analyzing now.
Only data from two stations at 39 deg.N and 35 deg. N along 165 deg. E are available.

http://radioactivity.mext.go.jp/en/contents/5000/4854/view.html

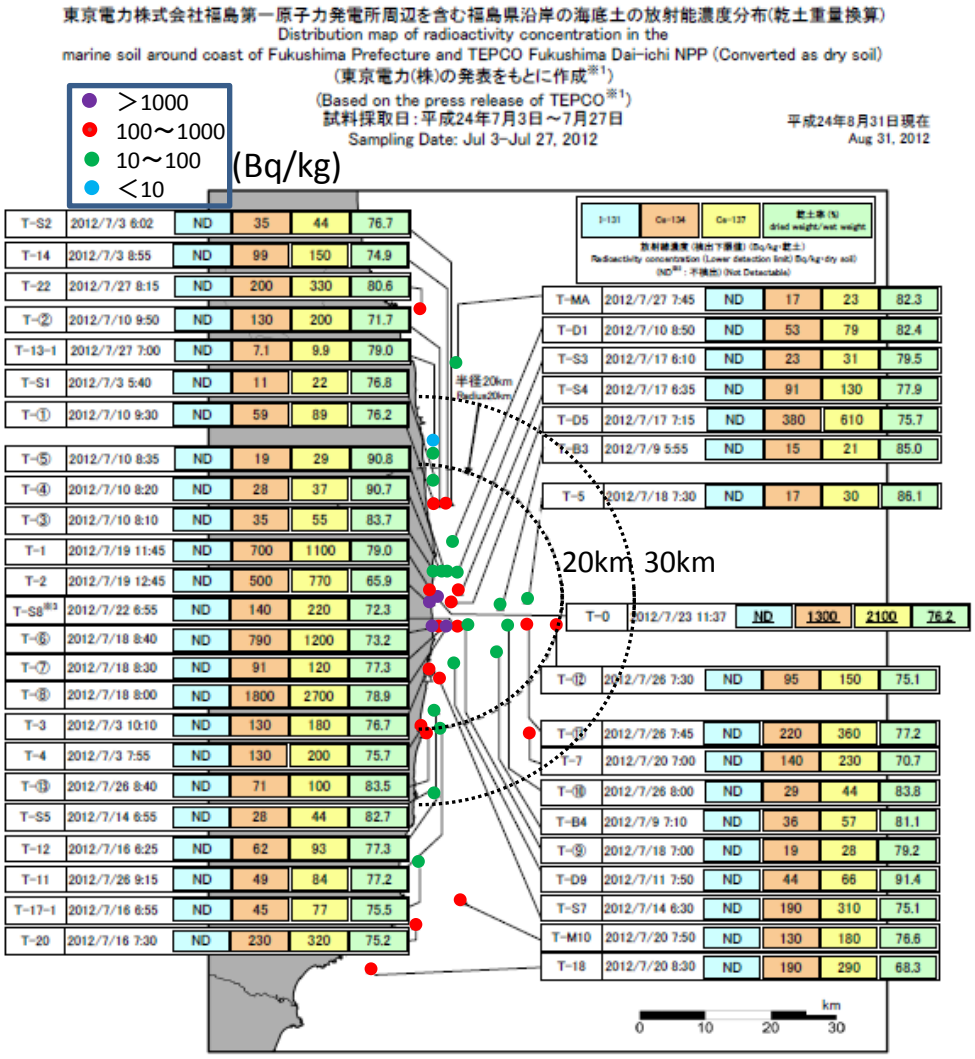
Marine soil in area (i)(ii)

Northern Side of the Water Discharge Canal of 5 and 6



(Bq/kg)

July, 2012	Cs-134	Cs-137
~20km	11~1800	21~2700
20~30km	7.1~140	9.9~230
30km~	17~230	23~330



http://www.tepco.co.jp/nu/fukushima-np/f1/index9-j.html

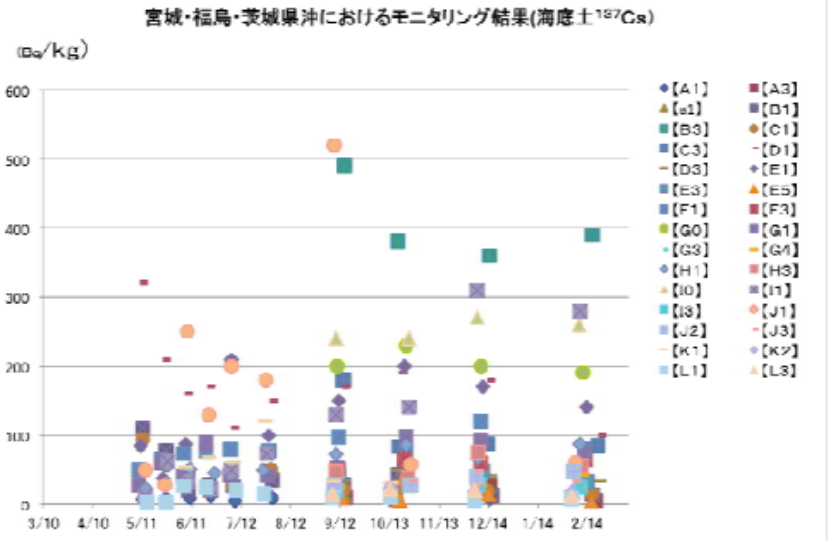
http://radioactivity.mext.go.jp/ja/contents/7000/6108/24/229_kando_0831.pdf

Marine soil in area (iii)

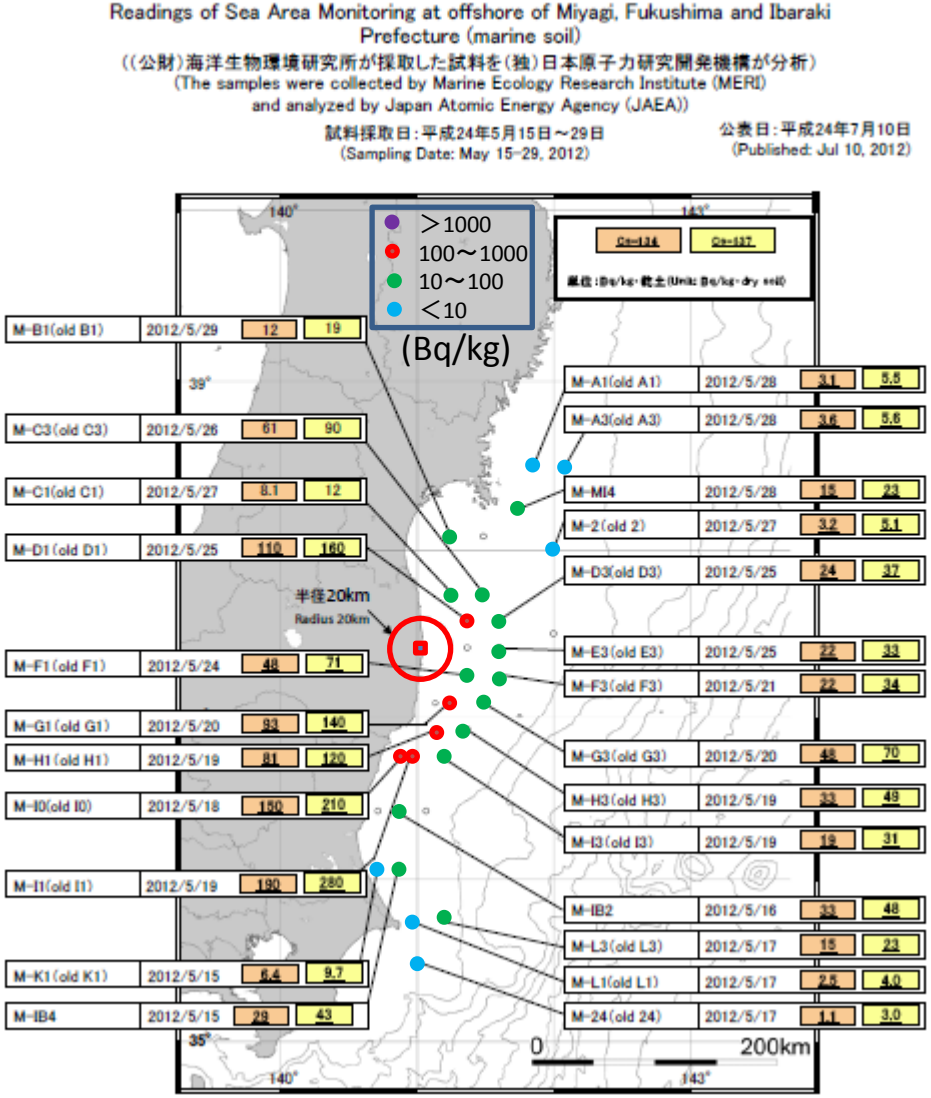
(Bq/kg)

15-29, May, 2012	Cs-134	Cs-137
Miyagi	~15	~23
Fukushima	~110	~160
Ibaraki	~190	~280

The concentration in marine soil varied widely, if taken at the same places.



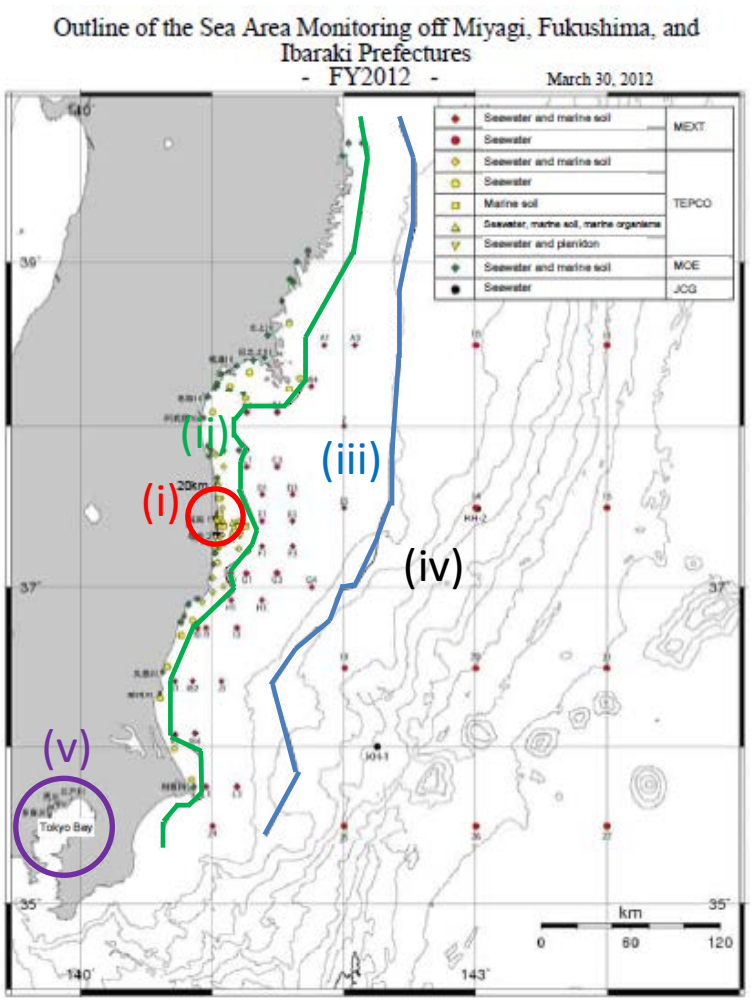
http://www.mext.go.jp/b_menu/shingi/chousa/gijyutu/019/shiryo/__icsFiles/afieldfile/2012/08/07/1324368_6_1.pdf (in Japanese)



http://radioactivity.mext.go.jp/ja/contents/6000/5703/24/229_so_0710.pdf

Current state of Cs-137 in seawater and marine soil in 2012

Area	Seawater (Bq/L)	Marine soil (Bq/kg)
(i) Close to NPP	1 -10 (discharge ports) 0.1-1 (Iwasawa coast)	20-3000
(ii) Coastal area	0.002-0.1	10-400
(iii) Off-shore area	BG-0.1	10-300
(iv) Outer sea area	BG-0.01	No data
BG before accident*	0.0011-0.0018 Offshore 1F NPP in 2010	0.8-1.4

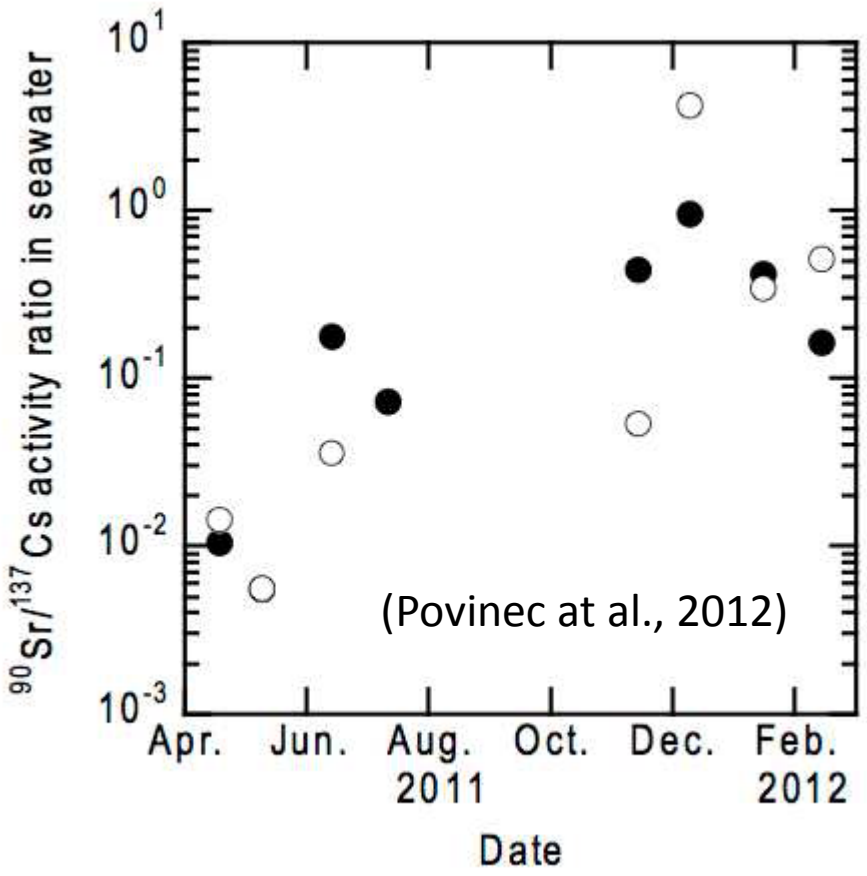


* http://www.kaiseiken.or.jp/publish/itaku/rep2011.pdf (in Japanese)

Sr-90 in seawater and marine soil

Near 1F NPP

- Seawater: ND~0.15(Bq/L), 100 times of BG(0.001), 0.1 time of ^{137}Cs
- Marine soil: ND～3.4(Bq/kg), 100 times of BG(0.03), 0.001 time of ^{137}Cs
- The ratio of ^{90}Sr/^{137}Cs was increasing, because of leakage of processed(Cs-removed) reactor water?



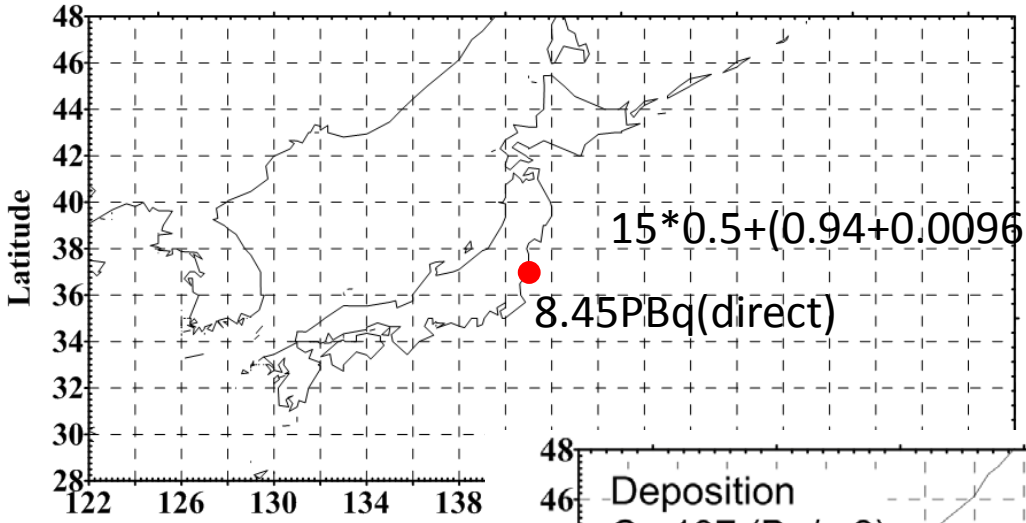
Pavel P. Povinec et al., Radiostrontium in the Western North Pacific : Characteristics, Behavior and the Fukushima Impact, *Environ. Sci. Technol.,* Just Accepted Manuscript, DOI: 10.1021/es301997c, (2012)

2. Simulation of marine dispersion in the Pacific Ocean

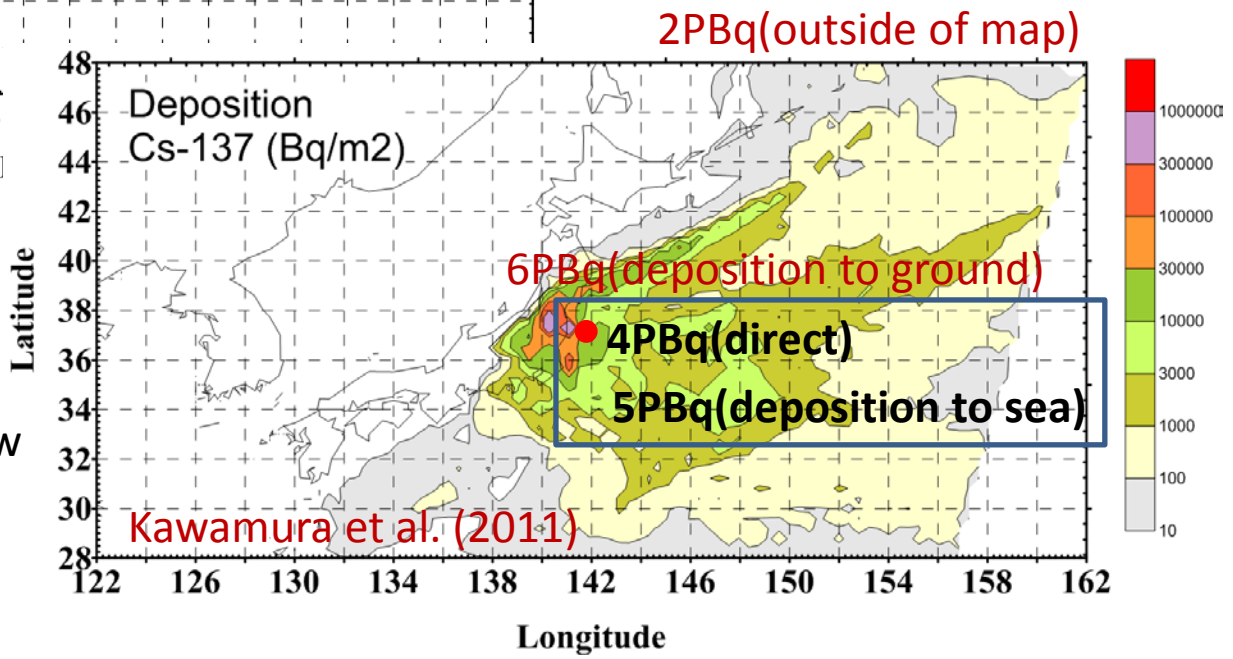
Re-simulation by LAMER

EU meeting in 2011

(Nakano and Povinec, 2012)



EU meeting now

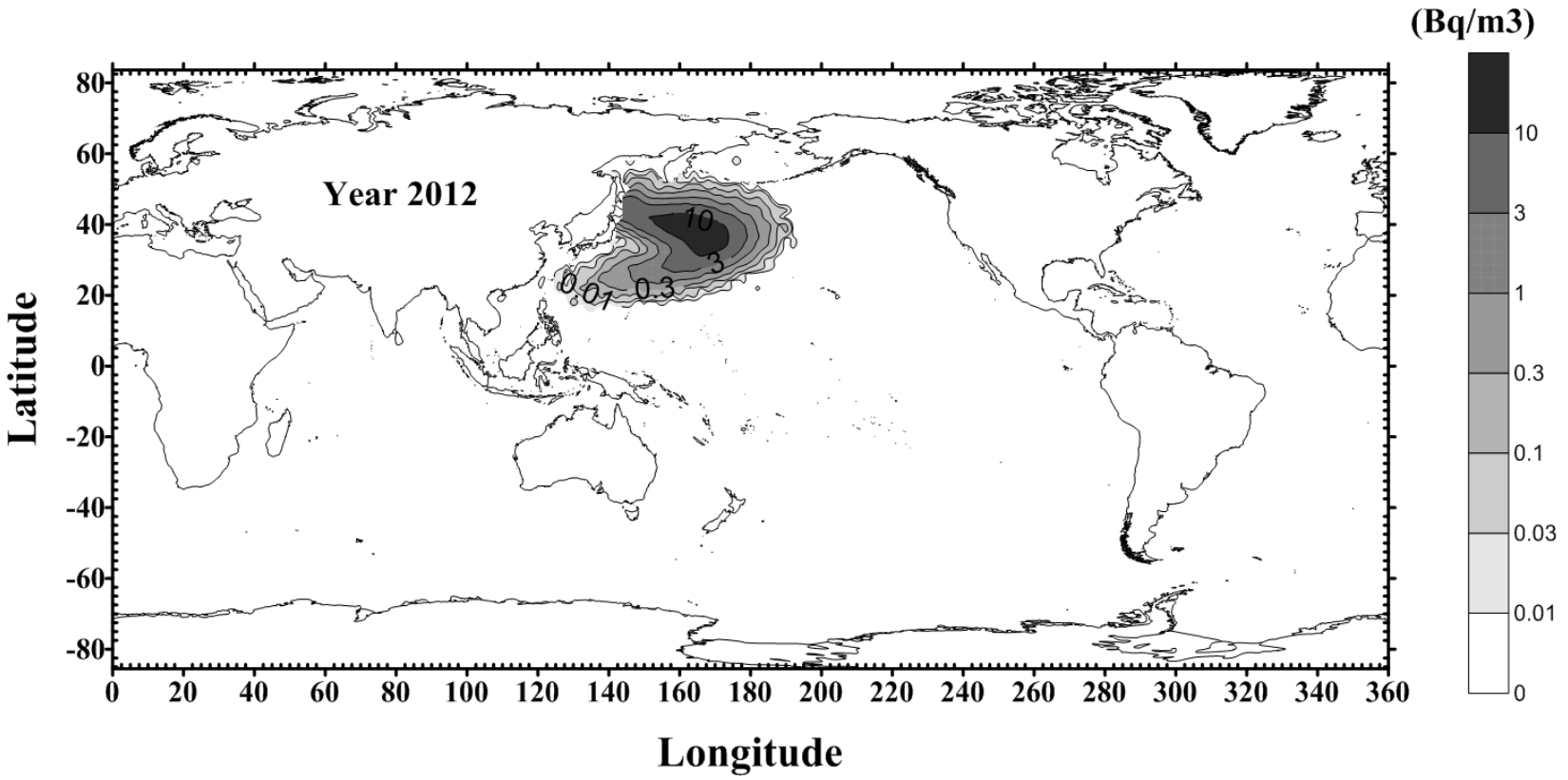


Nakano and Povinec, Long-term simulations of the 137Cs dispersion from the Fukushima accident in the world ocean, *Journal of Environmental Radioactivity* 111, 109-115,(2012)

Kawamura et al., Preliminary Numerical Experiments on Oceanic Dispersion of 131I and 137Cs Discharged into the Ocean because of the Fukushima Daiichi Nuclear Power Plant Disaster, *Journal of NUCLEAR SCIENCE and TECHNOLOGY*, Vol. 48, No. 11, p. 1349–1356 (2011)

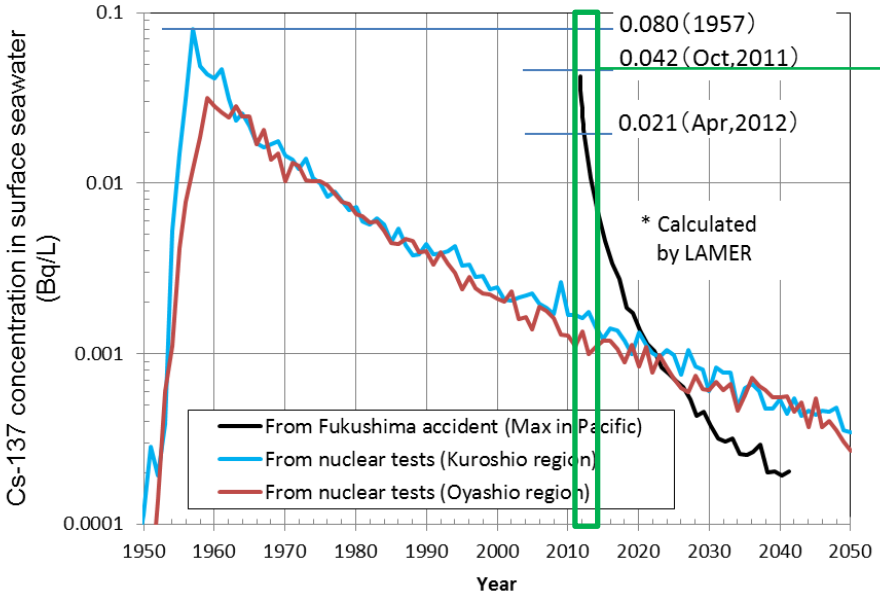
Re-simulation by LAMER

(Nakano and Povinec, 2012)

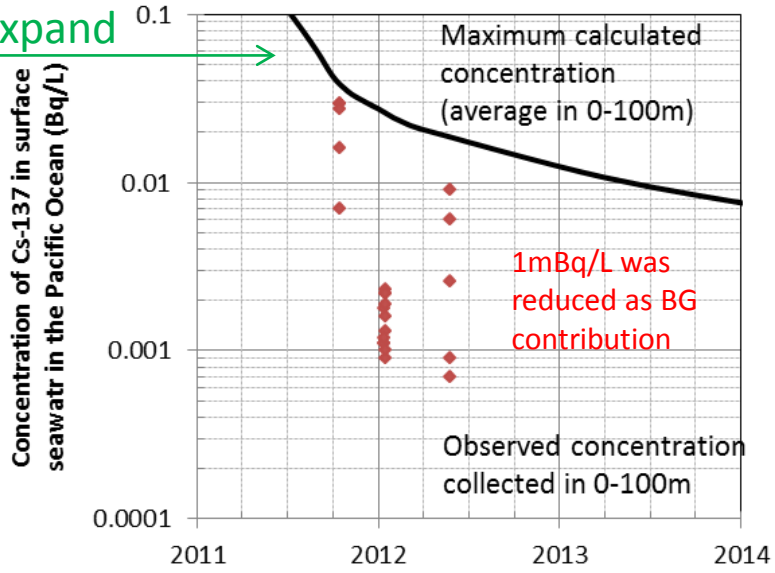


- Almost same movement with the previous calculation with the preliminary source term
- Maximum concentration of Cs-137 in April 2012 was calculated as 21 Bq/m^3 (=0.021 Bq/L) at 38N, 164E. (23 Bq/m^3 by the previous calculation)

Comparison with the observed concentration in seawater



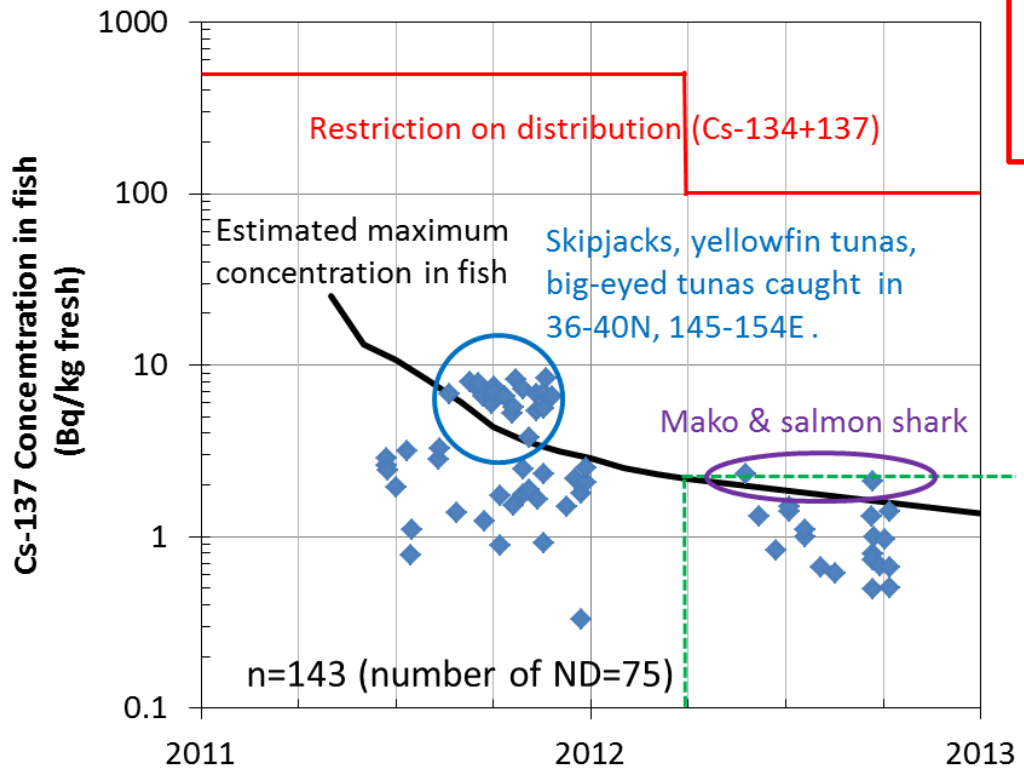
expand



Comparison of Cs-137 concentration in seawater outside 200 nautical mile line (= 370km) due to Fukushima accident (BG(0.001) was reduced.)

Nakano, unpublished

Simulated Cs-137 concentration in fish outside 200 nautical mile line



Simulated max concentration in fish at equilibrium at time(t)
= Cw(t)* CF(fish)

Cw(t): simulated maximum concentration in seawater

CF(fish):concentration factor of fish (=100)

If you take 64-g fish of this concentration (2 Bq/kg) everyday, you will receive 0.62μSv/a from ^{137}Cs and 0.80 μSv/a from ^{134}Cs .

The observed data was extracted from the website of "http://www.jfa.maff.go.jp/e/inspection/index.html"

Nakano, unpublished

Dose assessment in 2012-2014

Species	Internal dose in 2012 (μSv/a)			
	^{90}Sr	^{134}Cs	^{137}Cs	Total
Fish	0.0040	0.80	0.62	1.42
Crustaceans	0.00057	0.034	0.026	0.060
Cephalopods	0.00023	0.0062	0.0048	0.011
Shellfish	0.00074	0.026	0.021	0.047
Seaweed	0.0021	0.063	0.049	0.112
Total	0.0077	0.93	0.73	1.67

- Internal exposure by the intake of the marine products in 2012 would be 1.67 micro Sv per year mainly from $^{134+137}$Cs in fish, when adopting the maximum concentration and the averaged Japanese diet.
- Internal exposure in 2013 and 2014 would be 0.74 and 0.41 micro Sv per year, respectively.
- Because the dose is proportional to the consumption amount of sea food, most public in the world will get lower doses than the Japanese population.

^{134}Cs in surface water **By Aoyama (unpublished)**

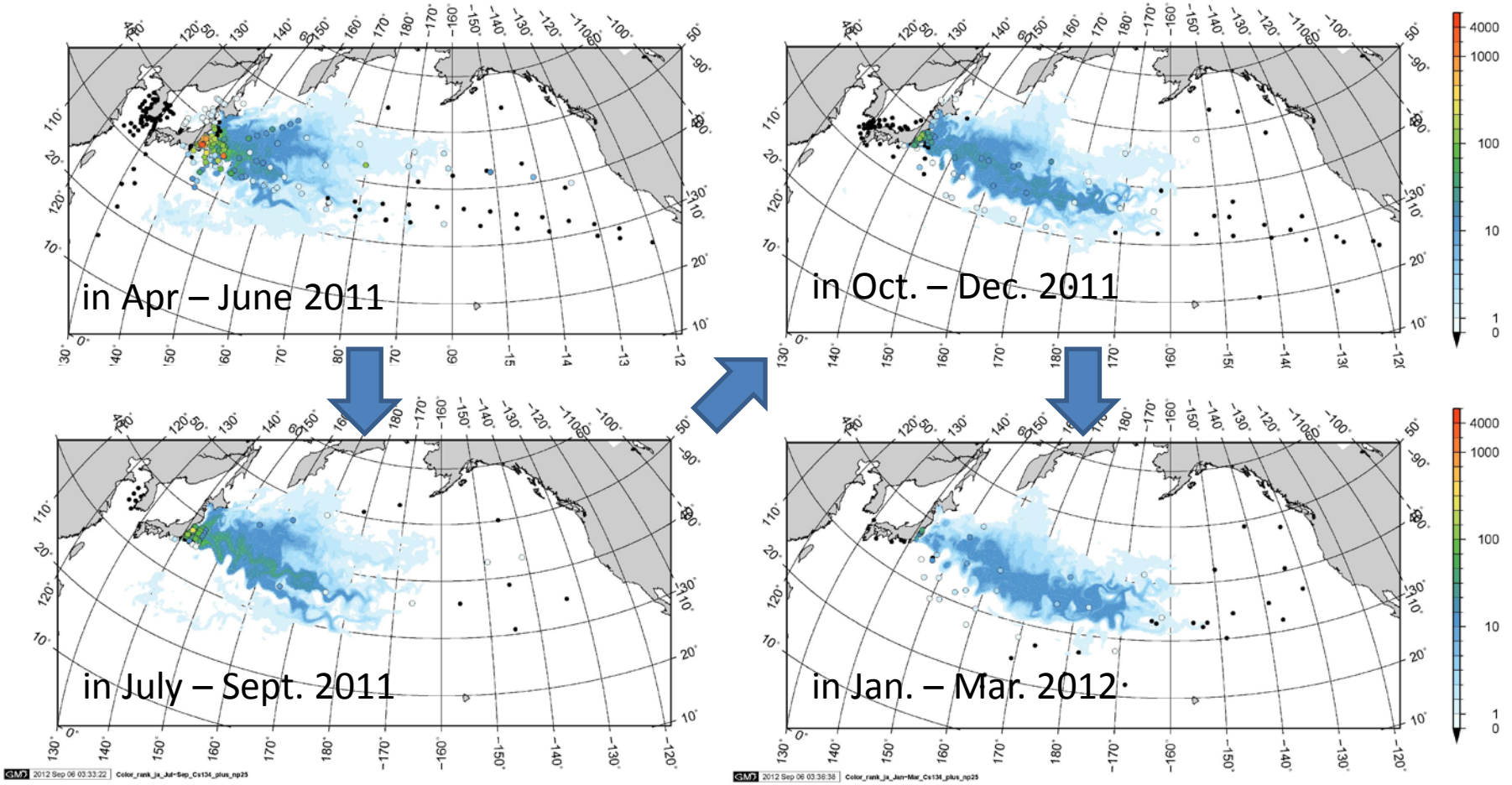
Data sources: NYK ships, Inoue et al., MEXT, Hakuho

Solid circle with color: observed data

Pattern: Atmospheric model with ocean model simulation

Source term Chino et al. 8.8 PBq for atmospheric release and Tsumune et al., 3.5 PBq for direct discharge

unit: Bq m-3



Conclusion

- The concentration of $^{134,137}Cs$ in seawater near 1F-NPP was considerably decreased to 1~10Bq/L in 2012, which is 1,000-10,000 times of BG level.
- The concentration of $^{134,137}Cs$ in the deep Pacific is BG~0.01 Bq/L, which is 10 times of BG level.
- The simulation by LAMER estimated the concentrations of ^{137}Cs in seawater and marine products. The result agrees the observation of them.
- The internal dose from Japanese consumption of all marine product was estimated to be 1.7, 0.74 and 0.41 micro Sv/a in 2012, 2013 and 2014, respectively.