International symposium by
Society of Remediation of Radioactive Contamination in Environment
Tokyo, 7 June 2013

Transport and dispersion of radiocesium from Fukushima Daiichi Nuclear Power Plant accident in the Ocean

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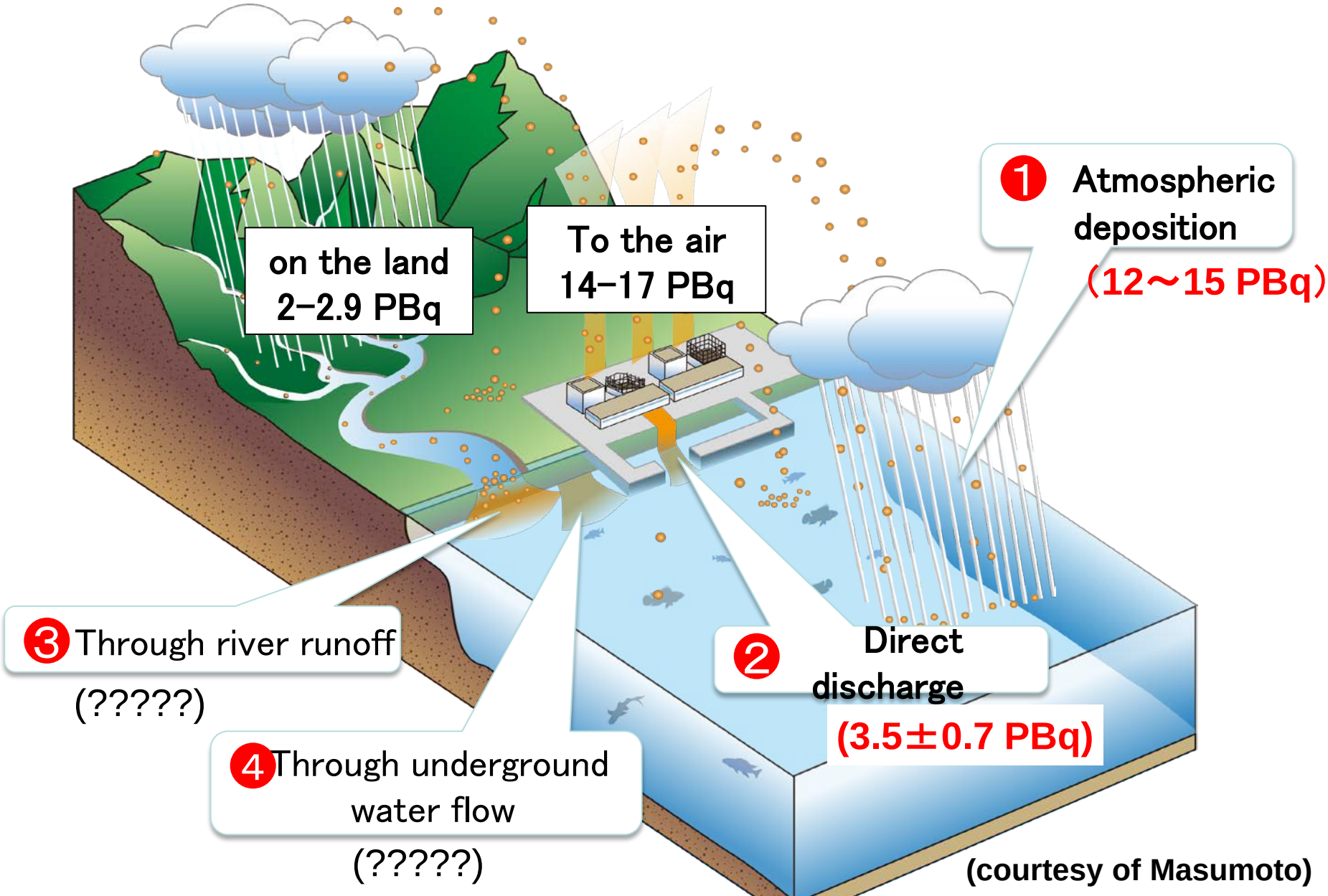
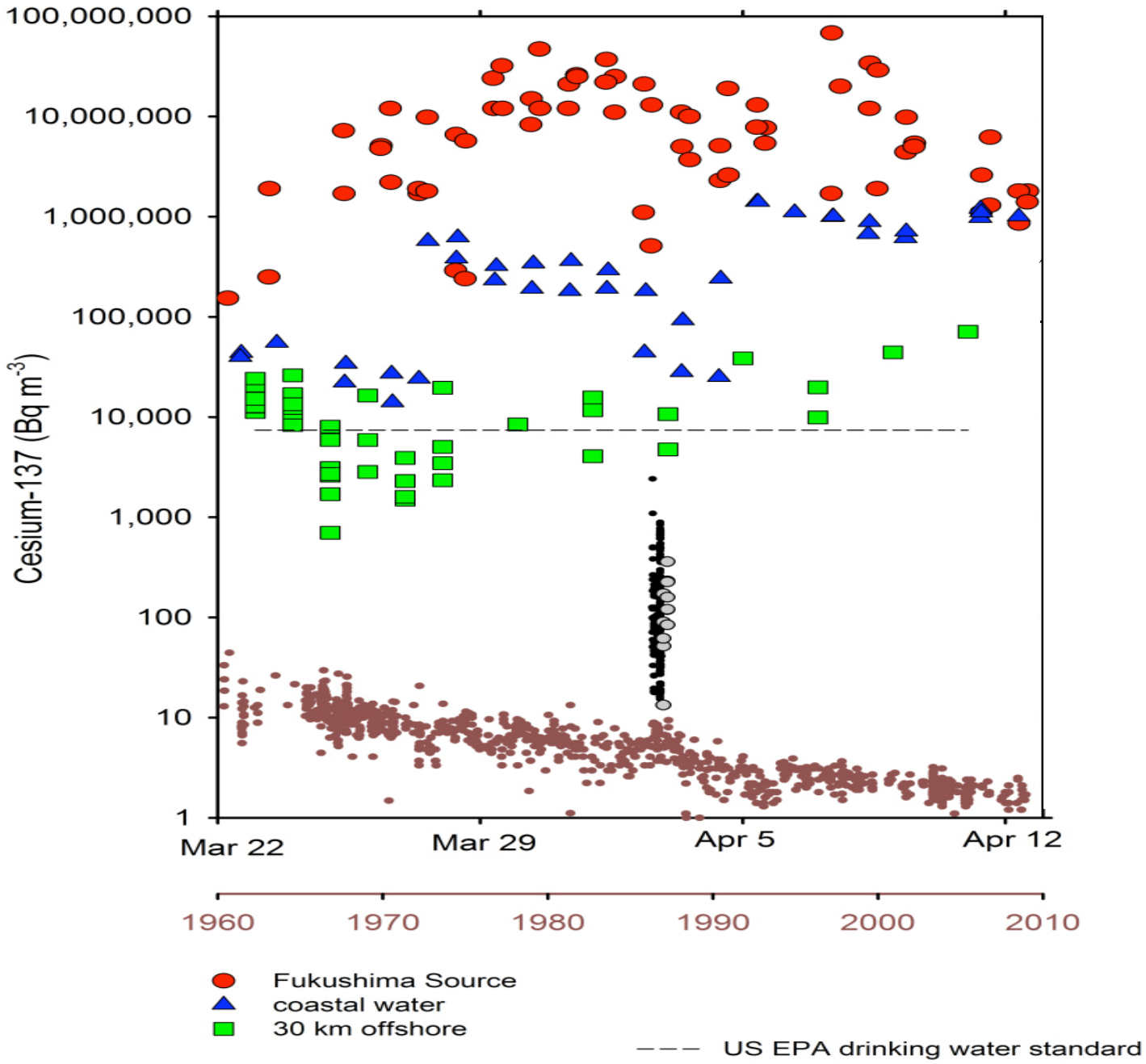
福島第一原子力発電所事故による放射性セシウムの海洋への輸送・拡散

海洋研究開発機構
本多牧生

Summary of budget of ^{137}Cs (by Aoyama of MRI)



(after Buesseler, Aoyama and Fukasawa, 2011)



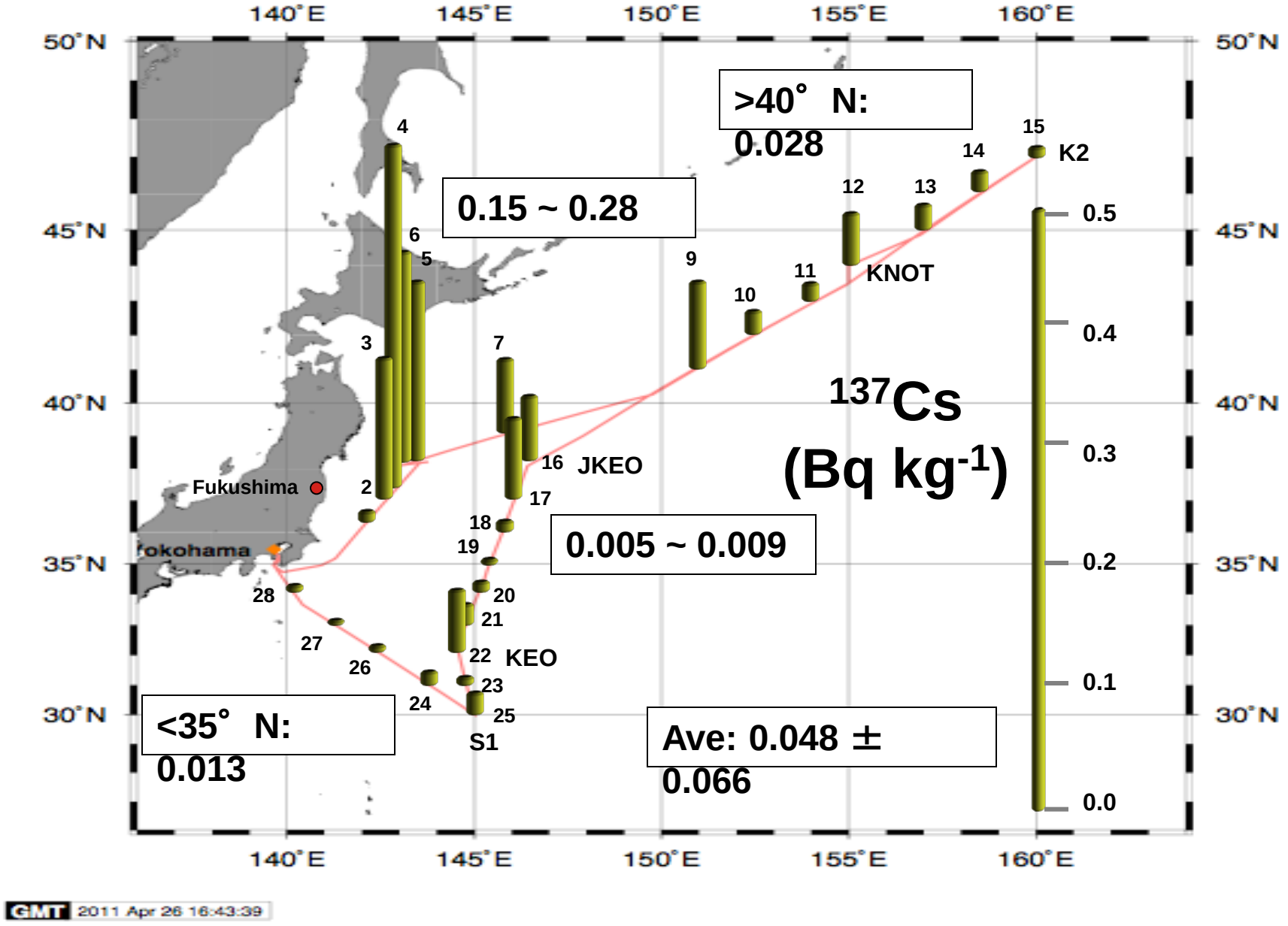
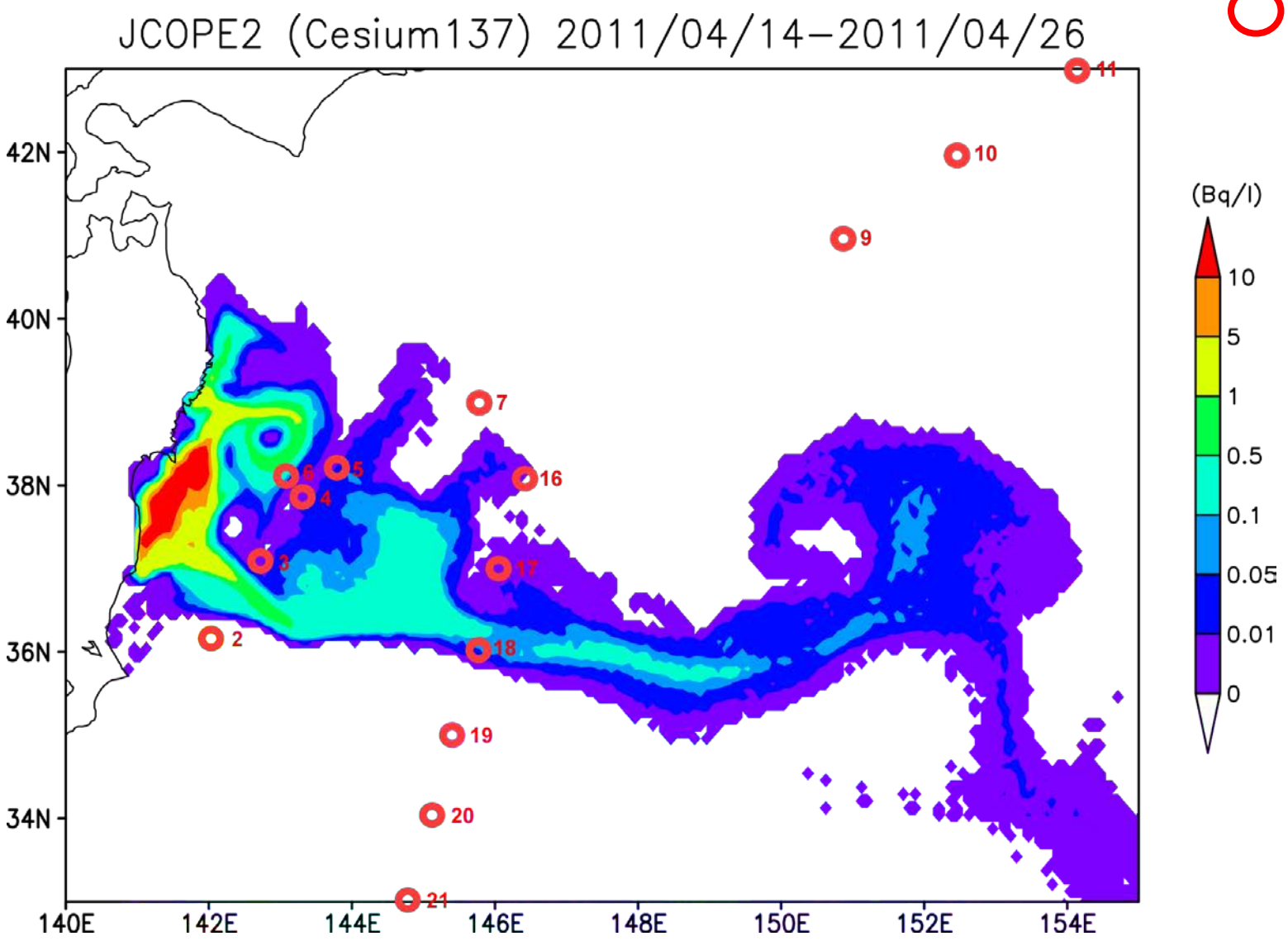


Figure 1 Horizontal distribution of ^{137}Cs in surface seawater of the western North Pacific

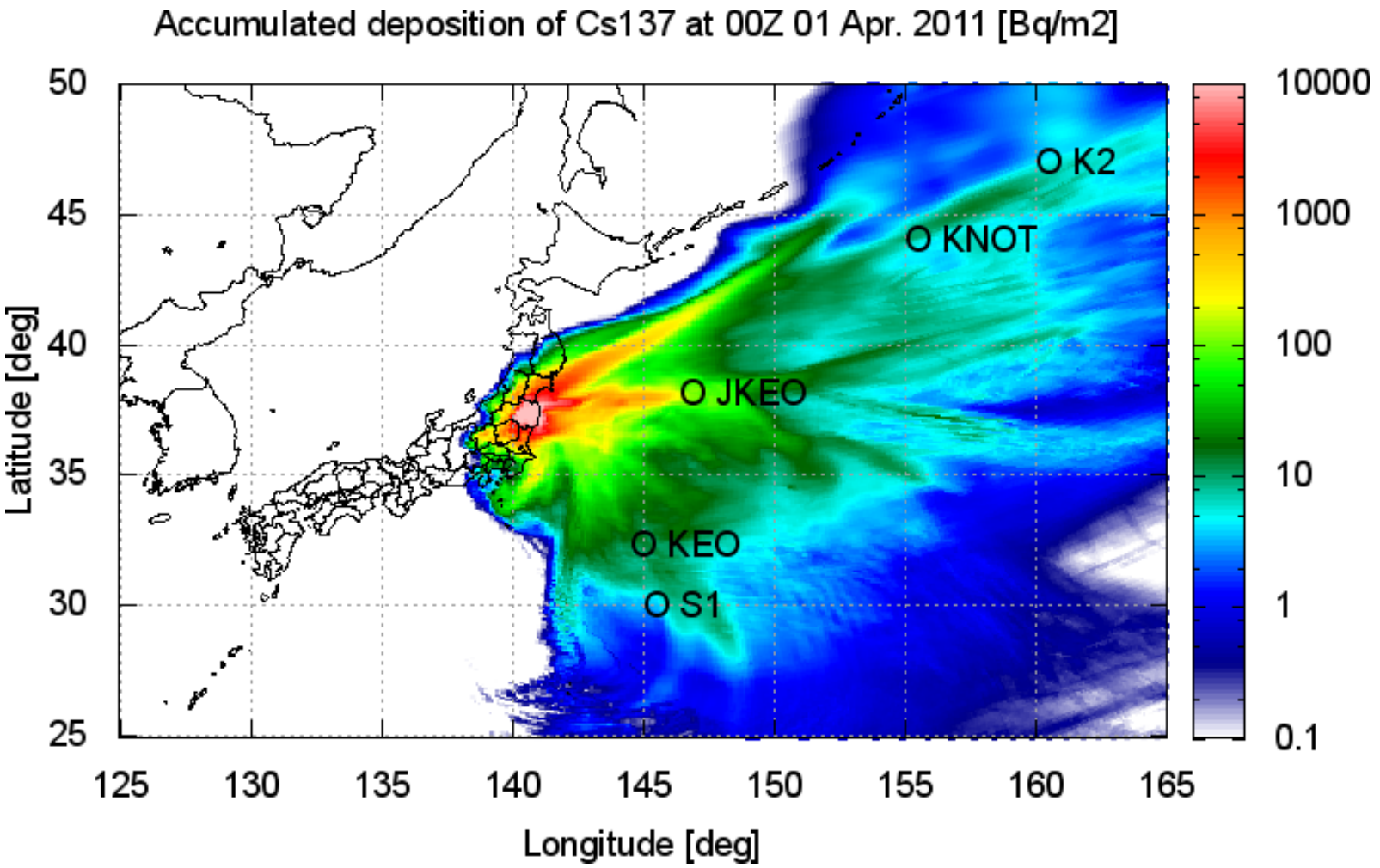
(Honda et al., Geochemical Journal, 2012)

Numerical simulation（1）
Dispersion of Contaminated Water



(Honda et al., Geochemical Journal, 2012)

Numerical simulation（2）
Dispersion of Contaminated Aerosol



(Honda et al., Geochemical Journal, 2012)

Sampling locations during the period from March 2011 to Oct. 2012

R/V Mirai

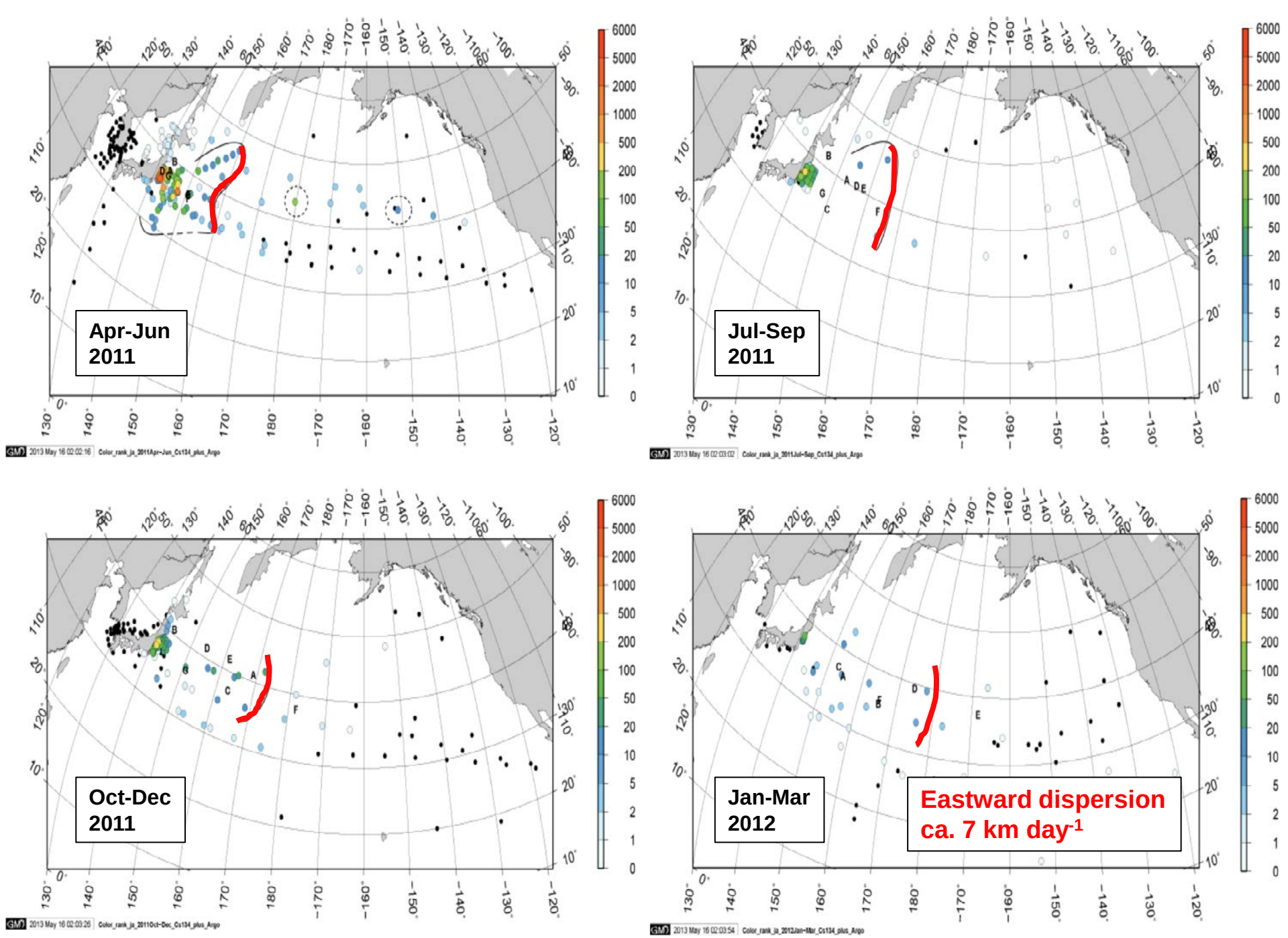
NYK AQUARIUS

R/V Hakuho Maru

凌風丸

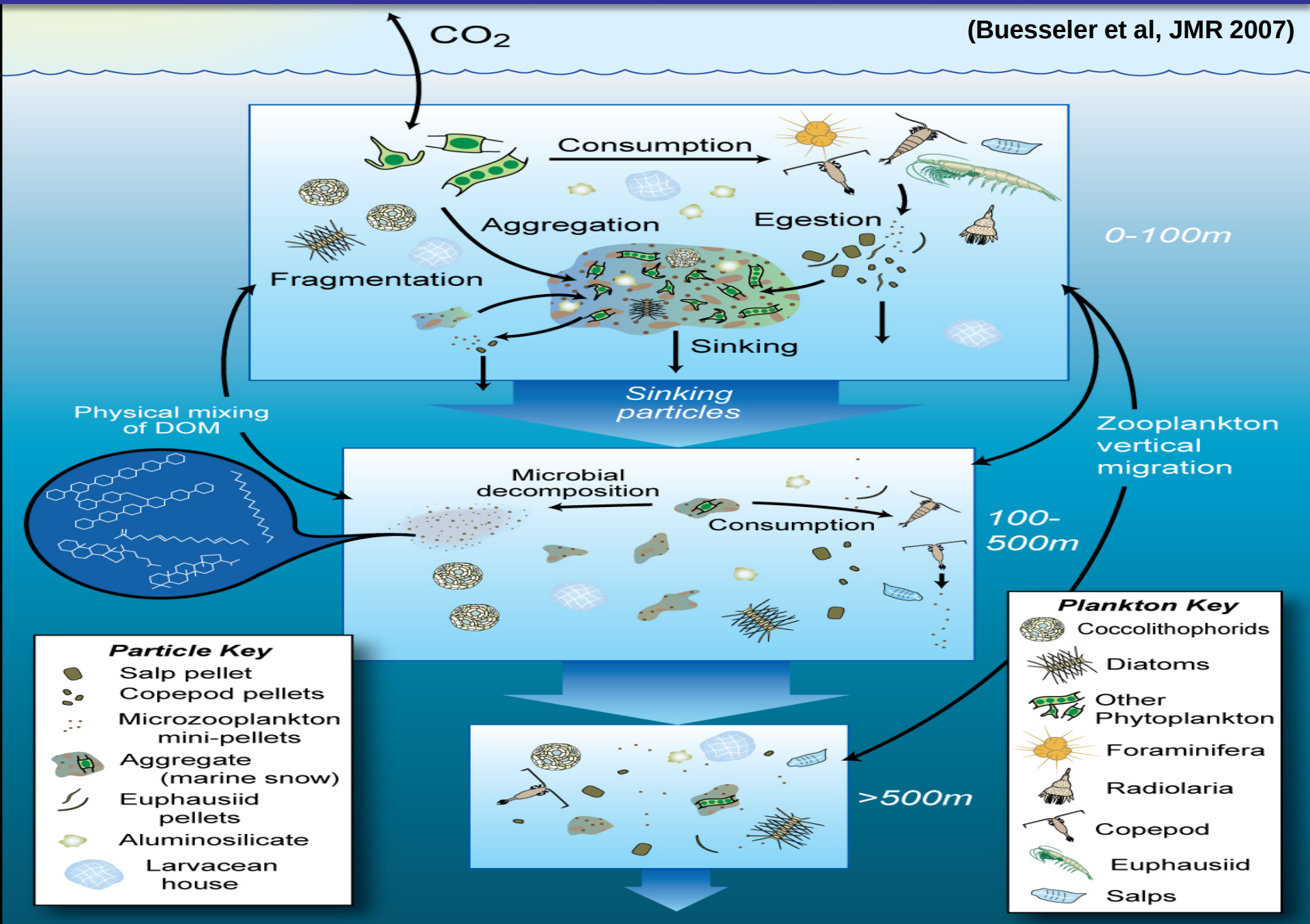
NYK Hèijin

(courtesy of Aoyama)

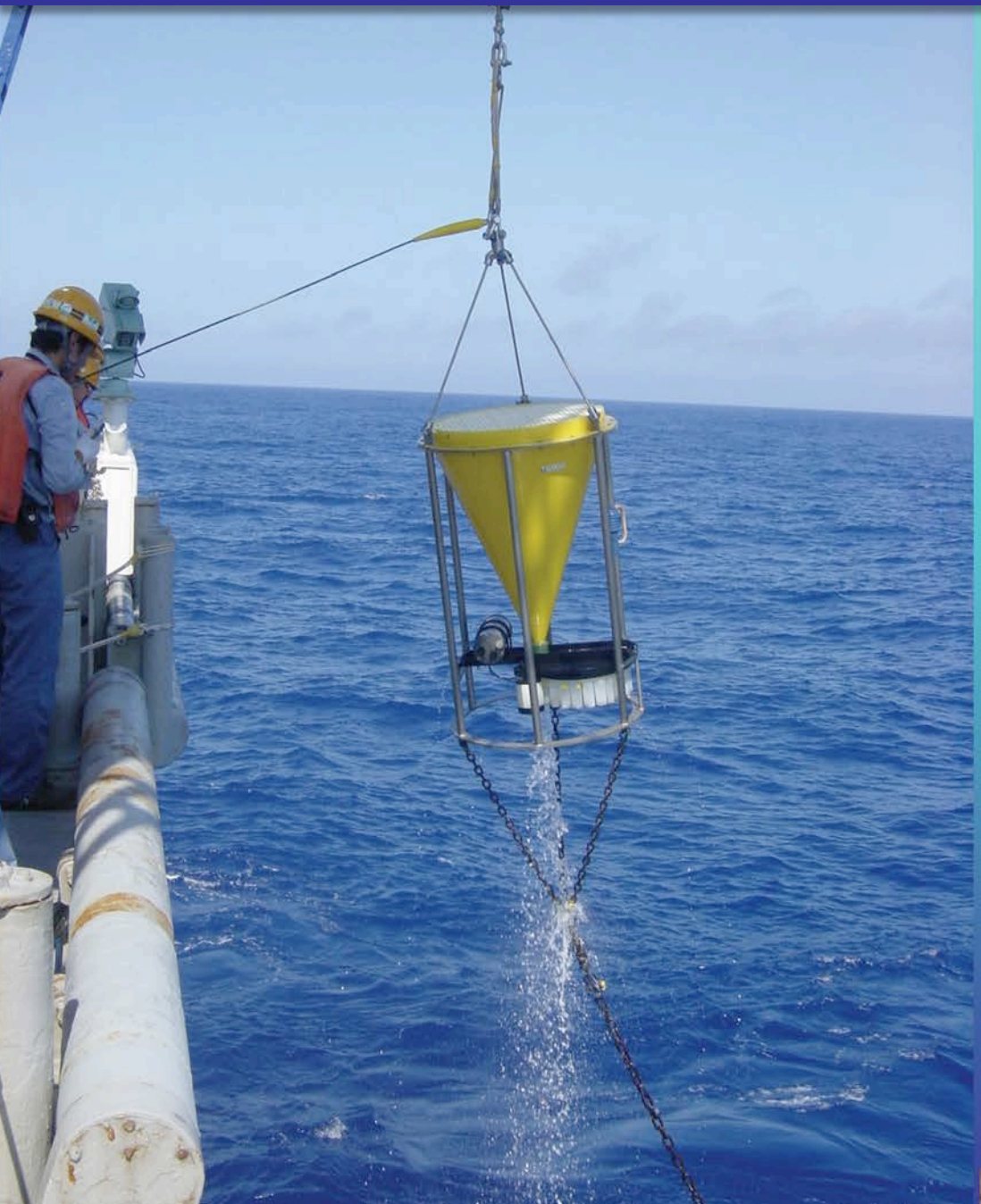


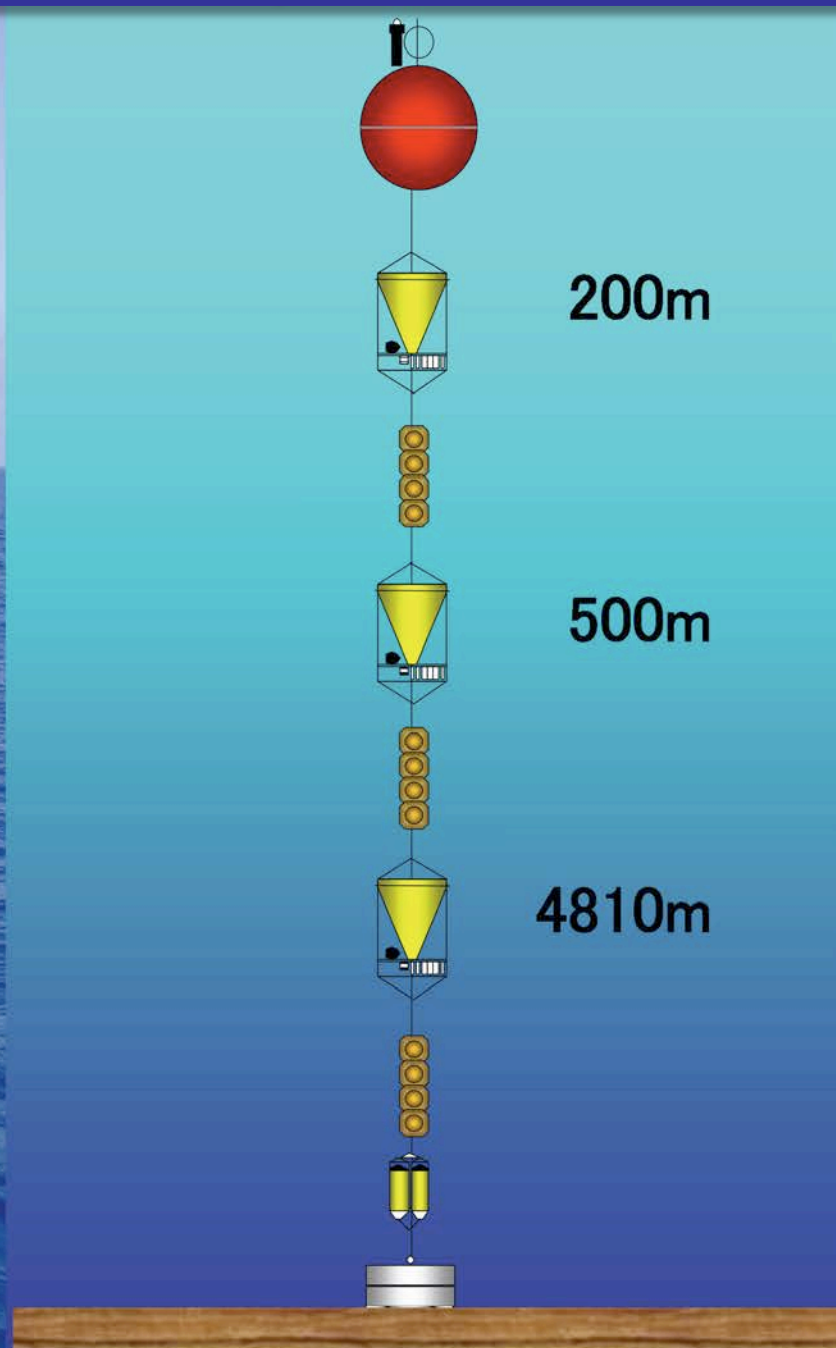
(after Aoyama et al., BG 10 3067-3078, 2013)

Vertical transport by "Biological pump"

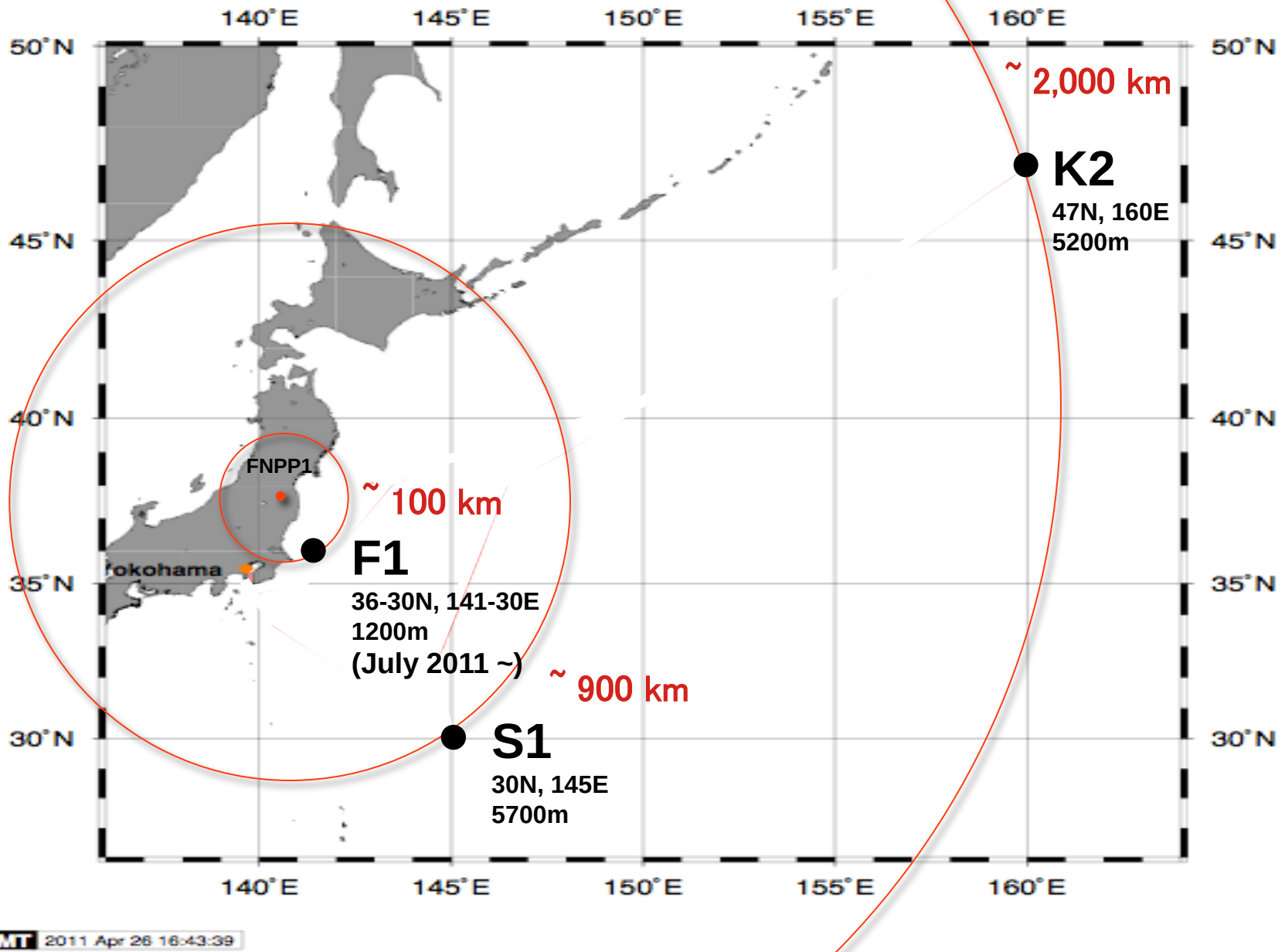


Time-series Sediment trap

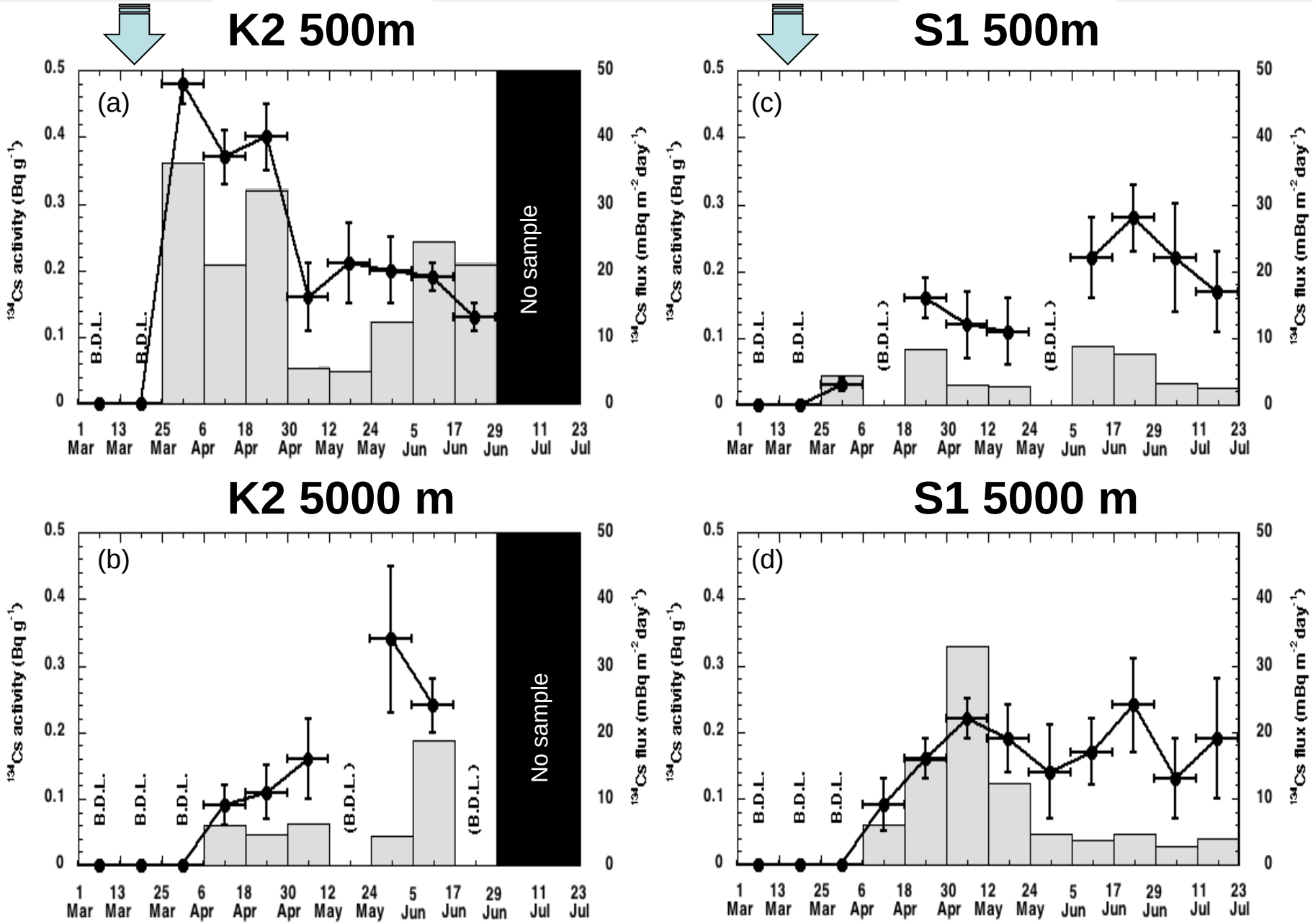




K2, S1 and F1

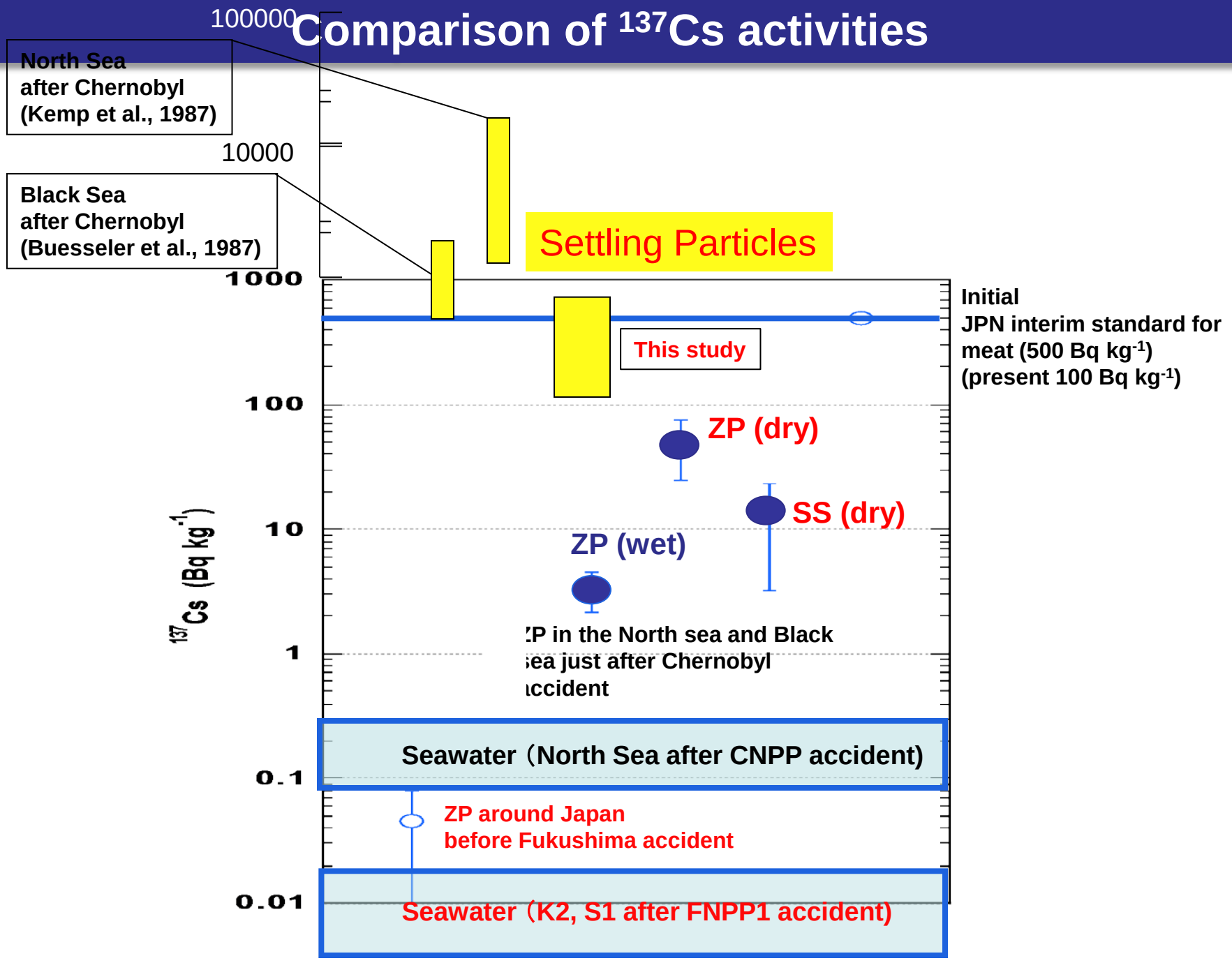

140°E
145°E
150°E
155°E
160°E
50°N
45°N
40°N
35°N
30°N
~ 2,000 km
K2
47N, 160E
5200m
FNPP1
~ 100 km
F1
36-30N, 141-30E
1200m
(July 2011 ~)
~ 900 km
S1
30N, 145E
5700m
GMT 2011 Apr 26 16:43:39

K2, S1: Activities and fluxes of ^{134}Cs



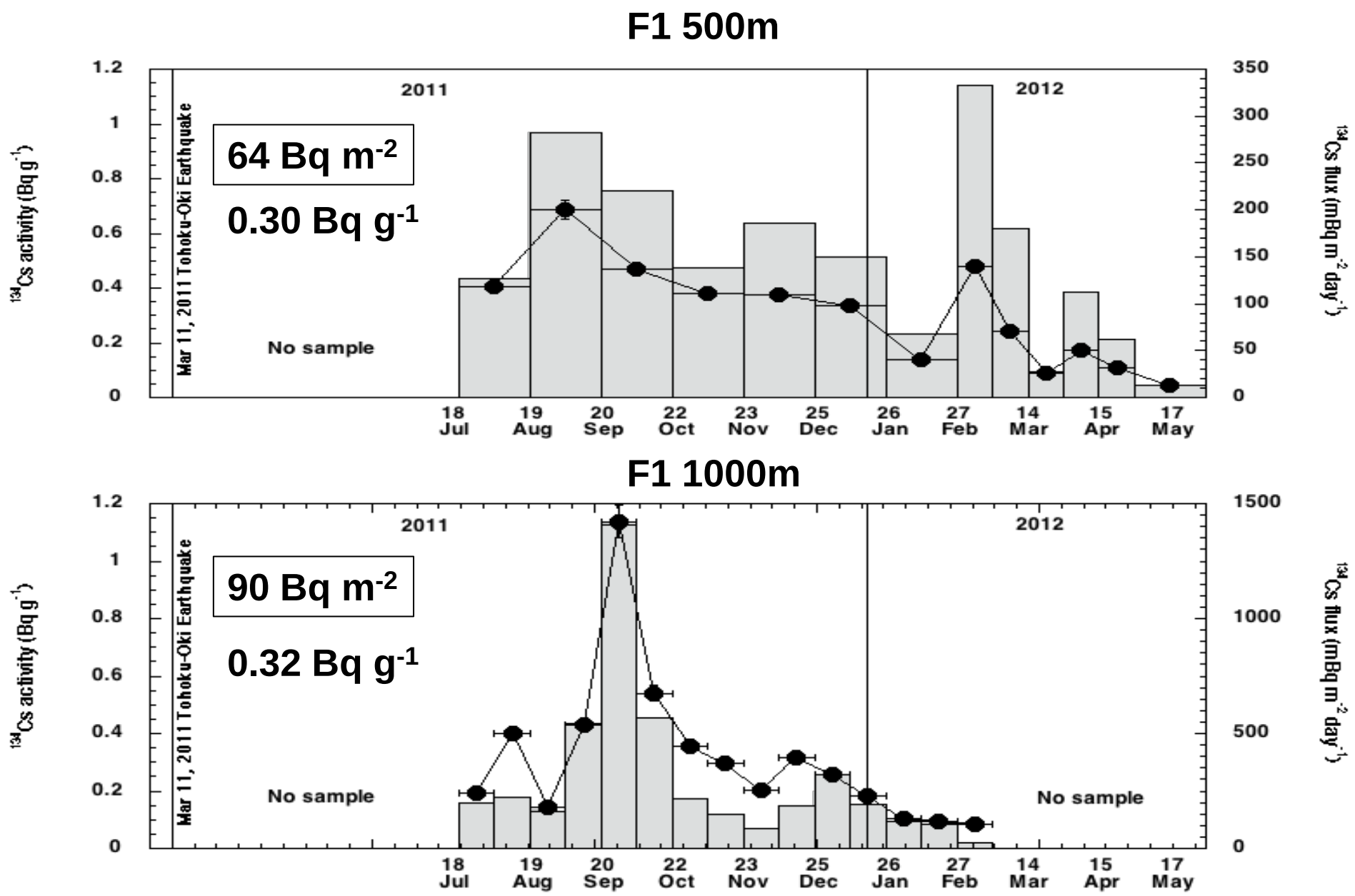
(Honda et al., BG 10, 3525-3534.2013)

Comparison of ^{137}Cs activities



^{137}Cs activities of seawater, suspended substances (SS) and zooplankton (ZP) are quoted from Honda et al., (2012).

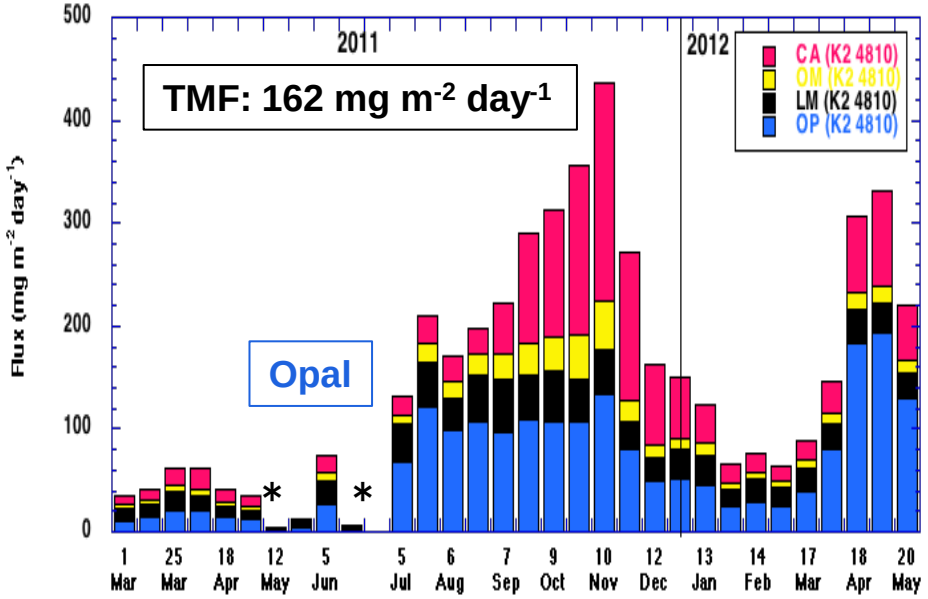
F1: Flux is 20 ~ 50 times larger than that at K2 and S1



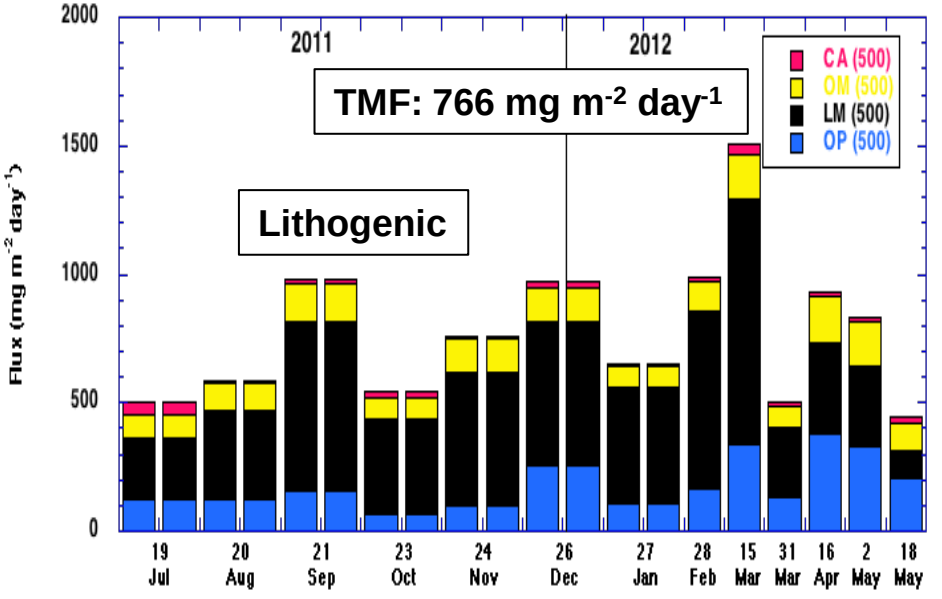
(Buesseler et al., in preparation)

Total Mass Flux and Chemical composition

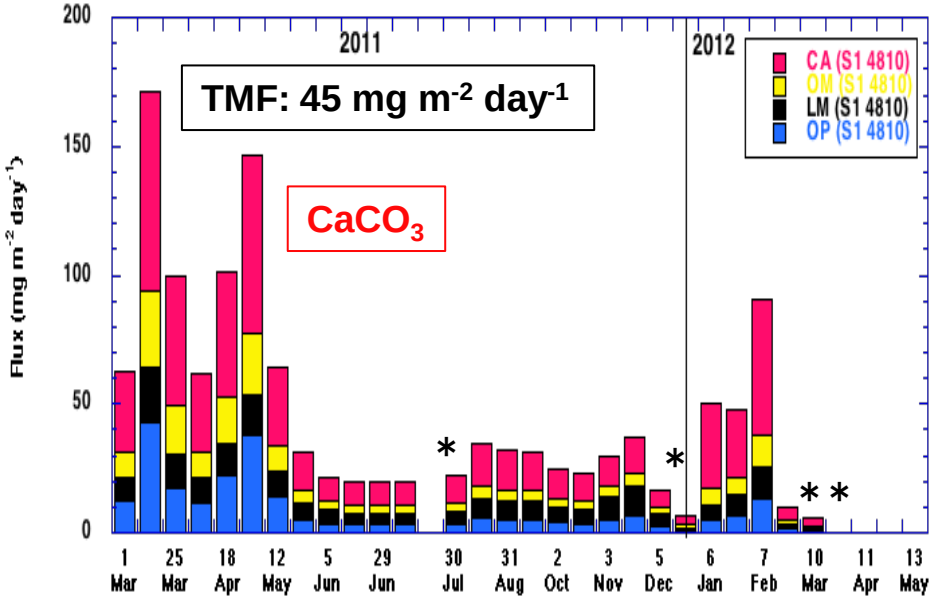
K2 5000m



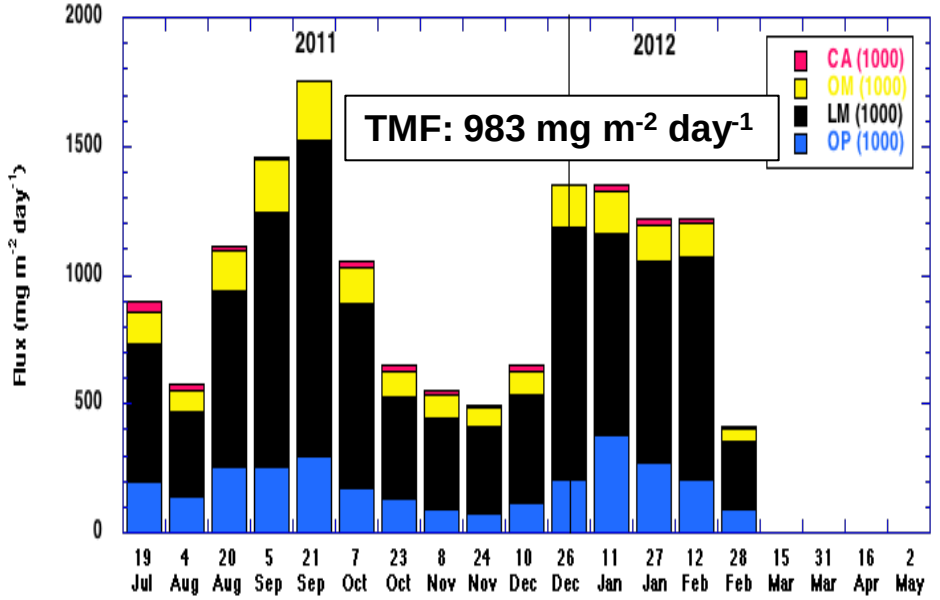
F1 500m



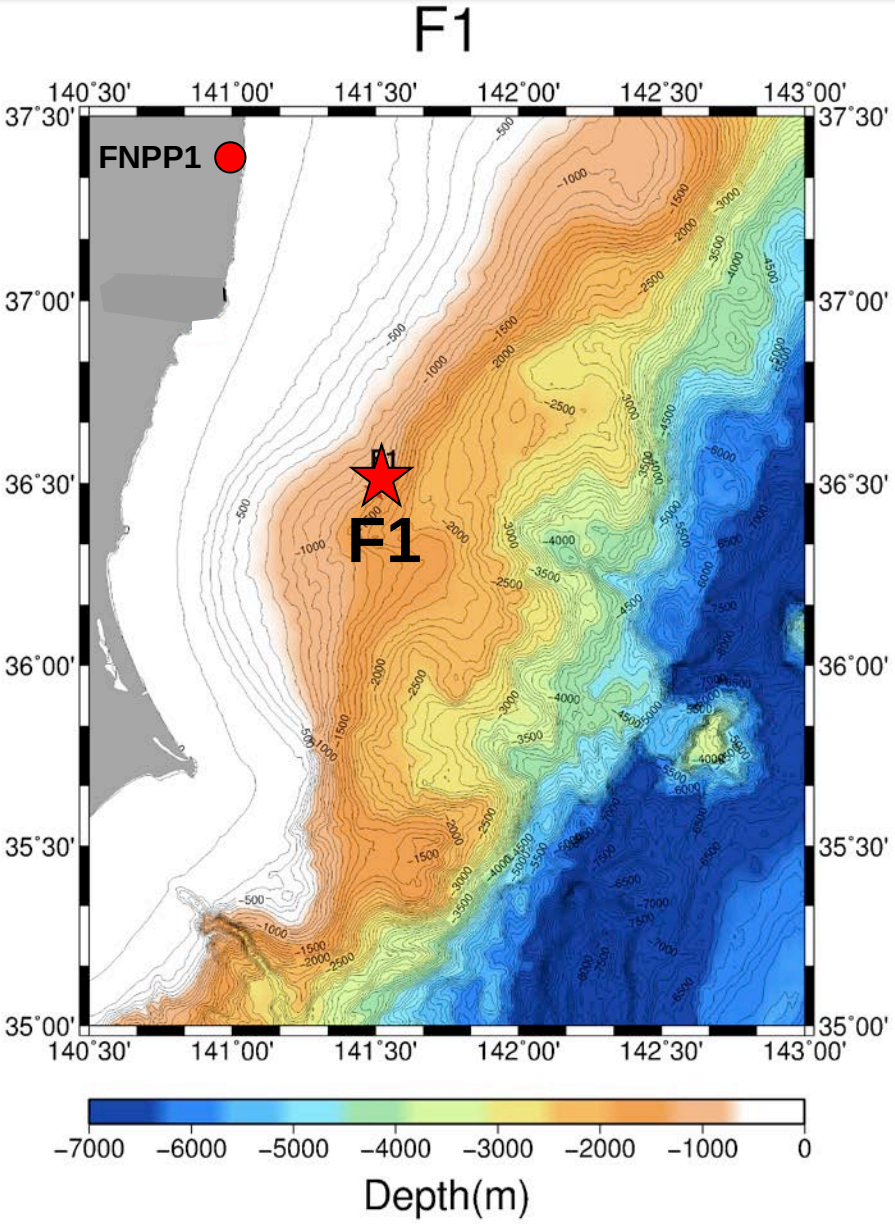
S1 5000m

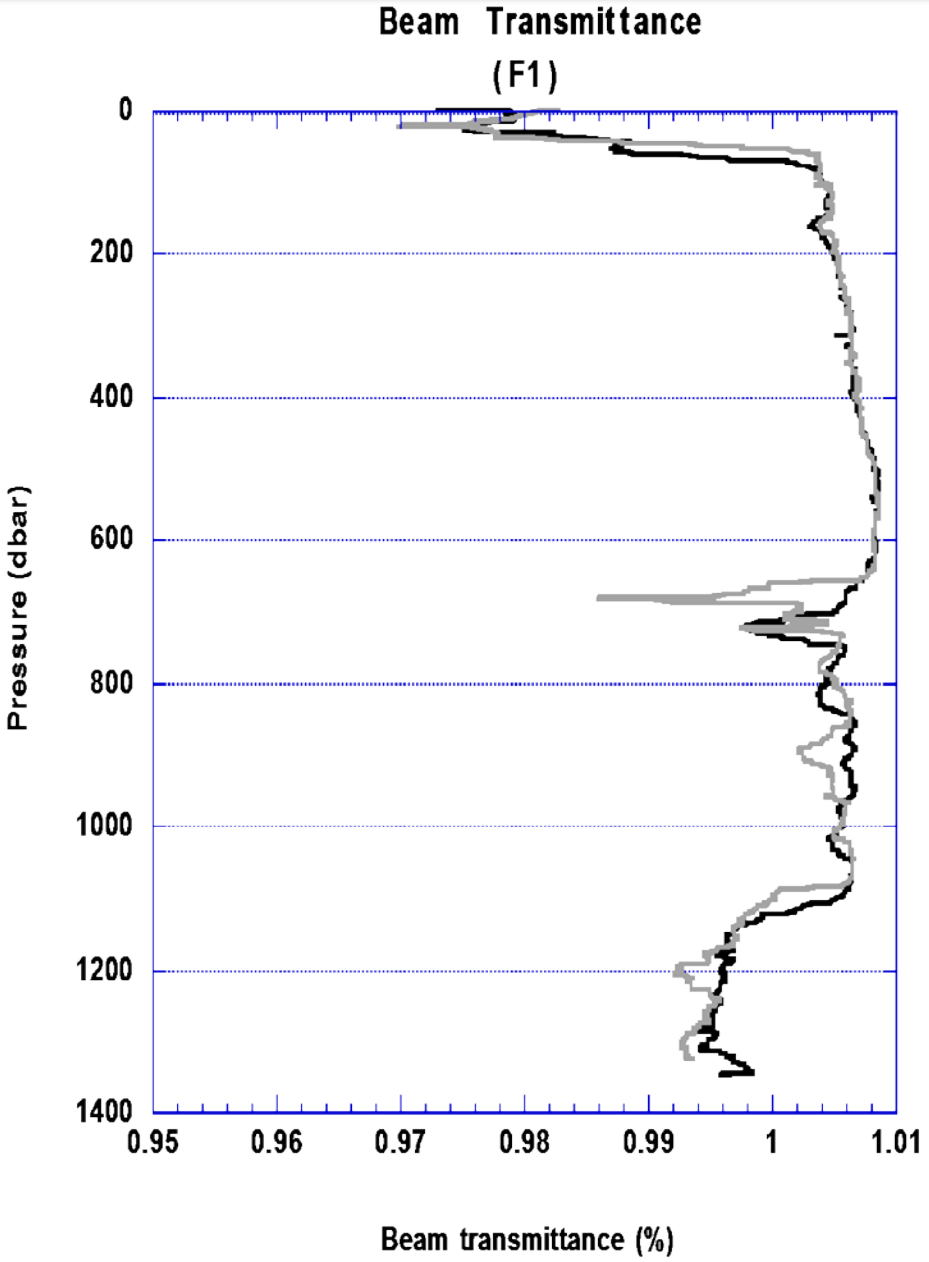


F1 1000m



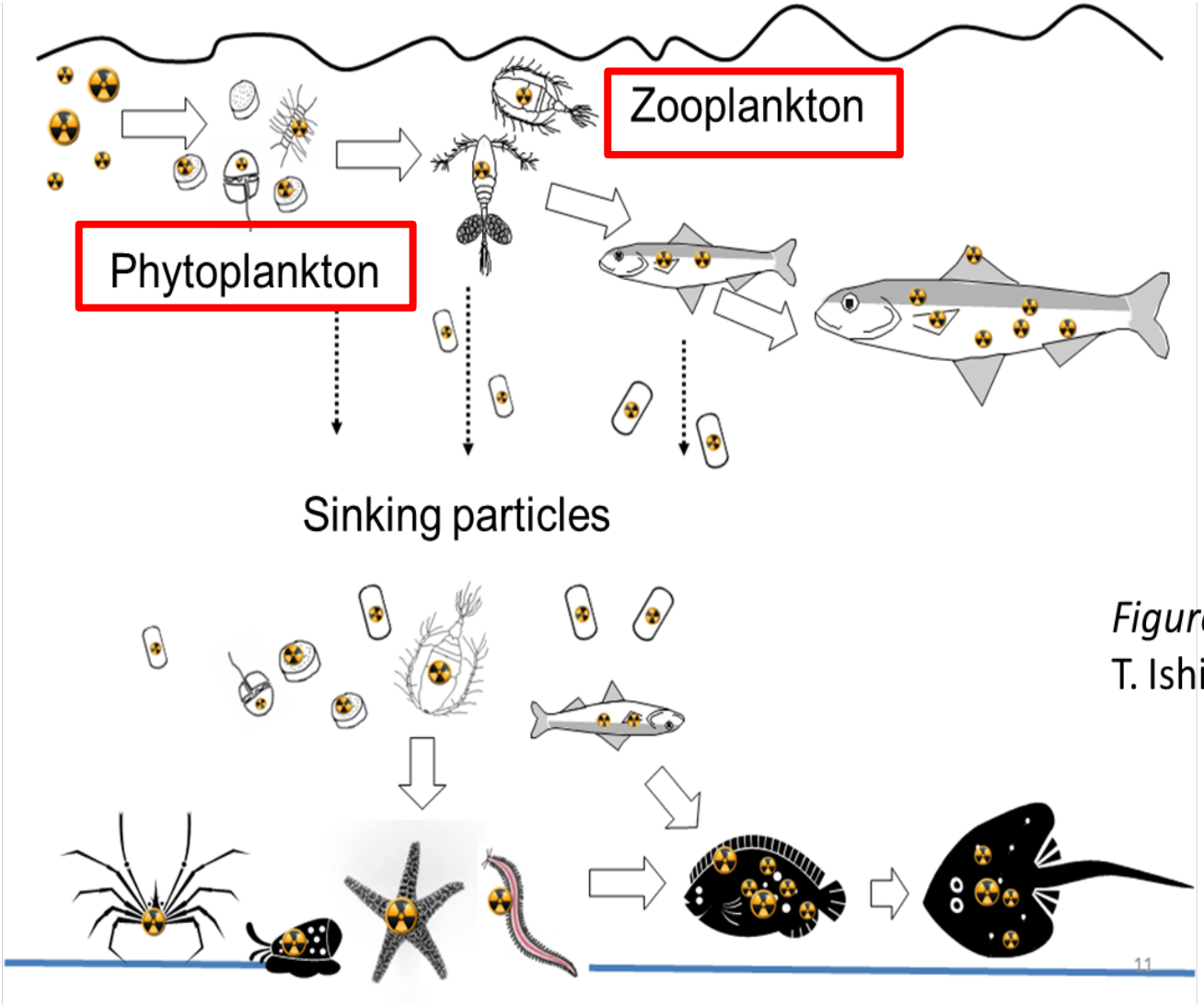
Lateral transport of contaminated lithogenic materials (?!)





MR11-05 Preliminary Cruise Report <http://www.godac.jamstec.go.jp/darwin/cruise/mirai/MR11-05/e

Fish radioactivity is likely sustained by radioactive food.



(courtesy of Kanda)

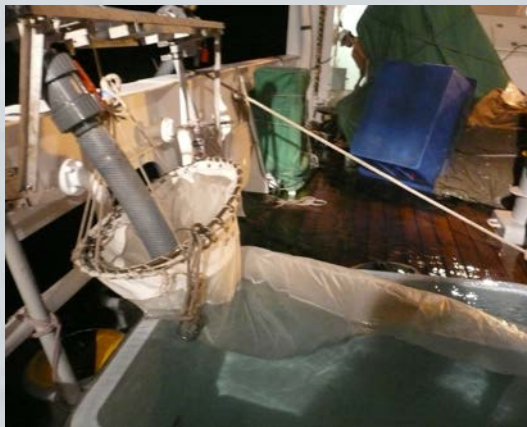
Plankton sampling

MTD Net

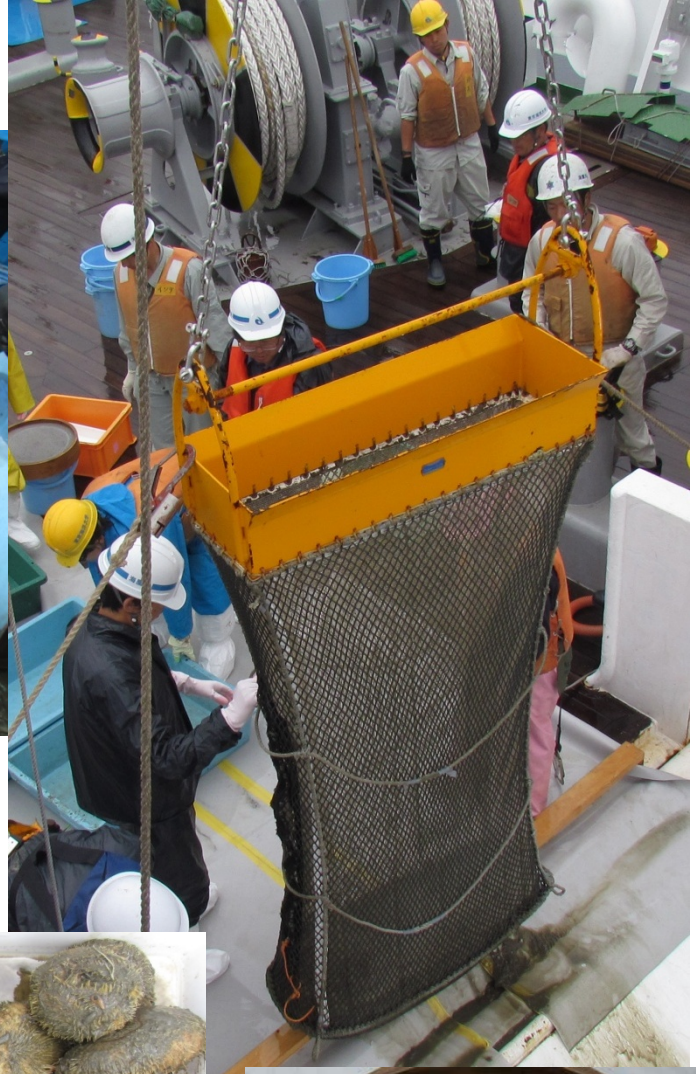
IONESS Multiple Opening/Closing Net

ORI Net

Sampling with a submersible pump



Dredge sampling for benthos



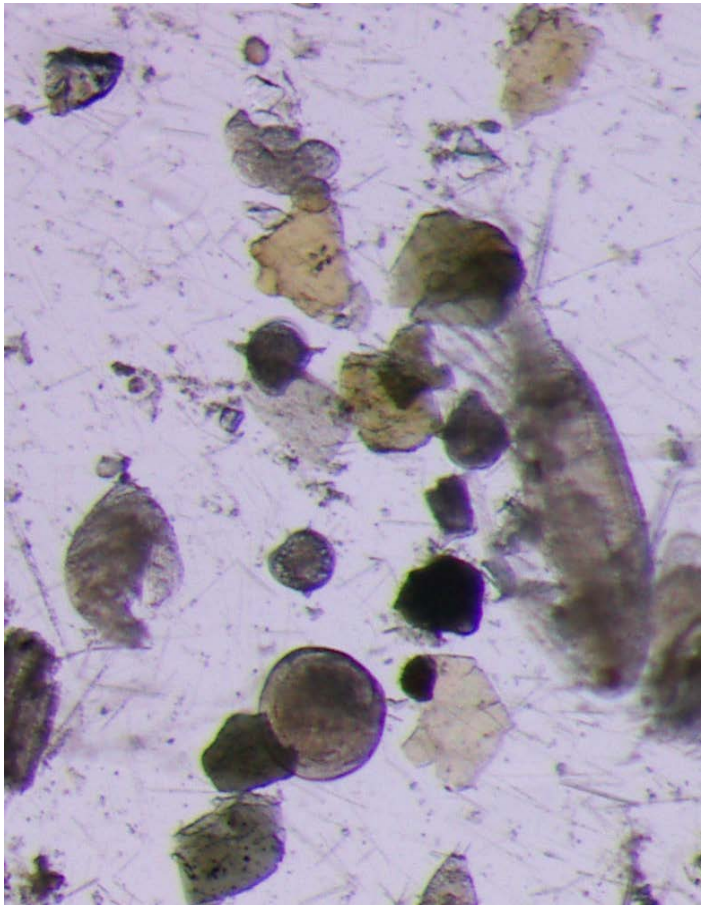
(courtesy of Kanda)

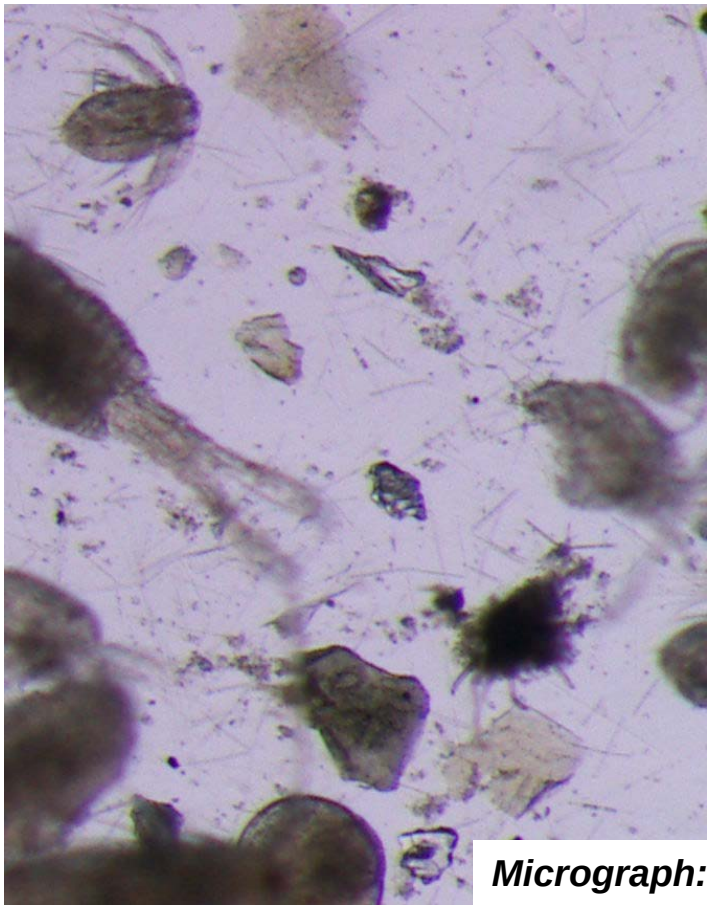
High ^{137}Cs in Plankton/Benthic organisms from shallow waters

Contaminated by suspended sediment?

Terrestrial organic matter? *"Spider leg hypothesis"*

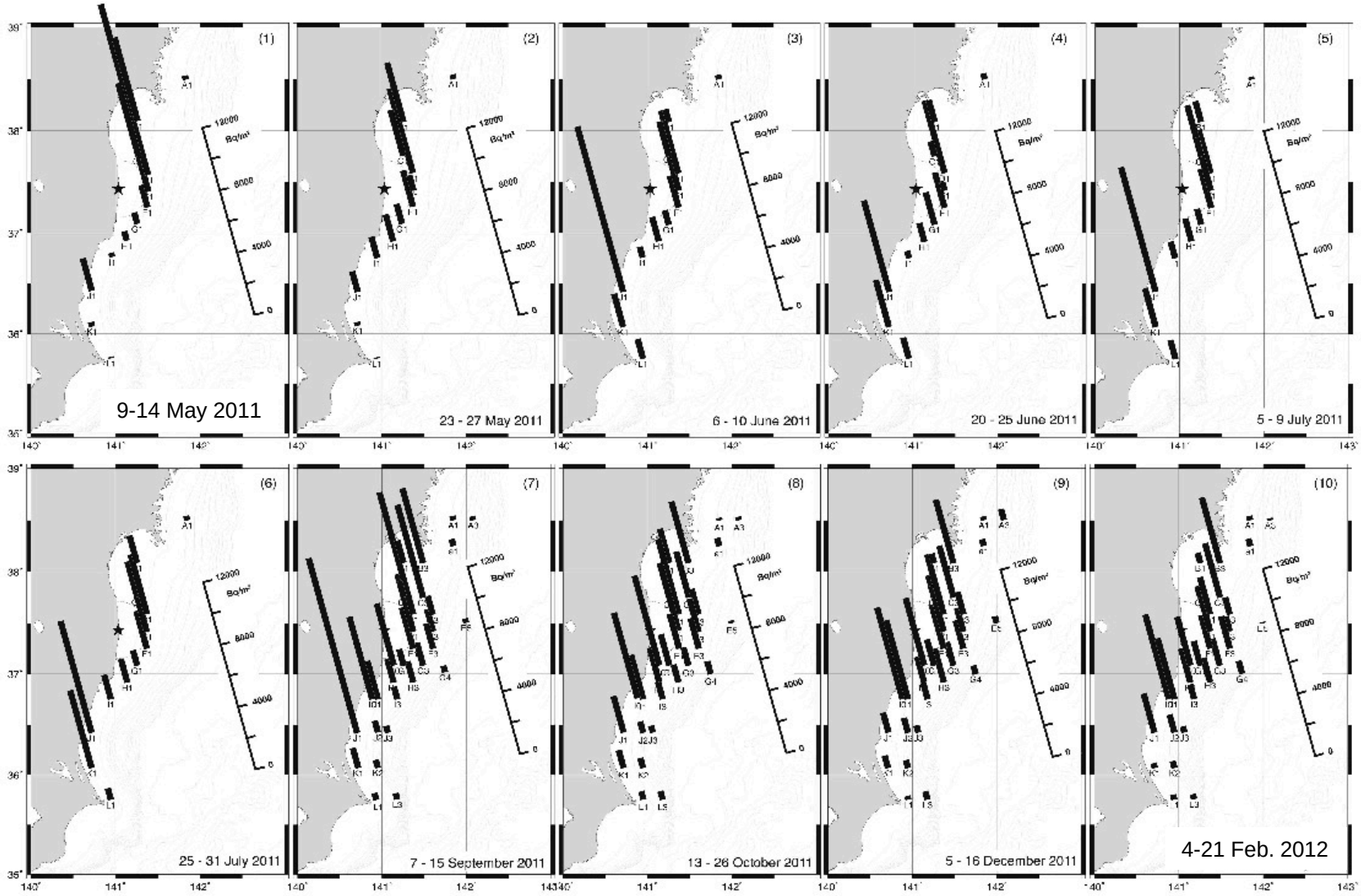
Transfer of ^{137}Cs from sediment to Plankton/Benthic org.?





Micrograph: **T. Ishimaru**

Inventory of ^{137}Cs in seafloor sediment off Fukushima, Miyagi and Ibaragi

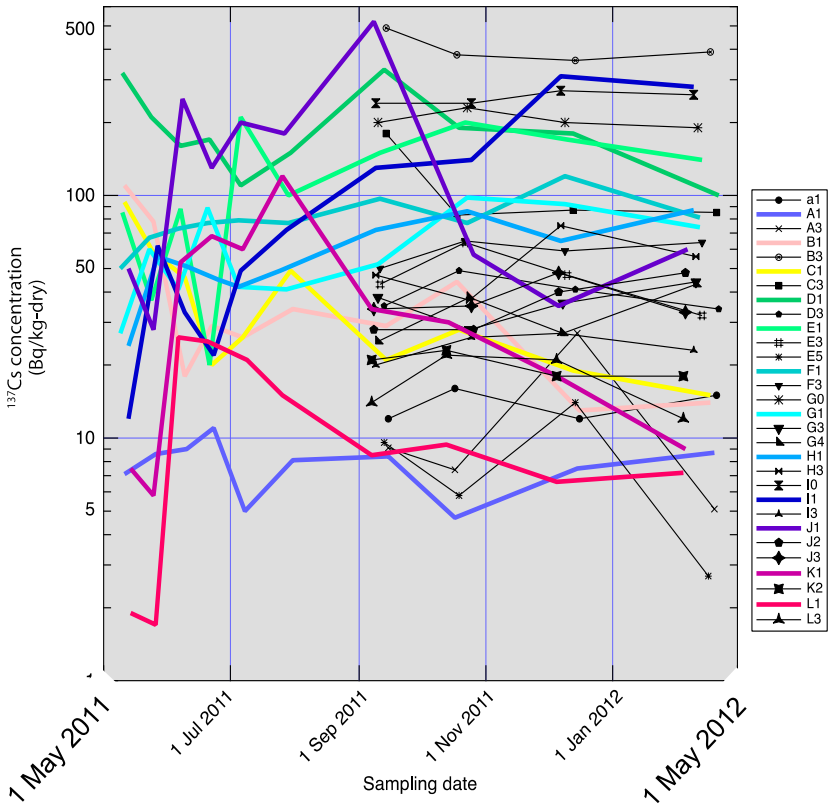


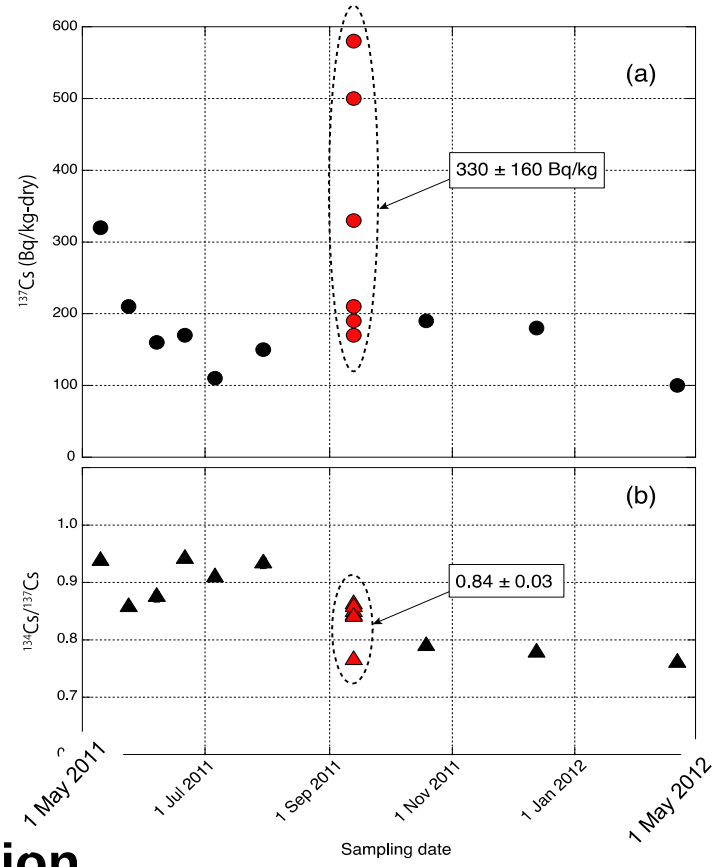
Inventory of ^{137}Cs (upper 3cm): ~ 40 TBq (0.1 – 2% of direct discharge)

(Kusakabe et al. BGD 2013)

Temporal variability of ^{137}Cs (left) and Reproducibility of ^{137}Cs (right)

(Kusakabe et al. BGD 2013)



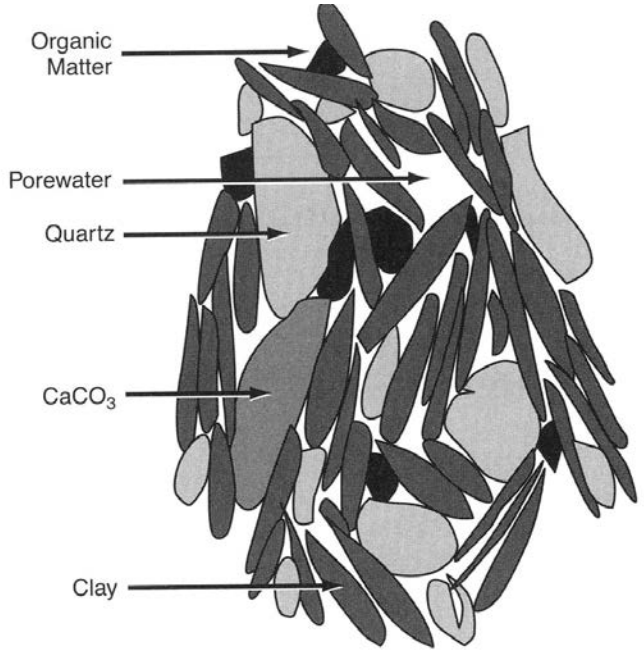


Lessons learned from sediment investigation

>> Concentration of radiocesium in seafloor sediment is unstable.
>> Distribution is not homogeneous.

Radiocesium is mobile (re-suspension, lateral transport, re-distribution).

Chemical structure of radiocesium is open question.

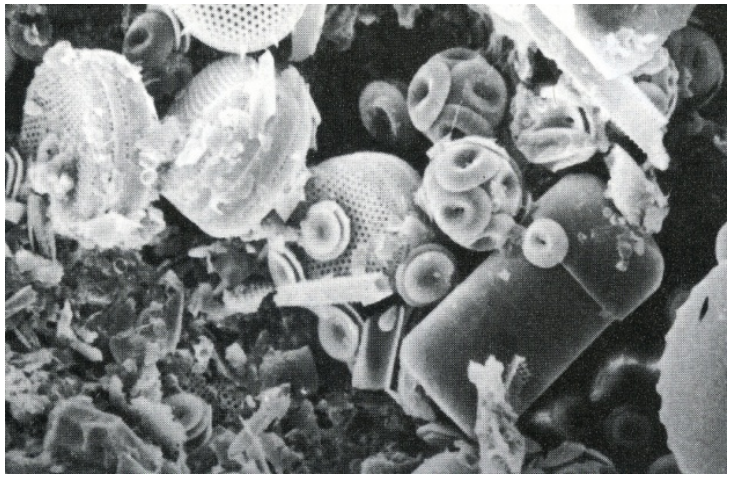


Ocean Biogeochemical Dynamics, J.L. Sarmiento and N. Gruber, Princeton Univ. Press, 2006

Marine sediment:

Biogenic particles
- Organic detritus
  - (transferrable to food web)
- Inorganic shells

Lithogenic particles (e.g. clay minerals)
- Terrestrial origin
- Cesium may bind strongly



Characterization of sediment and suspended particles is essential

An Introduction to the World's Oceans, 6th ed., A.C. Duxbury, A.B. Duxbury and K.A. Sverdrup, McGraw-Hill, 2000

(courtesy of Kanda)

Interdisciplinary Study on Environmental Transfer of Radionuclides from the Fukushima Daiichi NPP accident

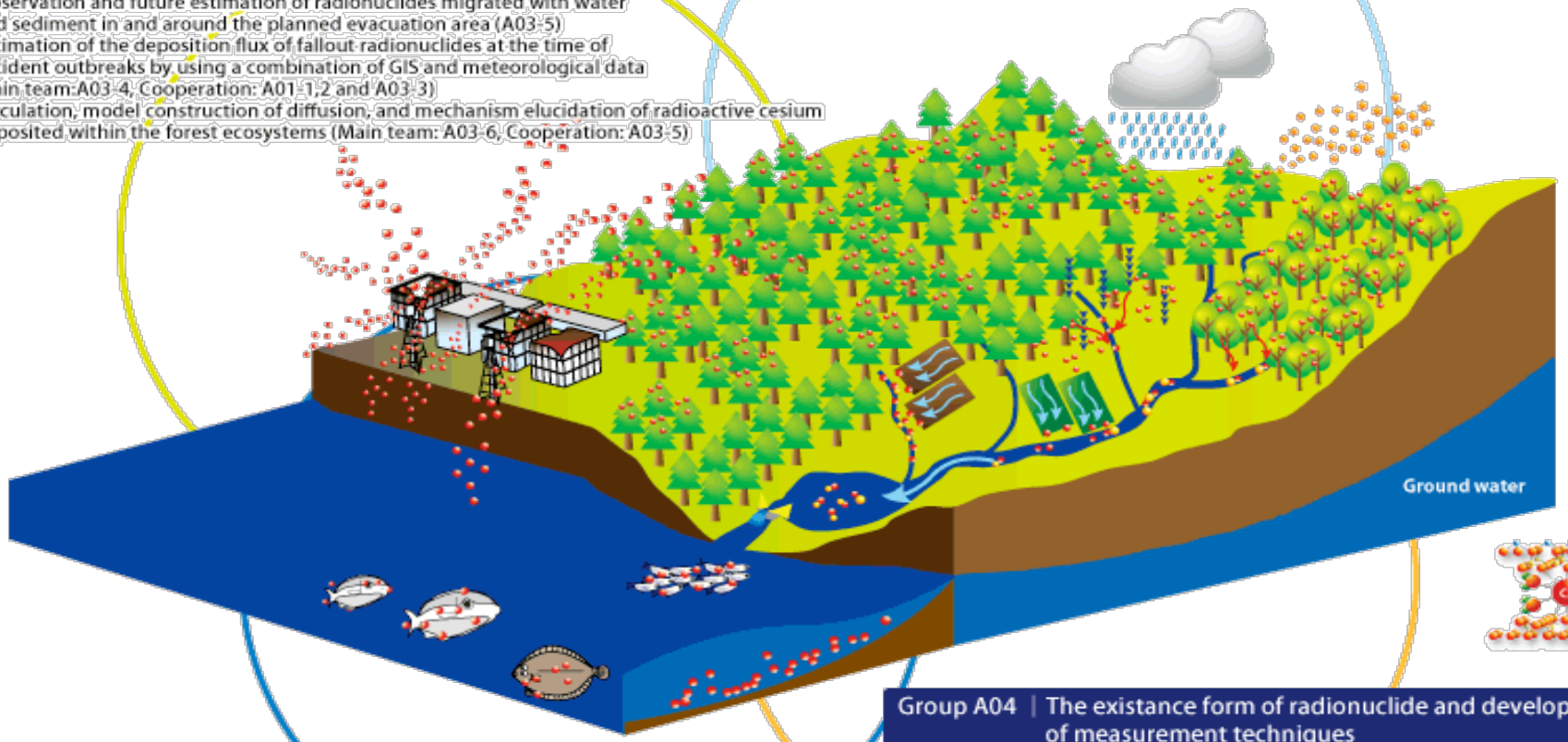
ISET-R
Interdisciplinary Study on Environmental Transfer of Radionuclides from the Fukushima Daiichi NPP Accident

Group A01 | The effect of radionuclides on the atmosphere

- Understanding the model of atmospheric circulation and migration process of radioactive fallout (Main team: A01-1,Cooperation: A01-2, A02-3)
- Understanding of atmpspheric deposition, diffusion processes, and the intraction with land (Main team: A01-2, Cooperation: A04)
- Understanding and recreating of re-entrainment of radionuclides deposited in soil and ecosystems, also modeling of the intraction on migration (Main team: A01-2, Cooperation: A03-3, A03-4, and A01-1)

Group A03 | The migration of radionuclides on the land

- Observation and future estimation of radionuclides migrated with water and sediment in and around the planned evacuation area (A03-5)
- Estimation of the deposition flux of fallout radionuclides at the time of accident outbreaks by using a combination of GIS and meteorological data (Main team:A03-4, Cooperation: A01-1,2 and A03-3)
- Circulation, model construction of diffusion, and mechanism elucidation of radioactive cesium deposited within the forest ecosystems (Main team: A03-6, Cooperation: A03-5)



Group A02 | The effect of radionuclides on the ocean

- Understanding the distribution factor and condition of radioactive materials in sea and seafloor
- Investigation of physical process and modeling of radionuclides in sea and seafloor
- Investigation of concentration process and estimation of migration process of radioactive materials in marine ecosystems (Main team: A02-3,4, Cooperation: A01-1, A03-7, and A04)

Group A04 | The existance form of radionuclide and development of measurement techniques

- Development of microanalysis technology and chemical form of radioactive materials with migration, measurement support for Team A01-03
- Understanding the actual condition, measurement and future estimation of radionuclides diffused from Fukushima Daiichi NPP

ISET-R URL: http://isetr.suiri.tsukuba.ac.jp/ISETRen/indexEN.html