Fukushima – a view from the ocean

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Cesium in the ocean: what do we know?

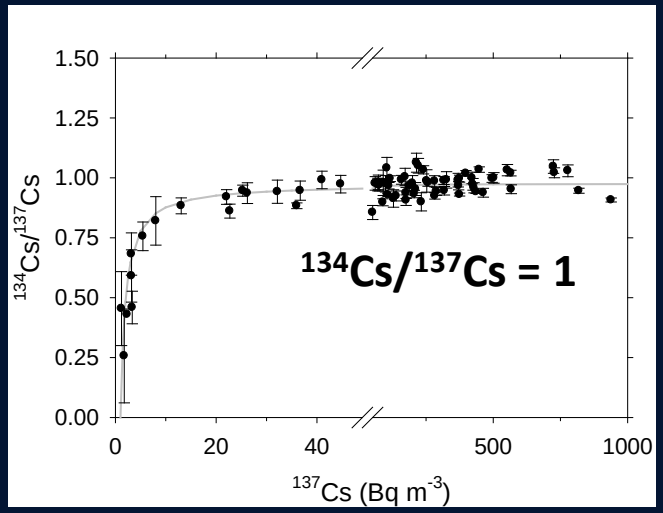
- ❑ mostly from 1960's weapons testing
- ❑ one of the major Fukushima radionuclides of concern
- ❑ soluble in seawater

^{137}Cs half-life = 30 years

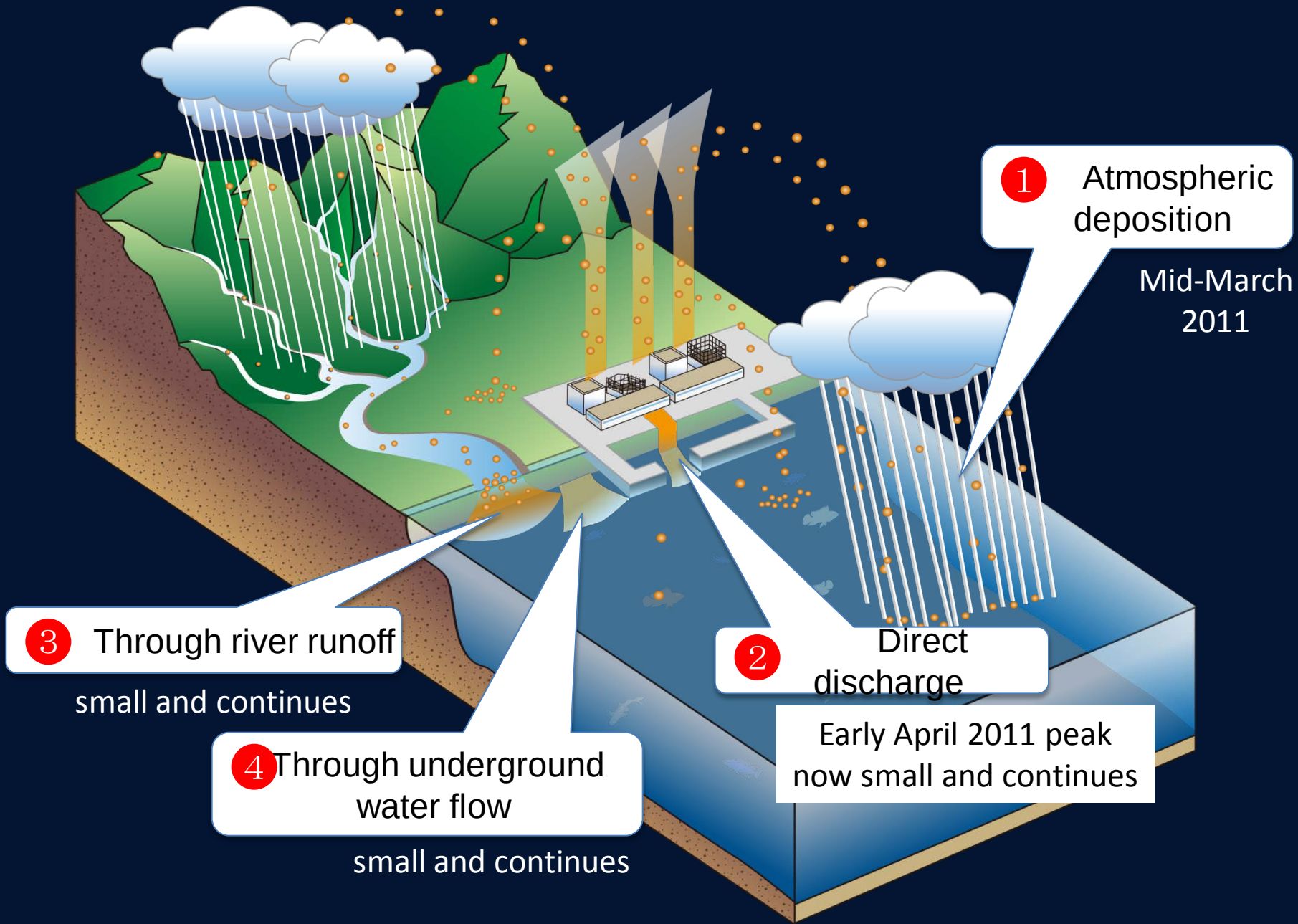
^{134}Cs half-life = 2 years

both isotopes of cesium have same chemical properties

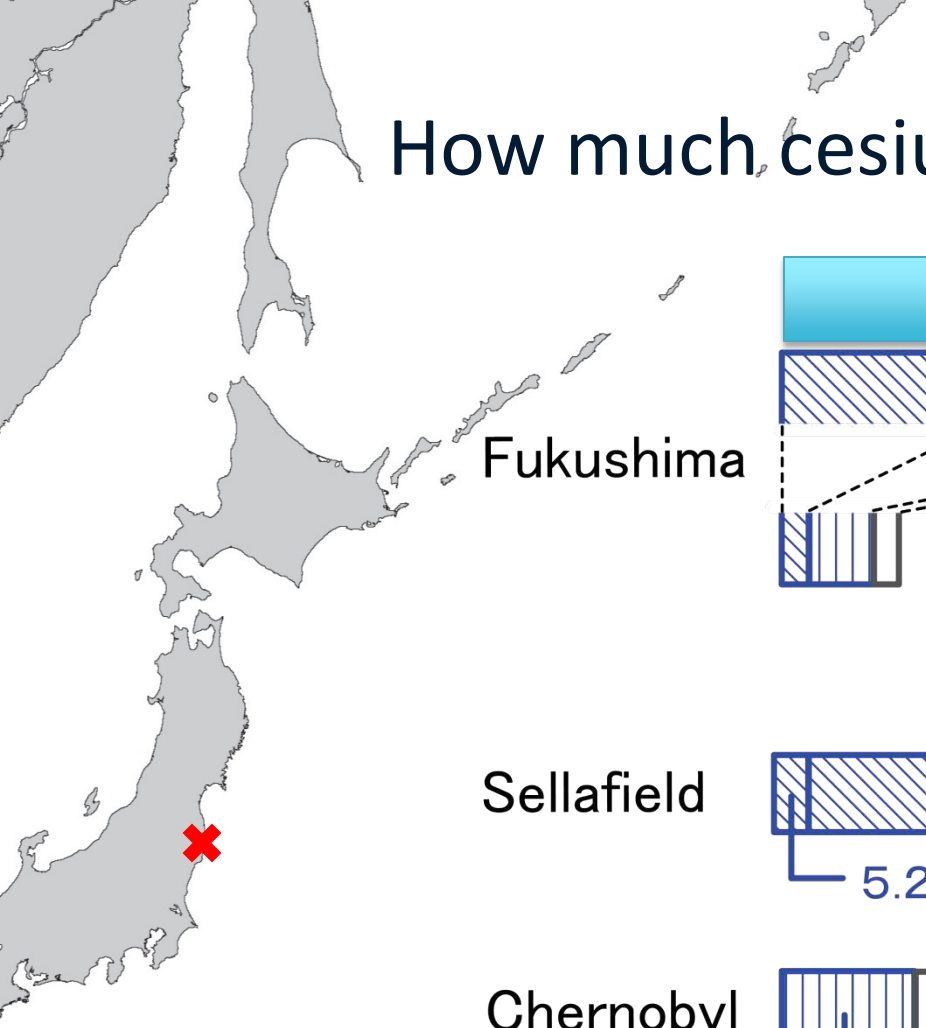
Fukushima Cs fingerprint

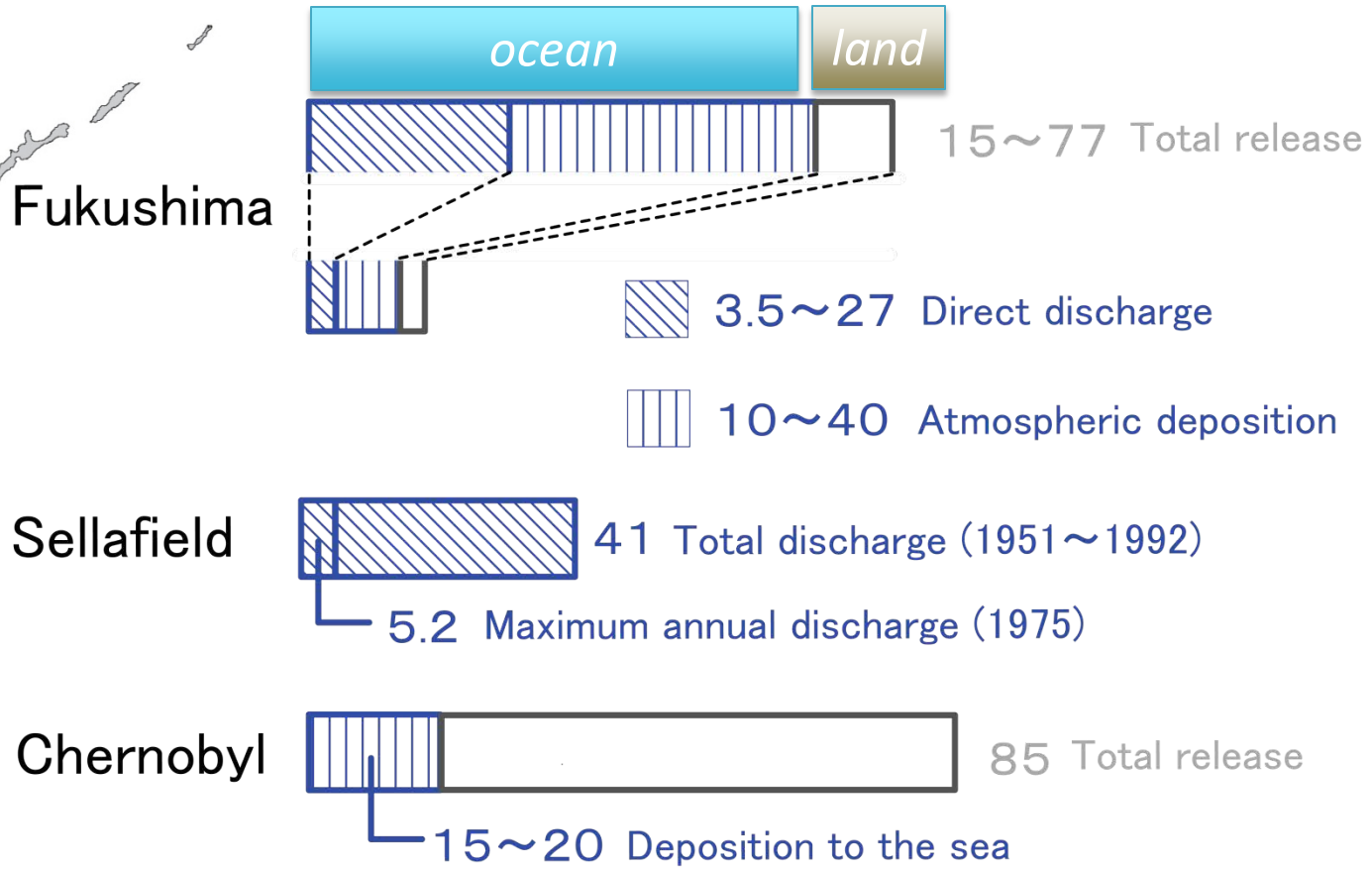


Sources of radionuclides to ocean



How much cesium-137 was released?



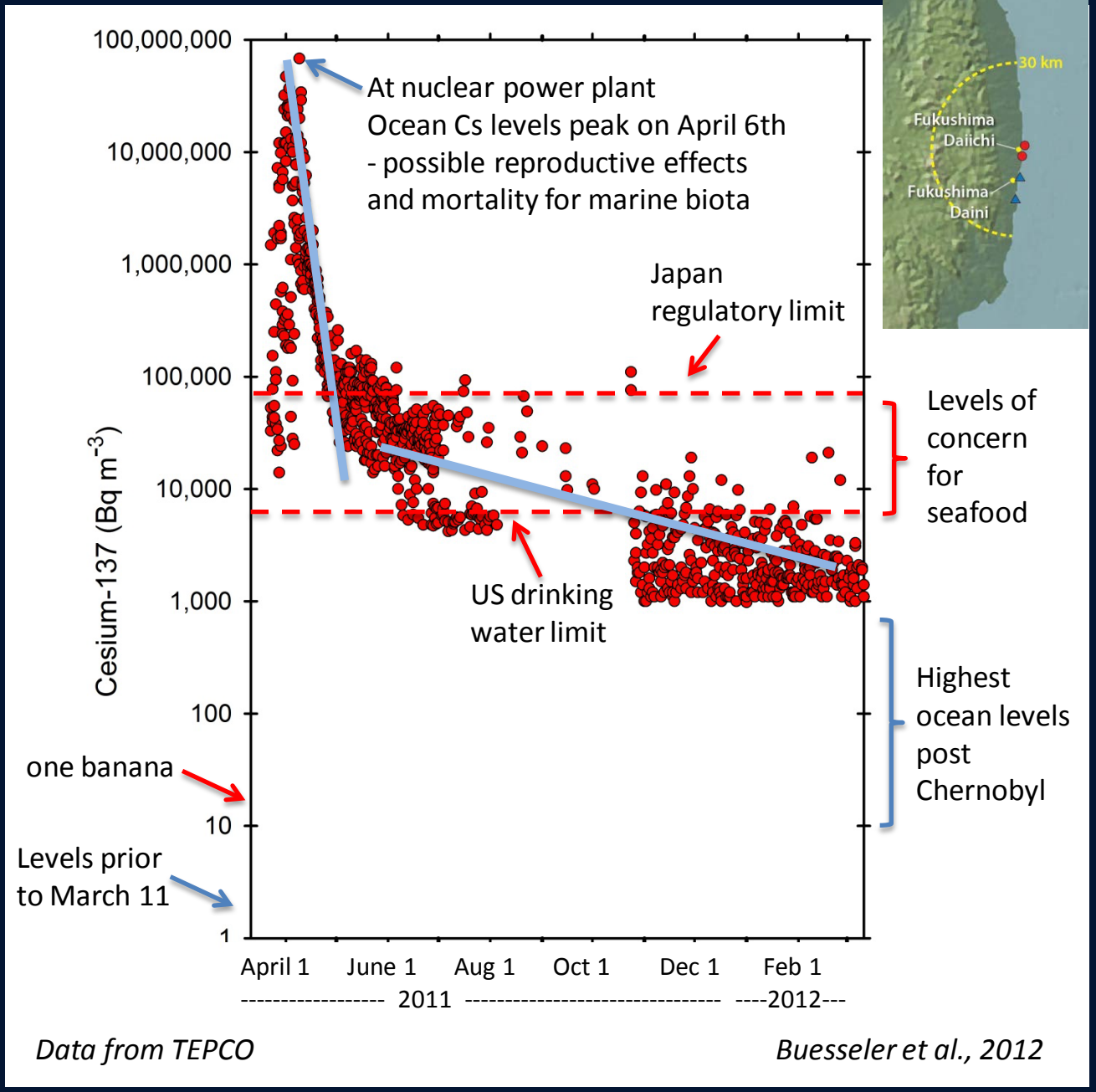


J. Kanda TUMST

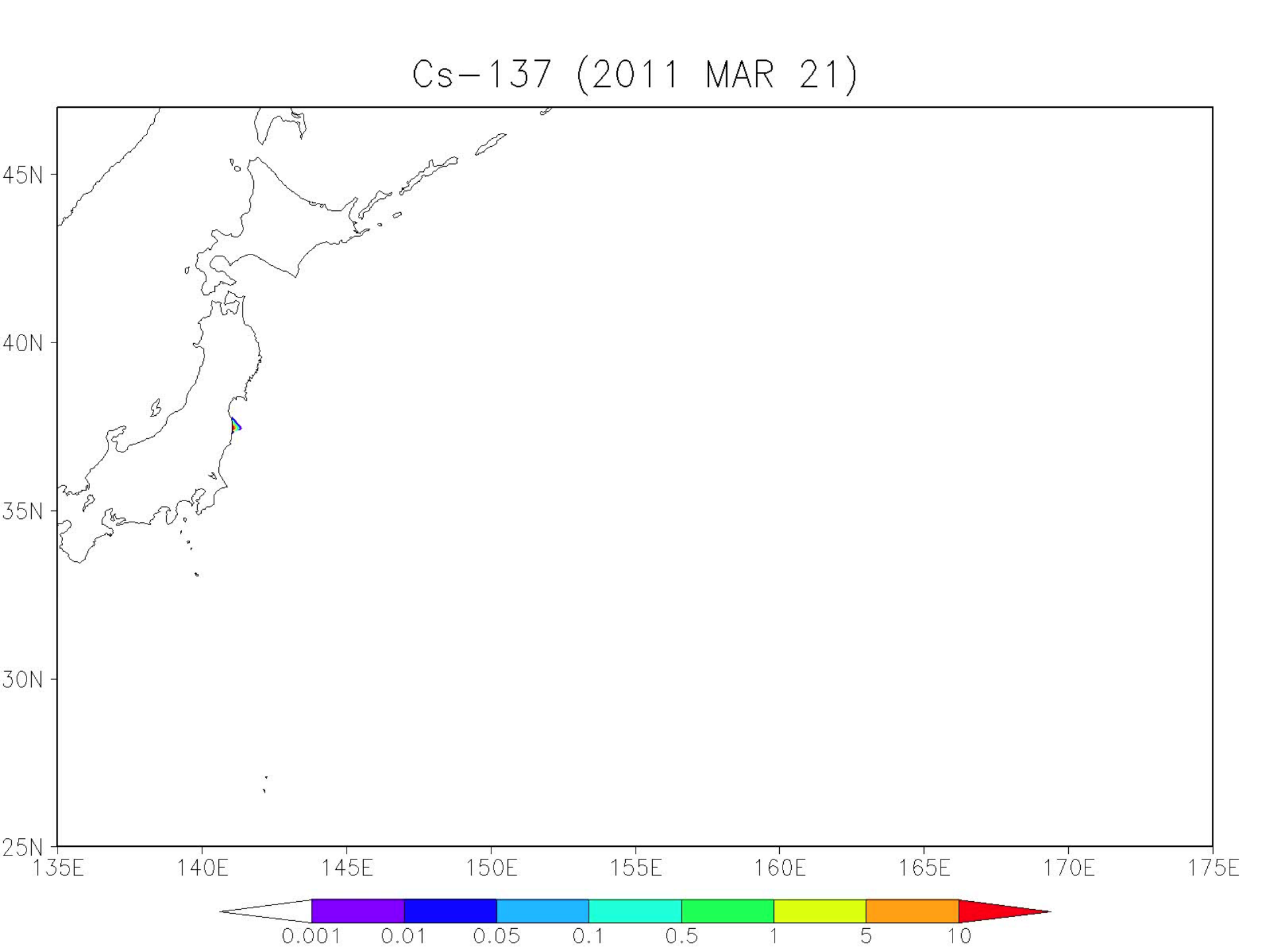
^{137}Cs release to the sea (PBq = 10^{15} Bq)

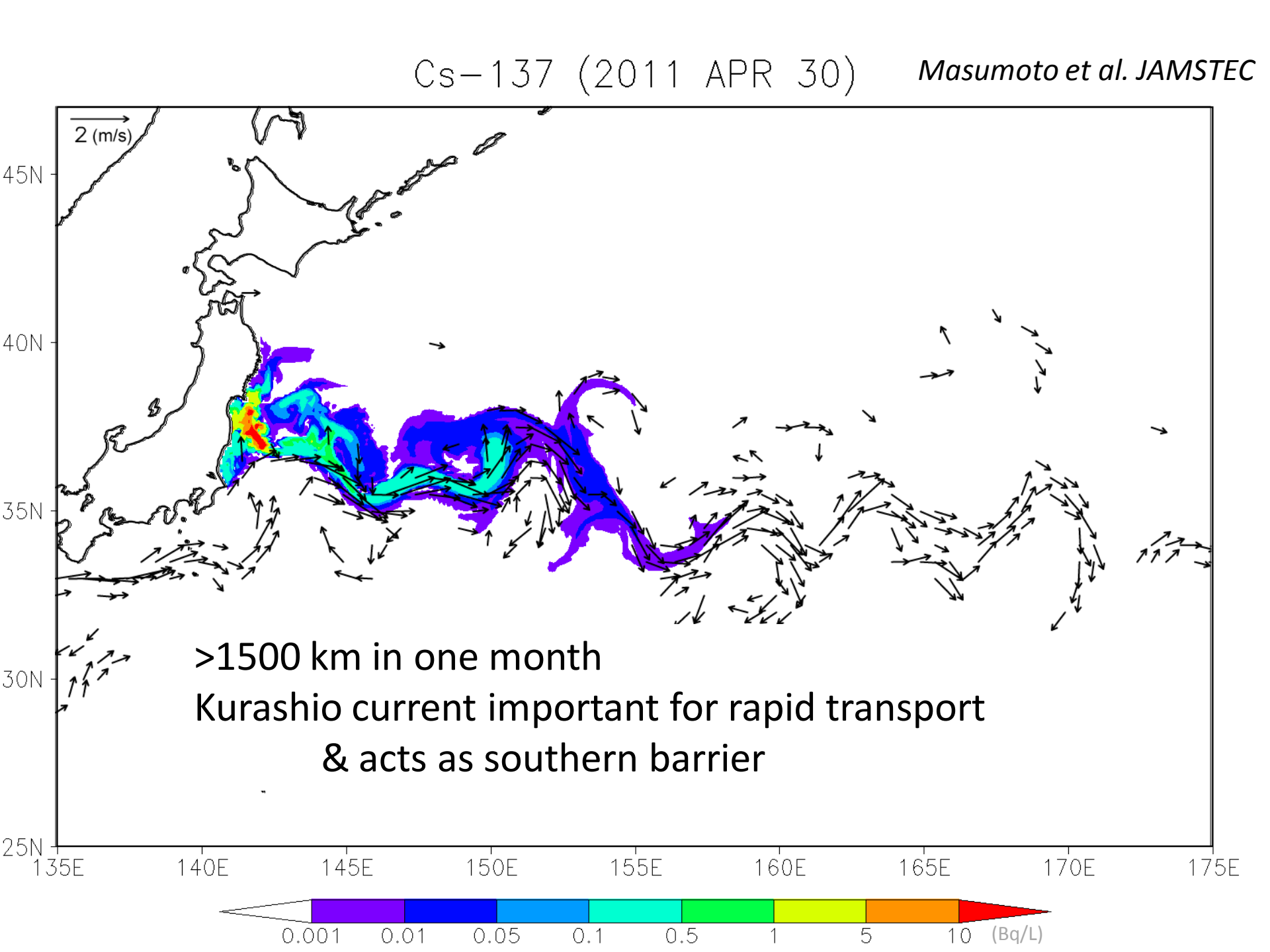
Data sources: Chino *et al*. (2011), Tsumune *et al*. (2012), Bailly du Bois *et al*. (2012). Morino *et al*. (2011), Stohl *et al*. (2011), Gray *et al*. (1995), Aarkrog (2003), UNSCEAR (2000)

One year history of cesium-137 in ocean off Fukushima

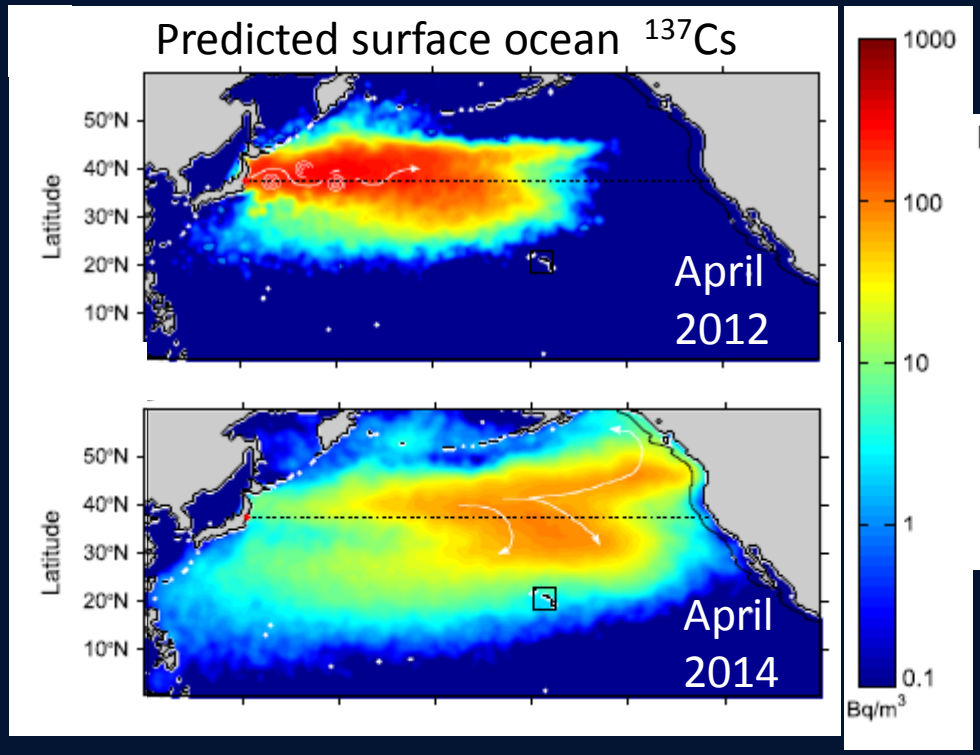


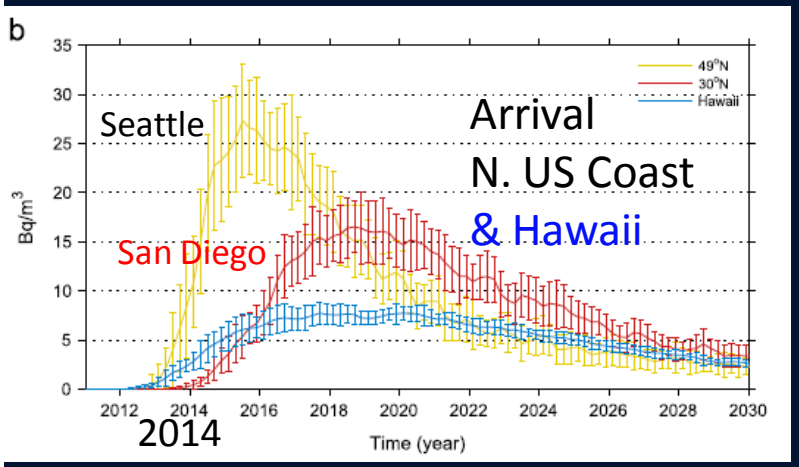
- ❑ Fukushima is an unprecedented event for the ocean
- ❑ levels highest in 2011, then leveled off
- ❑ reactor site remains a source
- ❑ levels now safe for marine biota & human exposure
- ❑ what about seafood?


Cs−137 (2011 MAR 21)
45N
40N
35N
30N
25N
135E
140E
145E
150E
155E
160E
165E
170E
175E
0.001
0.01
0.05
0.1
0.5
1
5
10


Cs−137 (2011 APR 30)
Masumoto et al. JAMSTEC
2 (m/s)
45N
40N
35N
30N
25N
135E
140E
145E
150E
155E
160E
165E
170E
175E
>1500 km in one month
Kurashio current important for rapid transport
& acts as southern barrier
0.001
0.01
0.05
0.1
0.5
1
5
10
(Bq/L)

How long until cesium reaches US west coast?

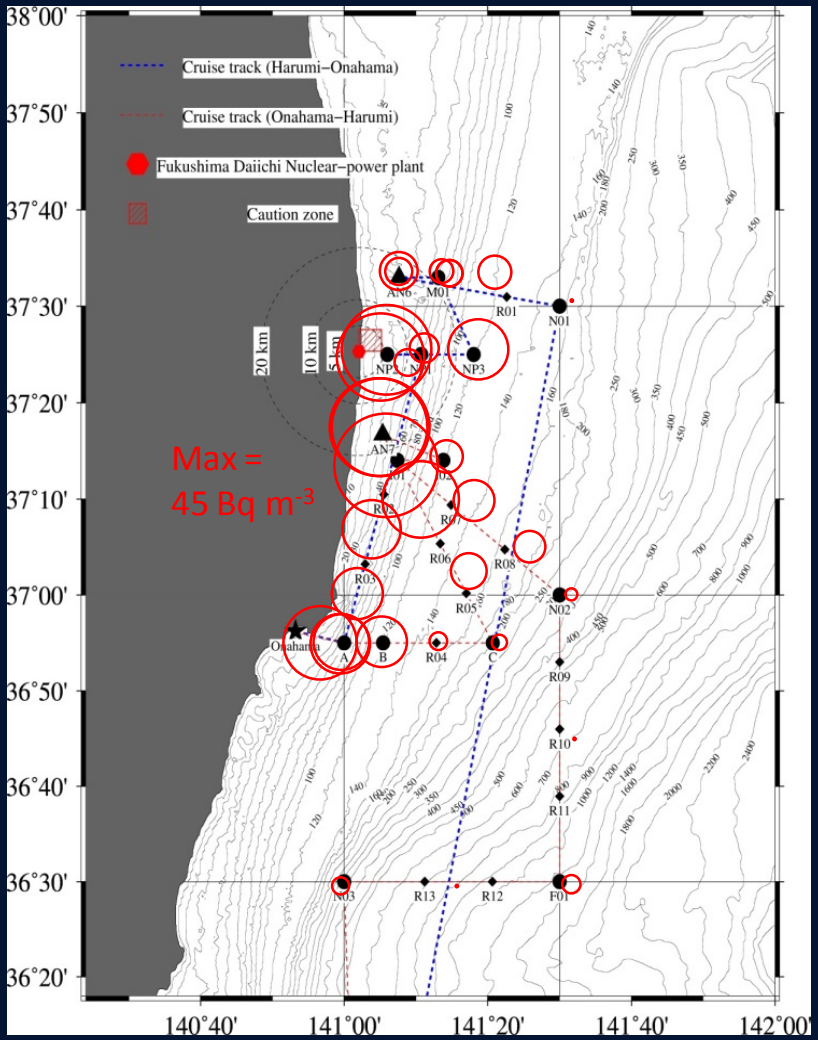




Rossi et al., DSRI, 2013

- Arrives 2013-2014 (after debris)
- Predicted ^{137}Cs off US varies from 1-2 to 30 Bq m^{-3} in different models (safe for exposure & fisheries)
- Little/no vertical data to test!

What about surface ocean cesium-134 in May 2013



- ^{134}Cs indicates continued source at NPP
- Highest Cs closest to shore, associated with locations of higher groundwater input

Buesseler, unpublished

How big is NPP source today?

For cesium isotopes

- Total today = 0.3 TBq/mo
- Source in March/April 2011 = 10-30,000 TBq/mo

For strontium-90

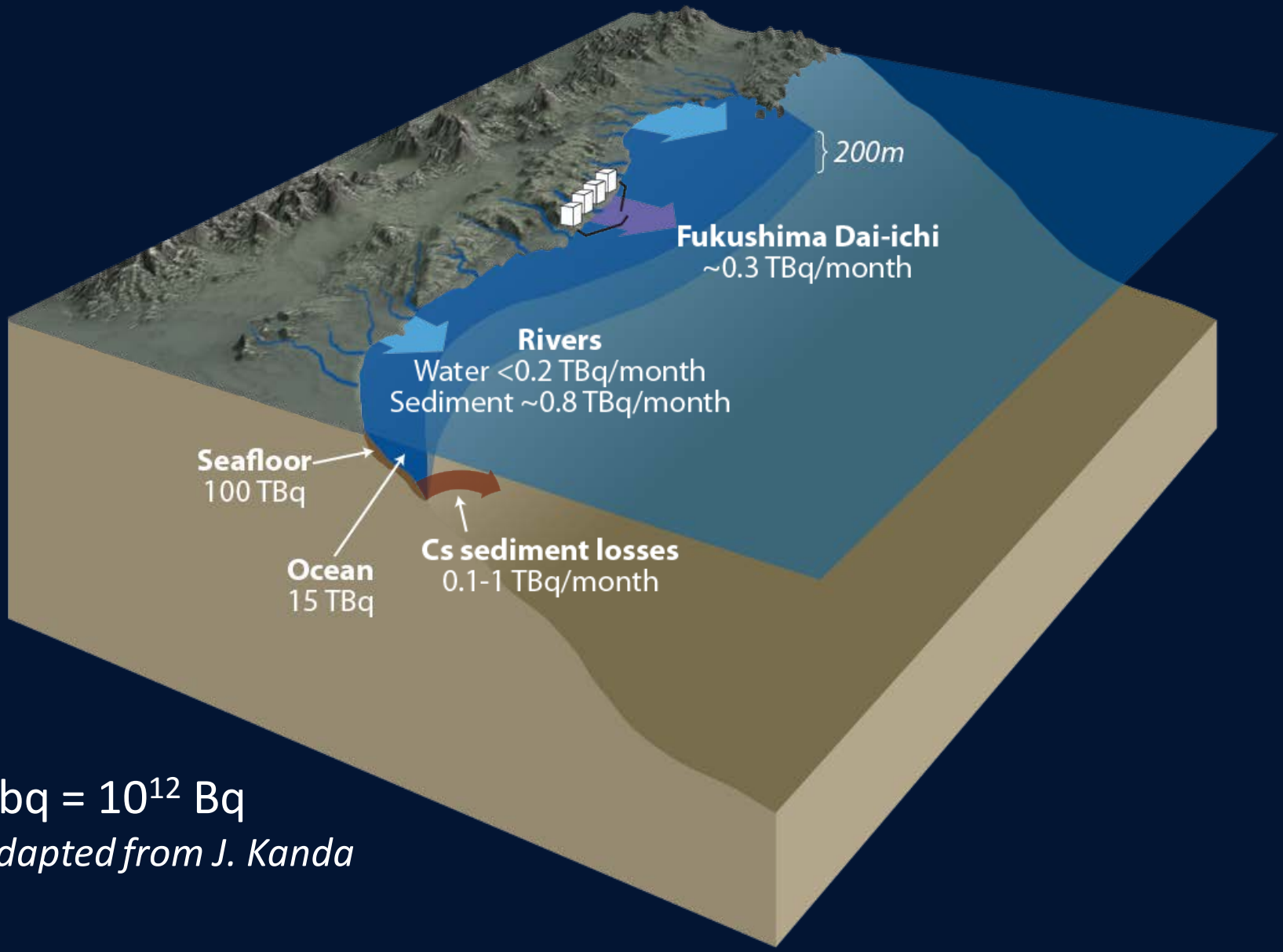
- Total today = 0.1 TBq/mo
- Source in March/April 2011 = 100 TBq/mo

At NPP, Cs is actively being removed from cooling water, and naturally sorbed to sediments, while ^{90}Sr and tritium are not

- w/diversion of groundwater, salt water intrusion could lead to Cs remobilization
- w/leaking tanks, large potential ^{90}Sr source

Each tank= 300 tons x 40 x 10^6 Bq/L = 12 TBq

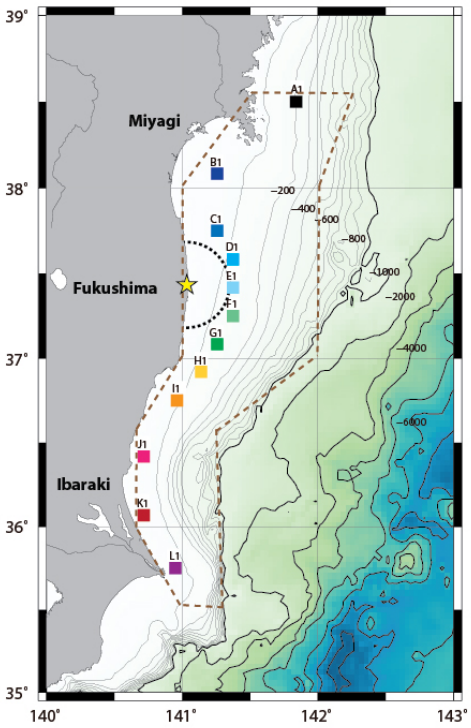
What are cesium-137 sources and sinks today?

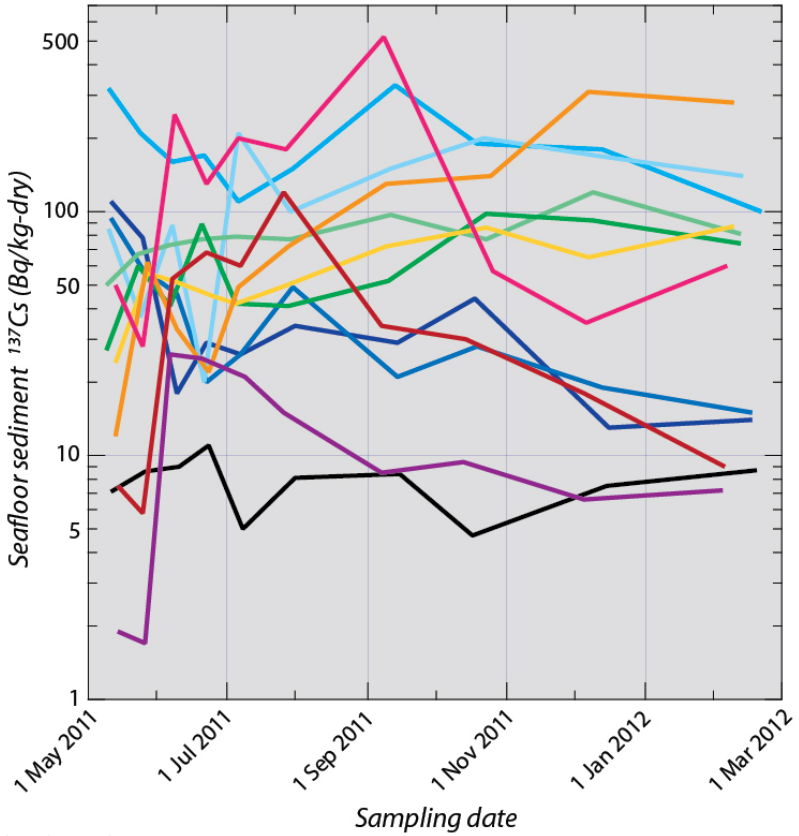


Tbq = 10^{12} Bq

adapted from J. Kanda

What about seafloor sediments?

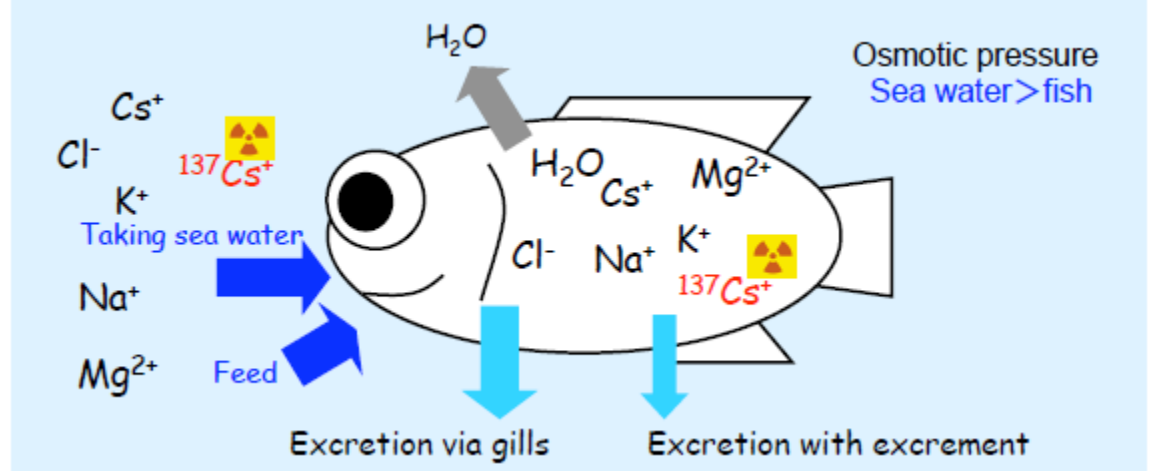




Adapted from Kusakabe et al., 2013 BG

- ❑ Variability common
- ❑ <0.1-0.2% Fukushima Cs found associated with seafloor
- ❑ Long term sink/source for Cs near Japan

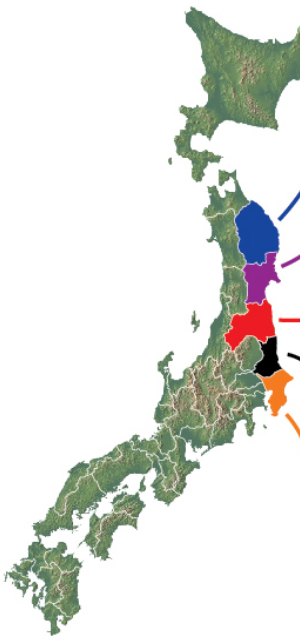
What about Fish and cesium accumulation?

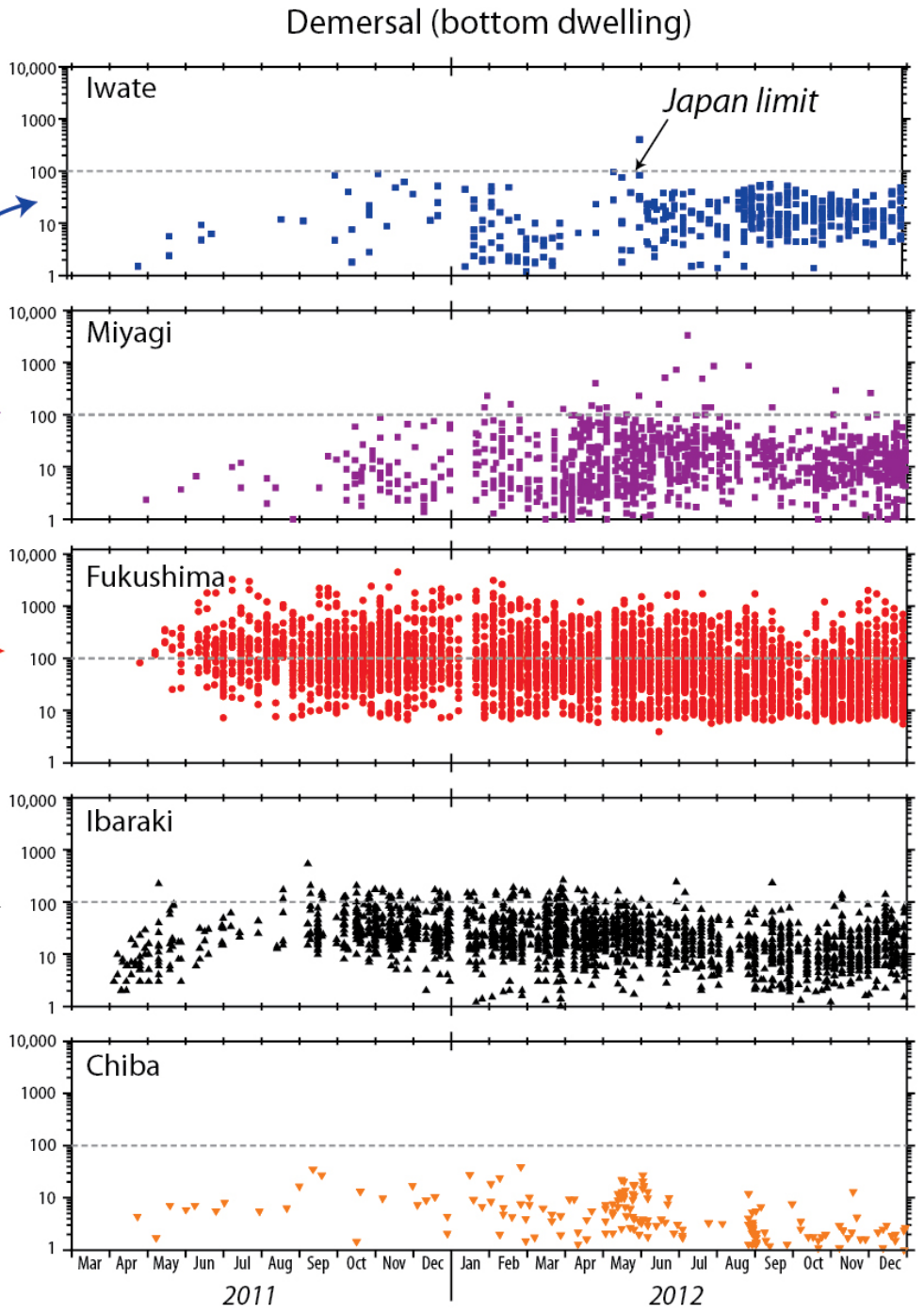


- Cesium uptake and loss from fish is rapid
- 50% loss in 50 days

information page from Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF)

Fisheries closed off Fukushima





Elevated Cs consistent with continued sources

Data from Japan Fisheries
Figure adapted from Buesseler, Science, 2012

Motivation to launch new Center of Excellence
Fukushima demonstrated

- Public interest, concern & anxiety

NATIONAL GEOGRAPHIC

Aug. 7, 2013 Fukushima's Radioactive Water Leak: What You Should Know

"it's actually thousands of times less than … in the immediate aftermath of the disaster, …" according to Buesseler.

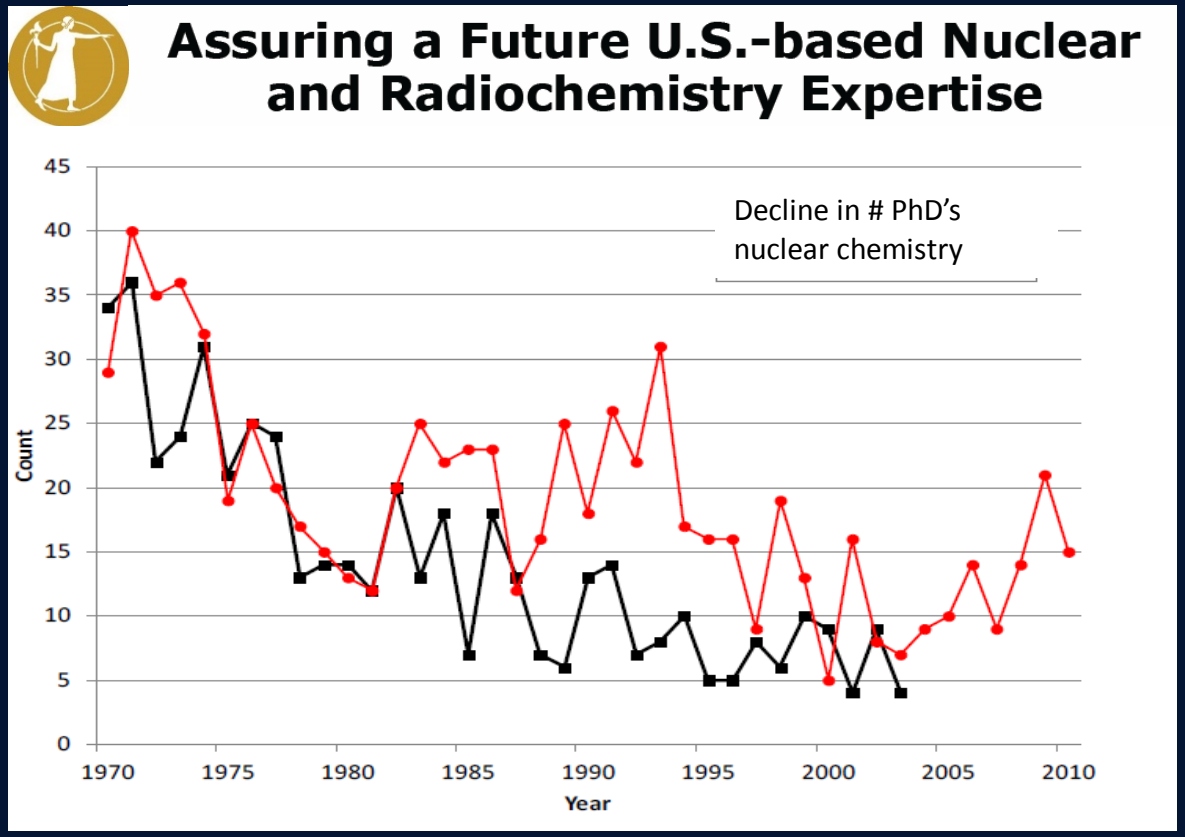
NBC Nightly News; ABC World News; Weather Channel; PRI the World; NPR; AP Tokyo; NY Times; Wall Street Journal; CNN; Science; New Scientist; LIveWire; Deutsche Welle; Anchorage Daily news; Canadian Broadcasting; NHK Japan, Surfer Magazine…..

- Need for trusted independent source of information

Motivation to launch new Center of Excellence

Fukushima demonstrated

- ❑ Public interest & concern
- ❑ Education & training need



CMER Center for Marine and Environmental Radioactivity

Mission

- to increase scientific and public understanding of natural and human-made radioactive elements in the oceans

Goals

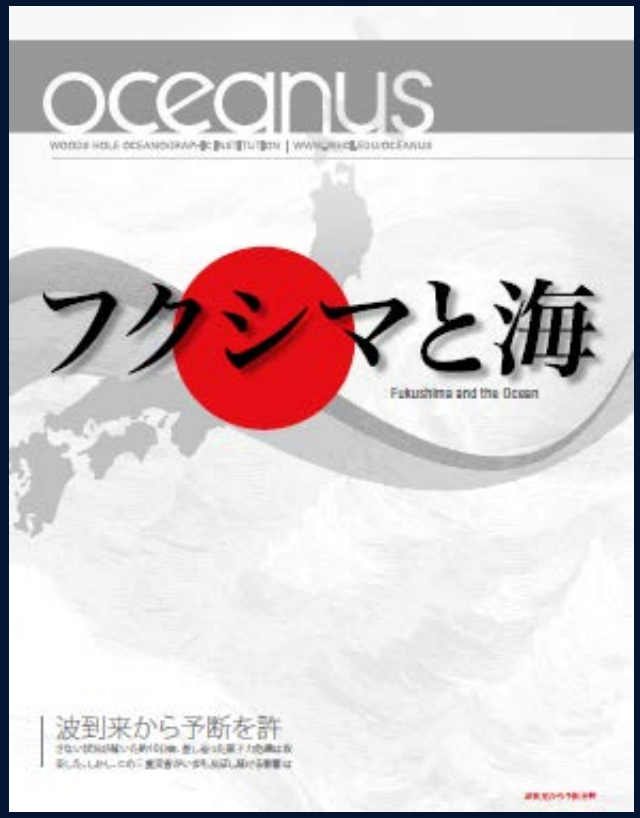
- public outreach
- education and training
- promote research & engineering

Activities thus far

- Nov. '12 and May '13 public events
- Oceanus
- http://www.whoi.edu/CMER
  Fukushima FAQ's

Multiple funding partners sought

- agencies, private, industry

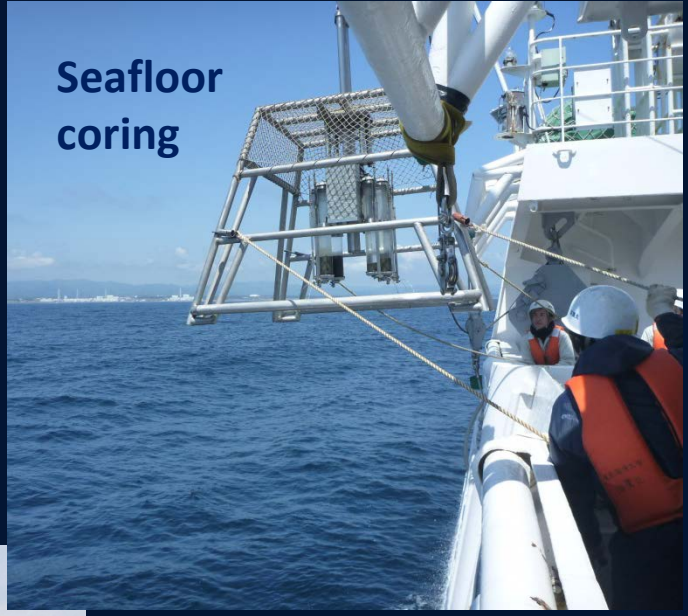


Fukushima- lessons learned from the ocean

- Fukushima NPP represents unprecedented release of radionuclides to the ocean off Japan
- Many reasons for study-

  Human health, radioecology, ocean tracers, future accidents
- Japan is leading studies, but confirmation by international labs will build public confidence (and increase scientific insights)
- Fukushima NPP site continues to leak radionuclides via groundwater and tanks (strontium-90 concern)
- Studies of fish are not enough- need long term studies of ocean, seafloor, rivers, etc. & new technologies
- Motivation for new Center for Marine & Environmental Radioactivity


Biota nets


Seafloor
coring


Autonomous groundwater
detectors


ASV Jetyak
AUV “Rad hopper”


AUV glider
rad detector


Current
drifter

What is needed next?

In response to ongoing leaks at Fukushima-

"An international alliance on research and clean-up would help restore shattered public trust"

Nature editorial Sept 3, 2013

In the long term, if it is in our national interest to-

- ❑ help public understand that we live in a radioactive world
- ❑ build workforce trained in radiochemistry
- ❑ promote science and engineering advances in ocean radiochemistry and radioecology

But, which agency(ies) will step up to the plate?