Fukushima – a view from the ocean

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http://cafethorium.whoi.edu

http://www.whoi.edu/CMER
PLUTONIUM ISOTOPES IN THE NORTH ATLANTIC
by
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B.A., University of California at San Diego, 1981

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
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WOODS HOLE OCEANOGRAPHIC INSTITUTION

SEPTEMBER 1986
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Chernobyl:
Oceanographic Studies in the Black Sea

—Studies on the radioactive fallout from Chernobyl provide information about the fates of nuclear discharges to the environment, and about the circulation of the nearest body of salt water—the Black Sea.

by Ken O. Buesseler

Oceanus®
Volume 30, Number 3, Fall 1987
Photos from Fukushima Dai-ichi security camera March 11

Tsunami 50 feet tall
Before and after March 11, 2011 satellite images
Before and after March 11, 2011 satellite images

Sendai coast
We live in a radioactive world (and ocean)

Human Sources of Cesium-137 Compared to Natural Radionuclides in the Ocean

Global nuclear weapons testing, 1950s-'60s
950 peta-Bequerels (PBq)

Chernobyl
100 PBq

Fukushima
10-50 PBq

Atmospheric Direct

Three Mile Island
0.00004 PBq

Most Abundant Natural Radionuclides in the Oceans

Uranium-238
37,000 PBq

Potassium-40
15,000,000 PBq

1 Bq = 1 Becquerel = one radioactive decay per second
1 PBq = peta-Becquerel = one million billion Bq
$10^{15}$ Bq = 1,000,000,000,000,000 Bq
What are levels of cesium-137 in ocean prior to Fukushima?

Map updated from Buesseler & Livingston 1990 by P. Morris
Sources of Fukushima radionuclides to the ocean

1. Atmospheric deposition
   Mid-March 2011

2. Direct discharge
   Early April 2011 peak now small and continues

3. Through river runoff
   small and continues

4. Through underground water flow
   small and continues
One year history of cesium-137 in ocean off Fukushima

Ocean Cs levels peak on April 6th - possible reproductive effects and mortality for marine biota

Levels prior to March 11

Data from TEPCO

Buesseler et al., 2012
One year history of cesium-137 in ocean off Fukushima

Levels of concern for biota

Levels of concern for eating seafood

Data from TEPCO

Buesseler et al., 2012
Kurashio current

Model of cesium transport - one month after disaster

Masumoto et al. JAMSTEC

Cs–137 (2011 APR 30)
Rapid response cruise in June 2011

Cesium-134

Becquerels/ cubic meter

0–3
10–30
100–300
1,000
3,000
What about Fish and cesium accumulation?

*information page from Japanese Ministry of Agriculture, Forestry and Fisheries*
Cesium remains high in bottom dwelling fish near Fukushima

Data from Japan Fisheries
Figure adapted from Buesseler, Science, 2012
Fisheries closed off Fukushima

Data from Japan Fisheries
Figure adapted from Buesseler, Science, 2012
How far and fast do Fukushima radionuclides travel?
Pacific Blue Fin Tuna migration- arrived in fall 2011

PACIFIC OCEAN CURRENTS

FUKUSHIMA  KUROSHIO CURRENT  SAN DIEGO  HAWAII  SEATTLE
Debris carried by currents and winds- arrived 2012

PACIFIC OCEAN CURRENTS

FUKUSHIMA

KUROSHIO CURRENT

HAWAII

SAN DIEGO
Radionuclides carried only by ocean currents

- 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!

Rossi et al., DSRI, 2013
In response, launched citizen scientist crowd funding site

Jan. 14, 2014

http://ourradioactiveocean.org
Success stories

- Public & media attention high
- >110,000 web views
- 30 sampling sites funded
- >320 donors
- >$50K raised
No Fukushima cesium YET along west coast & Hawaii

Cesium-137 = 1.4 Bq/m³
Cesium-134 < 0.2 Bq/m³
Our supporters

Alaska Ocean Observing System
Alaska SeaGrant
Bamfield Marine Science Centre
Cook Inletkeeper
David Suzuki Foundation
Deerbrook Charitable Trust
Dominical Real Estate
Gordon and Betty Moore Foundation
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Idaho Section of the American Nuclear Society
KUSP Santa Cruz
LUSH Cosmetics
Norton Sound Economic Development Corp.
Nuxalk Nation
Onset Computer
Pacific Blue Foundation
Picture Farm Company
and........

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Resurrection Bay Conservation Alliance
San Luis Obispo Mothers for Peace
Santa Barbara Channel Keeper
Say Yes! to Life Swims LLC
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University of Hawaii
West Hills STEM Academy
Woods Hole Oceanographic Institution
& thanks to more than 320 concerned citizens who have made donations!

Santa Barbara, CA
Fukushima showed
Public concern
Fukushima showed
Education/training need

Number of PhD's in nuclear chemistry

- 1970
- 1975
- 1980
- 1985
- 1990
- 1995
- 2000
- 2005

Number of PhD's: 0, 5, 10, 15, 20, 25, 30, 35, 40
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
Citizen Scientists

Support needed for

HOW
RADIOACTIVE
IS OUR OCEAN?

The release of radioactive contaminants from Fukushima remains an unprecedented event for the people of Japan and the Pacific Ocean. Help scientists at the Woods Hole Oceanographic Institution reveal the ongoing spread of radiation across the Pacific and its evolving impacts on the ocean.
Support needed for New Tools
Wave glider
Rad-band
Support needed for

To better understand our radioactive ocean

FAQ: Radiation from Fukushima

On March 11, 2011, a magnitude 9.0 earthquake—one of the largest ever recorded—occurred 80 miles off the coast of Japan. The earthquake created a series of tsunamis, the largest estimated to be over 30 feet, that swept ashore. In addition to the tragic human toll of dead, injured, and displaced, the earthquake and tsunamis badly damaged the Fukushima Daiichi nuclear power plant, eventually causing four of the six reactors there to release radiation into the atmosphere and ocean.

Since mid-2011, I have worked with Japanese colleagues and scientists around the world to understand the scope and impact of events that continue to unfold today. In June 2011, I organized the first international conference to discuss...