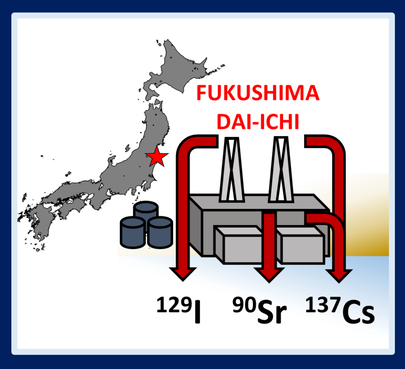

Fukushima Dai-Ichi derived ^{137}Cs, ^{90}Sr, and ^{129}I in surface seawater off the coast of Japan

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1. Introduction

This study measures and investigates Strontium-90, Cesium-137, and Iodine-129 activities in order to determine the sources and relative inputs of these radionuclides off the coast of Japan. Composite data from monitoring sources off the coast of Japan are compiled with data from four cruises from 2012 – 2016, and offer new data and insight into the longstanding problem of the release of radioactive contaminants from the Fukushima Dai-Ichi Nuclear Power Plant (FDNPP).

Isotope Properties

^{137}Cs ($T_{1/2}$ = 30.17 y)
- Volatile and particle reactive
- Conservative in seawater
- Large atmospheric deposition
- Found within reactor and surrounding beaches

^{90}Sr ($T_{1/2}$ = 28.9 y)
- Nonvolatile, less particle reactive than ^{137}Cs
- Sourced from reactor and storage tanks

^{129}I ($T_{1/2}$ = 15.7 Ma)
- Highly soluble and mobile
- Large atmospheric residence time and deposition

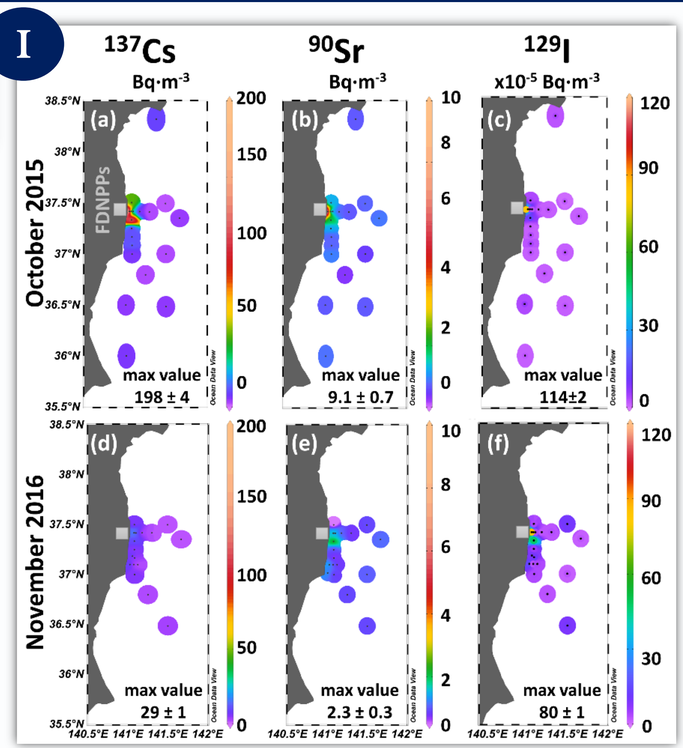
2. Data

^{137}Cs, ^{90}Sr, and ^{129}I in surface seawater in 2015 and 2016

The FDNPP is labeled as a grey box.

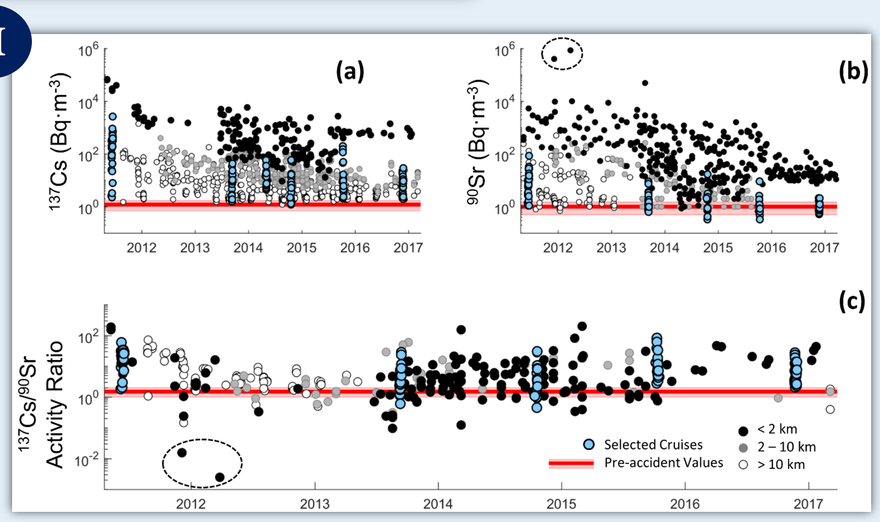
Highest concentrations are listed on each plot and are commonly located at the station closest to the FDNPP.

I



3. Results

II



Surface seawater ^{137}Cs and ^{90}Sr activities offshore of the FDNPP

Continued seawater monitoring of ^{137}Cs and ^{90}Sr show a steady decrease in these radionuclides over time, though they remain above pre-accident values (red line) through 2017.

Data sourced from the Japan Atomic Energy Agency database (white, grey, and black circles) and WHOI (blue circles). Dashed black circles represent accidental releases identified by Castrillejo et *al.* (2016).

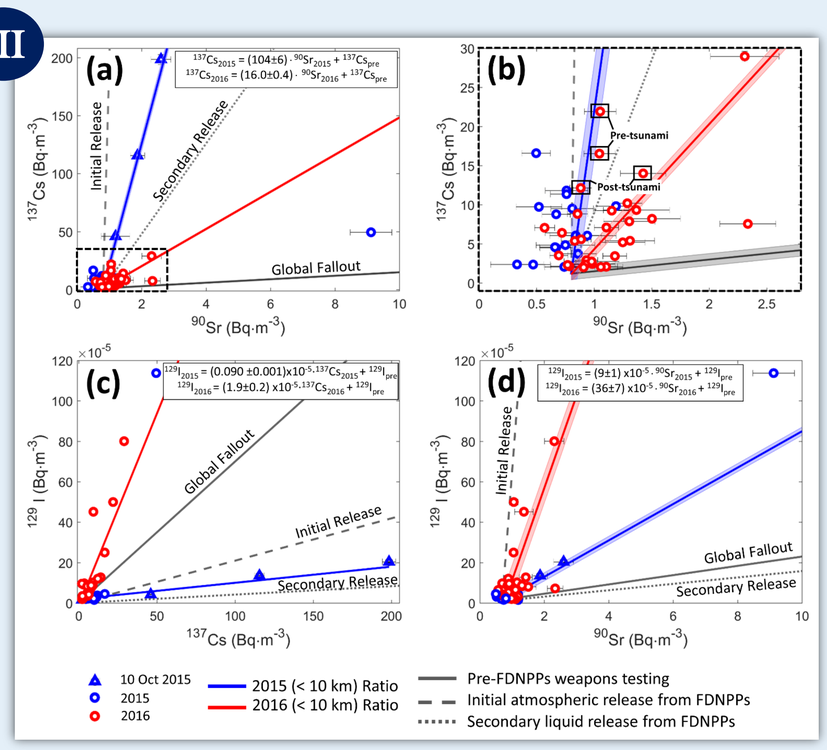
Activity ratios of ^{137}Cs/^{90}Sr, ^{129}I/^{137}Cs, and ^{129}I/^{90}Sr

Average Cruise Ratios*	2015	2016
^{137}Cs/^{90}Sr	11.6 ± 0.3	6.7 ± 0.1
^{129}I/^{137}Cs	5.89 x 10^{-6}	3.8 x 10^{-5}
^{129}I/^{90}Sr	4.57 x 10^{-5}	1.8 x 10^{-4}

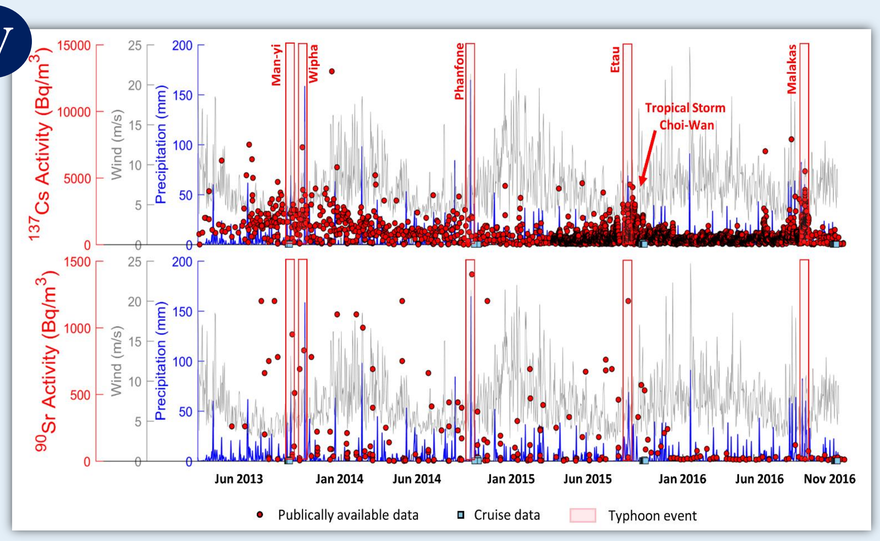
*sans 10 Oct 2015

Release Events	^{137}Cs/^{90}Sr	^{129}I/^{137}Cs
Pre-accident input from 1950's and 60's weapons testing	1.5	7 x 10^{-6}
FDNPP atmospheric fallout	1000	
FDNPP area 2011	39 ± 1	4.1 x 10^{-7}
FDNPP area 2013 (leaks)	3.5 ± 0.2	

III



IV



Rain and wind vs. ^{90}Sr and ^{137}Cs

High wind and rainfall coincides peak ^{137}Cs activities, but not necessarily peak ^{90}Sr activities. Some correlation with ^{90}Sr may be due to contaminated water storage container catchment overflow during high rain events (TEPCO, 2016).

4. Conclusions

- ^{137}Cs, ^{90}Sr, and ^{129}I concentrations off of the FDNPP have decreased over time, though continue to be above pre-accident levels
  - This decrease may be due to the construction of decontamination systems
- ^{90}Sr and ^{129}I is sourced from non-continuous releases from the FDNPP and its surrounding storage tanks
- High ^{137}Cs seawaters can be sourced from outside the FDNPP site, and is affected by rain, wind, and tides
- A high ^{137}Cs event on October 10, 2015 is likely the result of groundwater sources after storm conditions
- ^{137}Cs and ^{90}Sr concentrations decrease post-earthquake due to reduced inputs from FDNPP and advection of waters to the open Pacific Ocean
- The ^{137}Cs/^{90}Sr activity ratio is a reliable spatial tracer for water masses that have come into contact with FDNPP-contaminated waters. Due to very low ^{129}I activity in the ocean and variable source terms outside of the FDNPP, ^{129}I/^{137}Cs and ^{129}I/^{90}Sr activity ratios are less likely to be effective oceanographic tracers

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All references, data, and discussion can be found in further detail in Kenyon et al., 2020 (Environmental Science and Technology).