Input of I-129 Into The Western Pacific Ocean Resulting From The Fukushima Nuclear Event

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1. Motivation and Goal of the present work

The 2011 accident at the Fukushima Daiichi Nuclear Power Plant resulted in a localized and discrete input of a suite of radionuclides into the Pacific Ocean, both via atmospheric deposition and direct discharge. Significant scientific and technical resources have been committed towards mitigating the environmental and public health impacts of the released radioactivity. Events such as this also present the opportunity for scientific study into fundamental transport processes in the environment by exploiting released radioisotopes as unique signatures. This presentation will highlight the use of Iodine-129 released from Fukushima to trace the movement and mixing of water bodies in the Pacific Ocean.

2. Background

Iodine-131 (^{131}I) is a radioisotope of particular concern to public health officials. A high specific activity (half life = 8 days) coupled with a tendency to concentrate in marine organisms presents a unique hazard and thus, ^{131}I is routinely monitored for radiological assessments. By contrast, ^{129}I, which has a half life of 15.7 million years, presents virtually no environmental or public health risk and is not routinely measured as part of the response to a nuclear event. Iodine behaves as a conservative micronutrient in the ocean and has a residence time of 340,000 years. These features make ^{129}I an ideal tracer for studying ocean circulation and mixing.

3. Characterization of pre-event ^{129}I

To effectively exploit ^{129}I released from Fukushima as a long-term ocean circulation tracer, the pre-event "background" must be well known. Sparse literature data for ^{129}I in the Pacific Ocean were augmented with surface water measurements collected from the *OOCL Tokyo* during a west-east transect of the Pacific Ocean from 16 May to 29 May 2011 (Fig. 1). This vessel, through its participation in the US Voluntary Observing Ship (VOS) Program, had previously been fitted with scientific-grade sampling equipment which was essential to obtaining samples so soon after the Fukushima accident.

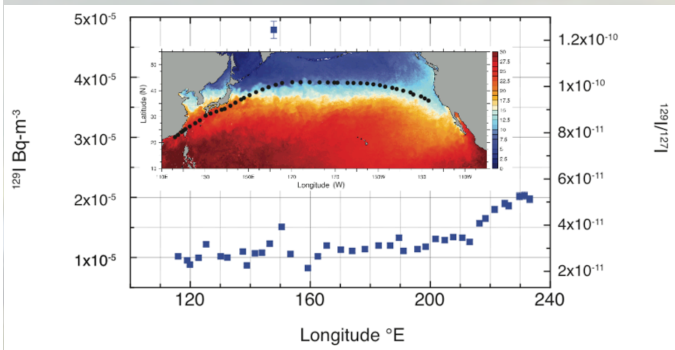

Figure 1. The ^{129}I concentration measured in surface samples collected from the May 2011 west-east transect of the Pacific Ocean by the OOCL Tokyo. Color scale on map inset shows mean sea surface temperature during the month of the cruise.

4. Quantifying the source term of ^{129}I

Another key element to utilizing ^{129}I for tracing ocean circulation is an accurate estimate of the total amount of ^{129}I released by the Fukushima accident (i.e., the source term). A dedicated hydrographic and radiochemistry cruise was conducted aboard the *R/V Ka'imikai-o-Kanaloa (KOK)* from 3 June through 11 June 2011 (sampling stations shown in Fig. 2). Funding for this research cruise was provided by a private foundation which was critical to deploying a research cruise of this scale quickly following the Fukushima accident.

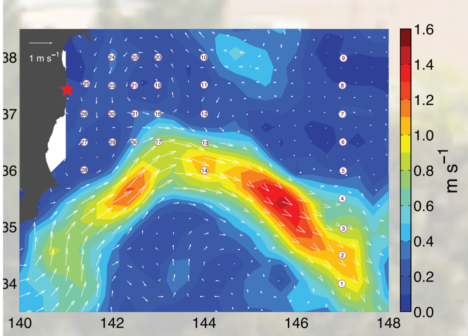

Figure 2. Map showing the sampling locations from the June 2011 cruise of the R/V KOK. White arrows represent current velocity vectors and color scale corresponds to first derivative of sea surface height.

By integrating the excess (i.e., amount over background) measured in all the hydrographic profiles (shown in Fig. 3), the total inventory of ^{129}I within the study area at the time of the cruise was estimated to be 1030 ± 140 MBq. Taking into account oceanic transport away from the study area prior to the cruise, the total estimated direct discharge of ^{129}I to the Pacific Ocean from Fukushima is approximately 1 kg. By comparison, the total release of ^{129}I from the Chernobyl nuclear accident has been estimated to be ~6 kg.

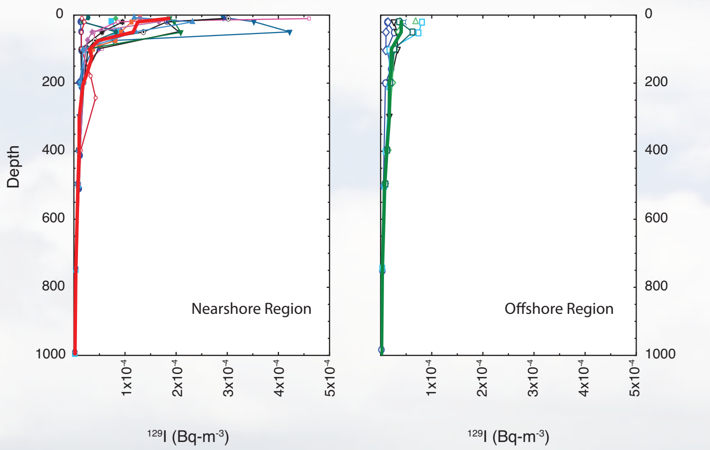

Figure 3. The ^{129}I concentration measured in hydrographic casts collected from the R/V KOK in June 2011.

5. Coupling ^{129}I data to ocean transport models

Unexpected nuclear accidents in the future have the potential to complicate the tracing of Fukushima ^{129}I. The relationship between ^{129}I and shorter-lived isotopes like ^{134}Cs (2.1 years) and ^{137}Cs (30 years), as shown in Fig. 4, can provide a unique signature that can be used to discriminate future releases to the Pacific.

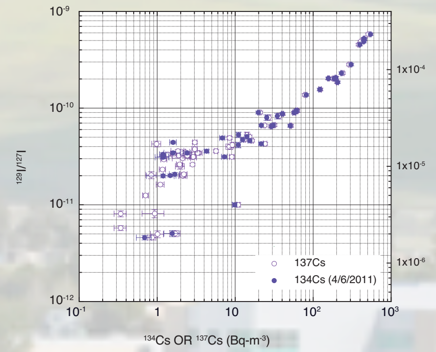

Figure 4. ^{129}I plotted as a function of ^{134}Cs and ^{137}Cs in the samples collected from the June 2011 R/V KOK cruise.

By using the derived Cs to ^{129}I relationship from Fukushima, additional sampling missions can generate data sets that can be compared to numerical models of radionuclide transport. One example is the high-resolution numerical Navy Coastal Ocean Model (NCOM) which has been used to model transport of effluent from Fukushima. The ^{137}Cs measurements from the R/V KOK cruise were compared to the output and offered an invaluable opportunity to refine the model. Future sample collection missions will provide additional data sets that can be used to further refine ocean transport models such as NCOM.

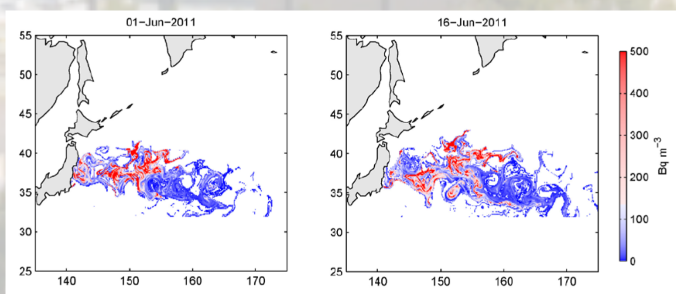

Figure 5. Results of numerical simulation of ocean transport of ^{137}Cs from Fukushima based on the Navy Coastal Ocean Model (NCOM). [From Rypina, I.I, Biogeosciences (2013), v10, p4973].

6. Acknowledgments

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