Reassessment of $^{90}$Sr, $^{137}$Cs and $^{134}$Cs in the Pacific Ocean and the coast off Japan derived from the Fukushima Dai-ichi Nuclear accident

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After the Tohoku earthquake and subsequent tsunami on March 2011, significant quantities of artificial radionuclides were released to the environment as a consequence of damage at the Fukushima Dai-ichi nuclear plants. Several studies estimated total discharges to the Pacific Ocean of about 100 TBq of $^{90}$Sr and of up to several tens of PBq of $^{137}$Cs and $^{134}$Cs in 2011 (Buesseler et al., 2012; Casacuberta et al., 2013). These initial releases led to concentrations of Cs isotopes in the water column of about 40 times larger than those of $^{90}$Sr. In this study, data on $^{90}$Sr, $^{137}$Cs and $^{134}$Cs concentrations in shallow profiles located off the coast of Japan to within 1 km of Fukushima NPP, as well as in a full transect from Japan to the West coast of North America are presented and compared to the 2011 data. Highest concentrations of $^{90}$Sr, $^{137}$Cs and $^{134}$Cs were found near the NPP, thus indicating continuation of releases of contaminated waters to the Pacific Ocean. However, the concentrations in 2013 have decreased about one order of magnitude for $^{90}$Sr and 2 to 3 orders of magnitude for Cs isotopes, compared to 2011. The $^{137}$Cs/$^{90}$Sr activity ratio in 2013 averaged 2.7±1.6 in samples collected close to the Fukushima Dai-ichi NPP. This lower ratio evidences that recent leakages of contaminated water from trenches and tanks storing water treated for Cs using zeolite sorption process are significantly enriched in $^{90}$Sr compared to Cs isotopes.

CRUISE 2011:

CRUISES 2013:

MAIN RESULTS: JUNE 2011

SEPTEMBER 2013

Evolution of the $^{90}$Sr/$^{137}$Cs activity ratio after March 2011

Table 1. Summary of the data including minimum, maximum and averaged values from K. D. cruise in June 2011 and Daisan Kazo Maru cruise in September 2013.

CONCLUSIONS:

- Samples collected from shallow profiles off the coast of Fukushima Dai-ichi NPP show continuous releases of $^{90}$Sr, $^{137}$Cs and $^{134}$Cs since the accident in 2011. Highest values for samples collected in September 2013 at 8.9±4, 125±3 and 54±1 Bq m$^{-3}$ for $^{90}$Sr, $^{137}$Cs and $^{134}$Cs, respectively.
- Despite these continued releases, overall concentrations have decreased in order of magnitude for $^{90}$Sr and 2-3 orders of magnitude for $^{137}$Cs and $^{134}$Cs between June 2011 and September 2013. New releases lead to an average $^{137}$Cs/$^{90}$Sr activity ratio in surface waters of 2.7±1.6, indicating that they are enriched in $^{90}$Sr relative to Cs isotopes resulting from the treatment of contaminated waters.
- The full transect along the Pacific Ocean shows that Fukushima-derived Cs has reached the mid Pacific Ocean, with values ranging from 0.88±0.09 to 7.8±0.2 Bq m$^{-3}$ for $^{137}$Cs and from 0.36±0.06 to 2.75±0.15 Bq m$^{-3}$ for $^{134}$Cs in 2013. All $^{137}$Cs activities are below 1.5 Bq m$^{-3}$ in the open ocean, hardly distinguishable from the global fallout derived signal.
- Future studies in 2014-2015 will assess the transfer of certain artificial radionuclides to marine biota (including plankton and macroalgae) within the frame of the COMET project.

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References: