Fukushima and the ocean- five years later

KEN BUESSELER^{1*}, MINHAN DAI², MICHIO AOYAMA³, CLAUDIA BENITEZ-NELSON⁴, SABINE CHARMASSON⁵, ROBERTA DELFANTI⁶, KATHERYN HIGLEY⁷, VLADIMIR MADERICH⁸, PERE MASQUE⁹, PAUL MORRIS¹⁰, DEBORAH OUGHTON¹¹, JOHN N. SMITH¹²

¹Woods Hole Oceanographic Institution, Woods Hole, MA, USA (*correspondence: kbuesseler@whoi.edu)

²Xiamen Univeristy, Xiamen, China (mdai@xmu.edu.cn)

³ Institute of Environmental Radioactivity, Fukushima University (r706@ipc.fukushimau.ac.jp)

⁴ University of South Carolina, Columbia, SC USA (cbnelson@geol.sc.edu)

⁵Institut de Radioprotection et de Sûreté Nucléaire, PRP-ENV, La Seyne/mer, France (sabine.charmasson@irsn.fr)

⁶ENEA, San Terenzo, Italy (roberta.delfanti@enea.it)

⁷School of Nuclear Science and Engineering, Oregon State University, Corvallis, OR, USA

(kathryn.higley@oregonstate.edu)

 ⁸Institute of Mathematical Machine and System Problems, Kiev, Ukraine, (vladmad@gmail.com)
⁹School of Science. Edith Cowan University,

Joondalup, Australia (Pere.Masque@uab.cat) ¹⁰Environment Laboratories, International Atomic

- Energy Agency, Monaco (p.morris@iaea.org) ¹¹Center for Environmental Radioactivity, Norwegian University of Life Sciences
 - (Deborah.oughton@nmbu.no)
- ¹²Bedford Institute of Oceanography, Dartmouth, NS Canada (John.Smith@dfo-mpo.gc.ca)

We provide an overview of radionuclides released from the Fukushima Daiichi Nuclear Power Plant five years after the accident. Key data sets are combined and we identify the challenges and surprises observed from oceanic radionuclide distributions. The emphasis is on cesium isotopes, though other radionuclides are also considered. Topics include: sources from atmospheric and ocean discharges in 2011 as well as estimates of ongoing releases from groundwater and operations during decommissioning; a cross Pacific Ocean time-series to track transport pathways and mixing in surface and subsurface waters; an extended time-series in marine fish that examines species specific variability in radionuclide content and how results fit current radioecological models; and the transport and burial of particle associated contaminants. Societal impacts are discussed including the difficulties in communicating complex issues and basic health physics to the public, in light of dose assessment models of expected health effects in Japan and along the west coast of N. America.