InFORMal Monitoring of Canada's Pacific Coast for Fukushima Radiation

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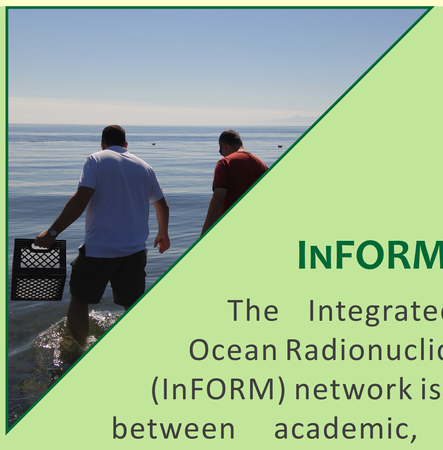
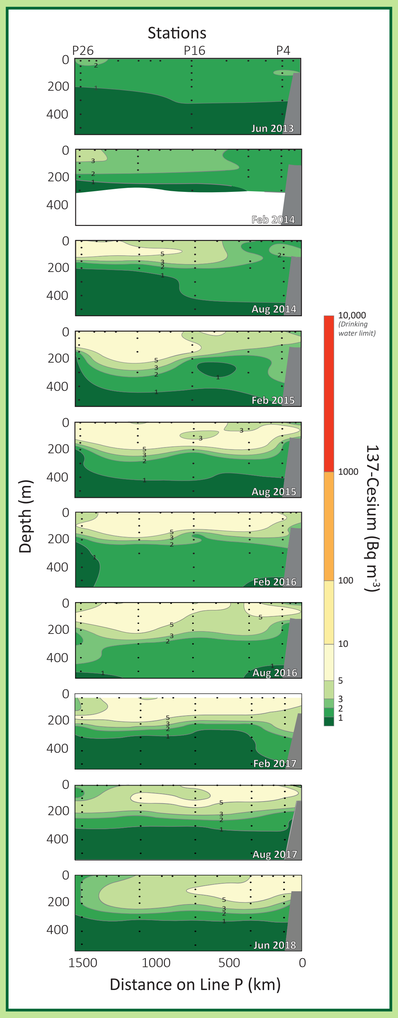
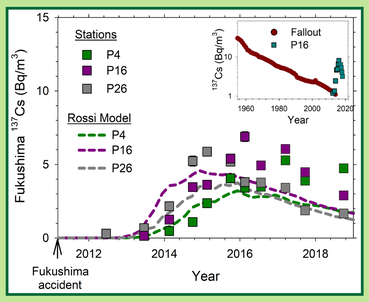


The InFORM Network

The Integrated Fukushima Ocean Radionuclide Monitoring (InFORM) network is a partnership between academic, government, private organizations, and citizen scientists to monitor the arrival of Fukushima-derived radionuclides (^{134}Cs, $t_{½}$≈ 2 yrs and ^{137}Cs, $t_{½}$≈ 30 yrs) in open ocean and Canadian coastal waters. From the Fall of 2014 through the end of 2019, the five-year monitoring effort has captured the peak of the radionuclide signal arriving in the northeast Pacific. Our transparent public communication of results informs public health, industry, and oceanographic research.





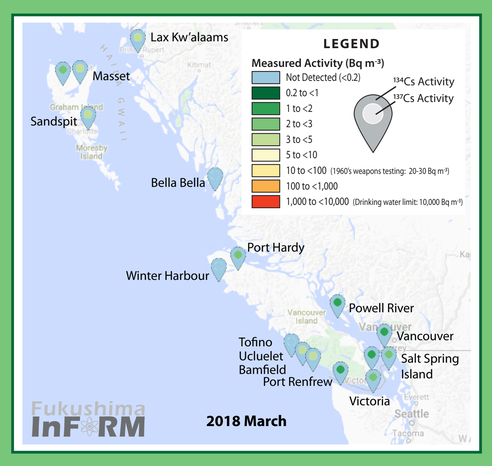
[Left] Timeseries of ^{137}Cs depth sections along Line P from Jun 2013 - Jun 2018.

[Above top] Locations of Line P stations (white) and streamlines denoting the Alaska Current (gray).

[Above bottom] Comparison of observations at P26, P16, and P4 with model predictions from Rossi et al. (2013) (updated after Smith et al. 2015). Observations are temporally in line with model estimates, however, concentrations of ^{137}Cs are double model predictions. Tracer observations will aid in refining model estimates of mixing.

Open Ocean Monitoring

- Repeat hydrography across the NE Pacific aboard Line P cruises (Feb and Aug) and other cruises of opportunity (CLIVAR, CCGS Laurier)
- Plume front detected at P26 in Jun 2013
- Backside of plume detected in Feb 2016, max Jun 2018 concentrations measured at P4, ~80 km offshore
- Northward flow in Alaska Current is 5 km d^{-1} (tortoise speed), but onshore flow through weak, disorganized flow regime is sharply reduced in 2014 - 2018 (~0.8 km d^{-1}, snail speed)
- Warm *Blob* reduced mixing, leaving the plume concentrated in surface waters, and slowed spread of plume's onshore transport
- Observations up to 7.2 Bq m^{-3} of ^{137}Cs
  - ~2x model predictions due to unpredicted mixing conditions



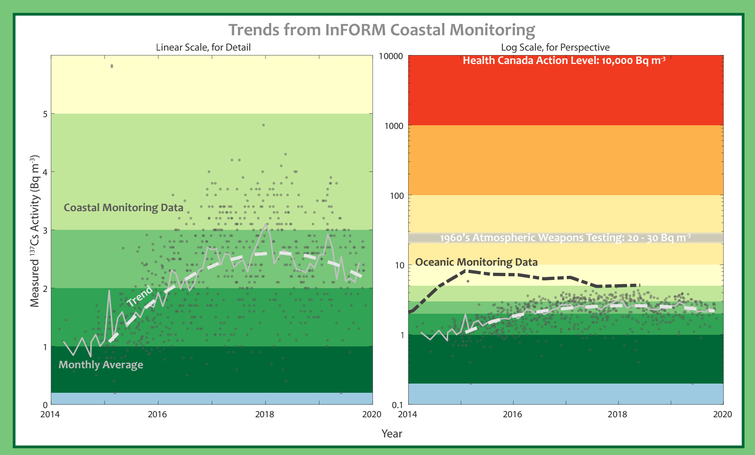
Coastal and Biotic Monitoring

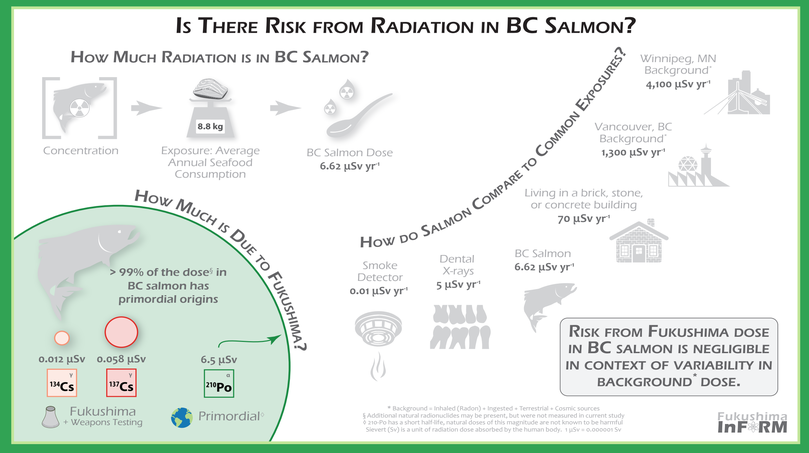
- Citizen scientists in 16 communities collected monthly water samples for five years
- Plume arrived in Feb 2015, peaked at ~3x background levels in Jan 2018
- Indigenous communities and researchers donated fish annually from 2014 - 2018
- ~550 salmon sampled + multiple species of shellfish
  - Just 2 salmon had trace levels (<0.07 Bq kg^{-1}) of ^{134}Cs
- Concentrations of ^{137}Cs were statistically stable over period

[Left] March 2018 results from citizen scientists near peak. (Note: Prince Rupert and Hartley Bay not sampled in March 2018.)

[Right/Left] Trend of ^{137}Cs in water samples collected along the entire BC coast.

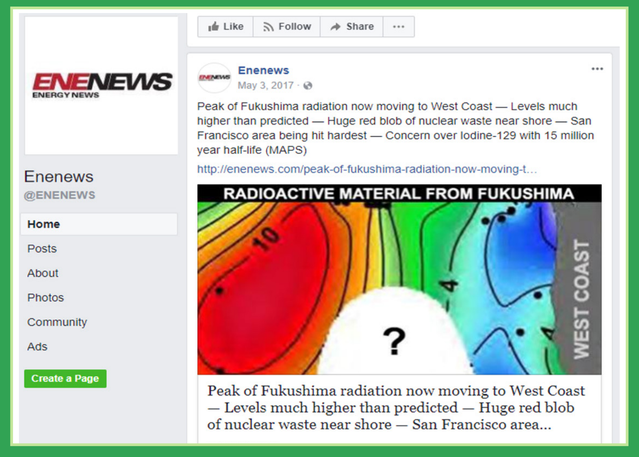
[Right/Right] Same as *Right/Left*, but plotted on log scale to show relationship between InFORM's coastal and offshore monitoring data and relevant benchmarks.

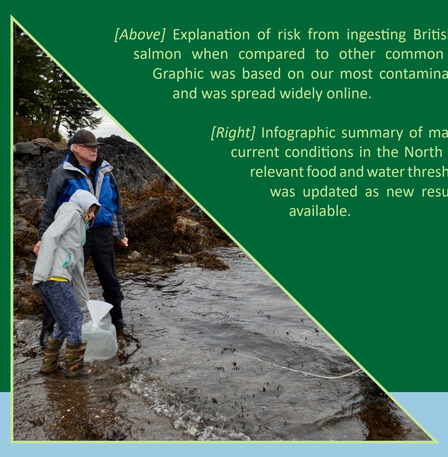




Risk Communication

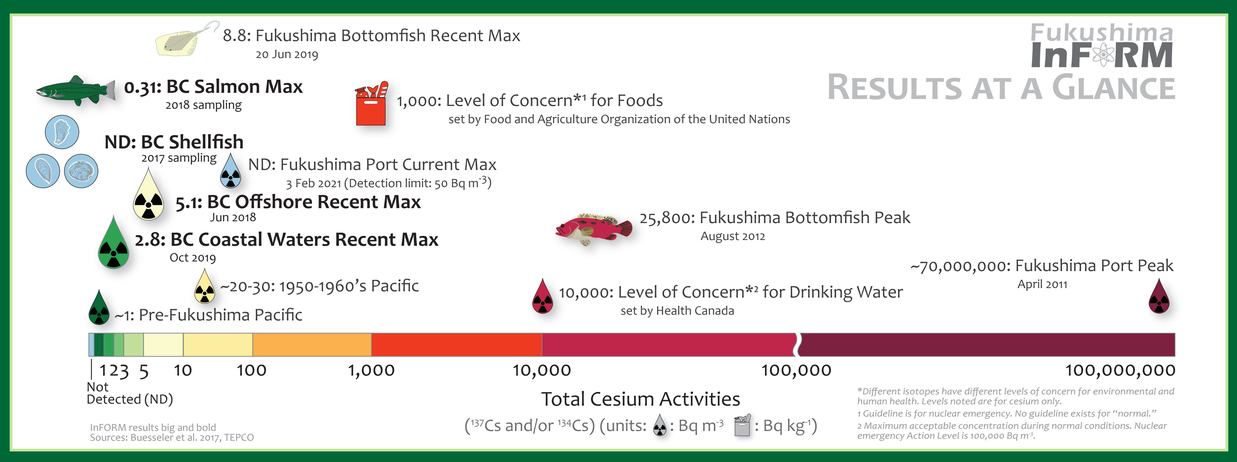
- Results disseminated through social media, e-newsletter, and website
- Held accountable by both pro-nuclear and anti-nuclear critics
- Unambiguous color in products (green = low risk, red = elevated risk)
- Placed observations into context of relevant radiological thresholds and other common exposures
- Targeted communication to Indigenous and fisheries stakeholders
- Dedicated time to address misconceptions about ocean health





[Above] Explanation of risk from ingesting British Columbia salmon when compared to other common exposures. Graphic was based on our most contaminated sample and was spread widely online.

[Right] Infographic summary of maximum and current conditions in the North Pacific with relevant food and water thresholds. Figure was updated as new results became available.



[Above] Example of data misinterpretation that was not uncommon on social media and highlights the pitfalls of rainbow colors in graphics. Such posts used alarmist language and exaggerated statements to stoke theories that the Pacific ecosystem was severely affected by Fukushima radiation. One particularly vocal activist threatened researchers personal safety and legal action was necessary.

Addressing conspiracies online took significant time. We had better success in establishing trust and explaining scientific observations on Facebook compared to Twitter, likely thanks to unlimited characters for discussion. Many of those we corresponded with were ultimately thankful to have a thoughtful conversation with a scientist.

Acknowledgments: Special thanks to our citizen scientists and First Nations partners who make this work possible — Funding and support provided by **MEOPAR** — Jenkins, C.E. (1969) Radionuclide distribution in Pacific Salmon, *Health Phys. 17:507-512.* — Rossi, V., et al. (2013) Multi-decadal projections of surface and interior pathways of the Fukushima Cesium-137 radioactive plume, *Deep-Sea Res. I.* 80: 37-46, doi: 10.1016/j.dsr.2013.05.015. — Smith, J.N., et al. (2015) Arrival of the Fukushima radioactivity plume in North American continental waters, *Proc. Nat. Acad. Sci.* 112(5): 1310-1315, doi: 10.1073/pnas.1412814112 — ***Contact: jonathan.kellogg@hakai.org***