

2011 Fukushima fallout: Aerial deposition on the sea ice scenario and wildlife health implications to ice-associated seals

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Introduction

- During 2011 Northern Alaska Pinnipeds (ice associated seals) experienced a significant mortality event.
- Fall 2011 National Oceanographic and Atmospheric Administration and US FWS declared an Unusual Mortality Event (UME).
- The UME investigation is exploring a mix of etiologies (infectious, endocrine, toxins, nutritional, radioactivity, etc.).
- As the outbreak occurred after the March 2011 Fukushima Dai-ichi nuclear power plant accident radioactivity was included.
- ¹³⁷ and ¹³⁴ Cesium (Cs) together were used as tracers of the Fukushima fallout.

Materials and methods

Gamma Spectrometry – Tissues

- Cesium is distributed principally in muscle tissues (Kozlikov and Meili 2003).
- A 175 grams of freeze dried tissue analyzed for ¹³⁷ and ¹³⁴Cs.
- Gamma analysis was done on an ORTEC GEM-15200 coaxial detector.
- NIST traceable calibrations standards and IAEA certified reference materials were used.

Atmospheric Deposition Information

- Various peer reviewed publications (Christoudias et al., 2013; Patero et al., 2012; Ten Hove, et al., 2012) .



Figure 1 - Diseased Ringed Seal



Figure 2 - Ringed Seal in Sea Ice Habitat



Figure 3 - Exposure Route on Sea Ice Habitat

Exposure on Sea Ice Habitat

- Inhalation of particulate and gaseous radionuclides.
- Contamination of fur and skin.
- External exposure on ice, in water and from sediments.
- Ingestion of food.

| Results of Analysis of UME 2011 Tissues for ^{134,137} Cs | | Bq/kg dry weight | |
|---|------------------------------------|-------------------|------------------------|
| Sample Description | Location | ¹³⁴ Cs | ¹³⁷ Cs ± 2σ |
| Ringed Seal (Control) | North Slope, AK | <MDA | 1.07 ± 0.44 |
| Bearded Seal (Diseased) | Little Diomedea, AK | <MDA | 0.99±0.34 |
| Ringed Seal (Diseased) | Pt Lay, AK | <MDA | 0.85±0.25 |
| Ring Seal (Diseased) | Hooper Bay, AK | <MDA | 0.55±0.26 |
| Ring Seal (Diseased) | Shishmaref, AK | <MDA | 1.34±0.36 |
| Historical Observations 1996 - 1997 (Copper, et al., 2000) | | Mean ± | |
| Bearded Seal (Healthy) | North Slope, AK & Resolute, Canada | NA | 0.80±0.47 |
| Ringed Seal (Healthy) | North Slope, AK & Resolute, Canada | NA | 0.60±0.26 |
| Spotted Seal (Healthy) | North Slope, AK | NA | 1.23±0.13 |

Table 1

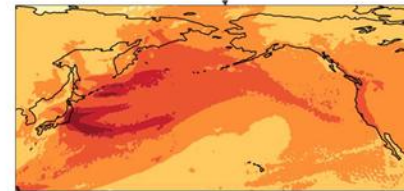
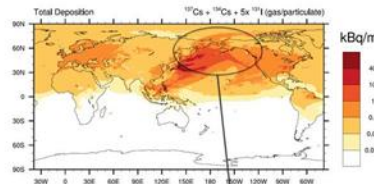


Figure 4 - Estimated ¹³⁷+¹³⁷Cs+¹³¹I Atmospheric Deposition in the Alaska Region (Christoudias et al. 2013)

Bq - SI derived unit for radioactivity equal to 1 disintegration per second. Gray (Gy) - SI derived unit for absorbed dose.

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Discussion & Conclusions

2011 Food Web Accumulation Exposure

- Tissue ¹³⁷Cs concentrations (Table 1) were low to cause UME symptoms (Yochim, Gulland et al. 2008; Garnier-Laplace, Beaugelin-Seiller et al. 2011).
- Observed concentrations comparable to pre-Fukushima studies.

- ¹³⁴Cs concentrations to low to detect.

Exposure to Fallout while on Ice in 2011

- 80% of the atmospheric ¹³⁷+¹³⁴Cs released by the Fukushima nuclear accident was deposited in the ocean.
- From March 12-16th 62% of calculated air mass trajectories followed a northern route through the Bering and Chukchi Seas (Christoudias et al. 2013; Hernandez-Ceballos, et al. 2012).
- Models suggest Pinnipeds may have been exposed while on ice to the following:
 - Near surface air ¹³⁷I range of 1000 to 100,000 μBq m⁻³ with a ¹³⁷Cs range of 100 to 10,000 μBq m⁻³ (Ten Hove et al. 2012).
 - Wet + dry deposition on the order of 1000 to 10,000 Bq m⁻² for ¹³⁴Cs+¹³⁷Cs+¹³¹I combined (Figure 5) (Christoudias et al. 2013).
 - Hot particles, nuclear fuel fragments, were detected in air samples taken in Svalbard, Norway (Patero et al. 2012).

Conclusions

- Tissue ¹³⁷+¹³⁴Cs concentrations and models suggest the 2011 fallout event does not represent acute or chronic radiological risks to Northern Pinniped populations.
- Based on modeled radionuclide concentrations the dose to Northern Pinnipeds on ice was less than the ERICA (Howard et al. 2008) risk assessment no-effects level of 10 μGy/hr with the following caveats -
 - Source terms for the Fukushima nuclear accident release vary greatly creating uncertainty in the models.
 - Knowledge gaps exist on extrapolating radiation dose to marine mammals (Garnier-Laplace et al. 2008).
 - Exposure to hot particles was not addressed.
 - Cannot rule out that increased radiological exposure in combination with a mixture of other contaminants represented an immunotoxic and thyroid gland disease risk during the period the animals were living on the ice (Moller et al. 2013; Ross et al. 1996; Cardis et al. 2005).
 - Ionizing radiation associated risk for skin defects (i.e. epilation, skin lesions) due to contact and external exposure can also not be excluded (Conrad et al. 1964; Barbaro 2006).
- Marine transported Fukushima radionuclides entering the Bering and Chukchi Seas in the future may represent a new stressor to the ecosystem (ICES 2013).

Further information

NOAA UME Web Site for Northern Alaska Pinniped Event
<http://www.alaskafisheries.noaa.gov/protectedresources/seals/ice/diseased/>

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