Environmental Sampling at Amchitka and Adak Islands, Alaska - 15317

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ABSTRACT

Amchitka Island is near the western end of the Aleutian Islands, approximately 2157 km (1340 miles) west-southwest of Anchorage, Alaska. The US government conducted three underground nuclear tests on Amchitka between 1965 and 1971 and has conducted biological monitoring on the island since before 1965; the most recent monitoring occurred in the summer of 2011. A working group of stakeholders collected samples of marine biota, sediment, and sea water for analysis of test-related radionuclides to determine if subsistence- and commercial-catch seafood in the ocean near Amchitka and Adak Island (a reference area) is safe to eat. Dietary intake information for the risk estimates used a range of diets based on published surveys of four Aleut villages and a composite diet. The risk estimates indicated that seafood harvested at Amchitka and Adak is considered safe for consumption at the intake levels for each of five diets evaluated. Although increased cesium concentrations (Cs-134) possibly related to the Fukushima Dai-ichi event were detected in certain samples; the increased levels have not resulted in unacceptable risk from the ingestion of these seafoods.

INTRODUCTION

Amchitka Island is near the western end of the Aleutian Islands, approximately 2157 km (1340 miles) west-southwest of Anchorage, Alaska. Amchitka is part of the Aleutian Island Unit of the Alaska Maritime National Wildlife Refuge, which is administered by the US Fish and Wildlife Service. Since World War II, multiple US government agencies have used the island for various military and research activities. From 1943 to 1950, the US Military occupied the island as a forward air base. During the middle 1960s and early 1970s, the US Department of Defense (US DOD) and the US Atomic Energy Commission (AEC) used a portion of Amchitka as a site for underground nuclear tests. During the late 1980s and early 1990s, the US Navy constructed and operated a radar station on the island.

Three underground nuclear tests were conducted on Amchitka Island. US DOD, in conjunction with AEC, conducted the first nuclear test (named Long Shot) in 1965 to acquire data to improve US capability of detecting underground nuclear explosions. The second nuclear test (Milrow) was a weapons-related test that AEC conducted in 1969 to study the feasibility of detonating a much larger device. Cannikin, the third nuclear test on Amchitka, was also weapons-related and occurred on November 6, 1971. With the exception of small concentrations of tritium detected in surface water shortly after the Long Shot test, radioactive fission products from the tests remain in the subsurface at each test location [1]. Fig. 1 shows the test site locations.

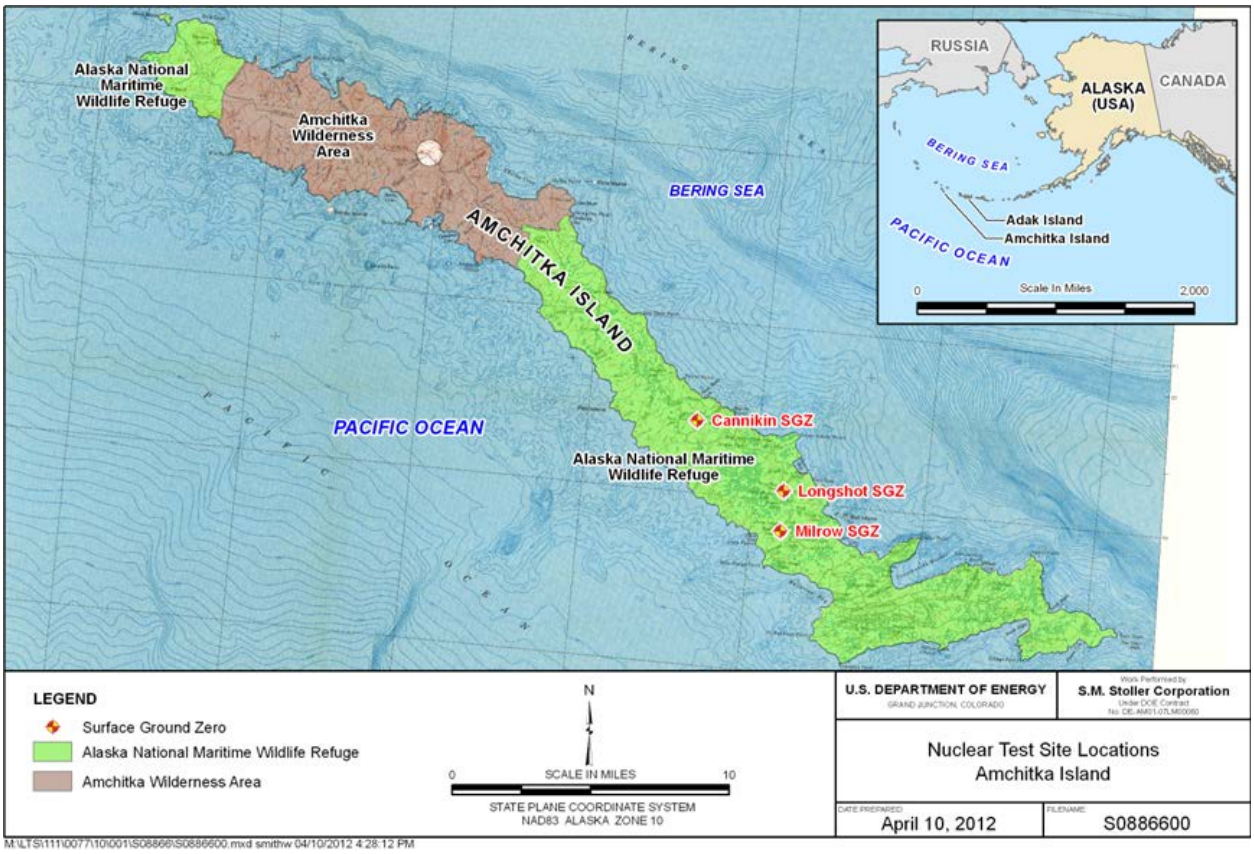

Fig. 1. Amchitka Test Site Locations

As a continuation of the environmental monitoring that has taken place on Amchitka Island since before 1965, US DOE in the summer of 2011 collected biological and seawater samples from the marine and terrestrial environment of Amchitka adjacent to the three detonation sites and at Adak Island, a background (reference) site 290 km (180 miles) east of Amchitka. The data quality objectives developed for the 2011 sampling included collecting selected marine flora and fauna, lichen, soil, and marine sediment and analyzing the samples for test-related radionuclides to determine if subsistence- and commercial-catch seafood is safe to eat.

DESCRIPTION

Samples were analyzed for Am-241, Cs-137, Pu-239, Pu-240, H-3, U-234, U-235, and U-238. In planning for the 2011 sampling event, a group of stakeholders representing the federal government, the State of Alaska, and the Aleutian Pribilof Island Association, collectively called the Amchitka Working Group, selected 14 biological species for analysis. A similar sampling event was conducted at Adak, which is used as a reference area unaffected by the underground nuclear tests at Amchitka. The previous investigations used the island of Kiska, Alaska, as the reference area, but the Amchitka Working Group decided that Adak would be a technically suitable reference location for the 2011 sampling event. The species sampled were chosen on the basis of diet information representing some of the subsistence- and commercial-catch seafood in the western Aleutian Islands [2].

Biological sampling began June 20, 2011, and continued through July 21, 2011. Two oceangoing research vessels provided the logistical support for the biological and seawater sampling operations. Biological sampling operations varied from personnel collecting samples from the island and along the shoreline to scientific divers performing two dives a day to collect the majority of the biological samples. Overall, a total of 350 biological samples and 166 seawater samples were collected. Fig. 2 and Fig. 3 show sample locations off Amchitka and Adak Islands, respectively.

The following biological species were selected for sampling during 2011.

- Dragon kelp (*Eualaria fistulosa*)
- Rockweed (*Fucus distichus*)
- Reindeer lichen (*Cladina* reindeer lichen)
- Gumboot or Pacific chiton (*Cryptochiton stelleri*)
- Horse mussel (*Modiolus modiolus*)
- Sea urchin(*Strongylocentrotus polyacanthus*)
- Rockfish (*Sebastes melanops* and *S. cilatus*)
- Irish lord (*Hemilepidotus jordani* and *H. hemilepidotus*)
- Rock greenling (*Hexagrammos lagocephalus*)
- Pacific halibut (*Hippoglossus stenolepis*)
- Pacific cod (*Gadus macrocephalus*)
- North Pacific giant octopus (*Enteroctopus dofleini*)
- Dolly Varden (*Salvelinus malma*)
- Glaucous-winged gull (*Larus glaucescens*) eggs

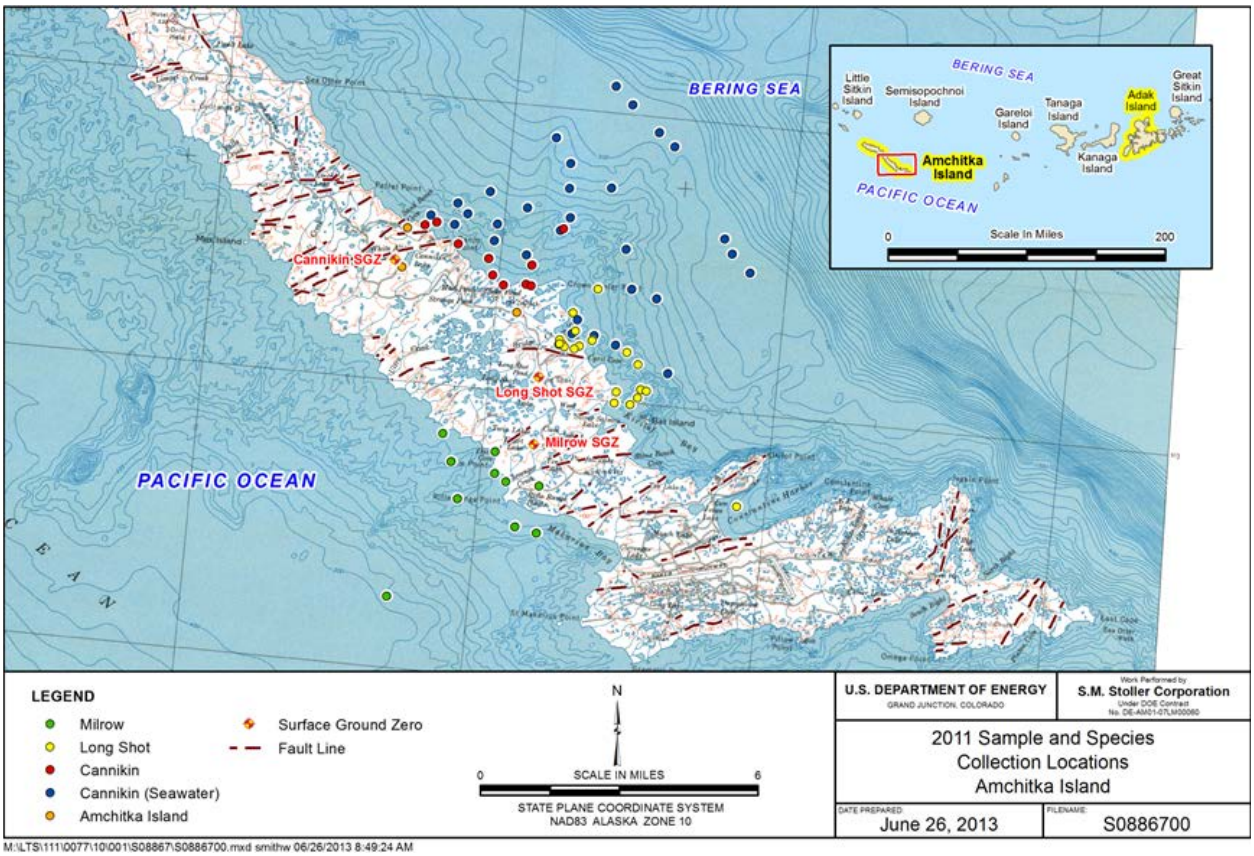

Fig. 2. Amchitka Island Sample Locations

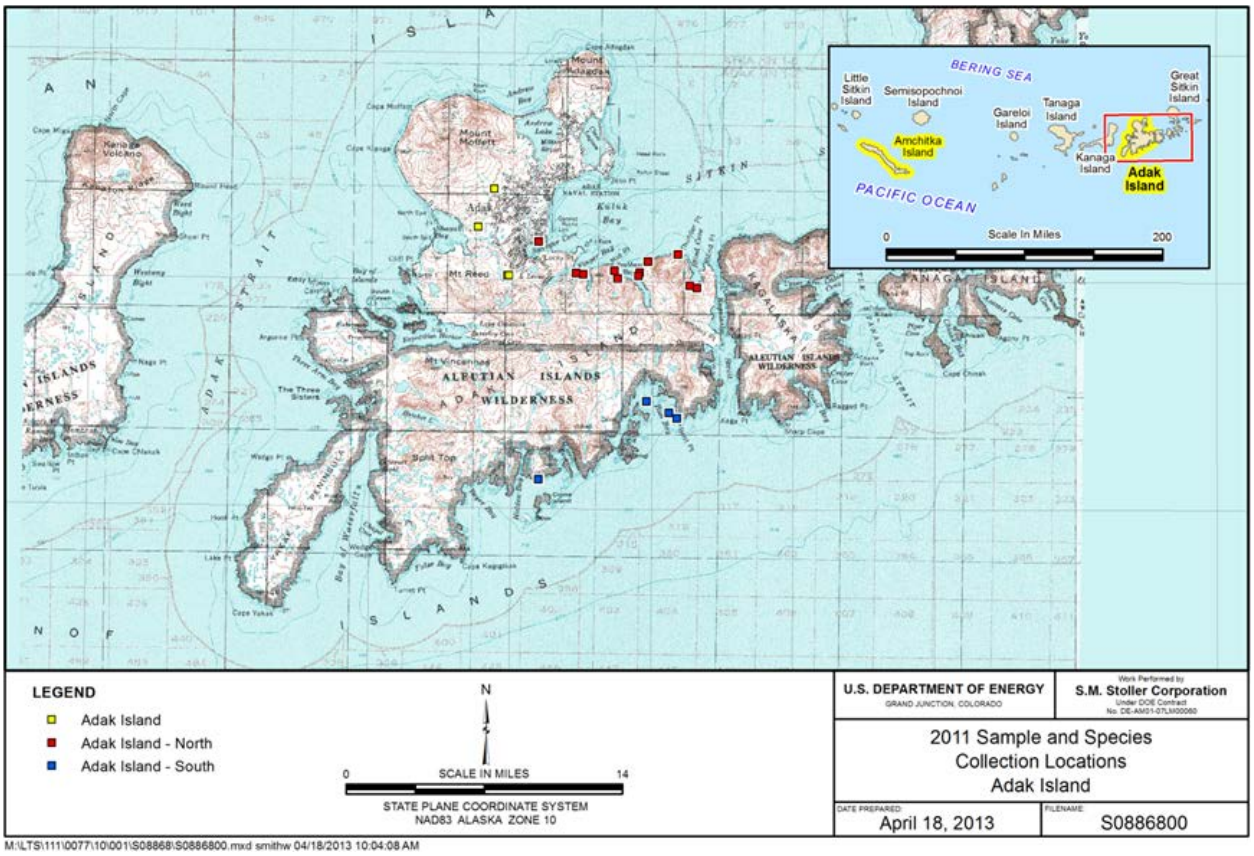

Fig. 3. Adak Island Sample Locations

DISCUSSION

Cs-137 Isotope

The data are reported as activity concentration wet weight for vegetation and fauna and as activity concentration dry weight for marine sediment and soil. All data are decay corrected to the date of sampling. Data are sorted according to species type and location. Gamma spectrometry measurements of Cs-137 and Cs-134 in marine sediment and soil are based on the <2 mm particle size fraction.

Fig. 4 and Fig. 5 show the Cs-137 content of marine vegetation and fauna collected across the Adak and Amchitka sites along with the minimum detectable concentration (MDC) for each species/media. Fig. 4 shows Cs-137 in selected marine vegetation and fauna and gull eggs. Fig. 5 shows Cs-137 in Dolly Varden, lichen, soil beneath the lichen, and marine sediment.

The Cs-137 content of horse mussel from both islands (Fig. 4) was highly variable and, excluding data developed for a single composite sample of gull eggs from Amchitka Island, contained the highest activity concentrations for the species/media shown in Fig. 4. The mean activity concentrations of Cs-137 in horse mussel tissue from the Adak and Amchitka sites were 0.26 and 0.34 Bq/kg (7.0 and 9.1 pCi/kg) wet weight, respectively. Cs-137 was detected at levels

up to several hundred times higher in Dolly Varden and several thousand times higher in reindeer lichen (Fig. 5).

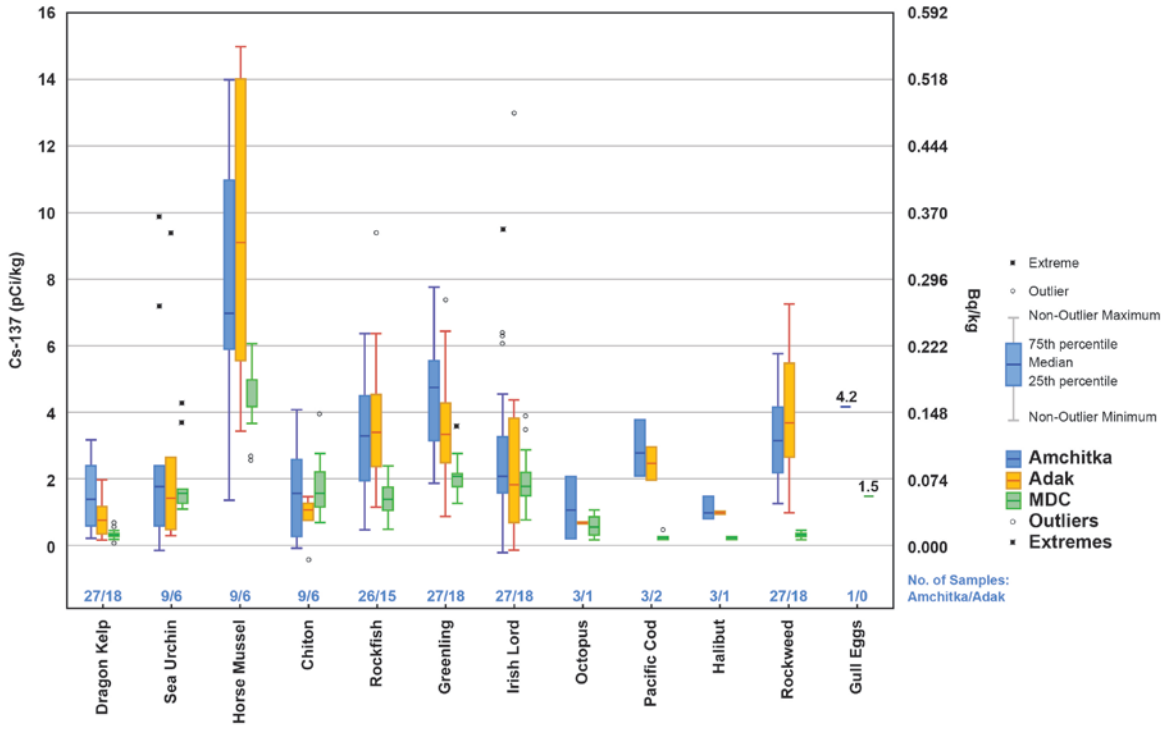

Fig. 4. Cs-137 in Selected Marine Vegetation, Fauna, and Gull Eggs

Results for Dolly Varden, lichen, soil, and sediment are plotted separately in Fig. 5 because of the much higher Cs-137 concentrations in those samples.

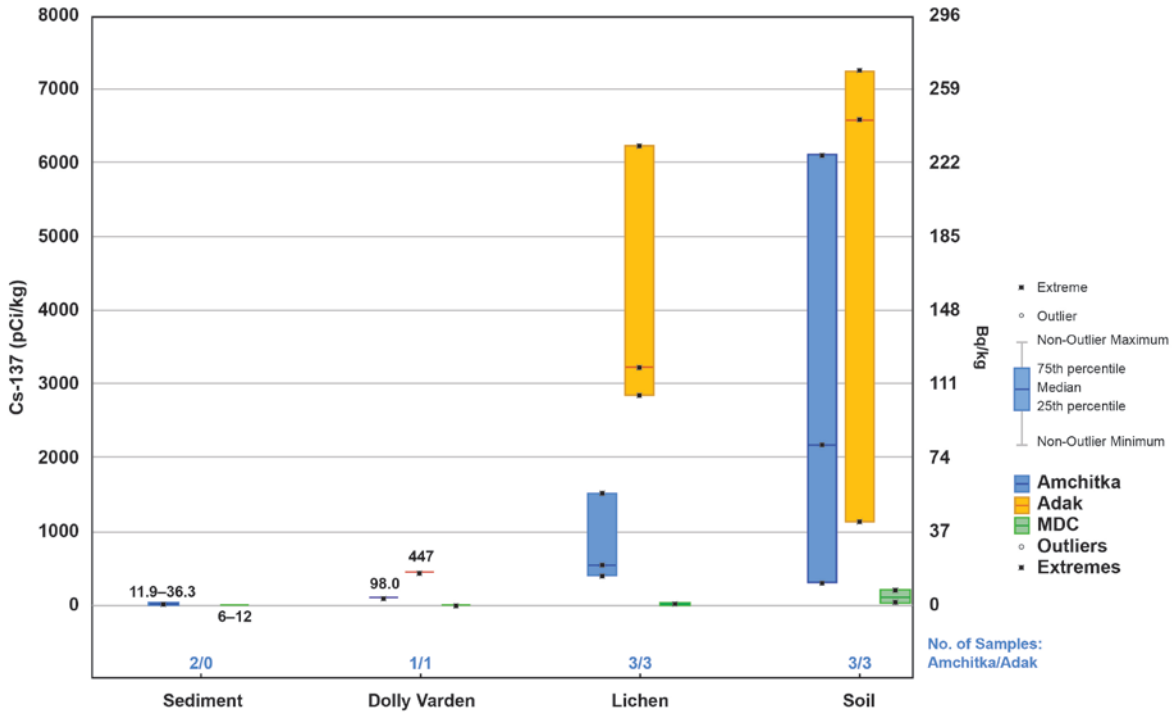

Fig. 5. Cs-137 in Dolly Varden, Lichen, Soil Beneath the Lichen, and Marine Sediment

Fig. 5 also plots raw data, given the small number of samples collected for each of these species/media.

Am-241 Isotope

Data are reported as activity concentration wet weight and are sorted according to species type and location. The results are reported as measured even if the reported value is less than the reported MDC. No weight corrections were made for the presence of sea salts in determining the Am-241 content of rockweed and dragon kelp. Fig. 6 is a box plot of Am-241 in selected marine vegetation, fauna, and gull eggs. Fig. 7 plots Am-241 in dragon kelp, rockfish, greenling, Irish lord, octopus, and rockweed.

Am-241 was measured by alpha spectrometry using ion-implanted-silicon charged-particle detectors. The estimated MDC for measurement of Am-241 by alpha spectrometry was 3.7×10^{-4} Bq (0.01 pCi). The mean reported sample measurement MDC for Am-241 expressed as activity concentration was 3.0×10^{-4} Bq/kg (0.008 pCi/kg) wet weight. Am-241 in the vast majority of samples was at or below the reported MDC. Data also appear to be more variable across individual species of fauna. While there are no significant outliers, this may indicate a lower quantity of these data compared to quantities obtained for other radionuclides.

The highest-quality data appear to have been obtained for sea urchin, octopus, and, to a lesser extent, dragon kelp. Few reliable laboratory intercomparison samples are available for performance testing of Am-241 at environmental concentrations. Quality assurance measures performed under this sampling event were limited to assessing the reproducibility of the alpha

spectrometric measurement by conducting a series of cross counts on different detectors. In this case, the results satisfied internal laboratory data quality requirements within the quantifiable capabilities of the technique.

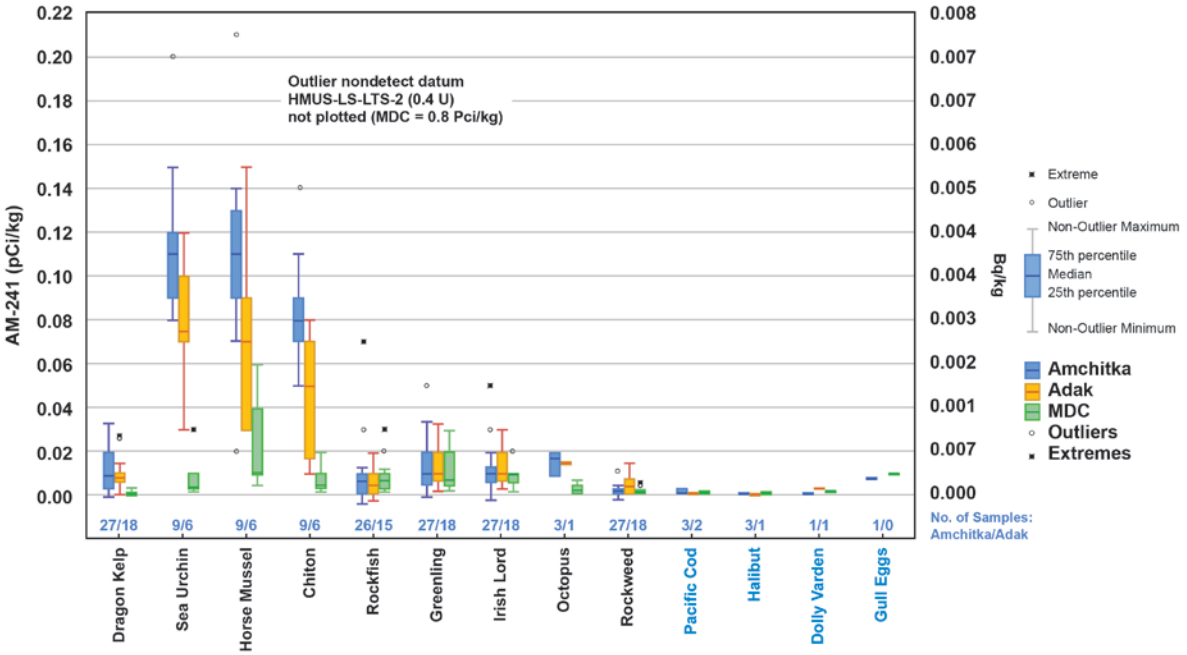

Fig. 6. Am-241 in Selected Marine Vegetation, Fauna, and Gull Eggs.

Species in the rightmost portion of the graph (in blue font) are those for which all results were less than the MDC. Fig. 7 provides a zoom-view of results for species with the lowest Am-241 concentrations.

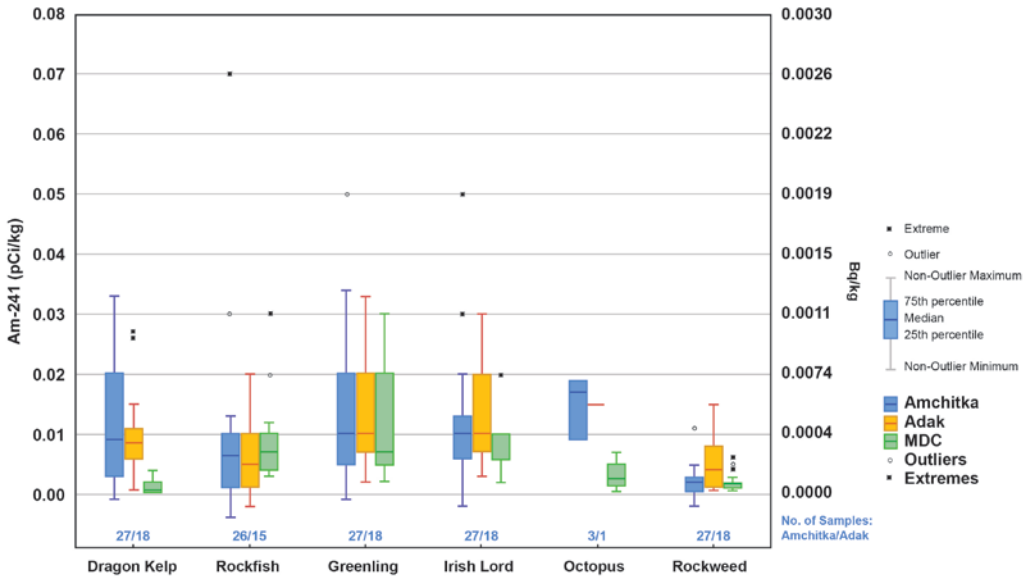

Fig. 7. Am-241 in Dragon Kelp, Rockfish, Greenling, Irish Lord, Octopus, and Rockweed.

Zoom-view of species with the lowest detectable Am-241 concentrations in Fig. 6. Detection frequencies were low (<20%) for rockfish, greenling, and Irish lord. Interisland comparisons are significant only for rockweed.

Plutonium Isotopes

The data are reported as activity concentration wet weight and are sorted according to species type and location. Data are reported as measured even if the reported value is less than the reported MDC. No weight corrections were made for the presence of sea salts in determining the plutonium content of rockweed and dragon kelp.

Fig. 8 and Fig. 9, respectively, are box plots of the Pu-239 and Pu-240 concentrations in selected marine vegetation and fauna, gull eggs, and lichen.

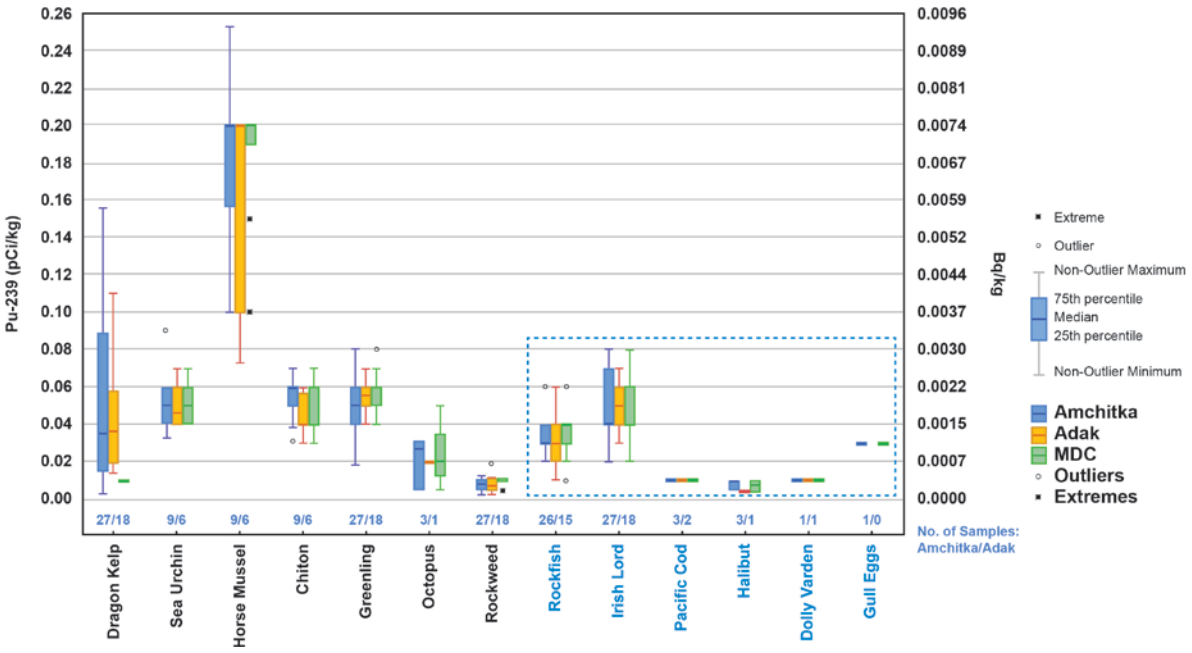

Fig. 8. Pu-239 in Selected Marine Vegetation, Fauna, and Gull Eggs

Species in the rightmost portion of graph (blue font, outlined) are those for which all results were less than the MDC.

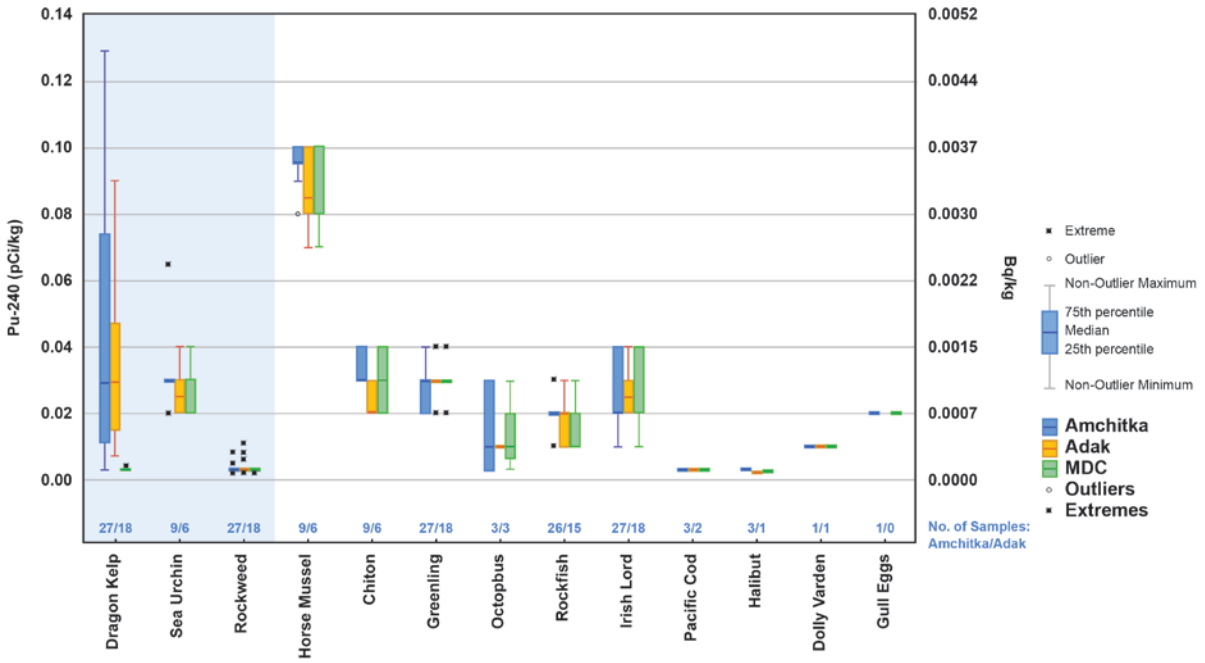

Fig. 9. Pu-240 in Selected Marine Vegetation, Fauna, and Gull Eggs

Only three species/media—dragon kelp, sea urchin, and rockweed (shaded)—had detectable levels of Pu-240. Results for remaining species were all below corresponding MDCs.

The vast majority of dragon kelp and rockweed samples contained quantifiable concentrations of Pu-239 or Pu-240, as did samples of chiton, octopus, sea urchin, and horse mussel. Levels of Pu-239 and Pu-240 in fish species are consistently at or below the reported MDC.

Based on the standard deviation of 10 reported replicate blank measurements, the estimated MDC for Pu-239 and Pu-240 is 0.0011 and 7.4×10^{-4} Bq (0.03 and 0.02 pCi), respectively. The mean reported sample measurement MDCs for Pu-239 and Pu-240 (excluding one outlier for a sample with a very low mass) expressed as activity concentrations were 0.0015 and 7.4×10^{-4} Bq/kg (0.04 and 0.02 pCi/kg) wet weight, respectively. Analyses of mass ratio and concentration performed on certified reference materials satisfied laboratory data quality requirements for both precision and accuracy. Similarly, a series of duplicate measurements met applicable data quality requirements within the quantifiable capabilities of the technique. High quality data appear to have been developed for plutonium isotopes in dragon kelp, as evidenced by the internal consistency of Pu-240/Pu-239 isotopic ratios measured in this species. Moreover, it appears reasonable that dragon kelp and possibly rockweed could serve as good indicator species for future trending analysis of plutonium contamination in this region.

Uranium Isotopes

Data are reported as activity concentration wet weight and are sorted according to species type and location. Quantifiable activity concentrations for U-234, U-235, and U-238 with reasonable

levels of precision are reported for all vegetation and fauna samples with the exception of U-234 in one horse mussel sample.

Fig. 10 through Fig. 15 are box plots of the U-234, U-235, and U-238 content of vegetation and fauna collected from the Adak and Amchitka sites. Because overall concentrations of these isotopes are very low, Fig. 13 through Fig. 15 are box plots for selected species and media with the lowest concentrations of U-234, U-235, and U-238, respectively.

No weight or analyte corrections were made for the presence of sea salts and inherent concentrations of uranium in ocean water for large-volume samples of rockweed and dragon kelp known to contain significant free and interstitial water.

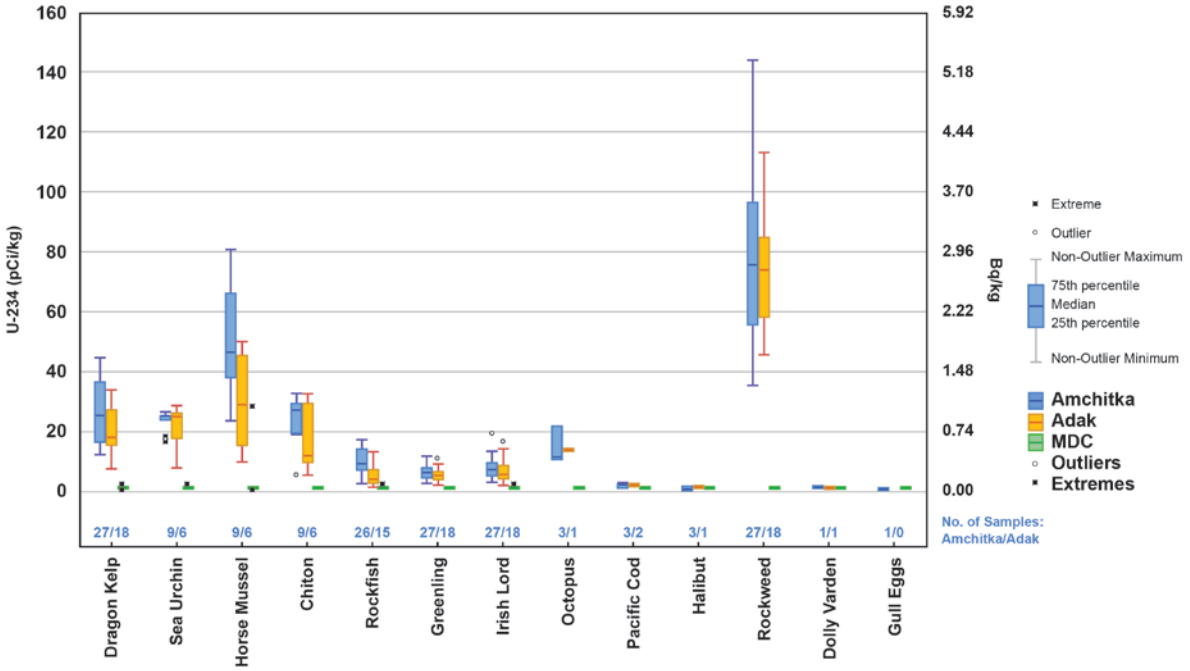

Fig. 10. U-234 in Selected Marine Vegetation, Fauna, and Gull Eggs

As found for the other U isotopes (Fig. 11 and Fig. 12), U-234 concentrations are highest in horse mussel and rockweed. Fig. 13 provides a zoom-view of results for species with lower U-234 concentrations (<0.92 Bq/kg [<25 pCi/kg]).

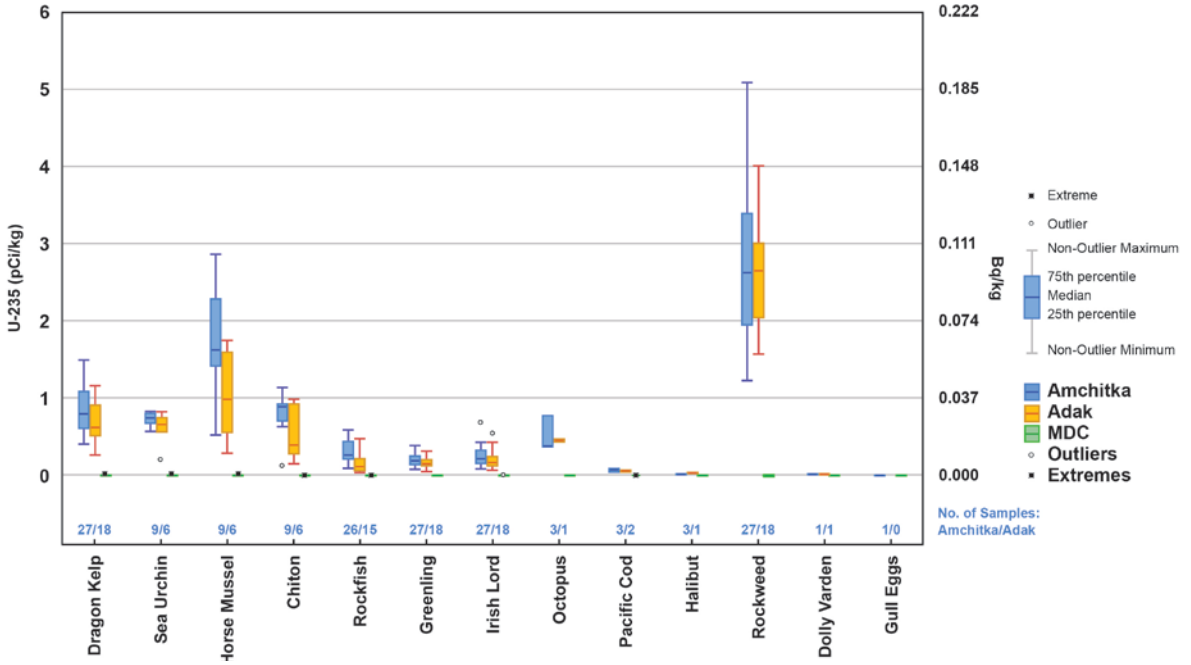

Fig. 11. U-235 in Selected Marine Vegetation, Fauna, and Gull Eggs

As is the case for U-234 and U-238, U-235 concentrations are highest in horse mussel and rockweed. Fig. 14 provides a zoom-view of results for species with lower U-235 concentrations (<0.037 Bq/kg [<1 pCi/kg]).

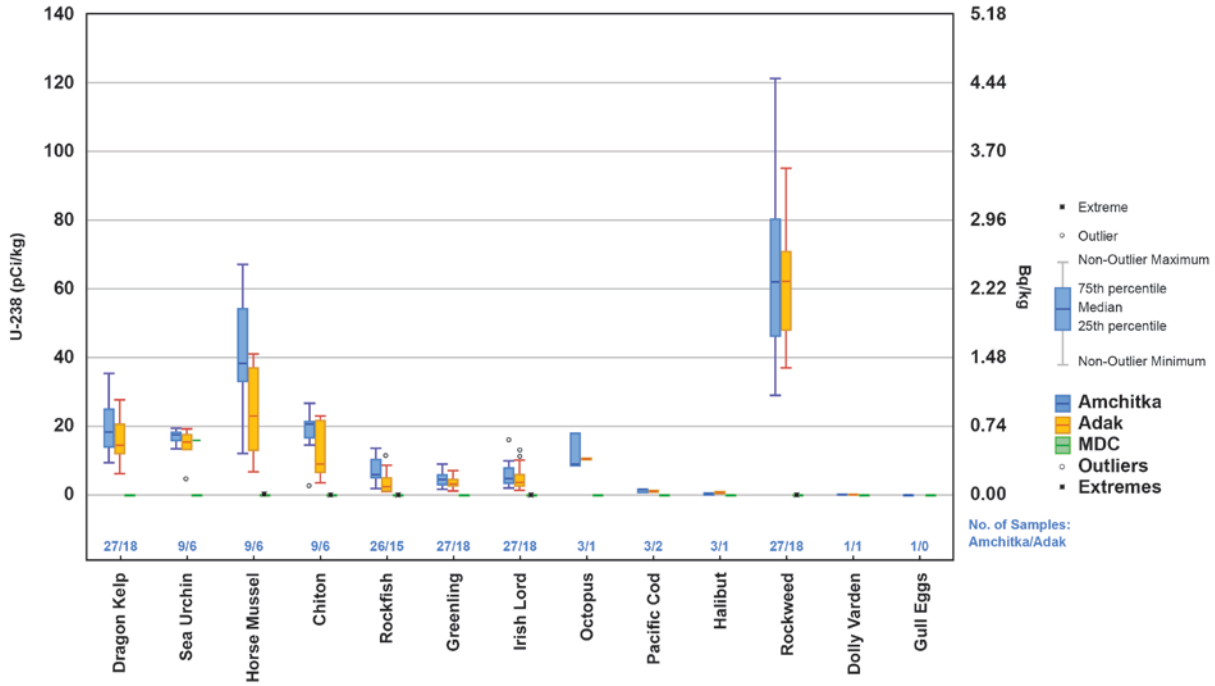

Fig. 12. U-238 in Selected Marine Vegetation, Fauna, and Gull Eggs

U-238 magnitude and distributions are very similar to those for U-234; concentrations are highest in horse mussel and rockweed. Fig. 15 provides a zoom-view of results for species with lower U-238 concentrations (<0.74 Bq/kg [<20 pCi/kg]).

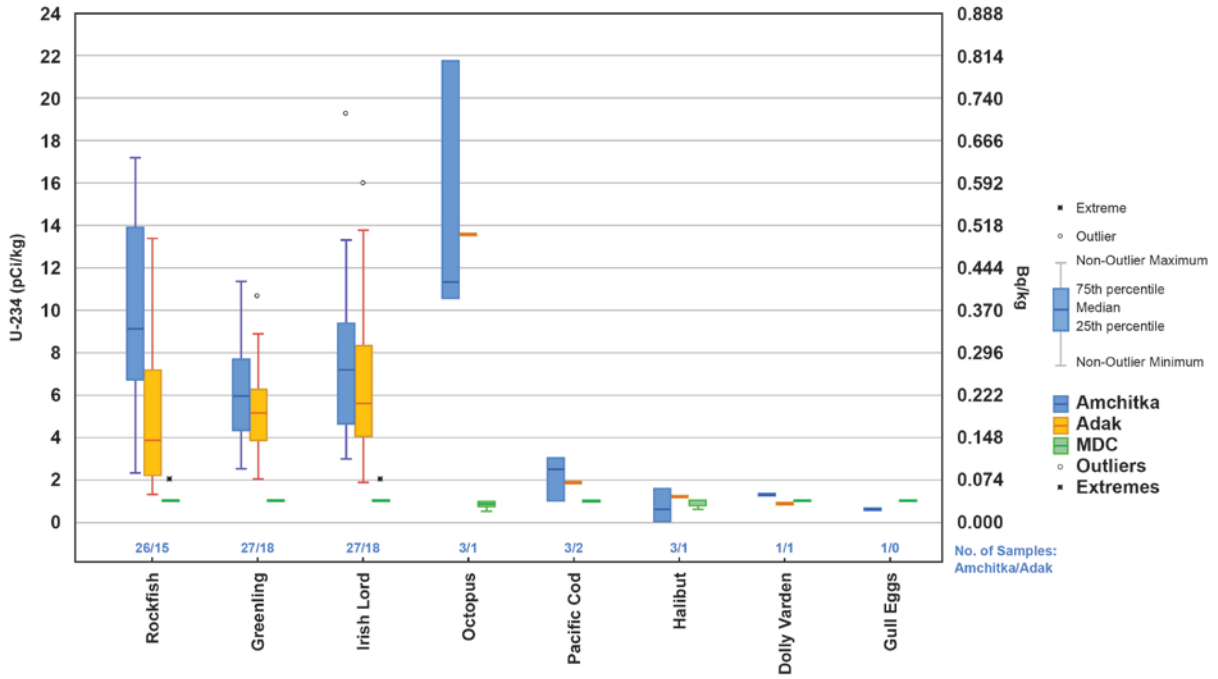

Fig. 13. Zoom View of U-234 in Species and Media with Concentrations <0.92 Bq/kg (<25 pCi/kg)

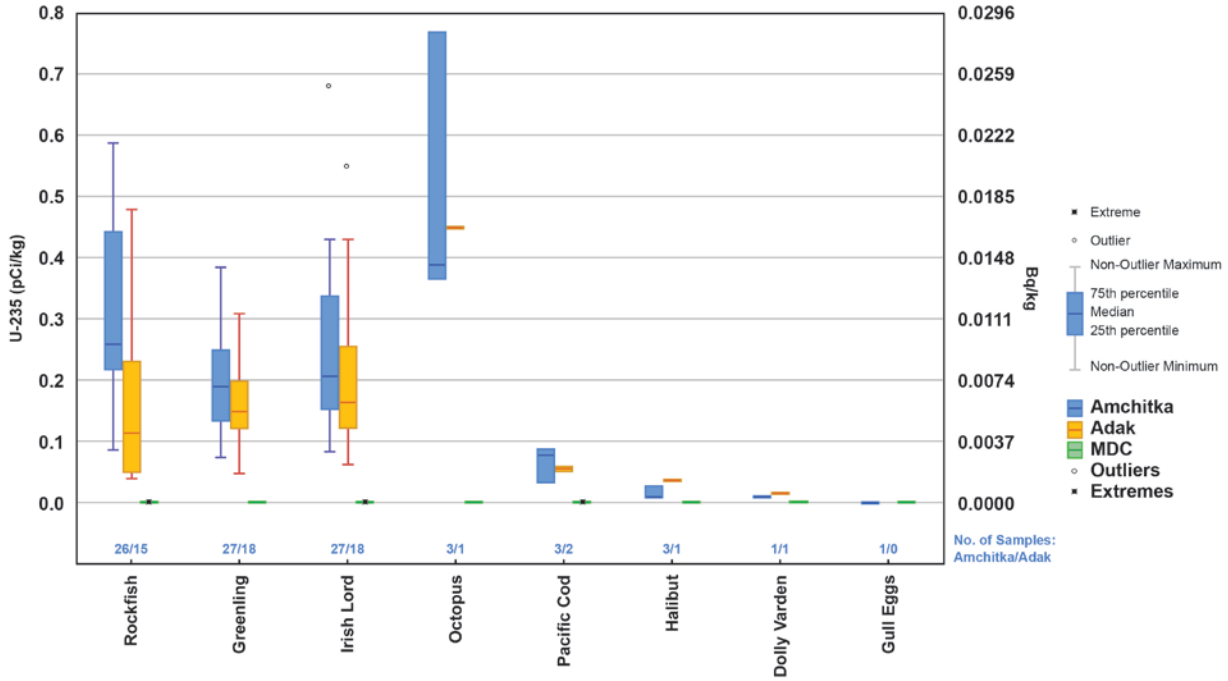

Fig. 14. Zoom View of U-235 in Species and Media with Concentrations <0.037 Bq/kg (<1 pCi/kg)

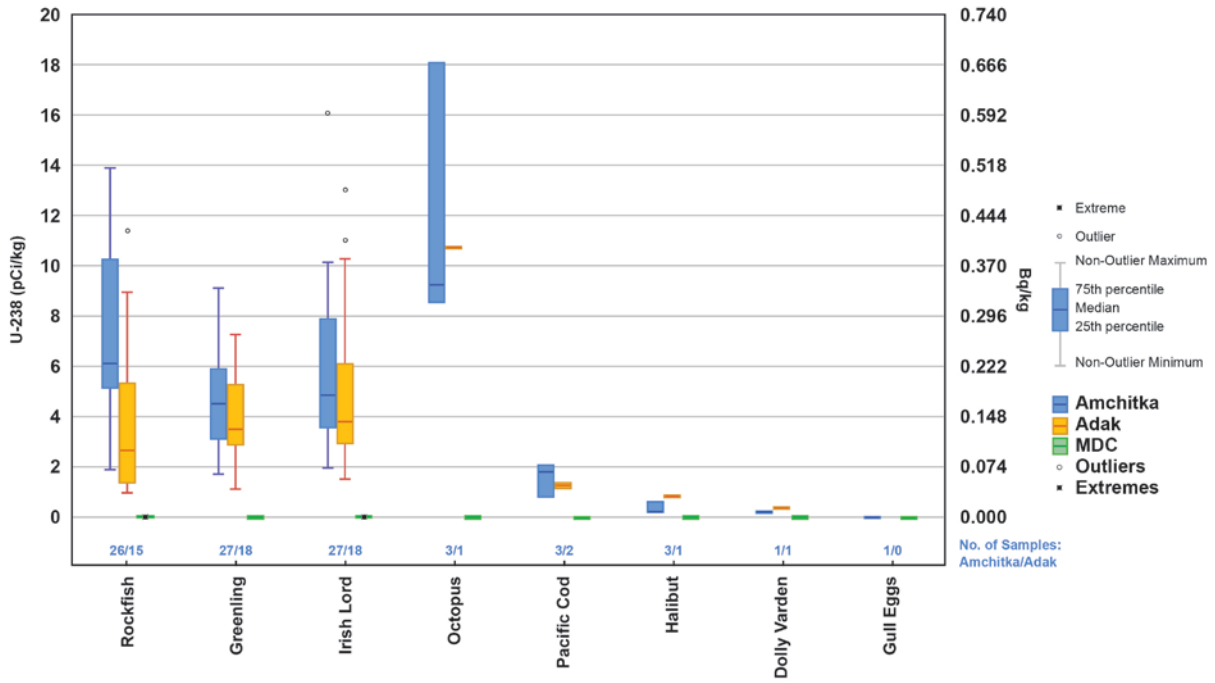

Fig. 15. Zoom View of U-238 in Species and Media with Concentrations <0.037 Bq/kg (<20 pCi/kg)

CONCLUSIONS

A statistical comparison of the data from Amchitka Island with the data from Adak Island (the reference location) indicates that the concentrations of radionuclides are comparable. Overall, there is a pattern toward slightly higher concentration at Amchitka. The measures that seem to show the most deviation have limited data above the detection limits.

To address the question of whether the seafood harvest is safe to eat, US DOE performed risk calculations using tissue data from the various seafood species collected in 2011 from Amchitka and Adak. A range of Aleut diets (based on published surveys of four villages) and a composite diet were used as dietary intake information for the risk estimates. The estimates for the five diets indicate that overall potential risks from the ingestion of seafood are similar and are at 2×10^{-5} or lower (i.e., within the US EPA's acceptable risk range of 1×10^{-6} to 1×10^{-4}). The primary contributors to risk are Cs-137 and the three uranium isotopes.

Risk estimates using Amchitka data are higher by 1×10^{-6} than those using Adak data. This difference is lower than the 1×10^{-5} risk level used by the State of Alaska as the benchmark for acceptable risk. Thus, based on the 2011 data collected for Amchitka and Adak, seafood harvested at Amchitka and Adak is considered safe for consumption at the intake levels for each of five diets evaluated. In addition, the increased cesium concentrations (Cs-134) detected in some samples, possibly related to the Fukushima Dai-ichi event, have not resulted in unacceptable risk levels from the ingestion of these seafoods.

REFERENCES

1. US DOE, *Long-Term Surveillance Plan for the Amchitka, Alaska, Site*, LMS/AMC/S01980, US Department of Energy Office of Legacy Management, Grand Junction, Colorado (2014).
2. US DOE, *Amchitka Island, Alaska Biological Monitoring Report 2011 Sampling Results,* LMS/AMC/S08833, US Department of Energy Office of Legacy Management, Grand Junction, Colorado (2013).