ADDENDUM TO

Final Report of the Consortium for Risk Evaluation with Stakeholder Participation
Amchitka Independent Science Assessment: Biological and Geophysical Aspects of Potential Radionuclide Exposure in the Amchitka Marine Environment

SELECTING RADIOLOGICAL DATA FOR BIOINDICATOR SELECTION

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An organization of The Institute for Responsible Management

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Abstract

In 2005 CRESP completed its report, *Amchitka Independent Science Assessment: Biological and Geophysical Aspects of Potential Radionuclide Exposure in the Amchitka Marine Environment*. The report noted that there were sedentary marine organisms present from the intertidal to 90 feet depths, with no indication that the kelp growth did not continue beyond this depth. There were also species with very low mobility that could serve as indicators of local exposure. The presence of these species is indicative of a fairly complex, sedentary base to diverse food chains, leading to higher trophic levels (predatory fish, birds, marine mammals, and humans). The report concluded that there are species present that would be at risk from radionuclide seepage. These species also form the basis for the subsistence lifestyle of the Aleut and Pribilof Islanders and for commercial fisheries. An elaborate sampling scheme of several species at four trophic levels, followed by analysis of several radionuclides, indicated that the foods examined are currently safe for human consumption with respect to radionuclides. The data were sufficient to form a basis for selection of bioindicators for long-term stewardship plan, but additional analyses of existing samples was recommended to aid in species selection.

In this addendum we report on the following additional analyses performed by CRESP after preparation of the Report (July 2005): 1) Additional actinide analyses of *Ulva* and kelp (including *Laminaria*), 2) Actinide analyses for additional Rock Jingles, Blue Mussels and Horse Mussels, and 3) Cesium-137, Co-60 and I-129 analyses of additional fish (Atka Mackerel, Rock Sole, Ocean Perch, Rock Greenling). These analyses were performed to aid in discrimination for bioindicator selection and provide additional clarification of differences in radionuclide content measured at Amchitka in comparison to Kiska. The overall conclusion of the *Amchitka Independent Science Assessment: Biological and Geophysical Aspects of Potential Radionuclide Exposure in the Amchitka Marine Environment* remains the same: 1) the foods tested are safe to eat, with radionuclide levels below published human health guidance levels, 2) our data do not suggest that radionuclides in biota collected from Amchitka are attributable to the Amchitka test shots, and 3) a combination of sedentary and mobile organisms at different trophic levels is ideal for a continued biomonitoring program at Amchitka.

INTRODUCTION

Amchitka is a DOE site in the Aleutian chain in the northern Pacific that was the scene of three underground nuclear tests in 1965, 1969 and 1971. The island is part of the Alaska Maritime National Wildlife Refuge system under the aegis of the US Fish & Wildlife Service (USFWS). DOE has remediated most surface contamination on the island, and it plans to "close" the site, and transfer it from its Environmental Management program to its Office of Legacy Management (OLM) in late 2006. OLM will retain responsibility for the shot cavities. As part of this transfer, DOE is seeking the approval of a Long-term Stewardship Plan to deal with the radionuclide wastes that will remain in place in the shot cavities.

For Amchitka, the issue is not one of surface cleanup but of dealing with the potential subsurface transport of radionuclides into the marine environment and into the food chain. The intense public concern and regulatory discussion that surrounded the subsurface environment was addressed by the signing of a Letter of Intent in June 2002 between DOE and ADEC. The Letter of Intent included stipulating closure in place for subsurface contaminants and a scientific assessment, by an independent scientific group. Plans for that assessment were to be developed by CRESP and implemented only after the plan was approved by four parties (the LOI signatories and USF&WS and A/PIA). The LOI also specified that the assessment was to serve as a basis for the long-term stewardship plan, the four parties would act as an independent review group to discuss the assessment and work on reaching agreement in place and long-term stewardship. The radiological assessment, as stipulated in the Letter of Intent, was to form the basis for both the baseline and developing a future biomonitoring plan.

In 2005 CRESP completed its report, *Amchitka Independent Science Assessment: Biological and Geophysical Aspects of Potential Radionuclide Exposure in the Amchitka Marine Environment*. The report noted that there were sedentary species present from the intertidal to 90 feet depths, with no indication that the kelp growth did not continue beyond this depth. There were also species with very low mobility (Sea Urchins, Rock Jingles, some fish) that could serve as indicators of local exposure. These species are indicative of a fairly complex, sedentary base to diverse food chains, leading to higher trophic levels. In short, there are species present that would be at risk from any radionuclide seepage if it occurred. These species also form the basis for the subsistence lifestyle of the Aleut and Pribilof Islanders, who might visit Amchitka and for commercial fisheries in the region. An elaborate sampling scheme of several species at four trophic levels, followed by analysis of several radionuclides, indicated that the foods examined are currently safe for consumption with regard to radionuclides. The data were sufficient to form a base for selection of bioindicators for long-term stewardship, but additional analyses of existing samples were recommended to aid in species selection.

The CRESP report also indicated that the actinides (particularly Pu239,240) were more likely to be found in kelp and invertebrates (lower trophic levels) than in fish and birds (higher levels), while the converse was true for Cs-137. Moreover, there was an indication of a higher proportion of values above the MDA for actinide levels in kelp and Rock Jingles from Amchitka than from Kiska, while there were more detectable cesium levels in fish from around Kiska than Amchitka.

In this addendum we report on the following additional analyses: 1) Cesium-137, Co-60 and I-129 analysis of additional fish (Atka Mackerel, Rock Sole, Ocean Perch, Rock Greenling), 2) Actinide analyses for additional Rock Jingles, Blue Mussels and Horse Mussels, and 3) Additional actinide analyses of *Ulva* and kelp (including *Laminaria*). These analyses were performed to aid in discrimination for bioindicator selection for a long-term stewardship plan and provide additional clarification of differences in radionuclide content measured at Amchitka in comparison to Kiska. There were no levels of Co-60 and I-129 above the MDA, and they are not discussed further.

We also note that CRESP researchers returned to the Aleutians to report on our findings in October 2005, as well as to make presentations to the public, to the U.S. Fish & Wildlife Service, and to A/PIA. In our discussions with Atka Fisheries officials, they noted that due to low catches of Halibut, their boats went to Amchitka Pass to fish for Halibut, and would continue to do so to try and meet their quotas. Further, they noted that they process only fillets, and that they remove the Halibut cheeks for local consumption on Atka, thus Halibut from Amchitka Pass are making their way into the subsistence culture as well. Continued biomonitoring of radionuclides in fish and other ecological receptors in the marine environment around Amchitka is thus relevant to Aleut people today.

METHODS FOR ADDENDUM

The samples for the analyses reported in this addendum were collected in 2004, and form part of the same baseline data set developed for the *Amchitka Independent Science Assessment*. Samples were prepared in the laboratory at Rutgers, using the same protocols (see Powers et al. 2005 available at www.cresp.org). All procedures followed our established protocols, with appropriate QA/QC in all laboratories, including data reporting.

Selection of samples for analyses was a function of obtaining sufficient radionuclide data for bioindicator selection. Thus our rationale for sample selection was to:

1. Increase sample sizes for actinide analysis of *Alaria fistulosa* and *Alaria nana* to allow selection among these two species of bioaccumulating kelp.
2. Analyze *Laminaria* as another possible bioindicator of primary productivity in the benthic environment.
3. Increase the sample sizes for actinide analysis of Rock Jingles from the three test shot areas and Kiska to ascertain whether Rock Jingles were a better accumulator than algae or kelp.

4. Analyze actinides in Blue Mussels (intertidal) and Horse Mussels (Benthic) to determine whether either of these species was a better accumulator than other species.

5. Increase sample sizes and add new species for Cesium-127 analysis in fish.

Below we present the reported concentrations of Cs-137 (Bq/kg, wet weight, 1000g) fish samples and for Pu-239,240 in algae (Figs 1 and 2).

Figure 1. Comparison of Cs-137 between Amchitka and Kiska for Fish. The figure plots the reported relationship for the 1000 g samples collected at (a) Amchitka and (b) Kiska. The reported values are open circles with error bars, the error bars represent reported value plus one standard deviation uncertainty on the top, and reported value minus one standard deviation at the bottom. The corresponding minimal detectable activities are shown as stars, and are also in Bq/kg.

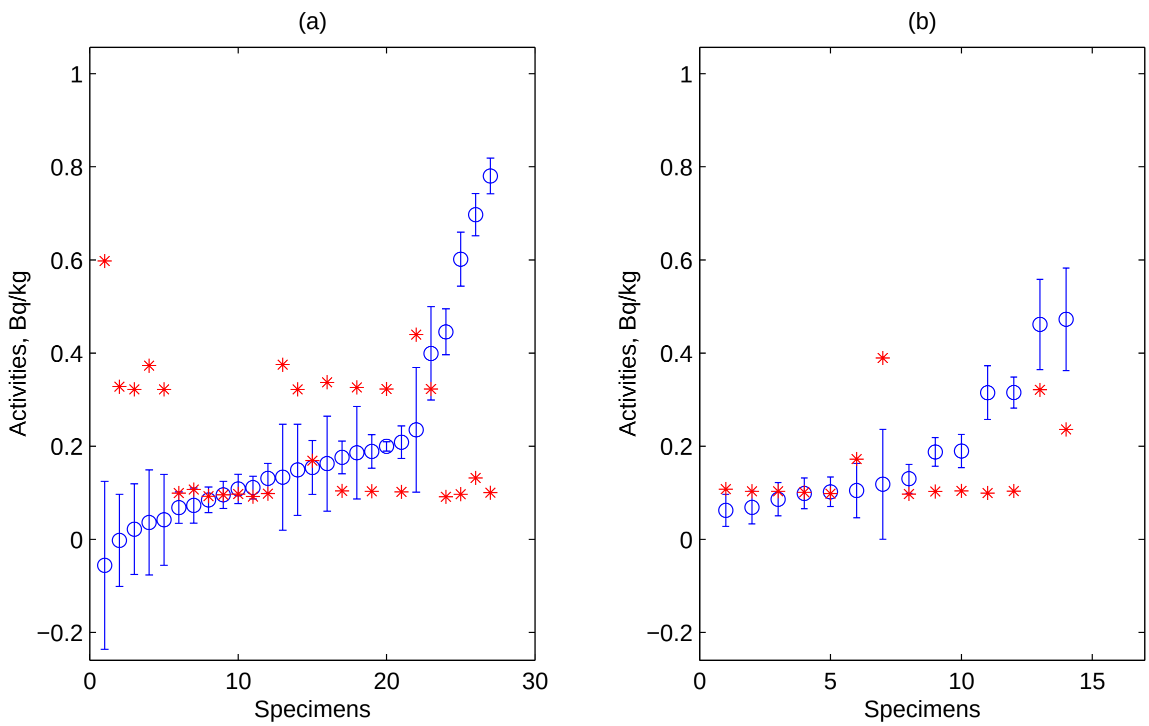
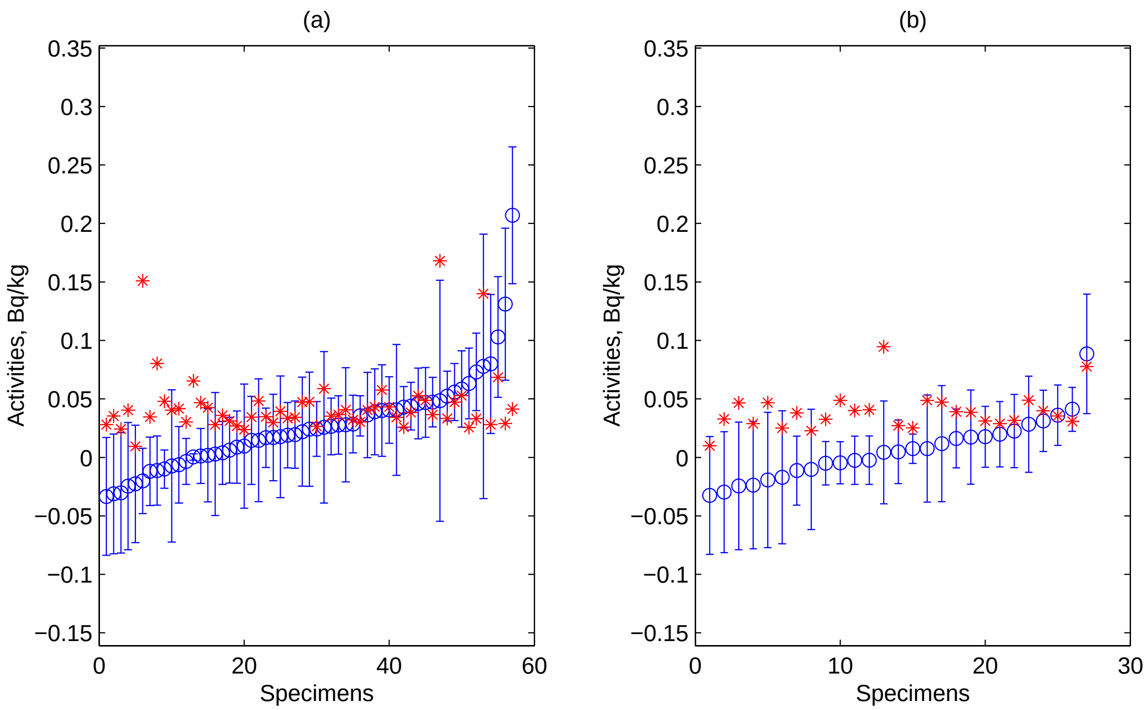


Figure 2. Comparison of Pu-239,240 for algae between Amchitka and Kiska. The figure plots the reported relationship for algae collected at (a) Amchitka and (b) Kiska. The reported values are open circles with error bars, the error bars represent reported value plus one standard deviation uncertainty on the top, and reported value minus one standard deviation at the bottom. The corresponding method detection activities are shown as stars, and are also in Bq/kg.



RESULTS

The objective of the work reported in this addendum was to provide additional data to select indicator species for biomonitoring.

Species Differences:

The first objective was to add additional analyses to allow discrimination among species. Additional analyses for algae added one genus (*Laminaria*), and additional composites for the other species. The full data set for *Ulva* and kelp is presented below (Table 1). The data suggest that, of the algae species examined, *Alaria fistulosa* and *Fucus* are the best accumulators of the radioisotopes examined. *Alaria fistulosa* had the highest levels (or the most hits) of Pu-239,240, and U-236, the anthropogenic radionuclides of interest. The naturally-occurring uranium isotopes were found in all species, although they also were highest in *fucus* and *alaria fistulosa*.

Table 1. Examination of Kelp/algae for use as bioindicators for actinides. Given is the mean (± standard deviation, wet weight) in Bq/kg with the values plus half the MDA. Where there were few values above the MDA for an isotope, those are listed in parenthesis (no statistical test was performed). A = primarily anthropogenic, N = primarily natural. (This is an update of Table 11.9 in Powers et al. 2005. (Both this Table 1 and Table 11.7 in Powers et. al 2005 are juxtaposed in the Appendix to this Addendum)

Isotope	*Ulva* N=12	*Fucus* N=14	*Alaria nana* N=21	*Alaria fistulosa* N=19	*Laminaria* N=18	Chi square (p value)
Am-241 A	(0.059)	(0.040, 0.022)	(0.039, 0.023)			3.22 $p < 0.52$
Pu-238 A	(0.024, 0.123)			(0.015)		
Pu-239,240 A		0.031 ± 0.017	0.031 ± 0.018	0.051 ± 0.05	0.020 ± 0.023	19.8 $p < 0.0005$
U-234 N	0.317 ± 0.121	3.124 ± 1.09	0.986 ± 0.518	1.005 ± 0.557	0.446 ± 0.209	52.3 $p < 0.0001$
U-235 N		0.147 ± 0.052	0.015 ± 0.015	0.052 ± 0.042	0.044 ± 0.041	43.6 $p < 0.0001$
U-236 A		(0.044)		(0.022, 0.016)		
U-238 N	0.246 ± 0.137	2.72 ± 0.953	0.843 ± 0.437	0.906 ± 0.484	0.431 ± 0.167	55.2 $p < 0.0001$

Figure 3 *Fucus* (left) and *Alaria nana* (right) growing in the Amchitka intertidal zone (photo J. Burger).

A second objective was to establish the best species for sampling sessile organisms to improve local exposure sampling in the intertidal areas. Hence CRESP decided to increase the number of analyses of Rock Jingles, and to analyze for the first time its samples of Blue Mussels (intertidal, subsistence food) and Horse Mussels (benthic, not usually accessible for subsistence). The data are presented in Table 2. We had initially added Horse Mussel because, as a benthic organism, we wanted to determine whether it was a better accumulator of radionuclides than Blue Mussel. There were no detects for Pu-238, and only one for U-236. While there were some significant differences (Horse Mussels had the highest levels), the differences were not great, and were probably not significant biologically.

Table 2. Comparison of invertebrates for use as bioindicators for actinides. Given are the means (± standard deviation, wet weight) in Bq/kg with the values plus half the MDA for those below the MDA. Where there are very few values above the MDA for an isotope, the actual values are given in parenthesis. For source, A = anthropogenic, and N = natural.

Isotope	Source	Rock Jingle	Blue Mussel	Horse Mussel	Chi square (p value)
Number of composites		21	9	8	
Am-241	A	0.021 ± 0.04	0.017 ± 0.004	0.016 ± 0.004	0,20 P < 0.90
Pu-238	A				
Pu-239,240	A	0.024 ± 0.012	0.019 ± 0.004	0.022 ± 0.011	0.49 P < 0.78
U-234	N	0.446 ± 0.079	0.598 ± 0.194	0.844 ± 0.804	5.69 P < 0.058
U-235	N	0.015 ± 0.026	0.021 ± 0.014	0.030 ± 0.048	1.28 P < 0.53
U-236	A	(0.011)			
U-238	N	0.345 ± 0.071	0.558 ± 0.165	0.730 ± 0.646	16.3 P < 0.003[a]

a. This difference is due to one high outlier, suggesting that this difference is not biologically significant.

Figure 4. Blue Mussels from intertidal rocks near Amchitka test shots

Additional analyses with fish allowed a comparison among more fish species, particularly some of the commercial species. Table 3 (below) presents the information on Cs-137 for the species where there were additional analyses, and for some fish not previously examined.

Figure 5. Irish Lord, Dan Snigaroff holding Dolly Varden.

Table 3. Additional data on Cs-137 for some fish species reported previously, and for additional fish species. Given are the values in Bq/kg, wet weight. This table supplements table 11.5 in Powers et al. (2005).

Species	Number of 1000 g analyses	Percent above the MDA	All values
Dolly Varden	2	100%	0.70, 0.78
Atka Mackerel	3	33%	0.102
Yellow Irish Lord	3	33%	0.132
Northern Sole	2	0	-
Ocean Perch	3	33%	0.108

Locational Differences

The total data set for algae/kelp in Table 1-2, and for fish (Table 3), can be used to evaluate differences between Amchitka and Kiska, the reference site. In general, our samples were evenly-balanced among the Amchitka test shots, aiming where possible for one sample from each test shot area and Kiska, resulting in more samples at Kiska than at any one Amchitka test shot. Below we compare the levels for Amchitka and Kiska (Table 4).

The percent of values above the MDA did not show a significant difference for any actinides. However, the mean Pu-239,240 values in kelp for Amchitka, though smaller in the new data, continued to be higher than those for kelp at Kiska (Table 4). The differences, although statistically significant, are very small and probably not meaningful biologically.

There were no differences in either the percent above the MDA or the mean levels for Cs-137 in fish from Kiska and Amchitka (see table 5).

Figure 6. Kiska Island (top), Amchitka Island (bottom)

Table 4. Comparison of actinide levels between Amchitka and Kiska for Algae. The means (Bq/kg, wet weight) were calculated using half the MDA for values below the MDA. The mean values are compared using the non-parametric Kruskal-Wallis one way analysis of variance and the proportion of detects is compared using a 2 X 2 contingency table. Both tests yield a chi square value. There were 57 algae analyses for Amchitka and 27 for Kiska. (This is an update of Table 11.10 in Powers et al. 2005; and both are in the appendix for comparison).

Isotope	Range of Reported Values	Mean ± SD	Kruskal-Wallis Chi Square (p)	Number of detects (%)	Contingency Chi Square(p)
Am-241					
Amchitka	< 0 - 0.035	0.015 ± 0.008	0.0 P = 0.98	3 of 57 (5.3 %)	0.15 P = 0.70
Kiska	< 0 - 0.075	0.016 ± 0.013		2 of 27 (7.41 %)	
Pu-239,240					
Amchitka	< 0 - 0.207	0.036 ± 0.034	3.69 P = 0.055	14 of 57 (24.6 %)	2.05 P = 0.15
Kiska	< 0 - 0.089	0.023 ± 0.016		3 of 27 (11.1 %)	
U-234					
Amchitka	0.080 - 4.82	1.168 ± 1.029	0.94 P = 0.33	57 of 57 (100 %)	0 P > 0.99
Kiska	0.117 - 5.11	1.067 ± 1.248		27 of 27 (100 %)	
U-235					
Amchitka	< 0 - 0.198	0.055 ± 0.054	1.57 P = 0.21	25 of 57 (46.9 %)	0.84 P = 0.36
Kiska	< 0 - 0.254	0.042 ± 0.066		9 of 27 (33.3 %)	
U-236					
Amchitka	< 0 - 0.044	0.002 ± 0.008	0.25 P = 0.61	3 of 57 (5.3 %)	1.47 P = 0.22
Kiska	< 0 - 0.019	0 ± 0.004		0 of 27 (0 %)	
U-238					
Amchitka	0.077 - 4.37	1.042 ± 0.914	1.39 P = 0.23	57 of 57 (100 %)	0 P > 0.99
Kiska	0.058 - 4.47	0.910 ± 1.056		27 of 27 (100 %)	

Table 5. Comparison of Cs-137 levels in Fish between Amchitka and Kiska. Comparison in high trophic level fish species (1000 gram samples only) for Black Rockfish, Halibut, Pacific Cod, Walleye Pollock, Ocean Perch, Atka Mackerel and Yellow Irish Lord (all fish species where Cs was detected in at least one composite sample). (This is an update of Table 11.8 in Powers et al. 2005 see appendix).

	Amchitka	Kiska	Statistical Test
Number of composites	20	12	
Number positive (%)	10	8	0.84, $P < 0.36$
Mean $\pm$ SD (using 1/2 MDA for non detects) (range)	0.152 $\pm$ 0.160 (< 0 - 0.602)	0.184 $\pm$ 0.139 (0.069 - 0461)	0.61, $P < 0.43$
Mean $\pm$ SD for detects only	0.257 $\pm$ 0.167	0.252 $\pm$ 0.120	0.08, $P < 0.93$

DISCUSSION

The additional data on Cs in fish, and actinides in kelp, Rock Jingles, Blue Mussels and Horse Mussels allowed us to:

1. Obtain information on a wider diversity of kelp, invertebrates, and fish for refining bioindicator selection.
2. Further test the hypothesis of locational differences in Cs-137 in fish and Pu-239,240 in kelp.
3. Evaluate our conclusions in light of additional samples.

Bioindicator Selection

One of our objectives was to provide more information to allow selection of bioindicators. We added 36 new kelp actinide analyses (previous N was 48). By adding both another genus (*Laminaria*), and additional composites of other species, we achieved greater significance and a clearer pattern of radionuclide distribution. *Laminaria* proved to be not as good a bioaccumulator of radionuclides as the other species, eliminating it as a possible bioindicator. The additional samples confirmed that *Fucus* and *Alaria fistulosa* were the best accumulators of radionuclides.

A second objective was to examine filter feeders in more detail. We increased our sample number of composites from 3 to 38, providing additional information for bioindicator selection among invertebrates. The differences among species were not great, and given that Blue Mussels are a subsistence food, and intermediate in levels, it is the best choice for an invertebrate bioindicator.

A final indicator selection objective was to increase the number of commercial fish species examined. We added additional composites for some species, and added additional species, bringing our fish species diversity from 6 to 10. This allowed us to include some key commercial and subsistence species in the analysis, and to conclude that Dolly Varden was a high accumulator.

Locational Differences

A final objective was to further examine the biota for differences between radionuclide levels at Amchitka and Kiska (our reference site). In the *Amchitka Independent Science Assessment: Biological and Geophysical Aspects of Potential Radionuclide Exposure in the Amchitka Marine Environment* we found that the percent of values above the MDA for Pu-239,240 in algae was higher at Amchitka than at Kiska, and the percent of values above the MDA for Cs-137 in fish was higher at Kiska than at

Amchitka. With the nearly doubling of the sample size for algae, the difference in the percent of values above the MDA disappeared, but there was a small, but borderline statistically significant difference in the mean values of Pu-239,240 in algae (Amchitka was higher). The difference is very small and probably not meaningful biologically.

CONCLUSIONS

The overall conclusions of the *Amchitka Independent Science Assessment: Biological and Geophysical Aspects of Potential Radionuclide Exposure in the Amchitka Marine Environment* remain the same: 1) the foods tested are currently safe to eat with regard to radionuclides, and radionuclide levels remain below published human health guidance levels, 2). our data do not suggest that radionuclides in biota collected from Amchitka are attributable to the Amchitka test shots, and 3) a combination of sedentary and mobile organisms at different trophic levels is ideal for a continued biomonitoring program at Amchitka.

Appendix

The following tables provide comparisons of tables originally provided in Chapter 11 (Powers, et al 2005), with the new tables from this addendum.

Table 1. Repeated from page 8 so that it can be compared to table 11.7 on the following page. Examination of Kelp/algae for use as bioindicators for actinides. Given is the mean (± standard deviation, wet weight) in Bq/kg with the values plus half the MDA. Where there were few values above the MDA for an isotope, those are listed in parenthesis (no statistical test was performed). A = primarily anthropogenic, N = primarily natural. (This is an update of Table 11.7 in Powers et al. 2005.)

Isotope	*Ulva* N=12	*Fucus* N=14	*Alaria Nana* N=21	*Alaria Fistulosa* N=19	*Laminaria* N=18	Chi square (p value)
Am-241 A	(0.059)	().040, 0.022)	(0.039, 0.023)			3.22 p < 0.52
Pu-238 A	(0.024, 0.123)			(0.015)		
Pu-239,240 A		0.031 ± 0.017	0.031 ± 0.018	0.051 ± 0.05	0.020 ± 0.023	19.8 p < 0.0005
U-234 N	0.317 ± 0.121	3.124 ± 1.09	0.986 ± 0.518	1.005 ± 0.557	0.446 ± 0.209	52.3 p < 0.0001
U-235 N		0.147 ± 0.052	0.015 ± 0.015	0.052 ± 0.042	0.044 ± 0.041	43.6 p < 0.0001
U-236 A		(0.044)		(0.022, 0.016)		
U-238 N	0.246 ± 0.137	2.72 ± 0.953	0.843 ± 0.437	0.906 ± 0.484	0.431 ± 0.167	55.2 p < 0.0001

Table 11.7 from Powers et al 2005 (The columns were rearranged to facilitate comparison.)

Table 11.7. Mean Actinide Differences Among Algae Species. Mean (± standard deviation) actinide values (Bq/Kg, wet weight) for kelp from both Amchitka and Kiska. Number of analyses was as follows: Alaria fistulosa = 10, A. nana = 12, Fucus = 14, and Ulva = 12. The mean values include both samples with and without measured values above minimum detectable activity level (entered as half the MDA). P values <0.05 indicate a significant difference among algae species using Kruskal-Wallis test.

Isotope	***Ulva*** N=12	***Fucus*** N=14	***Alaria nana*** N=12	***Alaria fistulosa*** N=10	**Chi square (p value)**
Am-241	0.017 ± 0.019	0.015 ± 0.014	0.018 ± 0.01	0.013 ± 0.006	1.64 (0.65)
Pu-238	0.021± 0.033	0.014 ± 0.005	0.018 ± 0.01	0.014 ± 0.005	1.59 (0.66)
Pu-239,240	0.014 ± 0.006	0.036 ± 0.031	0.029 ± 0.016	0.057 ± 0.065	11.9 (0.008)
U-234	0.317± 0.121	3.12 ± 1.087	0.77 ± 0.31	1.001 ± 0.64	35.1 (<0.0001)
U-235	0.025 ± 0.004	0.15 ± 0.052	0.039 ± 0.024	0.050 ± 0.035	30.9 (<0.0001)
U-236	0.018 ± 0.006	0.018 ± 0.008	0.019 ± 0.011	0.020 ± 0.013	2.37 (0.50)
U-238	0.246 ± 0.137	2.74 ± 0.95	0.68 ± 0.30	0.856 ± 0.48	37.3 (<0.0001)

Table 4. (Repeated from page 13 so that it can be compared with table 11.10 on the following page.) Comparison of actinide levels between Amchitka and Kiska for Algae. The means (Bq/kg, wet weight) were calculated using half the MDA for values below the MDA). The mean values are compared using the non-parametric Kruskal-Wallis one way analysis of variance and the proportion of detects is compared using a 2 X 2 contingency table. Both tests yield a chi square value. There were 57 algae analyses for Amchitka and 27 for Kiska. (This is an update of Table 11.10 in Powers et al. 2005) .

Isotope	Range of Reported Values	Mean ± SD	Kruskal-Wallis Chi Square (p)	Number of detects (%)	Contingency Chi Square(p)
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Kiska	0.058 - 4.47	0.910 ± 1.056		27 of 27 (100 %)	

Table 11.10 from Powers et al 2005

Table 11.10. Comparison of Actinide Levels Between Amchitka and Kiska for Algae. Comparison of radionuclide values in Algae[a] for Amchitka and Kiska islands including the ranges of concentrations reported, the means calculated (using half the MDA for values below the MDA[b]), and the proportion of detects (values > MDA) for each of the actinides. The mean values are compared using the non-parametric Kruskal-Wallis one way analysis of variance and the proportion of detects is compared using a 2 x 2 contingency table. Both tests yield a chi square value. There were 31 algae analyses from Amchitka and 17 from Kiska.

	Range and Means of Isotope Values			**Proportion of Detects**	
ISOTOPE	**Range of reported values**	**Mean + SD**	**Kruskal-Wallis Chi Square (p=)**	**Number of detects (%)**	**Contingency Chi Square (p=)**
Am-241					
Amchitka	<0 - 0.035	0.015 ± 0.008	0.04 (p=.84)	3 of 31 (9%)	0.05 (p=.82)
Kiska	<0 - 0.075	0.018 ± 0.016		2 of 17 (11%)	
Pu-238					
Amchitka	<0 - 0.123	0.019 ± 0.021	0.69 (P=.41)	3 of 31 (9%)	1.75 (p=.18)
Kiska	<0 - 0.006	0.013 ± 0.005		0 of 17 (0%)	
Pu-239,240					
Amchitka	<0 - 0.207	0.039 ± 0.040	5.68 (P=.017	11 of 31 (32%)	4.32 (p=.04)
Kiska	<0 - 0.041	0.018 ± 0.008		1 of 17 (6%)	
U-234					
Amchitka	0.195 - 4.820	1.447 ± 1.221	0.92 (P=.34)	31 of 31 (100%)	0 (p=.99)
Kiska	0.157 - 5.100	1.291 ± 1.526		17 of 17 (100%)	
U-235					
Amchitka	<0 - 0.198	0.071 ± 0.055	1.04 (p=.31)	16 of 31 (52%)	1.18 (p=.28)
Kiska	<0 - 0.254	0.066 ± 0.072		6 of 17 (35%)	
U-236					
Amchitka	<0 - 0.044	0.020 ± 0.011	2.34 (p=.13)	2 of 31 (6%)	1.14 (p=.27)
Kiska	<0 - 0.019	0.016 ± 0.005		0 of 17 (0%)	
U-238					
Amchitka	0.077 - 4.370	1.279 ± 1.100	1.14 (p=.28)	31 of 31 (100%)	0 (p=.99)
Kiska	0.058 - 4.470	1.080 ± 1.291		17 of 17 (100%)	

a=Algae include *Alaria fistulosa, Alaria nana*, *Fucus*, and *Ulva*.
b=There were no significant differences in MDA's for Amchitka and Kiska, including for Pu239, 240.